OPERATING LICENCE APPLICATION

for a nuclear power plant unit Olkiluoto 3

Teollisuuden Voima Oyj

Additional information

Teollisuuden Voima Oyj
Olkiluoto FI-27160, Finland
Telephone +358 2 83811
Internet www.tvo.fi

FOR THE ATTENTION OF THE GOVERNMENT OF FINLAND

OPERATING LICENCE APPLICATION FOR A NUCLEAR POWER PLANT UNIT OLKILUOTO 3

APPLICANT

Teollisuuden Voima Oyj (hereinafter referred to as "TVO"), Helsinki.

APPLICATION

The Applicant requests

- a licence referred to in Section 20 of the Nuclear Energy Act for the operation of the Olkiluoto 3 nuclear power plant unit constructed at Olkiluoto in Eurajoki (hereinafter referred to as "Olkiluoto 3") from the beginning of year 2018 to the end of year 2038.
- a licence to place in interim storage spent fuel generated by the operation of the Olkiluoto 3 plant unit in the spent fuel interim storage that is already operational at Olkiluoto (hereinafter referred to as the "KPA storage") pursuant to the operating licence concerning the interim storage from the beginning of year 2018 to the end of year 2038.
- a licence to place in interim storage nuclear waste generated by the operation of Olkiluoto 3 in the interim storage for intermediate level waste (hereinafter referred to as the "KAJ storage") and in the interim storage for low level waste (hereinafter referred to as the "MAJ storage") pursuant to the operating licence concerning the interim storages from the beginning of year 2018 to the end of year 2038.
- a licence to place in interim storage, at the Olkiluoto 3 plant unit, plant waste generated by the operation of the nuclear facilities located on the island of Olkiluoto from the beginning of year 2018 to the end of year 2038.

OBJECT OF APPLICATION

The application concerns a water-moderated and water-cooled pressurised water reactor plant with a nominal thermal output of 4,300 MW. In the reactor of a nuclear power plant unit, the uranium fuel heats the water which is circulated in the primary circuit by means of pumps. The pressurised water generates steam in the separate steam generators that are part of the primary circuit. The steam circulates in the secondary circuit and rotates the turbine and the generator. The type name of the plant is EPR (European Pressurised Water Reactor).

The application covers the storage of the nuclear fuel and nuclear waste included in the operation of Olkiluoto 3. Therefore, the application also concerns the right to possess, produce, handle, use and store nuclear waste and nuclear materials as well as other nuclear use items at the plant site as follows:

- An amount of spent nuclear fuel originating from the operation of Olkiluoto 3 equivalent to no more than 2,500 tonnes of uranium inside the KPA storage, of which no more than 520 tonnes of uranium inside the Olkiluoto 3 plant unit.
- 600 m^3 of power plant waste originating from the operation of the nuclear facilities located on the island of Olkiluoto inside the Olkiluoto 3 plant unit.
- Nuclear waste originating from the operation of the Olkiluoto 3 plant unit in the MAJ storage and KAJ storage within the maximum limits approved by the Radiation and Nuclear Safety Authority, while taking the storage needs of the Olkiluoto 1 and 2 plant units into consideration.
- Fresh nuclear fuel required for the operation of Olkiluoto 3, for the import of which a licence has been granted under the Nuclear Energy Act.
- Other nuclear use items required for the operation of Olkiluoto 3 as follows: nuclear use items already existing at the plant site

and other nuclear use items, assuming that an import licence under the Nuclear Energy Act has been granted for the materials that require one.

It is the applicant's intention to perform a periodic safety assessment for Olkiluoto 3 by the end of 2028. The content of the assessment is defined according to the applicable international and national recommendations and practices and the orders and requirements issued by the Radiation and Nuclear Safety Authority.

JUSTIFICATIONS OF THE APPLICATION

Application background information and earlier licences

In an application dated 15th November 2000, TVO requested from the Government a decision in principle referred to in Section 11 of the Nuclear Energy Act indicating that the construction of Olkiluoto 3 is in line with the overall good of society. In addition, the application also concerned the nuclear facilities related to the operations of Olkiluoto 3 and located at the same plant site, required for the storage of fresh nuclear fuel, for the interim storage of spent nuclear fuel, and for the processing, storage and disposal of low and intermediate level power plant waste.

The Government made the decision in principle which the application concerned on 17th January 2002. On 24th May 2002, Parliament decided to retain the decision in principle in force unaltered. TVO continued to prepare the project in accordance with the guidelines presented in the application for a decision in principle and the decision in principle proper.

In an application dated 8th January 2004, TVO applied for a licence referred to in Section 18 of the Nuclear Energy Act to construct Olkiluoto 3 in the Olkiluoto power plant site area.

On 17th February 2005, the Government made a decision which the application concerned to grant TVO a licence, pursuant to Section 18 of the Nuclear Energy Act, for the construction on the island of Olkiluoto in the municipality of Eurajoki of a pressurised water nuclear power plant unit with a nominal thermal output of 4,300 megawatts, whose general features and basic solutions for ensuring safety correspond to what is presented in the application for a construction licence. TVO launched the construction of Olkiluoto 3 in the spring of 2005, after receiving a construction licence from the municipality of Eurajoki (11th January 2015) and a construction licence under the Nuclear Energy Act (17th February 2005), and had it constructed according to the plans presented in the application for a construction licence and the detailed design bases that had been specified and approved during construction. A description of how the conditions of the construction licence have been adhered to is included in this application as Appendix 12.

Applicant

The applicant is TVO, domiciled in Helsinki. TVO is the owner and operator of the Olkiluoto nuclear power plant, located in the municipality of Eurajoki. In 2015, the two plant units of the power plant, Olkiluoto 1 and Olkiluoto 2, generated approximately 17% of all electricity consumed in Finland. The share of electricity generated by Olkiluoto 3 of all electricity consumed in Finland will be approximately 15%.

TVO owns 60 per cent of Posiva Oy (hereinafter referred to as "Posiva"), whose task is to take care of the disposal of spent nuclear fuel originating from the Finnish nuclear power plants of its owners. The remaining 40% of Posiva is owned by Fortum Power and Heat Oy ("FPH"), the owner and operator of the Loviisa nuclear power plant. The intention is to have the spent fuel disposed of by Posiva in a disposal facility constructed on Olkiluoto island, for the construction of which the Government granted a construction licence under Section 18 of the Nuclear Energy Act on 12th November 2015. It is the intention to begin the disposal of spent fuel originating from the nuclear power plants in Olkiluoto and Loviisa in the early 2020s.

More detailed information concerning the applicant is available in Appendices 1, 2, 8, 10 and 11 to the application.

Site

Olkiluoto 3 is located in the municipality of Eurajoki at the Olkiluoto nuclear power plant site owned by TVO.

More detailed analyses concerning the site are presented in Appendix 3 to the application.

Purpose of use

Olkiluoto 3 is used for the generation of electricity.

Olkiluoto 3 includes facilities and equipment required for the storage of fresh nuclear fuel, the interim storage of spent nuclear fuel before its transfer to the KPA storage and the processing and interim storage of low and intermediate level power plant waste. The KPA storage, KAJ storage and MAJ storage located at the plant site are also connected to the operation of the Olkiluoto power plant. The MAJ storage is considered to include the components storage intended for the storage and handling of contaminated components, for which the Radiation and Nuclear Safety Authority granted a licence for operations on 22nd February 2005.

Appendices 4 and 9 to the application present the analyses of the qualities and maximum amounts of nuclear materials and nuclear waste produced, processed, used or stored at the nuclear power plant unit and the plans for the arrangement of nuclear waste management.

Nominal output

The nominal thermal output of the reactor of Olkiluoto 3 is 4,300 MW. The net power output of the plant unit is approximately 1,600 MWe. The estimated annual electricity production is approximately 13 terawatt hours.

Time of operation

The planned time of operation for Olkiluoto 3 is at least 60 years.

A minimum service life of 60 years has been used as the starting point for the design of structures and components that are difficult to replace. A minimum service life of 30 years has been used as the starting point for the design of other structures and components. A minimum service life of 60 years can be achieved by replacing the latter structures and components during operation.

CONDITIONS FOR GRANTING THE LICENCE (SECTION 20 OF THE NUCLEAR ENERGY ACT)

Safety and environmental impacts

1) the nuclear facility and its operation meet the safety requirements laid down in this Act, and appropriate account has been taken of the safety of workers and the population, and environmental protection;

Pursuant to the Nuclear Energy Act, the starting point for the design, construction and operation has been to create a safe Olkiluoto 3 that meets the requirements set and that will not cause harm to the population, the environment or property. This has been implemented through preventive measures during the design and construction of the plant unit, functions that protect the plant during operational disturbances and in case of damage, and through functions that limit the consequences during accident situations. The design bases for Olkiluoto 3 have been continuously assessed during the construction, based on the best available knowledge. Furthermore, preparation for natural phenomena and disturbances in electricity supply at Olkiluoto 3 has been completely reassessed following the nuclear power plant accident that occurred in Japan in March 2011. The design, construction and future operation of Olkiluoto 3 follow the requirements concerning safety laid down in Chapter 2 a of the Nuclear Energy Act (Sections 7a–7r). An outline of the technical operating principles and features and other arrangements whereby safety has been ensured can be found in Appendix 5 to the application. At Finnish nuclear power plant units, the number of events that have been significant in terms of safety and that have disturbed the operation of the plant units has been low. None of the events have resulted in the exceeding of the radiation doses allowed for the personnel or radiation hazards to the environment.

Olkiluoto 3 meets the internationally advanced safety requirements that are in force in Finland and whose basic principles are included in the orders issued by the Radiation and Nuclear Safety Authority and, in more detail, in the Regulatory Guides on nuclear safety (YVL Guides), Regulatory Guides on radiation safety (ST Guides) and emergency preparedness guides (VAL Guides) published by the Radiation and Nuclear Safety Authority. In addition, the principles and guides published by certain other countries and the International Atomic Energy Agency (IAEA) have been taken into consideration. A description of the safety principles that have been observed and an evaluation of the fulfilment of the principles can be found in Appendix 6 to the application.

In Finland, the Radiation and Nuclear Safety Authority is the regulatory authority for nuclear safety supervising TVO's operations. TVO's operations have met the requirements of the national authorities. TVO's operations also require adherence to international agreements in the field of safeguards of nuclear materials, for example.

TVO is actively involved in different international forums of the nuclear energy industry. TVO's operations are also subjected to international peer reviews, and any areas for improvement that arise during them are taken into account in TVO's operations. The direct and indirect impacts on the population, nature and the constructed environment that Olkiluoto 3 has have been assessed in accordance with the Act on Environmental Impact Assessment Procedure. The coordinating authority has considered that the assessment report presented is sufficient, and the construction licence has observed the assessment report concerning the project and the coordinating authority's statement on it. During the implementation of the project, appropriate attention has been paid to the aspects presented in the statements concerning the assessment report.

TVO has an environmental management system that meets the requirements of standard ISO 14001:2004 and the EMAS directive 1221/2009. It is EMAS registered with code FIN-000039. TVO's environmental management system covers taking environmental aspects into account over the entire lifespan of nuclear energy generation and the principle of continuous improvement as regards the management of environmental matters.

A description of the measures to restrict the burden caused by the nuclear facility on the environmentcan be found in Appendix 7 to the application.

Nuclear fuel management and nuclear waste management

2) the methods available to the applicant for arranging nuclear waste management, including final disposal of nuclear waste and decommissioning of the facility, are sufficient and appropriate;

Olkiluoto 3 fuel management is implemented in a reliable and distributed manner using several sources of procurement and arrangements that are similar to those at TVO's operating plant units. The principle is to employ long-standing contracts and fuel reserves. A description of the plans to arrange nuclear fuel management can be found in Appendix 4 to the application.

Nuclear waste management uses the same plans, methods and waste management facilities as the existing plant unit. The plant site has in use disposal facilities for low and intermediate level power plant waste that can be expanded to cover the needs of Olkiluoto 3 as well. The expansion will not be required until several years have passed from the starting of Olkiluoto 3.

For a long time now, Finland has been developing the disposal of spent nuclear fuel. The intention is to have the spent fuel disposed of by Posiva in a disposal facility constructed on Olkiluoto island. The Government issued a decision in principle for the construction of this disposal facility on 21st December 2000. On 18th May 2001, Parliament decided to retain the decision in principle in force. Moreover, on 17th January 2002 the Government made a decision in principle that the Olkiluoto disposal facility can be expanded such that the spent nuclear fuel from the operation of Olkiluoto 3 can also be treated and disposed of at the facility. On 24th May 2002, Parliament decided to retain the decision in principle in force. According to the decision, disposal facilities corresponding to approximately 2,500 tonnes of uranium at maximum can be built for the needs of Olkiluoto 3. Posiva was granted a construction licence for an encapsulation plant and disposal facility on 12th November 2015. Posiva is planning to submit an operating licence application to start the disposal activities in 2020.

Plans concerning the decommissioning of the Olkiluoto 3 plant unit have been drawn up and their main principles are described in Appendix 9 to this application and in more detail in the final safety analysis report to be submitted to the Radiation and Nuclear Safety Authority.

A more detailed description of the Olkiluoto nuclear power plant's plans and methods available for arranging the management of nuclear waste, including the disassembly of the nuclear facility and the disposal of nuclear waste, and a description of the schedule of nuclear waste management and estimated costs can be found in Appendix 9 to the application.

Organisation and expertise

3) the applicant has sufficient expertise available and, in particular, the competence of the operating staff and the operating organisation of the nuclear facility are appropriate;

During the construction of Olkiluoto 1 and Olkiluoto 2 and over thirty years of their operation, as well as the construction of Olkiluoto 3, the personnel employed by TVO have accumulated significant expertise in the construction and operation of nuclear power. This expertise has been supplemented by the maintenance and development investments made at the plant units, the most significant of which have been the plant unit modernisation completed in 1994–1998, the extensive component renewals completed in 2010–2011 and the presently ongoing, extensive plant modifications.

The operating results of the current plant units at Olkiluoto have been among the best in the world. For some 20 years, Finland has been the world's leading country in terms of the annual load factors of nuclear power plants. The reliable operation of nuclear power plants is an indication of the high level of expertise in the field in Finland. The high load factor is also an indication that TVO's reliable electricity production has been needed. The construction of Olkiluoto 3 has substantially increased the company's expertise, as well as the expertise available to it, in next-generation plant units.

TVO has started the recruiting, training and qualification of operating personnel for Olkiluoto 3 by means of the procedures described in the YVL Guides in good time during construction. The other support personnel for the operation of Olkiluoto 3 have also been trained and, if so required by the YVL Guides, also qualified for their tasks. The continuous training of the operating organisation of Olkiluoto 3 and the maintenance of the competences has been ensured by means of training programmes.

A more detailed analysis of the expertise available to the applicant and the operating organisation of the nuclear power plant unit can be found in Appendix 8 to the application.

Financial and other prerequisites

4) the applicant is otherwise considered to have the financial and other prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations.

The applicant's financial and other prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations are presented in Appendices 10 and 11.

Summary

On the grounds of the information presented above and the more detailed analyses presented in the Appendices to the application, it is the opinion of the applicant that the prerequisites for granting an operating licence pursuant to Section 20 of the Nuclear Energy Act and the requirements concerning the overall good of society and the safety of Olkiluoto 3 pursuant to Sections 5–7 of the Nuclear Energy Act are met and the operating licence requested by the applicant may be granted.

ENFORCEMENT OF THE DECISION

The applicant requests that, when granting the licence, the Government decide under Section 31(2) of the Administrative Judicial Procedure Act (586/1996) that the decision be executed in spite of any complaints, since public interest requires that the execution is not delayed.

Starting production at Olkiluoto 3 without delays caused by any complaints is in line with the overall good of society. The starting of Olkiluoto 3 will reduce the costs to the society as Finland aims to achieve its international emissions goals. The starting of Olkiluoto 3 will also improve the reliability of Finland's electricity supply. Since the completion of Olkiluoto 3 has been significantly delayed from its original schedule, interrupting the process while waiting for the decision to become legally valid will cause instability on the electrical market and will adversely affect the regional employment situation by causing discontinuity on the labour market.

In Helsinki, 14 April 2016

TEOLLISUUDEN VOIMA OYJ

Jarmo Tanhua
President and CEO

Jouni Silvennoinen
Director

APPENDICES

Reports required under Section 34 of the Nuclear Energy Decree:

1. Extract from the trade register
2. Copy of the articles of association and shareholders' register
3. A description of settlement and other activities and town planning arrangements at the planned nuclear facility site and in its immediate vicinity
4. A description of the quality and maximum amounts of the nuclear materials or nuclear waste that will be fabricated, produced, handled, used or stored at the nuclear facility
5. An outline of the technical operating principles and features and other arrangements whereby safety has been ensured
6. A description of the safety principles that have been observed, and an evaluation of the fulfilment of the principles
7. A description of the measures to restrict the burden caused by the nuclear facility on the environment
8. A description of the expertise available to the applicant and the operating organisation of the nuclear facility
9. A description of the applicant's plans and available methods for arranging nuclear waste management, including the decommissioning of the nuclear facility and the disposal of nuclear waste, and a description of the timetable of nuclear waste management and its estimated costs
10. A description of the applicant's financial status, the plan for the administration of the finances of the nuclear facility and the production plan of the nuclear facility
11. The applicant's financial statements from 2004–2015
12. A description of how the provisions in the construction licence have been complied with

APPENDIX 1

EXTRACT FROM THE TRADE REGISTER

Separate appendix, not included in this hard copy version

APPENDIX 2

COPY OF THE

ARTICLES OF ASSOCIATION AND SHAREHOLDERS' REGISTER

Separate appendix, not included in this hard copy version

APPENDIX 3

A DESCRIPTION

OF SETTLEMENT AND OTHER ACTIVITIES AND TOWN PLANNING ARRANGEMENTS AT THE PLANNED NUCLEAR FACILITY SITE AND IN ITS IMMEDIATE VICINITY

TABLE OF CONTENTS

1. General

The site of the third nuclear power plant unit at Olkiluoto (OL3) meets the land use requirements set forth in the relevant legislation and regulatory guides on Nuclear Safety (YVL). The settlements in the Olkiluoto area are mainly recreational. The larger population centres with permanent settlement, the centres of Eurajoki and Rauma, are located at a distance of approximately 15–20 kilometres from Olkiluoto.

Land use in the Olkiluoto power plant site is presently controlled by the regional land use plan, the local plan for Olkiluoto and detailed plans that have been validated in 2014.

Supporting functions are under construction at Olkiluoto in relation to the construction of OL3 and the preparation for the construction of the encapsulation plant and disposal facility for spent nuclear fuel. The infrastructure at Olkiluoto is being renewed and supplemented.

2. Settlement and other activities

2.1 Activities in the Olkiluoto area

The Olkiluoto power plant area owned by Teollisuuden Voima Oyj (TVO) is located in the municipality of Eurajoki, at the western end of the island of Olkiluoto. The nuclear power plants Olkiluoto 1 and Olkiluoto 2, constructed between 1973 and 1980, are located in the plant area. Both plant units have a nominal net power output of 890 MWe. The nominal net power output of plant unit OL3 is 1,600 MWe.

The plant area also contains administrative buildings, a training and visitor centre, storage facilities, workshops, and an auxiliary heating plant, raw water purification plant, water demineralisation plant, sanitary water purification plant, accommodation village, landfill and spent fuel interim storage, interim storages for low and intermediate level power plant waste and a final disposal facility for power plant waste.

According to plans, Posiva Oy is constructing an encapsulation plant and disposal facility for spent nuclear fuel near the plant area, in the centre part of the island of Olkiluoto; its zoning and other arrangements are presented in Posiva's construction licence application (28 December 2012). The construction of the research facility (ONKALO) that will be connected to the disposal facility started in 2004. Construction license was granted to Posiva on 12th of November 2015.

The power plant is connected to the national electrical grid via six 400-kV and two 110-kV power lines. After the commissioning of OL3, there will normally be two 400-kV connections in use for each plant unit. The Olkiluoto 400-kV substation is located on the northern shore of the island, approximately two kilometres from the power plant. The 110-kV substation is located immediately to the north of the power plant.

The northern shore of the island of Olkiluoto has a dock and harbour which are located on land that is owned by the applicant. The harbour is open to public use and it has a six-metre deep shipping channel leading to it that is maintained by the Finnish Transport Agency. Between 5 and 10 people are employed by the harbour's different functions.

2.2 Settlements in the vicinity of Olkiluoto

The nearest residential buildings are located approximately three kilometres from the power plant area. There are less than ten buildings suitable for permanent residence on the island of Olkiluoto and the nearby island of Kornamaa. There are several buildings intended for permanent residence in the village of Ilavainen to the east of the island of Olkiluoto.

The protective zone of the nuclear power plant has 303 constructed recreational settlements, 37 unconstructed recreational settlements and 70 constructed residential buildings. According to the population data from Statistics Finland, the protective zone had a total of 50 inhabitants on 31 December 2014; see Figure 3.

The holiday accommodation area on the eastern part of the island of Olkiluoto has the Raunela estate; TVO has restored its buildings and surroundings to correspond to the situation at Olkiluoto before the arrival of the nuclear power plant.

At present, Olkiluoto can offer temporary accommodation for approximately 425 people in relation to work at the nuclear power plant; if necessary, accommodation capacity can be increased within the bounds of the permitted building volume in the plan.

Eurajoki is a coastal municipality located on the shore of the Gulf of Bothnia, and it is a part of the economic zone of Rauma.

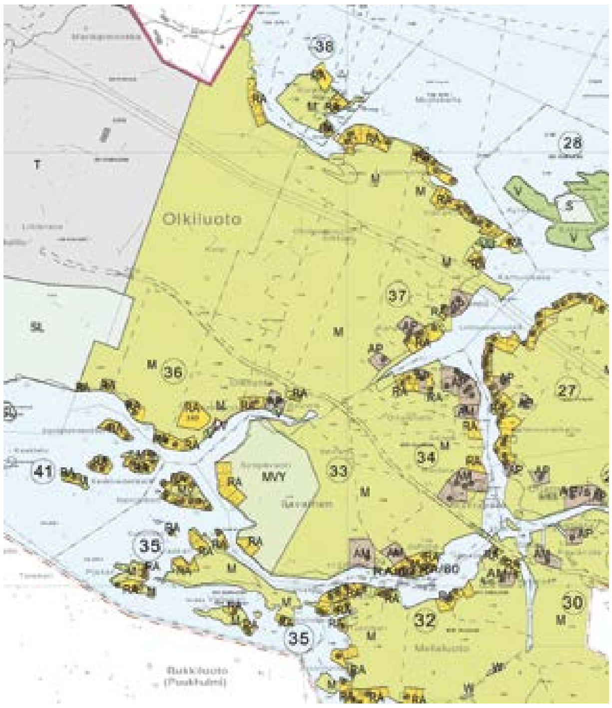


Figure 1. Holiday housing in accordance with the partial master plan for shore areas on the eastern side of the island of Olkiluoto.

The municipality of Eurajoki has approximately 6,000 inhabitants. The municipal centre is located alongside national road 8, approximately 15 kilometres north of the centre of Rauma and approximately 35 kilometres south of Pori. Figure 2 presents the location of Olkiluoto within Eurajoki and in relation to Rauma.

The neighbouring municipalities of Eurajoki are as follows:

- Rauma (approx. 39,900 inhabitants)
- Eura (approx. 12,200 inhabitants)
- Luvia (approx. 3,300 inhabitants)
- Nakkila (approx. 5,700 inhabitants)

Figure 2. Olkiluoto is located approximately 20 km away from the significant population centres, Rauma and Eurajoki..

The Rauma region, which consists of Eura, Eurajoki, Säkylä, Köyliö (until 31 December 2015) and Rauma, has approximately 65,500 inhabitants. Pori, which is located to the north-east of Olkiluoto, has approximately 85,000 inhabitants.

Figures 3 and 4 present the distribution of settlements around the nuclear power plant (at distances between 0–20 km and 0–100 km). The figures are based on data from Statistics Finland and they describe the situation as of 31 December 2014.

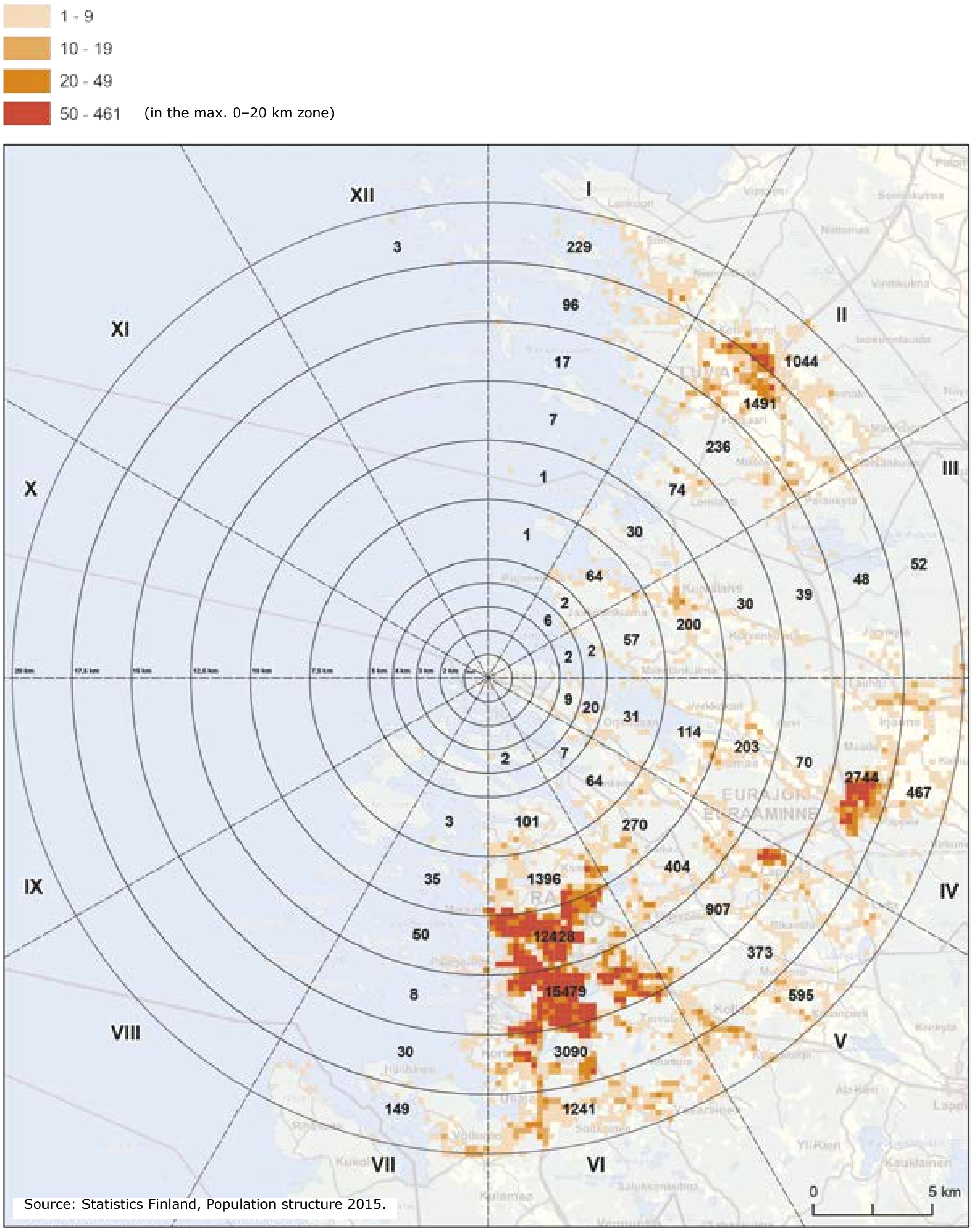


Figure 3. Population (31 December 2014) by sector and squares of 250 x 250 m in the surrounding areas of Olkiluoto, distances between 0 and 20 km.

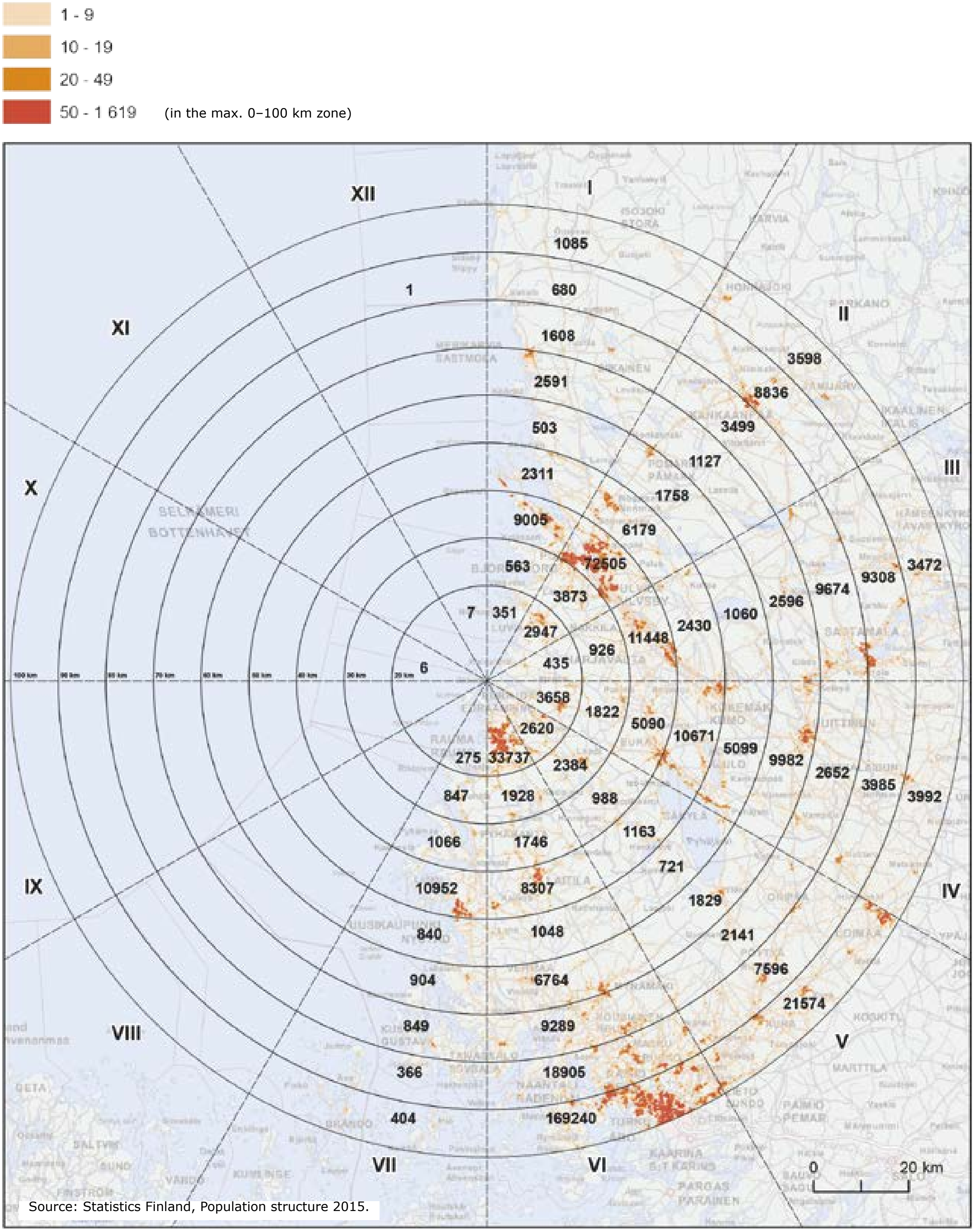


Figure 4. Population (31 December 2014) by sector and squares of 250 x 250 m in the surrounding areas of Olkiluoto, distances between 0 and 100 km.

2.3 Other activities in the surrounding areas of Olkiluoto

Only a small amount of agricultural activities take place near the power plant area at Olkiluoto. There are small cultivated plots in the eastern part of the island. The nearby waters are used for recreational fishing.

The villages of Ilavainen and Orjasaari, which are located to the east of the island of Olkiluoto (5-km radius), have very few activities and the OL3 plant unit will not significantly affect them. The amount of traffic that passes through these villages towards Olkiluoto has increased during the construction period of OL3.

Services, refining, agriculture and forestry are important areas in the economic structure of the municipality of Eurajoki. TVO is the largest employer in the municipality. The applicant employs approximately 730 persons at the nuclear power plant, in addition to which there are slightly over 300 contractor employees working at Olkiluoto. During annual outages, there are usually approximately 1,500 persons working at the power plant in addition to the normal number of personnel. A maximum of 4,500 persons have been working at the construction site for the OL3 plant unit. After the completion of the power plant, there will be approximately 150–200 persons working in Operations and Maintenance.

In 2012, the fields of business employing the inhabitants were divided as follows:

Primary production 5.4%
Refining 53.2%
Services 40.4%

Half of the inhabitants of Eurajoki work outside of the municipality in Rauma or Pori, for example. People commute to Eurajoki from a wide area, but the majority live in Rauma.

TVO has a significant direct and indirect effect in the province of Satakunta and in the Rauma region in particular. In 2015, 56% of those employed by TVO at Olkiluoto lived in Rauma, 18% lived in Eurajoki, 14% lived in Pori and 12% lived in other municipalities.

The most important farm lands in the nearby areas of Olkiluoto are located 20–40 km to the east of the power plant and 25–35 km to the northeast. There are a few commercial gardens located approximately 10 kilometres from the power plant that produce vegetables mainly for the Rauma region. The nearest dairy is located in Pori at a distance of approximately 35 kilometres. There are three milk-producing farms within a 10-kilometre radius of the nuclear power plant. There are several dozen milk farms within a 40-kilometre radius.

Three schools are located within a radius of approximately 10 kilometres from the nuclear power plant. These are primary schools and their pupils are between 6 and 13 years old.

3. Zoning arrangements and other arrangements

3.1 General

Olkiluoto has a valid regional land use plan, master plan for shore areas, master plan and detailed plan that indicate areas for the construction of nuclear power plants. For the most part, these plans have been updated to correspond with the content requirements of the new Land Use and Building Act and to take into account the requirements for the disposal of spent nuclear fuel.

3.2 Local plan

The valid detailed plans for Olkiluoto have a permitted building volume of 6.55 million cubic metres in the area designated for use as a nuclear power plant area; nearly 4 million cubic metres are available for future construction. The power plant area is located in the western end of the island of Olkiluoto.

The detailed plan that is valid in the area of the current nuclear power plant units and Olkiluoto 3 has been confirmed in 1997 and determined as up-to-date in 2014. The power plant area is marked as block area for industrial buildings and storage buildings *into which the construction of nuclear power plants and other facilities and equipment intended for the generation, distribution and transfer of energy and their related buildings, structures and equipment may be constructed unless this has otherwise been limited.*

Most of the water areas referred to in the detailed plan have been confirmed to be waters that may be used for the purposes of power plants, and *into which the piers and other structures and equipment required for power plants may be constructed in the vicinity of the industrial areas and storage areas.* The plan also indicates the waters where filling and embankment are allowed.

Furthermore, the Olkiluoto area has block area plans confirmed in 2005 for the accommodation buildings serving energy production, and earlier local plans for shore areas concerning the eastern part of the island of Olkiluoto.

Detailed plan for the disposal area

The municipality of Eurajoki approved the detailed plan and the amendment for the disposal area via its decision on 28 June 2010. The decision also included the partial overturning of the detailed plan and detailed plan for shore areas.

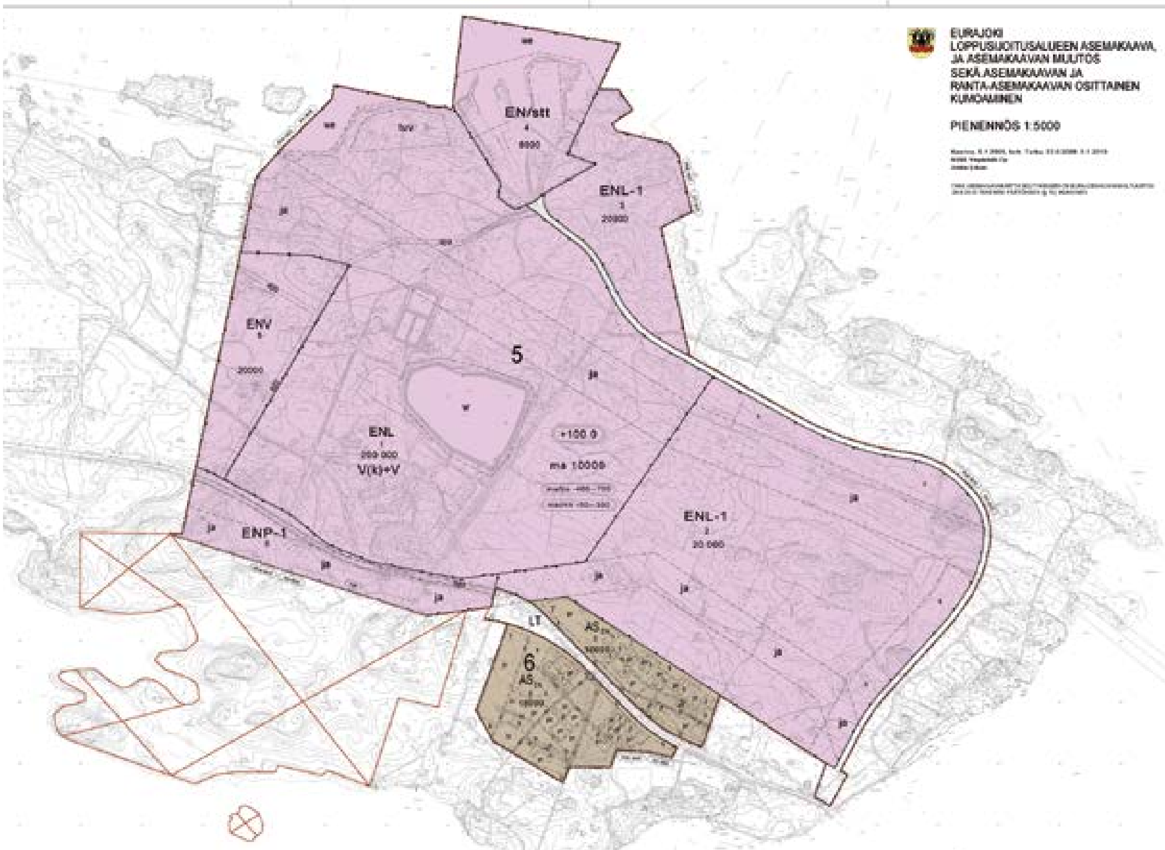


Figure 5. Detailed plan for the disposal area.

The plan indicates the areas and permitted building volumes for the buildings and structures of the disposal facility and the supporting functions for the facility.

3.3 Master plan

The modification of the local plan at Olkiluoto started in 2006 and the plan came into force in 2010.

The plan covers Olkiluoto in Eurajoki, the small islands (Kornamaa, Mäntykari, Munakari and approximately 20 smaller islands) to the north and northwest of Olkiluoto and the surrounding waters.

The most important goal of the local plan has been to maintain the land use prerequisites in the largest energy generation area in Finland, and to reserve areas for implementing the disposal of spent nuclear fuel in accordance with the Finnish legislation and the requirements set for the safety of operation.

The local plan for Rauma's northern shore areas and its amendment, confirmed in 1999, are in force as regards the shore areas of Rauma. The town council of Rauma approved the amendment of the local plan for Rauma's northern shore areas on 29 September 2008. The plan is legally valid.

The plan covers Kuusisenmaa, Leppäkarta, Lippo and Vähä-Kaalonperä and the waters surrounding these islands.

In December 2005, the municipal council of Eurajoki approved an amendment of the master plan for shore areas that reserved areas for an accommodation village and other functions serving energy generation in the southeast part of the island of Olkiluoto.

Master plan for shore areas in Eurajoki and its amendment
The purpose of the plan amendment started in 2010 is to verify the master plan for shore areas in Eurajoki to correspond to the current legislation and the present needs.

The plant area at Olkiluoto (energy generation area) and the Natura area are not included in the amendment of the master plan for shore areas, since a local plan was approved for these areas in May 2008. The holiday home areas on the eastern shores of Olkiluoto, the areas reserved for year-round habita-

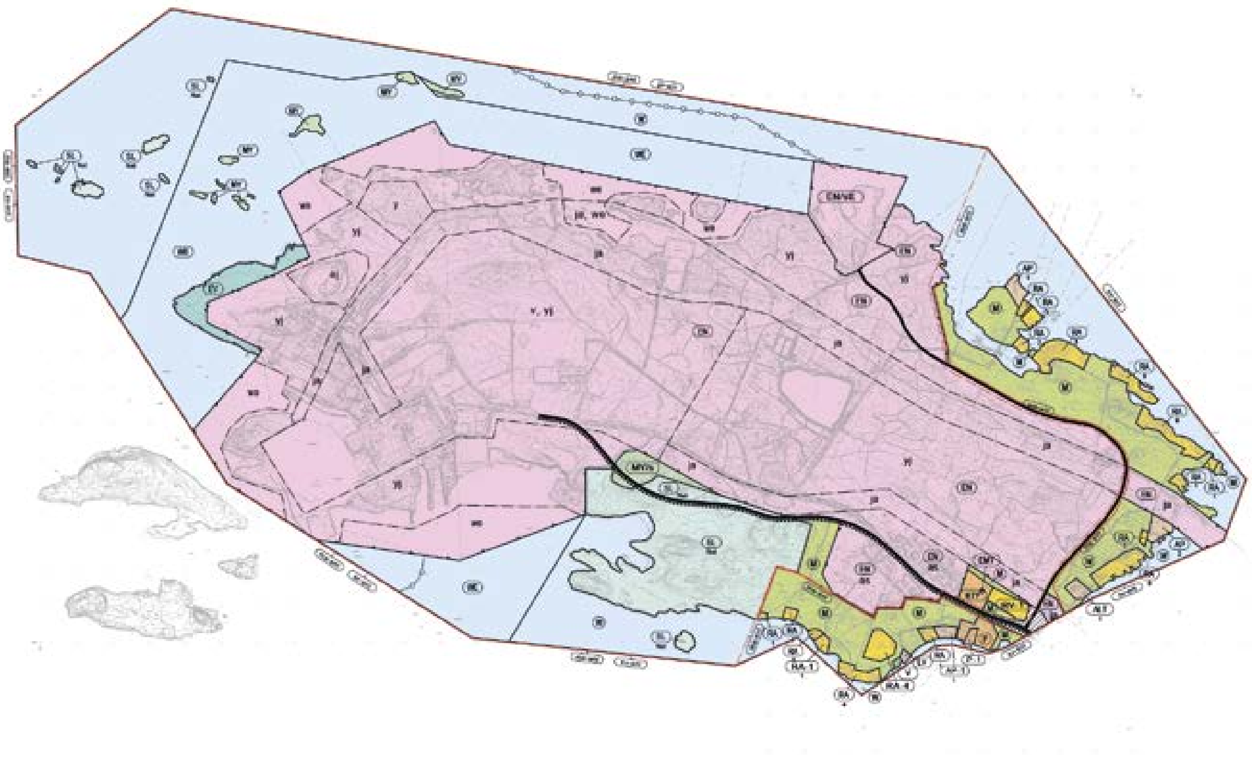


Figure 6. Local plans for Olkiluoto and the northern areas of Rauma.

tion and their hinterlands are included in the plan amendment, since the goals of the plan amendment involve the building sites.

3.4 Provincial plan

The goals for land use in the regional land use plan for Satakunta are based on the approved national land use goals that came into legal force in 2001. The Ministry of the Environment approved the provincial plan for Satakunta on 30 November 2011. The Regional Council of Satakunta started drafting the provincial plan for Satakunta in February 2003. The regional plan in force at that time was reviewed and updated into a provincial plan that corresponds with the requirements of the new Land Use and Building Act. The regional land use plan was submitted to the Ministry of the Environment for ratification on 1 March 2010. The regional land use plan for Satakunta was drawn up as an overall provincial plan. The regional land use plan supports the construction of power plants at Olkiluoto.

The regional land use plan takes into account the goals set for Olkiluoto's zoning by the Finnish government and the requirements of nuclear waste management. In the regional land use plan, the power plant area at Olkiluoto is marked as an area of community management (ET). Furthermore, the plan indicates a zone of energy management (EN1) for the Olkiluoto area; this is used to establish a nuclear power plant site area for facilities, buildings and structures serving energy generation and facilities and buildings implementing the disposal of spent nuclear fuel. A focus area for the development of energy management (en) is located around the plant area; development needs related to land use are focused in this area due to the energy management functions. The outermost area is a protective zone (sv2) for the nuclear power plants. The regional land use plan also indicates the power line routes leaving the area, the regional road, shipping and boating channels and the protection areas in the region.

The regional land use plan sets forth that special attention should be paid to matters of environmental protection, and that the processing and storage of radioactive waste should be arranged with absolute safety. The provincial plan also allows for constructing other energy generation capacity and other industry based on the energy generation in the region. The Liiklankari area is a nature conservation area in the provincial plan.

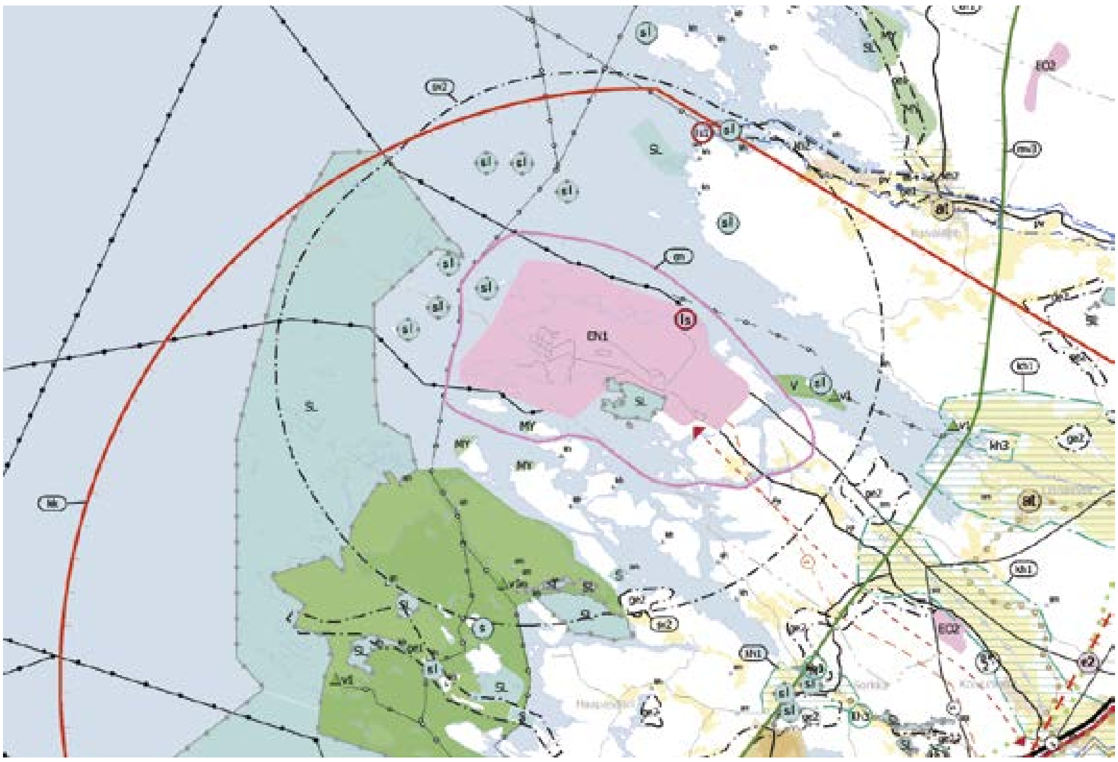


Figure 7. Extract from the provincial plan

3.5 Protective zones

The Radiation and Nuclear Safety Authority's Guides for Nuclear Safety define the protective zones surrounding the plant area of a nuclear power plant.

Depending on local conditions, the site area for a nuclear power plant shall extend to some 0.5–1 kilometres from the facility. As a rule, only nuclear power plant-related activities shall be engaged in in this area. The licensee shall have the authority of decision over all activities within the site area.

The protective zone extends to about a five kilometres' distance from the facility. Land use restrictions are in force within the zone. The protective zone shall not contain facilities inhabited or visited by a considerable number of people, such as schools, hospitals, shops, or significant places of employment or accommodation that are not related to the nuclear power plant. The protective zone shall not contain socially significant functions that could be affected by an accident at the nuclear power plant.

The number of permanent inhabitants, recreational housing, and recreational activities shall be limited inside the protective zone of a nuclear power plant, so that a rescue plan that allows for effective evacuation of the population may be drawn up and implemented for the area. Special attention shall be paid to the characteristics of the site's immediate surroundings, such as archipelagos that are difficult to cross and recreational settlements, for example, as well as other rescue activities that may be required under exceptional conditions.

Primarily, land use and construction decisions shall aim at maintaining the number of permanent and leisure-time inhabitants inside the protective zone at a level where it will not substantially increase during the construction and operation of a nuclear power plant from the time when the decision-in-principle was made under the Nuclear Energy Act.

An emergency planning zone extending to about 20 kilometres from the facility has been defined; the zone shall be covered by a detailed external rescue plan for the protection of the public drawn up by authorities. The protective zone is a part of the emergency planning zone.

The conditions set for protective zones are met at Olkiluoto. The number of permanent inhabitants inside the protective zone does not prevent effective rescue operations. Any activities that may jeopardise the safety of the plant unit have been moved sufficiently far. Limitations apply to land use in the nearby areas. Preparations have been made for the supervision of movement and transport within an area of limited movement and sojourn in accordance with the Ministry of the Interior's Decree (709/2003) and the site area itself.

Figure 8. Natura 2000, FI 0200073.

3.6 Nature conservation areas, Natura areas

There are Natura areas in the immediate proximity of the energy management area of Olkiluoto, both on the island of Olkiluoto and in the sea areas in front of the island. The Liiklankari nature conservation area is located on the southern shore in the centre of the island. At sea, the Natura area is located to the west of the island of Olkiluoto at a distance of some 2 kilometres. The operation of the existing plant units has not caused significant harm to the habitat types protected by the Natura areas, which means that it has been possible to undertake the construction of additional units in harmony with the state of the environment and without unnecessarily jeopardising the natural and environmental values. Protecting the conditions of the Natura areas to a sufficient degree has been taken into account during the design and construction of the OL3 unit.

3.7 Selkämeri National Park

The Act on the Selkämeri National Park was approved by the Finnish Parliament on 8 March 2011, with the area limitations presented in the legislation proposal. The Environment Committee amended the Act with the following section: *"Conducting cooling water from a nuclear power plant. Notwithstanding the declarations of game preservation, activities required for the remote intake and discharge of cooling water from the Olkiluoto nuclear power plant may be performed in the area of the Selkämeri National Park, subject to permission from Metsähallitus."*

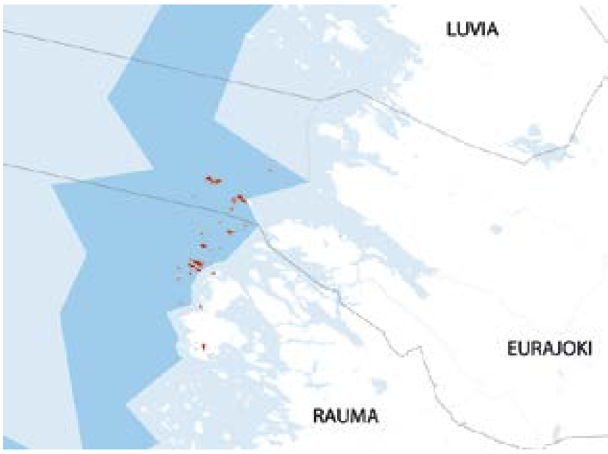


Figure 9. Selkämeri National Park

APPENDIX 4

A DESCRIPTION OF

THE QUALITY AND MAXIMUM AMOUNTS OF THE NUCLEAR MATERIALS OR NUCLEAR WASTE THAT WILL BE FABRICATED, PRODUCED, HANDLED, USED OR STORED AT THE NUCLEAR FACILITY

TABLE OF CONTENTS

1. INTRODUCTION

This appendix explains the nature and accumulated amounts of nuclear materials and nuclear waste being produced, processed, used or stored at the Olkiluoto 3 nuclear power plant unit. Waste treatment is also explained insofar as is necessary in order to determine the nature and amount of the waste. The amounts of decommissioning waste and power plant waste accrued by the plant unit have been estimated on the basis of the information provided by the plant supplier in its final safety analysis report and topical reports. The first plan for the decommissioning of the plant unit has been drawn up during the preparation of the operating licence application to submitted along with the final safety analysis report. The service life of the Olkiluoto 3 plant unit is assumed to be 60 years.

In addition to the nuclear power plant units, the power plant area at Olkiluoto includes an interim storage for spent fuel (KPA storage) and an interim storage for intermediate level waste (KAJ) and low level waste (MAJ) as part of the final disposal facility for power plant waste (VLJ). For the purposes of this appendix, the entire complex of nuclear facilities at the site is referred to as the Olkiluoto nuclear power plant or a power plant for short.

Nuclear material refers to special fissionable materials and source materials, such as uranium, thorium and plutonium, which are suitable for producing nuclear energy. At the Olkiluoto 3 plant unit, these materials only exist in the fresh and spent nuclear fuel.

According to the Nuclear Energy Act, nuclear waste refers to
a) radioactive waste in the form of spent nuclear fuel or in some other form, generated in connection with or as a result of the use of nuclear energy; and
b) materials, objects and structures which, having become radioactive in connection with or as a result of the use of nuclear energy and having been removed from use, require special measures because of the danger arising from their radioactivity.

Nuclear waste from a plant unit is divided into two main categories:
1) operational waste generated during the operation of the power plant, and
2) decommissioning waste generated from the decommissioning.

The first category includes the spent nuclear fuel, the used reactor internals and the power plant waste. The second category includes the activated decommissioning waste, contaminated decommissioning waste and very low level decommissioning waste. The spent fuel has a high activity level while the rest of the waste is low or intermediate level.

2. FRESH FUEL

The reactor core of the Olkiluoto 3 plant unit consists of 241 fuel as-semblies and includes a total of approximately 128 tonnes of uranium. The amount of fresh fuel loaded annually depends on the length of the operating cycles: in a one-year cycle, approximately one fourth of the fuel assemblies is replaced each year, whereas approximately one half of the assemblies is replaced at each refuelling, if the cycle is two years long. The number of assemblies being replaced depends on the required amount of energy being generated during the operating cycles as well as the largest allowed average burn-up per assembly. Assuming a one-year operating cycle and a maximum burn-up of 45 MWd/kgU per assembly, the reactor consumes approximately 65 assemblies per year, amounting to some 35 tonnes of uranium.

The 265 fuel rods of a single fuel assembly contain 530–540 kg of uranium. The uranium is inside the fuel rods in the form of sintered uranium dioxide tablets (UO2). The degree of enrichment of the uranium in terms of isotope ^{235}U varies per rod. The initial core loading of the reactor consists of fuel assemblies with an average ^{235}U concentration of 1.9–3.3%. The rod-specific average ^{235}U concentrations of replacement core loadings vary between 3% and 5%. A more detailed description of the fuel assembly is presented in the final safety analysis report submitted to the Radiation and Nuclear Safety Authority.

Fresh fuel is stored at the plant unit OL3 in the dry fresh fuel storage and the water-filled fuel pool. The dry storage has room for 110 assemblies, which corresponds to some 59 tonnes of uranium or nearly two annual refuelling batches. The storage capacity for fresh fuel in the fuel pools depends on the amount of fresh fuel inside the pools.

Teollisuuden Voima Oyj aims to maintain a stock of fresh fuel that corresponds to approximately one year of use at each plant unit.

3. NUCLEAR WASTE

3.1 Spent fuel

As a result of the nuclear reactions, new elements and radioactive isotopes have been formed in the fuel assemblies that are removed from the reactor. Part of the uranium in the spent fuel has been converted into fission products, plutonium and a small amount of other actinides. Depending on the degree of enrichment, spent fuel contains 94–96% uranium, 3–5% fission products and approximately 1% plutonium and other actinides.

Due to its radioactivity, the spent fuel generates heat upon removal from the reactor. The activity and heat generation of the fuel depend on the burn-up. The activity and heat generation of the spent fuel are reduced after removal from the reactor. The table below presents the activity and heat generation after different cooling times , when the fuel burn-up is 45 MWd/kgU and the uranium in the fresh fuel has a ^{235}U concentration of 4.0%.

Cooling time	Activity	Heat generation
0 yrs	7,350 TBq/kgU	2,030 W/kgU
1 yr	103 TBq/kgU	13 W/kgU
10 yrs	20 TBq/kgU	1.7 W/kgU
100 yrs	2 TBq/kgU	0.4 W/kgU
1,000 yrs	0.09 TBq/kgU	0.07 W/kgU
10,000 yrs	0.02 TBq/kgU	0.02 W/kgU
100,000 yrs	0.003 TBq/kgU	0.001 W/kgU
1,000,000 yrs	0.001 TBq/kgU	0.0005 W/kgU

The spent fuel assemblies are stored in pools of water. Initially, they are stored in the fuel pool of the power plant unit, from which they are transferred into the pools of the spent fuel interim storage (KPA storage) inside a transport cask. After decades of cooling, the spent nuclear fuel is transported from the KPA storage to Posiva Oy's disposal facility.

The combined capacity of the fuel pools at the Olkiluoto 3 plant unit is 954 assemblies (477 assemblies per pool). In order to meet the requirements in the Technical Specifications (TTKE) concerning the evacuation of the pools and the reactor, the maximum amount of fuel stored in the pools is limited to the capacity of one pool. In this case, the maximum amount of spent fuel at a specific point in time is 718 assemblies (477 in the pools, 241 in the core), which corresponds to some 382 tonnes of uranium.

The plant unit has been estimated to generate 4,069 spent fuel assemblies during its 60-year service life, corresponding to some 2,165 tonnes of uranium.

3.2 Used reactor internals

Used reactor internals refer to the decommissioned control rods, core measurement instruments and other reactor parts from inside the reactor pressure vessel that have been activated by neutron radiation, with the exception of the spent fuel assemblies or parts thereof. The corresponding parts that are inside the reactor at the end of the power plant's service life are also considered used reactor internals.

Over the 60-year service life of the plant unit, the estimated amount of spent reactor internals is some 310 tonnes, excluding control rods. In the final safety analysis report for the Olkiluoto 3 plant unit, the unpacked volume of this type of waste is estimated to be 120 m3 and the packed volume is estimated to be 500 m3. According to the decommissioning plan, the used reactor internals are largely disposed of by packing them inside the reactor pressure vessel that is placed in final disposal, which will reduce the proposed packed volume. The activity of the used reactor internals forms a substantial part of the activity of all decommissioning waste. The heavy reflector around the reactor core has the highest activity level; its total activity has been estimated to be 6.6·1017 Bq. The activity of the other activated reactor internals is at least one magnitude lower.

3.3 Power plant waste

Power plant waste can be divided into low and intermediate level waste in terms of its radioactivity. At Olkiluoto, low level waste is placed in the low level waste silo (MAJ) inside the final disposal facility for power plant waste (VLJ), whereas the intermediate level waste is placed in the intermediate level waste silo (KAJ). In the future, the VLJ facility will be expanded as necessary in accordance with its licence terms.

Power plant waste mostly consists of miscellaneous packaging, scaffolding, protective equipment, insulation and cleaning material waste accumulated during service and repair. Contaminated scrap metal and other contaminated components, such as different filters, are also included in this group.

For a substantial part of power plant waste, the activity level is so low that it can be released from regulatory control and taken to a landfill outside of the controlled area in the Olkiluoto power plant site or handed over for reuse. Most of the scrap metal can eventually be released from regulatory control after a storage period that reduces the activity and a decontamination process.

The compressible part of dry, low activity level power plant waste is packed as is or cut into pieces and packed inside 200-litre steel drums that can be compressed to half of their original volume. If necessary, contaminated scrap metal is cut into pieces, compressed and packed inside final disposal packages. Dry waste is initially stored in the waste storage facility of the plant unit or moved to the interim storage for low level waste (MAJ) or intermediate level waste (KAJ) according to its level of activity. After the activity of the waste has been determined, it is transported into the VLJ facility for final disposal.

Wet waste is solidified or dried. This includes ion exchange resins, evaporation residue from contaminated water, sludge and solvents. Some of them have low and some intermediate activity levels. Waste oil has a low activity level and it can be released from regulatory control and handed over for reuse.

Ion exchange resins are either dried inside drums (in-drum drying) or solidified with concrete or bitumen. Evaporation residue from contaminated water, solvents and sludge is dried inside drums or solidified with bitumen or another type of solidification agent; the choice and use of the agents is based on experience from the existing plant units. After the treatment and the definition of activity, the packages are stored in the waste storage of the plant unit before they are transferred to the other waste storages in the site area for possible further treatment or continued storage or into the VLJ facility for final disposal. The treatment and packaging method significantly affects the final disposal volume of the waste. The use of the methods described above is optimised on the basis of experience received during the operation of the plant unit.

The volume of power plant waste (including packaging) accumulated from the Olkiluoto 3 plant unit is estimated to be approximately 50–100 m^3 per year. The annual amount varies according to the types of maintenance, repair and modifications carried out at any given time. The total volume of power plant waste accumulated during the 60-year service life of the plant unit is estimated to be some 3,000–6,000 m^3. These figures can be compared to the amount of waste accumulated each year by the two operating power plant units at Olkiluoto. Between 1993 and 2002, the packing volume of power plant waste varied between 73 and 174 m^3 per year and was 122 m^3 on average. By the end of 2014, 3,998 m^3 of waste had been disposed of in the MAJ silo of the VLJ facility, while the KAJ silo contained 1,900 m^3 of waste.

The total storage capacity for power plant waste from the Olkiluoto 3 plant unit is approximately 560 m^3. Some 135 m^3 of storage capacity is available for liquid power plant waste (evaporator concentrates, sludge, oil and resins) and some 264 m^3 has been reserved for solid power plant waste (combustible waste, compressible waste, incombustible and uncompressed waste and cartridge filters). Treated power plant waste can be stored at OL3 in the drum storage for low activity level waste (122 m^3) and the drum storage for medium activity level waste (34 m^3).

Some storage also takes place in the waste treatment facilities. The plant unit also features several other rooms for the storage of power plant waste during maintenance and repair work, and longer-term storage of replaced components. The operating licence application includes an application for the storage of the above volume (maximum of 600 m^3) of power plant waste at the OL3 plant unit.

In addition to the Olkiluoto 3 plant unit, TVO has other storage facilities for low and intermediate level waste in the site area. The operating licence application requests permission to use the MAJ and KAJ storage facilities for the storage of power plant waste generated during the operation of the Olkiluoto 3 plant unit.

The radioactive substances contained in power plant waste are mostly activation products created by neutron radiation. Fission products and small amounts of actinides may also be carried into the waste as a result of fuel failures.

The final safety analysis report for the VLJ facility also takes into account the waste accumulated at the Olkiluoto 3 plant unit. The total activity of the waste contained inside the MAJ silo in 2080, when the silo is scheduled to be closed, is at most 2 TBq. For the KAJ silo, the estimate is approximately 400 TBq.

In 2011 TVO applied for a change to the conditions of the existing operating licence for the VLJ facility, and the Government issued an approving decision to the application in 2012. According to the new licence conditions, the licensee is allowed to dispose of low and intermediate level nuclear waste generated by the operation of the plant units Olkiluoto 1, Olkiluoto 2, Olkiluoto 3, their waste facilities and the VLJ facility, inside the VLJ facility in a permanent manner. Furthermore, radioactive waste controlled by the Radiation and Nuclear Safety Authority may be finally disposed of inside the VLJ facility to an extent where it does not detrimentally affect the final disposal of low and intermediate level nuclear waste. The total permitted activity for the disposed nuclear waste is 1,100 TBq for the intermediate level silo (KAJ silo) and low level silo (MAJ silo) of the VLJ facility combined. The Radiation and Nuclear Safety Authority may set nuclide-specific upper limits for the silos by virtue of Section 55 of the Nuclear Energy Act. Within the limits stated above, the licensee may also place small amounts of other radioactive waste originating from the Olkiluoto nuclear power plant for final disposal inside the VLJ facility. No nuclear fuel may be stored or disposed of in the VLJ facility. The final disposal must be completed up to the end of the closure stage in accordance with Section 33 of the Nuclear Energy Act during the validity of the operating licence; if the final disposal activities are still continuing upon the expiration of the licence, a new operating licence must be applied for.

3.4 Disassembly waste

The decommissioning of the Olkiluoto 3 plant unit is described in Appendix 9 to this application and the decommissioning plan for the Olkiluoto 3 nuclear power plant unit, which will be submitted to the Radiation and Nuclear Safety Authority together with the operating licence documentation as part of the final safety analysis report. The long-term safety case for the final disposal took into account the final disposal of decommissioning waste in accordance with the waste amounts and activities received from the plant supplier. The activity amounts were doubled in the analysis, which demonstrated that the final disposal of a possible fourth plant unit is possible.

The decommissioning waste generated during the decommissioning of the Olkiluoto 3 plant unit consists of activated and contaminated metal, concrete and other waste. Some of the decommissioning waste has a very low level of activity. Over 99% of the activity in the disassembly waste is in the activated internals of the reactor pressure vessel. The majority of the decommissioning waste volume, on the other hand, is taken up by contaminated decommissioning waste (pipes, valves, pumps, heat exchangers) and very low activity level decommissioning waste, such as the outer layer of the biological concrete shield.

Only the reactor pressure vessel with its internals and thermal insulation plates and the inside layer of the biological shield count as actual activated decommissioning waste. The parts of the reactor pressure vessel that are closest to the reactor core are activated in the neutron radiation. The reactor pressure vessel internals are activated the most. The most significantly activated components and their masses and volumes are as follows:

-	Pressure vessel	520 t, 312 m^3
-	Heavy reflector	94.3 t, -*
-	Core support cage	56.7 t, 148 m^3
-	Lower core support plate	24.3 t, 6 m^3
-	Upper core support plate	4 t, 0.9 m^3
-	Pressure vessel coating	3.8 t, - *
-	Biological shield	1,050 t, 450 m^3.

*) Volume is included in the pressure vessel volume

The starting point for TVO's decommissioning plan is that the pressure vessel can be placed in final disposal as an entire unit, with the reactor internals packed inside the pressure vessel.

The biological shield around the pressure vessel is made of reinforced concrete and it will mainly be activated in the part of its inner layer that is closest to the reactor. The outer layer, however, is classified as very low level waste. The biological shield creates approximately 1,050 tonnes of power plant waste with an unpacked volume of 450 m^3.

Contaminated disassembly waste mainly consists of waste generated by the disassembly of systems: pipes, pumps, valves, heat exchangers etc. The activity of the waste largely depends on the function and operation of the system in question. The volume of contaminated decommissioning waste from the plant unit is estimated at around 7,500 m^3. The largest part of this is taken up by the steam generators. The estimate assumes that eight steam generators will require final disposal. However, it is TVO's goal that the four steam generators will not be replaced, which will reduce the volume presented here by some 2,000 m^3.

The parts of the nuclear fuel elements (such as the control rods) are disposed of together with the spent fuel, and, therefore, they are not part of the decommissioning waste.

The above figures add up to some 5,000 t of decommissioning waste from the plant unit, with an uncompressed volume of 8,500 m^3.

The total activity of the decommissioning waste has been estimated at 7×10^{17} Bq. This estimate assumes that decommissioning begins immediately after the operation of the plant unit has stopped. The most part of the activity is made up by the short-lived isotope ^{55}Fe that has a half-life of 2.7 years. ^{55}Fe is insignificant in terms of the long-term safety of final disposal, for example.

The other nuclear facilities at Olkiluoto will create small amounts of decommissioning waste as a result of the operation of the Olkiluoto 3 plant unit. Spent fuel from the Olkiluoto 3 plant unit will be stored at the KPA storage and power plant waste will be stored inside the KAJ storage facility. The amount of radioactive waste and activity generated by their disassembly will be small in comparison to the disassembly of the Olkiluoto 3 plant unit.

APPENDIX 5

AN OUTLINE OF

THE TECHNICAL OPERATING PRINCIPLES AND FEATURES AND OTHER ARRANGEMENTS WHEREBY SAFETY HAS BEEN ENSURED

Contents

TVO – a pioneer in its own field

Teollisuuden Voima Oyj (TVO) is a non-listed public company founded in 1969 to produce electricity for its stakeholders at cost price. TVO is the developer, owner and operator of the Olkiluoto nuclear power plant.

The production of the nuclear power plant units in Olkiluoto (OL1 and OL2) covers about one sixth of the total electricity consumption in Finland. Half of this electricity goes to the industry, the other half is consumed by private households, service sector and agriculture.

Because of the need for increase in both self-sufficiency and additional capacity of electricity production, TVO is currently building a third power plant unit, Olkiluoto 3 (OL3). With the electrical output of approximately 1,600 MWe, OL3 will almost double the production capacity of the Olkiluoto power plant.

Solid nuclear expertise

TVO employs a staff of about 730, many of them with solid experience in the operation and maintenance of a nuclear power plant gained over several decades. This expertise is also utilised and further developed in the construction of the OL3.

Throughout its existence, TVO has provided further training to the employees and improved the competence of the staff in nuclear technology. The company's nuclear expertise is being sustained by participating in international development programmes. Also the upgrading and modernisation projects as well as development and construction projects carried out at the existing Olkiluoto units develop the staff's expertise. The modernisation projects implemented over the years have improved the safety as well as the production capacity and economy of the Olkiluoto power plant.

High in international ranking

TVO's nuclear expertise is clearly evident by the high capacity factors of the Olkiluoto plant units. The capacity factors of OL1 and OL2 have varied between 93% and 98% since the early 1990s, ranking among the very top by international comparison.

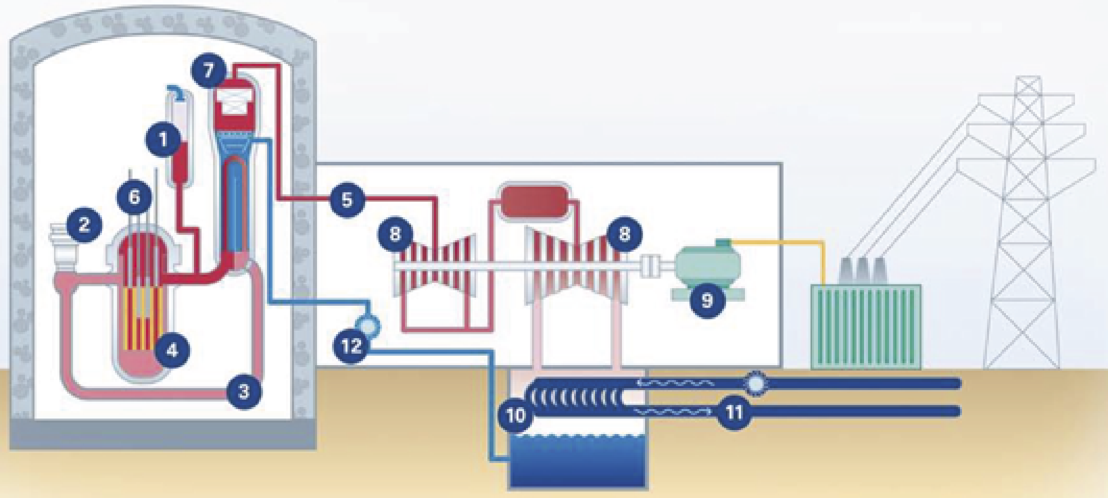
The high capacity factors indicate reliability of operation, among other things.

The results achieved are based on meticulous and proactive planning of annual outages and modifications.

The radiation exposure doses of the personnel, which have been consistently low at the Olkiluoto power plant, have also yielded good results in international comparison.

TVO's operating philosophy

As a nuclear power company, TVO is committed to a high level safety culture, which creates the comprehensive basis for all activities. According to the principles of the safety culture, issues are prioritised according to their safety significance and a high degree of operability and reliability of production are the key objectives of operation. Safety and factors affecting safety always take priority over financial considerations. The future vision of TVO is to be an acknowledged Finnish nuclear power company and a pioneer in its field. To achieve this goal, TVO acts responsibly, proactively and transparently, following the principles of continuous improvement in close cooperation with various interest groups.



Olkiluoto 3

Olkiluoto 3 (OL3) was decided to build for many reasons. The added capacity brought by OL3 not only meets the increasing demand but also compensates for the decreasing output of ageing power plants. Together with the use of renewable energy, the unit helps Finland to reach its carbon dioxide emission targets, contributes to the stability and predictability of electricity prices and reduces Finland's dependence on imported electricity.

It was on this basis that TVO submitted an application to the Government in November 2000 concerning a Decision in Principle for the building of a new nuclear power plant unit. The Government adopted a Decision in Principle, and Parliament ratified the Decision in Principle on 24 May 2002. The Decision in Principle states that building the new nuclear power plant unit is in the interest of society as a whole.

After a call for tenders, in December 2003 TVO took the decision to invest in the construction of a power plant unit with a Pressurized Water Reactor (PWR) with an output of approximately 1,600 MWe at Olkiluoto. The type of the unit is known as a European Pressurized Water Reactor (EPR). The unit is being built on a turnkey basis by a consortium formed by AREVA NP and Siemens. AREVA NP is delivering the reactor plant, and Siemens is delivering the turbine plant.

Experienced power plant suppliers

Both of the principal suppliers are leaders in their respective fields. AREVA NP has delivered the principal components for a total of 100 light-water reactor units – 94 pressurized water reactors (PWR) and 6 boiling water reactors (BWR). The most recently commissioned PWR units for which AREVA NP supplied the principal components are Civaux 1 and 2 in France, which went on stream in 1997 and 1999, respectively. AREVA NP also delivered the principal components to units which went on stream in Brazil (Angra 2) and China (Ling Ao 1 and 2) in 2002.

Siemens is one of the leading power plant suppliers in the world. The combined output of the power plants delivered by Siemens exceeds 600 GWe.

Technology based on solid practical experience

OL3 is an evolutionary unit compared with the current power plant units, meaning that its basic design is based on the proven technology of existing power plants. Its development was based on plants commissioned in France (N4) and Germany (Konvoi).

Safety features in particular have been developed further. The unit was originally designed to allow for the management of a severe reactor accident (cooling of core melt) and a large aircraft crash (double shell of the reactor containment building). In this appendix the safety principles of OL3 nuclear power plant are described, other safety measures to ensure safe use of OL3 are described in appendix 6.

Germany (Konvoi)		
Neckarwestheim 2	1,269 MWe	1989
Isar 2	1,400 MWe	1988
Emsland	1,290 MWe	1988
France (N4)		
Chooz 1	1,450 MWe	1996
Chooz 2	1,450 MWe	1997
Civaux 1	1,450 MWe	1997
Civaux 2	1,450 MWe	1999

Operating principle of a pressurized water reactor (PWR)

*A PWR plant has two circuits for heat transfer. Water is kept under high pressure by the **pressurizer (1)** and circulated by the **reactor coolant pumps (2)** in the **primary circuit (3)**, which transfers the heat from the **reactor (4)** to the **secondary circuit (5)** in the **steam generator (7)**. Reactor power is controlled by **control rods (6)**. The pressure in the secondary circuit is much lower than in the primary circuit, which makes the water in the steam generator boil. The steam from the steam generator makes the **turbine (8)** rotate. The turbine rotates the coaxially mounted **generator (9)**, generating electricity for the national grid. The steam from the turbine is cooled back to water in the **condenser (10)** with **sea water (11)**. Condensate water is fed back to the steam generator with **feedwater pumps (12)**, and the warm sea water is pumped back into the sea.*

60 years service life

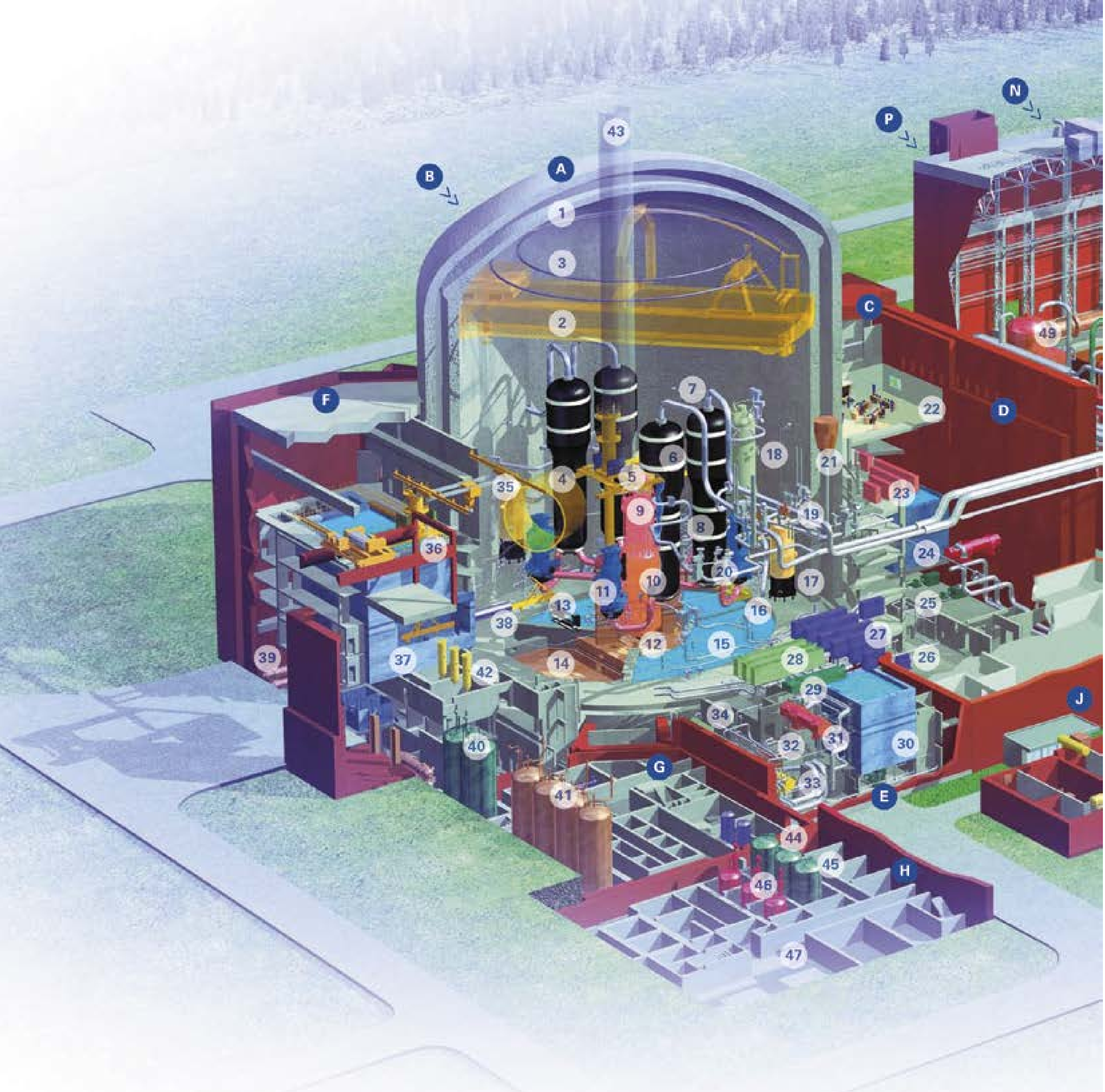
In addition to safety, the design of OL3 emphasizes economy in particular. The efficiency rate of the new unit, for instance, is 37% – some four percentage points higher than the original efficiency of OL1 and OL2.

The design is based on an expected service life of 60 years for the largest structures and components and 30 years for the more easily replaceable structures and components. Allowing in advance for such replacements enables the unit to have an economic service life of at least 60 years.

Compared with similar units recently commissioned in Europe, OL3 will have a reactor output about 1% greater and an electricity output about 10% greater.

OL3 is being delivered as a turn-key project. TVO has been responsible for site preparation and for the expansion of the infrastructure at Olkiluoto. Site preparation has involved earthmoving, excavation, road building, electrical power supply for the construction site and the building of the tunnels for the cooling water. The actual construction work that is the responsibility of the AREVA NP – Siemens consortium began in 2005.

Multi-stage quality control and inspection are carried out by representatives of TVO, plant supplier, subcontractors, and authorities.

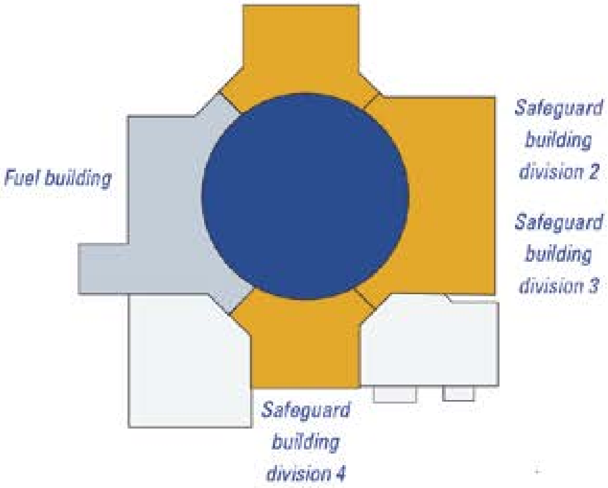


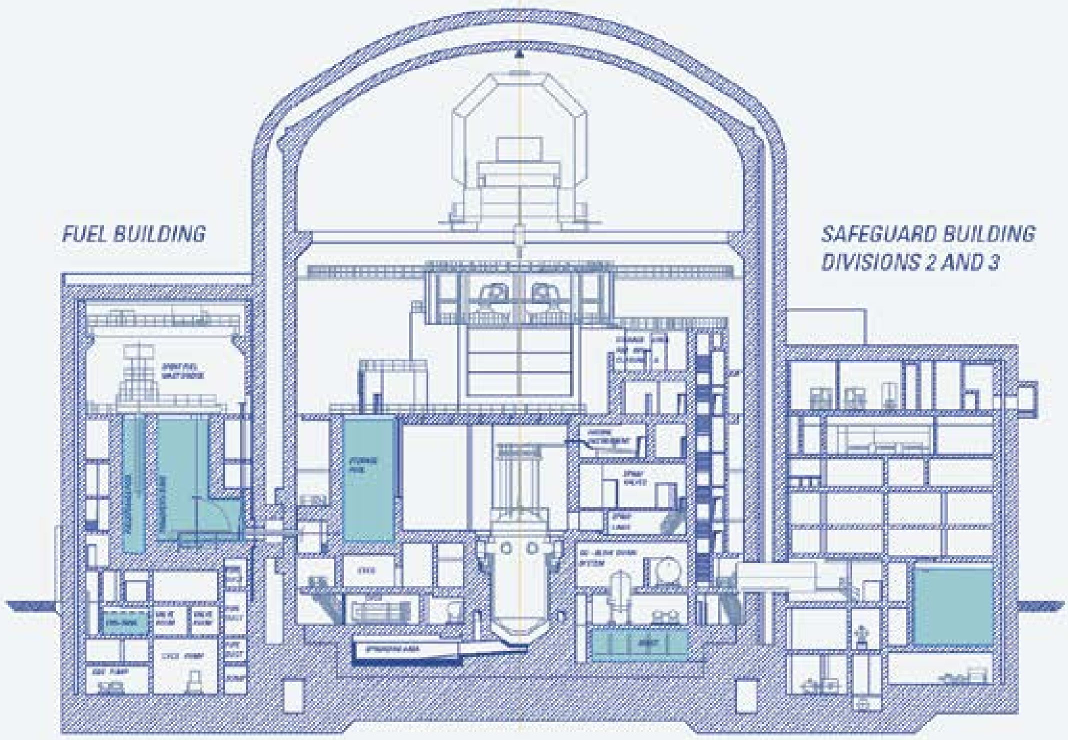
- *A* ***Reactor building***
- *1* *Inner and outer containment building*
- *2* *Reactor building main crane (polar crane)*
- *3* *Containment heat removal system: sprinklers*
- *4* *Equipment hatch (large components)*
- *5* *Refuelling machine*
- *6* *Steam generator*
- *7* *Main steam lines*
- *8* *Main feedwater lines*
- *9* *Reactor control rod drives*
- *10* *Reactor pressure vessel*
- *11* *Primary circuit reactor coolant pump*
- *12* *Primary circuit main coolant lines*
- *13* *Primary circuit volume control system heat exchangers*
- *14* *Core melt spreading area*
- *15* *Emergency cooling water storage (In-containment refueling water storage tank, IRWST)*
- *16* *Intake screens for the cooling system for reactor emergency cooling and containment heat removal system*
- *17* *Hydraulic accumulator of the reactor emergency cooling system*
- *18* *Primary circuit pressurizer*
- *19* *Main steam valves*
- *20* *Feedwater valves*
- *21* *Main steam system safety valve and relief valve exhaust silencer*
- *B* ***Safeguard building division 1***
- *C* ***Safeguard building division 2***
- *22* *Main control room*
- *23* *Computer room*
- *24* *Emergency feedwater tank*
- *D* ***Safeguard building division 3***
- *25* *Emergency feedwater pump*
- *26* *Medium head safety injection pump*
- *E* ***Safeguard building division 4***
- *27* *Switchgear room*
- *28* *Instrumentation & control room*
- *29* *Battery rooms*
- *30* *Emergency feedwater tank*
- *31* *Component cooling system heat exchanger*
- *32* *Low head safety injection pump*
- *33* *Containment heat removal system heat exchanger (sea water circuit)*
- *34* *Containment heat removal system heat exchanger*
- *F* ***Fuel building***
- *35* *Fuel building crane*
- *36* *Refuelling machine*
- *37* *Fuel pools*
- *38* *Fuel transfer tube*
- *39* *Fuel pool cooling system heat exchanger*
- *G* ***Reactor plant auxiliary building***
- *40* *Coolant supply and storage system*
- *41* *Coolant supply and storage system*
- *42* *Offgas delayer*
- *43* *Ventilation stack*
- *H* ***Radioactive waste processing building***
- *44* *Liquid waste collecting tank*
- *45* *Monitoring tanks*

46 *Concentrate tanks*
47 *Drum storage area*
I ***Emergency power generating building***
48 *Emergency diesel generators*
J ***Access building***
K ***Office building***
L ***Turbine building***
49 *Moisture separator/reheater*
50 *High-pressure feedwater preheaters*
51 *High-pressure turbine*
52 *Low-pressure turbine*
53 *Condensers*
54 *Cross over lines*
55 *Generator*
56 *Exciter*
57 *Feedwater tank*
58 *Turbine building main crane*
59 *Low-pressure feedwater preheater*
60 *Feedwater pumps*
61 *Low-pressure feedwater preheater*
M ***Switchgear building***
62 *Transformer boxes*
N ***Circulating water pump building***
O ***Essential service water pump building***
P ***Anti-icing pumps***
Q ***Auxiliary boiler building***
63 *Demineralized water storage tanks*
64 *Auxiliary stand-by transformer*
65 *Unit transformers*
66 *Auxiliary normal transformers*
67 *Switchyard*
68 *High-voltage lines*

Computer graphics: Images & Process

The reactor building is surrounded by the fuel building and four independent safeguard building divisions.





One unit, many buildings

The new OL3 power plant unit is being built to the west of the existing ones. The buildings in the new complex can be roughly divided into three parts: the nuclear island, the turbine island, and auxiliary and support buildings.

Nuclear island

The principal components of the nuclear island are the reactor containment, the fuel building and safeguard building divisions surrounding it. The reactor primary circuit is housed in a gas-tight and pressure-resistant double-shelled containment building, also known as the reactor building.

The fuel building, which houses pools for fresh and spent fuel, is on the south side of the reactor building and is about 50 m long, about 20 m wide and more than 40 m high. In addition to fuel storage, it is connected to workshop areas. Flanking the fuel building are the reactor plant auxiliary building and waste management building; the latter is used for handling plant waste.

The reactor building, fuel building and safeguard building divisions are designed to be able to withstand various types of external hazards such as earthquakes and pressure waves caused by explosions. All these buildings are built on the same base slab.

The reactor building, the fuel building and two of the safeguard building divisions are designed to withstand a crash by a large aircraft.

Reactor containment building

The OL3 reactor unit has a double-shelled containment building in reinforced concrete.

The shape of the building was chosen for strength and on the basis of construction technology. The inner containment is a prestressed cylinder in reinforced concrete with an elliptical cover. It is designed to withstand temperature and pressure loads that may be caused by pipe breaks. The massive outer containment is a cylinder in reinforced concrete that shares the same base slab as the inner containment and protects it against external hazards. This massive double-shell structure is a new safety feature which the earlier power plants do not have.

Preventing release of radioactive material in case of an accident sets extreme requirements on the leak-tightness of the containment building, which has an inner liner of steel for this reason. The tightness of the building is closely monitored. Any leaks which occur are arrested between the inner and outer shells of the containment building, then filtered and delayed in the annulus ventilation system before being conveyed to the ventilation stack.

Personnel access to the containment building is managed through a special airlock during normal operation. The airlock has double-sealed doors at both ends; it is impossible to open both ends of the airlock at the same time. Personnel access is at ground level. There is also an emergency airlock on the service floor at about 19 m level through which personnel access to and from the containment building can be managed.

The big equipment hatch on the maintenance platform is used during construction and annual outages for bringing large components and devices into the containment building. The main crane of the reactor building, located above the containment building service floor has a lifting capacity of 320 tonnes.

The reactor building has an external diameter of about 57 m, a volume of about 80,000 m^3 and a total height including underground levels of about 70 m. The ventilation stack is about 100 m high.

Lifting of the steel liner dome part in November 2009

Safeguard buildings

The OL3 plant unit has parallel redundant safety systems which are physically separated from each other to ensure safe operation under all circumstances. The safety systems are divided into four independent subsystems, each of which is housed in a separate safeguard building division. All four buildings have their own low head and medium head safety injection systems, a residual heat removal system, an intermediate cooling system, a sea water cooling system, and an emergency feedwater system. The electrical and instrumentation and control systems are located on the upper levels of the safeguard building divisions. The control room is located in one of the safeguard building divisions.

Buildings 2 and 3 are between the reactor building and the turbine island, and buildings 1 and 4 are on opposite flanks of the reactor building. Each of the buildings is about 30 m long, 20 m wide and 30 m high.

The power plant unit has four emergency diesel generators suppling power to the safety systems in case of loss of offsite power. There are also two additional diesel generators, station blackout diesels, independent of the above four. The emergency and station blackout diesel generators ensure that the safety systems have power supply even under abnormal circumstances.

Turbine island

The turbine building is almost 100 m long, 60 m wide and 60 m high, including underground levels. Its volume is about 250,000 m^3. Adjacent to it are the circulating water pump building and switchgear building. The main transformers and plant transformers are located to the north of the turbine building.

Auxiliary and support buildings

Beside safeguard building divisions 2 and 3, there is an access building, which contains locker rooms and washrooms, and a monitored accessway to the radiation-controlled area. There is a bridge from the access building to the office building, where radiation-controlled office space is available during annual outages. The power plant area also contains separate buildings for housing diesel generators, the sea water system buildings (mainly underground), and a number of minor support buildings.


September 2010


Primary circuit main components
1 Reactor pressure vessel
2 Main coolant line, hot leg
3 Steam generator
4 Main coolant line, cross-over leg
5 Reactor coolant pump
6 Main coolant line, cold leg
7 Pressurizer
8 Pressurizer surgeline

PRIMARY CIRCUIT

The OL3 primary circuit system consists of four individual loops. It is designed for a service life of 60 years and constructed to withstand the loads caused by every conceivable situation of operation or accident.

Primary circuit main functions

In each of the four loops comprising the primary circuit, the coolant leaving the reactor pressure vessel at a temperature of 328°C goes through the main coolant line hot legs to the steam generators, where heat is transferred to the secondary circuit. The coolant, its temperature now approximately 296°C, is returned by the reactor coolant pump to the reactor through the inlet nozzles. Inside the reactor pressure vessel, the coolant first flows down outside the reactor core. From the bottom of the pressure vessel, the flow is reversed up through the core, where the coolant temperature increases as it passes through the fuel rods and the assemblies formed by them.

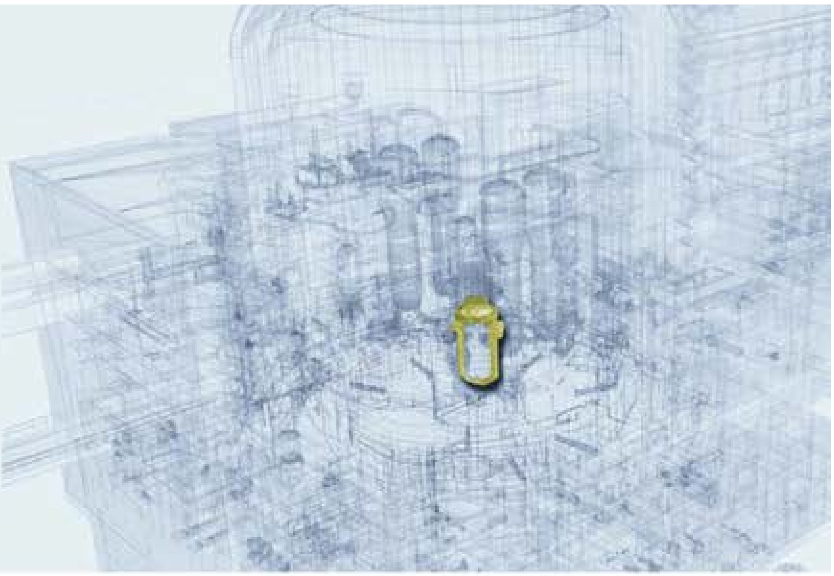
The pressurizer connected to the primary circuit keeps the pressure in the reactor high enough to prevent the coolant from boiling. Under normal conditions, the circuit is full of water which effectively transfer heat from the reactor core. Connected to one of the four individual loops, the pressurizer is larger in volume compared with the existing power plants so that it can better respond to any pressure transients during operation. This helps smooth pressure spikes and extends the useful life of the main components of the primary circuit.

Reactor cooling system properties

Reactor thermal power	4,300 MWth
Primary circuit flow	23,135 kg/s
Primary coolant flow per loop	28,330 m³/h
Coolant temperature in the cold leg	296°C
Coolant temperature in the hot leg	328°C
Primary circuit design pressure	176 bar
Primary circuit operating pressure	155 bar
Secondary circuit design pressure	100 bar
Main steam pressure under normal conditions	78 bar
Main steam pressure during hot shut-down	90 bar

The safety systems are designed so that in abnormal events they are able to perform a rapid shut-down of the reactor, known as a reactor scram. This ensures that the reactor releases as little energy as possible while also helping reduce pressure with maximum efficiency and keeping the actuation of the safety valves to a minimum.

Aligning of a cross-over leg.



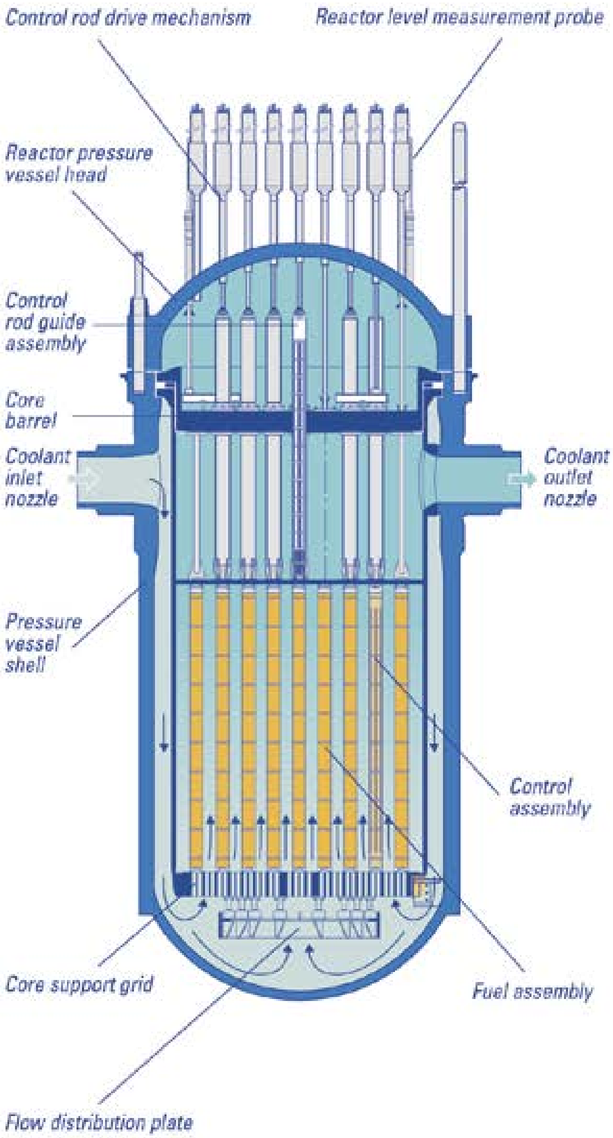
Properties of the reactor pressure vessel and its inner structures

Reactor pressure vessel	
Design pressure	176 bar
Design temperature	351°C
Life time (capacity factor 90%)	60 years
Inside diameter (under cladding)	4,885 mm
Wall thickness (under cladding)	250 mm
Bottom wall thickness	145 mm
Height with closure head	12,708 mm
Base material	16 MND 5
Cladding material	stainless steel
	(less than 0.06% cobalt)
Mass with closure head	526 t
End of life fluence level (E > 1 MeV)	
- design value	2.65 x 10^{19} n/cm²
- expected value	ca. 1 x 10^{19} n/cm²
Base material final RT_{NDT}	
(final ductile-brittle transition temperature)	ca. 30°C
Closure head	
Wall thickness	230 mm
Number of penetrations:	
- control rod mechanisms	89 pcs
- dome temperature measurement	1 pcs
- instrumentation	16 pcs
- coolant level measurement	4 pcs
Base material	16 MND 5*
Cladding material	stainless steel
	(less than 0.06% cobalt)
Upper inner structures	
Upper support plate thickness	350 mm
Upper core plate thickness	60 mm
Main material	Z3 CN 18-10 / Z2 CN 19-10**
Lower inner structures	
Lower support plate thickness	415 mm
Lower inner structure material	Z3 CN 18-10 / Z2 CN 19-10**
Neutron reflector	
Material	Z2 CN 19-10**
Weight	90 t

* low-alloy ferrite steel

** austenitic stainless steel

Cross-section of reactor pressure vessel and internal structures



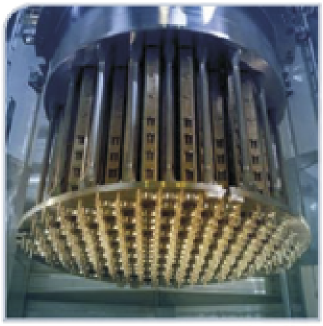
Reactor pressure vessel and internal structures

Pressure vessel

The reactor pressure vessel contains the reactor core. Both the pressure vessel and the vessel head are made of forged ferrite steel. They are also clad with stainless steel on the inside to prevent corrosion.

The pressure vessel is supported by beams which rest on the support ring in the top part of the reactor cavity, under the eight primary circuit pipes. The vessel head is fastened with bolts and a sealing gasket.

To manufacture the reactor with as few welding seams as possible, the flange and nozzle area of the pressure vessel is forged from a single piece of metal. There are no welding seams between the flange and the nozzles. Combined with the structure of the nozzles, this ensures that there is a considerable distance and a large volume of water between the nozzles and the top of the core. This minimizes the exposure of the structures to neutron radiation.



Source: AREVA

Reactor pressure vessel upper inner structures (Chooz 1, France).

Internal structures

The internal structures of the reactor pressure vessel support the fuel assemblies in the core, enabling the reactivity of the core to be controlled by the control rods and the fuel to be cooled with water under all circumstances. The inner structures are partly removed during refuelling and can be completely removed for an inspection of the inner wall of the pressure vessel.

The pressure vessel also contains upper internal structures, whose function is to support the top of the fuel assemblies and to keep them correctly aligned axially. These structures include the control rod guide thimbles, whose fastenings and beams are fixed to the control rod support plate and the upper core support plate.

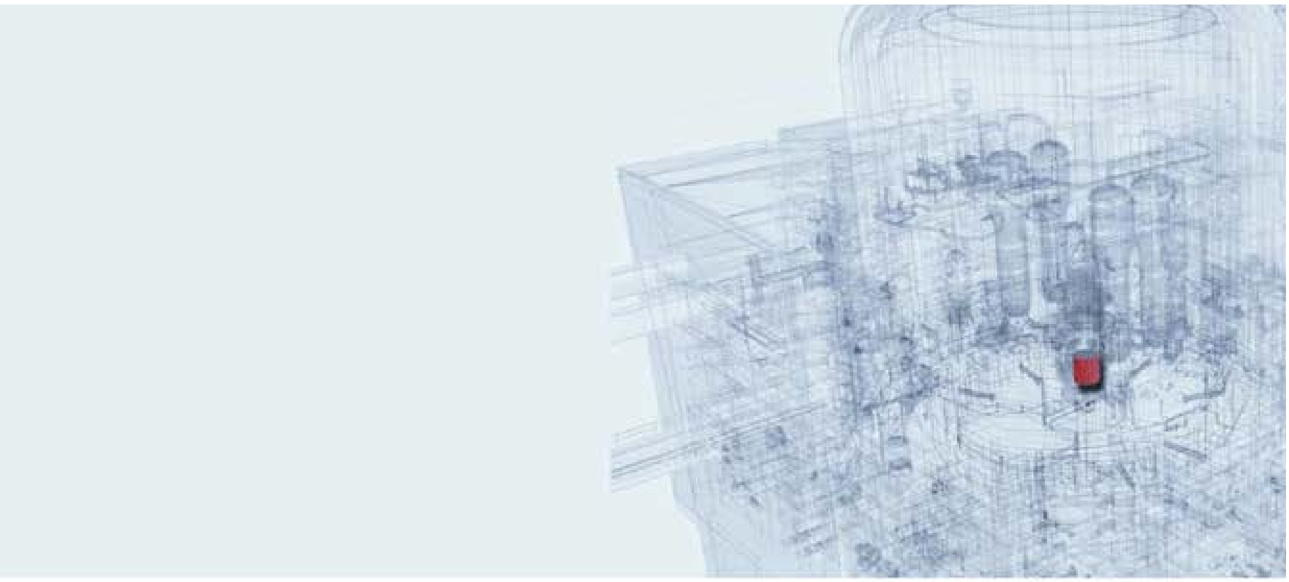
Core barrel

The flange of the core barrel rests on the machined flange of the pressure vessel, and is kept in place by a large spring. The fuel assemblies rest on a perforated core support plate, made of forged stainless steel and welded to the core barrel. Each fuel assembly is positioned by two pins 180° apart.

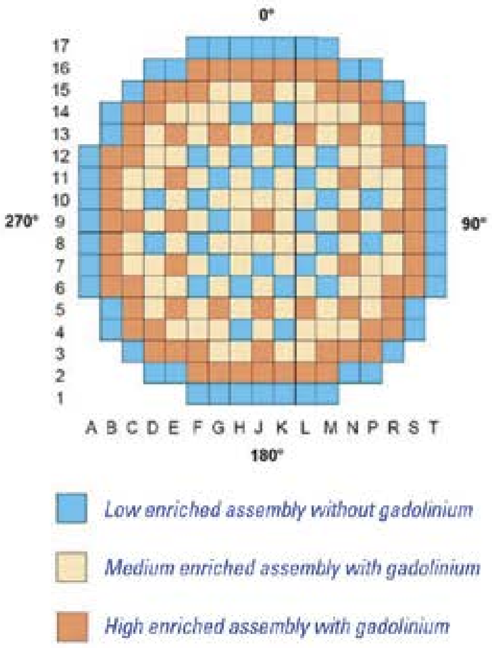
Neutron reflector (heavy reflector)

There is a steel neutron reflector, heavy reflector, around the polygonal core, between the core and the cylindrical core barrel. The reflector reduces the number of neutrons escaping from the core and flattens the power distribution. It also reduces the exposure of the pressure vessel to the neutron radiation that reduces ductility in its material, and also dampens any pressure spikes which the internal structures and fuel in the reactor might be exposed to in case of pipe break.

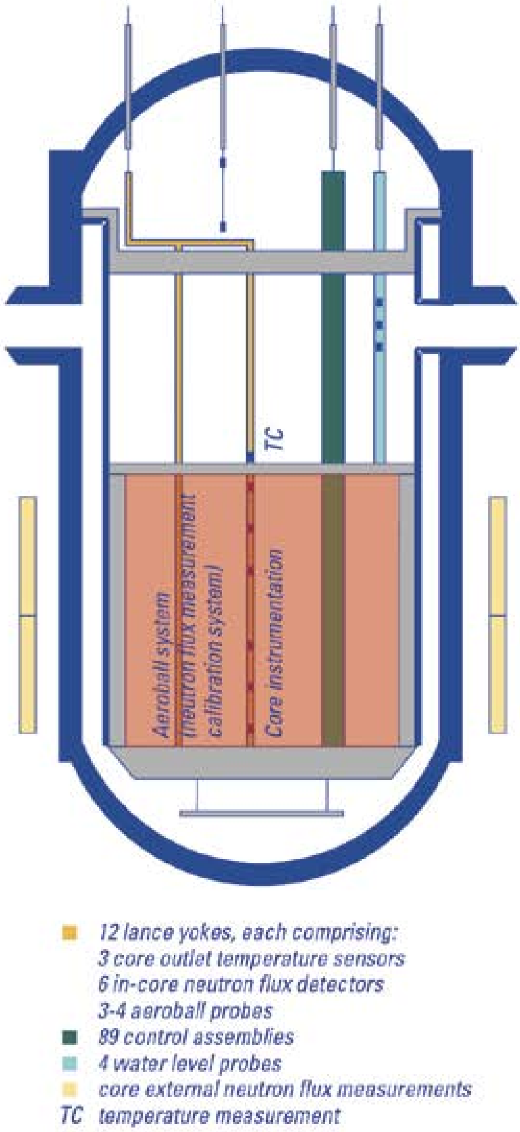
The heavy reflector consists of pieces of stainless steel piled up and linked together. The tie rods bolted to the core support plate keep the pieces in place axially. The heat generated in the steel by gamma radiation is absorbed by the primary coolant flowing through cooling ducts in the reflector.



Initial core loading



In-core instrumentation



Reactor core properties

Reactor thermal power	4,300 MWth
Operating pressure	155 bar
Primary coolant temperature in the inlet	296°C
Primary coolant temperature in the outlet	329°C
Equivalent diameter	3,767 mm
Active core height	4,200 mm
Number of fuel assemblies	241 pcs
Number of fuel rods	63,865 pcs
Average linear heat rate	156.1 W/cm

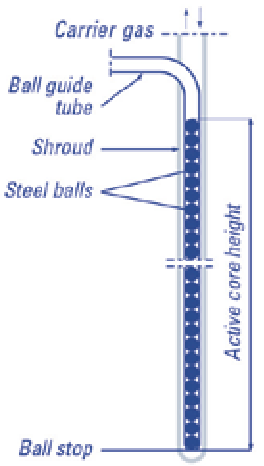
Reactor core and fuel

The OL3 reactor core consists of 241 fuel assemblies identical in structure. For the initial core loading, the assemblies are divided into three groups according to their enrichment level. The two groups with the highest levels of ^{235}U also contain gadolinium, which acts as a neutron absorber and thus reduces the reactivity of the initial phase of the reactor's operation and flattens the power distribution.

The number and properties of the fuel assemblies replaced annually depend on the fuel management plan chosen, particularly the load pattern and the length of the refuelling interval.

The refuelling interval of the reactor core can be 12 to 24 months.

The primary coolant, due to its composition, is a significant neutron moderator and reflector. The coolant conveys heat from the core at a pressure of approximately 155 bar and a temperature of 312°C on average. The primary coolant contains boron, which absorbs some of the neutrons. Adjusting the boron level helps control changes in reactivity that are fairly slow, such as the impact of fuel burn-up. Rapid changes in reactivity and in power output are controlled using the control assemblies.



Aeroball system

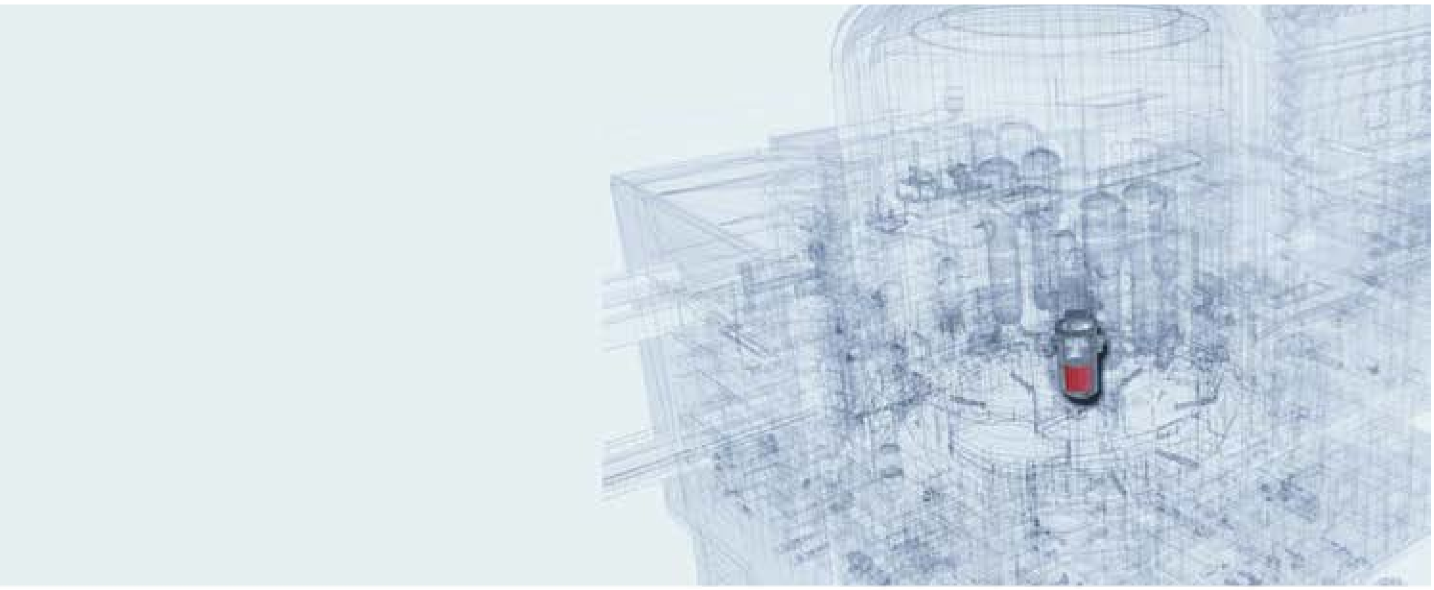
Balls made of a vanadium alloy are fed into 40 narrow tubes from above the reactor and pneumatically propelled to the reactor core through guide tubes in the fuel assemblies. The activation of the balls in one tube is measured at 36 points. The results are used to calibrate the devices used to measure the neutron flux in the reactor core.

The main core properties and operational conditions have been selected to achieve a high thermal power and low fuel costs. The OL3 reactor core is also designed to be adaptable to various refuelling intervals and operating situations.

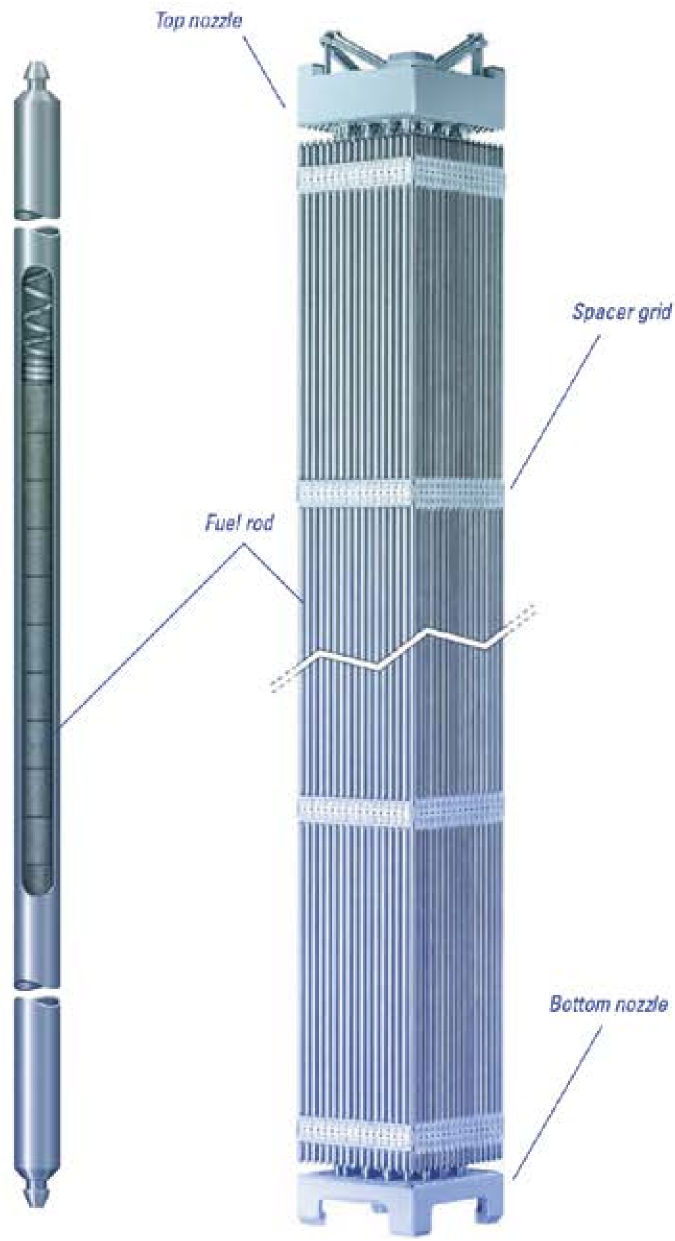
Core instrumentation

The core power is measured with both internal and external instrumentation. The fixed in-core instrumentation comprises neutron flux and temperature measurements monitoring the distribution of the neutron flux in the core and the temperature distribution in the upper part of the core. Ex-core instrumentation is used for power measurement and also for monitoring core sub-criticality during outages. All the penetrations required for core instrumentation are in the pressure vessel head.

The core power distribution is also measured at regular intervals using the aeroball system. The results thus achieved are used for calibrating fixed in-core neutron flux measurement devices.



17 x 17 fuel assembly



Fuel properties

Fuel	uranium dioxide UO_2
Fuel assembly type	17 x 17 HTP
Number of fuel rods per assembly	265 pcs
Number of guide thimbles per assembly	24 pcs
Number of spacer grids per assembly	10 pcs
Length of fuel assembly	4.8 m
Weight of fuel assembly	735 kg
Width of fuel assembly	213.5 mm
Cladding material	M5™
UO_2 pellet density	10.45 g/cm³
Fuel discharge burnup	45 MWd/kgU

Fuel assembly

A fuel assembly consists of fuel rods, spacer grids and top and bottom nozzles. The guide thimbles, spacer grids and the end pieces form the supporting structure of the assembly.

The fuel rods form a 17 x 17 matrix. Each fuel assembly contains 265 fuel rods, 24 guide thimbles and 10 spacer grids, tied together by end pieces at either end.

The bottom nozzle is shaped to distribute coolant flow evently. There is also a debris filter at the lower end to prevent any foreign objects that may end up in the primary circuit from entering the fuel assembly; such objects could mechanically damage it. The top nozzle has a leaf spring set on each side to achieve the force with which the fuel assemblies are kept stationary against the primary coolant flow.

The eight middle spacer grids in the fuel assembly are made of zirconium alloy. They have flow guides to enhance heat transfer from the fuel rods. The uppermost and lowermost spacer grids are made of nickel-based alloy because of their higher strength requirements.

Source: AREVA

The fuel supplier for the OL3 reactor is AREVA NP.

Fuel rods

A fuel rod is a tube containing compressed ceramic pellets of uranium dioxide (UO_2). The rods are welded hermetically leak-tight and pressurized using helium. The power of the reactor comes from the fission of the uranium in the pellets, mainly the isotope ^{235}U. The enrichment level of the pellets varies, being just under 5% at its highest. In some of the fuel rods, the fuel pellets are made of an alloy of UO_2 and Gd_2O_3, the latter helping to reduce reactivity and to flatten the power distribution in fresh fuel rods.

The cladding tubes of the fuel rods are made of a zirconium alloy. The cladding is the first barrier to the release of radioactive emissions as it separates the fuel and their fissile products from the primary coolant. There is space for fission gases within the fuel rod, which reduces the pressure increase caused by gases released from the uranium pellets in the nuclear reaction. The pellets are held in place by a spring inside the top of the fuel rod.

Fuel handling

Fresh fuel assemblies are stored either in the fresh fuel dry storage or in storage racks in the fuel pools where spent assemblies are also stored. During a refuelling outage, some of the spent fuel assemblies in the reactor are replaced with fresh ones. For example, if the reactor is being operated at 12-month cycles, one quarter of fuel is replaced annually. Different kinds of fuel assemblies are placed in the reactor in compliance with the restrictions on the reactor core and fuel use.

Fuel assemblies are moved between the reactor and the fuel building through the fuel transfer tube. There is a fuel handling machine in the reactor building and in the fuel building.

Core unloading takes about 40 hours in all, and core reloading plus a final core inspection using the camera in the refuelling machine takes about 45 hours. The final inspection is intended to ensure the correct placement of fuel assemblies in the core, following the refuelling plan. The Finnish Radiation and Nuclear Safety Authority (STUK), Euratom and the IAEA all participate in each final inspection to ensure the appropriate handling and safeguard measures of reactor fuel.

Spent fuel assemblies that have been in the reactor are kept under water at all times for cooling and radiation protection. Although 1 m of water would be sufficient radiation protection, at Olkiluoto the fuel assemblies are always kept under at least 3 m of water.

Spent fuel assembly handling

After being removed from the reactor, spent fuel assemblies are kept in the spent fuel pools in the fuel building for a few years to cool them off. At the same time, the radioactivity of the spent fuel decreases substantially.

After sufficient cooling, the spent fuel is transported to an interim storage facility at the power plant site using a spent fuel cask which is docked below the spent fuel pool using a transfer facility.

Before placement in the final repository, the spent fuel is kept in interim storage for several decades. During this time, the radioactivity and heat output of the fuel decrease to less than 1/1000 of their original values, making the further handling of the fuel much simpler.

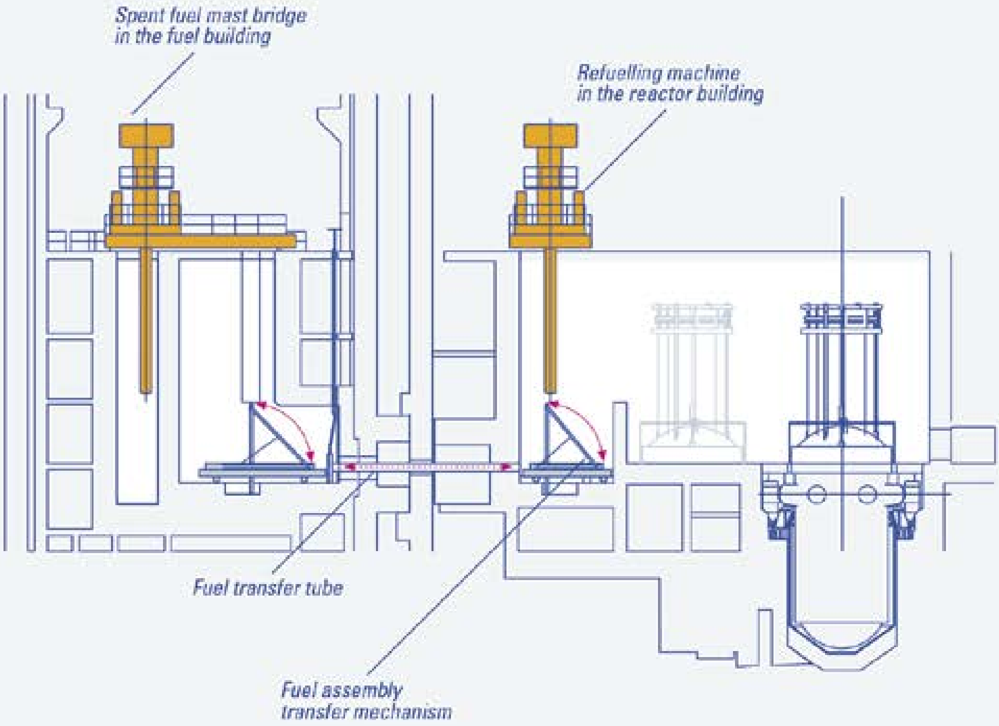
The final repository for spent fuel is being built at Olkiluoto by Posiva Oy, a company which is jointly owned by TVO and Fortum Power and Heat Oy, who will also be responsible for its operation. The spent fuel from the nuclear power plant units in Loviisa will also be deposited at Olkiluoto. Final disposal of spent nuclear fuel will begin 2024.

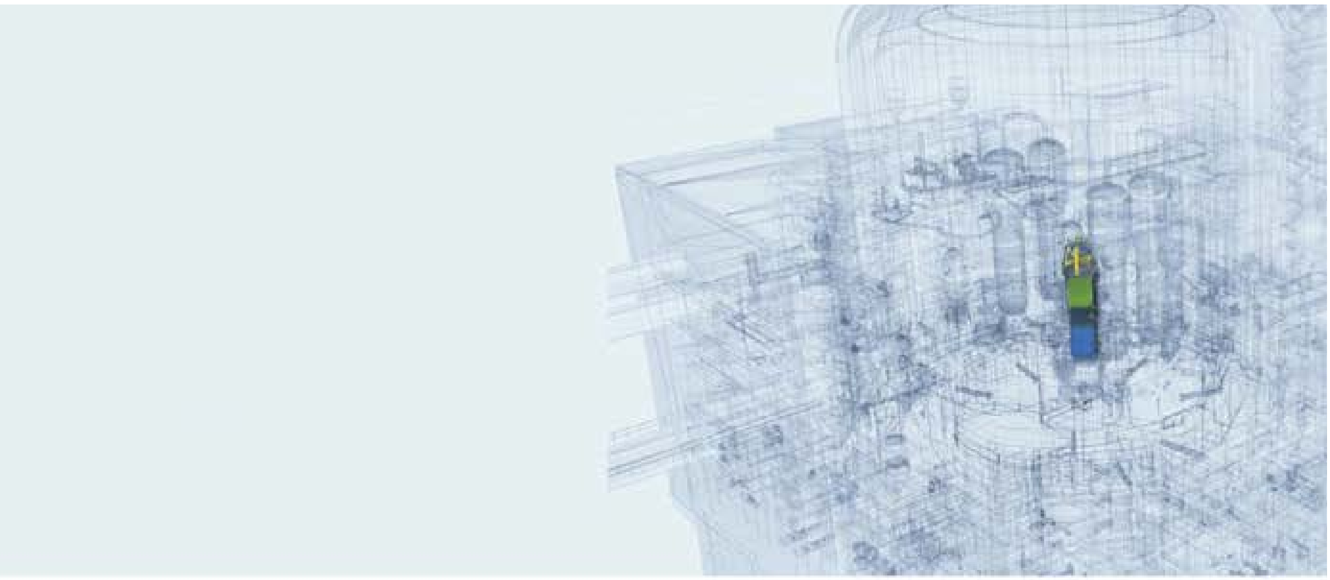
Transferring fuel out of and into the core

The refuelling machine lifts a fuel assembly out of the reactor core and transfers it to the transfer container, which is in a vertical position. The transfer mechanism turns the transfer container to a horizontal position and moves it from the reactor building through the transfer tube to the fuel building. The container is again turned to a vertical position, and the spent fuel mast bridge lifts the fuel assembly out and transfers it to the spent fuel storage rack in the spent fuel pool.

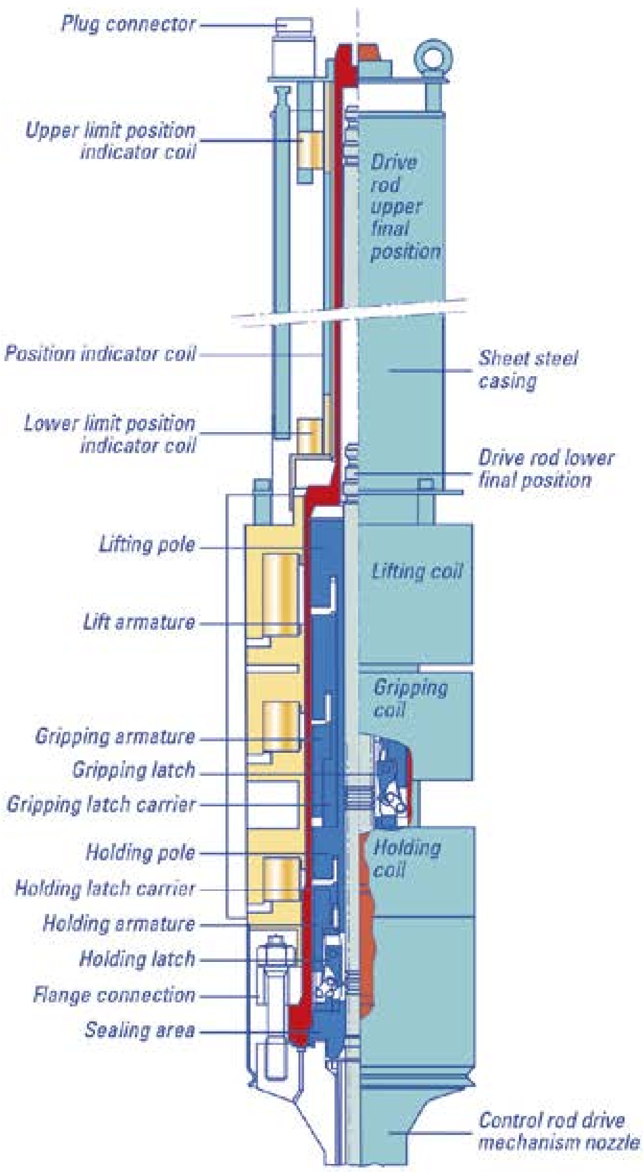
Installing new fuel assemblies in the core is performed using the same process in reverse.

Fuel transfer systems in the reactor building and fuel building





Cross-section of control rod drive mechanism



Control rod system properties

Rod cluster control assemblies	
Number	89 pcs
Weight	61.7 kg
Control rods per assembly	24
Absorber	
B4C part (upper part)	
- natural boron	19.9% ^{10}B atoms
- specific weight	1.79 g/cm^3
- external diameter	8.47 mm
- length	1,340 mm
AIC part (lower part)	
- weight composition: silver, indium, cadmium (%)	80,15, 5
- specific weight	10.17 g/cm^3
- external diameter	8.65 mm
- length	2,900 mm
Cladding	
Material	stainless steel
Surface treatment (external surface)	ion nitrification
External diameter	9.68 mm
Internal diameter	8.74 mm
Filling gas	helium
Control rod drive mechanisms	
Number of drive mechanisms	89 pcs
Weight	403 kg
Lifting power	>3,000 N
Travel range	4,100 mm
Stepping speed	375 mm/min or 750 mm/min
Maximum scram time allowed	3.5 sec

Materials austenitic and martensitic stainless steel

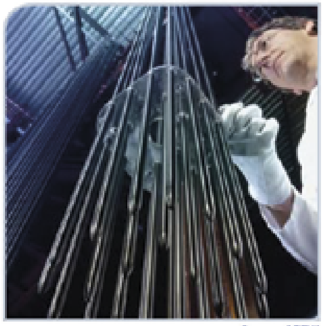
Reactor operation and control

The control assemblies are one system to control the reactor power. In addition to short-term power control, they also flatten vertical power distribution in the reactor core. In the long term, decreasing the boron content helps compensate for the loss of reactivity due to fuel burnup.

Control rod system

The control rod system is a part of the reactor power control system. It consists of the control assemblies formed with control rods, the control rod drive mechanisms and the control rod drive mechanism operating system. The system is used for controlling the reactor power and for a reactor scram. The control rods enter the core through guide thimbles in the fuel assemblies.

The control rod system is governed by the reactor control, surveillance and limitation system and manually by the control room operators. The reactor scram is triggered automatically by the protection system or its back-up system, a hardwired back-up system. An operator may also trigger the reactor scram manually.



Source: AREVA

The individual control rods of the reactor control assemblies move in the guide thimbles in the fuel assemblies. These guide thimbles are also used for placing instrumentation and neutron sources.

Control assemblies

There are 89 identical control assemblies. Each consists of 24 identical absorber rods attached to a single mount. The rods contain materials that absorb neutrons (silver, indium, cadmium and boron carbide). When the rods are completely inserted into the core, they almost totally cover the active length of the fuel assemblies.

The control assemblies are divided into separate control groups. The majority of them, 53 elements, are in the shut-down bank, which executes a rapid shut-down of the reactor, or reactor scram, if necessary. The remaining 36 elements control the temperature of the primary circuit and flatten vertical power distribution in the reactor core.

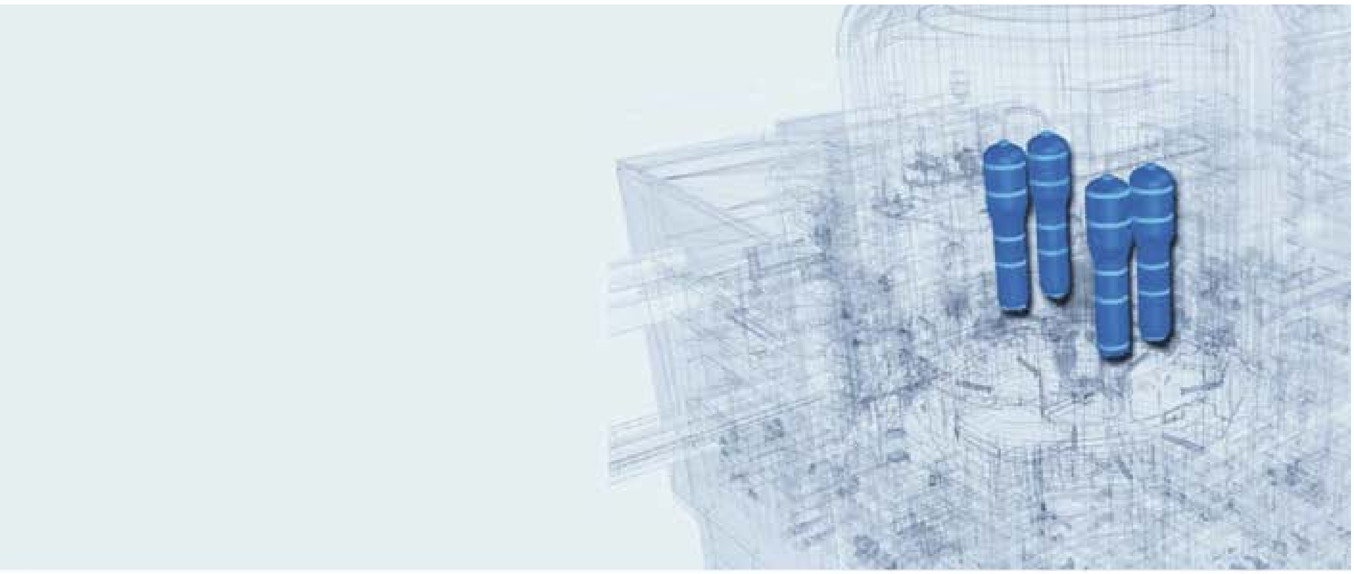
The control assemblies in the control bank are further divided into quadruplets, which are used in various drive sequences and insertion sequences depending on the refuelling interval in progress. The current insertion sequence and control assembly banks can be changed at any time regardless of the current reactor power.

The control bank in operation is regularly changed at intervals of about 30 days of power operation. This avoids fuel discharge burnup from affecting the effectiveness of the control and equalizes the burnup.

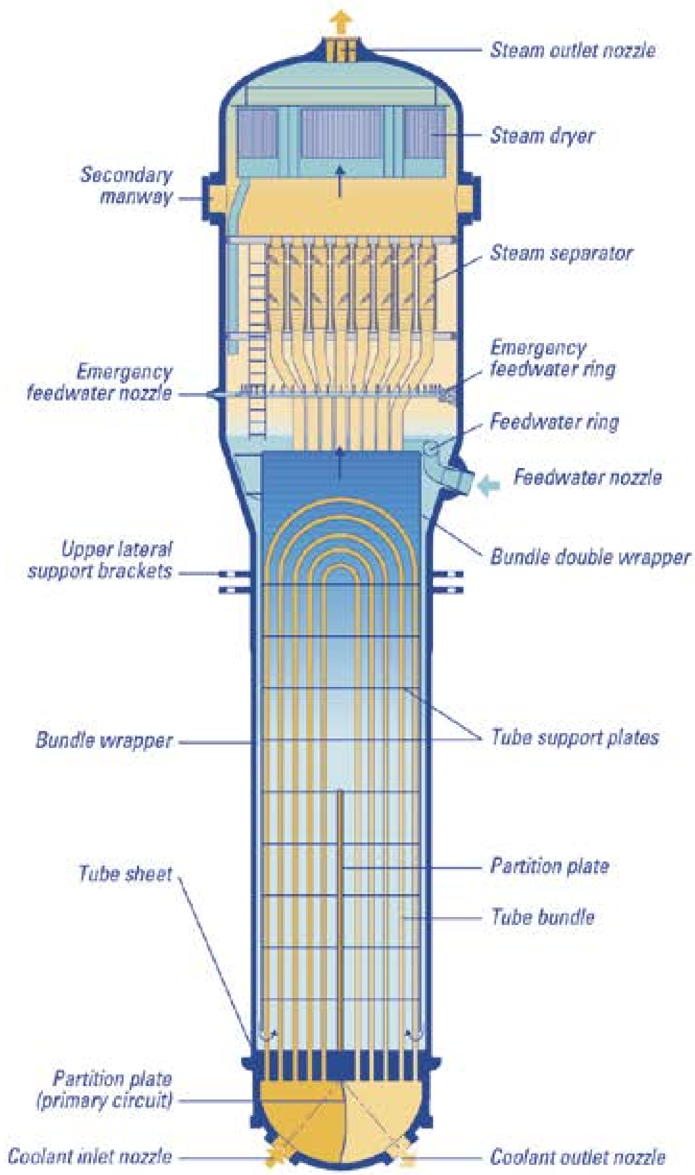
Control rod drive mechanisms

A control rod drive mechanism consists of the pressure housing with flange connection, the latch unit, the drive rod, the coils and their housings. The role of the control rod drive mechanisms in controlling the reactor is to move the 89 control assemblies throughout the length of the core and to keep them at any location required. Their secondary role is to drop the control assemblies into the reactor, thus stopping the chain reaction and shutting the reactor down in a number of seconds, particularly in a scram situation. When the reactor scram signal is activated, all operating coils are de-energized, the latches are retracted from the rod grooves, and the control assemblies drop into the core by force of gravity.

The control rod drive mechanisms are installed into adapters welded to the reactor pressure vessel head. Each drive mechanism is a separate entity that can be installed and removed independently of the others.



Cross-section of steam generator



Steam generator properties

Number of steam generators	4 pcs
Heat transfer surface per steam generator	7,960 m²
Primary circuit design pressure	176 bar
Primary circuit design temperature	351°C
Secondary circuit design pressure	100 bar
Secondary circuit design temperature	311°C
Heat transfer tube external diameter / wall thickness	19.05 mm / 1.09 mm
Number of tubes	5,980 pcs
Triangular pitch	27.43 mm
Total height	23 m
Materials	
Tubes	Inconel 690 alloy, heat treated
Shell	18 MND 5*
Cladding tube sheet	Ni-Cr-Fe alloy
Tube support plates	13% Cr-treated stainless steel
Other	
Total weight	520 t
Feedwater temperature	230°C
Main steam moisture content	0.25%
Main steam flow	2,443 kg/s
Main steam temperature	293°C
Main steam saturated pressure	78 bar
Pressure during hot shut-down	90 bar

*low-alloy ferrite steel

Primary coolant circuit

Steam generators

A steam generator is a heat exchanger which transfers heat from the primary coolant circuit to the water in the secondary circuit. As in a typical heat exchanger, the contents of the primary and secondary circuits never come into direct contact with one another. The steam generator in an EPR power plant unit is of the vertical type.

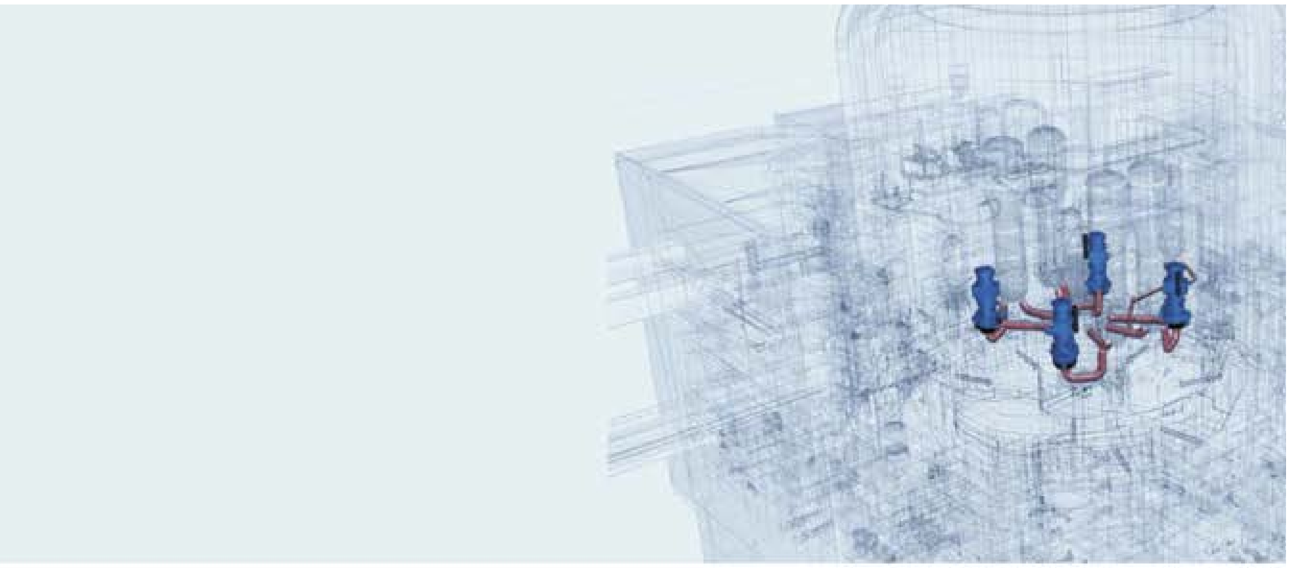
The primary coolant passes through U-shaped tubes in the steam generator. The feedwater of the secondary circuit, which is to be turned into steam, circulates inside the shell of the steam generator. The steam separators and steam dryer at the top of the secondary circuit portion separate the steam from the water. The separated water returns down along the outer shell of the steam generator. The feedwater pipes continously refill the secondary side of the steam generator with water equivalent to the mass of steam fed into the turbine.

The axial feedwater preheater enables not only a larger heat exchange area but also a saturation pressure of 78 bar, which is a significant factor in the high efficiency (37%) of the power plant unit. The tubes in the steam generator are made of wear-resistant and corrosion-resistant alloy called Inconel 690, which has a cobalt content of less than 0.015%. The shell of the steam generator is made of 18 MND 5 steel.

The design concept, with the cold feedwater being mixed with only 10% of the warmer recirculated water, ensures a larger temperature differential and hence a more efficient heat transfer. As a result, the main steam pressure of the OL3 steam generator is 3 bar higher per unit of heat exchange area than that of power plant units which the design is based on. The efficiency of the steam generator is achieved through the asymmetrical conveying of feedwater into a discrete channel separated from the walls of the steam generator.

In the design of the OL3 steam generators, particular attention was paid to the prevention of cross-flows in the secondary circuit and of the adverse effects caused by thermal layering due to the efficient heat exchange. The steam space has been enlarged, increasing the steam volume.

On the other hand, the steam generator also has a higher water volume than in the power plant units upon which the design is based. This improves the safety margin and increases the grace period in a situation where all feedwater systems malfunction and no cooling water is available for feeding into the steam generator.




Pump casing

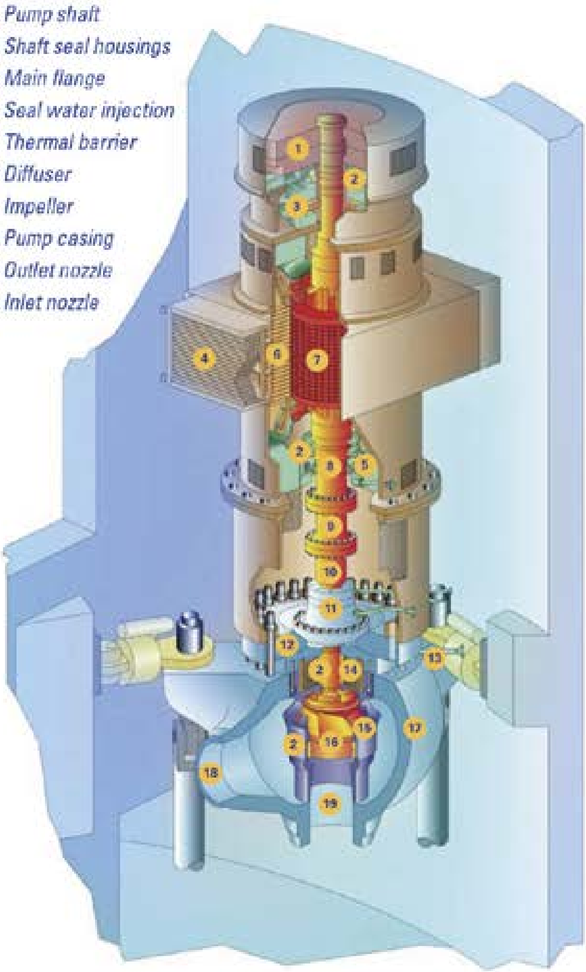
Reactor coolant pump and pipe properties

Pump	
Number of pumps	4 pcs
Design pressure	176 bar
Design temperature	351°C
Primary coolant flow	28,330 m^3/h
Design head	100.2 m ± 5%
Seal water injection	1.8 m^3/h
Seal water return	0.680 m^3/h
Speed	1,465 rpm
Total height	9.3 m
Total weight without water and oil	112 t
Motor	
Rated power	9,000 kW
Frequency	50 Hz
Main circulation pipes	
Internal diameter	780 mm
Wall thickness	76 mm
Material	Z2 CN 19-10*
Pressurizer connection pipe	
Internal diameter	325.5 mm
Thickness	40.5 mm
Material	Z2 CN 19-10*

*low carbon stainless austenitic steel

Cross-section of reactor coolant pump

1. *Flywheel*
2. *Radial bearings*
3. *Thrust bearing*
4. *Air cooler*
5. *Oil cooler*
6. *Motor (stator)*
7. *Motor (rotor)*
8. *Motor shaft*
9. *Spool piece*
10. *Pump shaft*
11. *Shaft seal housings*
12. *Main flange*
13. *Seal water injection*
14. *Thermal barrier*
15. *Diffuser*
16. *Impeller*
17. *Pump casing*
18. *Outlet nozzle*
19. *Inlet nozzle*



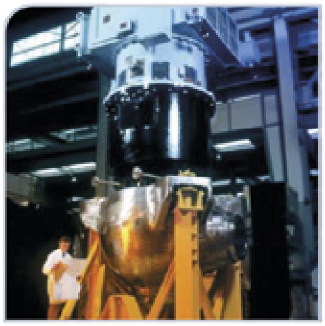
Reactor coolant pump

The reactor coolant pumps provide forced circulation of water through the reactor coolant system. This circulation removes heat from the reactor core to the steam generators, where it is transferred to the secondary circuit. In each of the four loops of the primary circuit, the reactor coolant pump is located between the steam generator outlet and the reactor inlet.

The reactor coolant pumps have hydrostatic bearings, which ensure a low vibration level. The OL3 reactor coolant pumps have three separate shaft seals and an additional standstill seal which is operated by gas pressure.

A reactor coolant pump consists of three main parts: the pump itself, the shaft seals and the motor.

The pump hydraulic cell consists of the impeller, the diffuser and the suction adapter. The pump shaft is in two parts connected by a spool piece which can be removed for seal maintenance. The shaft is supported on three bearings: two oil-lubricated bearings in the motor and one hydrostatic bearing at the impeller. There is a double-action thrust bearing at the top of the motor shaft, under the flywheel, to compensate axial forces.



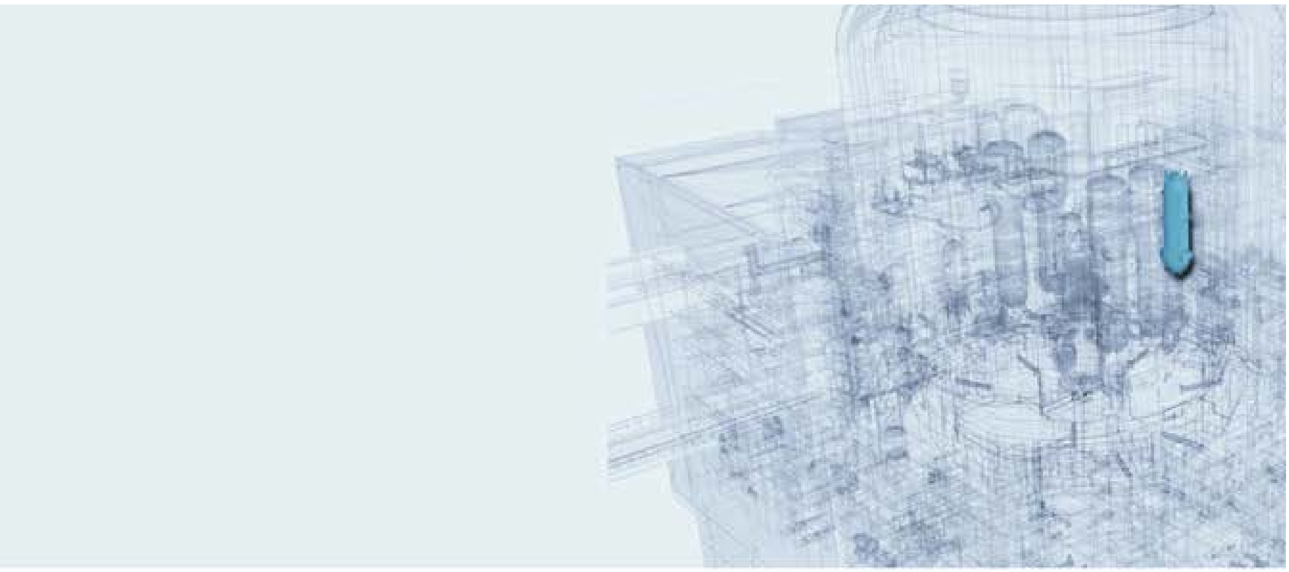
Source: AREVA

Reactor coolant pump at the Jeumont plant in France (N4, 1,500 MWe).

The shaft seal system consists of three dynamic seals assembled into a cartridge and a standstill seal. The first seal is a hydrostatically controlled leakage seal, which takes the full primary pressure. The second seal is a hydrodynamic seal which receives the remaining pressure but can also withstand the entire primary pressure if necessary. The third seal is also hydrodynamic and is a backup leak seal. The standstill seal ensures that no primary coolant is lost in the event of a loss of power or the simultaneous malfunction of all shaft seals when the pump is stopped.

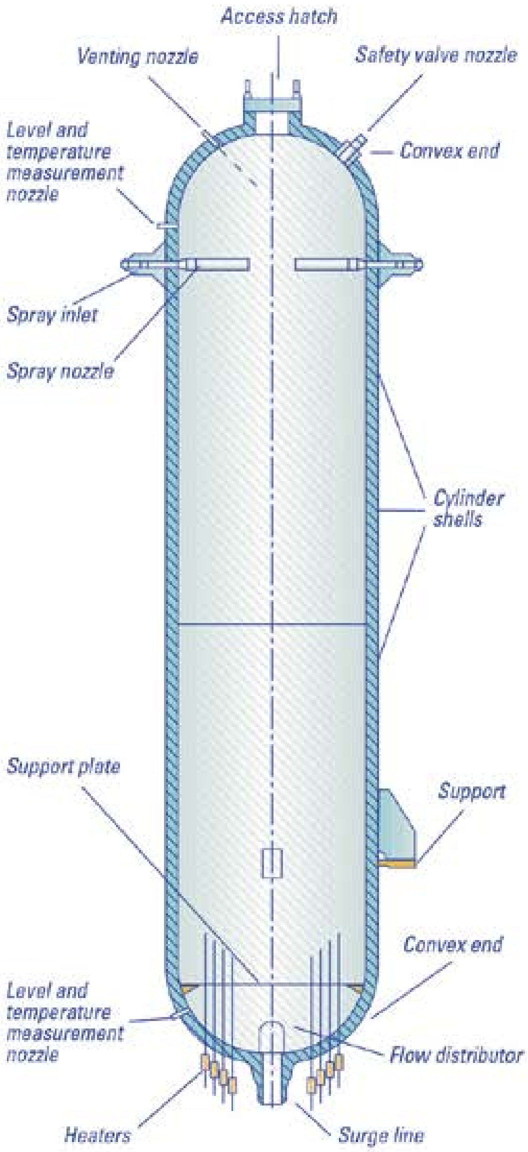
When the pump is in operation, the shaft seals are cooled and lubricated with seal injection water which is injected below the seals at a pressure slightly higher than that of the primary coolant. The third shaft seal, which is a backup to the first two, receives its cooling water from the demineralized water distribution system.

The motor is a drip-proof squirrel-cage asyncronous motor. A spool piece placed between the pump and the motor shafts and the shaft seal housing structure enable maintenance to be carried out on the seal pack without removing the motor.



Source: AREVA

Cross-section of pressurizer



Pressurizer properties

Design pressure	176 bar
Design temperature	362°C
Total volume	75 m³
Total length	14.4 m
Base material	18 MND 5*
Cylindrical shell thickness	140 mm
Number of heaters	108
Total weight, empty	150 t
Total weight, filled with water	225 t
Number of safety valves and capacity under design pressure	3 x 300 t/h
Relief valve capacity under design pressure (doubled for valves)	1 x 900 t/h

* low-alloy ferrite steel

Pressurizer

The pressurizer contains primary coolant in its lower part and steam in its upper part. The pressurizer is part of the primary circuit and is connected through a surge line to the hot leg of one primary loop. The purpose of the pressurizer is to keep the pressure in the primary circuit within specified limits.

The pressure in the primary circuit is controlled by regulating the steam pressure. For this purpose, the pressurizer has heaters in its lower part to produce steam and a spray system in its upper part to condense steam into water.

The pressure-relief and safety valves at the top of the pressurizer protect the primary circuit against excessive pressure. There are two parallel pressure-relief lines with valves which the operators can use, in the case of a severe accident, to relieve pressure quickly in the primary circuit: the primary coolant released from the primary circuit is discharged to the pressurizer relief tank, where a rupture disk breaks and releases the coolant into the containment building. There the steam condenses into water, which is collected in the emergency cooling water storage tank at the bottom of the containment building and pumped back into the reactor.

The maintenance platform running around the pressurizer facilitates heater replacement and reduces radiation doses during valve maintenance.

All components of the pressurizer shell, except for the heater penetrations, are made of forged ferrite steel with two layers of cladding. The material is the same as in the reactor pressure vessel. The heater penetrations are made of stainless steel and are welded using a corrosion-resistant alloy. The pressurizer supports are welded to its frame.

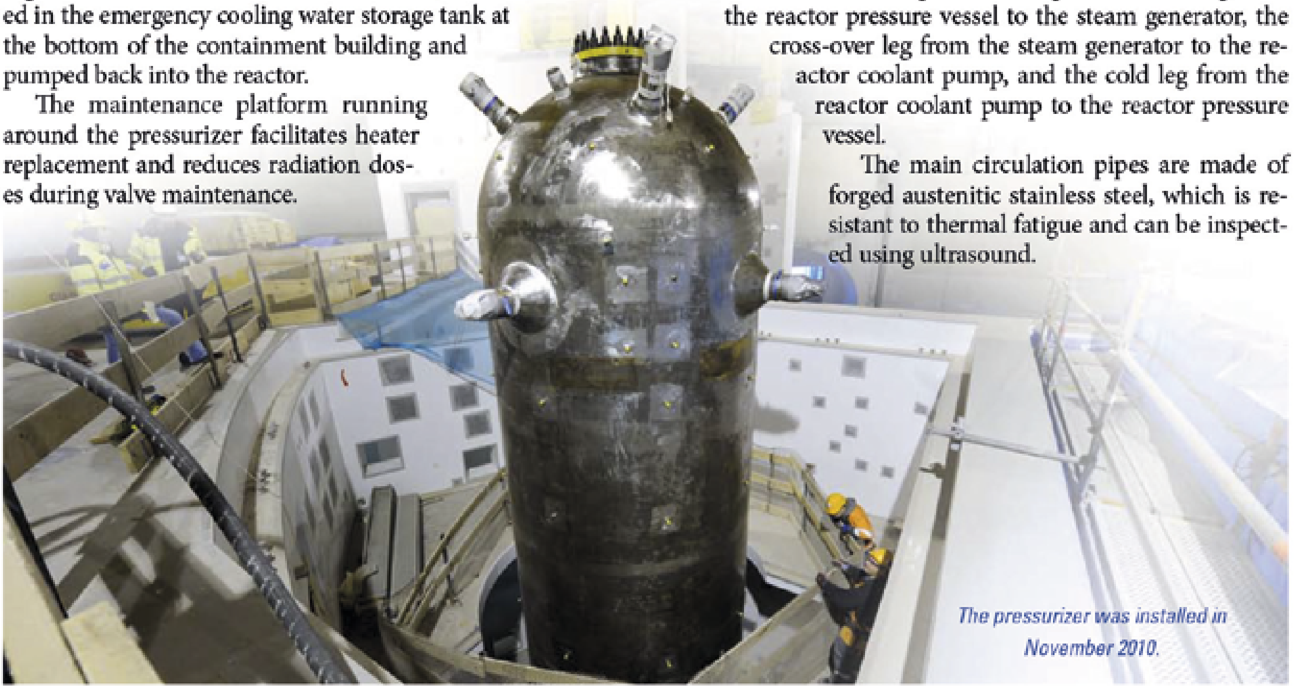
Compared with plants which the design of OL3 is based on, the volume of the pressurizer has been increased in order to smooth the response to operational transients.

Main coolant lines

The main coolant lines of the four loops that form the primary circuit and the pressurizer surge line are part of the reactor coolant system in the reactor building. The main coolant lines convey the primary coolant from the reactor pressure vessel to the steam generators and onward to the reactor coolant pumps, which return the coolant to the pressure vessel. One of the four loops is connected to the pressurizer.

Each of the four loops has three parts: the hot leg from the reactor pressure vessel to the steam generator, the cross-over leg from the steam generator to the reactor coolant pump, and the cold leg from the reactor coolant pump to the reactor pressure vessel.

The main circulation pipes are made of forged austenitic stainless steel, which is resistant to thermal fatigue and can be inspected using ultrasound.



The pressurizer was installed in November 2010.


1 Moisture separator reheater (MSR)
2 High-pressure turbine
3 Low-pressure turbine
4 Condenser
5 Generator
1
2
3
4
5

SECONDARY CIRCUIT

The purpose of the steam-water secondary circuit in the turbine plant is to convert the thermal energy of the main steam entering from the nuclear island into electrical energy through the turbine and generator as efficiently as possible and to return the secondary-circuit feedwater to the steam generators in the reactor plant. There is no radioactivity in the secondary circuit because the water of the primary and secondary circuits are separated from each other.

Main steam system

The main steam generated in the steam generators belonging to the primary circuit is fed to the turbine plant through the four main steam lines. The main steam is fed to the high-pressure (HP) turbine through the high pressure turbine stop and control valves located in each main steam line. Every main steam line has a relief train, safety valves and an isolation valve in the event of abnormal operation. The steam is conveyed through the relief system and the safety valves straight into the atmosphere.

The exhaust steam from the HP turbine is dried and reheated in the moisture separator reheaters (MSR). The reheating is performed in two stages, using extracted steam from the HP turbine extraction A7 and from the main steam extracted between the HP turbine stop and control valves.

From the MSRs, the reheater steam goes through the LP turbine stop and control valves to the three LP turbines.

The exhaust steam from the LP turbines is condensed in three separate sea water condenser units. In addition to condensing the steam from the LP turbines, the turbine bypass steam is also condensed in these condenser units.

The purpose of the turbine bypass steam system is to control the main steam pressure depending on the power plant operation mode.

Main condenser and condensate system

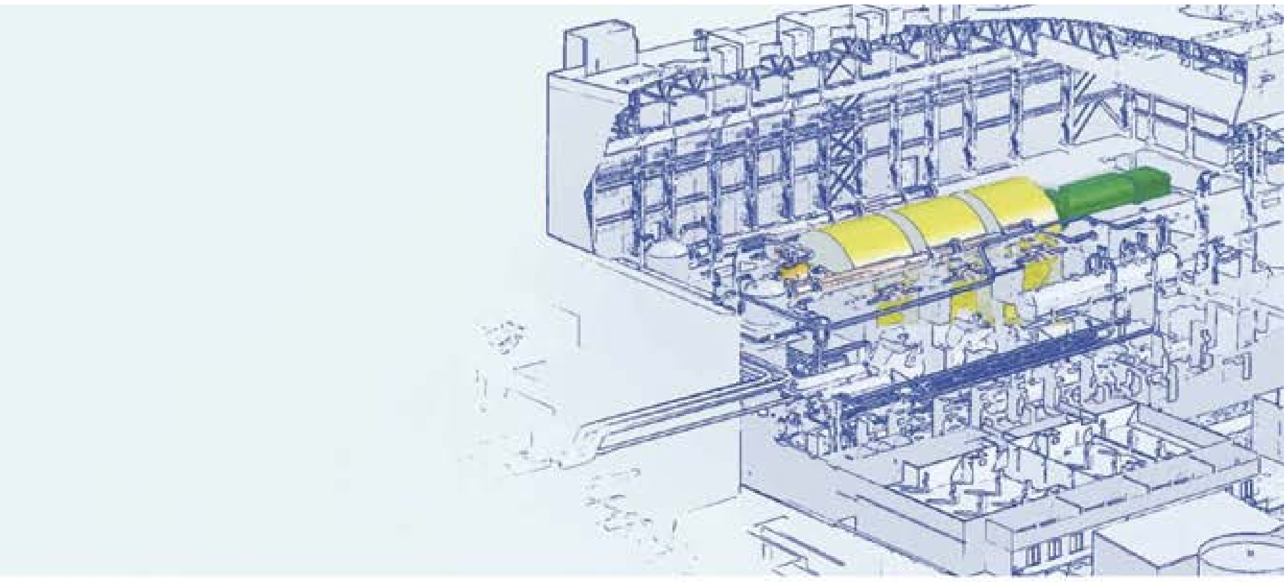
There are three condensate extraction pumps (CEP), two pumping the main condensate from the condenser condensate chambers (hot wells) to the feedwater storage tank through the low-pressure feedwater preheating system. The third pump acts as a stand-by pump.

The main condensate is preheated in four low-pressure feedwater heating stages to improve the efficiency of the steam-water process. The main condensate system also contains a mechanical condensate purification system for removing impurities.

Feedwater system

There are four feedwater pumps, three pumping feedwater from the feedwater storage tank through the high pressure feedwater preheating system to the steam generators. The fourth pump acts as a stand-by pump.

The feedwater is preheated in three feedwater heating stages in two trains, each train consisting of two high-pressure feedwater preheaters and the reheating stage 2 condensate coolers. The steam is extracted into the high-pressure feedwater preheaters from the HP turbine extractions A7 and A6. From the preheating system, the feedwater is conveyed through the feedwater valves in the safeguard building divisions into the steam generators.



The HP turbine is a double-flow turbine consisting of inner and outer casing structures split horizontally.

Lifting of the HP turbine rotor in September 2008.

Turbine plant main figures

General	
Gross electrical output	1,720 MWe
Net electrical output	1,600 MWe
Main steam pressure (HP turbine)	75.5 bar
Main steam temperature	290°C
Steam flow	2,443 kg/s
Rated speed	1,500 r.p.m.
HP turbine	1
LP turbine	3
Last expansion stage	
- exhaust area	30 m²
- last stage blade (LSB) airfoil length	1,830 mm
- overall diameter	6,720 mm
Length of turbine-generator rotor train	68 m
Condenser	
Cooling surface	110,000 m²
Cooling medium	sea water
Cooling water flow	53 m³/s
Vacuum at full load	24.7 mbar abs.
Sea water temperature rise	12°C
Feedwater	
Preheating stages	7
Final feedwater temperature	230°C

Inner casing of the HP turbine.

Turbines and generator

The thermal energy generated in the reactor is converted to mechanical energy by the turbines and then to electricity by the generator. The high 1,600 MWe power output of OL3 is partly due to the high efficiency of the turbine-generator set.

The single-shaft turbine-generator set consists of one HP turbine and three LP turbines, a generator and an exciter. Each turbine rotor is mounted on two bearings, i.e. there are double bearings between each turbine module.

The rated speed of the turbine-generator is 1,500 r.p.m., and its shaft length is 68 m. The planned service life of the replaceable components of the turbine is 30 years, and the planned service life of the turbine plant as a whole is 60 years.

The OL3 LP turbines are double-flow turbines with running blades attached to blade wheel discs shrunk on to the turbine shaft.

LP turbines

The three OL3 LP turbines produce approximately 60% of the gross power output of the power plant unit (approximately 320 MWe each). LP turbines are double-flow reaction turbines consisting of following main components:

- inner casings
- outer casings
- 9 expansion stages, stationary blade and running blade stages (6 stages with shrouded blades and 3 stages as free-standing blades)
- rotor (forged and machined spindle shaft where shrunk-on fitted forged and machined blade wheel discs)

HP turbine

The OL3 HP turbine produces about 40% of the gross power output of the power plant unit (650 MWe). It is a admission double-flow reaction turbine consisting of following main components:

- inner casing (cast, machined)
- outer casing (cast, machined)
- rotor (6.26 m and 100 t, forged and machined)
- 12 expansion stages, stationary blade and running blade stages

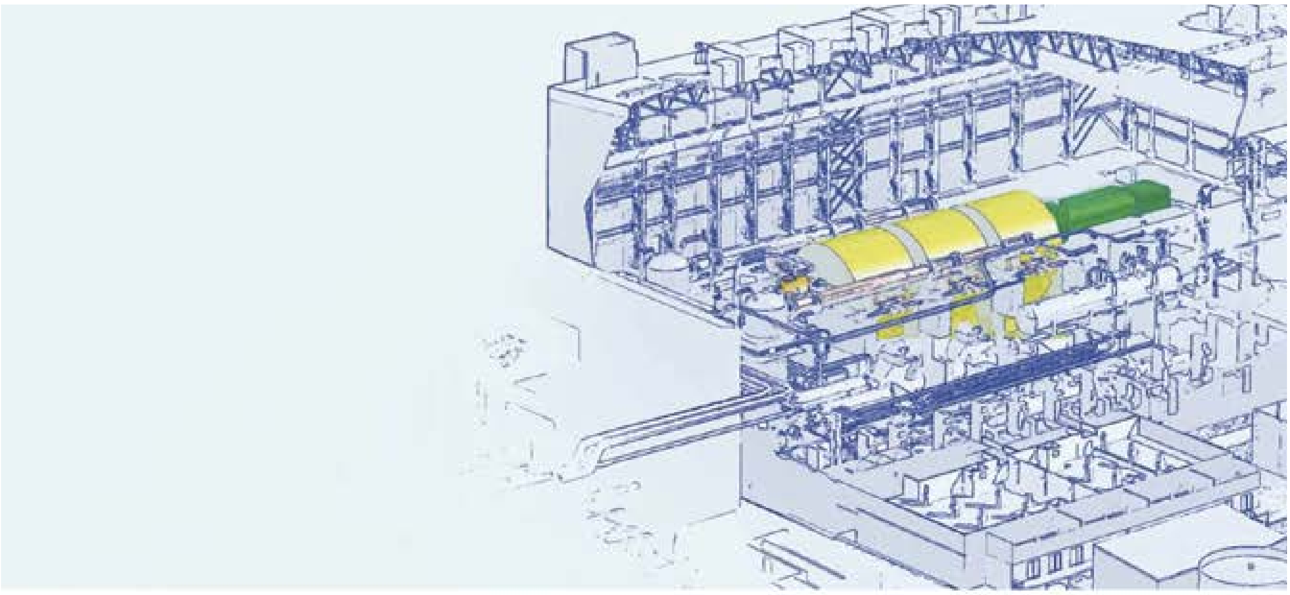
The inner and outer casings of the HP turbine are formed with horizontally split inner and outer casing constructions. The inner casing is attached to the outer casing construction. The stationary blades of the HP turbine and the running blade seal strips are attached to the HP turbine inner casing. The shaft seal constructions are attached to the HP turbine outer casing.

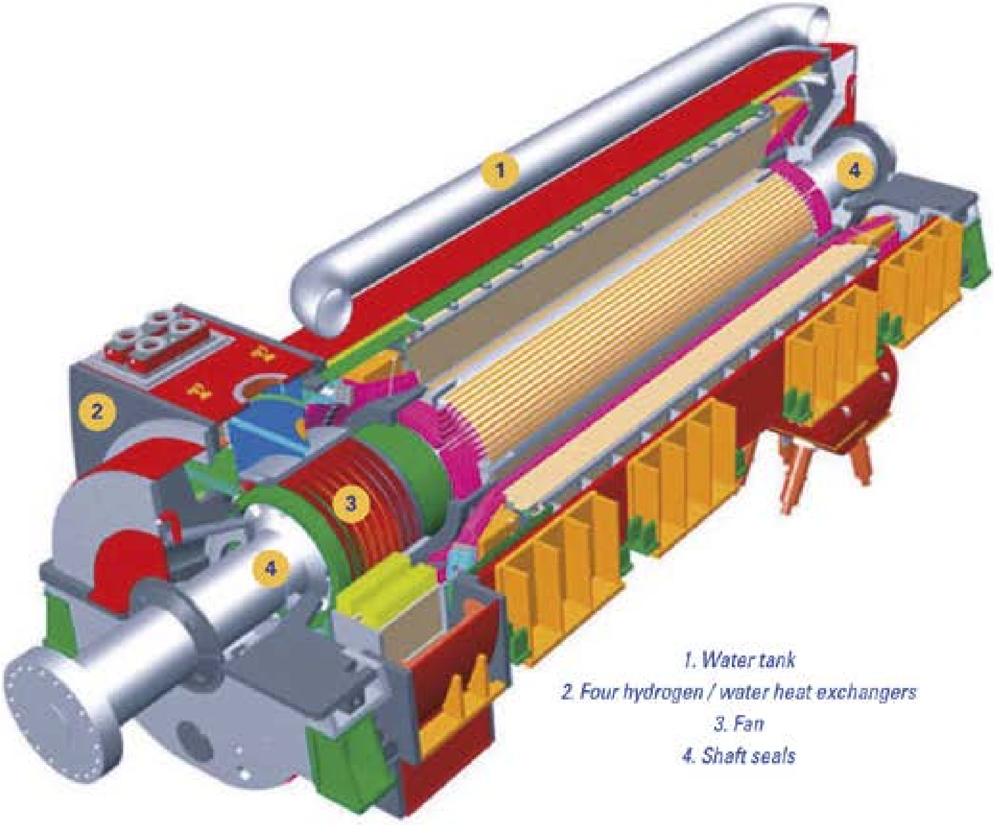
The HP turbine rotor is machined from the forging. The running blades of the rotor and the stationary blade seal strips are attached to the rotor machined blade and seal strip grooves.

The inner and outer casings of the LP turbines consist of inner and outer casing constructions split horizontally. The inner casing of an LP turbine is attached to the turbine foundation structure, and the outer casing is welded permanently to the condenser construction, which is supported by the base foundation structures. The stationary blades and running blade seal strips are attached to the inner casing structures. The thermal expansion of the outer casing structures is separated from the inner casing and rotor construction of the LP turbines.

The LP turbine rotor consists of a through-bored spindle shaft with eight blade wheel discs (four for each flow) shrunk-on fitted. The coupling flanges of the LP turbine rotors are also partly secured to the rotor shaft with a shrink-on fit.

The running blades and stationary blade seal strips of the LP turbine are attached to grooves machined in the blade wheel discs. The first six running blade stages are so called drum stages and have blade bands, and the last three blade stages are so called free-standing blades. The exhaust area of the last running blade stage is 30 m², produced by the 1,830 mm profile length of the last running stage blades (LSB). The stationary blades in the last stage are hollow vane type, and part of moisture of the expanding steam is separated via cuts on the hollow vane before the LSB stage.





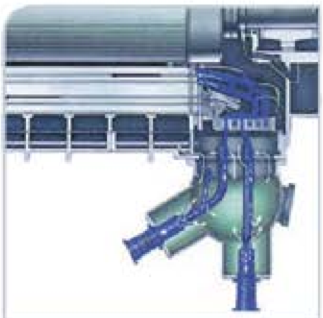
1. Water tank
2. Four hydrogen / water heat exchangers
3. Fan
4. Shaft seals

Generator properties

Rated speed	1,500 r.p.m.
Frequency	50 Hz
Effective power	1,793 MWel
Nominal rating	1,992 MVA
Power factor	0.9
Voltage	27 kV ± 5%
Efficiency	ca. 99%
Magnetization current	9,471 A
Cooling water temperature	45°C
Hydrogen cooling medium temperature	40°C

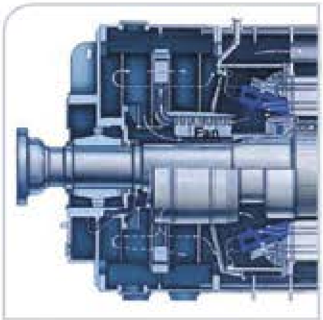
Generator

The OL3 generator is a four-pole, hydrogen-cooled generator with a brushless excitation system. The stator winding and the winding terminals are water-cooled.

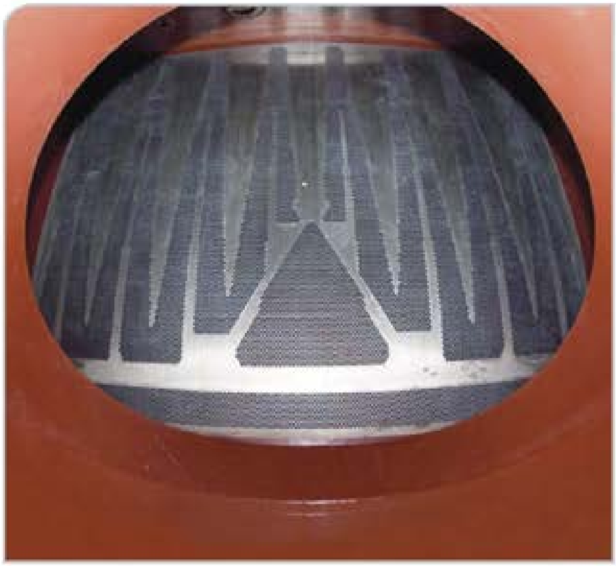


The generator output terminals transfer the electricity generated through the bus duct to the main transformer and onward to the national grid.

The rotor windings are cooled using hydrogen, which is conveyed axially through the windings at a pressure of 5 bar. The hydrogen is cooled in the hydrogen/water heat exchangers. The hydrogen circuit inside the generator is powered by a multistage fan mounted on the rotor.



The hydrogen-cooled generator rotor rotates at 1,500 r.p.m., weighs 250 t and is almost 17 m long.



Construction of cooling water tubes for condenser unit.

Condenser unit from the inside.

Two of the three turbine island condensor pumps are in use, one is a standby pump.

Condenser

The exhaust steam from the LP turbines is condensed into water in the condenser. There is a condenser unit under each LP turbine, divided into two separate sea water chambers. The structural design allows one sea water chamber to be removed and inspected without turbine shut-down.

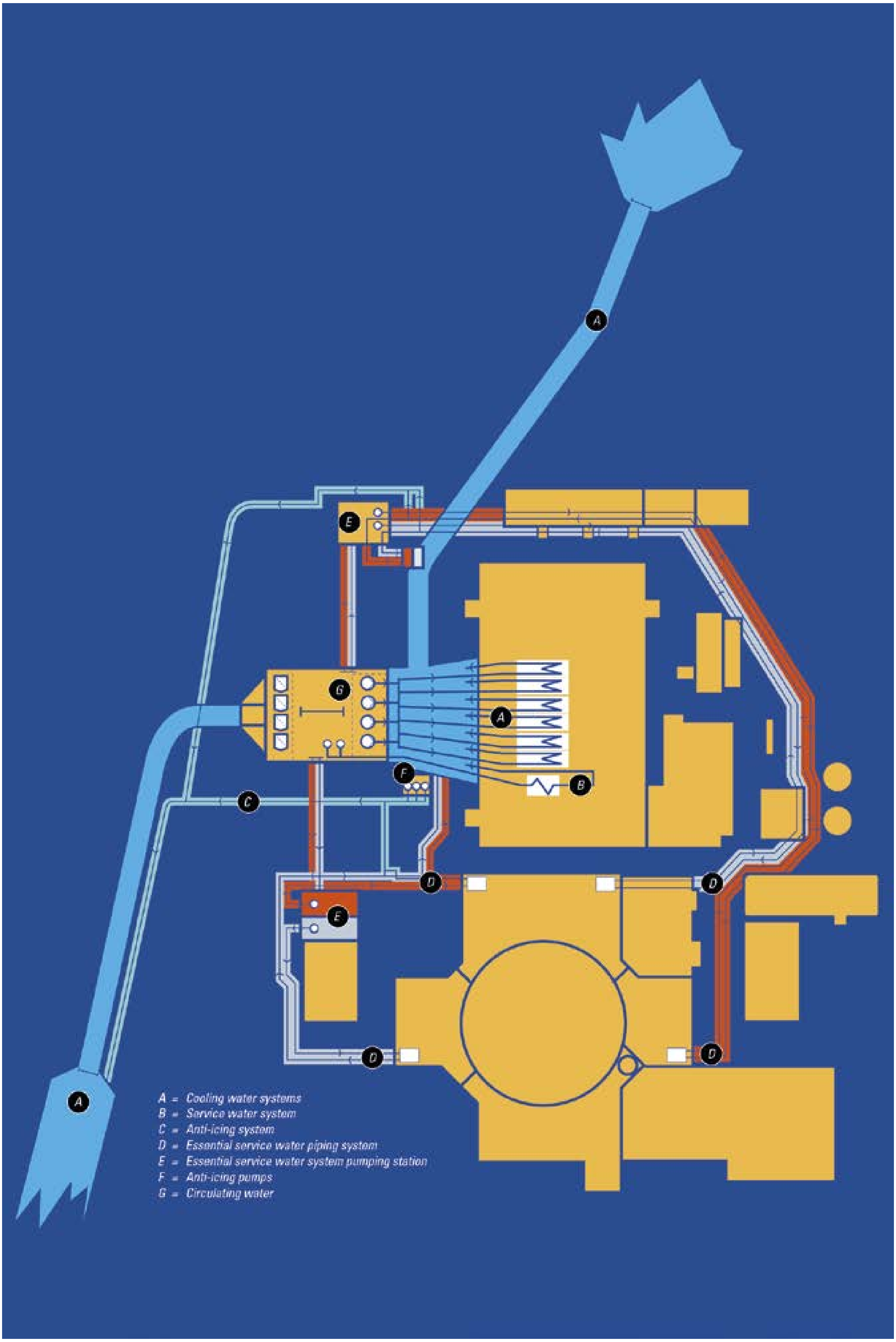
In addition to condensing the exhaust steam from the LP turbines, the condenser receives condensate and gas flows extracted from various process systems.

The condenser has a total cooling surface of about 110,000 m². The tube material used is titanium, which is highly resistant to sea water corrosion. The sea water used as coolant is fed into the tubes through the water chambers. The temperature rise of the cooling water in the condenser is about 12°C.

The condenser tubes are cleaned by feeding soft cleaning balls (Taprogge) into the cooling water flow and collecting them once they have passed through the condenser tubes.

The condenser must have a sufficient low vacuum in order to increase the power plant effeciency. The vacuum pump system maintains a sufficient vacuum in the condenser by extracting air and uncondensed gases.

One sea water chamber for a condenser section weighs about 250 t. There are six of them in total, two for each LP turbine.


A
E
G
A
F
B
C
D
D
E
D
D
A
A = Cooling water systems
B = Service water system
C = Anti-icing system
D = Essential service water piping system
E = Essential service water system pumping station
F = Anti-icing pumps
G = Circulating water

SEA WATER COOLING SYSTEMS

Sea water is conveyed along its own underground cooling water tunnel at a rate of 57 m^3/s into the OL3 pump station. Before entering the tunnel, major impurities are filtered out of the sea water with coarse screens. In the pumping station, the water is conveyed through four filtering lines to the sea water pumps. The filtering lines contain a fine screen and a chain basket filter to remove minor impurities from the sea water.

The cooling water intake tunnel has a cross-section of about 60 m^2.

The pumping station contains four sea water pumps, which are vertically mounted in a concrete casing. Each pump conveys about 13 m^3/s of sea water to the condensers. To cool the power plant systems, 4 m^3/s of the total sea water flow is used. From the condenser, the water goes to a seal pit and then through the outfall tunnel to the sea. The outfall channel is shared with OL1 and OL2.

The cooling water pumped by the sea water pumps is conveyed into a sea water condenser through the manifold shown below.

The safety system consists of four parallel trains, each capable of performing the required safeguard function on its own. The four parallel trains are located in separate buildings on different sides of the reactor building to eliminate the possibility of simultaneous failure.

NUCLEAR SAFETY

The general objective is to ensure the safety of the nuclear power plant so that its use causes no radiation risks to the health of employees or of people living in the vicinity, nor any other damage to the environment or property. The general principle is that no radioactive substances must ever be released into the environment.

In case of abnormal operation, OL3 has safety systems consisting of four redundant subsystems, each capable of performing the required safety function on its own.

Three functions are a prerequisite to ensure reactor safety under all circumstances:

1. Control of the chain reaction and of the power generated by it.
2. Cooling of the fuel also after the chain reaction has stopped, i.e. removal of residual heat.
3. Isolation of radioactive products from the environment.

Reactor safety is based on three protective barriers to prevent radioactive releases and on the defence-in-depth principle.

Three protective barriers

The concept of three protective barriers refers to a series of strong and leak-tight physical barriers between radioactive products and the environment. The barriers prevent releases of radioactive products in all circumstances.

First barrier

The uranium fuel in which radioactive products are formed is enclosed in a metal fuel rod cladding.

Second barrier

The primary circuit is a closed circuit made of thick steel. The reactor pressure vessel forms part of this circuit. The uranium fuel encased in metal fuel rods is within this vessel in the reactor core.

Third barrier

The primary circuit is completely enclosed by the leak-tight containment with massive concrete walls. The double concrete walls of the OL3 containment are built on a thick base slab, and the inner containment is covered with a leak-tight metal liner.

Any one of these barriers is tight enough to ensure that no radioactive materials can be released into the environment.

Safety features of OL3

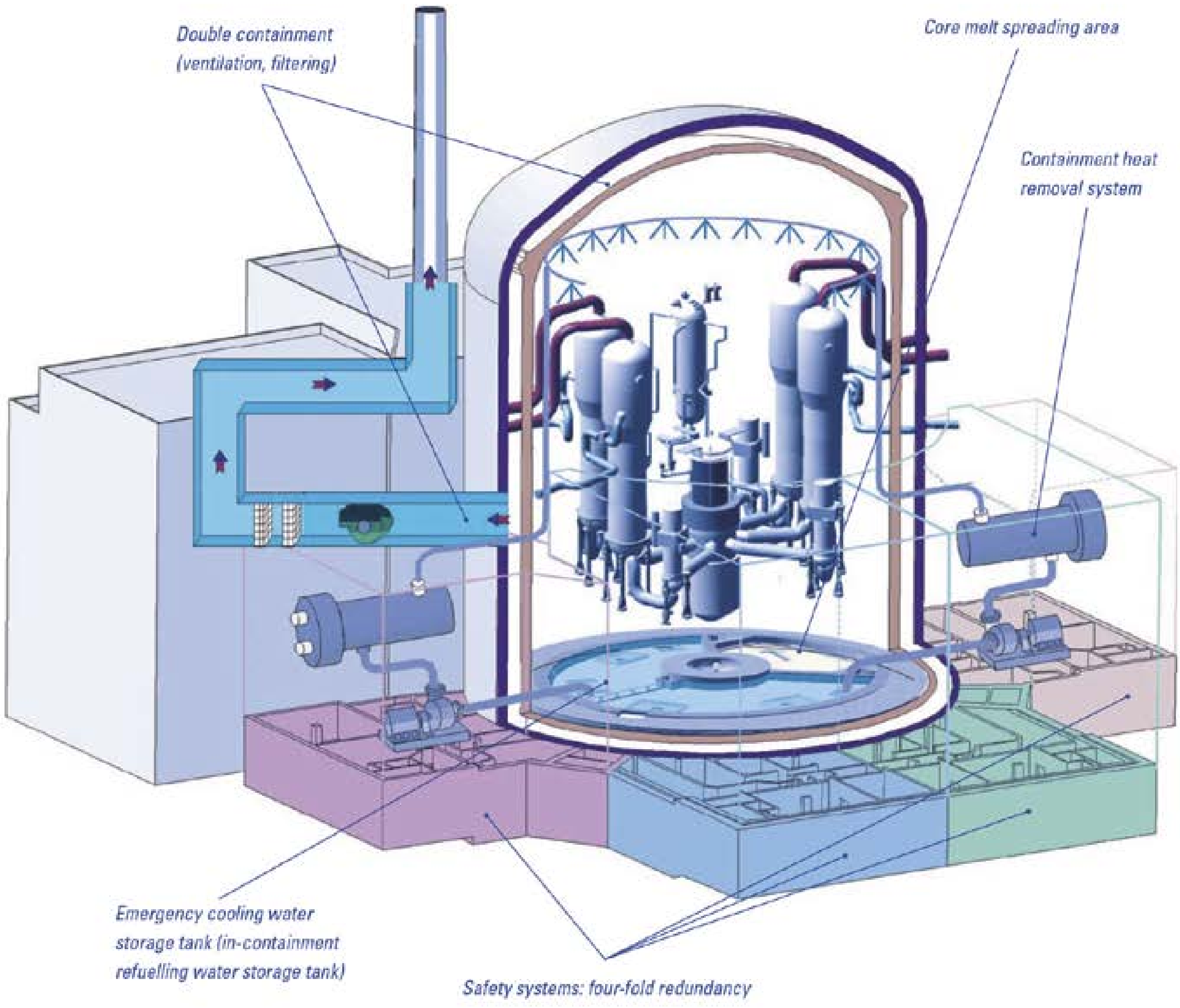
OL3 represents evolutionary technology developed on the basis of the most recent German Konvoi plants and French N4 plants. The operating experience from these plants has been carefully studied and considered for the design of OL3. In the development process, the main focus has been on safety systems and the prevention of severe reactor accidents, as well as minimizing the damage caused by an accident.

The design of the safety systems is based on quadruple redundancy of systems. It means that the systems consist of four parallel trains, each capable of performing the required safety task on its own. The four trains are physically separated and located in different parts of the reactor building in independent divisions.

Each of the four safeguard building divisions contains a low and medium-pressure emergency cooling system with the closed cooling and essential service water circuits cooling them, the steam generator emergency feedwater system, and the electrical equipment and instrumentation and control systems required for these systems.

Ceramic uranium fuel enclosed in a metal fuel rod cladding — *Reactor pressure vessel and primary circuit* — *Double concrete walls of the gas-tight containment*

Examples of principal safety features of Olkiluoto 3



The emergency cooling systems take their water from the in-containment emergency cooling water storage tank.

The probability of a serious reactor accident has been further reduced compared with earlier power plants by enhancing preventive systems. The OL3 systems have also been further developed to drastically limit the consequences of a severe accident.

Safety design

All the reactor protection and safety functions required to be instantly activated in an abnormal operating situation or accident are based on automatic systems. This allows for a planning period of 30 minutes for corrective actions by the plant control room.

The OL3 safety design is based on the concept that in the event of abnormal operation, the plant will automatically be transferred to a controlled state known as a hot shut-down and further, by manual control, to a stable cold shut-down. The controlled state is achieved by using the emergency feedwater system, the main steam relief train and the primary circuit emergency boron injection system. The level at which the residual heat removal system can operate (30 bar and 180°C) is attained by cooling through the secondary circuit and by lowering the pressure in the primary circuit. The emergency cooling or residual heat removal systems are then used to attain cold shut-down.

The volumes of the largest reactor components, i.e. the pressure vessel, the steam generators and the pressurizer, have been increased over previous plant designs to slow down the time progression of the reactor transients and to give the operators more time to initiate corrective actions.

The large steam volume of the steam generator means that it takes a long time to fill with water from the primary circuit in case of a ruptured heat transfer tube. The steam is conveyed from the damaged steam generator primarily to the condenser through the turbine bypass valves and not straight into atmosphere. When the condenser is not available, environmental releases from any leak between the primary and secondary circuits in the steam generators are minimized by lowering pressure through the turbine bypass relief valves and automatic isolation of the damaged steam generator. The activation pressure levels of the OL3 emergency cooling systems are lower than the pressure levels that open the steam generator safety valves so that in case of a leak between the primary and secondary circuits, the steam generator safety valves will not be actuated.

Emergency core cooling and residual heat removal system

The emergency core cooling system consists of low and medium-pressure injection pumps, nitrogen-pressurized pressure accumulators and the in-containment refuelling water storage tank. Under normal use, the system functions as a residual heat removal system when the plant unit is being powered down to a cold shut-down. The system consists of four separate divisions, each of which can independently pump water into the primary circuit using the low and medium-pressure injection pumps. Each subsystem is housed in its own safeguard building division and feeds into a different one of the four loops of the primary circuit. This arrangement ensures sufficient cooling capacity in case of loss of coolant.

Emergency boron injection

This design concept counteracts the rare event of a failed reactor scram. If the control assemblies fail to drop when the automatic scram conditions are actuated, the reactor coolant pumps stop and the emergency boron injection system, which has two lines and three pumps, starts up. The piston pumps used for emergency boron injection can pump boron-containing water at pressures up to 260 bar.

Residual heat removal

During normal use or in case of an accident, the excess energy and residual heat produced by the fuel can be transferred through the steam generators to the secondary circuit. The steam generators are provided with water through the feedwater system during normal use and the emergency feedwater system in case of an accident.

The emergency feedwater system consists of four separate parallel subsystems that are independent of each other, each of which feeds water into one of the steam generators. Each injection pump has its own emergency feedwater tank. The tanks and systems are housed in separate compartments in the safeguard building divisions.

Residual heat can be removed either through the steam generators to the secondary circuit and then through the condensers to the sea or by release of steam into the outside air through the main steam relief trains. In case of a complete coolant loss in the secondary circuit, pressure in the primary circuit can be lowered by steam discharge into the containment through the pressurizer relief lines or safety valves. In such cases, make-up water is injected into the primary circuit using the low and medium-pressure injection pumps, and the 2,000-tonne in-containment refuelling water storage tank is cooled using an intermediate cooling circuit powered by an emergency diesel generator, or using the independent containment heat removal system. Heat is transferred through the cooling chain formed by the reactor cooling system, the closed cooling water system and essential service water system to the ultimate heat sink. The suction pipes of the safety systems have a guard pipe up to the first isolation valve to prevent water loss in case of a suction pipe break.

Essential service water system

The essential service water system is a safety system consisting of four physically separated pumping chains housed in the four safeguard building divisions. The system transfers heat from the heat exchangers of the closed cooling water system, which cools the safety systems, to the sea.

In addition to the four main chains, the essential service water system has two dedicated pumping chains which form part of the independent heat transfer chain that is used in case of a severe accident.

Preparedness for severe reactor accidents

In the design of OL3, a severe reactor accident is addressed: even if the multiple redundant and independent safety systems were all to fail, the impact of the event beyond the power plant site would be minor in terms of both time and range.

Situations that would result in a release of any significant amounts of radioactive products into the environment have been virtually eliminated.

The integrity of the reactor containment building in case of a core meltdown is ensured with structures that retard the progression of core melt and a passive core melt cooling system. At the bottom of the containment, there is a core melt spreading area consisting of a metal structure (core catcher) covered with a 10 cm layer of sacrificial concrete. The purpose of the catcher is to cool the core melt and to protect the base slab of the reactor building against damage that might lead to leaks. Water circulates in cooling channels under the core melt spreading area, and water will also rise above the core melt. The large area of the core catcher (170 m^2) ensures cooling of the core melt.

If the reactor pressure vessel fails, the core melt is collected at the bottom of the reactor pit. The transfer of core melt from the reactor pit into the spreading area is initiated as a passive event, with the hot core melt forcing its way through the aluminium plug into the core catcher. The 50 cm layer of sacrificial concrete over the aluminium plug melts into the core melt, delaying the failure of the plug until all the core melt has accumulated in the reactor pit under the pressure vessel.

As the core melt enters the spreading area, the cooling system is passively activated. The sacrificial concrete over the core catcher melts into the core melt. Cooling continues as a passive process with water from a tank inside the reactor containment, flowing down by gravity into the channels under the core catcher and onto the core melt.

The efficiency of the cooling system is sufficient to solidify the core melt within a few days, after which the post-accident long-term management can begin.

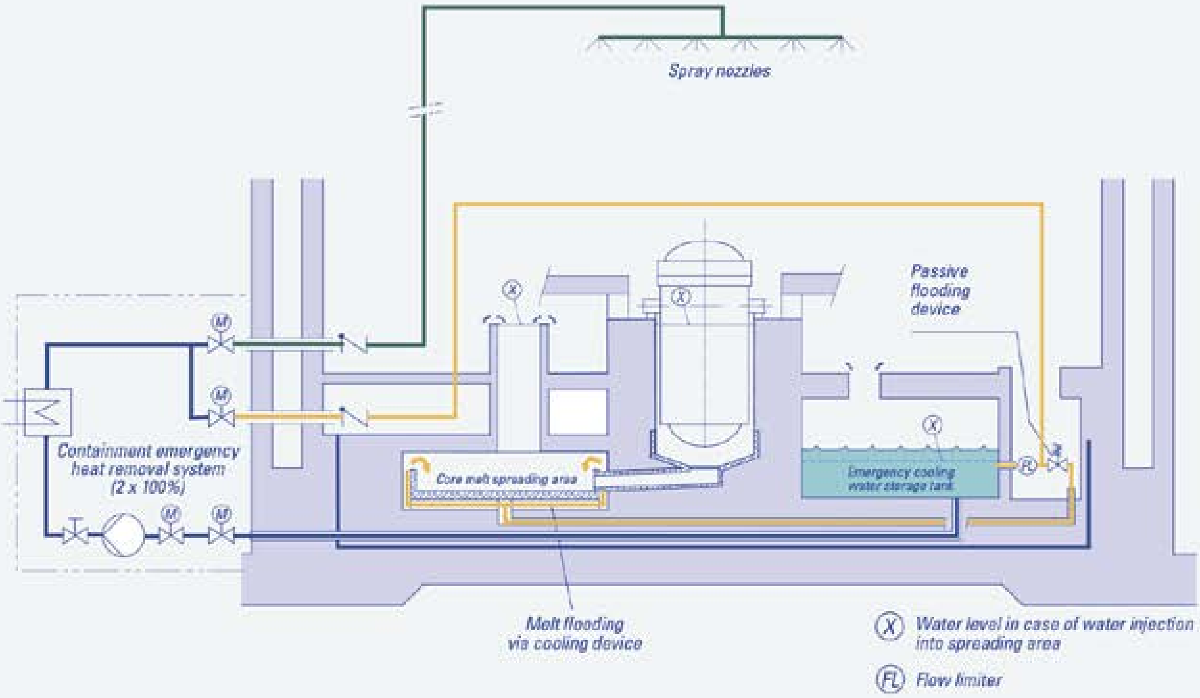
Emergency cooling water storage tank

Core melt spreading area

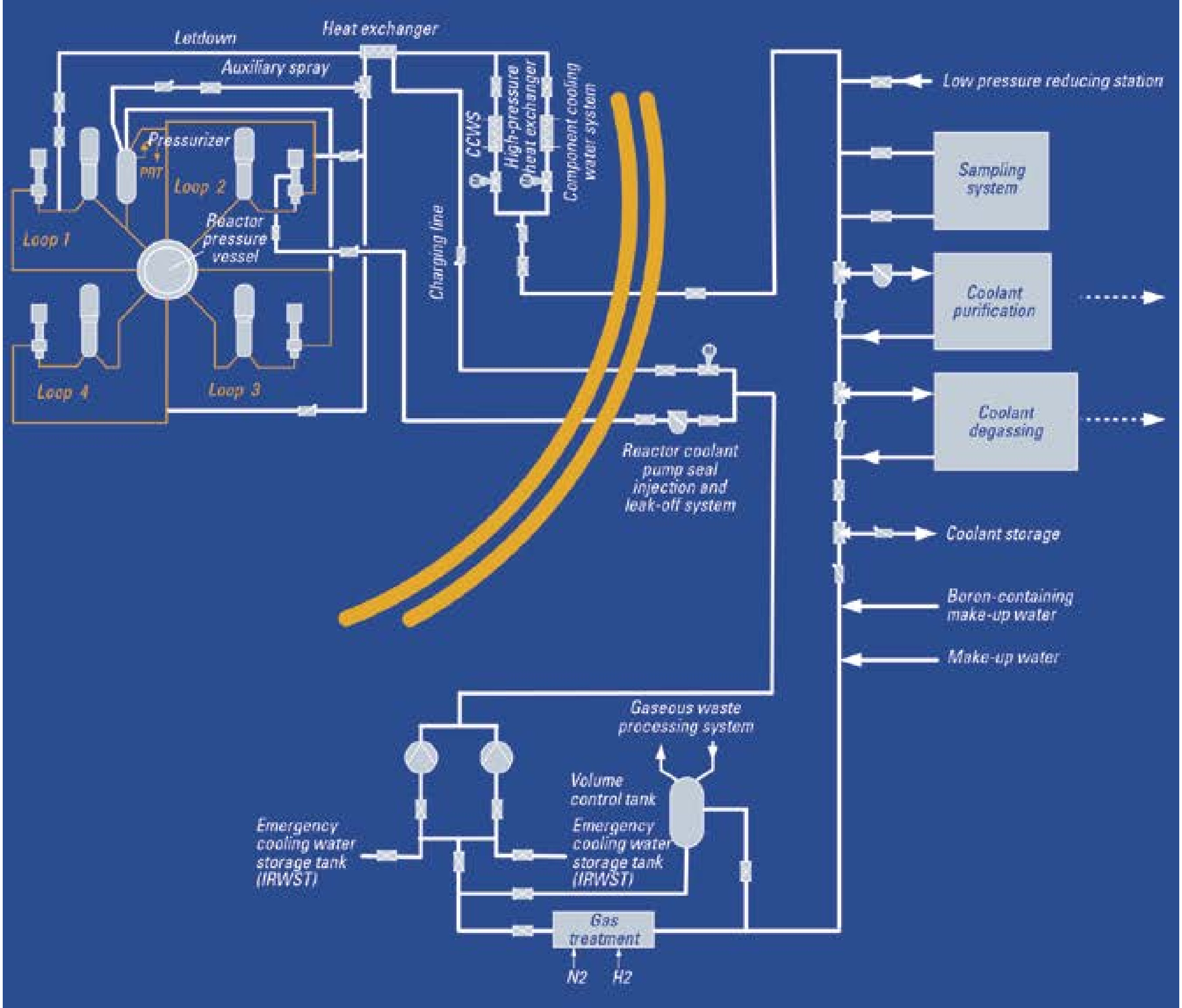
Source: AREVA

Core melt cooling system

In the highly unlikely event of a core meltdown at OL3, the core melt is transferred to the core melt spreading area, where it is cooled and solidified.



Coolant handling system



WATER CHEMISTRY AND VOLUME CONTROL SYSTEMS

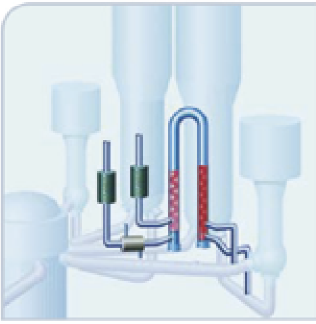
OL3 has a total of about 120 process systems for handling liquid, steam and gas flows. The chemical and volume control system of the reactor plant is an essential one, acting as an interface between the high-pressure primary circuit and the low-pressure systems.

The coolant treatment systems manage the boron content in the primary circuit coolant, water chemistry, purification of the circulating coolant, injection and control of chemicals, dissolved gases in the coolant; and the degassing, handling and storage of extracted coolant in various situations. The systems are also used for preparing, storing and injecting the boron solution needed for various systems in the plant. During outages, the systems ensure the availability of make-up water needed in the draining and refilling of the primary circuit.

The most important of the coolant treatment systems is the chemical and volume control system, which is directly connected to the regulation of the chemical and physical properties of the coolant in the primary circuit, e.g. its boron content and volume.

The chemical and volume control system also manages the reactor coolant pump seal injection and leak-off. The volume control system inlet line is also the source of coolant for the pressurizer auxiliary spray system, which helps lower pressure in the pressurizer.

Boron is used in OL3 in the form of boric acid dissolved in water. The boron content of the primary circuit coolant is regulated by adding either pure water or boric acid solution to the coolant fed into the circuit, as required. The volume of the coolant added to and extracted from the primary circuit must be consistent with the running situation.



The boron content of the make-up water added to the primary circuit is monitored with double continuous-action measurement devices that control the automatic safety function.

Boron and make-up water system

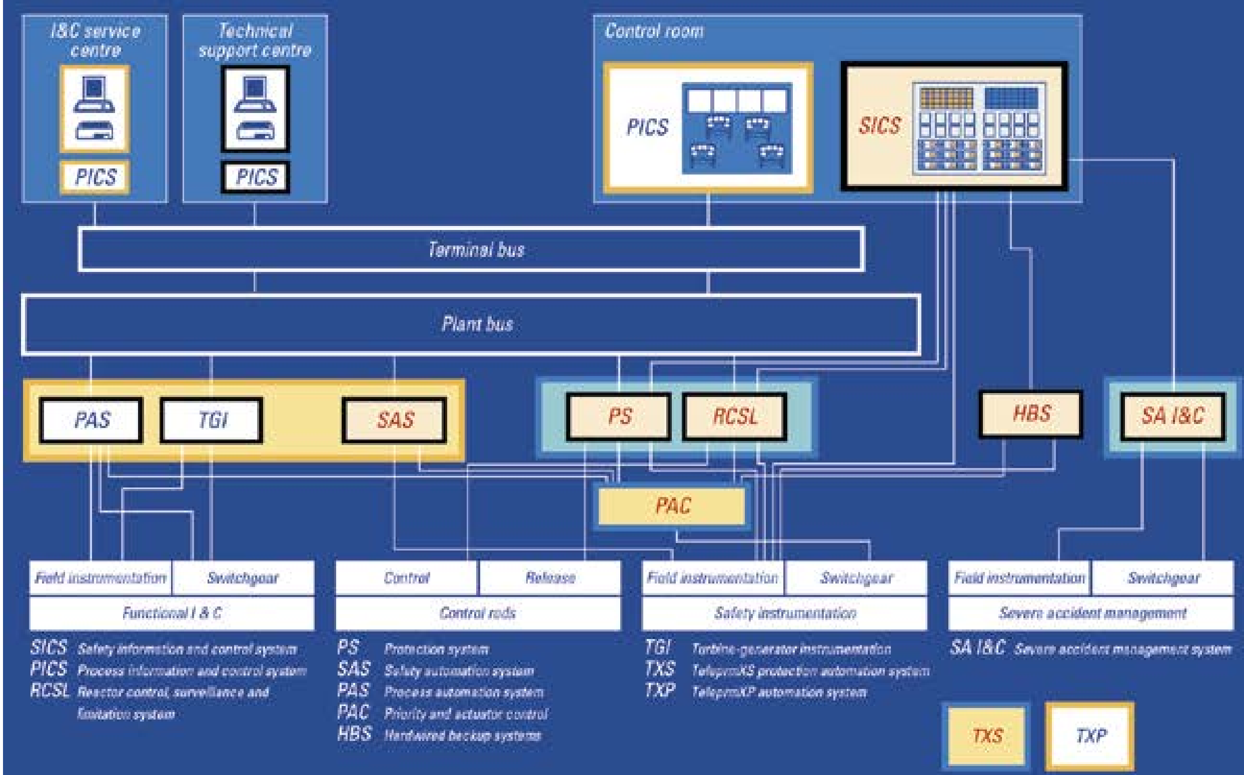
The boron in the coolant is enriched with regard to one of its two natural isotopes (^{10}B, ca. 30–32% by weight). Its purpose is to compensate for residual reactivity in the reactor core. The boric acid solution is stored at a concentration of 4%, which corresponds to about 7,000 ppm of boron. All the solutions required for the plant systems are made from this storage solution, using pure ion-exchanged water for diluting.

Controlling core reactivity

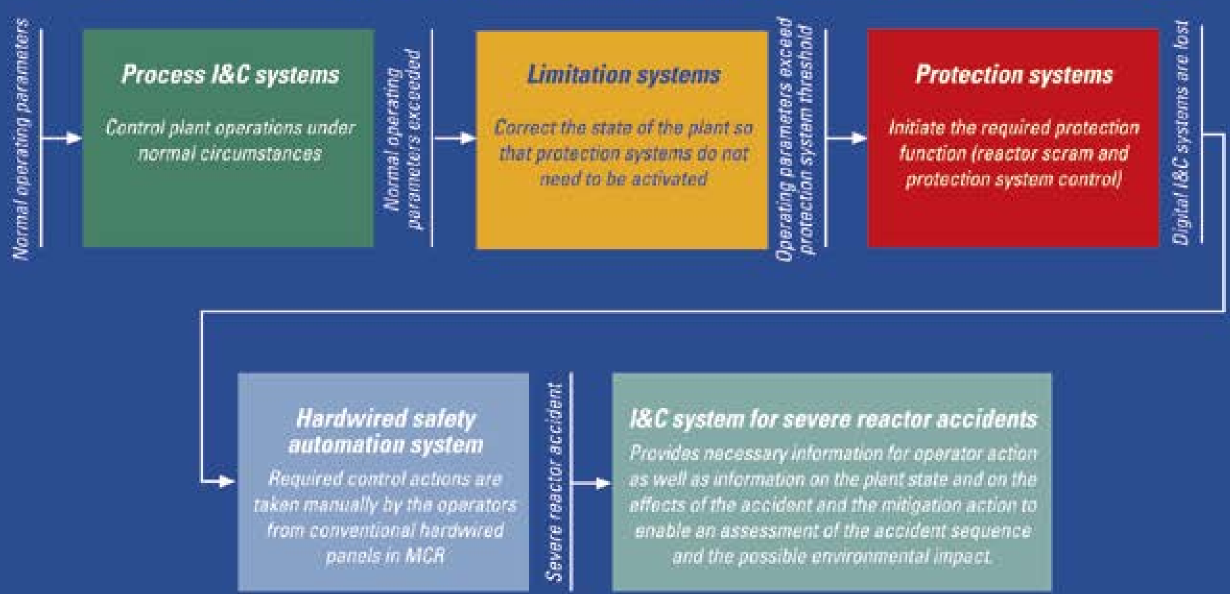
Core reactivity is at its highest at the beginning of the refuelling interval because of the fresh fuel. When fresh fuel is loaded into the core, all control rod assemblies are inserted, and the primary circuit, the reactor pool and the transfer pool are filled with a boron solution whose concentration is about 1,550 ppm. The boron injection system is always used when the reactor is powered down to a cold shut-down, so as to ensure the sub-critical state of the reactor regardless of its temperature. When the reactor is powered up, the control rod assemblies are first retracted, after which the boron level rod in the primary circuit is decreased by diluting until the critical level is reached. The boron level maintained during use is always less than 1,200 ppm.

Slow changes in power output over the long term and the decline in the neutron flux due to fuel discharge burnup are compensated for by lowering the boron level gradually until it reaches a level of about 5 ppm just before refuelling.

Instrumentation & control systems architecture



Functional levels of Instrumentation & control system according to the safety concept



INSTRUMENTATION AND CONTROL SYSTEMS

Instrumentation and control (I&C) systems consist of field instrumentation, control systems as well as I&C user interfaces used for the monitoring and control of the plant.

Safety and availability have been emphasised in the design of I&C systems for OL3. The I&C systems of the plant unit are fully automated using proven digital technology, backed up by conventional hardwired technology.

Design bases

The functions and equipment of the I&C systems, just like all other systems, are classified according to their nuclear safety significance. The equipment used to implement the I&C systems fulfil the quality requirements based on the respective safety classification. The OL3 I&C systems and the associated functions and equipment are designed to comply with the general principles of nuclear safety, including physical and functional separation, diversity and redundancy. For example, the emergency cooling system and the emergency feedwater system, each consisting of four redundant and independent subsystems, also have four redundant and independent control system subsystems.

According to the design basis of the plant, the protection I&C shall be capable of responding to transients and accidents for the first thirty minutes without operator intervention. This gives the operators time to establish the cause of the transient and to investigate the required transient and emergency procedures. The monitoring and control of the plant is implemented using the workstation-based user interface in the main control room. Each operator has a specific work area in the main control room, with several display screens, which present the information on the basis of which the operators carry out the actions required for the control and monitoring of the plant. A conventional hardwired panel is provided for use as backup in case of the workstation-based user interface is not available. The unit can be brought to a safe shutdown state in a controlled manner also from a remote shutdown station, if necessary.

Architecture

The I&C architecture is designed to follow the defence-in-depth principle. The following functional levels have been defined to ensure safety:

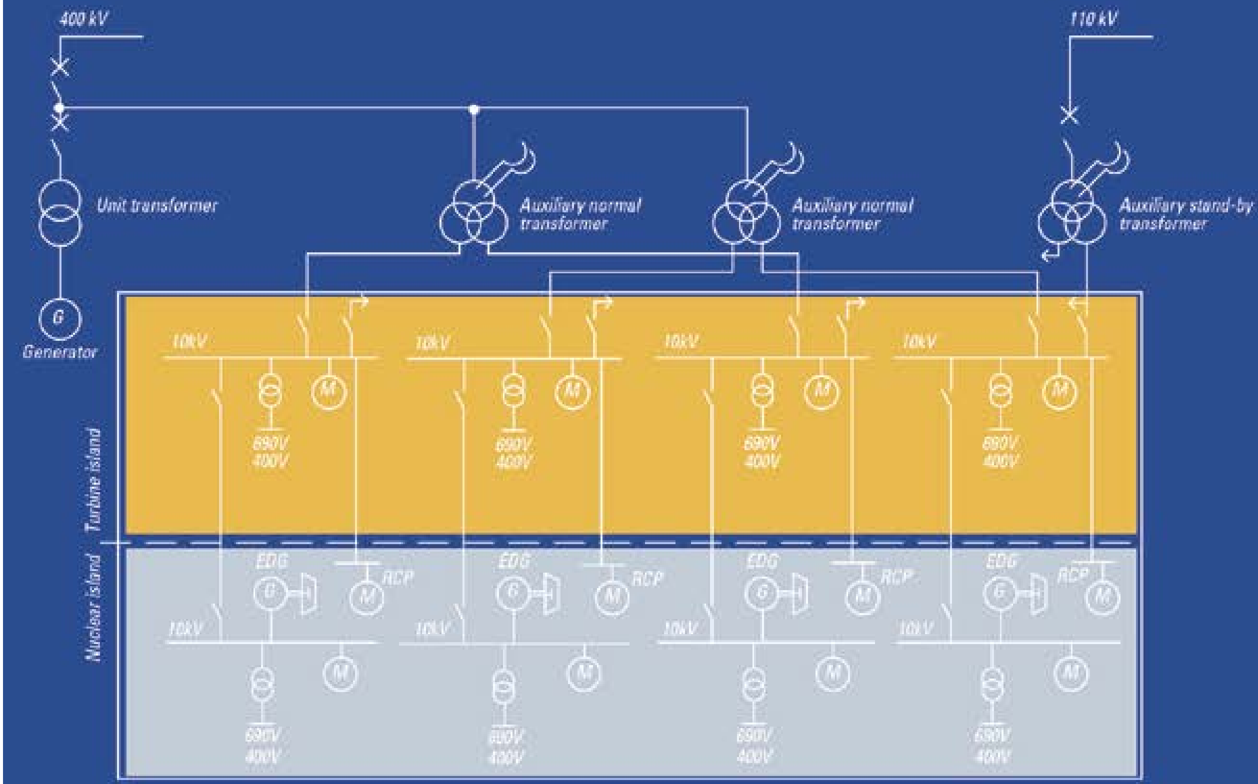
1. The process I&C systems, which maintain the state of the plant unit within normal operating parameters.
2. Limitation systems, which take corrective action to restore normal operation if normal operating parameters are exceeded.
3. The reactor protection system, which automatically initiates the required safety functions (reactor scram and any situation-specific action required), if the plant or process parameters exceed any of the protection system limit values.
4. The hardwired safety automation system, which is independent of the other I&C systems and can be used if the digital I&C systems are lost.
5. The severe accident management system, which is independent of the other I&C systems and used for the severe accident management.

I&C system functions

All the subsystems of the I&C system (measurements, controls, instrumentation, user interface) are divided into different levels by functions:

- Level 0 (process instrumentation or process interface) consists of e.g. sensors and switches.
- Level 1 (I&C system level) consists of control loops involved in reactor protection, reactor control, surveillance and limitation functions, safety and process automation.
- Level 2 (process monitoring and control) consists of the user interfaces, i.e. the workstations, the control panels in the main control room, the remote shutdown station and the technical support centre. Level 2 also comprises the I&C systems, which link user interfaces to system-level I&C.

Simplified schematic of the Olkiluoto 3 power plant unit



ELECTRICAL POWER SYSTEMS

The electrical power systems have two purposes: to transfer the electricity generated into the external grid and to supply and distribute the electricity needed by the power plant itself. The former function involves the generator busbar, the main transformer and the 400 kV switchyard and power line. The latter function involves the auxiliary unit transformers, medium-voltage switchgear, diesel generators and low-voltage distribution network.

The generator busbars between the generator and the main transformer are independent, single-phase busbars with earthed metal cladding. The main transformer consists of three single-phase units. The transformer is cooled with oil running through the coils, which is cooled by a separate, external water-cooling circuit.

400 kV power line isolator chain.

The electricity needed by the power plant itself is taken from the 400 kV grid through two auxiliary unit transformers, which are backed up by an auxiliary stand-by transformer connected to the 110 kV grid. These two power supplies are independent of one another.

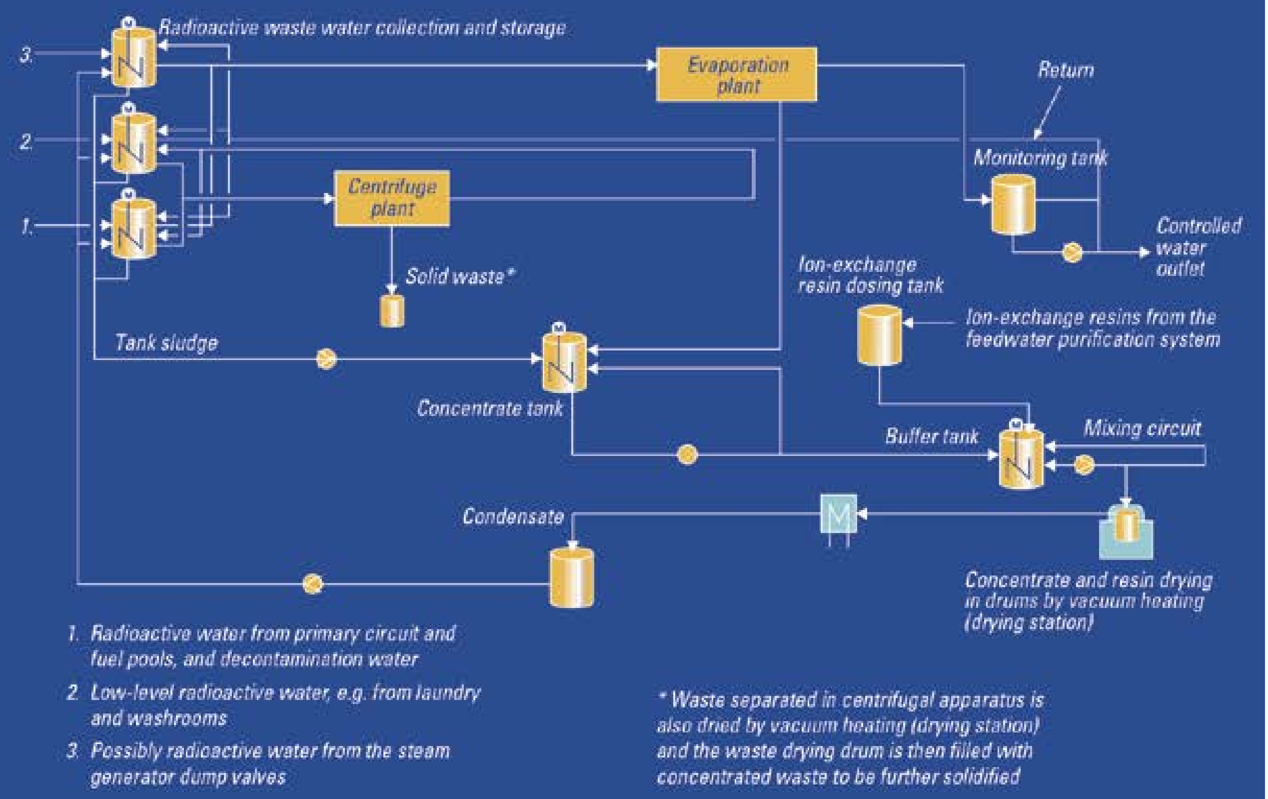
The reactor plant electrical power system is divided into four parallel and physically separated sub-divisions. The power supply to equipment critical for the safety of each division is backed up with a 7.8 MVA diesel generator. The busbars of the diesel generators can also be supplied by the Olkiluoto gas turbine plant.

The systems are designed to ensure sufficient capacity for maintaining nuclear safety even if one division fails and another is simultaneously out of operation due to maintenance.

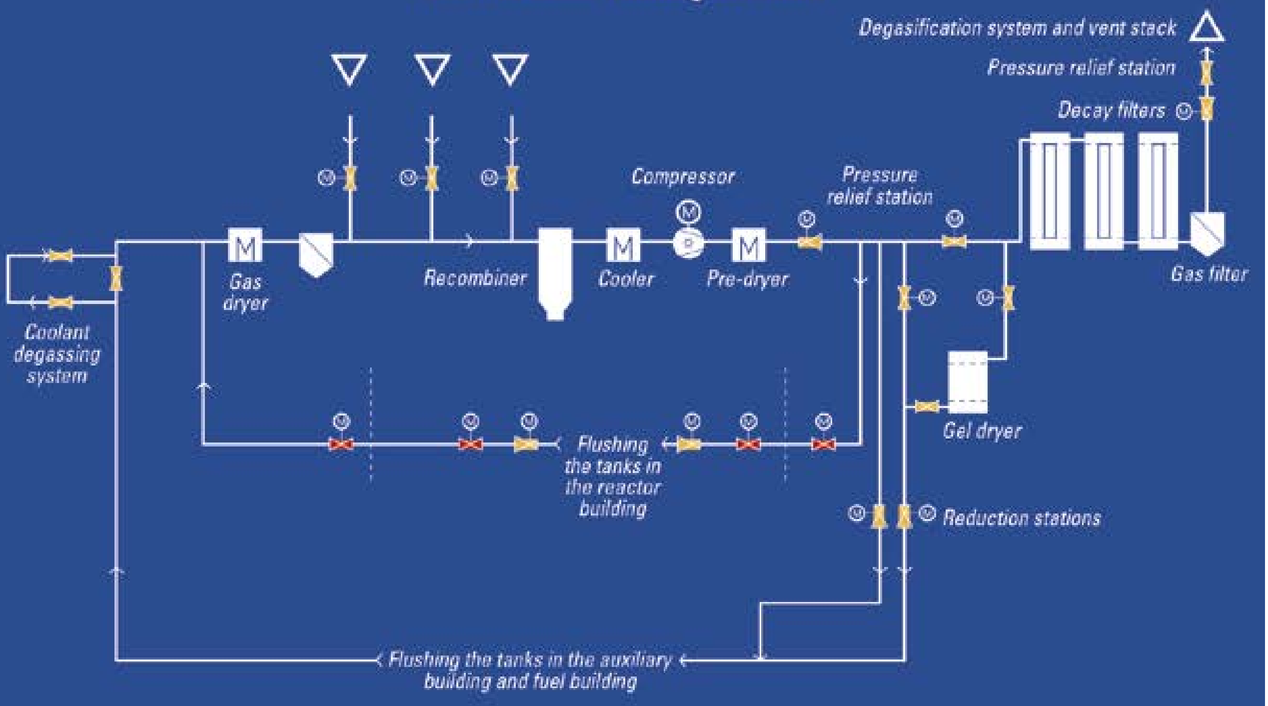
Safety-critical systems are connected to backed-up electrical power systems. These are systems that ensure safe reactor shutdown and residual heat removal and prevent the spreading of radioactivity.

In case of the loss of all external power supplies, the malfunction of all four diesel generators at once, i.e. the complete loss of all AC power, the plant unit has two smaller diesel generators with an output of approximately 3 MVA each. These ensure power supply to safety-critical systems even in such a highly exceptional situation.

Discharge of clean water



Gaseous waste handling schematic



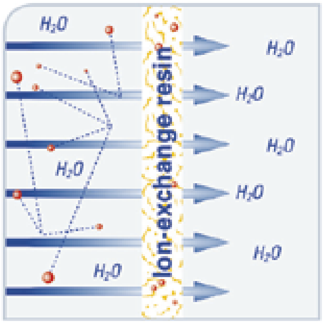
WASTE PROCESSING SYSTEMS

Radioactive waste is classified on the basis of its radioactivity and physical and chemical properties. Each type of waste is processed appropriately. High-level radioactive waste is kept separate from low-level radioactive waste at all times, and there are separate processing lines for different types of solid, liquid and gaseous waste.

Solid operating waste

Solid operating waste is divided into low-level waste and intermediate-level waste. No solid waste classified as intermediate-level waste requiring final disposal is produced, in substance, at the OL3 unit.

Low-level waste comprises materials and substances contaminated with radioactivity. Such material includes fire-resistant fabrics, plastic covers, protective clothing, and low-active components, such as seals, removed from the systems. Low-active waste is divided into the following groups; mixed maintenance waste, scrap metal, waste dried in a barrel, filter elements, filter inserts and solidified mixed liquids.



Impurities in the coolant are bound into the ion-exchange resins by a chemical reaction and thus removed from the circuit.

Processing of mixed maintenance waste and scrap metal

So-called small items representing low-level waste are collected at the point where they are produced either into plastic bags or directly into 200-litre steel barrels and transported to the sorting facility for sorting according to their activity content and type. Waste collected into bags is later packed in barrels. The compactable waste packed in barrels is compacted to a smaller volume in the barrels and some of the barrels are also compressed to half of the original size in vertical direction. Large items are packed either in steel boxes or directly in concrete boxes, and the barrels are also placed in concrete boxes before they are emplaced in the operating waste repository for final disposal. Mixed maintenance waste is very low-level waste as a rule.

Processing of filter elements and waste dried in barrels

Waste dried in barrels primarily consists of evaporator concentrates, tank bottom sludge, ion exchange resin and filter elements used in the purification of process water. Waste of this type is first stored in tanks and then mixed in a drying process.

The ion exchange resins, evaporator concentrates and other sludges are after tank storage dried in the barrel drying facility provided in the waste processing building of OL3. A filter element can be placed in the barrel before the drying is started. The filter element will then become enclosed in the drying material. The waste to be dried is placed in a 200-litre barrel and dried through heating in a vacuum, until 90% of the waste is dry. Heating is continued at a temperature of ca. 130°C until all water has evaporated. The condensed water is returned to the liquid waste processing system.

The initial activity level of the waste and filter elements dried in barrels can be equal to intermediate-level waste. These waste groups are first stored inside the OL3 unit, before they are transferred to TVO's interim storage for intermediate-level waste, where the waste is kept until Co-60, which is the primary (>90%) nuclide making the waste radioactive, has undergone 5–10 half-lives. After that the waste can be emplaced for final disposal in the operating waste repository like other low-level waste.

Processing of solidified mixed waste

Solidified mixed waste includes e.g. different waste oils contaminated with activity. The activity of the waste oil is measured and the oil is placed in 200-litre barrels for solidification in the system already used for waste generated at OL1 and OL2.

Final disposal

The solid operating waste produced at OL3 is placed in concrete boxes and transferred for final disposal to the operating waste repository located in Olkiluoto. The repository is also used for final disposal of operating waste generated at OL1 and OL2. Accurate records are maintained of all solid waste emplaced in the repository (activity data and location in the repository).

Liquid waste

All water removed from the unit is collected from the liquid waste collection and processing systems into inspection tanks where samples are taken for activity measurements and chemical analyses. When an acceptable inspection result is obtained, separate permission is issued to discharge the water from the unit.

Offgases are delayed, filtered and conveyed from the plant into the atmosphere through a 100-metre-high ventilation stack.

Gaseous waste

Gaseous radioactive waste mostly consists of fission gases released from the nuclear fuel and dissolved in the primary coolant and in the airspace of the tanks of the associated auxiliary systems. These fission gases include e.g. noble gases Krypton and Xenon. The concentrations of the fission gases, the hydrogen added to create the chemical conditions required by the reactor coolant, and other dissolved gases are controlled in the degasifier, which is included in the chemical and volume control system of the primary circuit. If necessary, the gases dissolved in the coolant can be removed completely. The amount of fission gases in the coolant is proportional to the integrity of the fuel. Light water reactors also produce gaseous waste, when neutron radiation activates the natural Argon contained in air and present in the airspace that surrounds the structures of the reactor pressure vessel. A residual concentration of Argon can also be dissolved in the primary coolant. Argon-41 is a short-lived isotope with a half-life of less than two hours.

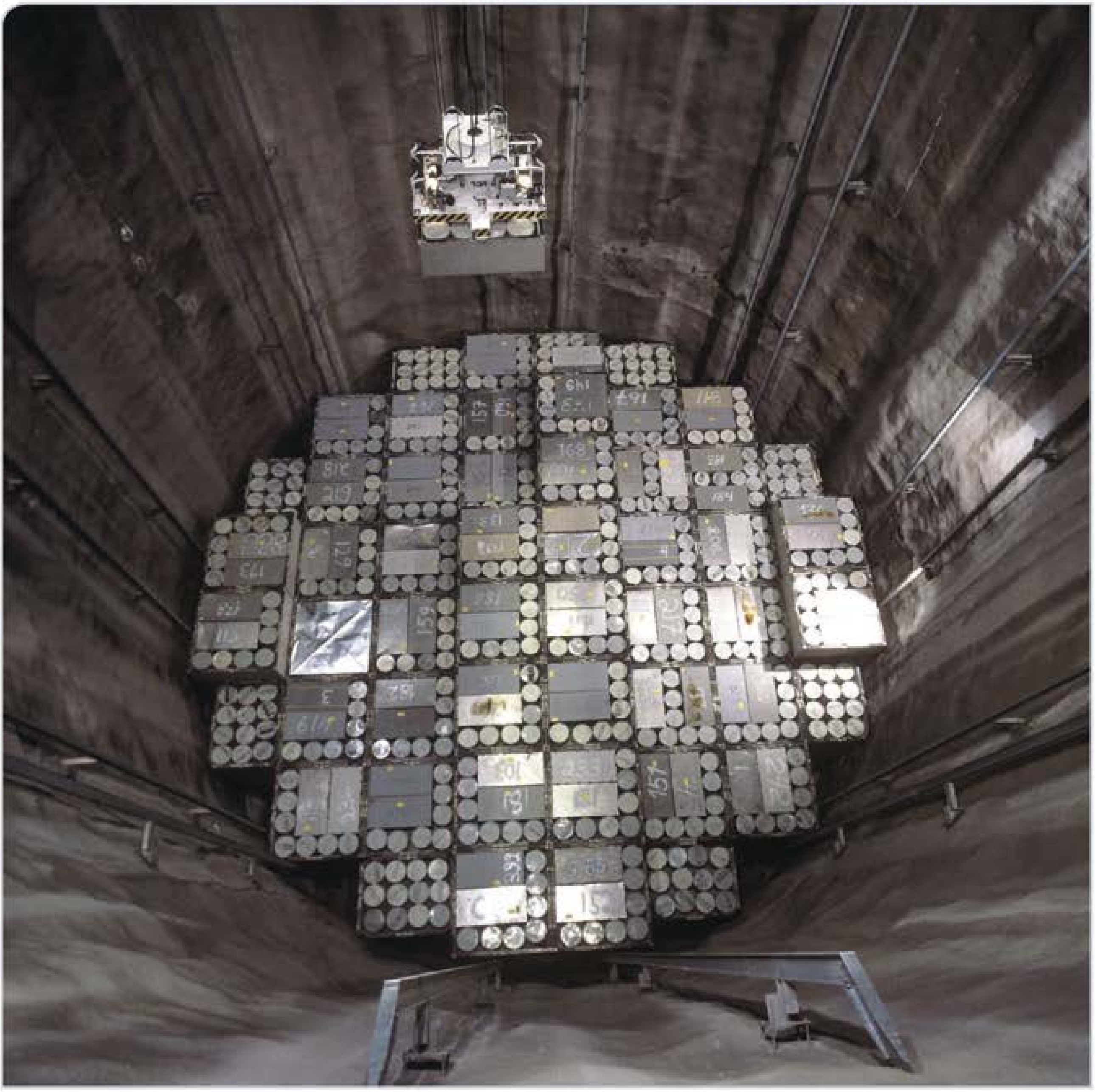
In order to minimize gas emissions, a gaseous waste processing system based on a semi-enclosed circuit has been selected. It consists of two parts: the flushing unit and the delay unit. The flushing unit is designed to receive gas from the degasifier and the coolant storage tanks, to reduce the hydrogen concentration of these gases catalytically by converting hydrogen gas into water, and to flush with inert nitrogen gas various storage tanks where waste gases may accumulate. The pressurised active carbon filters of the delay unit are designed to retain radioactive noble gases (Xenon, Krypton) so as to reduce their radioactivity to an acceptable level before the gases are released. From the delay unit the gases are released for further processing into a ventilation system equipped with separate filters. Plant start-up and shut-down, process actions and events such as nitrogen flushing of the reactor pressure vessel head can cause a substantial gas flow to the gaseous waste processing system.

The overflow is in this case conveyed through the active carbon filter units of the delay unit in the pressurised part of the system and further through the mechanical coarse and micro filters to the vent stack. The activity level of the gas flow is analysed in the ventilation system and if an excessive activity level is detected, the gas flow is diverted after the mechanical filters further to an iodine-treated active carbon filter system. The mechanical filters of the ventilation system retain any active aerosols and other small particles possibly contained in the waste air. The iodine-treated active carbon filters of the same system bind any radioactive iodine possibly introduced into the waste gas as a result of e.g. severe fuel damage.

The systems involved in the processing of waste gases are designed to either completely retain or delay the radioactive materials contained in the gas flow until their activity has been reduced to an acceptable level. The activity of all gases released from the plant is finally monitored with continuously operating activity measurements in the vent stack.

Some of the solid plant waste is packed into 200-litre drums.

A special vehicle takes the waste packages to the Olkiluoto disposal repository.



TRAINING SIMULATOR

Part of the OL3 power plant supply to TVO will include a full-scope training simulator, which will be completed and ready for use one year before the first fuel loading of the power plant unit. The simulator can replicate exactly the functions of the new unit, and the simulator control room is a full-scale replica of the real one. The simulator will mainly be used for operator training before the power plant unit is started up, and subsequently for annual supplementary training.

Simulator control room being tested in the manufacturer's facilities.

The purpose of the training simulator is for personnel to practise all possible events that may occur at the power plant unit, including transients and accidents, and to validate operation, abnormal operation and emergency operation procedures.

The plant supplier is responsible for designing and building the simulator together with several well-known suppliers in the field. The simulator and its auxiliary facilities will be housed in a new annexe to be built at the existing TVO training centre.

3D process models are utilized in training the nuclear power plant operators.

Technical data

General

Reactor thermal power	4,300 MWth
Electrical power, gross	1,720 MWe
Electrical power, net	1,600 MWe
Efficiency	ca. 37%
Primary coolant flow	23,135 kg/s
Reactor operating pressure	155 bar_{abs}
Coolant temperature in the reactor pressure vessel, average	312°C
Coolant temperature in the hot leg	328°C
Coolant temperature in the cold leg	296°C
Electricity output per year	ca. 13 TWh
Sea water flow	57 m^3/s
Service life	ca. 60 years
Building volume	1,000,000 m^3
Containment volume	80,000 m^3
Containment design pressure	5.3 bar

Reactor core

Number of fuel assemblies	241
Active core height	4.2 m
Core diameter	3.77 m
Total fuel weight	ca. 128 tU
Fuel enrichment level, initial core loading	1.9%—3.3% ^{235}U
Fuel enrichment level, reloading	1.9%—4.9% ^{235}U
Fuel consumption per year	ca. 32 tU
Fuel consumption per year	ca. 60 assemblies

Fuel

Fuel	uranium dioxide UO_2
Assembly type	17x17 HTP
Fuel rods per assembly	265
Guide thimbles per assembly	24
Spacer grids per assembly	10
Length of fuel assembly	4.8 m
Weight of fuel assembly	735 kg
Width of fuel assembly	213.5 mm
Cladding material	M5™
UO_2 pellet density	10.45 g/cm^3
Fuel discharge burnup	45 MWd/kgU

Control assemblies

Number of control assemblies	89
Absorber length:	
lower part	2,900 mm
upper part	1,340 mm
total length	4,717.5 mm
Absorber material	
lower part	silver, indium, cadmium
upper part	boron carbide

Pressure vessel

Inner diameter	4.9 m
Inner height	12.3 m
Wall thickness	250 mm
Bottom thickness	145 mm
Thickness of stainless steel cladding	7.5 mm
Design pressure	176 bar
Design temperature	351°C
Weight with cover	526 t

Turbine plant

Turbine generator unit	1
Gross electrical output	ca. 1,720 MW
Main steam pressure	75.5 bar
Steam temperature	290°C
Steam flow	2,443 kg/s
Rated speed	1,500 r.p.m.
HP turbine	1
LP turbine	3
HP turbine stop and control valves	4/4
LP turbine stop and control valves	6/6
Last stage	
– exit annulus area	30 m²
– blade length	1,830 mm
– overall diameter	6,720 mm
Turbine-generator shaft length	68 m

Condenser

Cooling surface	110,000 m²
Cooling medium	sea water
Sea water flow	53 m³/s
Vacuum at full load	24.7 mbar
Temperature rise	12°C

Feedwater

Preheating stages	7
Final feedwater temperature	230°C

Generator

Nominal rating	1,992 MVA
Power factor, nominal	0.9
Rated voltage	27 kV ± 5%
Frequency	50 Hz
Rated speed	1,500 r.p.m.
Cooling, stator coils	water
Cooling, rotor	hydrogen
Magnetization current	9,471 A
Cooling water temperature	45°C
Hydrogen cooling medium temperature	40°C

Power supply

Main transformer	3 x 1-phase
Nominal rating	3 x 701 MVA
Rated voltage	410/27 kV
Auxiliary unit transformers	2
Nominal rating	90/45/45 MVA
Rated voltage	400/10.5 kV
Auxiliary standby transformer	1
Nominal rating	100/50/50 MVA
Rated voltage	110/10.5 kV
Emergency power supply	4 x EDG and 2 x SBO
Nominal ratings	4 x 7.8 MVA and 2 x 3.0 MVA
Turbine plant diesel engine	1
Nominal rating	1.6 MVA

APPENDIX 6

A DESCRIPTION OF

THE SAFETY PRINCIPLES THAT HAVE BEEN OBSERVED, AND AN EVALUATION OF THE FULFILMENT OF THE PRINCIPLES

INDEX

APPENDIX 6A

MEETING THE REQUIREMENTS

OF THE RADIATION AND NUCLEAR SAFETY AUTHORITY'S REGULATION CONCERNING THE SAFETY OF NUCLEAR POWER PLANTS

1. Introduction

This document presents a summary of how the requirements of the Radiation and Nuclear Safety Authority's regulation concerning the safety of a nuclear power plant, (STUK Y/1/2016, 1st January 2016), are met at the plant unit Olkiluoto 3. The document also analyses the meeting of the requirements related to limiting values that have been moved to the Nuclear Energy Decree (Section 22 b).

In the document, the text of the decree is written in italics, while a normal typeface is used to describe how a specific requirement is met.

This report has been drawn up as part of the operating licence application for the Olkiluoto 3 plant unit. The report is based on the Final Safety Analysis Report (FSAR) for the plant unit.

A similar safety assessment was performed for Appendix 8 of the construction licence application on the basis of Government Decision 395/91 concerning the safety of nuclear power plants. At this time, the assessment was based on the preliminary safety analysis report.

2. General safety

2.1 Section 3 Demonstration of compliance with safety requirements

1. The safety of a nuclear power plant shall be assessed when applying for a construction licence and operating licence, in connection with plant modifications, and when the periodic safety assessments are being carried out during the operation of the plant. In connection with the safety assessment, it shall be demonstrated that the nuclear power plant has been designed and implemented in a way that meets the safety requirements. The safety assessment shall cover the operational states and accidents of the power plant. The safety of a nuclear power plant shall also be assessed after an accident has taken place and, where necessary, based on the results of safety studies.

2. Nuclear power plant safety and the technical solutions of its safety systems shall be assessed and substantiated analytically and, if necessary, experimentally.

3. The analyses shall be maintained and revised if necessary, taking into account the operational experience gained from the plant in question and other nuclear power plants, the results of safety studies, plant modifications and developments in calculation methods.

The technical decisions of the plant unit have been justified by means of extensive disturbance and accident analyses where the behaviour of the plant unit has been demonstrated to correspond to the design basis and safety criteria. The methodology of the disturbance and accident analyses, the performed analyses themselves and the calculation software used and the main results of the analyses are described in the final safety analysis report (FSAR).

The design bases for the plant unit's mechanical systems and equipment are discussed in the general section of the FSAR. The load specifications form an essential part of the design bases. These specifications have been used to perform the structural dimensioning of systems and equipment, strength analyses being an essential part thereof. As regards primary circuit equipment, the summary of the strength analyses is presented in the topical report of the FSAR.

The failure mode and effects analyses have been drawn up as dedicated documents for some of the plant unit's systems as part of the system design, and these analyses are used in connection with the probabilistic risk analysis (PRA) in order to support and document the modelling. The FSAR contains a summary of the level 1 and level 2 PRAs and refers to the PRA document that is maintained as a dedicated documentation complex. The topical report demonstrates the adequacy of the principle of diversity by using a so-called deterministic common cause failure analysis. Several analyses have been drawn up during the I&C system design in order to demonstrate failure tolerance according to the failure analysis concept. The prepared analyses include failure mode and effect analyses, common cause failure analyses (including unintended operation), interface analyses, DID analyses and quantitative reliability analyses.

The design bases concerning internal and external threats are presented in the FSAR. The PRA contains the internal and external threat analyses.

These analyses will be updated in accordance with the instructions in the safety manual.

The utilisation of operating experience and safety studies during the design of the plant has been described in connection with Section 21.

The above requirements from the Radiation and Nuclear Safety Authority's regulation are met.

4. The analytical methods employed to demonstrate compliance with the safety requirements shall be reliable, verified and qualified for the purpose. Analyses shall demonstrate that the safety requirements are met with a high degree of certainty. Any uncertainty in the results shall be considered when assessing the meeting of the safety requirements.

The calculation software used in the deterministic disturbance and accident analyses performed for the operating licence has been described in the appendix to the FSAR. It also presents detailed descriptions of the physical models used by the software.

The selection of the used models and the choice of calculation parameters have been justified in the FSAR's methodology reports. They present the methods for choosing the range of variation for the variables affecting the outcome of the analyses in a manner that ensures their conservative effect on the final result.

The dimensioning of the functional values and capacity for safety systems is based on the analysis of design basis accidents. These analyses apply conservative initial assumptions in accordance with the YVL Guides provided by the Radiation and Nuclear Safety Authority in order to ensure that the final results are conservative. In practice, this means that the range of variation for each variable is chosen in a manner that has the most detrimental effect on the final result. If it is not entirely clear how the range of variation for a specific variable should be selected in order to ensure a conservative final results, the FSAR methodology reports present sensitivity analyses concerning the matter. As regards the operation of the safety systems, the analyses have applied a minimum capacity in accordance with the postulated failures in the YVL Guides.

In contrast to the FSAR analyses, the success criteria analyses in connection with the PRA are mainly based on a "best estimate" type of approach, i.e. the goal is to use realistic safety system capacity requirements per initiating event. The success criteria analyses drawn up to support the PRA are presented in the appendix to the PRA.

Strength analyses have been compiled using both commercial software and dedicated software that the plant supplier has developed as a result of years of work. As regards commercial software, their sufficient qualification on the part of the author and their correct commissioning has been verified. The software developed by the plant supplier has been reviewed during calculation audits, and a sufficient amount of validation reports have been received concerning them to demonstrate that they perform their tasks correctly. Furthermore, the correspondence of the models within the calculation software to the physical problem in sufficient detail has been confirmed by means of comparison calculations or experiential results.

The safety cases will be reviewed according to the operating licence conditions, YVL Guides and STUK's separate decisions during the renewal of the operating licence and the periodic safety assessments.

The requirements concerning safety assessment, analyses and calculation methods in Section 3 of the Radiation and Nuclear Safety Authority's regulation are met.

2.2 Section 4 Safety classification

1. The safety functions of a nuclear power plant shall be defined and the systems, structures and components that implement them and relate to them shall be classified on the basis of their safety significance.

The safety classifications for systems, structures and components are presented in the classification document. The classification for each system is presented separately for mechanical equipment, I&C equipment and electrical equipment. Furthermore, a safety class has been defined for each system as a whole. For systems and classified equipment groups in safety classes 1–3, the functions that the system or equipment group participate in or that define their safety class have been defined. The safety class for each component is determined by the function with the highest safety class that the device participates in. Therefore, the safety classification is entirely functional in nature. As such, the mechanical equipment in safety class 1, which is the most demanding, have been considered to participate in the function "retaining primary circuit pressure".

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

2. The actions taken on systems, structures and components that implement safety functions or are related to them in order to ascertain the requirements set for them and their compliance must be commensurate with the safety class of the location..

The scope and precision of TVO's assessment, inspection and testing are specifically defined by the safety class of the systems and components involved. The same also applies to the pre-inspection activities and supervision exercised by STUK. The inspections are used to determine that the design and manufacturing processes of the plant supplier and its subcontractors and the routines observed in the installation work are commensurate with the safety significance of the systems, structures and components in question.

The classification document also defines the quality class and seismic classification of the equipment and their aircraft crash tolerance requirement. The safety significance of the equipment determines the quality requirements to be applied. Separate tolerance requirements for ambient conditions have been defined for electrical equipment located inside the reactor building, safeguards buildings and fuel buildings as well as in specific separate rooms. The qualification of the equipment has been used to demonstrate that the equipment can operate reliably under the intended conditions throughout its entire planned service life. The qualification included artificial ageing of the equipment as regards temperature and radiation before the equipment was exposed to actual accident conditions.

The requirements of Section 4 of the Radiation and Nuclear Safety Authority's regulation are met.

2.3 Section 5 Ageing management

1. The design, construction, operation, condition monitoring and maintenance of a nuclear power plant shall include provision for the ageing of systems, structures and components that are important to safety, in order to ensure that they meet the requirements on which design is based throughout the entire service life of the plant, with the necessary safety margins.

2. There shall be systematic procedures in place for the prevention of ageing that weakens the operability of systems, structures and components and for the early identification of their need to be repaired, modified or replaced. To ensure that the technology used is up-to-date, safety requirements and the suitability of new technology shall be regularly assessed and the availability of spare parts and support functions monitored.

Plant unit ageing management is one of the focus areas of the organisation units within the fields of electricity generation, technical services and safety. The aim is to keep the plant units continuously up to date and in good condition in terms of both safety and production capacity.

The ageing management of the Olkiluoto 3 plant unit is integrated into the ageing management programme of the OL1/2 plant units and the KPA storage, which in turn has been drawn up in accordance with the requirements of the relevant YVL Guide. The ageing management programme will be supplemented with plant component specific information before the plant enters commercial operation. The final safety analysis report's topical report on ageing is one of the reference documents for OL3's ageing management programme.

The ageing management procedures and responsibilities at the Olkiluoto nuclear power plant have been defined in the organisation manual and in TVO's procedure titled "Plant unit lifetime management at TVO". Ageing management is included in the tasks for both technical experts and maintenance personnel. TVO also has access to a network of experts that includes representatives from the plant supplier, equipment manufacturers, research institutions and cooperation bodies formed by power companies.

The possible ageing mechanisms of systems, structures and components have been assessed and taken into account in the design and construction of the OL3 plant unit through material choices and structural decisions, for example.

Ageing management is focused on systems, structures and components that are significant in terms of safety. The focusing is done by utilising the safety classification, maintenance classification, probabilistic risk assessment and the locations selected for the risk-informed in-service inspection programme.

The locations included in the ageing management programme are listed, the identified ageing mechanisms are allocated for the locations and the preventive maintenance and inspection programmes for managing the ageing mechanisms are defined. Preventive maintenance, periodic tests, in-service inspections and performance tests are used to monitor the progress of ageing and to take preventive corrective action.

System and equipment owners are appointed for OL3's systems and equipment; they are responsible for ensuring, on their part, that the systems and equipment remain operable.According to the given schedule, the system and equipment owners prepare a report for their own area of responsibility that discusses ageing, for example. The other key reports related to the detection of ageing are the quality control revision report, annual outage report, summary report for primary circuit loads and the summary report for the ageing of electrical and I&C equipment. Similarly to the OL1 and OL2 plant units, a list of any measures that are expected to be required in the future will be maintained. The list presents an estimate of the activities that will be required over the course of the next ten years. The list will be updated annually based on the information that is current at any given time. An annual follow-up report on ageing management will also be drawn up in accordance with the YVL Guides and submitted to the Radiation and Nuclear Safety Authority.

The requirements of Section 5 of the Government Decree are met.

2.4 Section 6 Management of human factors relating to safety

1. Attention shall be paid to the avoidance, detection and correction of human errors and the limiting of their effects throughout the service life of the nuclear power plant. The possibility of human error shall be taken into account in the design of the nuclear power plant and in the planning of its operation and maintenance, so that human error and deviations from normal plant operations due to human error do not endanger plant safety or lead to common cause failures.

The foundation for the safe use of nuclear facilities is laid during the design stage, and the effects of human factors are also taken into account via the following constituents: the principles of redundancy, diversity and separation and a defence-in-depth approach to safety.

According to the redundancy principle, systems which perform the most important safety functions are able to carry out their functions even though an individual component in any system fails to operate and, additionally, any component affecting the safety function is out of operation simultaneously due to repairs or maintenance.

According to the principle of diversity, systems based on diverse principles of operation are used to ensure the most important safety functions as far as possible. Furthermore, the Technical Specifications of the plant unit limit the simultaneous preventive maintenance of these systems. The application of the principle of diversity limits the effects of maintenance errors on the implementation of the safety function. Errors that remain in the system after maintenance and errors during maintenance have both been taken into account.

According to the principle of separation, safety systems which back up each other as well as parallel parts of safety systems have been separated from each other so that their failure due to an external common cause is unlikely. For example, separation allows a human error that occurs during maintenance to be limited to one safeguards building and its subsystems.

The defence-in-depth approach to safety means, for example, that the plant unit I&C consist of independent systems designed to implement the adjustment, limitation and protection functions. Furthermore, the plant unit protection system has been designed according to the 30-minute rule. According to this principle, the operating personnel are not anticipated to perform any control activities during the first 30 minutes. The plant automation must ensure that the plant is transferred to a safe state. The purpose of this decision is to avoid human errors caused by time pressure and stress.

The management of human errors is prepared for during the construction stage of the plant unit by verifying and validating the instructions and other documents to correspond with the operation of the plant unit. This work is still partially in progress for the OL3 plant unit.

The creation of human errors, their occurrence and, thereby, their consequences can be reduced by systematically applying good working methods and practices. These have been developed in the nuclear energy industry and in other fields where safety is a critical concern. TVO has commissioned Human Performance tools. The methods of human error reduction used at TVO include pre-job briefing, post-job briefing, clear communication and peer checking by means of pair work or independent verification. These methods will be taken into use during the commissioning stage of the OL3 plant unit. Furthermore, human factors are considered in the reporting and analyses of different events.

Ensuring competence is a key part of human performance management. TVO is continuously training its personnel in order to ensure competence and expertise.

Competence is a key factor in the selection of contractors. Contracting agreements aim at long-term cooperation, which allows the suppliers to be trained and familiarised with TVO's special requirements. TVO has standardised procedures and up to date instructions for all of the above functions. They also apply to the OL3 plant unit.

Learning from operational events is a part of the management of human factors. The same reporting and event investigation methods will be observed during the operation of OL3 as are currently followed at OL1 and OL2. During the operation stage, the effects of human factors can be divided into three parts: management of plant modifications, maintenance and operation.

During the design of plant modifications, the management of human factors is based on the precise documentation of the plant's design bases and their updating and management. Modifications are planned to be performed in a manner where all subsystems of the safety systems are not modified simultaneously. This procedure aims to prevent the occurrence of common cause failures or unavailability. Furthermore, multiple, independent inspections of modifications and their effects on the operation of the plant are performed during the design stage. During the implementation of modifications, the effects of human factors have been observed by means of careful planning and the creation of precise instructions, independent post-work inspection and the verification of operability after modification work has been completed.

During maintenance, the effects of human factors are partially maintained by means of the design basis features described above. Work control, such as the management of work by means of a dedicated work management system, allows maintenance work to be limited to a specific number of subsystems. In addition, simultaneous work in several subsystems has been partially prevented by administrative means (access to keys, for example). Maintenance is continuously developing work control and information systems that support it. Furthermore, detailed instructions are provided for maintenance activities in terms of both technology and working methods.

Ergonomics is important for control room activities and special attention has been paid to it during the design stage. The operating personnel has actively participated in the implementation of the user interfaces, and control room functions will be developed further during operation.

The competence of control room personnel has been ensured by means of training and licence hearings. TVO also has clear selection criteria and procedures for control room personnel, and continuous work is being done in order to develop them. The qualifications of the control room personnel are also verified by the regulatory authority. TVO has developed routines in place for ensuring and developing the competence of control room personnel.

The requirements of Section 6 of the Radiation and Nuclear Safety Authority's regulation are met.

2.5 Section 7 Limitation of radiation exposure and releases of radioactive materials

1. Pursuant to Section 3 of the Radiation Act (592/1991), Section 2 and Chapter 9 of the Act also apply to the radiation exposure of the employees and surroundings of a nuclear power plant. The maximum values for radiation exposure to workers are enacted in Chapter 2 of the Radiation Decree (1512/1991).

2. The maximum values for radiation exposure caused to the population in the vicinity of a nuclear power plant due to its operation, anticipated operational occurrences or accidents are enacted in the Nuclear Energy Decree (161/1988).

The radiation safety of employees at a nuclear power plant is ensured by meeting the requirements of the Radiation Act and Decree, the decisions, orders and regulatory guidelines issued on their basis, and by adhering to TVO's own, more specific radiation protection instructions.

TVO has in place a programme that aims to keep the individual doses and collective doses of the workers as low as reasonably achievable (ALARA). The ALARA programme combines the most important goals concerning the radiation protection of the workers and the reduction of their doses. The completion of the tasks and goals of the programme are monitored by the ALARA group.

Radiation protection and the ALARA principle are taken into account during the planning and implementation of work and the development of working methods and devices.

The radiation protection know-how and competence of the radiation workers are maintained and developed by means of training. Furthermore, information from the radiation protection field is distributed to the company's personnel and contractors via the radiation protection contact person system.

According to the Radiation Decree (1512/1991), the annual radiation dose for a person engaged in radiation work shall not exceed an average of 20 mSv over five years or a value of 50 mSv in one year. Annual doses over 20 mSv can be accepted only in justified exceptions. The ALARA programme also includes a goal stating that no radiation dose received at TVO may exceed 10 mSv per year. For the plant unit OL3, there is an additional goal, that the highest annual dose from OL3 for a person would not normally exceed 5 mSv.

According to the YVL Guides, the collective annual dose of the plant unit personnel shall not exceed the value of 0.5 manSv per net electric power of 1 GW during normal operation of the plant. In the case of Olkiluoto 3, this means a collective annual dose of 0.8 manSv. The goal for OL3 is to keep the collective annual dose at a maximum of 0.5 manSv.

The details related to the meeting of the requirement have been defined and justified in the final safety analysis report.

Radiation workers are divided into radiation work categories and placed under individual dose monitoring and medical surveillance. The dosimetric service is responsible for the individual monitoring. These are implemented according to the detailed instructions in the radiation protection manual.

TL dosimeters as well as real-time work dosimeters equipped with alarms are used to monitor the doses of the radiation workers. The possible internal dose is measured by means of exit monitors at the border of the controlled area, the whole body count monitor at the main gate of the power plant or STUK's measuring equipment.

The requirements of Section 7 of the Radiation and Nuclear Safety Authority's regulation are met.

The meeting of the dose limits set for the local population in the Nuclear Energy Decree is demonstrated below.

2.6 Limiting value for normal operation (Nuclear Energy Decree, Section 22 b(1))

The limit for the annual dose of an individual in the population, arising from the normal operation of a nuclear power plant or another type of nuclear facility equipped with a nuclear reactor, is 0.1 millisievert.

TVO will report the dose caused to a representative individual of the critical population group due to the combined releases from the nuclear power plants on an annual basis. After the commissioning of the Olkiluoto 3 plant unit, its dose will also be taken into account in the calculations. The reporting and calculation is performed by applying the methods that are regulated in more detail in STUK's YVL Guides. An individual's dose is reported as a 50-year effective dose commitment for an individual in the critical population group.

In recent years, the combined annual dose caused to an individual of the local population by the OL1 and OL2 plant units has been in the region of 0.1–0.4 μSv. The doses caused by the normal operation of OL3 have been assessed in chapter 11 of the final safety analysis report. The dose is clearly below the set limiting value.

The site area specific dose limit of 0.1 mSv has been considered a starting point when defining the limits for releases of radioactive substances presented in the Technical Specifications (TTKE) of the Olkiluoto plant units. However, the Technical Specifications for OL3 present clearly lower action levels resulting from the design of the plant than will result from the dose limit when a share of 10% of the noble gas and iodine emissions from the site area is reserved for OL3. Exceeding the action levels according to the design would imply that the plant's emission limitation systems have faults that require action. One of the consequences may be a requirement to shut down the plant. This process ensures that the releases remain below the limiting value.

The requirement in the Nuclear Energy Decree concerning the limiting value for normal operation is met.

2.7 Limiting value for an anticipated operational occurrence (Nuclear Energy Decree, Section 22 b(2))

The limit for the annual dose of an individual in the population, arising as the result of an anticipated operational occurrence, shall be 0.1 millisievert..

Operational occurrences whose initiating events are expected to occur more than once per one hundred years are called anticipated operational occurrences. In the final safety analysis report (FSAR) for the Olkiluoto 3 plant unit, these events are referred to as DBC2 conditions.

Anticipated operational occurrences are defined into groups with similar physical characteristics:

- increase in heat removal from the primary circuit
- decrease in heat removal from the primary circuit
- reduction of cooling flow
- primary circuit pressure increase or decrease
- deviations in reactivity and power distribution
- increase in reactor coolant inventory
- decrease in reactor coolant inventory
- primary–secondary leak.

Different initiating events are studied in each of these groups. Based on the performed analyses, sufficient fuel cooling will be maintained during anticipated operational occurrences and the events will not jeopardise the integrity of the fuel cladding or the primary circuit.

The doses caused by operational occurrences and accidents are discussed in the FSAR. As regards operational occurrences, the doses caused to individuals from the critical population groups by the following two initiating events are studied in more detail:

- breakage of one steam generator pipe (with "best estimate" assumptions)
- loss of condenser vacuum.

Based on the results of the analysis, a leak in one steam generator tube will not cause releases into the environment and the dose caused by the loss of condenser vacuum will be very small.

The requirement concerning limiting values for an operational occurrence in the Nuclear Energy Decree is met.

2.8 Limiting values for an accident (Nuclear Energy Decree, Sections 22b(3–7))

The limit for the annual dose of an individual in the population shall be 1 millisievert for class 1 postulated accidents, 5 millisievert for class 2 postulated accidents, and 20 millisievert for a design extension condition.

The release of radioactive substances caused by a severe reactor accident or a severe accident at a nuclear power plant may not result in the need for large-scale population protection measures or prolonged restrictions on the use of large areas of land and water.

To limit long-term effects, the limit for an atmospheric release of caesium-137 shall be 100 terabecquerel. The probability of exceeding this limit shall be extremely low.

The probability of a release during an early phase of an accident requiring population protective measures shall be extremely low.

In the final safety analysis report (FSAR) for OL3, accidents are classified as follows according to their estimated frequencies:

- Class 1 postulated accidents (DBC3): 10^{-4}/year < f < 10^{-2}/year
- Class 2 postulated accidents (DBC4): 10^{-6}/year < f < 10^{-4}/year
- Design extension conditions (complex sequences): f < 10^{-4}/year
- severe reactor accidents: f < 10^{-6}/year.

The above classification of events does not completely correspond to the classification in the current YVL Guides. However, this classification pursuant to the FSAR can be used when demonstrating that the requirements in Government Decrees and regulatory guidelines are met, since it is stricter than the set requirements. For example, the DBC3 class includes events with a lower frequency than is required, and the criteria for class 1 postulated accidents in the YVL Guides are nevertheless followed for all DBC3 events.

The accidents are analysed in the OL3 FSAR, and the doses caused by the accidents to a representative of the local population and the collective dose at radius of 100 km from the plant unit are also studied. As regards individual doses, the doses for an infant and an adult are analysed according to the location where the dose is received. The source term for the release caused by the accident is calculated according to the design values and the Technical Specifications values.

Accidents in classes DBC3 and DBC4 are discussed in the FSAR, and the discussed accident types have been divided into the same physically similar groups as operational occurrences. Furthermore, postulated accidents include the following groups:

- operational occurrences where the first scram signal fails (DBC3)
- operational occurrences combined with other additional failures (DBC3)
- operational occurrences where the reactor scram fails (ATWS events) (DBC4).

The dose caused to a representative of the local population by postulated accidents is also analysed in the FSAR. The dose limits are not exceeded in any of the calculated cases.

The FSAR has studied three different events in relation to design extension conditions (DEC):

- breakage of 10 steam generator pipes inside a single steam generator
- main steam line break with one steam generator pipe broken
- 1 steam generator pipe broken and the steam generator blow-off system stuck open.

Furthermore, the following DEC scenarios have been studied in separate reports:

- boiling of the fuel pools as a result of the loss of the external electrical grid and pool cooling
- aircraft crash in the waste building.

In all of the analysed DEC scenarios, radiation doses to the environment remain below the set limiting value of 20 mSv.

Severe reactor accidents are discussed in the FSAR on the basis of three different initiating events:

- large loss of coolant accident
- small loss of coolant accident
- total black-out accident.

The FSAR uses the “best estimate” principle to study the least favourable scenario where the initiating event is a large loss of coolant accident and the assumption is that 10% of the leak inside the containment is directly carried into the buildings surrounding the containment. In this accident scenario, the radiation dose to the most exposed individual is small and will not cause immediate health detriments. The ^{137}Cs releases will also be very small in this scenario.

The probability of the ^{137}Cs releases exceeding 100 TBq has been assessed in the level 2 PRA analyses. On the basis of the analyses, the probability of this event will be substantially below the value of $5 \cdot 10^{-7}$/year presented in the YVL Guides. The requirement concerning long-term effects is also met on this basis.

The need to protect the members of the public during the early stages of a severe accident has been analysed by estimating the magnitude of the direct radiation dose and inhaled dose caused by the releases from a severe accident. The results of the calculation indicate that no protection measures would be required.

The Nuclear Energy Decree’s requirements concerning limiting values during accidents are met at the Olkiluoto 3 plant unit.

3. Nuclear safety

3.1 8 § Site safety

1. The impact on safety of local conditions as well as how well security and emergency preparedness arrangements can be realised shall be considered when selecting the site for a nuclear power plant. The site shall be such that the impediments and threats posed by the plant to its vicinity remain extremely minor and heat removal from the plant to the environment can be reliably implemented.

The suitability of Olkiluoto as a location for nuclear power plants was assessed in site studies before the construction of the plant units in the 1970s. Later environmental impacts assessments have been performed in connection with the OL3 and OL4 plant projects, for example. The site description presented in the final safety analysis report is common for OL1, OL2 and OL3. The site description is presented in the final safety analysis report for OL3.

TVO's nuclear power plant is located on the Finnish coast, on the island of Olkiluoto. Olkiluoto is located in a sparsely populated area and there are no major population centres in its immediate vicinity. The cities nearest to the nuclear power plant are Rauma, some 13 km south of the plant site, and Pori, some 34 km to the northeast. The western part of the island of Olkiluoto is owned by TVO.

There is no permanent habitation in the area owned by TVO. The area has an accommodation village that is intended for outage personnel, the constructors of new plant units or workers employed in the modification of the existing plant units. There are recreational settlements in the areas near Olkiluoto. Air traffic is limited near the nuclear power plant and marine traffic is being supervised.

The nuclear power plant is surrounded by a protective zone pursuant to the YVL Guides that extends to a distance of 5 km from the plant. This area has land use limitations. No dense settlements are allowed inside the protective zone. Industry whose products could be detrimentally affected by the nuclear power plant is also not allowed. The protective zone does not have any production facilities that could jeopardise the safety of the plants by its own activities.

Similarly to the Olkiluoto 1 and 2 plant units, Olkiluoto 3 also has a dedicated cooling water inlet that is located to the south of the plants. Cooling water from Olkiluoto 3 is discharged into the same channel as the cooling water from the Olkiluoto 1 and 2 plant units. The discharge channel flows to the southwest, into the Iso-Kaalonperä bay. Different cooling water arrangements were modelled before construction in order to achieve the smallest possible environmental effects. In addition to the increase in temperature, the cooling water does not burden the environment with any nutrient loads or oxygen consuming loads.

The requirements of Section 8 of the Radiation and Nuclear Safety Authority's regulation are met.

3.2 9 § Defence-in-depth

1. In order to prevent anticipated operational occurrences and accidents, and to mitigate the consequences thereof, the operational principle of defence-in-depth shall be implemented in the design, construction and operation of a nuclear power plant.

2. The operational defence-in-depth principle compliant design shall cover the following levels of defence:

> *1) prevention to ensure that the operation of the plant is reliable and deviations from normal operational conditions are rare;*

The probability of accidents is directly proportional to the frequency of operational occurrences. The number of operational occurrences can be effectively reduced by applying high quality standards to the design and implementation of the plant unit.

The probability of accidents is directly proportional to the frequency of operational occurrences. The number of operational occurrences can be effectively reduced by applying high quality standards to the design and implementation of the plant unit.

According to the principle of defence-in-depth, the plant unit has been designed and constructed to prevent the development of operational occurrences by means of its technical characteristics. Reactor power behaviour is naturally controlled. This has been achieved by designing the reactor in a manner where an increase in coolant temperature or the presence of steam in the coolant will increase neutron flux out of the core, which in turn reduces reactivity and tends to limit power increase. A temperature increase in the uranium fuel itself will also reduce reactivity. A reactor designed in this manner is naturally stable as regards small power disturbances.

However, natural stability alone is not sufficient to achieve a sufficient disturbance tolerance for operation. For this reason, the plant unit is equipped with control systems that allow for controlling the steam generator and pressuriser water level, the reactor and steam generator pressure and the reactor power, among others. The purpose of the control systems is to eliminate any small disturbances in the plant's operating conditions, reducing their effect on the operation of the plant to a minimum.

The design of the plant unit provides a good starting point for the prevention of disturbances and accidents by reducing the frequency of initiating events.

In addition to the structure of the plant, the organisation operating the plant also plays a central role in the prevention of disturbances and accidents. In this respect, the most important areas of the organisation's operation are maintenance and operations and, at a later stage, the management of plant modifications.

In maintenance activities, human factors are managed by means of administrative procedures and working methods. As an example from the field of work planning and management, work permits for work in the safety systems of the operating power plants OL1 and OL2 are only issued for one subsystem at a time. Furthermore, the equipment and systems are comprehensively tested after work is complete. Human errors may cause common cause failures in very rare cases, but their probability can be reduced by distributing work and developing testing procedures. Administrative routines that have been proved successful by TVO's earlier experience will also be followed at the plant unit Olkiluoto 3.

In operations, the human factor is observed by maintaining comprehensive, up-to-date and clear instructions, applying specifically defined competence requirements to personnel, following up on the requirements and arranging appropriate training. The thorough training of operating personnel for their tasks is a prerequisite for the starting of the plant unit. Annual training on the plant-specific training simulator will also remain an essential part of the training.

TVO has implemented methods that aim at reducing, detecting and correcting human errors; these include peer checking, clear communication, independent verification and pre-job briefing, for example. Development work related to these methods is being performed continuously as part of operations.

The above requirement is met.

2) control of anticipated operational occurrences to provide for deviations from the normal operational conditions of the plant by equipping the plant with systems able to prevent the extent to which anticipated operational occurrences may develop into accidents and, where necessary, able to bring the plant to a controlled state;

Between the control and protection systems, the plant unit has a limitation system that is part of safety class 3. Its purpose is to prevent minor faults or disturbances in the control or operating systems from developing into operational occurrences that require a reactor scram. This is most often implemented by dropping a few pre-selected control rods into the reactor core (partial scram), which reduces reactor power and makes the disturbance easier to control.

In some cases, the disturbance itself is so large that the limitation system cannot control its consequences. Should this occur, the reactor is automatically shut down in order to prevent the disturbance from becoming an accident.

The above requirement is met.

3) control of accidents by equipping the nuclear power plant with systems that function automatically and reliably to prevent severe fuel damage in postulated accidents and design extension conditions; manually actuated systems can also be used to control accidents, if this is justified on the grounds of safety;

The plant unit has a safety class 2 protection system whose main task is to protect the integrity of the fuel cladding and the primary circuit by stopping the reactor when necessary. The system will also initiate the emergency cooling of the reactor if a coolant leak occurs in the primary circuit. In order to protect the environment, the same system will initiate the closing of the isolation valves on the process pipelines that pass through the containment wall under accident conditions.

The system is built with four parallel, independent subsystems in order to ensure reliable operation. The operation of two subsystems is sufficient for initiating the necessary protection function. The "fail safe" principle has also been applied to the protection system where applicable. If a part of a subsystem fails, the subsystem will set itself to the state required for starting the protection function.

Furthermore, the protection system has been designed in a manner where the condition for triggering a scram when necessary can be received from at least two independent variables. Therefore, the common cause failure of all measurement probes of a specific type cannot prevent the safe shutdown of the reactor.

The protection is based on programmable and computer-based technology. Its operation is secured by a safety class 3 protection automation system that uses another I&C platform. A non-computerised back-up system is also available; it can bring the reactor to a controlled state (hot shutdown) during the most common disturbances or minor accidents even if neither of the programmable systems mentioned above is operating as intended. The manual functions of the back-up system use conventional hard-wired technology. The plant can be brought to a safe state with the manual functions of the back-up system.

The above requirement is met.

> *4) containment of release in severe reactor accidents by equipping the nuclear power plant with systems that ensure that the containment remains sufficiently leak tight in severe reactor accidents, so as not to exceed the set severe accident release limits;*

The management of severe reactor accidents is described in detail below.

The above requirement is met.

> *5) mitigation of consequences by making provisions for limiting radiation exposure to the population in a situation where radioactive materials are released into the environment from the plant.*

The task and responsibility definitions required in an accident situation are presented in the emergency response plan. Activities pursuant to the emergency response plan are practised at periodic intervals, and the first exercise will take place before the commissioning of the plant unit.

The above requirement is met.

3. The levels of defence shall be as independent of one another as is reasonably achievable.

4. Carefully examined, tested, high quality technology that is empirically proven shall be employed at the defence-in-depth levels.

5. The measures necessary to bring a situation under control or to prevent radiation hazards shall be planned in advance. When arranging the operations of the licensee's organisation, it shall be ensured that anticipated operational occurrences and accidents are reliably prevented and that effective technical and administrative arrangements are in place to ensure that personnel are able to function properly in the event of anticipated operational occurrences and accidents.

The systems designed for the different levels of defence-in-depth have been designed to be independent of each other, so that the failure of a system operating on one level will not prevent the systems on the other levels from performing as intended. However, systems intended for the management of severe reactor accidents can also be used for the management of design extension conditions, provided that this does not jeopardise the capability of the system to manage its task proper if the situation should develop into a severe reactor accident.

The plant is equipped with appropriate safety systems for the mitigation of the consequences of accident situations (see section 11), but it is also important that the operators know the correct procedures for disturbances and emergencies. Instructions have been prepared for these situations. Furthermore, the main control room has a safety parameter display system in addition to the normal process information; it can be used to quickly view the values of variables that are important to safety and the status of systems and equipment important for the management of accidents.

Substantial releases of radioactive substances into the environment could only occur during severe reactor accidents. The plant units are equipped with systems that allow the environmental consequences of severe reactor accidents to be limited to an acceptable level (see section 10).

The requirements of Section 9 of the Radiation and Nuclear Safety Authority's regulation are met.

3.3 Section 10 Engineered barriers for preventing the dispersion of radioactive materials

1. In order to prevent the dispersion of radioactive materials, the structural defence-in-depth safety principle shall be implemented.

2. The structural defence-in-depth safety principle compliant design shall serve to limit the dispersion of radioactive materials into the environment by means of successive barriers, which are the fuel and its cladding, the nuclear reactor cooling circuit (primary circuit) and the containment.

The operation of a nuclear power plant creates radioactive materials mainly as a result of the splitting of uranium cores inside the fuel tablets made of uranium dioxide. These fuel tablets are ceramic pellets that will by themselves contain most of the created radioactive materials under normal operating conditions where the temperature of the uranium dioxide does not rise too high.

The plant unit uses the 17 × 17 fuel type. The uranium dioxide tablets are packed inside cladding tubes, which in turn are assembled into fuel assemblies. The cladding tubes have gas-tight seals at the end. Based on its characteristics, the cladding material M5 is well suited for the conditions present inside the reactor and it also meets the exceptional durability requirements set by the high temperatures.

After the fuel rod cladding, the next barrier against the spreading of radioactive material is the pressure-retaining boundary of the primary circuit. The pressure vessel is made of low-alloy steel and its inside is lined with stainless steel. The main coolant lines that connect with the pressure vessel are made of stainless steel. The pressuriser is made of ferritic steel and lined with stainless steel on the inside. The steam generator tubes are made of corrosion resistant Alloy 690.

The starting point for the primary circuit design has been that only a very small portion of the fuel rods contained in the reactor core may lose their integrity during normal operation. The primary circuit is equipped with a reactor water purification system that allows any accumulated fission products and corrosion products activated by neutron radiation to be filtered out of the primary circuit water.

The reactor's primary circuit, steam generators and a part of the piping connecting to these components is surrounded by a cylindrical, gas-tight containment made of pre-stressed concrete that rests on a concrete slab. The inner walls of the containment are covered by a gas-tight metal liner.

The inner containment is surrounded by an outer containment made of reinforced concrete. The annulus between the inner and outer containment is normally kept at a vacuum, and any leakage from inside the inner containment can be filtered with the emergency ventilation system before it is released into the environment.

The design and dimensioning of the containment takes into account the loads caused by severe accidents. Furthermore, the plant concept includes the necessary severe accident management systems. This allows for ensuring the integrity of the containment during a severe reactor accident. The amounts of radioactive materials released into the environment are also maintained at an acceptable level.

The principle of consecutive barriers is followed in the design of OL3.

3. The fuel, reactor, primary circuit of the reactor, and the cooling circuit (secondary circuit) of a pressurised water reactor removing heat from the primary circuit, water chemistry of the primary and secondary circuit, containment and safety functions shall be designed so as to meet the following safety objectives.

a) In order to assure the integrity of fuel

i. the probability of fuel failure shall be low during normal operational conditions and anticipated operational occurrences;

ii. during postulated accidents, the rate of fuel failures shall remain low and cooling properties of the fuel shall not be endangered; and

iii. the possibility of a criticality accident shall be extremely low.

No melting may occur in the fuel pellets during normal reactor operation, and the cladding temperature of the fuel rods may not substantially exceed the coolant temperature. In practice, this means that the fuel rod's power output per unit of length, or linear output power, and the amount of heat transferred from the fuel rod into the coolant in relation to the properties of the coolant are kept within the allowed range. The meeting of the limitations is confirmed by means of the core monitoring system by utilising the reactor-physical calculations and the measurement results provided by the reactor instrumentation.

The power of the fuel rods is limited to a level where the pressure inside the rods will not exceed the normal operating pressure of the coolant.

The fuel is dimensioned in a manner that, after being used in a reactor, it endures long-term storage and handling connected to disposal.

The probability of fuel damage during anticipated operational occurrences, or transients, must be very small. This requirement may also limit the highest allowable fuel rod power during normal reactor operation. The sufficient durability of the fuel in these scenarios is demonstrated by means of transient analyses that form an essential part of the safety analysis report for a nuclear power plant unit. Typical transients include the loss of the external electrical grid, which results in the stopping of the main coolant pumps, or fluctuations in the primary circuit pressure due to unnecessary activation of the pressuriser spray system, for example. In order to optimise fuel economy, the analyses of dimensioning transient may be performed per cycle going forward. In this case, the results of the analyses only need to be conservative as regards the conditions of a single operating cycle, which may significantly reduce the required amount of conservativeness.

During class 1 accidents, the number of fuel rods reaching heat transfer crisis shall not exceed 1% of the total number of fuel rods in the reactor. Furthermore, the temperature of the fuel cladding may not exceed 650 °C.

The cooling properties of the fuel shall not be jeopardised during class 2 postulated accidents. This means that the fuel assemblies must not melt or otherwise be damaged severely enough to prevent the free falling of control rods into the reactor or the entrance of cooling water into the assemblies. Moreover, the temperature of the fuel cladding must not rise so high that the metal/water reaction between hot metal and water vapour could occur to a substantial degree. The amount of fuel damage during postulated accidents must be kept as low as possible. In practice, this requirement is interpreted to mean that fuel cladding damage cannot occur in more than 10% of the fuel rods.

The behaviour of the reactor during postulated accidents has been demonstrated to be acceptable by means of the accident analyses inFSAR. For their part, these analyses have formed the basis for the dimensioning of the plant unit's safety systems. In order to ensure sufficient safety margins, the analyses make unfavourable assumptions concerning the values of physical quantities and the operation of the safety systems.

Any possible criticality accidents have also been discussed in the FSAR analyses. These may include, for example, the ejection of a control rod from a pressurised reactor or the passage of a plug containing a low boron concentration or clean water into the reactor core. These accident chains have been acceptably analysed by using the standard criteria for class 2 accidents.

Furthermore, any event sequences that may lead to inadvertent criticality during refuelling have been analysed. These have been found to be extremely unlikely due to the multiple verification routines (coolant boron concentration, core neutron flux measurement, fuel handling procedures) used during refuelling.

The requirements of item 3a) are met at the plant unit; however, in class 1 accident situations where fuel goes into a heat transfer crisis, the maximum temperature of the cladding may exceed 650 °C. Even in these cases, it has been separately demonstrated that the present temperatures will not lead to cladding damage.

b) In order to ensure primary and secondary circuit integrity,

i. the primary circuit of a nuclear power plant shall be designed and manufactured following high quality standards so that the probability of hazardous faults in structures and of any mechanisms threatening their integrity remains extremely low and any faults which occur can be detected reliably;

ii. the primary circuit shall, with sufficient margins, withstand the stresses arising in normal operational conditions, anticipated operational occurrences, postulated accidents and design extension conditions;

iii. the primary circuit of a nuclear power plant, the systems immediately connected to it and systems, structures and components important to the safety of the secondary circuit of a pressurised water reactor shall be reliably protected during anticipated operational occurrences and all accident scenarios, in order to prevent damage caused by over-pressurisation;

iv. the hydrochemical conditions in the primary circuit of a nuclear power plant and the secondary circuit of a pressurised water reactor shall not result in mechanisms that threaten their integrity; and

v. the plant shall be equipped with reliable leak monitoring systems:

In addition to appropriate planning and sufficient design margins, ensuring the integrity of the primary circuit is based on careful manufacturing and the use of first-class materials. This allows for ensuring that the size of a defect that leads to a sudden rupture in a pressure-retaining device of the primary circuit must be large enough for it to be observed as a leak during plant operation or discovered during in-service inspections. In-service inspection programmes play a key role in ensuring the integrity of the primary circuit. The pressure-retaining parts of the primary circuit are also monitored by means of precise leak monitoring systems in order to detect cracks that jeopardise integrity before they become dangerously large. This same principle, known as break preclusion, has also been applied to the containment-internal parts of the steam and feedwater lines, and to the steam lines up to the support point located outside of the containment and downstream of the isolation valve.

In addition to the methods for ensuring primary circuit integrity, the main components of the primary circuit and the main coolant pipes themselves have been equipped with rupture supports that will limit the dynamic effects of main coolant pipe breaks if necessary. Regardless of the above, the cooling properties of the reactor core even during an unlimited guillotine break of the main coolant pipes have been demonstrated by means of calculations. In this respect, there are multiple levels of protection.

The summary programme for basic inspections and in-service inspections describes the non-destructive in-service inspections for components in safety classes 1 and 2 (pressure vessels, pumps, piping, their supports and reactor pressure vessel internals) and other structures important for nuclear safety.

The summary programme defines all of the targets for non-destructive testing, the testing methods, approval limits, test scheduling, general principles for the risk-informed piping inspection programme, the methods for reporting on the tests and the assessment of any possible defect indications. Furthermore, the summary programme defines the requirements for the qualification activities of the in-service inspections mentioned above that aim to improve their reliability. The possible failure mechanisms for each in-service inspection target and the observability of the possible defects have been discussed in the initial data for each qualification.

The design of the primary circuit has taken into account the radiation embrittlement of the reactor pressure vessel walls due to fast neutrons. The development of the radiation embrittlement is also followed within the context of the in-service inspection programme. To this end, samples made of the same material as the pressure vessel are stored in the reactor pressure vessel during normal operation. They are removed from the reactor in accordance with the in-service inspection programme in order to test for any changes in strength.

The purpose of the hydrochemistry maintained in the primary circuit is to prevent the corrosion of the entire circuit and the surfaces of the fuel assemblies, thereby maintaining, for its part, the integrity of the pressure boundaries and the nuclear fuel cladding. Optimised chemistry can contribute to high availability and long service life, which in turn promote safety. Chemistry can also be used to assist in minimising the spread of activated corrosion products onto the surfaces of process systems. The creation of activation products and their spreading across the entire primary circuit can be substantially affected by choosing the main chemistry parameters (boron, lithium and hydrogen) correctly and controlling their concentration.

The hydrochemistry of the primary circuit largely concerns controlling the chemical effects of boron. Diluted boron is used in the coolant in order to capture thermal neutrons. Boron is added to the primary coolant in the form of boric acid, which is a weak acid. In the case of OL3, the natural isotope distribution of boron (approx. 20% of isotope 10B and 80% of isotope 11B) has been enriched to 30–32% of 10B. The reasons for the increase in enrichment are boosting its effect on reactivity, optimising chemistry and the design criteria for the related systems.

The acidity of boric acid is neutralised by means of lithium, which is added to the coolant in isotope form with an enriched concentration of 7Li. 7Li has been selected because it is naturally created when thermal neutrons and the 10B isotope react under reactor conditions.

Reactor conditions also continuously give rise to water radiolysis reactions that release oxygen and short-lived radicals such as oxygen compounds. In order to prevent these effects, excess hydrogen is added to the coolant. The excess hydrogen diluted in the coolant also creates reductive conditions that minimise the oxidation of the basic materials in the primary circuit and nuclear fuel.

A common goal for the secondary circuit hydrochemistry is to ensure the high availability of the plant, the integrity of the primary and secondary circuit pressure boundaries, long service life and the prevention of corrosion phenomena, in particular the effects of erosion corrosion.

The purpose of the hydrazine–ammonia hydrochemistry maintained in the secondary circuit is to prevent the corrosion of the entire circuit and, in particular, the structures of the steam generators, thereby maintaining the integrity of the circuit and its components and the protective oxide layers.

The feedwater is alkalified with ammonia that is generated from the hydrazine through a decomposition reaction until the pH value is ≥ 9.9. The residual oxygen in the coolant is consumed by the reactions of the slight excess hydrazine. The thermal gas removal in the feedwater tank is also significant. The residual hydrazine creates reducing conditions in the feedwater in order to protect the components against corrosion. The monitoring of impurities in the water and steam circulation can significantly affect the creation and spreading of corrosion products in the water and steam circulation, the conditions created on the secondary side of the steam generators and, thereby, the heat transfer capacity.

Water is being continuously blown off from the secondary side of the steam generators in order to remove accumulated impurities and corrosion products. The blow-off condensate is cleaned by means of mechanical filters and ion exchange before it is returned into the condenser. Blow-off has a substantial effect on the water quality of the steam generators and the amount of impurities in any possible clearances. The amount of corrosion products that may accumulate in the steam generators can also be reduced with the mechanical 100% condensate cleaning that has been connected to the feedwater system.

There is plenty of international operating experience available concerning the secondary circuit hydrochemistry selected for OL3.

Disturbances during which the routing of steam into the turbine condenser is obstructed or reactor shutdown fails may cause an increase in primary and secondary circuit pressure. In these situations, the primary circuit pressure is limited to an acceptable level by using the pressuriser spray system and the pressuriser safety valves, if necessary. The design basis states that anticipated operational occurrences must not create a need for opening the primary circuit safety valves.

On the secondary side, each steam generator has one blow-off valve and two safety valves. As regards the steam generators, the operation of the blow-off valve is sufficient during anticipated operational occurrences and the pressure will not reach the opening limit of the safety valves.

The reactor protection and scram system will also participate in the limiting of the primary and secondary circuit pressure. The primary or secondary circuit design pressure will not be exceeded during anticipated operational occurrences where the reactor scram works as intended. For OL3, this design pressure is 176 bar (abs) for the primary circuit and 100 bar (abs) for the secondary circuit. During postulated accidents, the design pressure can be exceeded by at most 10%; in cases where the reactor scram fails, it may be exceeded by 20%. Design extension conditions also allow exceeding the design pressure by 20%.

The overpressure protection analyses that form the basis for the dimensioning of the overpressure protection system use extremely unfavourable or conservative assumptions: for example, some of the blow-off and safety valves are assumed to remain closed and the first scram limit is not assumed to trigger a scram. Due to this conservative approach, the overpressure protection system has significant excess capacity. The overpressure protection analyses have been separately prepared for the primary and secondary circuits.

The overpressure protection function also implements the principle of diversity (see section 11). The blow-off valves and safety valves on the secondary side are of different types. On the primary side, the reactor pressure will remain below the approval limit of 120% even if the safety valves have a common cause failure if the pressuriser spray system and secondary side overpressure protection system are operating as intended.

The leakage of reactor water or steam from the process is monitored by means of multiple leak monitoring systems. There are measurement points for air temperature and relative humidity inside the containment that can detect an increase in the atmospheric temperature or relative humidity inside the containment due to leaking and condensing reactor water. The amount of condensate accumulated by the containment air coolers, and in some cases, the amount of water accumulated in the floor wells, is also supervised. All of these measurements provide information or even alarms concerning leaks that exceed the approval limit, but they will not start any automatic protection or limitation functions. In case of a larger containment-internal leak, the reactor protection system will automatically start the reactor and containment isolation and reactor scram due to high containment pressure.

There is a dedicated system available for the monitoring of containment-external leaks.

Steam generator tube leaks, or primary–secondary leaks, are monitored by means of the steam line activity measurements. Each steam line is monitored by four measurements that will automatically start the management of primary–secondary leaks by means of 2/4 logic.

The requirements of item 3b) are met.

c) In order to ensure containment building integrity:

i. the containment shall be designed so that it maintains its leak tightness during anticipated operational occurrences and, with a high degree of certainty, during accident scenarios,

ii. pressure, radiation and temperature loads, radiation levels on plant premises, combustible gases, impacts of missiles and short-term high energy phenomena resulting from an accident shall be considered in the design of the containment; and

iii. the probability of containment leak tightness becoming endangered as a result of reactor pressure vessel fracturing shall be extremely low.

iv. The nuclear power plant shall be equippe with systems that ensure the stabilisation and cooling of molten core material generated during a severe accident. Direct interaction of molten core material with the load bearing containment structure shall be reliably prevented.

Despite the *break preclusion* principle described above, the design of the containment has also taken into account large primary circuit pipe breaks from the outset. The dynamic phenomena and temperature and radiation loads related to pipe breaks and severe accidents have also been considered during the design of the containment, as is presented in the system description for the containment and its appendices. In order to remove the problem related to combustible gases generated during the oxidation of the fuel material, the reactor containment is equipped with passive catalytic recombinators that can reduce the hydrogen concentration in the atmosphere in a controlled manner.

The breakage of the reactor pressure vessel at high pressure during a severe reactor accident could directly jeopardise the integrity or leak-tightness of the containment. In order to reduce this risk, the pressuriser is equipped with a separate, manually started pressure reduction system that is single failure tolerant in terms of its active components, i.e. valves.

The stabilisation and cooling of the molten core material and preventing its interaction with the structures of the containment is based on routing the molten core material discharged from the pressure vessel into the molten core spread area located below it. Based on the spreading and cooling tests, the relatively large floor area of the room in question has been found to allow for the molten core material to be stabilised and cooled. The spread area is automatically and passively flooded when the molten core material reaches it. At the same time, the water penetrates the cooling water channels located below the floor surface, which promotes the cooling properties of the molten core material and prevents any interaction between the molten core and the structures. The water required for the flooding is received from the internal emergency cooling water storage tank. The analyses for severe reactor accidents are discussed in the general section of the FSAR.

The requirements of item 3c) can be considered to be met at the plant unit.

The requirements of Section 10 of the Radiation and Nuclear Safety Authority's regulation are met.

3.4 Section 11 Safety functions and provisions for ensuring them

1. In ensuring safety functions, inherent safety features attainable by design shall be primarily utilised. The combined effect of a nuclear reactor's physical feedbacks shall be such that it mitigates the increase in reactor power.

The utilisation of inherent safety characteristics for the plant unit's safety functions is at the same level as in the newest currently operating pressurised water reactors.

The principle of inherent stability has been one of the design bases of the reactor. This means that the physical feedback loops in the reactor work to resist any changes in the power output. Among other things, this means that the temperature of the fuel and coolant or the steam concentration of the coolant must act to reduce the reactivity of the reactor core. At low temperatures, an increase in reactor temperature will increase reactivity. An increase in reactor temperature will always reduce reactivity near the normal operating temperature and during power operation. Therefore, when starting the reactor, the residual heat from the main coolant pumps is used to bring the temperature to a level where the reactivity effect of the temperature becomes negative. The extraction of the reactor control rods and making the reactor critical can only begin after this.

The fact that the plant unit can survive a two-hour complete loss of alternating current without fuel damage also contributes to inherent safety. This is made possible by the large amount of water contained in the steam generators.

The operation of the containment in the short term is based on its high volume and pressure tolerance; in the long term, the removal of residual heat from the containment requires the operation of active systems. The management of the hydrogen content in the containment atmosphere after an accident is based the use of passive autocatalytic recombinators.

The requirement concerning inherent safety is met at least in a similar manner as in the latest operating pressurised water reactors.

2. If inherent safety features cannot be utilised in ensuring a safety function, priority shall be given to systems and components which do not require an off-site power supply or which, as consequence of a loss of power supply, will settle into a state that is preferable from the safety point of view.

The quick reactor shutdown (scram) can be actuated without any external energy by dropping the control rods into the core. A loss of electricity in the control rod drive circuits will also cause the control rods to drop into the reactor core.

The overpressure protection of the reactor and steam generators is also possible without external energy by means of mechanical, pressure-controlled pilot valves or spring-loaded safety valves.

The operation of the pressure accumulators that participate in the emergency cooling of the reactor is based on the energy stored in pressurised nitrogen gas. However, the other parts of the reactor emergency cooling and residual heat removal are based on the use of conventional, active systems.

The reactor protection system's functions for which an unambiguously safe state can be defined are started according to the fail-safe principle. In this case, the loss of electricity supply to the protection function will lead to the starting of the function. The functions for which an unambiguously safe state can be defined are the reactor scram, turbine trip and the closing of the main steam isolation valves.

The OL3 plant unit meets the requirements of this item.

3. In order to prevent accidents and to mitigate the consequences thereof, a nuclear power plant shall have the systems to shut down the reactor and maintain it in a subcritical state, to remove the residual heat generated in the reactor, and to retain radioactive materials within the plant. The principles of redundancy, separation and diversity shall be applied in the design of these systems in order to ensure the implementation of the safety function even in the event of a failure.

Within the plant unit, stopping the reactor and maintaining it subcritical is normally arranged by means of control rods and by increasing the boron concentration of the coolant. Control rods can be inserted either rapidly by means of dropping or more slowly with the electro-mechanical actuators.

If the control rods are not moving at all for some reason, the reactor can be shut down safely under all postulated disturbances by means of the automatically started emergency borating system.

At high pressure, the residual heat created by the reactor is normally evacuated into the secondary circuit through the steam generators, and from there further into the turbine-condenser or the environment through the steam generator blow-off valves. At low pressure, residual heat is transferred directly from the primary circuit into the sea through the residual heat removal system, diesel-backed secondary cooling system and diesel-backed seawater system.

The retention of radioactive substances at the plant unit is primarily achieved by isolating the primary circuit and containment in situations where a risk of fuel damage or primary coolant leak exists. Therefore, all of the pipelines passing through the containment wall that are connected to the primary circuit or the containment gas space have two consecutive isolation valves, with the exception of the lines connecting to the containment instrumentation where isolation valves have been replaced by chokes.

If the activity leaks out of the inner containment into the annulus between the inner and outer containment, the emergency ventilation system is used to prevent it from spreading into the environment. The annulus is normally kept at a slight vacuum, and in accident situations, all exhaust air from the annulus is routed through the filters of the emergency ventilation system. The emergency ventilation is automatically started due to an increase in the containment pressure or when switching to diesel-backed electricity supply.

The parallel subsystems of the safety systems have been physically and electrically separated by placing them inside four discrete safeguards buildings. This limits the effect of external factors, such as flooding and fires, to one subsystem.

The effect of common cause failures in safety systems on the safety of the plant unit has been reduced by using at least two systems with different operating principles for the same safety functions. The above presents how the principle of diversity is met in terms of reactor shutdown. During a common cause failure of the safety valves, the overpressure protection of the primary circuit can also be arranged by means of the pressuriser spray system and the secondary side pressure regulation. In the secondary circuit, the steam generator blow-off valves and safety valves are of different types, and they can replace each other in terms of the overpressure protection function.

The medium-pressure emergency cooling system is available for cooling the reactor (supplying water into the reactor); if this system fails, the low-pressure emergency cooling system can be started after the reactor pressure has been reduced.

Residual heat can be removed from the reactor either into the steam generators (normal method) or, in case of emergency, by blowing air into the containment, from where the heat can be transferred into the sea by means of the low-pressure emergency cooling system or a separate containment emergency cooling system. At low pressure, heat can also be removed directly from the reactor by means of the residual heat removal system.

Sequences of events where the safety system primarily intended for managing the situation develops a common cause failure that prevents operation have been widely analysed as design extension conditions. These analyses have demonstrated that the principle of diversity is met in the design of the plant unit.

The OL3 plant unit meets the requirements of this item.

4. It shall be possible to execute the main safety functions necessary for transferring to, and remaining in, a controlled state, even if any single component of a system relating to the function is inoperable and even if any other component of a system participating in the execution of the same safety function, or a component of a support or auxiliary system necessary for the operation of the system, is simultaneously out of use due to repair or maintenance.

5. Common cause failures shall only have a minor impact on plant safety.

According to the design basis of the plant unit, the reactor can be shut down with a sufficient margin even if the most reactive control rod remains completely extracted from the core. Furthermore, as described above, the reactor can also be safely shutdown with the extra borating system that has 2 × 100% capacity.

The systems used for reactor cooling and residual heat removal have been divided into four parallel, independent subsystems. These safety functions can be implemented under all operational conditions and during all accident situations if two out of these four subsystems are operating as intended.

The failure tolerance requirement stated above (the N+2 criterion) is met at the OL3 plant unit.

The aim has been to minimise the effect of common cause failures on the safety of the plant by applying the principle of diversity in the manner described under item 3 above.

The OL3 plant unit meets the requirements of items 4 and 5.

6. A nuclear power plant shall have in place on-site and off-site electrical power supply systems in the event of anticipated operational occurrences and accidents. It shall be possible to supply the electrical power needed for safety functions using either of the two electrical power supply systems.

The plant units have the following electrical power supply systems:

- When the plant is running, the plant unit's own generator supplies the house loads via the internal house load transformers.
- If the connection to the external grid is lost while the plant unit is running, the unit tries to switch to house load operation. In this case, the plant unit’s own generator remains in operation and only supplies the house loads.
- If the plant unit’s own electricity generation is interrupted, the house loads are supplied by the external 400 kV network via the main transformer and the house load transformers.
- If the connection to the 400 kV network has been lost, and transfer to house load operation is unsuccessful, electricity supply is automatically switched to the external 110 kV network via the start-up transformers. When switching to 110 kV supply, the plant unit condenser and the low power (auxiliary) feedwater system will remain operable, but the main feedwater pumps and main coolant pumps will stop, which leads to a reactor scram.
- If the house load option and both external networks have been lost, the plant unit has four emergency diesel generators, one for each subsystem. These automatically start and supply the systems required to bring the plant unit to a safe state.
- Loads for which the 10-second voltage interruption caused by the starting time of the diesels cannot be accepted are supplied by the battery-backed network.
- To prepare for a common cause failure of the emergency diesel generators, there are two station blackout diesels

that may be started manually if required. They can be used to supply the loads that are required to bring the reactor to a safe state in two subsystems.

External electricity supply is improved by a gas turbine plant located in the site area. If necessary, it can be connected to supply the loads that are important for the safety of the plant unit.

The above requirement concerning the supply of electrical power is met.

7. The nuclear power plant shall have the necessary components and procedures for securing the removal of residual heat from the fuel in the reactor and inside the storage pools for a period of three days independently of the off-site supply of electricity and water in a situation caused by a rare external event or a disruption in the on-site electrical distribution system.

This requirement is not part of the original design basis for the OL3 plant unit. According to the transitional provision in Section 27 of the Radiation and Nuclear Safety Authority's order on the safety of nuclear power plants, the above requirement shall apply to the OL3 plant unit "to the extent that the application is justified under the principle laid down in Section 7a of the Nuclear Energy Act, taking into account the technical solutions of the nuclear power plant unit in question".

TVO has designed arrangements for the OL3 plant unit that can be used to ensure residue heat removal during a loss of alternating current supply. After these arrangements have been implemented, the requirement is met at least in the extent required in Section 27. A plan for principles concerning the modifications has been submitted to STUK.

8. The management of severe reactor accidents and the monitoring of the plant's status during severe accidents shall be implemented by means of systems that are independent of the systems designed for normal operation, anticipated operational occurrences and postulated accidents. The leak-tightness of the containment during a severe reactor accident shall be reliably ensured.

9. The plant shall be designed so that it can be brought into a safe state after a severe accident.

Reducing reactor pressure is an essential part of the management of severe accidents. A separate pressuriser pressure reduction system is available for this purpose, and it is single failure tolerant in terms of its active devices (valves). If necessary, the pressure can be reduced manually according to the emergency procedures.

The flooding of the molten core spread area is started automatically and passively once the molten core is released into the space. Containment pressure increase is limited by means of a separate containment emergency cooling system that has a separate secondary cooling circuit and seawater circuit. The system is single failure tolerant (capacity 2 × 100%) and its electricity supply can be arranged by means of the station blackout diesels described above.

During a severe accident, the hydrogen concentration of the containment atmosphere is reduced in a controlled manner by ensuring, on the one hand, that hydrogen is evenly distributed across the entire volume of the containment and, on the other hand, by removing hydrogen from the atmosphere inside the containment. Both functions are based on passive solutions that are highly tolerant of equipment failure.

In the long term, any overpressure inside the containment can also be discharged in a controlled manner through the filtered containment ventilation system.

A dedicated severe accident I&C system that is independent of the other plant unit instrumentation is available for the controls and measurements required for severe accident mitigation. Sampling the atmosphere inside the containment is also possible.

The requirements of Section 11 of the Radiation and Nuclear Safety Authority's regulation are met.

3.5 12 § Safety of fuel handling and storage

1. In the handling and storing of nuclear fuel, adequate cooling and radiation protection of the fuel shall be ensured.

2. Nuclear fuel storage conditions shall be maintained such that the leak tightness or mechanical endurance of a fuel assembly is not substantially degraded during the planned storage period.

3. Damage to the cladding of the fuel assemblies during handling and storage must be prevented with a high degree of certainty.

4. The possibility of a criticality accident shall be extremely low.

5. The probability of a severe accident shall be extremely low.

The lifting equipment used for fuel handling is of a type that sets itself to a safe state as a result of the loss of external power supply. Furthermore, the handling safety of irradiated fuel, in particular, has been ensured by means of the automatic limitation and protection functions of the transfer machine.

Criticality safety is an important factor in the storage and handling of fuel. Criticality safety analyses have been performed for all storage environments, which include the fresh fuel storage and the fuel pool racks. The analyses have taken into account the different possible disturbances, such as the filling of the fresh fuel storage with water, water density variations in the fuel pools and changes in the storage geometry. Criticality caused by a possible refuelling error has been observed in the design of the fuel handling systems and in the methods used for fuel handling.

In order to prevent mechanical damage to fuel and substantial changes to the storage geometry (deformation of the fuel racks), the dropping of loads has been considered in the mechanical design of the lifting equipment with sufficient security margins. Furthermore, the handling route for the hatches between the pools in the fuel building has been constructed in a manner that prevents the handling of the hatches above the pools.

The hydrochemistry of the fuel pools is being carefully controlled in order to prevent the detrimental effects of long-term pool storage on the integrity and mechanical durability of the fuel and its feasibility for final disposal. The requirements for hydrochemistry are presented in TVO's chemistry handbook and in the Technical Specifications for the plant unit and the KPA storage.

The possibility of severe accidents has also been considered in the design of the fuel storage and cooling systems. The fuel can be cooled by means of other methods even if the fuel pool cooling system proper is inoperable. Sufficient cooling capacity has been demonstrated by means of analyses.

The requirements in Section 12 concerning fuel handling and storage are met.

3.6 13 § Safety of handling and storage of radioactive waste

1. Waste generated during the operation of a nuclear power plant, the activity concentration of which exceeds the limits set by the Radiation and Nuclear Safety Authority shall be treated as nuclear waste.

2. Waste shall be sorted, categorised and handled in an appropriate manner in terms of its storage and final disposal, and stored safely.

The low and intermediate level power plant waste generated at TVO's nuclear facilities is disposed of in the VLJ facility which received an operating licence on 9 April 1992. In 2006, according to the terms of the operating licence, TVO submitted a report on the safety of the VLJ facility, its operating experience, and the new packaging and filling techniques for power plant waste. In its statement on 26 March 2008, the Ministry of Employment and the Economy stated that it has no comments on the description.

STUK has approved the periodic report pursuant to the operating licence for the VLJ facility, the updated safety case for the VLJ facility and its final safety analysis report.

Decommissioning waste from the plants is largely similar to the low and intermediate level waste, and current plans indicate that it will be disposed of in the extensions built in the VLJ facility and the disposal shaft constructed for the reactor pressure vessels. The decommissioning plan for the plants, which describes the plans for the storage and disposal of decommissioning waste, was last updated in 2008.

The KPA storage acts as the interim storage for high-activity spent fuel. The KPA storage has been expanded to accommodate the needs of the operating plant units (OL1 and OL2) and OL3. In relation to the expansion, the design of the KPA storage was inspected and determined suitable for the interim storage of spent fuel from OL3. STUK stated this in the safety assessment that formed the basis for its decision. The exception is that accidents involving the spent fuel transportation cask for Olkiluoto 3 have not yet been analysed. The reason is that the purchase of this cask is not financially justifiable before the plant has been commissioned and it has been operating for a period of time.

Posiva Oy is responsible for the research related to the disposal of spent fuel and its practical implementation. The disposal of spent nuclear fuel into the bedrock has been studied since the

1980s. Olkiluoto in Eurajoki was selected as the disposal location according to area screenings across Finland, site studies and an environmental impact assessment. After the site selection, several comprehensive bedrock studies have been completed in the area of Olkiluoto. The research tunnel "Onkalo" that stretches to a depth of approximately 400 metres is currently being excavated at Olkiluoto. It will provide detailed information on the conditions and characteristics of the bedrock selected for the disposal. The goal is to place the first batches of spent fuel in disposal in 2024.

The Radiation and Nuclear Safety Authority has issued a separate regulation on the safety of the disposal of nuclear waste (STUK Y/4/2016, 1 January 2016); the meeting of its requirements is demonstrated during the licensing processes of the VLJ facility and the spent fuel disposal.

The requirement of Section 13 of the Radiation and Nuclear Safety Authority's regulation is met.

3.7 Section 14 Protection against external events affecting safety

1. The design of a nuclear power plant shall take account of external events that may challenge safety functions. Systems, structures, components and access shall be designed, located and protected so that the impacts of external events deemed possible on plant safety remain minor. The operability of systems, structures and components shall be demonstrated in the plant-external ambient conditions on which their design is based.

2. External events shall include exceptional weather conditions, seismic events, the effects of accidents that take place in the environment of the facility, and other factors resulting from the environment or human activity. Design must also take account of illegal activities undertaken to damage the plant, and a large aircraft crash.

As regards the preparation for external threats, the design of the OL3 plant unit has taken into account the natural external threats as well as unlawful action aimed at damaging the plant.

Natural phenomena

The preparation for external threats at the OL3 plant unit, its design bases and design parameters are presented in the final safety analysis report and its appendices. The systematic identification, screening and quantitative analysis of external threats, that is, phenomena that affect the plant by means of land, sea and air, is presented in the appropriate section of the probabilistic risk analysis (PRA). The analysis includes determining the strengths and frequencies of the phenomena and the significance of the most important external threats as regards the core damage frequency of the OL3 plant unit. The probabilistic risk analysis has ensured that the most important individual phenomena or common phenomena have been comprehensively analysed and that their risk significance is sufficiently small in order to fulfil the numeric design requirements of the plant while taking into account the uncertainty related to the phenomena.

The sufficiency of the design margins when the design basis is exceeded has been ensured by means of separate analyses as regards threats where the operation of the key safety systems is necessary in order to achieve a safe plant status. The external threats that have been taken into account in the design of the OL3 plant unit and listed in the final safety analysis report are

- design basis earthquake,
- aircraft crash,
- explosion shockwave,
- high and low outside air temperatures,
- air humidity,
- wind loads,
- missiles caused by wind,
- low and high seawater temperatures,
- rain loads and external flooding,
- lightning,
- external threats related to cooling water and cooling air intake, threats occurring in the plant area, and
- loss of the external grid.

Based on its duration, the latter is either an anticipated operational occurrence or a design basis accident.

Seismic requirements

The requirements of the YVL Guides have been taken into account regarding the seismic loads. The design basis earthquake is presented in the final safety analysis report.

The buildings, systems and components are classified into seismic classes S1, S2A and S2 in the classification document.

The YVL Guides include seismic classes S1 and S2. Class S2 is divided into two subclasses: S2A and S2. Structures and buildings in class S2A are designed while taking into account the seismic requirements in order to avoid damage to class S1 structures and components. Class S2 has no requirements concerning earthquake tolerance.

The PRA contains a six-stage earthquake analysis for the OL3 plant unit. The definition of the seismic hazard is placed on a site-specific analysis. On the basis of the analysis, the risk caused by earthquakes meets the design requirements stated in the YVL Guides, while taking into account the uncertainties of the analysis. Seismic initiating events account to approximately 1% of the core damage frequency.

Preparation for aircraft crashes and explosions
The design requirements for mitigating the consequences of an aircraft crash are presented in the appropriate appendices to the final safety analysis report that are kept confidential pursuant to Section 78 of the Nuclear Energy Act and Section 24.1(7) of the Act on the Openness of Government Activities.

The design requirements and the shape of the explosion shockwave are presented in the final safety analysis report. The design requirements concern buildings that are important in terms of safety.

Other external threats
The design requirements for other external threats are presented in the final safety analysis report. .

- Outside air temperature and humidity
- Wind loads and missiles caused by wind
- Seawater temperature
- Rain loads (rain, snow) and external flooding
- Lightning
- Threats related to cooling water intake (ice, frazil ice, oil releases, algae, corrosion, other sea fauna)
- Threats related to cooling air intake (insects, frosting, snow and freezing)
- Threats in the plant area
- Loss of the external grid.

In order to ensure that the design values and margins presented in the final safety analysis are sufficient, separate analyses have been drawn up in terms of what are known as cliff-edge phenomena. Separate analyses have been drawn up to demonstrate the sufficiency of the design margins in case of low and high air temperature, high wind, high seawater temperature and high seawater level. The loss of ultimate heat sink has been separately analysed in the FSAR transient analyses and the appropriate topical report that demonstrates the cooling properties of the reactor under all operational states.

Low seawater temperatures that carry the risk of supercooled water freezing in the screens of the inlet water channel (also referred to as frazil ice) have been prepared for in the design of the OL3 plant unit by recycling seawater heated by the condenser from the discharge channel into the inlet channel in order to heat the incoming water.

Access routes leading to the plant site and located inside it have been constructed in a manner that minimises the effect of external threats. The most severe identified threat that could affect the access connections is the blocking of the road leading to the site area due to a storm or a similar natural phenomenon. Preparations for this scenario have been made in the emergency response plan.

PRA - Identification and analyses of external threats
The probabilistic risk analysis (PRA) presents the analysis of other external threats to the OL3 plant unit apart from earthquakes which have been described above. The PRA analyses external threats that cause the shutdown of the plant either due to a scram or a Technical Specifications (TTKE) requirement. The frequency of initiating events due to external threats is low and most of them are included in the initiating event statistics for transient initiating effects. External events may, however, cause initiating events where all plant safety systems do not work in the intended manner. The analysis is divided into a systematic identification of external threats and quantification of initiating events after a screening.

During the identification phase, the key initial data for the analysis, i.e. the special characteristics of the plant site/unit were compiled and recorded in a database for further analysis. The systematic identification of external threats is divided into three categories based on the route of their effects: air (A##), ground (G##) or cooling water (W##). A key part of the analysis is the identification of common threats in addition to individual threats. The initiating events to be quantified were selected by applying six different screening criteria for individual phenomena and four screening criteria for common threats. Most of the identified threats were left outside the quantification, since their significance was found to be very small in terms of the plant risk on the basis of the qualitative analysis. It should be noted, however, that there is great uncertainty related to the assessment of the frequency of initiating events. Plant site specific information or estimates were primarily used in the assessment of the originating event frequencies. After the identification and screening of external threats, the external individual and common threats are as follows:

Individual threats:

- A01 Storm (high wind)
- W10 Organic matter in the cooling water
- W08 Frazil ice
- W12 Oil releases

Common threats::

- Storm (high wind) and snowfall.

The significance of external threats in terms of the core damage risk amounts to approximately 4% of the total core damage frequency. The most significant initiating event is the effect of an oil release in the sea (W12).

Since the total core damage frequency is acceptable when considering the proportion of external threats and their related uncertainties, including cliff-edge phenomena, the design requirement in the YVL Guides as regards external threats can be considered to be met.

Provisions for different events endangering plant safety have been made in accordance with the analysis of external threat prevention at Olkiluoto nuclear power plant. These provisions are divided into structural precautions and other preventive actions, actions taken during the event and actions limiting the consequences of the event. The provisions have been assessed in the memorandum that concerns the meeting of the requirements in STUK's regulation concerning security arrangements.

The probability of an aircraft crash at Olkiluoto has been minimised by means of the no-fly zone EF P25 Olkiluoto defined in the decree concerning aviation limitations due to plant safety (1374/2009, amended by 614/2015); therefore, no new aviation limitations are required at Olkiluoto.

The possibility of a terrorist attack performed with an aircraft has been taken into account in the design and construction of the new plant unit in order to ensure its safety functions according to the authority regulations.

The requirements of Section 14 of the Radiation and Nuclear Safety Authority's regulation are met at the OL3 plant unit.

3.8 15 Section 15 Protection against internal events affecting safety

1. The design of a nuclear power plant shall take account of any internal events that may challenge safety functions. Systems, structures and components shall be designed, located and protected so that the probability of internal events remains low and impacts on plant safety minor. The operability of the systems, structures and components shall be demonstrated in their design basis interior ambient conditions.

2. Internal events shall include fires, flooding, explosions, electromagnetic radiation, pipe breaks, container breakage, falling of heavy objects, the impacts of missiles due to explosions and component failure, and any other internal events.

The protection against internal events at the plant unit OL3 has been discussed in Section 3.4 of the final safety analysis report. The design has considered the following internal events:

- piping damage
- damage to tanks, pumps and valves
- missiles
- drops of loads
- plant-internal explosions
- fires
- plant-internal flooding.

Furthermore, the design of the plant unit has considered specific separate phenomena, such as electromagnetic interactions and pressurisation caused by possible electric arcs at the switchgear plants or a short circuit of the emergency diesel generator.

Internal events must not jeopardise bringing the plant to a safe state or cause the simultaneous unavailability of the main control room and remote shutdown station. They must also not jeopardise the integrity of systems and structures important to safety. These include the following:

- Building parts important to safety (the containment and its internal structures, structures that separate the parallel subsystems of the safety systems, structures related to fire compartmentation)
- Pressure-retaining primary circuit boundary (except during events where the initiating event itself is a primary circuit leak or pipe break)
- The internal parts of the reactor pressure vessel, including the fuel
- Pressure-retaining parts of the main steam and feedwater systems (except when their failure is the initiating event itself)
- The fuel pools and their structures.

The following briefly describes how the above internal events have been prepared for in the design of the plant unit OL3.

Piping damage

The consequences of piping damage may be local or global by nature. Local consequences include the dynamic effects of a pipe break, such as impact loads and jet loads, while global consequences include the effects of the pipe break on the conditions inside the room, such as temperature, pressure and air humidity.

Considering the dynamic effects of pipe breaks means that the dynamic consequences must not damage parallel legs of the safety systems or the structures important to safety stated above. The safety systems are located inside four separate buildings outside of the reactor building. In this case, the consequences of a pipe break in one safety system would only be limited to the system in question.

In facilities that contain several parallel subsystems of systems important to safety, the parallel structures are protected by means of distance and protective structures. These facilities include the reactor and fuel buildings. The main steam lines and feedwater lines have also been designed in a manner where the breaking of a single pipe will not damage the corresponding pipes in other steam generator circuits and the breaking of a steam pipe will not jeopardise the integrity of the feedwater line in the same steam generator circuit (and vice versa).

The structures important to safety must be dimensioned to withstand the applicable loads.

Triple verification has been applied in particular to the primary circuit main coolant pipes, the main steam line parts (from the steam generator to the fixed support point downstream of the isolation valve) and the feedwater line parts (from the steam generator to the containment penetration):

- The pipes have been designed according to the break preclusion principle, which makes the probability of their catastrophic failure extremely small, practically non-existent
- The pipes are equipped with rupture supports in order to limit the dynamic effects of pipe breaks
- The structures important to safety, in particular the reactor pressure vessel and its internal parts (including the fuel and control rods), the steam generators and the containment penetrations have been dimensioned to withstand the loads caused by an unlimited guillotine break of the said pipes.

The global effects of pipe breaks may jeopardise the operability of systems and components important to safety by adversely affecting their operating environment. The dimensioning ambient conditions have been defined for the following facilities in terms of pressure, temperature, air humidity and radiation, if necessary:

- Containment
- Safeguards buildings, including the valve spaces for the main steam and feedwater systems
- Fuel building.

The equipment important for safety located in these facilities must be able to perform its safety tasks under the dimensioning ambient conditions even during the final stage of their planned service life. In practice, this requirement is only significant in terms of electrical equipment. The demonstration of their ambient condition tolerance occurs according to separate ambient qualification routines.

In the annulus between the inner and outer containment, the high-energy pipes run inside jacket tubes, which prevents the creation of adverse ambient conditions as a result of possible piping damage. In some facilities, such as the diesel building, the loss of one parallel subsystem due to ambient conditions is considered acceptable.

The spreading of adverse ambient conditions from the non-safety-classified buildings into the buildings important for safety has been prevented.

Damage to tanks, pumps and valves

The consequences of damage to tanks, pumps and valves have been studied during the design of the plant unit by applying the same principles as described above for the consequences of piping damage. However, the load cases are slightly different: impact loads related to piping damage have not been studied, but on the other hand, the risk of missiles caused by damage to high-energy tanks, in particular, has been considered.

Missiles

Missiles may be created when rotating or pressurised equipment is damaged. Rotating equipment may include pumps, fans, compressors or turbines, for example.

Missile protection aspects have been considered in the design of the following buildings:

- Reactor containment and containment annulus
- Safeguards buildings and valve spaces in the main steam and feedwater systems
- Diesel buildings
- Pump buildings for the diesel-backed seawater system.

As regards safety systems, missile protection is based on the physical separation of parallel subsystems by means of sectioning structures and distance. This limits the possible damage to one subsystem.

Inside the containment, both the safety systems proper and the parallel steam generator circuits are protected with structures that prevent the possible missiles from damaging the other steam generator circuits and jeopardising the integrity of the containment.

The systems and equipment also employ design decisions that aim to prevent the generation of missiles. These include overspeed protection for rotating equipment and mechanical structures that can retain missiles. As regards the plant unit's own low pressure turbines, calculations have been used to demonstrate that any possible missiles cannot penetrate the walls of the turbine casing. Considering an aircraft crash in the design of the plant, for its part, provides sufficient protection against any turbine missiles originating from the adjacent plant units.

Drops of loads

In addition to the safety classification itself, the classification document presents four requirement classes for lifting equipment according to the risks involved in their load handling. In the lower requirement classes, the consequences of the dropping of the load have been shown to be acceptable based on the physical separation of safety systems or the sufficient dimensioning of the structures.

Lifting equipment in the higher requirement classes includes the fuel transfer machines, the polar crane in the reactor building and the crane in the fuel building. This lifting equipment has been designed in a manner where no individual failure or damage can lead to the dropping of the lifted load. Furthermore, analyses have been used to demonstrate that not even the dropping of the dimensioning load will jeopardise the cooling properties of the fuel inside the reactor or fuel pools. Limited fuel damage is possible, however. The reactor pressure vessel lid and the reactor pool deck support beams are examples of dimensioning loads for the polar crane.

Administrative limitations concerning the lifting routes and lifting heights are also used to minimise risks related to lifting.

Plant-internal explosions

The prevention of plant-internal explosions has been the primary design goal. The aim has been to limit the use of explosive gases as far as possible in buildings important to safety. The goal is to prevent the creation of explosive gas mixtures in systems that contain explosive gases (such as the gaseous waste treatment system). Special attention has been paid to managing the amount of hydrogen that is generated inside the containment during accident situations.

If the creation of an explosive gas mixture cannot be completely ruled out, the goal for the design has been to limit the consequences of a possible explosion to an acceptable level.

Fires

Fire protection has three levels of defence-in-depth:

- Prevention of the ignition of fires
- Prevention of the spreading of fires
- Management (detection and extinguishing) of fires.

The parallel subsystems of the safety systems have been separated in a manner that allows the consequences of a possible fire to be limited to one subsystem. In order to ensure this, the structures separating parallel subsystems have a two-hour fire tolerance requirement.

One design basis has been that all the equipment inside the same fire compartment, limited by sectioning structures, can be destroyed. If this is not acceptable for some equipment, this equipment must have been separately protected with structures that have sufficient fire tolerance. These solutions have been necessary in situations where a cable belonging to a specific electrical subsystem runs inside facilities that house another subsystem.

The design has also ensured that any fires will not jeopardise the integrity of the primary circuit or the containment. Especially in case of a loss of coolant accident or severe reactor accident, it is important that the hydrogen concentration of the containment is limited to a level where rapid combustion that jeopardises the integrity of the containment cannot occur, and that a hydrogen fire is prevented from becoming an explosion under the potentially rapid and large hydrogen generation of an accident. The hydrogen management concept for the containment has been designed with this in mind.

In case of a fire inside the main control room, the plant can be brought to a safe state by means of actions taken in the auxiliary control room.

When assessing the effects of the fire on nuclear safety, a simultaneous, independent operational occurrence or accident is not assumed. However, the consequences of the fire on the operation of the plant and the separate systems have been considered.

In principle, a fire limited to one parallel subsystem of a safety system will not jeopardise the ability to manage postulated accident situations.

Plant-internal flooding

In order to protect the parallel subsystems of safety systems against the effects of flooding, the spreading of the flood from one subsystem space to another has been prevented by means of design. The spreading of floods from the non-safety-classified buildings into the safety-classified buildings has also been prevented.

Plant-internal flooding in spaces where sufficient separation between systems cannot be achieved can create a possible common cause failure mechanism. The important safety functions must be ensured even under these circumstances. If some systems or equipment important to safety cannot be sufficiently protected against the simultaneous effects of flooding by means of physical separation, they have been designed to withstand the consequences of flooding.

Considering the consequences of flooding in a specific building or room requires identifying the possible sources of flooding, which allows for estimating the maximum volume of flooding water. This is also affected by any possible alarms received for the flooding and whether the flood can be isolated. In the worst case, it must be assumed that the entire water inventory from the leaking system is released into the room in question. Flood sources may include leaks in tanks or pipelines containing water or the inadvertent start-up of fire-fighting systems using water.

Once the maximum volume of flooding water is known, it must be ensured that this water volume can be routed into spaces in the building (usually in the bottom part) that do not contain equipment that is important for safety and sensitive to flooding. Such equipment is usually electrically operated. This requires that a sufficient building volume and water routes are available. Equipment important to safety can also be located on platforms or podiums above the estimated flooding level.

Any pressure difference loads caused by flooding on the structures of the plant have been considered during the design.

The requirements of Section 15 of the Radiation and Nuclear Safety Authority's regulation are met at the plant unit OL3.

3.9 Section 16 Safety of monitoring and control

1. The control room of a nuclear power plant shall contain equipment that provides information on the operational state of the nuclear power plant and any deviations from normal operation.

At the OL3 plant unit, the control and monitoring of the plant occurs from the main control room that is located in safeguards building 2. The main control room includes all of the systems required for monitoring and controlling the process and relaying information, which allow for managing the monitoring and control of the plant unit under all operational states, including commissioning, refuelling, power operation and possible accident situations.

Furthermore, both emergency diesels have their own local control rooms that allow the diesel unit to be started and synchronised manually when necessary.

OL3 also has a large number of process system specific self-standing systems with local user interfaces. Alarm information is taken to the main control room from these systems.

The monitoring and control of the plant unit is performed by means of the workstation-based Process Information and Control System (PICS). The main control room has four identical work areas: one for the shift supervisor, one for the reactor operator, one for the turbine operator and one for the assistant operator. In an accident situation, the place of the assistant operator is occupied by a safety engineer. Each work area contains several PICS system displays. The operators also have access to three jumbo displays, a plant television system, a fire alarm system, the functions required for starting the gas turbine and the necessary public access and alarm systems.

The PICS system contains control and information displays, alarm lists and trend displays required for the monitoring and control of the plant. The digital operating instructions can also be opened on the PICS system displays. The navigation of the system is mouse-driven.

The main control room also contains the Safety Information and Control System (SICS) which is used for monitoring and shutting down the plant if PICS is not available for some reason. If the operability of the PICS cannot be restored within 4 hours, the plant is operated to a safe state by means of the SICS. Earthquake tolerance is included in the design basis for the SICS.

Some of the functions of SICS are also included in the Hardwired Backup System (HBS). These functions are also available when programmable I&C has been lost completely. The HBS functions are labelled on the SICS panel in order to simplify the work of the operator in cases where programmable I&C is not available for one reason or another. HBS (SICS) also acts as an accident management system when the plant is transferred to a regular state following an accident. However, SAS (PICS) should be primarily used.

A dedicated severe accident I&C system with measurements is also available. The functions are related to SICS.

In the I&C subproject of the OL3 project, the user interface and control room matters are within the area of responsibility of process I&C. The area of responsibility monitors that the design, implementation, testing and commissioning of the Consortium's different control room interfaces and user interfaces follow TVO's requirements, authority requirements and the principles presented in Chapter 18 of the FSAR, Human Factors Engineering. Special attention has been paid to the operation of the Consortium in the verification and validation of control room solutions, functions and instructions. The future operators of OL3 are actively involved in the development of the user interfaces and they provide comments for the documentation and display diagrams that will be displayed in the control room.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

2. A nuclear power plant shall contain automatic systems that actuate the safety functions whenever required and control and supervise their operation during anticipated operational occurrences in order to prevent accidents and during accidents in order to mitigate their consequences.

At OL3, the main I&C systems have been divided into different lines of defence.

The main task of the operating I&C is to keep the plant at a normal operational status.

When a deviation from the normal operational status occurs, the first functions to activate are those of the preventive line of defence. Their goal is to prevent the transients from becoming accident situations. If the preventive line cannot stop the progress of the transient, the next line of defence is the main line that starts the safety functions required during design basis operational occurrences and accidents.

After the main line of defence, there remains the risk mitigation line that aims to prevent the occurrence of severe accidents and to mitigate their consequences. This line of defence aims to stop the most complex sequences, such as the total loss of programmable I&C and common safety system failures.

The systems performing the functions of the different lines of defence have been sufficiently isolated from each other, and the implementation also considers the necessary diversity. System-internal redundancies have also been constructed in accordance with the safety significance required from the system.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

3. These automatic systems shall be capable of maintaining the plant in a controlled state long enough to provide the operators with sufficient time to consider and implement the correct actions.

One of the design bases for OL3's protection system has been the 30 minute rule, which means that no active operator action is required for the first 30 minutes during design basis operational occurrences or accidents. The implementation of this rule requires that the safety systems operate at least at their planned minimum capacity. If this is not the case, operator action may be required earlier. Emergency procedures have been prepared for these exceptional conditions, and they allow the operating personnel to operate the plant to a safe state.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

4. The nuclear power plant shall have an emergency control post independent of the control room, and the necessary local control systems for shutting down and cooling the nuclear reactor, and for removing residual heat from the fuel in the nuclear reactor and the spent fuel stored at the plant.

The plant unit has a separate Remote Shutdown Station (RSS) that allows the plant to be shut down to a safe state in case the main control room has been lost (power operation or post-transient condition, DBC1/DBC2). The remote shutdown station has two PICS workstations for the reactor operator and turbine operator. The functions of these workstations are completely identical to the PICS workstations in the main control room. The remote shutdown also has a fire alarm system and the necessary public access and alarm systems.

The remote shutdown station also has some functions implemented with conventional technology, such as a scram button located on a panel. The control systems of the main control room and remote shutdown station have been separated in a manner where the nuclear reactor and residual heat removal can only be controlled from one control location at a time.

The remote shutdown station is included in the design for the main control room and the user interfaces and its implementation, verification and validation are described in the quality plan and V&V plan for the main control room and the user interfaces.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

The requirements of Section 16 of the Radiation and Nuclear Safety Authority's regulation are met.

3.10 Section 17 Taking the safety of the decommissioning into consideration in the design and the safety of decommissioning

1. The design of a nuclear power plant and its operation shall take account of the decommissioning of plant units so that it is possible to limit the volume of nuclear waste for final disposal accumulating during the dismantling of units, and radiation exposure to workers due to the dismantling of the plant, and to prevent radioactive materials from spreading into the environment during decommissioning and the handling of waste.

The decommissioning of OL3 is discussed in chapter 20 of the final safety analysis report and in the separate decommissioning plan that is submitted together with the operating licence documentation. The Nuclear Energy Act states that, after the operation of the plant has started, the decommissioning plan must be updated every six years. Going forward, it will be purposeful to discuss the decommissioning plan for all of the Olkiluoto plant units within the same document. The *Decommissioning plan for the Olkiluoto nuclear power plant* that concerns the plant units OL1 and OL2 and the KPA storage was submitted to the Ministry of Employment and the Economy

During the design of the plant, one of the factors guiding the design of all systems has been the principle of separating the systems and equipment containing activity into dedicated rooms. One of the criteria for material choices has been the goal to achieve a low level of contamination, and the systems have been designed in a manner that allows for their easy decontamination.

During operation, the amount of waste requiring final disposal is limited mainly by keeping the contamination of the plant as low as possible. Radiation Protection's ALARA principle of keeping radiation doses at a suitably low level also serves the low contamination goal of the future decommissioning.

The contamination of the OL3 plant unit will be monitored regularly in a similar manner to the OL1 and OL2 plant units (DOSRAT and MADAC measurements). The basic design for OL3's radiation measurement point system has been laid out in the diploma thesis Uuden ydinvoimalaitoksen huoltoseisokkien aikaisten säteilyannosnopeuksien mittapistejärjestelmä ja huoltoseisokkien säteilyannosten minimointi (Measurement point system for service outage-time radiation dose rates at a new nuclear power plant and minimising radiation doses during service outages). TVO's experience in reducing the level of contamination at the OL1 and OL2 plant unit has provided valuable insight into minimising the amount of foreign material in the primary circuit, for example.

Minimising the radiation doses during decommissioning in terms of both the employees and the environment can be achieved by means of the purposeful planning and systematic implementation of the decommissioning. The stages described in more detail in the decommissioning plan are as follows:

- Stopping power operation and removal of fuel from the plant unit
- Decontamination and the removal of contaminated process systems and their decontamination, if necessary
- Removal of the pressure vessel and the activated components.

During all stages, the active waste is treated and packed for interim storage and further for final disposal.

The requirements of Section 17 of the Radiation and Nuclear Safety Authority's regulation are met.

4 Chapter 4 Safety of the construction and commissioning of a nuclear power plant

4.1 18 § Safety of construction

1. During construction, the holder of a construction licence for a nuclear power plant unit shall ensure that the plant is constructed and implemented in compliance with the safety requirements and using the approved plans and procedures.

The Land Use and Building Act and Decree contain provisions concerning zoning, municipal building codes, planning and construction of shore areas, plot distribution, redemption related to civil engineering, general requirements for construction, licences related to construction and other forms of construction supervision. In addition to these provisions, the YVL Guides issued by the Radiation and Nuclear Safety Authority and the Finnish Building Code (RakMK) have been followed during the implementation of the buildings.

Different design bases were drawn up for buildings classified in terms of nuclear safety that take into account the safety requirements of the YVL Guide. The design specification of the containment, which is a part of safety class 2, is based on current Eurocodes and, in particular, on Eurocode EC2, prEN 1992-1-1, April 2003, "Design of Concrete Structures". During the development of the specification, it was also ensured that it meets the commonly used containment standard ASME Section III, Division 2, Subsection CC (ACI 359), Concrete Containments. A dedicated design specification was also drawn up as the design basis for the containment liner plate based on ASME (ACI STANDARD 359–04). Severe reactor accidents, among other things, have been considered in the design of the containment, and earthquakes and large aircraft crashes have been observed in the design of the plant.

A dedicated design specification was drawn up for nuclear safety class 3 buildings, also based on the Eurocodes. Standards approved in Finland have been used as the design basis for buildings that are not classified in terms of nuclear safety. The design of the long-term durability of the concrete structures also meets the requirements of the Finnish Concrete Code BY 50 (2004).

As regards exit routes, the Finnish Building Code has been followed whenever possible. The interpretations of the regulations have been agreed on during meetings between the licensee and the necessary authorities (building inspector, STUK, fire authorities). The plans for structures classified in terms of nuclear safety have been inspected by an independent consultant before their submittal for authority approval. The construction has been carried out by means of approved plans.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

2. The licensee shall ensure that the plant supplier and the subcontractors delivering services and products important to safety act in compliance with the safety requirements.

The meeting of the regulations concerning the construction of plant unit OL3 has been ensured by means of monitoring activities, work stage inspections, structural inspections and structural reviews carried out during the construction of the plant and assessed during the commissioning inspections of the structures and buildings.

The plant supplier and its contractors providing services and products important for safety have also been regularly audited during the construction project.

The OL3 nuclear power plant unit has been constructed and implemented according to the safety requirements by using approved plans and methods. The plant supplier and its subcontractors have acted according to the safety requirements during construction. The observed deviations from the approved instructions, standards and specifications have been or will be processed according to planned procedures that have been approved by the authority.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

The requirements of Section 18 of the Radiation and Nuclear Safety Authority's regulation are met

4.2 19 § Safety of commissioning

1. In connection with the commissioning of a nuclear power plant unit, the licensee shall ensure that the systems, structures and components and the plant as a whole operate as designed.

The plant supplier will be drawing up a Commissioning Manual for the commissioning of the power plant; its technical part describes the testing of the plant's systems, structures and components and the joint functional tests for the entire plant.

The technical part contains the test programmes used during the commissioning of the plant and the detailed test programmes and instructions, such as the following:

- The overall plant commissioning programme
- Phase commissioning programmes
- System commissioning programmes
- Standard test instructions for equipment and components
  - Commissioning worksheets
  - Standard commissioning instructions
- Detailed system commissioning instructions.

The overall plant commissioning programme is a framework programme that describes the different stages of test operation and the plant test operation at every stage on a general level. The overall plant commissioning programme defines the goals for the test operation and refers to the appropriate authority regulations. The overall plant commissioning programme also clearly differentiates between non-nuclear and nuclear test operation. The overall commissioning programme lists all of the phase and system specific test programmes required at different stages of the commissioning, the joint operation tests and the standard tests. The overall commissioning programme also describes the inspection and approval procedures for the different commissioning programmes and the principles of reporting the results.

The system commissioning programmes describe the tests performed for each system during all the stages of the commissioning, right up to the end of nuclear commissioning when the plant is operating at full power. The system commissioning programme is supplemented with references to standard test instructions and detailed instructions.

Phase commissioning programmes are used starting from the non-nuclear joint operation test phase (cold and hot tests with no nuclear fuel) and until the end of the test operation of the nuclear systems. The phase commissioning programmes describe how the test operation of the plant systems is tied together into commissioning programmes that cover the entire plant. These phase commissioning programmes use system-specific test programmes, the plant's normal operating procedures and standard test instructions.

All of the commissioning programmes prepared by the plant supplier are submitted to TVO for approval. As the licensee, TVO submits the commissioning programmes to the authority for approval or information. The result reports from the test operation are processed in the same manner; they are submitted to TVO for approval and further to the authority for approval or information in accordance with the YVL Guides.

The commissioning programmes drawn up by the plant supplier are comprehensive and they have been drawn up with a goal to ensure that the design bases of the plant's systems, structures and components are met.

The requirements of the Radiation and Nuclear Safety's regulation are met as regards commissioning.

2. At the commissioning stage, the licensee shall ensure that an expedient organisation is in place for the future operation of the nuclear power plant, alongside a sufficient number of qualified personnel and instructions suitable for the purpose.

The power plant's operating line organisation and nuclear safety organisation and their management relationships, tasks, authorities and qualification requirements are presented in the administrative rules of the Olkiluoto nuclear power plant that is required by Section 122 of the Nuclear Energy Decree (161/1988). The administrative rules observe the responsibilities and leadership relations of the OL3 unit during its construction and operation. The regulatory authority has approved the management code.

Teollisuuden Voima Oyj's organisation and the tasks of the organisation units have been presented in more detail in the separate organisation manual that observes the responsibilities and leadership relations of the OL3 unit during its construction and operation.

The commissioning organisation and its operation are described in the organisation part of the plant supplier's Commissioning Manual which the licensee has approved and submitted to STUK for information. The power company has used this plan to prepare a resource estimate and plan concerning the amount of in-house personnel required during the commissioning, and has estimated that the plant supplier's resource estimates are purposeful. The licensee has drawn up its own commissioning plan for OL3 that describes the different stages of commissioning, the performance of the tests and the arrangement of the licensee's organisation for the commissioning of OL3.

The same personnel that will be operating, supervising and maintaining the plant unit will participate in its commissioning. This personnel has participated in the technical implementation of the plant and the evaluation and approval of its technical documentation from the beginning of the project. Each of TVO's employees have been assigned position-specific qualification requirements and personal training plans. The persons appointed for the commissioning organisation are experts in their area of responsibility and qualified for their tasks through their work on the OL3 project or in the operation of the OL1/OL2 plant units.

Operation and commissioning instructions have been prepared for the commissioning of the equipment and systems; they have been approved by the power company and the regulatory authority (STUK) and will be used during the commissioning of the OL3 plant unit.

The commissioning instructions are based on the final safety analysis report (FSAR) and the Technical Specifications (TTKE) created for the plant unit. These documents, similarly to the operating instructions that are significant for safety, have been approved by the power company and the regulatory authority before commissioning is started.

The validation of the above instructions and practices is a significant part of the commissioning stage; this means that their applicability for the safe operation of the plant is ensured.

The requirements of Section 19 of the Radiation and Nuclear Safety Authority's regulation are met.

5 Safety of the operation of a nuclear power plant

5.1 20 § Safety of operation

1. The organisation operating a nuclear power plant shall be responsible for the plant's safe operation.

In accordance with Section 9 of the Nuclear Energy Act, it is the licensee's duty to ensure the safety of the use of nuclear energy and to see to the security, emergency response and other arrangements necessary to reduce nuclear damage that do not rest with the authorities.
The administrative rules of the Olkiluoto nuclear power plant describe the tasks, responsibilities and authorities that are significant in terms of nuclear safety and radiation safety. The administrative rules are constantly updated and require approval from STUK. No changes to the administrative rules are taken into use without approval from STUK.

The administrative rules present TVO's organisation and its leadership relations and the tasks, authorities and responsibilities of the persons and organisation units that participate in the following activities:

- the plant's operational activities
- supervision of reactor operation
- safety during the construction of Olkiluoto 3
- emergency response arrangements, security arrangements and safeguards of nuclear materials
- inspections and follow-up related to nuclear safety.

The administrative rules present the responsible managers referred to in Section 7 k of the Nuclear Energy Act and their deputies and the persons responsible for emergency response arrangements, security arrangements and safeguards of nuclear materials referred to in Section 7 i of the Nuclear Energy Act and their tasks, authorities and responsibilities.

The Operations section of the OL3 Operations unit is primarily responsible for the operational activities of the OL3 plant unit. The OL3 Operations section belongs to TVO's Operations unit and is a part of TVO's Electricity Production business, which is led by a business manager. He/she also acts as the responsible manager referred to in Section 7 k of the Nuclear Energy Act. According to TVO's basic organisation, which is described in the administrative rules, TVO's Electricity Production business has access to TVO's different organisations and their expertise during operation.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

2. The control room of a nuclear power plant unit shall be constantly manned by a sufficient number of operators aware of the state of the plant, systems and components.

The Technical Specifications (TTKE) define the minimum staffing for the main control room and the plant area per plant unit, and they also contain provisions concerning the working time of the shift personnel. At least two persons approved according to the Radiation and Nuclear Safety Authority's YVL Guides shall be in the control room or its immediate vicinity at all times.

The shift personnel is divided into seven shift crews. Each shift includes a shift supervisor, reactor operator, turbine operator, area operator and two field supervisors. The shift supervisor is responsible for meeting the Technical Specifications requirements concerning minimum staffing and working hours for the shift. If the crew is short-staffed, but not below the minimum, the shift supervisor will consider the situation in order to determine whether reinforcements are needed.

The tasks of the shift personnel are defined in the procedures included in the operations manual. All shifts are responsible for monitoring adherence to the Technical Specifications, supervising the operating condition of systems, writing defect reports, maintaining overall housekeeping standards at the plant, locking doors, performing test operation, preparing work permits etc. The shift crew has a personal feel of the plant unit.

The shift supervisor, reactor operator, turbine operator and area operator are responsible for ensuring that the control room has an overall understanding of the status of the plant unit during operating procedures. The licensed operators and the shift supervisor guide and supervise the activities of the field operators at the plant. The shift personnel perform the inspection rounds according to the operations routines in the control room and at the plant unit. As regards the plant monitoring performed in the control room, trend follow-up for the reactor and turbine processes is performed at the beginning, middle and end of the shift, at a minimum. The plant camera system is used in the monitoring of the containment and the other facilities with high radiation or contamination levels.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

In the control and supervision of a nuclear power plant, written instructions that correspond to the current structure and operational state of the plant shall be used.

The instructions guiding Teollisuuden Voima Oyj's activities have been compiled into separate manuals that cover all the functions related to the operation, maintenance and technical support functions of the plant in a sufficient manner. The most important instructions and manuals that guide the operation of the nuclear power plant have also been approved by the regulatory authority.

The plant supplier has prepared the Technical Specifications and the commissioning, operating, testing and maintenance instructions for the plant unit, among other things. Furthermore, the instructions in use at the OL1/OL2 plant units have also been updated in order to guide the activities at the OL3 plant unit.

The organisation units responsible for maintaining the instructions in the manuals and the procedures followed during their maintenance have been defined. Each organisation unit that is responsible for instructions included in the plant instructions is also required to keep the instructions up to date. Even if there is no immediate need for change, the instructions are periodically reviewed according to the quality system. All the instructions that are important in terms of safety and instructions that directly affect the practical performance of different operations are immediately updated when needs for change occur.

Each year, TVO's Quality and Corporate Social Responsibility functions perform several follow-up inspections that assess the company's operation. The inspections are normally focused on a specific function, such as operations. The review also verifies that the instructions are sufficient and up to date. Furthermore, the documents are supervised by means of separate periodic reviews (covers the entire process from the authoring of the document to its storage).

The Technical Specifications define that the operation of the plant units OL1, OL2, OL3 and the KPA storage and VLJ facility must adhere to technical specifications that define the highest allowed limiting values, the conditions and limitations to plant use resulting from the operability of structures, systems and components, the frequency and types of tests performed on structures, systems and components and the administrative procedures followed during the operation of the plant. The control room carries out the actions according to approved instructions.

Instructions that are intended to guide the performance have been prepared for normal operation as well as disturbances, accidents and emergencies; more instructions are prepared when necessary. The head of the Operations section, the on-call officer or the manager of the Operations unit will be contacted if necessary. A separate Severe Accident Management Guide has been prepared for the emergency response organisation in preparation for severe accidents. It is not a part of the operations manual proper.

- The plant unit will employ an electronic operations manual that shows the instructions in XML format on the operator's display terminals. Online process values have been directly embedded in the electronic instructions, which allows the operator to easily gather the status of the plant process and there is no need to switch to a process display in order to verify a specific value. The instructions have direct links to related instructions. Traditional printed instructions are also available in the OL3 control room for use as back-ups.

Most of the instructions required for operation have been compiled in the operations manual. Operating orders and operational bulletins are also used to regulate operation. The plant supplier has delivered all of the operating instructions, disturbance instructions or emergency instructions required for the operation of the plant, or will deliver them in good time before fuel is loaded into the reactor. After commissioning, they will be updated on a four-year cycle. All the instructions in the operations manual are updated electronically. Based on operating experience from OL1/OL2, the updates to the procedures are mainly due to modifications and improvement proposals from the operating personnel.

The plant instructions are sufficiently comprehensive and up to date for meeting the requirements for the flawless performance of functions important for safe operation.

The review and approval process for plant instructions meets the requirements set for it and operates as intended.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

Written orders and appended instructions shall be issued for the service and repair of components.

Operation and maintenance instructions, periodic test programmes and the preventive maintenance tasks required for drawing up preventive maintenance programmes are provided for the operation and maintenance of the plant unit. TVO uses this documentation to draft the preventive maintenance programme for the plant.

The planning, control, implementation and reporting of work at the plant unit is performed by means of the plant supplier's CMS work management system and TVO's TTJ work management system. The plant supplier (CFS) uses CMS during the commissioning until the provisional takeover (PTO). TVO prepares for the commissioning of its own work management system (TTJ) during the test operation and commissions it once readiness for using the work management system exists, however at the latest after the PTO.

The work management systems (CMS and TTJ) are used to plan and control defect reports, commissioning tests and periodic tests, maintenance work and process isolations. They are used to ensure that the necessary process isolations and restorations are completed and that any matters required for occupational safety are attended to. Furthermore, the systems are used to divide the work into phases, provide the instructions and schedules for the work phases and to reserve the human and material resources.

The defect reports and any work requests that affect the operation of the plant unit are approved by the shift supervisor. Other work requests are approved by the organisation that fulfils them. The organisation responsible for fulfilling an approved work request sets up one or more work tasks. The organisation responsible for planning and implementation manages the work planning and defines the instructions and resources required for the work as well as the resources.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

3. For anticipated operational occurrences and accidents, instructions suitable for the identification and control of incidents shall be available.

For anticipated operational occurrences and emergencies, instructions suitable for the identification and control of incidents are available. The instructions will be supplemented as necessary during the lifecycle of the plant.

OL3's plant unit specific instructions (normal start-up and shutdown instructions, disturbance and emergency instructions) are flow diagrams where the tasks of the shift supervisor and the reactor and turbine operators are recorded. These flow diagrams contain references to more detailed procedures for starting a main coolant pump, for example. There are separate procedures for the shift supervisor and the different operators.

The plant unit's on-call officer has dedicated instructions for identifying the situation and monitoring the safety functions. The on-call officer has an appointed task during disturbances and emergencies at the plant. The shift supervisor is responsible for the tasks of the on-call officer before he/she arrives at the plant.

The emergency instructions are divided into event and symptom based instructions. The emergency instructions are always switched to on the basis of the H alarm (Hazard alarm, usually 8 pcs) issued by the plant computer. Emergency instructions consist of the following, separate instructions:

- Identification instructions for establishing whether the emergency is event or symptom based
- Follow-up instructions for safety functions (dedicated instructions for the early stages of an emergency, event-based emergencies, symptom-based emergencies and severe reactor accidents
- The actual emergency instructions for event and symptom based emergencies.

Background documentation that explains/justifies the strategy applied to specific instructions will be drawn up for the plant specific disturbance and emergency instructions. The update needs for disturbance procedures usually result from modifications, experience from simulator runs or international experience.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

4. Operational measures concerning the nuclear power plant, as well as events having an impact on safety, shall be documented so that they can be analysed afterwards.

To prevent the reoccurrence of a disturbance, it is important to be aware of all immediate causes and root causes. Sufficient documentation concerning the disturbance is a prerequisite for the investigations performed in order to determine them. The control room is responsible for compiling the information both during and outside office hours, and submits the compiled information to the head of the Operations section for the preparation of the report. The list of printouts to be collected is included in the shift's operational disturbance report form. From the Operations section, the shift's operational disturbance report with the necessary supplementary documentation is submitted to the Reactor Safety section for analysis. The Reactor Safety section prepares an analysis of the operation of the safety systems and the behaviour of the process variables during the disturbance as soon as possible after the disturbance. The analysis is appended to the reports drawn up concerning the disturbance. These include special reports, scram reports and operational disturbance reports.

The reports drawn up for a disturbance are defined in the procedure "Olkiluodon ydinvoimalaitoksen käytöstä laadittavat raportit" (Reports prepared concerning the operation of the Olkiluoto nuclear power plant). The reports that are drawn up for events according to the procedure are known as the scram report, operational disturbance report, event report and special report. A root cause analysis report may also be drawn up for the event in order to prevent the reoccurrence of events.

The Mechanical Maintenance office draws up a report for equipment failures leading to production limitations and planned shutdowns intended for repairing any defects. Any separate memorandums concerning disturbances are stored in the relevant offices.

The requirements of Section 20 of the Radiation and Nuclear Safety Authority's regulation are met.

5.2 21 § Taking operating experience and safety research into consideration in order to improve safety

1. Safety-significant operational events shall be investigated for the purpose of identifying the root causes as well as defining and implementing the corrective measures.

TVO has created procedures for the drawing up of event-based operational event reports. TVO uses the following forms of reporting in event-based operational event reports: special report, event report, operational disturbance report, scram report and root cause analysis.

The existing instructions are followed for drawing up the operational event reports and for defining the corrective actions. If the root cause of the event cannot be unambiguously determined during the investigation or the event involves several different organisations, TVO's instructions state that a separate root cause analysis must be drawn up that extends the investigation in order to determine the root cause.

Tasks that are defined as corrective actions during the operational event reports are scheduled and the responsible organisations for the tasks are defined. The completion of the tasks is tracked in TVO's systems. TVO has drawn up event reports for events that have taken place during the construction of OL3.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

2. In order to continuously improve safety, there shall be regular monitoring and assessment of operational experience feedback, the results of safety studies and technical developments at the plant in question and at other nuclear power plants.

Since the EPR is an evolution-type plant concept, its design has been able to utilise information that has been accumulated from the design and operating experience of earlier plants, in particular in France and Germany. The plant supplier has described these activities in the appropriate topical report of the final safety analysis report for OL3. The participation of French and German power companies in the basic design of the EPR concept has boosted the utilisation of operating experience.

However, the monitoring and utilisation of operating experience is not limited to the basic design stage of the plant option; instead, it is a part of the plant supplier's continuous operation. The primary sources of operating experience are the cooperation with the VGB (Vereinigung der Grosskraftwerkbetrieber) and FROG (Framatome Owners´ Group) groups, the event database maintained by INPO (Institute of Nuclear Power Operations) and the event reports published by the IAEA. The FROG group, for example, has representation from a total of approximately 70 organisations operating pressurised water reactors. According to the plant supplier, any events that correspond to at least class INES 1 on the International Nuclear Event Scale are evaluated and the lessons learned are used in ensuring the safety of new plant units.

TVO has also been monitoring operating experience concerning pressurised water reactors during the construction stage of the plant unit, that is, since early 2005. It has also been monitoring nuclear power plant events that deal with electrical systems, for example, and are therefore mostly independent of the plant type and interesting in terms of OL3. The main sources for the monitoring have been the event reports published by WANO, the IRS event reports published by the IAEA and nuclear power plant events discussed in the industry press.

Any significant events and events requiring additional information have been collected, and the plant supplier has been asked to assess the significance of the events in terms of the safety of the plant unit. The collected events are mainly of a nature that have been considered to have a potential effect on the design decisions of the plant unit. However, the selection also includes events that have been considered necessary to observe when drawing up the operation or testing instructions or the Technical Specifications. One example of a modification made due to the processing of these events is a design change made during the construction of the plant unit that aims to reduce the risk of the loss of fuel pool water.

TVO is involved in the NordERF cooperation with Swedish nuclear power companies. NordERF processes operating experience from several different sources. The experience is prescreened on the basis of their relevance to the power plants included in the NordERF cooperation, and any significant operating experience is subjected to a more detailed review and discussed during a joint meeting. The NordERF cooperation started in early 2014 and it has also involved pressurised water reactors since the beginning.

TVO is a member of the VGB group that processes operating experience from the plants that form the basis of the EPR plant concept. The group has wide representation from the German Konvoi plants, among others, and it also discusses operating experience from EDF's nuclear power plants that is presented by their representative. Furthermore, TVO has been maintaining contact with the future operating organisation of the EPR plant being constructed in Flamanville, and the intention is to continue these activities. Going forward, OL3's operating organisation will assess whether the operating experience activities need to be expanded from their current state.

TVO's operating experience group assesses events from TVO's own nuclear power plants and other power plants from the point of view of different branches of technology. In order to enable possible further action, the operating experience group will inform the different branches of technology within TVO's organisation about any events that it considers significant in terms of OL3 in a suitable format and scope.

The research and development activities conducted in order to support the design decisions of the EPR plant concept have been described in the final safety analysis report for the plant unit. The design has been largely able to draw on experience from the design and operation of earlier French and German plants. New, specific experiments have mainly been required in order to verify the characteristics of the EPR design insofar as they differ from the equivalent characteristics of earlier power plants.

The internals of the EPR plant's reactor differ significantly from the equivalent components in earlier plants. Among the differences are the use of a heavy reflector in the EPR and the differences in the structures of the control rods and their control equipment. For this reason, extensive heat and flow technology tests of the pressure vessel internals have been performed in order to ensure the functionality of the plant concept. The tests have partially been specific to OL3, since, for example, the insertion of control rods during the guillotine break of a main coolant pipe has not been required for the basic EPR version, but it is considered necessary for ensuring the cooling properties of the fuel in the Finnish requirements that were in force at the time of the plant's design. The performed tests have indicated that the pressure vessel internals are compliant with the requirements.

The characteristics of the emergency cooling systems also differ from earlier plants. In order to improve the management of primary–secondary leaks, the head of the medium-pressure emergency cooling system pumps has been lowered. As a result, the functioning and efficiency of emergency cooling has required experimental confirmation, in particular in the case of medium-sized primary circuit leaks.

A substantial part of the experimental activities supporting the design of the EPR has been related to the verification of characteristics related to severe reactor accident management. Above all, this is due to the fact that the EPR is the first nuclear power plant being constructed in Europe whose design has considered the possibility of severe reactor accidents from the beginning. The performed tests cover all the stages of a severe reactor accident, from the starting of core damage inside the reactor pressure vessel to the moment when the molten core material has spread into the spread area on the bottom floor of the containment. The management of hydrogen inside the containment has also been studied experimentally. The tests performed have confirmed the functionality of the severe reactor accident management concept.

A part of the tests described above have been performed in parallel with the construction of the of the plant unit. This is especially true for the OL3 specific tests. TVO's safety group has been regularly following up on the progress and results of this testing during its meetings.

Experiments have also been performed within the framework of the Finnish Research Programme on Nuclear Power Plant Safety, SAFIR, which have been beneficial during the evaluation of the design decisions of the OL3 plant unit, even though the intention has not been to make the tests specific to OL3. Experiments concerning the behaviour of structures during an aircraft crash are examples of this.

Operating experience and experimental research have been utilised in the design of the plant unit in a manner that meets the requirements in the Radiation and Nuclear Safety Authority's regulation.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

3. Opportunities to technically and organisationally improve safety resulting from operational experience feedback, safety studies and technical developments shall be evaluated and implemented to the extent justified on the basis of the principles laid down in Section 7 a of the Nuclear Energy Act.

TVO has instructions concerning operating experience activities that are used for evaluating operating experience and implementing the necessary changes at TVO's nuclear facilities.

The Finnish Research Programme on Nuclear Power Plant Safety is a central forum for performing research and improving competence. The SAFIR 2010–2018 programmes have created competence and models that are also suited for the technology and operation of an EPR type reactor. TVO's experts have been involved in all of the groups that guide the programme, actively providing information concerning the research needs and the questions related to the operation of the plant. Most of the research is still ongoing and it will be updated during the planning of the programmes. The goal of the programme is to ensure the competence and preparedness available to the authorities; therefore, plant-specific questions always require plant-specific research.

As regards I&C, the research programmes have studied the means by which I&C work will be implemented at OL3, and they have provided information related to the licensing of OL3 and the qualification of the control room. The research related to requirements management has also been available for the needs of OL3.

In terms of fuel research, the parameter analysis of the areas of effect and the development of the calculation system will be useful in practice. New information has also been received for the activity inventory of the EPR fuel assembly and the residual heat analyses.

Research in material technology and lifetime management has mainly been focused on modern nickel-based materials, dynamic yield ageing in stainless steels and the characterisation of fracture mechanisms in dissimilar ferrite and austenitic metal joints.

As regards structures, MMI, Scanscot and Pöyry have performed "benchmark" analyses for buildings and structural parts, which have been used as basis for commenting on the analyses and approval criteria drawn up by the plant supplier's designer. The durability of the structures and the relaying of vibration into the equipment and components have been studied in relation to aircraft crash and earthquake loads.

The aircraft crash research and load analysis performed within the framework of the SAFIR programme have been closely related to the OL3 containment, which makes them very usable for the purposes of this project. Furthermore, some of the methods produced in connection with the PSA studies have already been taken into use. Following the development of the methods is important.

The structural durability of the containment, containment liner and other structural parts has been analysed by means of linear and non-linear strength models. The mock-up tests performed before the implementation of the structures are also a part of the power plant specific research. They have been used to ensure that work is successful during concrete casting and the different work phases.

The plant supplier has performed extensive studies when determining the acceptability criteria for the containment liner plate, for example. The Nugenia Accept project that took place between 2012–2014 carried out experimental research concerning the durability of the liner plate. In addition to the plant supplier's own analyses, Energiforsk's research programme has analysed the preservability of the force of the reinforcement steels in OL3's containment.

As a separate technology project, TVO has launched a project related to estimating the ageing of a new type of dissimilar metal joint in cooperation with research organisations and Swedish power plants. The project studies a model joint for OL3's main steam line by experimental methods. The results will be utilised in lifecycle management. If necessary, similar research projects will be started by using experience from the other EPR operators and international research programmes.

TVO has put substantial effort into the future research infrastructure and its development during the construction of the OL3 plant unit, and this is expected to continue after operation has started. After the experimental reactor project JHR MTR in France is started around 2020, it will enable fuel and materials testing to be performed in a versatile reactor environment far into the future. The new hot chamber facilities in the VTT Technical Research Centre of Finland's nuclear safety house will be taken into use in 2018, and they are expected to offer opportunities for researching activated structural materials – including reactor internal materials which have been impossible to study in Finland thus far. The Lappeenranta University of Technology has been developing preparedness for thermodynamic experiments. The cooperation has enabled the verification of flow models and accident models and the development of multi-phase flow models. Experimental work has also helped to establish good connections with international research projects.

The requirements of Section 21 of the Radiation and Nuclear Safety Authority's regulation are met.

5.3 Section 22 Operational Limits and Conditions

1. The Operational Limits and Conditions of a nuclear power plant shall include the technical and administrative requirements for ensuring the plant's operation in compliance with design bases and safety analyses. Furthermore, the requirements for ensuring the operability of systems, structures and components important to safety, as well as the limitations to be observed when the equipment is inoperable, shall be given in the Operational Limits and Conditions.

The Technical Specifications (TTKE) for the plant unit consist of a requirement and justification part. The layout of the document is based on *NUREG-1431: Standard Technical Specification.*

The document sets forth technical requirements for all of the structures, systems, equipment, process variables and instrumentation presented in the final safety analysis report of the plant that meet at least one of the following five (5) criteria:

Criterion 1: Instrumentation that is used to detect a substantial reduction of the primary circuit pressure boundary and to indicate it within the control room.

Criterion 2: A process variable, plant characteristic or operational limit that is the initial assumption for an analysis of a postulated accident or anticipated operational occurrence and that leads to the damage of a fission product release barrier or jeopardises its integrity.

Criterion 3: A structure, system or component that is a part of the primary success scenario and whose operation or start-up is a part of the preparation for a postulated accident or anticipated operational occurrence, and which leads to the damage of a fission product release barrier or jeopardises its integrity. For OL3, this criterion has been expanded to apply to design extension conditions (DEC).

Criterion 4: A structure, system or component that has been demonstrated to be significant in terms of the health and safety of the population through operating experience or a risk-informed analysis (PRA).

Additional criterion: Requirements that the Radiation and Nuclear Safety Authority (STUK) has demanded. Examples of these are the Technical Specifications requirements concerning release limits and heavy lifting.

The scope of the administrative requirements is based on TVO's practices that have been followed for decades at the OL1 and OL2 plant units. The differences between the plant types have been taken into account in the set requirements.

The justification part of the document describes the background of the technical and administrative requirements, presents the connection between the set requirements and the applicable safety analyses, and justifies the operational limitation times for the defined failures and the performance intervals for the required monitoring activities.

The verification of performance for structures, devices and components that are important for safety is based on meeting the monitoring requirements defined in the Technical Specifications. The monitoring requirements have been defined in a manner that allows for unambiguously determining whether the Technical Specifications requirement targeted by the monitoring is met. If it is discovered that the requirement is not met, the process moves to a failure scenario: this can be defined as "one subsystem unavailable" or "process variable exceeding the limit", for example. Any existing unavailability must be restored to a compliant status within the operational limitation time defined in the failure scenario. If the restoration is unsuccessful, the plant unit must be operated to the safe state defined by the failure scenario.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

2. The plant shall be operated in compliance with the Operational Limits and Conditions, and compliance with them shall be monitored and any deviations reported.

The shift supervisor is directly responsible for ensuring compliance with the Technical Specification. The operational monitoring of the nuclear power plant is the responsibility of the Nuclear Safety Supervision team within the Nuclear Safety competence centre. If it is discovered that the operation of the plant deviates from the Technical Specifications, a report concerning the matter must be drawn up according to TVO's procedures and the YVL Guides and submitted to the Radiation and Nuclear Safety Authority for approval. The reporting is managed by the Nuclear Safety Supervision team.

The requirements of Section 22 of the Radiation and Nuclear Safety Authority's regulation are met.

5.4 Section 23 Condition monitoring and maintenance to ensure the safety of the facility

1. Systems, structures and components important to the safety of a nuclear power plant shall be operable in accordance with the requirements on which their design is based.

2. Operability and the effects of the operating environment shall be monitored by means of inspections, tests, measure-

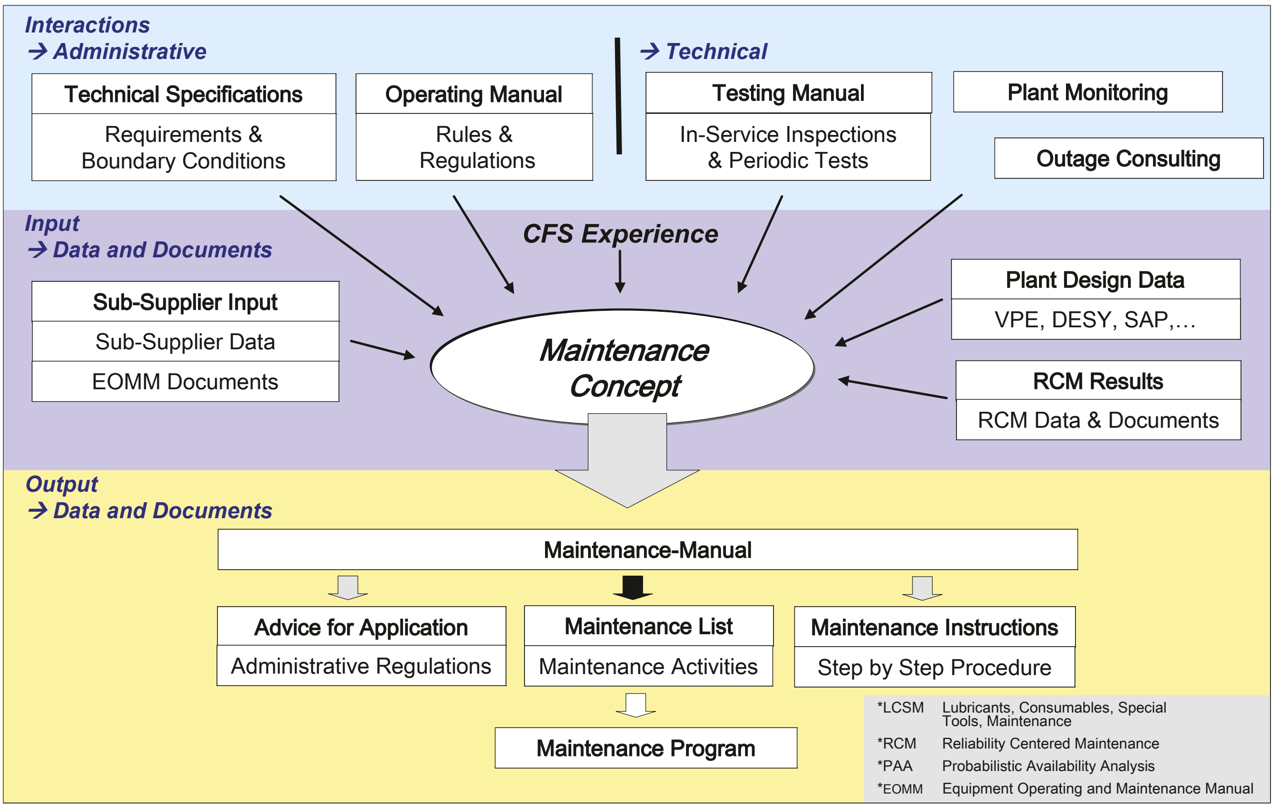


Figure 1 Maintenance concept

ments and analyses. Operability shall be checked in advance by regular maintenance, and provisions shall be made for maintenance and repairs in the event of any deterioration in operability. Condition monitoring and maintenance shall be planned, supervised and implemented so that the integrity and operability of systems, structures and components are reliably preserved throughout their service life.

A maintenance concept related to the planning of the maintenance programme has been drawn up in cooperation with the plant supplier, and the documentation presented in Figure 1 has been used as the initial data.

The input data and documents for the concept are the preventive maintenance tasks recommended by the equipment manufacturer, the maintenance instructions for the equipment and the results from the RCM (Reliability Centred Maintenance) analysis. The interaction with administrative and technical issues, such as the requirements in terms of condition monitoring, outage planning and Technical Specifications is also observed; these are not directly used as input data, but they are mainly used in the scheduling, optimisation and planning of the maintenance tasks. The output data and documents form the preventive maintenance plan that includes an outline of the preventive maintenance tasks and intervals and the equipment maintenance instructions, on the basis of which TVO will draw up the final preventive maintenance programmes into the existing maintenance information systems.

The most important initial data used in maintenance planning are presented in more detail below.

Maintenance classification

At the Olkiluoto 3 plant unit, the maintenance planning for equipment is based on dividing the equipment locations into four maintenance groups, similarly to Olkiluoto 1 and Olkiluoto 2. The maintenance class is selected on the basis of the effects of equipment failure on the safety and availability of the system and the entire plant. The classification takes into account the significance of the equipment in terms of operational reliability and safety. The maintenance class affects the spare parts arrangements for the equipment location and the selection of preventive maintenance and condition monitoring tasks. The division of the maintenance classes is roughly as follows:

Class 1: the equipment is maintained in working order at all times
Class 2: limited unavailability is allowed for the equipment
Class 3: financially justified preventive maintenance is allowed
Class 4: no planned preventive maintenance.

Using the RCM method in maintenance planning

The RCM method is used in the maintenance planning of equipment that is important in terms of the safety and availability of the plant unit; it is used to define/verify the maintenance classes, maintenance procedures and the intervals for the maintenance tasks. The starting points for the RCM method are the Technical Specifications, the probabilistic risk analysis (PRA), the operational reliability analyses (PAA) and expert assessments.

Testing manual

The in-service tests and inspections are compiled in a nuclear and conventional testing manual according to the procedures created in cooperation with the plant supplier. The plant supplier will submit the in-service testing and inspection tasks to TVO separately.

Condition monitoring

At the Olkiluoto 3 plant unit, condition monitoring is divided into continuous and periodic parts. The most important equipment at the plant unit will have fixed condition monitoring systems that will contribute to the preparation of the maintenance programme. In addition to the condition monitoring systems, Maintenance and Operations will also be performing periodic monitoring and measurement rounds according to task lists.

The plant unit will have the following types of fixed condition monitoring systems, for example:

- condition monitoring system for rotating equipment
- condition monitoring system for valves
- condition monitoring system for the primary circuit
- vibration monitoring system for the main steam line and main feedwater line
- temperature transient monitoring system for the primary pipes
- leak monitoring system for the main steam lines
- leak monitoring system for the main steam lines inside the containment
- containment leak rate measurement system
- foreign material monitoring system for the primary circuit
- containment monitoring system

A diploma thesis has also been written on the condition monitoring systems of the Nuclear Island that explain how the information available from condition monitoring can be used for maintenance control.

The condition monitoring for the turbine side main components and the process systems is performed by using the information generated by the system instrumentation. It is utilised either directly for the control, monitoring and protection of components and systems or indirectly for the control, monitoring and analysis of components and systems by means of discrete monitoring systems.

Condition monitoring related to the following functions, for example, is being planned for the Turbine Island:

- monitoring system for thermal tension in the critical turbine parts
- surveillance system for the final blades in the low pressure turbines, Bessi
- surveillance and analysis system for the vibration in the turbine and generator shafts and bearing supports, and a tracking system for their operating parameters
- tracking system for the operating parameters of the Turbine Island's main components, monitoring system for the heat balance tracking, surveillance system for the electric motors of the main pumps and a failure data collection system.

In addition to the fixed condition monitoring systems, periodic condition monitoring will take place at OL3; this includes the measurements and inspections performed during the operation of the equipment. These include vibration measurements, process monitoring and visual inspections, for example. These tasks are compiled into plant round lists that contain several simultaneously performed tasks and their correct order of performance. The plant round lists are planned together with the maintenance planning.

Spare parts planning

The planning of the spare parts inventory for the plant unit has been roughly divided into three categories as follows:

- Large spare parts with long delivery times (critical spares)
- Spare parts defined in the purchasing contract (SS App.2 att.1 and 2)
- Spare parts defined during the preparation of the maintenance programme.

Large spare parts with long delivery times have been purchased as part of the plant unit's delivery contract. The spare parts lists defined in the purchasing contract mainly cover the spare parts needs for the warranty period. As regards preventive maintenance, the spare parts inventory needs will be specified during the creation of the preventive maintenance programme, when the additional spare parts purchasing requirements and reserve amounts will also be defined. OL3 will employ the same spare parts policy as OL1 and OL2.

Maintenance instructions

The plant supplier will deliver the preventive maintenance instructions for the equipment to TVO. The drawing up of the instructions will follow the project procedure DP12.3 prepared in cooperation between TVO and the plant supplier. It describes the information required for the maintenance instruction. The procedure DP12.3 is used for creating the maintenance instructions for important equipment that has been manufactured specifically for OL3. The maintenance instructions for standard equipment are based on general standards.

The administrative procedures in the Maintenance Manual for OL1 and OL2 will be updated to cover the needs of OL3, as well. The administrative procedures will be updated before the operating licence stage.

Planning and maintenance of the preventive maintenance programme

TVO will inspect the tasks (preventive maintenance, in-service testing and inspections) received from the plant supplier and create maintenance programmes by combining and scheduling the tasks, planning the necessary resources and ensuring the availability of spare parts. An action plan has been drawn up for the necessary actions.

Similarly to Olkiluoto 1 and Olkiluoto 2, the process equipment for the Olkiluoto 3 plant unit will be divided into equipment responsibility areas. Each equipment responsibility area will be appointed an equipment owner who will be responsible for the maintenance planning in his/her area in the future. Maintenance planning includes, among other things, the planning of the preventive maintenance and condition monitoring programmes and spare parts planning for the equipment responsibility area, establishing the need for modifications and improvements and maintaining and developing the preparedness for repairing faults.

Maintenance work control

The activities related to commissioning are managed with the plant suppliers CMS (Commissioning Maintenance Support) system. When the commercial operation of the plant begins, OL3's maintenance activities will be controlled and managed using TVO's administrative data systems, similarly to OL1 and OL2.

The requirements of Section 23 of the Radiation and Nuclear Safety Authority's regulation are met.

5.5 Section 24 Radiation monitoring and control of releases of radioactive materials

1. The radiation levels of nuclear power plant rooms and the activity concentrations of indoor air and the gases and liquids in the systems shall be measured, releases of radioactive materials from the plant monitored, and concentrations in the environment controlled.

The radiation levels and releases of radioactive substances are monitored and limited at the plant unit. These tasks are implemented by the waste treatment, ventilation and radiation measurement systems, among others. The actual radiation meters at the OL3 plant unit are connected to the JYK (room radiation measurement) system.

The tasks of the radiation measurement system are related to the monitoring of ionising radiation, such as the surveillance of radioactivity concentrations, dose rate measurements and surveillance of the passage of radioactivity. The system also manages radiation monitoring after an accident. In order to perform these tasks, the system implements the following functions:

- Process activity monitoring
- Monitoring of direct radiation and airborne radioactivity
- Measurement of radioactive releases
- Radiation measurements during accident situations
- Personnel monitoring
- Contamination measurement
- Activity definitions for waste packaging
- Environmental radiation monitoring

The plant unit's systems are used to comprehensively monitor the radiation levels in the rooms, the activity concentrations of the indoor air and the gases and liquids inside the system and the releases of radioactive substances from the plant unit. The common weather mast for plant units OL1, OL2 and OL3, the environmental radiation measurement system and TVO's environmental monitoring system are also used to supervise the environmental emissions and activity concentrations in the environment.

Measurements of dose rate caused by external radiation, surface contamination measurements, air activity concentration measurements and worker radiation dose and internal radioactivity measurements (whole body counting) are performed each year as separate measurements.

The purpose of radiation measurements of the systems is to monitor the transport of radioactive materials in the liquid and gas process systems inside the plant. The measurements of radioactive effluents are aimed to monitor liquid and gaseous release of radioactive materials from the plant.

The requirements of Section 24 of the Radiation and Nuclear Safety Authority's regulation are met.

6 Organisation and personnel

Section 25 Management, organisation and personnel: ensuring safety

1. When designing, constructing, operating and decommissioning a nuclear power plant, a good safety culture shall be maintained. Nuclear safety and radiation safety shall be made priorities in all activities. The decisions and activities of the management of all organisations participating in the above-mentioned activities shall reflect its commitment to safety-promoting operating methods and solutions. Personnel shall be encouraged to work responsibly and to identify, report and eliminate factors that compromise safety. Personnel shall be given the opportunity to contribute to the continuous enhancement of safety.

TVO's operational results on the OL1 and OL2 plant units have been excellent even by international standards. A good safety culture is one of the prerequisites for reliable operation. TVO has been transferring practices created through the operation of OL1 and OL2, such as matters related to quality management, to OL3 already during its construction and preparation for production. Safety culture follow-up procedures have been developed and implemented at the OL3 construction site. TVO defines safety culture according to IAEA's INSAG 4 document:

"Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance."

Safety culture is involved in all of TVO's operations, documents and working methods. The commitment of TVO and TVO's employees to a high level of safety culture has been recorded in chapter 4 of the procedure "Teollisuuden Voima Oyj:n toimintajärjestelmä" (Teollisuuden Voima Oyj's activity management system). Adherence to the safety culture is emphasised during TVO's induction training events and in TVO's Code of Conduct. Internal and external communication emphasises the importance of a high level of safety culture.

One of the prerequisites for a good safety culture is the good financial standing of the company and the management's clear vision of the future of its activities. TVO aims to operate the plant units for a minimum of 60 years. This can be achieved by maintaining the plant units in like new condition. As regards personnel, future needs are constantly being anticipated in terms of both quantity and quality (such as competence requirements).

The status of the safety culture must be monitored and the culture must be continuously developed. Processes shall be in place for this purpose. TVO uses the IAEA's model for assessing the safety culture. TVO has performed safety culture self-assessments for the OL1 and OL2 units in 2004, 2007, 2010 and 2013 and for the OL3 project organisation in 2008. Experts from the IAEA trained and consulted TVO during the self-assessment of 2004. Their opinion was that the self-assessment of TVO's safety culture had been performed adequately and, therefore, the findings were valid. TVO performed the self-assessment of 2007 in the same manner. The safety culture self-assessment has been combined to an assessment of the functionality and coverage of the management system, and the following assessment will be performed during 2016. The questionnaires for the self-assessment in 2010 and 2013 included TVO's personnel participating in the OL3 project and TVO's long-term consultants. TVO's expertise in safety culture assessments has been purchased as a consultation service for other nuclear power plants and TVO is actively participating in development activities related to safety culture in international organisations and national research programmes. TVO also has access to expertise in making separate, extensive safety culture studies. Furthermore, TVO has standardised procedures in place for determining the effects of human and organisational factors on events; this includes safety culture.

In 2009, TVO established a safety culture group to provide recommendations and advice. It processes the information concerning safety culture received by different means and uses it to form an overall picture of the state of the safety culture and to forward matters for further processing at TVO when necessary. The group assesses TVO's activities during the operation of the nuclear facilities and the different stages of the OL3 project.

Separate instructions have been drawn up concerning the safety culture assessment procedure at the OL3 construction site. This procedure is used as the basis for the publication of a bi-annual report concerning the state of the safety culture at the OL3 construction site.

According to the results of the self-assessments, safety culture at TVO is at level 2 on the IAEA's three-tier scale; at this level, a good safety culture promotes the achievement of safe and reliable operation and good production results.

TVO regularly performs benchmarking and studies related to the state of the working community. These include worker satisfaction studies which are performed by an external expert approximately once every three years; the latest was completed in the autumn of 2015. The organisation units also perform different analyses as required. The actions for improvement are determined on the basis of these studies. The latest analysis of this type was completed in early 2015.

TVO has two focus areas in the development of its safety culture: a learning organisation and zero tolerance. The latter means that no deviations from safety-related regulations or requirements will be allowed. A learning organisation is the third and most advanced level in the IAEA's safety culture classification. A learning organisation means the same as the continuous improvement which is recorded in TVO's values and general principles for operation. As part of activity planning goals for 2016, TVO has drawn up a safety culture programme for reaching level 3 on the IAEA's three-tier scale.

TVO uses several reporting methods. Low-level events are reported anonymously as safety observations in the Kelpo application, to which everyone working at Olkiluoto has access, or by means of a safety observation card. The same application is also used to record any deviations observed in the activities and to monitor the realisation of repairs and corrective actions. In addition to the Kelpo system, the deficiencies discovered and observations made during the construction of OL3 are also recorded in a dedicated information system created for the OL3 project.

An event report is drawn up for events that are significant in terms of safety or the development of activities. The corrective actions proposed on its basis are nearly always focused on conduct. In addition, operational disturbances are reported in accordance with authority requirements and the required summary reports are compiled at regular intervals.

In 2011, TVO started CAP (Corrective Actions Programme) activities that aim to assess the quality of TVO's operations and produce suggestions for improvement. CAP activities consist of analysing the information collected by different means and looking for common factors that are used to draw up recommendations for the organisation when necessary.

In addition to reporting, TVO has various channels through which anyone can bring up areas for improvement. These include initiative programmes and drawing up improvement proposals.

The requirements of the Radiation and Nuclear Safety Authority's regulation are met.

2. The organisations participating in the design, construction, operation and decommissioning of a nuclear power plant shall have a management system in place to ensure the management of nuclear and radiation safety and quality.

TVO's management system is described in the activity management system approved by the President and CEO. The procedure "Teollisuuden Voima Oyj:n toimintajärjestelmä" (Teollisuuden Voima Oyj's activity management system) constitutes a quality management programme that sets requirements for TVO's activities in the manner required by Section 36 of the Nuclear Energy Decree. The procedure was last updated in June 2015.

The quality management system for the construction of additional production capacity is presented in the Olkiluoto 3 project's quality manual that is a part of TVO's activity management system and approved by the Radiation and Nuclear Safety Authority. The quality manual presents the quality management practices for the OL3 project up to the moment when OL3 transfers to commercial operation. After this point, the quality management practices are solely described in the procedure "Teollisuuden Voima Oyj:n toimintajärjestelmä" (Teollisuuden Voima Oyj's activity management system) within TVO's activity manual; this procedure covers the entire activity management system at TVO. The quality manual for the OL3 project has been replaced by the quality plan for the OL3 project and it will replace the current quality manual once it has received approval from STUK. The quality plan was submitted to STUK for approval on 22 December 2015.

It is the understanding of TVO that the transfer of the plant unit to the operation stage will not require substantial changes in the general part of the activity management system. The practices that are currently in use will also apply to a situation where OL1, OL2 and OL3 are in operation.

As regards the instructions included in the activity management system, the plant unit and plant type specific operation and maintenance instructions will be separately drawn up for the needs of the OL3 plant unit; the existing manuals will be updated as regards the other functions.

The quality management system for the procurement of nuclear fuel is presented in the quality manual for nuclear fuel procurement that is a part of the activity management system and approved by the Radiation and Nuclear Safety Authority. In addition to safety and quality management, the activity management system covers the management of environmental matters and occupational health and safety.

The documents that were considered during the drawing up of the activity management system include the YVL Guides from the Radiation and Nuclear Safety Authority, the standards ISO 9000, ISO 9001, ISO 14001, OHSAS 18001 and the document IAEA Safety Requirements No. GS-R-3, The Management System for Facilities and Activities, where applicable.

The procedure “Teollisuuden Voima Oyj:n toimintajärjestelmä” (Teollisuuden Voima Oyj’s activity management system) includes the following:

- TVO’s mission and values
- General principles for operation
- Quality assurance principles for operational processes
- General descriptions of the operational processes and their controls and resources.

The procedure “Teollisuuden Voima Oyj:n toimintajärjestelmä” (Teollisuuden Voima Oyj’s activity management system) is included in the activity manual that also includes the operative instructions required for quality management and the company-level policies. The organisation and management relationships of the Olkiluoto nuclear power plant are presented in the administrative rules and the organisation manual. The administrative rules are submitted to STUK for approval and the organisation manual is submitted for information.

The requirement in the Radiation and Nuclear Safety Authority’s regulation is met.

The objective of the management system is to ensure that nuclear safety is prioritised without exception, and that quality management requirements are commensurate with the significance to safety of the activity. The management system shall be systematically assessed and further developed.

TVO’s instructions ensure the safety of production. TVO and its personnel are committed to a high level of safety culture which is that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.

The procedure “Teollisuuden Voima Oyj:n toimintajärjestelmä” (Teollisuuden Voima Oyj’s activity management system) describes the basic principles of operation, including the principles for ensuring nuclear safety. The procedure states that, in case of conflict between safety and financial aspects, safety will always take priority.

The procedure also presents the quality assurance principles for the most important functions; they specify the operational principles and requirements that are required for the implementation of functional processes that affect nuclear safety or operational reliability. The quality assurance principles complement the general principles for operation.

Requirements have been set for the products and functions according to their safety significance, while taking into account the requirements set forth in the field of technology specific requirements in the YVL Guides and STUK’s decisions.

The structure, tasks, responsibilities of TVO’s organisation and the related authorisations are presented in detail in the organisation manual. Any tasks, responsibilities and authorisations that are significant in terms of nuclear safety or radiation safety are presented in the administrative rules of the Olkiluoto nuclear power plant.

The coverage assessment of TVO’s activity management system has utilised the following documents: Safety Reports Series No. 22, Quality standards: Comparison between IAEA 50-C/SG-Q and ISO 9001:2000, IAEA, 2002, and Management Systems Standards: Comparison between IAEA GS-R-3 and ISO 9001:2000, IAEA, Draft 5/2008.

TVO’s activities are regularly assessed from various viewpoints and by many different parties. The assessments are focused on the activity management system or a part thereof either directly or indirectly.

The assessment methods used include the following, for example:

- Internal audits performed by TVO
- Self-assessments performed by the organisations
- Third-party assessments of TVO’s management system that are based on international standards and performed by third parties
- Management system assessment performed by TVO
- Management reviews
- Evaluation of operating experience from TVO’s plant and other plants

- CAP activities
- WANO Peer Reviews, follow-ups and Technical Support Missions (TSMs)
- TVO's work satisfaction surveys and other psychological analyses within the organisation
- Inspections and reviews performed by STUK.

Separate analyses have been and will be performed as necessary based on observed functional deviations, for example. The latest analysis of this type was completed in early 2015.

The basic principles for the verification of activities are described in the procedure "Teollisuuden Voima Oyj:n toimintajärjestelmä" (Teollisuuden Voima Oyj's activity management system). Quality Management (SQ) is responsible for verifying the compliance of operations by means of audits. TVO's Quality Manager has the authority required for the planning and implementation of quality management.

The results of the performed assessments are discussed to the necessary extent by TVO's administrative bodies, in TVO's Management Group meetings, in the Safety Group meetings if necessary, in plant meetings, in the meetings of the organisation units and in a compiled manner during management reviews where the aim is to focus and prioritise the actions to be taken on a company level.

Internal audits

Internal audits are performed by Quality Management (SQ) in accordance with the methods described in the procedure "TVO:n toiminnan todentaminen" (Verification of TVO's activities). Internal audits are carried out each year according to a compiled programme. The internal audits that are targeted towards quality management during the construction phase of the plant unit are also performed by Quality Management (SQ) in accordance with the methods described in the procedure "Auditointi OL3-projektissa" (Audits for the OL3 project).

Self-assessment for organisations

A self-assessment of operations is performed every second year in accordance with the focus areas and criteria defined for the assessment in question.

Third-party assessments

Based on third-party assessments, TVO has been granted the following management system certificates for meeting the requirements set for the system:

- Operation and construction stage: quality management, ISO 9001:2008 (DNV Certification Oy)
- Ecological management, ISO 14001:2004 (DNV Certification Oy),
- Ecological management, EMAS 721/2001 (SYKE)
- Operation and construction stage: management of operational health and safety, OHSAS 18001:2007 (DNV Certification Oy)
- Assessment of TVO's pressure vessel manufacturing, ISO 9001:2008 and
- ISO 3834-2:2005 (SFS Inspecta Oy)
- Assessment of TVO's accredited inspection body,
- SFS – EN ISO/IEC 17020:2004 (FINAS).

Management review

Management reviews are performed twice per year. According to the procedure, the management reviews discuss matters related to quality management, management of ecological matters and occupational health and safety management in accordance with international standards, as well as matters related to nuclear safety. The management reviews discuss the state and applicability of the management system in a documented manner. The most important matters in terms of nuclear safety and radiation safety are also discussed by the Safety Group.

If necessary, the management reviews present company-level corrective actions, proposals for the planning of strategic operations and suggested focus area goals for the company. These focus area goals related to the management system have included, for example, improvements in the processing of deviations, improving the efficiency of supplier reviews, more effective functional processes and improving their benchmarking.

The procedure for management reviews within the OL3 project is described in the OL3 project's quality manual.

The requirements of the Radiation and Nuclear Safety Authority's regulation are met.

3. The management system shall cover the organisation's all functions that influence nuclear and radiation safety at the nuclear power plant.

TVO's activity management system covers the production activities at Olkiluoto nuclear power plant, maintaining and developing the production capacity, construction of additional production capacity and the functions required for their control and resourcing. Furthermore, TVO's activity management system covers the construction and commissioning stage of the OL3 plant unit.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

For each function, requirements significant in safety terms shall be identified, and the planned measures described in order to ensure compliance with requirements. The procedures of the organisation shall be systematic and instructed.

The procedure "Teollisuuden Voima Oyj:n toimintajärjestelmä" (Teollisuuden Voima Oyj's activity management system) describes the basic principles of operation. This chapter defines the documents, methods and functions that are used to ensure nuclear safety in particular. The documents mentioned herein both guide and specifically define the requirements, methods and functions that have been drawn up in order to ensure nuclear safety.

These documents include the classification document, the Technical Specifications (TTKE) and the probabilistic risk assessment (PRA). The procedure presents the quality assurance principles for the most important functions; they specify the operational principles and requirements that are required for the implementation of functional processes that affect nuclear safety or operational reliability, as well as written general descriptions of the functional processes. The quality assurance principles complement the presented general principles for operation. The functions are described in detail in the different manuals and separate procedures. The database for procedures currently includes 2,667 procedures.

The requirements of the Radiation and Nuclear Safety Authority's regulation are met.

4. Systematic procedures shall be in place to identify and correct any deviations significant in terms of nuclear and radiation safety. If changes have to be made to approved plans during construction or operation, they shall be implemented systematically and in a controlled manner.

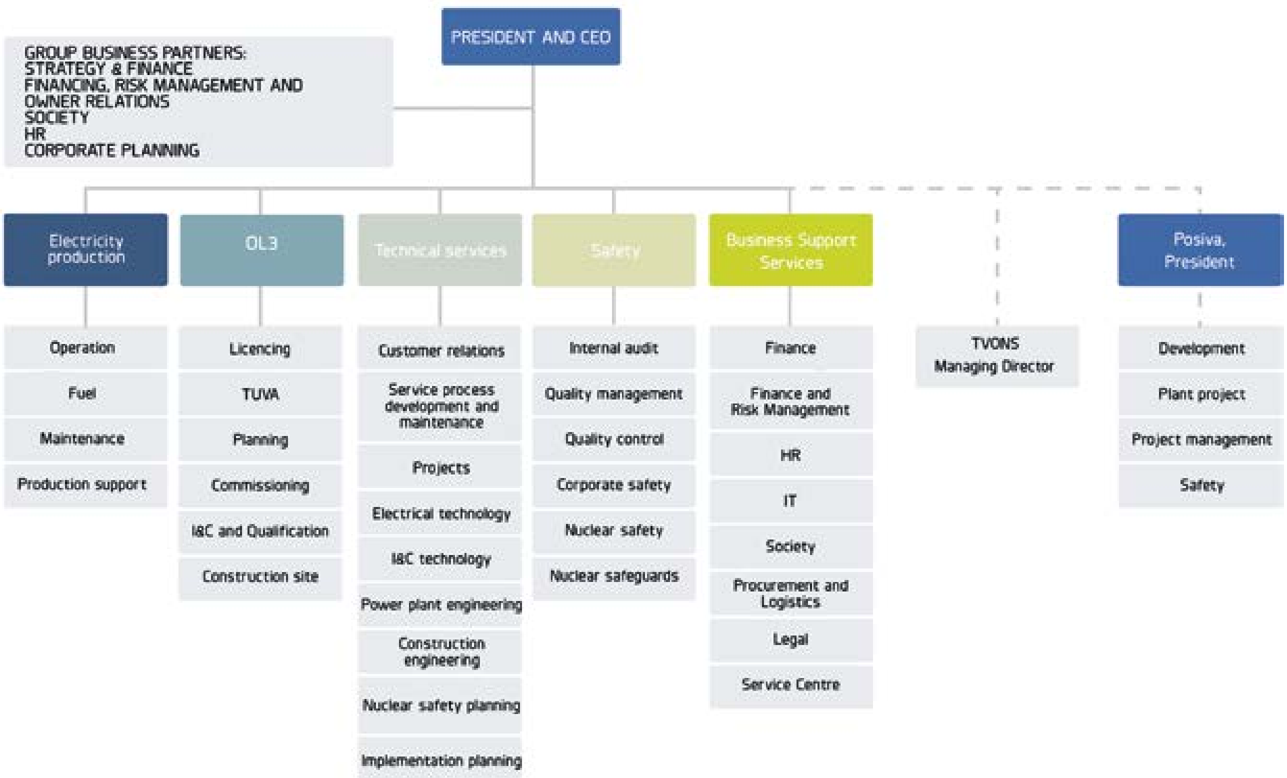


Figure 2. TVO's basic organisation.

The procedure “Teollisuuden Voima Oyj:n toimintajärjestelmä” (Teollisuuden Voima Oyj’s activity management system) describes the principles for processing deviations and implementing corrective and preventive actions.

The practices for processing and reporting deviations and near misses are presented in the procedure “Poikkeamien ja muiden havaintojen käsittely” (Processing of deviations and other observations) in the activity manual.

The Kelpo application has been developed for reporting and processing deviations. It was launched in May 2002. The application provides a flexible process for reporting deviations with a low threshold, and everyone working at Olkiluoto has access to it. The Kelpo application has been developed in order to allow it to display the different phases of the corrective actions and any possible changes to them in a documented manner.

The status of the corrective actions for the deviations is discussed during the bi-annual management reviews.

The methods for managing deviations during the construction stage of OL3 are presented in a separate procedure.

Change management is presented in the modification planning instructions for the operation stage and in the change management process and the procedure “OL3 Konfiguraatiohallinnan suunnitelma” (OL3 Configuration management plan) for the construction and commissioning stages.

The requirements of the Radiation and Nuclear Safety Authority’s regulation are met.

5. The licensee shall commit and oblige its employees and suppliers, subcontractors and other partners contributing to safety relevant activities to engage in systematic safety and quality management.

TVO requires that its business partners and their employees working at Olkiluoto commit to a high level of safety culture and high-quality operation. This means that companies and persons in a direct or indirect contractual relationship will operate responsibly in accordance with TVO’s nuclear safety and quality policy, environmental policy and information safety principles.

The activity management system presents TVO’s company-level policies and values that are used to communicate commitment to a high level of safety culture and continuous improvement. TVO’s personnel are expected to follow the practices presented in the activity management system and in the manuals and instructions. Persons in supervisory positions must ensure, for their own organisation, that all operations follow the provided instructions. These requirements are communicated to the contractual partners within the contract documents. To the people working at the plant site, these matters are also communicated via the access training and induction training. TVO has also published separate instructions and booklets that explain the commitment to a high level of safety culture.

TVO’s activity management is constantly maintained and developed. The developments ensure the compliance of the activity management system and its usability during the validity of the operating licences for TVO’s different plant units.

The requirements of the Radiation and Nuclear Safety Authority’s regulation are met.

6. The lines of management within the licensee’s organisation and the tasks and responsibilities of employees shall be defined and documented.

Representatives from TVO's shareholders participate in the company’s management by means of the General Meeting, the Board of Directors and the committees set by it. The company’s administration and management follow the Corporate Governance principles approved by the Board of Directors.

TVO’s Board of Directors consists of representatives appointed by the shareholders. The Board has appointed the following committees that report to it and assist it in its duties:

- Select committee for Auditing and Financing.
- Select committee for OL3.
- Select committee for Nuclear Safety.
- Select committee for Appointment and Rewards.

The Board has also appointed the following committees and control groups that assist the operative management:

- Operations committee
- Financing committee
- Economics committee
- OL3 committee.

TVO’s operations are led by the President and CEO, whose direct reports are the Directors of business and services and the group’s Business Partners. The President and CEO reports to the Board concerning the operation and results of the company.

Table 2. Training days for internal training of TVO's employees by topic in 2014–2015.

		DAYS 2014	DAYS 2015
00	General technology	174	58
10	Nuclear technology	912	691
20	Plant technology	793	1069
30	Operations technology	1833	2185
40	Maintenance	499	492
50	Protection and emergency preparedness	1347	964
60	Administration and finances	69	100
70	ICT	239	341
80	Cooperation and communication	543	432
90	Other training	259	727
	TOTAL	6,668	7,059

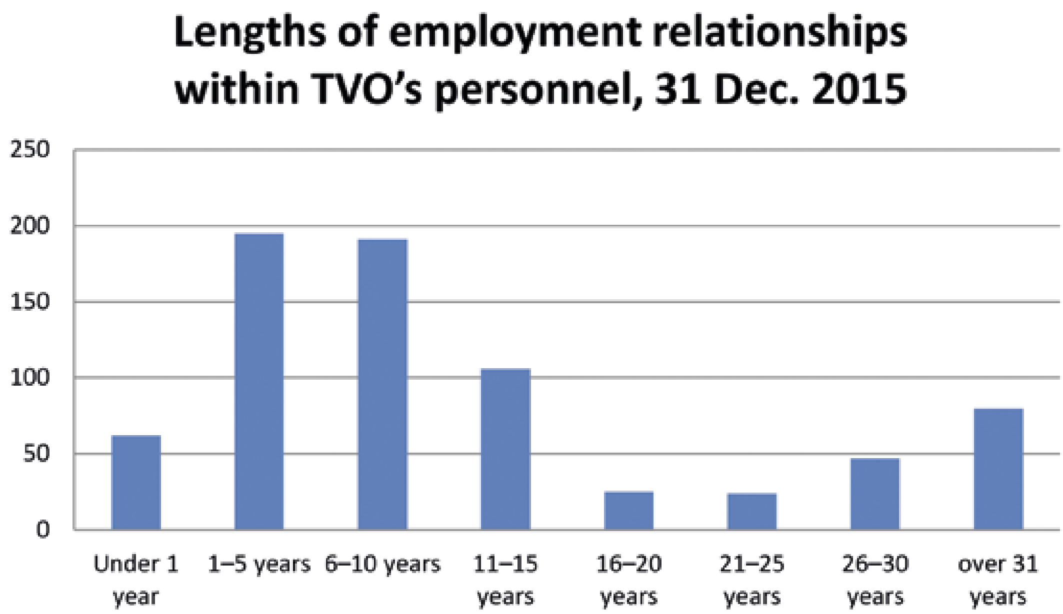


Figure 3. Lengths of employment relationships within TVO's personnel

The President and CEO is assisted by the Management Group that includes the President and CEO, the Directors, the President and CEO for Posiva and a representative from the personnel and his/her deputy in accordance with the Act on Personnel Representation in the Administration of Undertakings. The President and CEO acts as the chairman.

The responsible manager referred to in the Nuclear Energy Act is the Director of Electricity Production and his/her deputies are the Development Manager for Electricity Production and the unit manager for Production Support. The responsible manager for the construction of the OL3 plant unit is the Safety Manager and his/her deputy is the senior expert.

TVO's organisation is divided into three business units and three service functions. TVO's business units are Electricity Production and the OL3 project, in addition to which Posiva is a third business unit at the group level. The services required by the group and the business units are centrally produced by the service functions. The service functions include Technical Services, Safety and Support Services. Safety is also responsible for the supervision tasks that require independence.

The business units are led by business directors and the service functions are led by service directors.

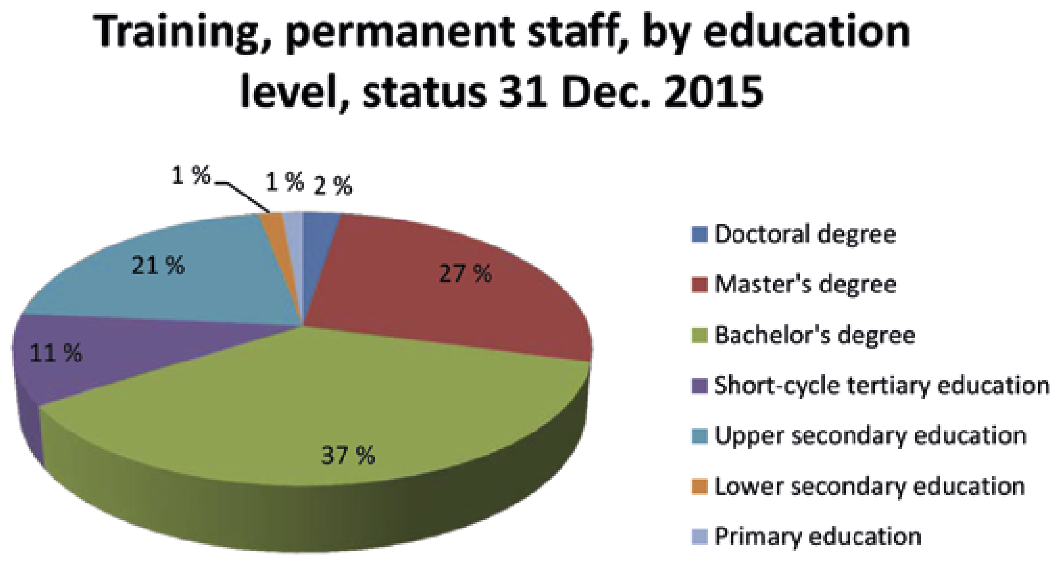


Figure 4. Training for TVO's employees by level in 2015.

The business units and service functions are divided into units or competence/service centres and further into teams or sections.

Units and competence/service centres are led by managers, sections are led by section heads and teams are led by team supervisors.

The service functions also have tasks (roles) for development representatives, service representatives and customer representatives. A representative is responsible for a specific area. The title of Business Partner is independent of the organisation hierarchy. It depicts the role of leading and developing a service function within a business unit.

Experts form bodies that report to the President and CEO, directors or managers. Experts operate in special tasks within their field. There are three levels of experts: executive experts, senior experts and experts.

For the management of cross-functional tasks or topics, the management has set up workgroups that include representatives from different organisation units. These include the following, for example:

- Safety group
- Plant meeting
- Information Security group
- Fuel group
- Outage group
- ALARA group
- Operating Experience group
- Risk Management group
- Ageing Management group
- Safety Culture group

The composition and tasks of the workgroups are defined in the organisation manual appendix "Meetings and workgroups", with the exception of the Safety group whose rules of procedure are defined in the administrative rules of the Olkiluoto nuclear power plant.

Different expert groups may be assembled to discuss specific topics, if necessary. The purpose of these groups is to simplify the processing of matters and to promote information transfer and cooperation across the boundaries of organisation units.

The organisation manual describes the structure of TVO's organisation, the task areas, responsibilities and authorisations for the organisation units, the general principles for developing the organisation and the principles for cooperation in more detail. The organisation manual is submitted to STUK for information. Figure 2 presents TVO's basic organisation.

Any tasks, responsibilities and authorisations that are significant in terms of nuclear safety or radiation safety are described in the administrative rules of the Olkiluoto nuclear power plant. The administrative rules are constantly updated and require approval from STUK. No changes to the administrative rules are taken into use without approval from STUK.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

The work of the organisation shall be evaluated and developed and any risks associated with it assessed regularly. The impact on safety of major organisational changes shall be assessed in advance.

TVO follows and monitors the operation of the organisation by means of supervisor activities, meetings within the organisation units and groups, records, setting of goals and the benchmarking of activities, for example. Independent supervision of the organisation's activities is arranged through different audits, operating experience activities and assessments. If necessary, the organisation is changed or the task descriptions of the units are specified in order to clearly define the boundaries. The impact on safety of major organisational changes is assessed according to an established procedure.

The risks related to the operation of the organisation are assessed according to drafted procedures. Furthermore, significant functions that are relevant in terms of nuclear safety and radiation safety are analysed in connection with the probabilistic risk analysis (PRA).

Historically, TVO has low personnel turnover and most of it occurs through retirement (28 people in 2015) (Figure 3). TVO has prepared for preserving competence in connection with retirement. In 2015, a new model for operation was launched which centralised functions and removed duplicate activities. Changes in the model for operation permanently reduced work, and 42 employment relationships were terminated as a result of the cooperation negotiations with the personnel.

During the 30 years of operation, TVO has amassed a substantial amount of data concerning the technical systems of the plant and the operation of the organisation. TVO's activity management system, the data and its methods of use have all been comprehensively documented. Operations are guided precisely by several manuals, in particular the operations and maintenance manuals that contain instructions for operation and preventive maintenance. The positive safety culture that TVO has developed is also an important part of ensuring competence.

Competence is manifested in people and in the means of action. Personnel competence development is a continuous activity that is guided by the key competences derived from the company's strategy and the competence requirements defined for the individual. The meeting of these requirements is followed as part of the supervisor activities and in a coordinated manner at the company level. This is supported by the competence management data system. The number of personnel training days has usually been approximately 9–10 days per year per person; in 2015, it was approximately 9.3 days per person (Figure 4).

For TVO's own employees, the internal training days in 2014 and 2015 were divided in accordance with Table 2.

On 31 December 2015, the company permanently employed 730 persons, of which 78% have a training background in technology or natural sciences; this includes 14 doctors or licentiates, 144 Masters of Science in Engineering, 232 engineers and 54 technicians and vocational-level engineers. Alongside the employees with a background in technology or natural sciences, the company employs persons with financial or legal expertise in the nuclear industry.

Personnel turnover has been historically low at TVO and long employment relationships have been the norm, which has formed a good basis for ensuring and maintaining competence. TVO is also aware that the retirement of the personnel (approximately 25 people per year in 2010–2015) and the recruiting of new employees (approximately 50 people per year in 2010–2015) require actions in order to ensure the transfer of the accrued know-how and plant knowledge to the new experts. These efforts are supported by the good and comprehensive documentation concerning plant technology and practices.

Task rotation is also used to maintain and develop competence. Approximately 50–60 internal task changes were performed each year in 2010–2014.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

7. Duties significant to safety shall be designated. Training programmes shall be prepared for the development and maintenance of the professional skills of the persons working in these positions, and adequate command of the functions in question must be verified.

TVO's training manual includes instructions for maintaining personnel competence and developing the competence of new recruits and persons switching tasks.

The TAITO data system is used for managing personnel competences and their development; this system allows for verifying the special roles, competence areas and training of the personnel.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

8. The licensee shall employ an adequate number of competent staff to ensure the safety of the nuclear power plant. The licensee shall have the professional expertise and technical knowledge required to construct and operate the plant safely, to maintain the equipment important to safety, and to manage accident scenarios.

TVO has over thirty years of experience in the operation of a nuclear power plant. Competence management for the operating personnel (control room personnel) is an important part of operations. TVO continuously follows the recruiting needs of the operating personnel, and training groups (each with 4–8 persons) started in 2003, 2004, 2006, 2008, 2009, 2011, 2012 and 2014. The members of the training group will become licensed operators after approximately two years of training.
The instructions in the training manual describe the minimum requirements for the training of operating personnel and operators. TVO is engaged in continuous development of the selection processes and training of the operating personnel. Operating experience from TVO's own nuclear power plants and other nuclear power plants (including foreign plants) is constantly utilised as part of the basic and further training of the operating personnel. Methods for assessing the efficiency of training (including self-assessment) have also been taken into use in connection with the training of operating personnel; these methods are used to ensure the comprehensiveness of the scope and content of the training.

TVO also has substantial experience in the utilisation of a nuclear power plant simulator in the training of operating personnel and extensive knowledge of the particular didactics of simulator training. In addition to plant technology, the simulator is also used to train working methods, such as control room communication. In 2015, 10 days of simulator training were arranged per operator in order to maintain and develop the professional competences of the control room personnel for OL1/OL2. The competence management of the operating personnel also includes maintaining the licences and providing different displays of professional skill; TVO has established procedures for these purposes. Plant operation is three-shift work with special requirements. Over the years, TVO has accumulated substantial expertise in managing the stress caused by shift work.
The future control room personnel of the OL3 plant unit, some 30 operators that will be licensed, have been recruited in 2005 and 2008 to start training for their tasks. The OL3 plant supplier is responsible for training OL3 specific matters, but the experience and expertise received from training the OL1/OL2 control room personnel has been utilised during the preparation of the training plans and programmes for the OL3 control room personnel.
The initial training for the operating personnel of OL3 included trainings intended for all of TVO's personnel and the courses according to the function group specific special training programmes (currently known as function-specific training requirements).

Training related to supervisor activities and employment relationships has also been arranged for shift supervisors.

The plant supplier is responsible for providing training on the OL3 specific matters in several phases. After the initial training received at TVO, the plant supplier arranged the basic training that started the introduction to the plant's operation. Plant courses I and II were held after this. The training was resumed with plant course III that was completed in early 2010 and plant course IV, a week-long portion of which was completed during a simulator training exercise at the turn of 2011 and 2012. The final part will be completed during the basic simulator training period proper. The operating personnel for OL3 have completed the written test required for the operator licence in the spring of 2010.

The training for the shift supervisors and operators included a one-month familiarisation period at foreign plant units, of which three weeks were arranged before the training provided by the plant supplier and one week after plant courses I and II. The training for the I&C systems took place at the plant supplier's training centre in Germany.

Between and alongside training, the OL3 operator trainees (shift supervisors and operators) have been participating in, for example, the assessment of the design documentation for OL3 and the inspection of the operating instructions for OL3, and familiarising themselves with the plant unit during its construction, installation and commissioning stages.

Outside of the plant supplier's basic training, a 19-day shift-specific OL3 simulator training was arranged for the OL3 operator trainees in the autumn of 2011. In 2013, the OL3 operator trainees had 5 days of simulator training an 4 days of theory training. In 2014, the OL3 operator trainees had 2 days of theory training and a 3-day simulator training exercise for the shift supervisors.

Since 2012, the OL3 operator trainees have participated in the shift work related to the commissioning of OL3 in the combined operating organisation of the plant supplier and TVO; since 2013, this work has been resumed as continuous shift work. The tasks of the combined operating organisation have included participation in the commissioning of systems and managing the operation of the systems used during commissioning.

OL3 field operators were recruited in the autumn of 2015, which was when their training for the nuclear commissioning of the plant started.

The practices of device ownership, technology ownership, system ownership, plant function ownership and the related reporting are also used as tools for maintaining and developing maintenance competence and technical competence concerning the plant. Similar practices and routines will also be introduced for OL3 when the operation of the plant is transferred to TVO.

TVO also uses external expertise in its activities when necessary. The means of action has been to establish contacts with facilities, companies and organisations that represent the highest possible level of expertise in the fields related to the operation of the company. The company has in force contracts concerning maintenance services and expert services with several domestic and international parties. TVO has long-term cooperation contracts with the most important plant suppliers, component suppliers and service suppliers. Regular assessments are arranged in order to determine the expertise and competence of the suppliers.

TVO has participated, and continues to participate, in several national and international development programmes in the field of nuclear power. This allows the company to receive the latest information concerning developments in the field and to maintain functional contacts with experts in the field. Representatives from the company take an active role in the operation of domestic and international organisations in the energy and nuclear energy industries.

Long operating experience and the OL3 project have provided TVO with substantial expertise and competence regarding the requirements of designing, constructing and operating nuclear power facilities.

An emergency response organisation has been appointed in preparation for accident situations. The practices related to the management of accident situations can be found in the emergency response plan and the emergency procedures. The emergency response organisation is being trained and it conducts regular emergency response exercises according to varying scenarios.

TVO also employs a Human Performance expert, whose expertise is utilised in the maintenance and development of competence alongside training activities and external expertise.

Between 2000 and 2015, the number of persons permanently employed by TVO grew by 253. Growth has been particularly strong since 2004, the main reason for this being the OL3 project.

When compared to the situation preceding the OL3 project, the number of personnel within Maintenance and Operations Support under the Electricity Production business unit has increased substantially, most of which is due to the OL3 project and the new additional functions at Olkiluoto (such as Posiva Oy). The substantial increase (approximately one third) in the number of operating personnel is due to the recruiting of control room personnel for OL3. In terms of operational safety, particular emphasis has been laid on processing operating experience.

Work related to fuel and reactor physics was reorganised in 2015. The number of personnel has grown slightly. The reasons for the addition have been the analyses related to the Olkiluoto 3 project and the establishing of readiness for commissioning, the licensing of new fuel types and the reduction of hours that were previously purchased from consultants.

Due to the long experience in the operation of the nuclear facilities, TVO has established an experienced and committed supplier network that includes, for example, suppliers who perform fuel work and inspections in the specialist fields of nuclear technology. TVO has been buying 7–8 months of this fuel-related from outside vendors each year.

The Technical Services function has working relationships with the most significant plant and equipment suppliers. Contact is maintained regularly. The Technology department has some work that it outsources, and some of the contractors have decades of experience in working with TVO. Their work areas are located at Olkiluoto. The Nuclear Safety Planning competence centre, which is responsible for ensuring the safety of the plant during modifications and updating the safety case for the nuclear power plants, for example, is a part of the Technical Services function.

The Safety function consists of four competence centres: Quality Control, Nuclear Safety, Corporate Safety and Quality Management. Out of these, the Quality Control competence centre includes TVO's independent inspection organisation.

The number of personnel involved in safety has grown significantly since 2004. The reorganisations performed in 2014 and 2015 make precise comparisons more difficult. The OL3 project explains part of the growth, but resources have also been added for the plant units OL1 and OL2. Since the challenges in this area are related to securing experienced personnel, TVO has maintained a long-term approach to developing its recruits into experts in the different fields of nuclear safety. Each year, the Safety function purchases 2–4 person-years of expert services.

Expertise from TVO's other organisation units has been and will be used to perform the functions that are important for safety and the responsibility of the organisations mentioned above. This type of internal networking can even out the seasonal workload variations and have the work performed in a purposeful manner. Moreover, an external network of consultants has been utilised for the manufacturing supervision and condition monitoring of the nuclear fuel. Consultants have also been used for specific special analyses and independent verification calculations.

Long-term cooperation with competent consultants has been implemented on a partnership basis (i.e. some of the tasks have been performed under the leadership of TVO's own work management). Using consultants for the types of work listed above has been a long-term decision by TVO in order to maintain a sufficient network of consultant. Lately, these organisations have not employed any actual contractors for work tasks that are significant to safety.

The number of personnel involved in TVO's safety-related tasks has increased in recent years. The growth in the number of personnel can mostly be explained by the OL3 project, but the persons recruited for it will also benefit the operation and development of the OL1 and OL2 plant units.
The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

9. The licensee shall have a group of experts, independent of the other parts of the organisation, working as support for the responsible manager, said group convening on a regular basis to handle safety-related issues and issue recommendations thereon if necessary.

TVO has a Safety group for which the President and CEO has appointed the chairman, members, their personal deputies and vice chairman and secretary from among the members.

The Safety group acts as a body that provides recommendations and statements in nuclear safety and quality management questions related to the structure, operation, decommissioning and fuel and nuclear waste management of the Olkiluoto nuclear power plant and the construction of OL3.

The Safety group consists of a chairman and at least six and at most twelve proper members; the majority of whom are from outside of the Operations and Project departments. The Safety group may also include expert members from outside TVO.

The Safety group contains expertise from at least the following fields:

- Operational technology for nuclear power plants
- Operational safety
- Reactor safety
- Reactor physics and nuclear fuel
- Chemistry and radiochemistry
- Materials and inspections
- I&C technology
- Electrical technology
- Radiation safety and radiation protection
- Process technology and mechanical technology
- Reliability and probabilistic risk analysis
- Quality management
- Design basis expertise for BWR and PWR plants
- The OL3 project

The rules of procedure for the Safety group, which describe the purpose, composition, meeting schedule, quorum, tasks, authorisation and records of the group, are contained in chapter 5.2 of the administrative rules for the Olkiluoto nuclear power plant.

At present, the Safety group is chaired by the director of the Nuclear Safety function. The Safety group meetings are held approximately once per month. Minutes are drawn up for the meetings and submitted to STUK for information. The Safety group maintains a list of the recommendations it has provided.

Each year, the director of the Nuclear Safety department draws up a review of safety matters and safety culture for TVO's Board of Directors.

The practices currently in place and their further development ensures clear management relationships and personnel competence during the validity period of the operating licences for the nuclear power plant units at Olkiluoto.

The requirement in the Radiation and Nuclear Safety Authority's regulation is met.

The requirements of Section 25 of the Radiation and Nuclear Safety Authority's regulation are met.

7. Summary

Based on the above, the Olkiluoto 3 plant unit and its operation meet the requirements of the Radiation and Nuclear Safety Authority's regulation concerning the safety of nuclear power plants (STUK Y/1/2016, 1 January 2016) and the requirements in Section 22 b of the Nuclear Energy Decree.

APPENDIX 6B

MEETING THE REQUIREMENTS

OF THE RADIATION AND NUCLEAR SAFETY AUTHORITY'S REGULATION CONCERNING THE EMERGENCY RESPONSE ARRANGEMENTS AT A NUCLEAR POWER PLANT

1. Introduction

This appendix presents a summary of how the requirements of the Radiation and Nuclear Safety Authority's regulation concerning the emergency response arrangements at a nuclear power plant (STUK Y/2/2016) are met at the plant unit Olkiluoto 3.

In the appendix, the text of the decree is written in italics, while a normal typeface is used to describe how a specific requirement is met.

This report has been drawn up as part of the documentation that will be submitted to the Radiation and Nuclear Safety Authority (STUK) in connection with the operating licence application for plant unit Olkiluoto 3. The report is based on the Final Safety Analysis Report (FSAR) for the plant unit and TVO's emergency response plan.

2. Planning of emergency response arrangements

2.1 3§ Planning criteria

1. Emergency response arrangements shall be planned to ensure that emergency situations are quickly brought under control, the safety of the individuals in the site area is assured, and swift action is taken to prevent or limit radiation exposure to population in the emergency planning zone

The requirement presents a principle. The emergency response organisation is convened under the circumstances defined in the emergency response plan. The organisation contains the necessary workforce and expertise for surviving any identified or postulated accident situations. The availability of the organisation is regularly tested by means of test calls and drills that are used to ensure that the actions can be started quickly.

According to the emergency response plan, any personnel that is not required for treating the situation will be evacuated from the site area in all situations where an elevated risk of radiation releases exists. If necessary, the personnel can use the civil defence shelters in the area for protection. The emergency response officer (and the shift supervisor, before the emergency response officer assumes the command) is also authorised to use the plant's high-power alarm to sound a general alarm that requires the local population to seek cover indoors, if this is considered to be justified due to a threat of radioactive discharge and the rescue authorities have not yet assumed command of the rescue operations.

2.Planning shall take account of a simultaneous risk to nuclear safety occurring in all nuclear facilities in the site area and their potential consequences, especially the radiation situation on the site and in the surrounding area and the opportunities to access the area.

3. Planning shall take account of the fact that the emergency situation could continue for a long-term period.

4. Planning shall be based on analyses of the progress over time of severe accident scenarios resulting in a potential release. In such a case, variations in the state of the plant, the development of events as a function of time, the radiation situation at the plant, radioactive releases, radioactive release routes and weather conditions shall be taken into account.

5. Planning shall take account of events reducing safety, their controllability and the severity of consequences, and *threats related to unlawful action and the potential consequences thereof.*

The emergency response plan defines a sufficient emergency response organisation for managing a simultaneous accident at all plant units. The plan has been drafted while taking into account that the site area may be severely contaminated, causing the organisation to be moved indoors or placed in an alternative facility. Emergency response organisation will be supplemented with OL3 specific roles in good time before first OL3 emergency response exercise.

The planning has been based on both realistic and extremely conservative analyses concerning how an accident situation may develop. These analyses are discussed in the emergency response plan and in the FSAR accident analyses.

Preparations have been made for the management of long-term accidents by reserving food rations, water and rest facilities for the use of the emergency response organisation.

The emergency response plan also discusses emergencies caused by unlawful action.

6. Emergency response arrangements shall be consistent with the operation, fire prevention and physical protection of the nuclear power plant.

The emergency response arrangements are subordinate to the Nuclear Safety function and they are a part of the same competence centre as fire-fighting and physical protection, which makes coordination substantially easier. The emergency response plan contains tasks for the security organisation and the plant fire brigade.

7. Emergency response arrangements shall be compatible with the external rescue plan drawn up by the authorities in the event of a nuclear power plant accident.

The emergency response arrangements are regularly reviewed with the rescue authorities, and their coordination is tested in a joint exercise held every three years.

8. The planning criteria shall be reviewed regularly and whenever necessary

The planning criteria are regularly reviewed in accordance with the terms of the operating licence as part of the periodic safety assessments, and whenever necessitated by modifications, new technological or scientific information or operating experience.

2.2 4§ Preparation

1. Provisions shall be made by the licensee 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 corrective action needed to manage or limit the accident, the continuous and effective exchange of information with the authorities, and communications to the media and the general population.

2. When analysing the situation, the technical status of the plant and release of radioactive materials, or threat thereof, as well as the radiation situation inside the plant and in the site area and emergency planning zone shall be assessed.

The emergency response organisation contains appointed persons for each position listed in the section, and they have the necessary expertise for the tasks. The organisation contains the management sections, a technical support organisation that is capable of analysing the situation in technical terms and making decisions, appointed authority contact persons who will proceed to their appointed authority management locations after receiving the alarm, and a sufficient amount of technical personnel capable of performing repairs and maintenance.

3. In emergency situations, the licensee shall be prepared to carry out radiation monitoring in the site area and in the precautionary action zone. The licensee shall also take meteorological measurements and shall be capable of assessing the dispersion of radioactive materials and the resulting radiation exposure of the population in the emergency planning zone.

A sufficient number of radiation measurement teams have been separately appointed for the emergency response organisation in order to supplement the nuclear power plant's continuously-operating fixed radiation measurement network. Weather measurements are taken with the weather mast that is discussed in more detail in the appropriate system description of the FSAR. As a rule, the dispersion modelling for radioactive substances is performed by using weather information, the release term assessed on the basis of the measurements and a Gaussian dispersion model that can also be used with no electrical equipment in case of a complete loss of power supply. This provides sufficiently detailed information for planning protective measures and making decisions on them.

4. To prepare for an emergency situation, the licensee shall have appropriate staff alarm systems, places of assembly in the site area, evacuation arrangements, the necessary personnel protective equipment, radiation measuring instruments and iodine tablets available.

5. The licensee shall provide arrangements for contamination measurements of personnel, and their decontamination.

The emergency response plan describes the staff alarm systems, the places of assembly in the site area and the outline of the evacuation arrangements. The necessary protective equipment and radiation measurement devices have been placed at the locations defined in the emergency response plan. Staff decontamination can be arranged by using either the normal decontamination facilities at the plant or separately defined temporary facilities.

6. To manage emergency operations, there shall be an emergency response centre, which shall be able to maintain proper working conditions during the emergency situation, and which shall also be available during long-term power failures.

7. There shall be a designated area outside the site area from which to command the plant's emergency operations, if the emergency response centre is not available.

The emergency response centre at the OL3 plant unit is located in the safeguard buildings, and it is available under all emergency situations, with the exception of a fire in the emergency response centre. Furthermore, the emergency response organisation can utilise a back-up management centre elsewhere in the site area. The support group that analyses the situation and plans the responses works in these facilities.

If these facilities are not available, the emergency response organisation will transfer to the nearby facilities that have been reserved for the purpose in the emergency response plan.

8. There shall be reliable communication and alarm systems in place to manage emergency operations for the purposes of contact within and outside the nuclear power plant.

9. The licensee shall ensure that there are automatic data transmission systems in place to send information essential in terms of the emergency operations to the emergency response centre of the Radiation and Nuclear Safety Authority.

The most important means of communication in an emergency situation are the telephone system and the Virve system. Any measurement data that depicts the state of the plant unit and that is essential in terms of the accident situation will be submitted to STUK by means of the "STUK connection" system. These systems are described in more detail in the appropriate system descriptions.

10. There shall be management arrangements and an organisation in place for the maintenance and development of emergency arrangements.

The maintenance and development of emergency response arrangements has been described in the emergency response plan; according to it, the Corporate Safety Competence Centre is responsible for the emergency response arrangements. Additionally, each group within the emergency response organisation has a dedicated person who is responsible for the development of the group's activities.

2.3 5 § Emergency response instructions

1. In addition to what is set out in Sections 35 and 36 of the Nuclear Energy Decree (161/1988) on plans for the arrangements for security and emergencies, and in Section 48 of the Rescue Act (379/2011) on rescue plans, the licensee shall prepare the emergency response instructions necessary in light of the operations of the emergency response organisation.

This requirement is met in two ways. On the one hand, the emergency response plan in itself is more extensive than the Sections of the Nuclear Energy Decree stated above require, since it contains fairly precise instructions for each person or group. On the other hand, the emergency response plan is complemented by the disturbance and emergency procedures included in the Operations Manual and the system-specific operating instructions that are applied on their basis.

2.4 6 § Emergency response organisation

1. The licensee shall have management arrangements in place and an organisation for operations during an emergency situation. The duties of personnel implementing emergency arrangements shall be specified in advance.

The emergency response plan presents the emergency response arrangements on a general level and also defines the emergency response organisation by person and task. The tasks for each person are defined in the instructions for the person or group.

2. The licensee shall ensure that the personnel needed in emergency situations are promptly available. There shall *also be enough personnel to bring a long-term emergency situation under control.*

The telephone numbers for the persons appointed to the emergency response organisation are part of the emergency response plan. The automated paging function is tested monthly. The number of personnel allows the organisation to work in shifts.

3. Preparedness to act

3.1 7 § Emergency response arrangements for a nuclear power plant being commissioned

1. The licensee shall ensure that a nuclear power plant unit being commissioned has adequate emergency response arrangements in place for it prior to the import of nuclear fuel into the plant unit.

2. The emergency response arrangements shall comply with the emergency plan before fuel is transferred into the reactor. An emergency exercise shall take place before fuel is transferred into the reactor to demonstrate that the emergency response arrangements function properly.

For the most part, the emergency response arrangements currently match the emergency response plan since the OL3 plant unit follows the same emergency response arrangements as the plant units OL1 and OL2. Insofar as the OL3 plant unit has its own arrangements, they will be commissioned according to a separate plan.

3.2 8 § Maintenance and development of the preparedness to act

1. The licensee shall arrange preparedness training for all nuclear power plant personnel and other permanent or temporary employees working in the site area.

Emergency response training is included in the compulsory training for all personnel who are permanently employed at the nuclear power plant.

2. The licensee shall arrange appropriate preparedness exercises on an annual basis. At least every three years, the preparedness exercise shall take place as a joint exercise with the authorities. The emergency exercises shall be evaluated based on the set preparedness objectives.

The preparedness exercises have been arranged according to the requirement with nuclear power plants that are in operation. The latest joint exercise with the authorities took place in 2014. Reports are always drawn up for the preparedness exercises; they describe the exercise and provide a critical assessment of the experience gained. With OL3 preparedness exercises same procedures are going to be followed as with nuclear power plants that are in operation. First exercise will be held before loading of the fuel at OL3.

3. The licensee shall draw up a training plan covering a period of at least three years to ensure that training is given in all sectors of the preparedness to act at regular intervals.

TVO has prepared the required plans for all the appointed roles or groups in the emergency response organisation.

4. Emergency response arrangements shall be regularly evaluated. When developing the emergency response arrangements, attention shall focus on the experience gained and conclusions drawn concerning the management of emergency situations, the experience gained from the exercises as well as on research and technical developments.

The emergency response arrangements are being continuously developed and assessed on the basis of the results. Operating experience from emergency situations at other power plants and the results from the national nuclear safety research programme are also taken into account, among other things. The emergency response arrangements are being developed on the basis of technical developments, while still maintaining the reliability of the arrangements under all conditions.

5. The facilities and equipment reserved for emergency situations shall be available and maintained in good working order at all times.

The facilities and equipment reserved for emergency situations are kept in operating condition by means of a preventive maintenance programme. The Radiation and Nuclear Safety Authority follows up on the matter during its inspections within the context of the Periodic Inspection Programme.

6 .Furthermore, the emergency plan and instructions shall be kept up to date.

The emergency response plan contains provisions regarding its updates.

4. Action in an emergency situation

4.1 9 § Action in an emergency situation

1. In an emergency situation, the licensee shall take the measures required under the emergency plan and other necessary measures without delay in order to control the situation and prevent or limit radiation exposure.

The shift crew forms the part of the emergency response organisation that is permanently posted at the plant unit and immediately initiates the actions that are necessary for controlling the situation on the basis of the disturbance and emergency procedures. The safety analyses in the FSAR indicate that the different parts of the emergency response organisation have sufficient time for performing their tasks.

4.2 10 § Flow of information in an emergency situation

1. The licensee shall notify the Radiation and Nuclear Safety Authority and the emergency response centre concerned without delay of any declaration of an emergency situation and the classification of the emergency situation in compliance with Section 2(2).

The shift supervisor instructions in the emergency response plan includes the instructions in accordance with the requirement.

2. During an emergency situation, the licensee shall submit to the officer in charge of rescue operations referred to in Section 34 of the Rescue Act (379/2011) and the emergency response centre concerned as well as the Radiation and Nuclear Safety Authority a current situation assessment on the event and any relevant decisions concerning the nuclear power plant and justifications thereof.

The group “Emergency response centre support” within the emergency response organisation manages this task.

4.3 11 § Command of operations in an emergency situation

1. Sections 147–148 of the Nuclear Energy Decree contain provisions concerning the management responsibilities for rescue operations and security arrangements.

2. The licensee is responsible for the matters related to nuclear safety and radiation safety at the nuclear power plant. In an emergency situation, the on-site emergency manager of the nuclear power plant, as specified in the emer-

gency plan, shall initiate and command the work of the emergency response organisation at the power plant.

The shift supervisor makes the decision to declare the emergency situation. The shift supervisor acts as the emergency response manager until the person appointed as the emergency response manager arrives at the site and assumes the leadership responsibility. The emergency response plan provides the emergency response manager with extensive authority to manage the situation. Since the emergency response manager is the manager of the nuclear power plant, his/her deputy or a person at a similar level within the organisation, he/she also has the social prerequisites for exercising his/her authority.

3. The nuclear power plant's on-site emergency manager shall issue recommendations on actions to protect the population to the commander of rescue operations, until the Radiation and Nuclear Safety Authority assumes responsibility for issuing such recommendations.

4. The nuclear power plant's on-site emergency manager shall ensure that personnel who are familiar with nuclear safety and radiation safety are designated to assist the commander of rescue operations.

The provisions concerning the leadership responsibility and its transfer are repeated in the emergency response plan and the security standing order. The transfer of responsibility is practised during the joint exercises arranged with the authority.

4.4. 12§ Termination of an emergency situation

1. The emergency plan shall define the criteria governing the termination or reduction of measures taken due to an emergency situation. A precondition for the termination of an emergency situation is that the nuclear power plant has been brought into a safe state, releases of radioactive materials do not exceed the thresholds set for normal operation and the necessary post-emergency measures are initiated.

The emergency response plan includes the said criteria.

2.If rescue operations continue after the termination of the emergency situation, the licensee shall be prepared to engage in cooperation corresponding to that which occurs during an emergency situation.

The emergency response plan contains the same requirement.

5. Miscellaneous provisionst

13 § Measures pertaining to rescue operations

1. Provisions concerning the licensee's obligation to participate in the drafting of an external rescue plan for an accident occurring in a nuclear power plant are laid down in Section 48 of the Rescue Act and by virtue of the said Act.

This section is referential. The external rescue plan has been drafted and the documentation that TVO has produced for it has been submitted to Satakunta Rescue Services.

2. The licensee shall, in cooperation with the local rescue services, supply the population within the emergency planning zone with instructions to be followed in the event of an emergency situation and distribute iodine tablets in advance. In an emergency situation, the licensee shall participate in the warning of the population within the protective zone.

Iodine tablets are distributed to the population within the protective zone at regular intervals. If necessary, the licensee will use the high-power alarm to alert the population; the decision concerning its use in a general emergency is made by the commander of rescue operations or, if the rescue authorities have not yet assumed the responsibility, by the emergency response manager.

3. The licensee shall maintain continuous preparedness to assist in rescue work in an emergency situation. Such measures shall be practised in cooperation with the authorities concerned. Plans for measures related to rescue operations are included in the emergency plan.

The emergency response plan defines the tasks for TVO's plant fire brigade. These actions are practised in cooperation with the authorities according to the training plan for the emergency response organisation and fire brigade.

6. Summary

Based on the above, the emergency response arrangements for the Olkiluoto 3 plant unit meet the requirements in the Radiation and Nuclear Safety Authority's regulation concerning emergency response arrangements at a nuclear power plant (STUK Y/2/2016, 1 January 2016).

APPENDIX 6C

MEETING OF THE REQUIREMENTS

OF THE RADIATION AND NUCLEAR SAFETY AUTHORITY'S REGULATION CONCERNING THE SECURITY ARRANGEMENTS AT A NUCLEAR POWER PLANT

1. Introduction

This appendix presents a summary of how the requirements of the Radiation and Nuclear Safety Authority's regulation concerning the security arrangements in the use of nuclear energy (STUK Y/3/2016) are met at the plant unit Olkiluoto 3.

In the appendix, the text of the regulation is written in italics, while a normal typeface is used to describe how a specific requirement is met.

This report has been drawn up as part of the documentation that will be submitted to the Radiation and Nuclear Safety Authority (STUK) in connection with the operating licence application for plant unit Olkiluoto 3. The report is based on the Final Safety Analysis Report (FSAR) for the plant unit and TVO's security standing order. Since the decree is public, this document has also been drafted in a manner that does not limit its publicity.

2. Bases of security

2.1 Design bases 3§

1. The design of security shall be based on risk analyses of the activity to be secured, and protection requirements assessed on the basis thereof.

The design of the security arrangements is based on the threats that TVO determined in cooperation with the authority before STUK confirmed the design basis threat via its decision 2/Y42217/2013. The original design basis threat, the consideration of which is discussed in the final safety analysis report and its appendices, did not include all of the threats mentioned in decision 2/Y42217/2013. These are taken into account in accordance with Section 7 of the Nuclear Energy Act in a manner similar to the application of new YVL Guides. The matter is discussed in more detail in the DBT application assessment.

2. Security shall be consistent with the operation, fire safety and emergency response arrangements of nuclear energy.

TVO's Corporate Safety Competence centre is responsible for all of the above arrangements, which makes their coordination natural.

3. Furthermore, security shall be consistent with the rescue service, emergency and special situational plans drawn up by the authorities.

The security arrangements have been coordinated in the manner presented in the requirement. The efficiency of the arrangements is tested during the regularly arranged joint exercises and training events between TVO and the authorities.

4. The Nuclear Energy Decree (161/1988) contains provisions regarding the definition of the design basis threat and the threat from unlawful activity towards the use of nuclear energy.

The section does not contain a requirement concerning TVO.

2.2 4 § General planning of a nuclear facility

1. Structures, systems and components important to the safety of a nuclear facility as well as the locations of nuclear material and nuclear waste shall be designed to facilitate the effective implementation of security, taking into account the requirements for nuclear and radiation safety.

Security arrangements have been a special focus area in the layout design of the facility. The meeting of the requirements is demonstrated in the final safety analysis report, its appendices and the documents referred to herein.

2. Security shall be based on the utilisation of several security arrangement zones placed within each other so that systems and components important to safety, and nuclear material and nuclear waste, are afforded particular protection and access control and the control of goods traffic can be arranged..

According to the YVL Guides, the site area is divided into the outdoor area, plant area, protected area and vital area. The area where a specific space is located depends on its significance in terms of nuclear safety.

3. The security arrangement zones shall support effective and purposeful security arrangements against unlawful action. The security arrangement zones shall have in place arrangements for detecting unlawful action.

The final safety analysis report discusses the barrier effects of different interfaces. Since the interfaces are structural and any buildings that are important for the safety of the plant unit have been constructed to withstand earthquakes, among other phenomena, the protection of the interfaces is usually adequate without alteration. Wherever this level is not sufficient, the structures have been dimensioned to withstand the threat of unlawful action that may be targeted towards them.

4. Advanced, purposeful data security principles shall be utilised in the planning and maintenance of the nuclear facility and its information, communications and automation systems. Effective methods shall be in place for observing and preventing unlawful action and targeted towards systems that are important to safety as well as limiting their detrimental consequences.

The power plant's information, communications and I&C systems have been divided into different levels according to the defence-in-depth principle and based on their importance in terms of nuclear safety or disturbance-free operation. Platform-specific information security plans have been observed in the development, testing and installation of I&C systems. The protection, control and adjustment systems of the OL3 plant unit are not connected to any external networks. Connections with TVO's own discrete networks are unidirectional on a physical level.

5. The nuclear facility shall prepare for managing abnormal situations arising from information security threats.

This requirement is met. Preparedness for abnormal situations and the related procedures have been described in more detail in the information security plan.

2.3 5 § Personal security

1. Appropriate security clearances according to the Act on Security Clearances (726/2014) shall be carried out in order to ensure the personnel vetting of persons working at the nuclear facility and participating in the treatment and transportation of nuclear material and nuclear waste. Access rights and rights of use pertaining to information related to each task shall be defined. Measures for preventing threats related to persons shall be implemented systematically and extended to the subcontractors utilised by the licensee, and persons in the employ thereof.

Security clearances are performed on all persons working at the Olkiluoto nuclear power plant. Their level depends on the tasks of the person in question. Persons will only be granted access rights to the information systems and archive material that are required for the performance of their work. Instructions for these procedures are provided in the personnel manual, information management manual and security arrangements manual.

2. Passage rights of persons working at the nuclear facility shall be defined for the area of the nuclear facility. A form of identification that grants access rights shall be kept visible when in the nuclear facility area.

All persons working at the Olkiluoto nuclear power plant are granted an access card that also acts as a form of personal identification referred to in Section 52 a of the Occupational Safety and Health Act. An access area commensurate with the person's tasks is defined. Internal instructions state that the access card must be visible at all times.

2.4 6 § Implementation of security and security maintenance

1. Security shall be implemented in compliance with design bases, security standing order, security plan and other approved documents. All documents concerning security shall be kept up to date.

This requirement is met. The technical parts of the security arrangements at the OL3 plant unit have been implemented by means of a consistent document hierarchy that follows the design stages. Security arrangements that have been implemented by administrative means are based on the security standing order, security plan and the more detailed documents drawn up on their basis. In order to ensure that the requirement is met, all instructions are reviewed at regular intervals. Keeping the technical documents up to date is ensured by means of relevant provisions in the modification planning instructions.

2. The effectiveness of security may not be significantly reduced by any failure of a single security system, structure or component. Security shall be implemented so that the level thereof does not significantly decrease in the event of any common-cause failures, disturbances or accidents at the nuclear facility, such as an electric power failure or fire.

Since the security arrangements have been implemented while applying the principle of defence-in-depth, the loss of any single system will not cause a substantial loss of the level of security arrangements. Preparations have been made for situations such as electric power failures and fires by implementing redundant power supplies for the most important systems and by constructing an auxiliary alarm centre. Due to the layout decisions of the plant unit, any disturbances or accidents caused by the plant process will not cause substantial detriment to the security arrangements.

3. Annual exercises shall be taken to practice procedures in compliance with the security plan and security standing order in a threatening situation. Regular exercises shall also be arranged with the authorities concerned.

This requirement is met. The matter is discussed in more detail in the final safety analysis report.

4. Nuclear facility personnel shall be familiarised with security arrangements and procedures contributing to the implementation of these at the workplace.

A segment concerning security arrangements is included in the induction training for everyone working at Olkiluoto and in the more extensive course arranged for TVO’s own personnel.

3. Security monitoring

3.1 7 § Transaction of business at the nuclear facility

1. For the purpose of transacting business at the nuclear facility, measures for preventing threats related to the transaction of business shall be planned. The transaction of business also comprises visits to the nuclear facility. Therefore, the planning of visits and programmes thereof shall take account of security perspectives.

Visitors arriving at the nuclear power plant are always appointed an area for their visit and a personally responsible host who will supervise the visitor during the entire course of the visit.

Visiting activities at the nuclear power plant are centred around the visitor centre, whose placement takes into account the necessary security aspects. Visits to other sites are arranged taking the nature of the group into account. Visits to the site area are only arranged for expert groups, and the visitors are always accompanied by security personnel.

2. The identity of persons transacting business with the nuclear facility shall be ascertained. Security control related to transacting business shall utilise the appropriate control equipment and up-to-date technology suitable for the purpose.

An identification document issued by the authorities is required for all persons transacting business at the nuclear power plant. Security control utilises modern technology that is discussed in more detail in the system descriptions for the systems in question.

3 Movement in the area of the nuclear facility shall be restricted in compliance with the purpose of the transactions, and controlled.

This requirement is met. The number of persons transacting business at the nuclear facility is kept as low as possible by arranging most of the meetings and goods transport in bespoke facilities outside of the site area proper.

3.2 8 § Control of passenger and goods traffic

1. Vehicles, persons and objects and materials carried by them as well as goods transport equipment shall be checked in order to ensure that no dangerous objects are brought onto the nuclear facility site without permission. Movement at the nuclear facility shall be restricted and controlled so that the security arrangements aspects and safety aspects can be taken into consideration effectively.

Written procedures based on risk analyses and the principle of defence in depth are available for inspecting transports and persons.

2. Passage and goods traffic control shall be arranged in the necessary way, even in connection with nuclear material or nuclear waste transports and any related storage.

This requirement mainly concerns the KPA storage and waste transport to the VLJ facility and Posiva's disposal facilityA dedicated security plan is followed for the transport and storage of nuclear fuel.

The nuclear facility shall have in place appropriate methods for the detection and prevention of the unauthorised extraction of nuclear materials, nuclear waste, radioactive substances and confidential information.

Supervising the unauthorised removal of the above materials and information is implemented by technical and administrative means.

4. Security personnel and preparation for threats

4.1 9 § Qualification requirements for security personnel

1. Security personnel, as referred to in section 7 l of the Nuclear Energy Act (990/1987), shall have completed basic guard training in compliance with section 24 of the Private Security Services Act (282/2002), or other sufficient security sector training. In addition, security personnel shall comply with the general qualifications as laid down in section 24.

The security personnel meet the requirements in this requirement.

2. Moreover, any member of the security organisation of a nuclear facility shall demonstrate that he/she possesses the knowledge required for the task, concerning:

1) the security standing order and principles and instructions concerning the operations of the security organisation;
2) the leading principles of operations and the functions to be secured within the facility;
3) rescue, emergency and special situation plans for operations; and
4) any other required operating instructions enabling the security person to perform his/her duties correctly and safely

A training plan has been drawn up for the security personnel that includes induction and further training. The plan meets the requirements in the decree.

4.2 10 § Special requirements regarding the use of forcible means and forcible means equipment

1. A security guard who carries forcible means equipment, or whose duties require being prepared to use such equipment in the face of a threat, shall meet the qualification requirements for carrying forcible means equipment as laid down in section 29 subsection 2 of the Private Security Services Act. The security standing orders of a nuclear facility include provisions on user training for forcible means equipment other than those referred to in section 29 subsection 2 of the Private Security Services Act, and demonstrating evidence of the required skills and monitoring thereof.

A training plan has been drawn up for the security personnel that includes induction and further training. The security personnel that may be required to use forcible means during the performance of their duties receive appropriate training for the forcible means equipment and maintain their skills through regular practice. Trainer qualifications have been separately defined.

2. The security organisation of a nuclear facility may only use forcible means equipment complying with the security standing orders, possessed by the licensee or security services supplier.

The security standing order defines the forcible means equipment available to the security organisation.

3. Section 7o of the Nuclear Energy Act (990/1987) contains provisions concerning the right of security personnel to use forcible means.

This is a reference and not a requirement.

4.3 11 § Alarm centre

1. A nuclear facility shall have a central alarm centre for the purposes of security, and a stand-by centre. Both centres shall be capable of maintaining redundant and secure communication with the police and the nuclear facility's control room. The stand-by centre shall be separated from the central alarm centre proper by means of distance and structural decisions, preventing the simultaneous loss of both centres due to the same external or internal reason. The central alarm centre or stand-by centre shall always be manned by at least one person responsible for emergency functions.

The Olkiluoto nuclear power plant has an alarm centre and a stand-by alarm centre for the purposes of security arrangements. Their characteristics have been described in more detail in the appropriate FSAR system descriptions. The centres are separated from each other very thoroughly by functional and physical means. Instructions for the security organisation contain the decree's provisions concerning staffing at the alarm centres.

2 In connection with the transport or storage of nuclear material or nuclear waste, emergency communication and arrangements shall be implemented in the manner required for the protection of transport or storage.

The alarm arrangements for transport are defined in the transport security plans.

4.4 12 § Command centre and leadership

1. The nuclear facility shall have a permanent person employed for managing the security organisation as well as a command centre and a stand-by centre equipped for threat scenarios. Both centres shall be capable of maintaining redundant and secure communication with the police and the nuclear facility's control room. The stand-by command centre shall be separated from the command centre proper by means of distance and structural decisions, preventing the simultaneous loss of both centres due to the same external or internal reason.

The managerial relationships of the security organisation are defined by the security standing order and its supplementary documents in a manner where the security organisation always has one clearly defined leader who is present at the site area.

2 A nuclear facility shall designate an appropriately equipped room for the use of the police in commanding operations for the prevention of unlawful action being taken against the nuclear facility.

The Olkiluoto nuclear power plant has facilities that have been selected in cooperation with the police to serve as the police command centre and stand-by centre in case of unlawful action.

3 In a nuclear facility, excluding a research reactor, the same person cannot simultaneously act as the person responsible for commanding the security organisation and emergency functions.

This requirement is met. The matter is discussed in more detail in the security standing order.

5. Threats

5.1 13 § Actions to be taken when under threat

1. Immediate action commensurate with the situation shall be taken during a threat.

2. Whenever a threat has been detected, the alarm shall be raised with the police immediately. Information on the threat and its progress shall be submitted to the police as far as possible before they arrive at the scene.

The security standing order and guard instructions contain the necessary provisions.

3. When a threat has been detected, the person in charge of the security organisation will take control of measures preventing the threat. The Nuclear Energy Decree contains provisions concerning the transfer of leadership responsibility for security-related threats to the police.

4. The licensee shall appoint a sufficient number of persons with expertise in nuclear safety and radiation safety to assist the police. The licensee is responsible for the matters related to nuclear safety and radiation safety at the nuclear facility.

If necessary, experts with the necessary expertise from the emergency response organisation of the Olkiluoto nuclear power plant are appointed to support the security organisation.

5.2 14 § Notification of the Radiation and Nuclear Safety Authority (STUK)

1. The Radiation and Nuclear Safety Authority (STUK) will be notified without delay when a threat arises. The licensee shall ensure that the Radiation and Nuclear Safety Authority (STUK) is kept informed of the threat and its progress, even in cases where the security organisation command is committed to activities aimed at preventing the realisation of the threat.

The security standing order and guard instructions contain the requirements in accordance with the decree. Separate persons have been appointed for maintaining communication with STUK.

6. Miscellaneous provisions

6.1 15 § Drafting of plans

1. Plans on security, and measures to prepare for threats, shall be prepared in cooperation with the appropriate police authorities.

The plans on security arrangements and the related emergency response arrangements have been implemented in cooperation with the local and national police units.

6.2 16 § Obligation to observe confidentiality and secrecy

1. Section 16 Provisions on the obligation to observe confidentiality and secrecy are laid down in section 78 of the Nuclear Energy Act, and sections 14 and 41 of the Private Security Services Act.

The training related to confidentiality is provided to the entire personnel as part of the induction training. Information security is discussed in the company's information security policy and the related lower-level documents.

7. Summary

Based on the above, the security arrangements for the Olkiluoto 3 plant unit meet the requirements in the Radiation and Nuclear Safety Authority's regulation concerning security arrangements in the use of nuclear energy (STUK Y/3/2016, 1 January 2016).

APPENDIX 7

A DESCRIPTION OF

THE MEASURES TO RESTRICT THE BURDEN CAUSED BY THE NUCLEAR FACILITY ON THE ENVIRONMENT

TABLE OF CONTENTS

1. ENVIRONMENTAL IMPACTS ASSESSMENT

Environmental studies have been performed at Olkiluoto for nearly 40 years. The studies were initiated with comprehensive analyses concerning the basic status of the environment, and after the power plant was started, the effects of its operation have been tracked with extensive environmental monitoring programmes, the most significant of which involve the monitoring of radioactive discharges and the loads caused by cooling water and wastewater. The information concerning the environmental impacts of the plant units Olkiluoto 1 (OL1) and Olkiluoto 2 (OL2) will be utilised when evaluating the environmental effects of plant unit Olkiluoto 3 (OL3).

The releases into the environment from the facility occur in a controlled manner through the collection and processing systems for gaseous and liquid radioactive material. The nuclear power plant unit includes facilities and equipment required for the interim storage of spent nuclear fuel (for a few years) and the treatment and interim storage of low and intermediate level power plant waste. The separate interim storage for spent nuclear fuel (KPA storage) has been expanded to cover the needs of the OL3 plant unit. The plant site also features interim storage facilities for intermediate level waste (KAJ storage) and low activity level waste (MAJ storage). They can be used for the storage of nuclear waste generated during the operation of the OL3 plant unit without any plant modifications at this point.

The environmental impacts of the nuclear power plant unit will be evaluated throughout the entire service life of the unit. The project to construct a third plant unit at Olkiluoto started with an environmental impact assessment (EIA) procedure in accordance with the Act on Environmental Impact Assessment Procedure (468/1994). This allowed the project to receive a comprehensive assessment of the environmental impacts of the project and its different implementation options at an early stage. The EIA procedure was also used to provide the general public with information concerning the project and opportunities to participate in its planning.

The EIA procedure was not applied to increasing the capacity of the KPA storage, since it does not cause significant adverse environmental impacts comparable to the impacts of the projects listed in Section 6 point 7 (b–d) of the EIA Decree. However, this appendix also analyses the environmental impacts of the use of the KPA storage where applicable.

The environmental impacts of the OL3 plant unit have been discussed in more detail in connection with the environmental permit and cooling water intake permit procedure. A separate Natura assessment procedure has been completed concerning the effects of the project on the Natura nature conservation areas.

The environmental impact assessment has observed the combined impacts of the existing activities in the area and the activities that are planned for the area. There have been no substantial changes in the environment of the site area that would have affected the results of the environmental impact assessment. This appendix describes the environmental impacts of the OL3 power plant unit and the design bases for preventing environmental damage and limiting the burden on the environment.

TVO uses a certified environmental management system that meets the requirements of the international ISO 14001 and the EMAS directive. Furthermore, the Olkiluoto power plant is included in the industrial energy efficiency agreement, and the energy efficiency system is integrated into the environmental management system. TVO's environmental management system covers taking the environment and energy questions into account over the entire lifespan of nuclear energy generation, and the principle of continuous improvement as regards the level of energy efficiency.

2. RADIOACTIVE SUBSTANCES

2.1 Principle of isolation

The process of heat generation in a nuclear power plant is based on the splitting of uranium nuclei in the fuel of the nuclear reactor. This process generates radioactive substances that are isolated from the environment by means of multiple release barriers.

The fuel is inside the reactor pressure vessel, sealed inside gas-tight protective cladding. The fuel cladding and the reactor pressure vessel with its cooling water circuit form two nested release barriers around the fuel. The reactor containment, which has a steel lining on its inner walls, acts as the third and final release barrier between the radioactivity contained in the fuel and the environment.

The volume of the fuel used by the nuclear power plant is very small in comparison to the amount of energy it contains. The process that generates the heat does not need to be connected to the environment in order to operate. This allows for applying the principle of isolation that uses the protective layers described above. According to this principle, the radioactive substances created in the fuel, which account for the predominant part of the activity created in the nuclear power plant process, are retained within a small volume inside the plant unit.

An amount of radioactive substances that is low when compared to the radioactivity of the fuel is generated as a result of activation, as the cooling water flowing inside the reactor passes through the reactor core. Any substances released from the fuel as a result of possible fuel cladding failures are also carried over into the reactor cooling water. This activity is retained inside the reactor system or routed into other closed systems, such as the reactor water purification system, after which the radioactive substances are treated using nuclear waste management methods.

The principle of isolation is also applied to the waste management of the nuclear power plant. Radioactive waste is packed and supervised in a manner that ensures that no harmful releases into the environment can occur. The waste is disposed of in the bedrock. The waste packages and the technical protective layers surrounding them ensure that the waste is isolated from the organic environment in the long term. When the technical protective layers lose their integrity after an extended period of time, the activity of the waste will have reduced to a fraction of the original level and the amount of activity released only places a minor load on the environment. Nuclear waste management for the Olkiluoto 3 plant unit is discussed in Appendix 9 to this application.

2.2 Emissions during normal operation and operational occurrences

During operation, releases of radioactive substances are generated when processing water or gases removed from the reactor cooling system inside the purification systems, for example. At the power plant unit, reducing the activity of gaseous substances before their release into the environment is mainly based on delaying the release, which allows short-lived radionuclides to lose most of their activity before they are released into the environment. Radioactive substances that are released through the ventilation system in the KPA storage are measured and reported to the Radiation and Nuclear Safety Authority each quarter. In practice, there have been no detectable radioactive releases from the KPA storage (with the exception of a very small release of tritium), and these are not expected to substantially increase after the expansion of the KPA storage.

In order to limit the activity of effluents at the power plant unit, the water released into the environment is purified by means of filtration or evaporation. There are no direct radioactive water effluents from the KPA storage, since its active waste water is processed together with the active waste water from plant unit OL1. The releases of activity into the sea from the KPA storage are included in the releases from OL1 and not presented separately. The expansion of the KPA storage will cause a very small increase in the radioactive effluents from OL1.

All systems containing radioactivity are located inside plant rooms that are a part of the controlled area. Leakages and drain waters from the controlled area are led into collection tanks, from which they can be routed to purification or, if the activity is sufficiently low, released into the environment. The ventilation system is used to maintain the controlled area at a vacuum when compared to the ambient air pressure. The ventilation exhaust flow is filtered if necessary and routed into the plant unit's ventilation stack that has instruments for monitoring the activity level of the exhaust air.

The treatment and purification arrangements for radioactive materials are implemented in a manner that allows the releases caused by normal operation and anticipated operational occurrences to be kept at a level where the radiation dose caused to the local population is only a fraction of the limit values concerning the safety of nuclear power plants that are provided in the Nuclear Energy Decree (161/1988). The limiting value for releases during normal operation is 0.1 millisieverts per year. The limit value for the annual dose of an individual in the population, arising as the result of an anticipated operational occurrence, is also 0.1 millisieverts. The allowed release limits for radioactive materials from plant units in the same site area are defined in a manner where the combined releases do not cause a dose that would exceed the limiting value.

The radiation dose caused by the releases during the normal operation of Olkiluoto 3 to an individual of the nearby population is estimated to be below 0.001 millisieverts per year; in other words, it is of the same magnitude as the dose caused by the existing plant units. The KPA storage accounts for an insignificant share of the releases during normal operation.

During operation, the dose is estimated on the basis of results from release monitoring based on continuous measurement or sampling and the weather information registered by the weather mast. The calculation models have been approved by the Radiation and Nuclear Safety Authority. The estimated dose is less than 1% of the limit value and less than 0.03% of the average radiation dose that Finnish people receive annually from other radiation sources. Finns receive an average radiation dose of 3.2 millisieverts per year. Most of this is caused by natural radiation sources, the most significant of which is the radioactive radon gas that is released into indoor air from the soil. The other exposure is mostly due to background radiation from space and the soil and food, construction materials and healthcare procedures. The radiation dose caused by natural background radiation varies by area. For example, the dose caused by external radiation from soil and buildings varies between 0.17 and 1.0 millisieverts at different locations in Finland.

The annual radiation dose of less than 0.001 millisieverts that is caused by the Olkiluoto 3 plant unit on the local population results in a theoretical cancer risk that is insignificant in comparison to the risk level caused by the average annual dose of approximately 3 millisieverts and its regional variations.

In conclusion, it can be stated that the amounts of radioactive substances released into the environment during normal operation are so small that they are insignificant in terms of human health.

2.3 Releases in accident situations

In order to prevent accidents and to limit their consequences, the design, construction and operation of the plant unit follows safety principles and regulations that have been specified in Appendix 6 to this application. The same safety principles and regulations are applied as regards the KPA storage. The accident analyses presented in the final safety analysis report of the KPA storage have been updated to take into account the expansion of the storage.

The plant unit's design basis accidents include, for example, situations where a leak is formed in the reactor coolant system and the safety systems operate as intended. In these accident situations, no limitations concerning access or the use of foodstuffs are required in the areas surrounding the power plant. The radiation dose to the local population must not exceed the limiting values defined for postulated accidents in the Nuclear Energy Decree (161/1988). The limiting values for annual doses have been defined for different accident classes based on their postulated frequency of occurrence. Class 1 postulated accidents can be assumed to occur less frequently than once during any period of a hundred years of operation, but at least once during any period of a thousand years of operation. Class 2 postulated accidents can be assumed to occur less frequently than once during any period of a thousand years of operation. The limit value for the annual dose of an individual of the population is 1 millisieverts for class 1 accidents and 5 millisieverts for class 2 accidents. The dose is calculated as a sum of the effective dose due to external radiation in any one year and the committed effective dose from the intake of radioactive substances over the same period of time. The integration time for adults is 50 years.

The limits apply to the radiation dose of a representative individual from the most exposed population group. The presented dose limits are of the same magnitude as the radiation dose received by average Finns from other radiation sources over the course of a year. If an average Finn receives the dose corresponding to the limiting value of a postulated accident once during their lifetime, it will increase their radiation burden by approximately 2%. This change is minor when compared to the variation in lifelong dose caused by natural radioactivity in different regions of Finland.

Design extension condition refers to an accident where an anticipated operational occurrence or class 1 postulated accident involves a common cause failure in a system required to execute a safety function, caused by a combination of failures identified as significant on the basis of a probabilistic risk analysis (PRA) or a rare external event, and which the plant unit is required to withstand without severe fuel damage. The limiting value for the annual dose of an individual in the population, arising from a design extension condition, is 20 millisieverts. This corresponds to the annual radiation dose that is allowed for a radiation worker as a five-year average..

In the case of a severe reactor accident, it is assumed that the plant's safety systems are not operational as a result of a leak in the reactor system or other damage. This may result in severe damage to the reactor core, as a result of which some of the radioactive substances contained in the fuel are released into the reactor containment. According to the design requirements, the containment must limit the amount of radioactivity released into the environment in a manner which causes neither acute health detriments to the population in the vicinity of the nuclear power plant nor any long-term restrictions on the use of extensive areas of land and water. Pursuant to the Nuclear Energy Decree (161/1988), *the release of radioactive substances caused by a severe reactor accident or a severe accident at a nuclear power plant shall not result in the need for large-scale population protection measures or prolonged restrictions on the use of large areas of land and water. To limit long-term effects, the limit for an atmospheric release of caesium-137 shall be 100 TBq. The probability of exceeding this limit shall be extremely low.* The Radiation and Nuclear Safety Authority's Guides for Nuclear Safety set forth numeric design goals for the core damage frequency and the probability of a release that exceeds the above limiting value.

The final safety analysis report (FSAR) for the plant unit uses detailed analyses to demonstrate that the plant unit meets the requirements for accident situations set forth in the Nuclear Energy Decree (161/1988). Probabilistic risk assessments (PRA) are used to demonstrate that the probability of exceeding the limiting value for a severe reactor accident is very small.

2.4 Actions taken in order to reduce environmental impacts

Minimising the environmental impacts of radioactive releases is based on minimising releases according to the principle of isolation described above. In accordance with the Radiation and Nuclear Safety Authority's Guides, releases must be limited by using the Best Available Techniques (BAT). The BAT approach refers to production methods, methods for the purification of releases and methods for operational planning, construction, maintenance and operation that are as effective and advanced as possible, technically and financially viable, and can be used to prevent or effectively reduce the pollution of the environment due to the operation. The water treatment and off-gas systems of the plant have been designed with this approach in mind.

The waters and gases released into the environment are effectively purified by collecting the radioactive substances contained in them into filters that are stored as solid nuclear waste, isolated from the environment. During operation, the releases of radioactive substances are so minor that their effect on the radiation dose to the environment is insignificant.

The solid radioactive waste accumulated in the filters is temporarily stored on the premises at OL3 and in the interim storage for intermediate level waste in the site area. Later, the intermediate level waste from OL3 will be disposed of in the extension of the VLJ facility.

Radioactive wastewater will be led into the containers at the waste building via fixed pipelines. There are separate collection containers for primary circuit water. The treatment of wastewater depends on its composition. Centrifugal separation and evaporation are used to separate solid particles and solidify liquid waste. The process can be improved by using different chemicals according to the situation, and biological methods can also be used for organic waste. The steam that is generated in the evaporation process is liquefied and collected into a monitoring tank. The sufficiently low activity level of the water released into the environment is determined by using a sampling-based measurement and a separate measurement that monitors the radiation level of the pumping line and stops the pumping when the limiting value set for the radiation level is exceeded.

Gaseous radioactive waste mainly consists of the fission gases xenon and krypton, which are dissolved into the primary coolant as a result of fuel failures. These are discharged into the degasification system along with the other gases that have accumulated in the primary circuit, such as hydrogen and oxygen. The degasification system consists of flushing and delay sections. Gases can be released from the flushing section in order to reduce the hydrogen concentration. In the delay section, the radioactive xenon and krypton are delayed, which causes their amounts to fall very low as a result of radioactive decay. The gas released from the off-gas system is routed into the ventilation stack that has a continuous activity level measurement.

The plant's safety systems aim to ensure that releases are controlled even in accident situations. Nevertheless, preparations are also made for activities that can be started in an accident situation in order to prevent the unnecessary radiation exposure of the population. The power plant operator's own emergency preparedness organisation is prepared to perform the necessary radiation measurements in the site area and its vicinity, to issue the necessary alarms to the nearby area and the authorities and to estimate the effects of any possible radiation doses released into the environment due to the accident. In an accident situation, the rescue services organisation of the authorities is responsible for any population protection activities that may be considered necessary.

2.5 Analysis methods for environmental impacts

Standardised calculation models are available for estimating the convection of radioactive substances in water systems, the atmosphere and food chains. They can be used to estimate the radiation doses of the environment on the basis of measured and anticipated releases. The models take into account all the significant exposure routes through which radioactive substances can be carried inside the human body. The information concerning the environment and the living habits of the population that are required for the models have been analysed and selected to suit the environment at the site area. The calculation of airborne convection uses meteorological measurement information that is produced by the continuously operating measuring instruments at the plant site.

The actual conditions of the site area and its surroundings cannot be completely described in the dose calculations due to the high variation in the variables describing the environment and the living habits of the population. This is compensated for by selecting numeric values for the variables in the models that tend to increase the radiation dose calculated on the basis of the releases. This conservative approach that tends to overestimate the doses aims to ensure that the actual doses caused to humans are always smaller than the calculated values.

2.6 Monitoring programme

The releases of radioactive substances from the nuclear power plant occur through monitored discharge routes. The total activity and nuclide concentration of the releases are measured. The direct measurement of the doses caused in the environment by the emissions is impossible due to their small size when compared to natural background radiation and its variations. The concentrations of radioactivity are measured by means of an environmental radiation monitoring programme that includes, among other things, determining the activity concentrations of some 400 environmental samples each year.

The radiation and radioactivity in the environment are monitored according to a monitoring programme that is updated at least once every five years. The updates of 2008 and 2009 added sampling points that can be used to detect any releases that could be carried further to the sea due to the increase in cooling water flow caused by OL3. The radiation monitoring programme was last updated in 2012. The measurement and sampling targets are external radiation, air, rain water, soil, milk, grain, garden products, meat, pasture grass, natural plants, game, household water landfill water, groundwater, seawater, periphyton, sedimenting matter, bottom sediment, fish, aquatic plants, benthos and the local population.

During the operation of OL1 and OL2, as a result of the low amount of released radioactive substances, the measurements of the monitoring programme have not indicated any changes in the radiation dose levels of the power plant environment that would be distinguishable from natural background radiation. In precise nuclide-specific measurements, individual samples have shown small amounts of radioactive substances that originate from releases at the power plant. The detailed environmental monitoring results are presented to the Radiation and Nuclear Safety Authority in the quarterly and annual reports.

3 COOLING WATER AND WASTEWATER

3.1 Load

The Olkiluoto 3 plant unit utilises cooling water at a rate of approximately 60 m^3/s. The water passes through the turbine condenser inside the piping and returns to the sea 12oC warmer. The cooling water is extracted from the OL3 plant unit's own intake channel and discharged into the expanded cooling water discharge channel for the existing plant units OL1 and OL2. On 19 June 2006, the Environmental Permit Agency of Western Finland granted TVO a permit (no. 13/2006/2) in accordance with the Water Act to route the cooling water required by OL3 from the sea. The licence conditions concerning the discharge of cooling water have been defined in the environmental permit for the power plant.

The KPA storage acquires its cooling water from Olkiluodonvesi, which is also where the warmed cooling water is discharged. After the expansion, the cooling power and cooling water flow may increase approximately twofold. After the commissioning of OL3, the cooling water is mixed with the cooling water intake of three nuclear power plant units (approximately 140 m^3/s in total); for this reason, the thermal load is not anticipated to have substantial environmental effects. The thermal load of the KPA storage will be at its highest, approximately 4 MW, after the decommissioning of OL1 and OL2.

Wastewater created in the power plant area includes the water from the raw water treatment plant and demineralisation plant, the water from the liquid waste treatment plant, the rinsing water from the chain basket filters, sanitary wastewater and laundry wastewater. The wastewater fractions are treated by mechanical, chemical or biological methods or combinations thereof before they are discharged into the sea. The wastewater causes minor nitrogen and phosphorus loads as well as oxygen consumption loads in the sea areas. The loads caused by non-radioactive wastewater are regulated in the environmental permit of the power plant.

3.2 Environmental impacts of the load

The water areas surrounding the site area allow for the supply of the cooling water required for the Olkiluoto 3 plant unit and the discharge of the cooling water back into the sea. The sea area around Olkiluoto is fairly open and provides a good environment for the mixing and circulation of water. Winds have a strong effect on the currents.

The construction of the Olkiluoto 3 plant unit will increase the amount of cooling water; as a result, the growth in the warmed-up area that stays open during the winter is directly proportional to the thermal power released into the sea. The rise in temperature that is caused by the combined effects of three power plant units will extend to a distance of a few kilometres from the discharge site. However, the water temperature will only rise by several degrees in the very top layer of the waters surrounding the discharge site. The rise in temperature is most clearly observable during a cold winter, as the sea area in front of Olkiluoto remains open and the ice around it is weakened. The temperature increase caused by cooling water and the size of the warmer area vary by weather, season and the degree of utilisation of the power plant.

Experience has shown that the effects of cooling water on the other characteristics of seawater are very low. The oxygen situation in front of Olkiluoto has been good almost without exception, and the situation is not expected to drastically change as a result of the thermal load. The biological effects of warm cooling water in the water system are due to the extended growth period in the ice-free areas. This increases the basic production of phytoplankton, but not substantially when compared to the natural variation.

The effects of cooling water on the fish populations in the area are expected to remain at the current level. Cooling water affects the movements and occurrence of specific species of fish in the area. The usability of the fish is not affected by cooling water. Cooling water does cause limitations on ice fishing. After the operation of OL3 has started, TVO will analyse the passage of fish to the plant unit with the cooling water in accordance with the permit it has received pursuant to the Water Act.

The concentrations of nutrients in the sea areas in front of Olkiluoto are typical of the coastal waters of the Bothnian Sea. Since the increase in wastewater load is minor, it is not expected to affect the state of the sea area. The rivers that flow towards the sea area have the largest impact on the nutrient and solid matter loads in the sea areas in front of Olkiluoto.

3.3 Analysis methods for environmental impacts

The environmental impacts of the Olkiluoto power plant have been assessed by utilising survey and follow-up information that has been gathered in the surrounding areas of Olkiluoto for nearly 40 years. Calculation methods based on computer modelling have been used to support the design of the cooling water solutions for the new plant unit.

The dispersion of the cooling water from the Olkiluoto 3 plant unit and its impact on seawater temperatures and the ice situation have been analysed by means of a three-dimensional flow model developed by Suomen Ympäristövaikutusten Arviointikeskus Oy (YVA Ltd). The modelling examined the differences between different intake and discharge location options, and the results were available when the optimal placement and structure for the unit's cooling water intake and discharge was being optimised.

3.4 Actions taken in order to reduce environmental impacts

The environmental effects of cooling water can mainly be influenced by the purposeful design of the intake and discharge structures. The intake and discharge locations of the Olkiluoto 3 plant unit have been positioned in a manner that minimises warm water recirculation and maintains the discharge water temperature as low as possible. In order to minimise the adverse effects, the discharge flow is guided in a manner that effectively mixes the warm water with the surrounding bodies of water.

The environmental permit decision for the Olkiluoto power plant requires analysing the recirculation of cooling water and taking actions in order to prevent it. TVO has constructed an embankment in the strait between the islands of Olkiluoto and Kuusisenmaa in order to prevent recirculation. The Environmental Permit Agency of Western Finland granted TVO a permit (no. 52/2009/2) for the construction of the embankment.

The amount of wastewater generated at the power plant is minimised by means of water use planning and recycling. The wastewater generated from the operation of Olkiluoto 3 is treated either at the OL3 plant unit or in the common wastewater treatment systems for the Olkiluoto power plant.

3.5 Monitoring programme

The environmental effects of the Olkiluoto nuclear power plant are being monitored in accordance with the environmental permit granted by the Environmental Permit Agency of Western Finland. The comprehensive environmental monitoring programme covers, among other things, the monitoring of the amount and temperature of cooling water, the monitoring of the operation and load of the sanitary water purification plant, the physicochemical and biological monitoring of the sea area, the monitoring of the ice situation and fishery research.

The results of the environmental monitoring are reported for each monitoring session and as an annual report. The annual report is submitted to the Centre for Economic Development, Transport and the Environment of Southwest Finland, which acts as the environmental supervision authority and fishery authority, the environmental authorities of the municipality of Eurajoki, and several other national and local authorities.

4. OTHER ENVIRONMENTAL IMPACTS

Other environmental impacts caused by the operation of the Olkiluoto 3 plant unit include noise, waste, releases into the air from the auxiliary power sources and the storage and use of chemicals and liquid fuels in the site area. The realisation of these effects is regulated in the environmental permit for the Olkiluoto power plant unit and the permit for the industrial processing and storage of hazardous chemicals. As regards the carbon dioxide emissions of the emergency diesel generators TVO is included in the emissions trade system.

5. EFFECTS ON NATURA AREAS

The possible effects of the Olkiluoto 3 plant unit on Natura 2000 areas were already examined during the environmental impact assessment. After this, the effects were assessed in more detail in a separate Natura assessment (Report by Insinööritoimisto Paavo Ristola Oy on 17 May 2001 and site visit report on 31 August 2001). The reports state that the consequential effects of the new plant unit cannot be considered substantial in terms of the conservation of natural values in the Natura areas. In its statement on 26 June 2001, the Centre for the Environment of Southwest Finland stated that the operation of the new unit would not be likely to cause significant changes to those natural values of the Rauma archipelago area (FI0200073) proposed for inclusion in the Natura conservation programme that were used as the basis for the proposal.

6. ENVIRONMENTAL PERMITS

On 19 June 2006, the Environmental Permit Agency of Western Finland granted TVO an environmental permit to expand the Olkiluoto nuclear power plant by constructing the OL3 plant unit (no. 12/2006/2 and 11/2006/2). The environmental permit was discussed by higher instances: the Administrative Court of Vaasa made a decision on the matter on 28 August 2008 and the Supreme Administrative Court gave its decision on 16 September 2009. The decision by the Supreme Administrative Court gave legal force to the environmental permit. The environmental permit is valid until further notice, and an application to amend the requirements of the permit was submitted to the authorities on 30 April 2014.

7. CONCLUSIONS

The OL3 nuclear power plant unit underwent a comprehensive environmental impact assessment procedure, during which the implementation of the new power plant was not found to have any significant adverse effects on the environment that could not be reduced to an acceptable level. Due to the careful adherence to the principle of isolation, the operation-time releases of radioactivity from the nuclear power plant are so low that they do not have an effect on the environment or the local population. Even in accident situations, the releases will be so small that environmental effects are low and will not prevent the normal use of the environment. The cooling water from the Olkiluoto 3 plant unit is not considered to be unreasonably detrimental to the water systems in the region.

The environmental effects of OL3's operation will be monitored by means of monitoring programmes, and the results will be reported to the regulatory authorities in the manner required by the monitoring programmes. The environmental effects of the plant unit and the implementation of its monitoring programme will also be evaluated in connection with the renewal of the operating licence and the review of the environmental licence.

APPENDIX 8

A DESCRIPTION OF

THE EXPERTISE AVAILABLE TO THE APPLICANT
AND THE OPERATING ORGANISATION OF THE NUCLEAR FACILITY

TABLE OF CONTENTS

1. GENERAL DESCRIPTION OF THE ORGANISATION

The power plant's operating line organisation and nuclear safety organisation and their management relationships, tasks, authorities and qualification requirements are presented in the administrative rules of the Olkiluoto nuclear power plant that are required by Section 122 of the Nuclear Energy Decree (161/1988). Furthermore, the administrative rules present the responsible managers referred to in Section 7 k of the Nuclear Energy Act and their deputies and the persons responsible for emergency response arrangements, security arrangements and safeguards of nuclear materials referred to in Section 7 i of the Nuclear Energy Act and their deputies, and their tasks, authorities and responsibilities. The administrative rules observe the responsibilities and leadership relations of the Olkiluoto 3 (OL3) plant unit during its construction and operation. The administrative rules have been approved by the Radiation and Nuclear Safety Authority.

The Operations section's organisation for the OL3 plant unit is part of the Operations unit within Teollisuuden Voima Oyj's Electricity Production business and it is managed in a similar manner to the Operations sections of the OL1 and OL2 plant units. The OL3 Operations section reports to the Vice President of Production of Teollisuuden Voima Oyj. Figure 1 presents the organisation of Teollisuuden Voima Oyj.

Teollisuuden Voima Oyj's organisation and the tasks of the organisation units have been presented in more detail in a separate organisation manual that also presents the organisation and responsibilities for the OL3 plant unit. The organisation manual has been submitted to the regulatory authority (STUK) for information. The following only presents an outline of the organisation.

2. ADMINISTRATIVE BODIES, SELECT COMMITTEES AND COMMITTEES

The company has a Board of Directors that consists of representatives named by the General Meeting.

The Board has appointed the following select committees that report to it: the select committee for Auditing and Financing, the select committee for OL3, the select committee for Nuclear Safety and the select committee for Appointment and Rewards.

The Board has appointed the following committees and guidance groups to assist the operative management: the Operations committee, the Financing committee, the Economics committee and the OL3 committee.

3. GENERAL MANAGEMENT

TVO's operations are led by the President and CEO, whose direct reports are the Directors of business and services and the group's Business Partners. The President and CEO reports to the Board concerning the operation and results of the company.

The President and CEO is assisted by the Management Group that includes the President and CEO, the Directors, the President and CEO of Posiva and a representative from the personnel and his/her deputy in accordance with the Act on Personnel Representation in the Administration of Undertakings. The President and CEO acts as the chairman.

TVO's organisation is divided into three business units and three service functions. TVO's business units are Electricity Production and the OL3 project, in addition to which Posiva is a third business unit at the group level. The services required by the group and the business units are centrally produced by the service functions. The service functions include Technical Services, Safety and Support Services. Safety is also responsible for the supervision tasks that require independence.

The business units are led by business directors and the service functions are led by service directors.

The business units and service functions are divided into units or competence/service centres and further into teams or sections.

Units and competence/service centres are led by managers, sections are led by section heads and teams are led by team supervisors.

The service functions also have tasks (roles) for development representatives, service representatives and customer representatives. A representative is responsible for a specific area. The title of Business Partner is independent of the organisation hierarchy. It depicts the role of leading and developing a service function within a business unit.

Experts form bodies that report to the President and CEO, directors or managers. Experts operate in special tasks within their field. There are three levels of experts: executive experts, senior experts, and experts.

For the management of cross-functional tasks or topics, the management has set up workgroups that include representatives from different organisation units. These include the following, for example:

- Safety group
- Plant meeting
- Information Security group
- Fuel group
- Outage group
- ALARA group
- Operating Experience group
- Risk Management group
- Ageing Management group
- Safety Culture group

The composition and tasks of the workgroups are defined in the organisation manual appendix "Meetings and workgroups", with the exception of the Safety group whose rules of procedure are defined in the administrative rules of the Olkiluoto nuclear power plant.

Different expert groups may be assembled to discuss specific topics, if necessary. The purpose of these groups is to simplify the processing of matters and to promote information transfer and cooperation across the boundaries of organisation units.

The organisation manual describes the structure of TVO's organisation, the task areas, responsibilities and authorisations of the organisation units, the general principles for developing the organisation and the principles for cooperation in more detail. The organisation manual is submitted to STUK for information. Figure 1 presents TVO's basic organisation.

4. ELECTRICITY PRODUCTION

The task of the Electricity Production business unit is to manage the commissioning, operation and maintenance of the company's nuclear facilities, operations support, training the control room personnel in terms of plant and operations technology, supervising the environmental impacts related to the business unit's operations and planning and implementing outage operations.

The task of the business unit is to ensure that the structure of the company's nuclear facilities continuously allows for economically optimised energy production while meeting the safety requirements.

The task of the business unit is also to suggest and justify structural changes to the nuclear facilities and to participate in their design and implementation, and to prepare for the operation of new nuclear power plant units.

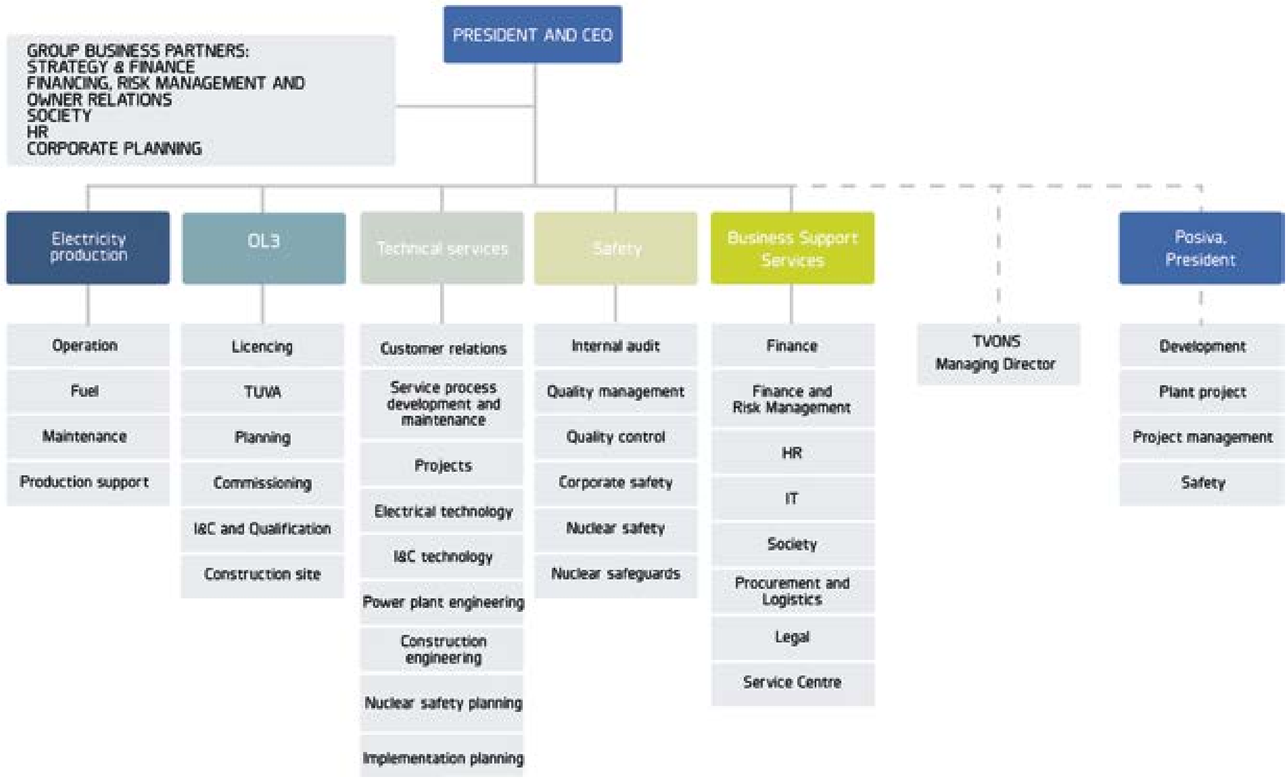


Figure 1. TVO's basic organisation.

The business unit draws up the annual investment plans, maintains a long-term investment plan and tracks their implementation.

The business unit is also responsible for the procurement of nuclear fuel and fuel for the Meri-Pori power plants as well as for power management.

The business unit must perform its tasks in a manner whereby electricity production is economically optimised and compliant with the requirements and goals set for nuclear safety, quality assurance and environmental protection.

4.1 Operations unit

The unit includes the following sections, teams and areas of responsibility:

- OL1 Operations section
- OL2 Operations section
- OL3 Operations section
- Operations Support team
- Power Management responsibility area

The task of the unit is to operate the plant units Olkiluoto 1, Olkiluoto 2 and Olkiluoto 3 and the KPA storage in accordance with the company's objectives and obligations as well as the regulations and guidelines, and to plan and develop the operational activities of these plant units.

The task of the unit is to coordinate and supervise the activities at the plant units Olkiluoto 1, Olkiluoto 2 and Olkiluoto 3 in order to ensure that the activities are safe, economical and systematic.

The manager of the Operations unit has the following separate tasks:

- Acting as the project manager for the OL3 project's TUVA subproject
- Acting as the TVO OL3 Operation Manager during the commissioning stage of the OL3 project.

4.1.1 Operations sections and Operations Support team

The activities of the Operations sections are led by section heads, who are responsible for operating the plant unit within their area of responsibility according to the guidelines and regulations that are in force. The head of the OL1 Operations section is responsible for supervising the operation of the KPA storage and VLJ facility and for operating the KPA storage according to regulations and guidelines. The section head is responsible for applying for and maintaining the licenses required by the OL1, OL2 and OL3 operating personnel, the drafting of the disturbance and scram reports, launching investigations concerning operational occurrences and making or requesting the decision for starting the plant in accordance with the Technical Specifications. The shift supervisors, outage coordinator, power plant engineers and operations technicians report to the section head.

- During preparation for electricity production, the tasks of the head of the OL3 Operations section are as follows:
- Managing the use of the control room, work permit office and field operator resources required for the commissioning of the OL3 in the OL3 project's common OIO organisation.
- Acting as the TVO OIO Operation Manager during the commissioning stage of the OL3 project.

The most important tasks of the Operations Support team include:

- Drawing up the production forecasts and plans for the plant units.
- Maintaining and developing the instructions and documents related to the operation of the plant units.
- Drawing up the reports concerning the operation of the plant units and submitting daily reports to STUK.
- Monitoring, analysing and reporting the power level variations of the plant units and compiling statistics concerning them during the operating cycle and in connection with plant modifications.
- Advance planning of the functional periodic tests performed by Operations, coordinating their performance and arranging supervision.
- Supervising the performance of the periodic tests that are important to safety and assessing the acceptability of the test results.
- Training the operating personnel, in particular in terms of plant technology, operations technology and simulator training.

4.2 Maintenance unit

The unit includes the following teams:

- Electrical and I&C Maintenance planning
- Mechanical Maintenance planning
- Mechanical Maintenance
- Electrical and I&C Maintenance
- Property Maintenance
- Property Management

The task of the unit is to ensure the preventive maintenance, condition monitoring, repair and modifications of the buildings, properties and mechanical equipment in the Olkiluoto area. Furthermore, the task of the unit is to participate in the planning and implementation of structural modifications regarding mechanical, electrical and I&C equipment and systems, and managing the electrical work, I&C work, condition monitoring and repair work for the buildings and properties in the Olkiluoto area.

4.3 Production support

The unit includes the following teams and representatives:

- Radiation Protection
- Chemistry
- Fuel and Waste Handling
- OL3 Representative

The task of the unit is to take care of the planning, implementation and supervision of functions related to power plant chemistry, activity measurements, radiation monitoring and the environmental research and monitoring within the area of responsibility of the Electricity Production business unit and the planning, implementation and supervision of radioactive waste handling activities and to participate in the planning, implementation and supervision of fuel handling activities.

The unit is responsible for ensuring that the MAJ and KAJ storages and the VLJ facility are being operated in accordance with regulations and guidelines.

The unit is responsible for managing decontamination tasks, laundry operations and the operations, supervision, reporting and development of housekeeping and waste management within the controlled area and other specified areas.

The tasks of the unit manager include:

- Ensuring chemical safety in accordance with the methods described in TVO's safety analysis report and the chemical licences in cooperation with the other supervisors of chemical use.

4.4 Fuel unit

The unit includes the following teams:

- Procurement
- Calculation and supervision

The unit manages TVO's nuclear fuel throughout its lifecycle, i.e. from the purchase of uranium up to the point when the fuel elements have been disposed of, and the procurement of coal for the Meri-Pori power plant. This includes fuel procurement, planning its transport, handling, use, inspections and storage and ensuring their implementation.

5. TECHNICAL SERVICES

This function provides services for the Safety function and the group's business units: Electricity Production, OL3 and Posiva.

The task of the service function is to, for its part, ensure that the company's business units have access to sufficient services for the continuous economical optimisation of the nuclear facility's structure while fulfilling the safety regulations. Performing this task requires, for example, analysing technical problems, utilising experience from outside the company and closely monitoring the technical developments within the nuclear energy industry.

The task of the service function is to take care of, for its part, the drawing up of programmes and plans that are required in order to ensure the nuclear safety and operability of the company's nuclear facilities and coordinating their implementation, and the analysing of events and conditions that affect or jeopardise nuclear safety and operability.

The service function supports the preparation and construction of new nuclear facilities by means of its services.

The task of the service function is to offer services for analysing the defects observed at the company's nuclear facilities and the anticipation of postulated defects and damage, and to offer services related to drawing up action/repair plans for targets that are critical in terms of safety and production in order to prepare for repairing defects and damage.

The task of the service function is to ensure the feasibility and profitability assessment, basic planning and implementation planning of the structural modifications made at the nuclear facilities. The service function also participates in annual outage planning and the outage functions.

Furthermore, the service function is responsible for managing the general design principles and safety analyses of the nuclear facilities.

The service function draws up the annual investment plans for the operating nuclear facilities and infrastructure, maintains a long-term investment plan and tracks their implementation.

The service function is responsible for managing the drawing up or acquisition of the company's plans and programmes related to nuclear waste management, the drawing up or acquisition of safety analyses related to the disposal of power plant waste, and acquiring the relevant authority approvals.

The service function is responsible for developing project control methods and tools.

The service function coordinates the research and development activities of the company and follows international development and events within the nuclear energy industry.

The Technical Services function contains seven competence centres: Power Plant Engineering, Construction Engineering, Electrical Engineering, I&C Engineering, Nuclear Safety Engineering, Implementation Engineering, and Projects.

The task of the competence centres is to ensure the competence within their area of expertise and its development, the optimal acquisition of external personnel resources and the optimal usage of personnel and competence. The competence centres distribute workers between continuous services and projects according to their prepared plans.

6. SAFETY

The Safety function comprises the following competence centres and areas of responsibility/responsible individuals:

- Competence centre for Nuclear Safety
- Competence centre for Corporate Safety
- Competence centre for Quality Management
- Competence centre for Quality Control
- Person responsible for nuclear material safeguards
- Internal audit
- Person responsible for safety development

The task of the function is to take care of the drawing up of programmes and plans that are required in order to ensure the nuclear safety, quality management, quality control, corporate safety and nuclear material safeguards of the company's nuclear facilities and coordinating their implementation, the analysing of events and conditions that affect or jeopardise nuclear safety and operability, and the supervision of the implementation of the required improvements.

Furthermore, the task of the Safety function is to independently supervise the compliance of the general design principles and safety analyses of the nuclear facilities and to ensure the licensing of the nuclear facilities as required under the Nuclear Energy Act.

The Safety function is also responsible for and takes care of the operation of the company's inspection organisation and its internal audit.

The person responsible for safety development is responsible for the development of the Safety function.

The manager of the Safety department acts as the chairman of the Safety group.

7. SUPPORT SERVICES

Support Services produces the support services required by all business and service units within the TVO group and manages their policies and performance.

The director of Support Services is responsible for providing support services for the business units and for ensuring the performance of service production.

The heads of the competence centres are responsible for leading, organising and resourcing their own support functions as a whole, and for participating in the development of the functional model for all of the support functions and finding synergy benefits.

The manager of a service centre leads the organisation of the service centre and is responsible for its organisation and resourcing.

The appointed Business Partners support the business management in strategic, tactical and operative planning, decision making and implementation from the point of view of their own functional expertise.

8. OL3 PROJECT

The business unit is responsible for implementing the Olkiluoto 3 project according to the schedule and cost goals and in a manner whereby the requirements set for the safety, technical performance and economy of the plant unit are met.

The business unit is responsible for implementing the Olkiluoto 3 project according to the plant supply contract and the other contracts and requirements concerning the project.

The business unit ensures that TVO acquires the licences and authority approvals required for the progress of the project in a timely manner.

The business unit leads the OL3 project and coordinates and supervises all of the tasks required by the project, even when TVO's other parts are responsible for performing individual tasks.

In cooperation with the rest of TVO's organisation, the business unit ensures that the following tasks are performed:

- The progress of the OL3 project is communicated to a necessary extent in cooperation with the Communications unit.
- Sufficient preparations are made for the operation of the Olkiluoto 3 plant unit in terms of the instructions and personnel required during the operation stage and the training of personnel.
- Fuel and nuclear waste management are arranged for the plant unit Olkiluoto 3.
- Human resources and office services are arranged for the project.
- Training and competence development are arranged for the project personnel.

The implementation stage of the OL3 project has been organised into subprojects that comprise the work and procedures required for the completion of the OL3 project:

- Planning
- I&C and Qualification
- Construction site
- Commissioning
- Licencing
- Preparing for production

The subprojects are led by subproject managers that report directly to the manager of the OL3 project.

The services required for the business unit are acquired from the competence centres and service centre within the support services, the Technical Services, the Safety function and Electricity Production.

9. ANALYSIS OF THE EXPERTISE AVAILABLE TO TEOLLISUUDEN VOIMA OYJ

9.1 Human resources and training

On 31 December 2015, the company permanently employed 730 persons, of which 78% have a training background in technology or natural sciences; this includes 14 doctors or licentiates, 144 Masters of Science in Engineering, 232 engineers, and 54 technicians and vocational-level engineers. Alongside the employees with a background in technology or natural sciences, the company employs persons with financial or legal expertise in the nuclear industry.

A substantial number of the persons currently working in positions connected to the Olkiluoto 3 plant unit have entered the service of Teollisuuden Voima Oyj during the planning and construction stages of the OL3 project. Their expertise concerning the OL3 plant unit has been ensured by means of basic training that is suitable for planning and construction stage positions and by ensuring sufficient experience in different positions in the field. These persons have been and will be assigned mainly to positions within the operation, technical support and maintenance of the OL3 plant unit.

Experienced personnel from the OL1, OL2, and Loviisa nuclear plant units and the best experts in different fields of technology have been used as consultants in the project's coordination, planning and safety-related tasks. In practice, all of the organisations within TVO have provided their efforts and expertise for the benefit of the OL3 project. This arrangement has ensured that the OL3 plant unit can also benefit from Teollisuuden Voima Oyj's experience in the operation of nuclear power plants that has been accumulated over the years.

Expert partnerships with French and German nuclear power plants have also been signed during the course of the project and planning information has been exchanged. The assessments of the experts who participated in the planning and construction stages and the authority's statements regarding the sufficient expertise of the plant supplier consortium have been positive.

TVO has provided training for its personnel as well as contractors, in particular as regards the specific characteristics of a nuclear power plant, the related operating practices, safety culture and technology. Table 1 presents the development of training days in 2006–2015, and Tables 2 and 3 present the actual training days for TVO's personnel and contractors in 2014–2015, broken down by topic.

Table 1. Development of training days at TVO in 2006–2015

	Total	Internal	External	Clerical employees Total	Workers Total
2006	11,065	10,290	775	10,379	686
2007	10,166	9,446	720	9,299	867
2008	8,847	8,271	576	7,874	973
2009	8,835	8,058	777	7,540	883
2010	7,482	6,967	514	6,470	655
2011	11,137	10,278	859	9,982	1,015
2012	8,636	7,711	924	7,222	1,414
2013	7,892	7,207	685	6,794	712
2014	7,272	6,668	604	6,531	740
2015	7,392	7,059	332	5,673	1719

For TVO's own employees, the internal training days in 2014 and 2015 divided as follows:

Table 2. Training days for internal training of TVO's own employees by topic in 2014–2015.

	Days 2014	Days 2015
00 General technology	174	58
10 Nuclear technology	912	691
20 Plant technology	793	1,069
30 Operations technology	1,833	2,185
40 Maintenance	499	492
50 Protection and emergency preparedness	1,347	964
60 Administration and finances	69	100
70 ICT	239	341
80 Cooperation and communication	543	432
90 Other training	259	727
Total	**6,668**	**7,059**

For contractors, the training days arranged at TVO are divided by topic as follows in 2014 and 2015:

Table 3. Training days for internal training of contractors by topic in 2014–2015.

	Days 2014	Days 2015
00 General technology	31	27
10 Nuclear technology	121	73
20 Plant technology	58	20
30 Operations technology	28	1
40 Maintenance	191	79
50 Protection and emergency preparedness	1,575	1,260
60 Administration and finances	26	8
70 ICT	73	93
80 Cooperation and communication	44	4
90 Other training	20	459
Total	**2,167**	**2,024**

A total of some 170 weeks of training have been ordered from the plant supplier in connection with the OL3 plant delivery. This training is intended for the operating personnel, maintenance personnel and technical support personnel of the OL3 plant.

A total of 1,430 days of training related to OL3 were arranged during 2015. The enclosed table presents the development of OL3 training in 2010–2015 and the distribution of OL3 training by topic in 2015 for TVO's own personnel and for subcontractors.

Table 4. Development of OL3 training days 2011-2015

Year	Duration (days)	Number of participants
2011	3931	2577
2012	1186	1204
2013	672	822
2014	401	448
2015	1430	1037

Table 5. Development of the distribution of internal OL3 training in 2010–2015, TVO's own personnel

	Days 2010	Days 2011	Days 2012	Days 2013	Days 2014	Days 2015
00 General technology	0	0	0	0	0	0
10 Nuclear technology	61	763	120	50	12	19
20 Plant technology	806	1,424	472	114	56	843
30 Operations technology	246	889	205	348	199	361
40 Maintenance	0	81	0	0	0	19
50 Protection and emergency preparedness	1	46	3	0	20	41
60 Administ. and finances	55	33	0	0	0	0
70 ICT	1	122	7	21	20	31
80 Cooperation and communication	20	22	0	0	0	0
90 Other training	0	0	0	5	0	0
Total	1,190	3,380	807	538	307	1,314

Table 6. Development of the distribution of internal OL3 training in 2010–2015, contractors

	Days 2010	Days 2011	Days 2012	Days 2013	Days 2014	Days 2015
00 General technology	0	0	0	0	0	0
10 Nuclear technology	118	165	134	33	12	3
20 Plant technology	43	139	93	77	2	14
30 Operations technology	0	0	24	0	3	0
40 Maintenance	0	0	0	0	0	19
50 Protection and emergency preparedness	12	64	22	0	62	42
60 Administr. and finances	50	17	0	0	1	0
70 ICT	1	62	8	6	2	31
80 Cooperation and communication	34	26	0	2	0	0
90 Other training	0	0	0	0	0	0
Total	258	473	281	118	82	111

The launch of the OL3 construction project gave birth to the need to create a common induction training for all employees working at the construction site. The area induction training was started in 2004, and its purpose is to provide everyone working at the construction site with basic information concerning safety culture, TVO's code of conduct, safe working and emergency response arrangements. Training is provided in Finnish and English (using interpreters if necessary). The number of training days has been directly proportional to the progress of the project.

Starting from the beginning of 2011, the structure of the induction training was modified to support the commissioning and operation stage of the plant by dividing it into a general part and a radiation protection part. The training documentation has been translated into eight languages. The general part of the induction training had the following number of participants in 2015:

- The Finnish training was completed by 1,599 persons, of which 756 completed the online revision. There were 68 training events.
- The English training was completed by 1,977 persons, of which 56 completed the online revision. There were 101 training events.

The radiation part of the induction training had the following number of participants in 2015:

- The Finnish training was completed by 936 persons, of which 555 completed the online revision. There were 63 training events.
- The English training was completed by 20 persons. There were 9 training events.

9.2 TVO's personnel policy

TVO views the development of its personnel as an investment towards safe, high-quality operations also in the future. TVO's principle has been to develop methods for improving personnel competence and its training activities in a manner that allows for maintaining the competence of the personnel in addition to allowing continuous learning and improvement.

In connection with the OL3 project, TVO has also created methods for improving the know-how and managing the expertise of all persons participating in the construction and commissioning of the plant unit. These methods are based on the expertise gained from the operating plant units and the construction project as well as good practices. TVO utilises an annual training programme that is used to systematically compile the training needs of the company each year. Over the course of the entire OL3 project, the annual training programme has also contained training that is aimed at ensuring competence for the purposes of OL3. The persons working on the OL3 project have been placed in expert tasks within the fields of nuclear safety and technology, and they will be placed in the operation, technical support and operations and maintenance of the OL3 well before these functions are taken into use at the OL3 plant unit. Personnel turnover within the OL3 project has been low and TVO has not needed to worry about losing competence related to OL3 power plant technology.

During the OL3 project, the Radiation and Nuclear Safety Authority has stated for its part that TVO has plenty of experience from the operation of OL1 and OL2, and that it has also accumulated experience in the OL3 project.

The new personnel hired for the OL3 project will train for their future operations tasks during the construction and commissioning stages. In 2010–2015, TVO has recruited some 300 new employees.

In addition to people, competence within the organisation is contained in the overall way of doing business. Several instructions and manuals guide the operations of the nuclear power plant, and the most important of them have also been approved by the regulatory authority. The plant supplier has prepared the Technical Specifications and the commissioning, operating, testing and maintenance instructions for the OL3 plant unit, among other things. Furthermore, the instructions in use at the OL1/OL2 plant units have also been updated in order to guide the activities at the OL3 plant unit.

Personnel competence development is a continuous activity that is guided by the key competence areas derived from the company's strategy and the competence requirements defined for individuals. The meeting of these requirements is followed as part of supervisor activities and in a coordinated manner at the company level. This is supported by the competence management data system. Each TVO's employee has been assigned position-specific qualification requirements and personal training plans that are reviewed and assessed each year in cooperation with the supervisors.

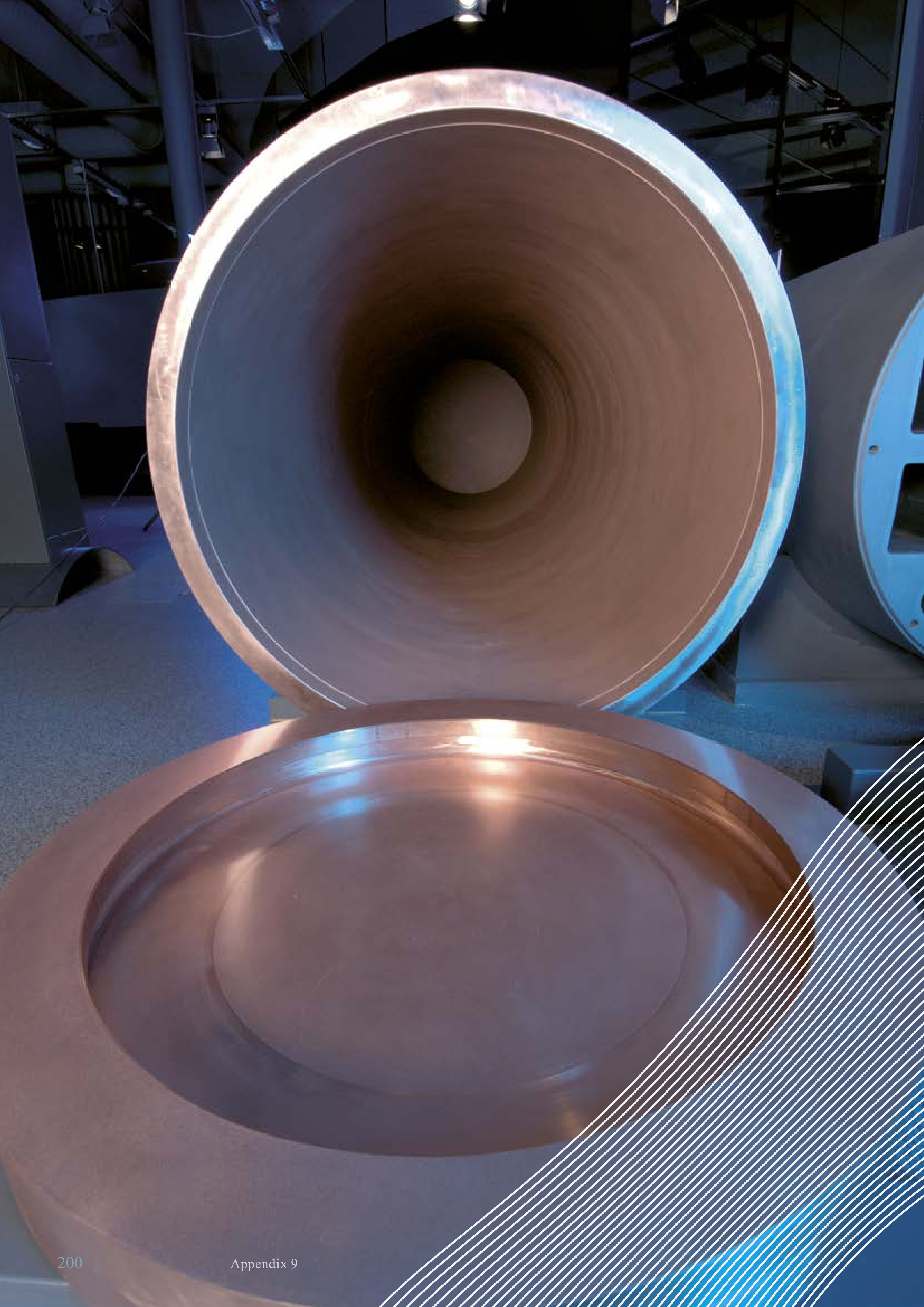
The annual personnel development reviews performed at TVO systematically review the future training needs, the efficiency of training and the actions taken. The items assessed include the training programmes by course and the other methods of personnel development.

The professional competence of the personnel who have participated in the basic training and continuous refresher training, been employed by the company for an extended period of time and participated in the OL3 project has developed continuously; it is the opinion of TVO that this represents the expertise that is required for taking care of the tasks related to a nuclear power plant.

TVO also uses external expertise in its activities when necessary. The method has been to establish contacts with facilities, companies and organisations that represent the highest possible level of expertise in the fields related to the operation of the company. The company has in force contracts concerning maintenance services and expert services with several domestic and international parties. TVO has cooperation contracts with the plant suppliers, component suppliers and service suppliers that are the most important and essential in terms of its functions. Regular assessments are arranged in order to determine the expertise and competence of the suppliers.

TVO has participated, and continues to participate, in several different national and international development programmes in the field of nuclear power. This allows the company to receive additional information concerning the latest developments in the field and to maintain well-functioning contacts with experts in the field. Representatives from the company take an active role in the activities of domestic and international organisations in the energy and nuclear energy industries.

Moreover, Teollisuuden Voima Oyj has signed contracts on separate expert tasks with several domestic and foreign plants and companies. Teollisuuden Voima Oyj is also a member of several nuclear energy industry groups, such as WANO, INPO, VGB, BWROG and NORDSÄK/ERFATOM; their expertise is available to the company.



APPENDIX 9

A DESCRIPTION OF

THE APPLICANT'S PLANS AND AVAILABLE METHODS FOR ARRANGING NUCLEAR WASTE MANAGEMENT, INCLUDING THE DECOMMISSIONING OF THE NUCLEAR FACILITY AND THE DISPOSAL OF NUCLEAR WASTE, AND A DESCRIPTION OF THE TIMETABLE OF NUCLEAR WASTE MANAGEMENT AND ITS ESTIMATED COSTS

TABLE OF CONTENTS

1. INTRODUCTION

The Radiation and Nuclear Safety Authority's regulation concerning the safety of nuclear power plants (STUK Y/1/2016, 1.1.2016, Section 13) and the Radiation and Nuclear Safety Authority's regulation concerning the safety of disposal of nuclear waste (STUK Y/4/2016,1.1.2016) contain provisions regarding the treatment, storage and disposal of radioactive waste. The Nuclear Energy Act (990/1987, Chapter 7) contains provisions concerning preparation for the costs of nuclear waste management. According to the Nuclear Energy Act, the licensee under a waste management obligation shall present a plan concerning the implementation of nuclear waste management every three years. The YJH programme for nuclear waste management was last updated in 2015 (YJH-2015). The programme also covers nuclear waste management for Olkiluoto 3. Figure 1 presents a summary of the nuclear waste management schedule.

The starting point for the requirements of nuclear waste management is ensuring safety by isolating the waste from organic environment. The disposal of nuclear waste is planned in a manner where the safety of the disposal does not require supervision.

The licensee for the nuclear power plant is responsible for the implementation and costs of the plant's nuclear waste management. Waste management related to spent nuclear fuel, used reactor internals, power plant waste and power plant decommissioning waste are addressed separately below. An analysis of the costs of nuclear waste management has also been presented. The quality and amount of waste are covered in appendix 4 to the operating licence application.

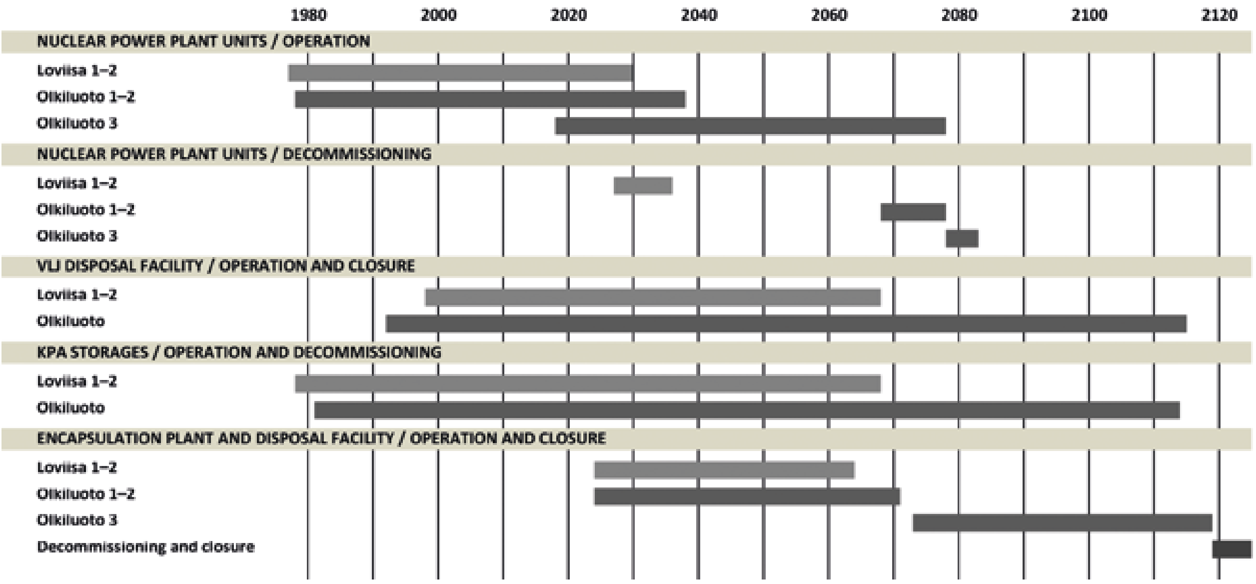


Figure 1. Schedule for the implementation of nuclear waste management according to the plant description.

2. PRINCIPLES OF NUCLEAR WASTE MANAGEMENT

Pursuant to the amendment of the Nuclear Energy Act that was enacted on 29th December 1994, nuclear waste generated in connection with or as a result of the use of nuclear energy in Finland shall be handled, stored and permanently disposed of in Finland, with specific exceptions. As a result of the amendment, Teollisuuden Voima Oyj (TVO) and Imatran Voima Oy (IVO), currently Fortum Power and Heat Oy (Fortum), established a joint company called Posiva Oy on 19th October 1995 in order to manage the research required for the disposal of spent fuel from its nuclear power plants and the construction and operation of the encapsulation plant and disposal facilities. TVO has a 60% shareholding in Posiva.

TVO manages the interim storage of spent nuclear fuel, the low and intermediate level waste and the decommissioning plans by itself. If necessary, Posiva will also perform expert tasks in these fields. Pursuant to the Nuclear Energy Act, TVO is responsible for all of its nuclear waste.

The starting point for the design of the disposal of spent nuclear fuel is that fuel is placed in interim storage at the power plant until the beginning of the disposal. The production activities at Posiva's disposal facility can begin approximately in 2024.

TVO disposes of low and intermediate level power plant waste in the underground plant waste facility (VLJ) that received an operating licence in 9th April 1992; in November 2012, the operating licence was updated to account for the power plant waste from the Olkiluoto 3 plant unit. At present, the licence is valid until the end of 2051.

There are three main phases in the arrangement of nuclear waste management: waste treatment, interim storage and disposal. The treatment and interim storage stages are in implementation for spent fuel, used reactor internals and power plant waste, and they will be arranged at the power plant or inside the power plant site area. Waste treatment in order to reduce the amount of waste has been performed and can be performed outside of the power plant area through separate licensing. The disposal stage has started for the power plant waste, whereas the disposal of spent fuel and used reactor internals will take place in the future. All stages of the management of waste accumulated during decommissioning will not become topical until after several decades.

3. SPENT NUCLEAR FUEL

3.1 Storage of spent nuclear fuel

Storage on site
After its removal from the reactor, spent fuel is typically stored for 3–8 years in a water pool located in the fuel building. The water cools the nuclear fuel and protects the environment from the radiation emitted by the fuel. The fuel pool has a partition wall that allows for isolating two separate pools in a possible evacuation scenario.

The total capacity of the pool halves located in the fuel building is 954 positions, 686 of which are available within the operating area of the fuel building's transfer machine. When considering the possible need for emptying the reactor core, which contains 241 fuel assemblies, the fuel building has approximately 445 storage positions for fuel assemblies.

The two outer rows of the racks located next to the pool walls are not within the operating area of the fuel building's transfer machine as they are only within the operating area of the hoist. These 268 positions are primarily intended for use in case of pool evacuation, but they can be used for the temporary storage of spent fuel during operation, provided that the radiation protection of the storage has been appropriately arranged.

During normal operation, the internal storage capacity of the Olkiluoto 3 (OL3) plant unit is sufficient for use as the only storage for approximately 7 years of reactor operation, depending on the lengths of the operating cycles. During operation, preparations must be made for the emptying of any pool when necessary by moving the fuel assemblies inside it into other pools in the plant area.

Transfer of fuel from the plant to the spent fuel interim storage
Spent nuclear fuel is transported from the plant to the interim storage for spent nuclear fuel (KPA storage) by using a transfer cask specifically designed for this transport. The transfer cask is transported from the plant to the KPA storage in a horizontal position, similarly to the casks for the current plant units OL1 and OL2. The design of the transfer cask takes into account fuel integrity, criticality safety, sufficient fuel cooling, radiation shielding and preventing the dispersion of radioactive substances. The transfer cask handling systems at OL3 are based on wet transport, but the handling systems also enable dry transport. The KPA storage expansion project that was completed in 2014 took wet transport into account, and there are currently no plans to equip the KPA storage with systems required for dry transport.

During the wet transfer from the reactor hall to the KPA storage, the transfer cask is rinsed with demineralised water by using the plant unit's systems in order to remove any water containing boric acid that may have been left inside the cask during its filling. At the end of the rinsing process, the transfer cask is filled with demineralised water. Therefore, the wet transfer does not require modifications to the existing systems at the KPA storage. The reception activities performed for the transfer cask at the KPA storage are similar to those employed in the fuel transfers of the current plant units.

In 2015, the decision was made to use wet transport when transporting TVO's fuel from the KPA storage to Posiva's encapsulation plant. However, this does not rule out the possibility of using wet transport in the future, as the technical prerequisites for it exist at the OL3 plant unit.

Storage at the KPA storage
Storage will resume at the spent fuel interim storage (KPA storage) which is already available at Olkiluoto and which has now been licensed for the needs of OL3. The activity and heat generation of nuclear fuel are reduced during storage. After 20 years of interim storage, for example, the activity of the nuclear fuel is down to a few thousandths of the level that was present when the fuel was removed from the reactor. The spent fuel is stored in the water pools of the fuel building and KPA storage until all the fuel has been transported to the spent fuel encapsulation plant managed by Posiva.

3.2 Encapsulation and disposal of spent fuel

For the purposes of the disposal of nuclear fuel, TVO owns the joint venture Posiva Oy together with Fortum. Posiva Oy is responsible for the final disposal of spent nuclear fuel. The disposal site and the future disposal facility are located at Olkiluoto. Posiva was granted a construction licence for its nuclear waste facilities on 12th November 2015, and the disposal activities are scheduled to start in early 2024. The disposal of spent nuclear fuel is described in Posiva's licensing process and in the YJH-2015 nuclear waste management programme.

For the disposal, the spent fuel is transferred from the KPA storage to the encapsulation plant, where it is packed inside steel and copper canisters. After the encapsulation, the canisters are moved one by one to the disposal facility that is located at a depth of 400–450 metres and placed in dedicated disposal holes inside a disposal tunnel. After the tunnel is full, it is closed with a plug, which concludes the disposal of the spent nuclear fuel. Once all of the spent fuel has been disposed of, the encapsulation plant is decommissioned, the other facilities of the disposal facility are filled and the plant is closed.

Concept of safe disposal

Posiva's disposal concept is based on the KBS-3 solution developed by SKB in Sweden. One of the basic elements in the concept is the principle of multiple release barriers (Figure 2) that isolate the spent fuel by means of several release barriers that supplement each other. According to the concept, it is unlikely that an individual detrimental phenomenon or uncertainty could lead to the inoperability of the entire system.

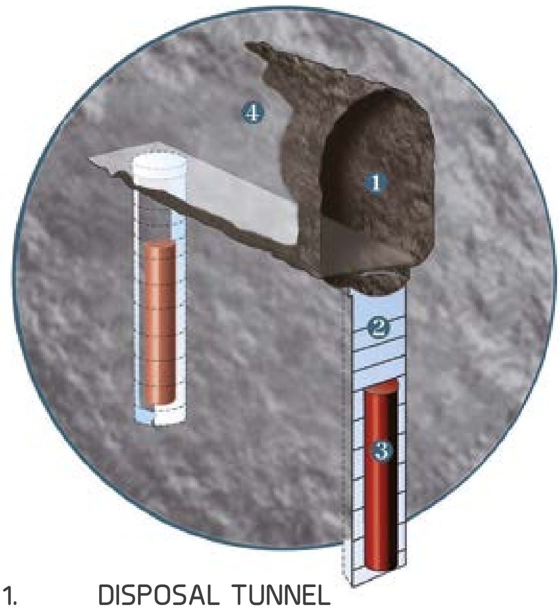
There are two versions of the KBS-3 solution: KBS-3V, where the canisters are placed individually inside vertical disposal holes, and KBS-3H, where the canisters are placed consecutively inside long, horizontal disposal holes. Out of these, KBS-3V is currently the main option.

The requirement for the design and construction of all the technical release barriers is that they must not significantly reduce the safety functions of the other release barriers (whether constructed or natural).

The spent fuel assemblies that have been transported to the encapsulation plant inside transfer casks are installed and enclosed inside the cast iron interior section of the copper canister inside the handling cell (Figure 3, Table 1). The lid of the copper canister is friction stir welded shut. The filled and sealed canister is transferred to the disposal facility, which is located at a depth of approximately 420 metres, by means of a canister lift.

Number of canisters and dimensioning basis

Figure 4 presents the annual accumulation of spent fuel at OL3 and, as a point of reference, the corresponding information from OL1/2. Operating cycles based on one- and two-year refuelling cycles have been initially planned for OL3, and the maximum burnup value is considered to be 50 MWd/kgU.



1. DISPOSAL TUNNEL
2. BENTONITE BUFFER
3. FINAL DISPOSAL CANISTER
4. TUNNEL BACKFILL

Figure 2. The multiple barrier principle for disposal. The different release barriers supplement each other, and the bedrock is the final release barrier.

Figure 3. Copper-iron canisters: on left, the canister type for Loviisa 1–2 (VVER 440), the Olkiluoto 1–2 (BWR) canister type in the middle and Olkiluoto 3 (EPR, OL3) on the right.

4. STORAGE OF USED REACTOR INTERNALS

The storage and disposal of the used reactor internals from the Olkiluoto 3 (OL3) plant unit will be carried out by means of the same methods and practices that are followed for the Olkiluoto 1 and 2 plant units. The main difference is that the used control rods (finger control rods) from Olkiluoto 3, which is a pressurised water reactor, can be stored together with the spent fuel assembly. Used reactor internals can be stored in the fuel pools of the plant unit until they are packed for disposal either during

Table 1. Main dimensions and weights for different canister types..

MAIN DIMENSIONS	LOVIISA 1–2	OLKILUOTO 1–2	OLKILUOTO 3
Outer diameter (m)	1.05	1.05	1.05
Overall length (m)	3.60	4.80	5.25
Total volume (m³)	3.0	4.1	4.5
Assembly positions (pcs)	12	12	4
Amount of fuel (tU)	1.4	2.2	2.1
Total weight (t)	18.6	24.3	29.1

Table 2. Information regarding anticipated fuel accumulation at the OL plant units.

FUEL INFORMATION	OL1–2	OL3
Planned service life (a)	60	60
Estimate of accumulated assemblies (pcs)	14,622	3,840
Average burn-up upon disposal of the entire group of assemblies (MWd/kgU)	38.2	45.4
Number of capsules (pcs)	1,219	960
Corresponding tonnage (tU)	2,555	2,054

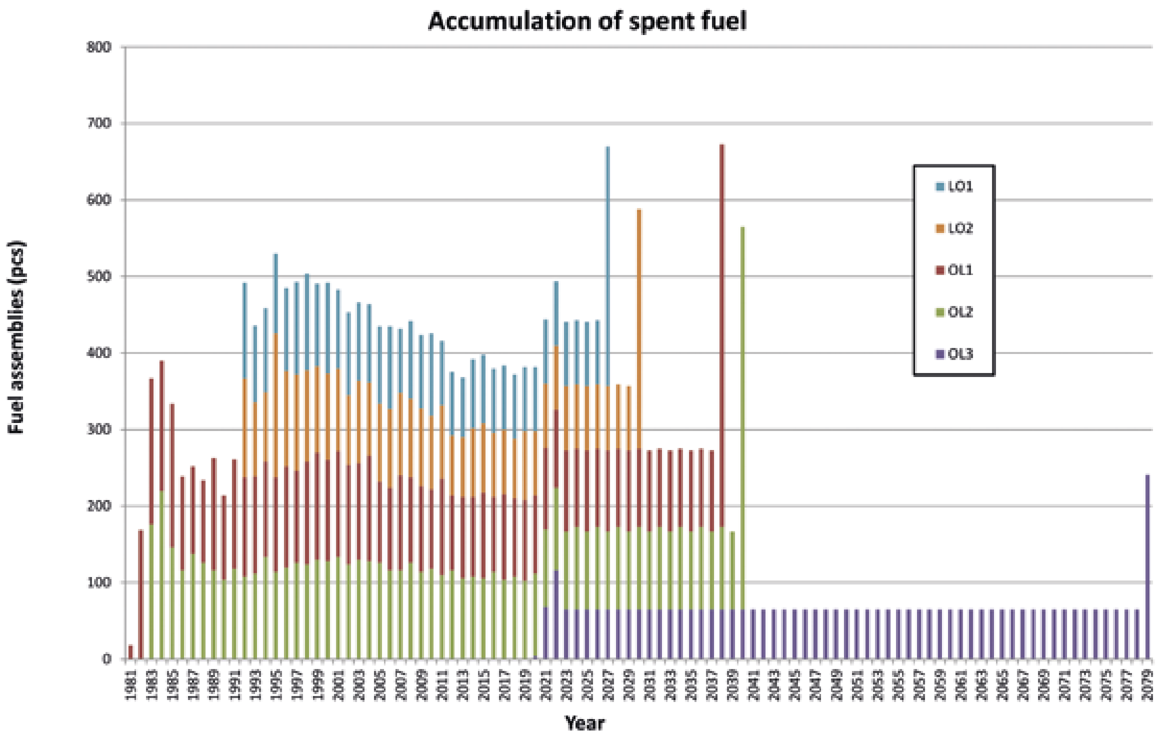


Figure 4. Variation in the number of fuel assemblies per disposal batch between the different Finnish nuclear power plant units. Planned values are presented from the year 2016 onward. The size of the final core is 500 assemblies for OL1–2, 313 assemblies for LO1–2 and 241 assemblies for OL3.

the disassembly of the plant unit or, in some cases, during operation. Used reactor internals can also be transported into the pools of the KPA storage.

For permanent disposal, the construction of disposal silos next to the VLJ facility has been proposed; this plan also includes all the reactor circuit components from the OL3 plant unit with the exception of the control rods mentioned above.

5. POWER PLANT WASTE

5.1 Storage of power plant waste

Power plant waste refers to low and intermediate level waste generated during the operation of a nuclear power plant, such as ion exchange resins used for the purification of process water, contaminated scrap accumulated from maintenance work and miscellaneous dry waste. The starting point for the management of power plant waste, too, is that all waste is treated, stored and disposed of in Finland. Power plant waste may be processed elsewhere in order to reduce the amount of waste, for example, but the radioactive portion of the power plant waste returns to Finland. The waste treatment equipment of the Olkiluoto 3 plant unit may be used to treat plant waste from the Olkiluoto 1 (OL1) and Olkiluoto 2 (OL2) plant units and Posiva.

Power plant waste may be divided into two main classes: maintenance waste and wet waste. At present, most of the power plant waste from Olkiluoto is immediately processed and packed for further treatment, storage and disposal.

The compressible part of dry, low level maintenance waste is packed as is or cut into parts and packed inside 200-litre steel drums that are compressed to half of their original volume. Contaminated scrap metal is decontaminated, cut into pieces and compressed if necessary, and packed into drums, steel crates (external volume 1.3 m^3) or concrete crates (internal volumes 3.9 or 5.8 m^3). Dry waste is initially stored in the waste storage facilities of the plant units or moved to the interim storage for low level waste (MAJ) or intermediate level waste (KAJ) according to its level of activity. After the activity of the waste has been determined, it is transported into the VLJ facility for disposal. Similar methods will also be used at Olkiluoto 3.

At Olkiluoto 3, the ion exchange resins and liquid waste will be dried inside drums using the in-drum drying method. In the first stage, the dried waste generated as a result of the drying is placed in interim storage at the plant unit or the KAJ storage. When the current silo space is reduced during the expansion of the VLJ facility, the technical release barriers will be designed while taking into account the dried waste from OL3. The treatment methods available for liquid waste and sludge also include solidification with concrete and other binding agents, the choice and use of which are based on experience from the current plant units. The use of the methods described above is optimised on the basis of experience received during the operation of the plant unit.

Waste oil may be solidified by means of special powders, but their low activity has mostly allowed them to be cleared from supervision at the operating plant units.

The waste building of the Olkiluoto 3 power plant unit can hold 168 drums of intermediate level waste and 610 drums of low level waste. Going forward, the plan is to place the dried intermediate level waste inside drums in the KAJ facility for interim storage until the expansion of the VLJ facility is complete. This is done because the current silos of the VLJ facility would require a separate concrete layer as a released barrier for the waste dried inside the drums. During the expansion of the VLJ facility, the disposal silos will be equipped with sufficient release barriers for the waste packed inside drums, as well. The expansion is planned to take place in the 2030s.

The KAJ storage and the components storage located in connection to the MAJ storage can also be used for the interim storage of large contaminated metal components. The MAJ storage is mostly only used to store maintenance waste bags with very low activity levels and scrap that will be cleared later on.

5.2 Disposal of power plant waste

The disposal facility for power plant waste, also known as the VLJ facility, is located on the cape of Ulkopää at Olkiluoto. The construction of the VLJ facility started in 1988 and it was commissioned in 1992. According to the current estimate, the facility will be expanded for the disposal of waste from OL3, used reactor internals and power plant disassembly waste in the 2030s. Plans suggest that the operation of the VLJ facility will continue past the expiration of the current operating licence at the end of 2051, which means that a new licence will be applied for in good time.

At present, the intermediate level waste silo in the VLJ facility can hold 17,360 drums and the low activity level waste silo can hold 24,800 drums, which amounts to 8,400 m3 of drums in total. According to the original design basis, this corresponds to the plant waste accrued from 40 years of operation of the two plant units at Olkiluoto and 60 years of operation of the KPA storage. During the actual operation, different compacting methods have allowed for reducing the volume of the accumulated waste. At the end of 2014, after approximately 35 years of operation of the Olkiluoto 1 and 2 plant units, the MAJ silo was 60% full and the KAJ silo was 51% full. The disposal of small-user waste held by the state started in 2015.

Figure 5 presents the general structure of the VLJ facility, taking into account the planned expansions. The facility consists of an above-ground control room, an access tunnel, an excavation tunnel, a shaft, a silo for low level waste (MAJ silo), a silo for intermediate level waste (KAJ silo), a crane bay above the silos and auxiliary facilities. The waste silos and their surroundings are presented in more detail in Figure 5; Figure 6 presents the location of the VLJ cave on the island of Olkiluoto. The structure and operation of the facility are described in detail in its final safety analysis report.

The operating stage of the VLJ facility has been planned in a manner that ensures low radiation doses for the operating personnel. No foreseeable event will release significant amounts of radioactive substances into the environment. The long-term safety analysis of the VLJ facility was updated in 2006 according to the terms of the operating licence, and it will be next updated in 2021.

The disposal of power plant waste utilises the principle of multiple release barriers. Even if one of the barriers proves weaker than expected, the other barriers will ensure that the disposal will not cause substantial radiation doses at any stage. The operation of the release barriers is based on their passive characteristics. The safety of disposal does not require monitoring after the closing of the VLJ facility.

6. DECOMMISSIONING OF THE POWER PLANT

The Nuclear Energy Act (990/1987), the Radiation and Nuclear Safety Authority's regulation on the safety of the disposal of nuclear waste (STUK Y/4/2016, 1st January 2016) and the YVL Guides define the goals for nuclear power plant decommissioning activities in Finland. According to the amendment of the Nuclear Energy Act enacted on 1st June 2008, the plan for the decommissioning of the nuclear facility is presented every six years.

Pursuant to the YVL Guides, radiation safety must be considered at all stages, starting from the design of the nuclear facility. The design must take account of the operation of the nuclear facility, which includes the commissioning of the plant, normal operation, operational disturbances, postulated accidents and the decommissioning of the facility. During the design stage of the nuclear facility, the YVL Guides present

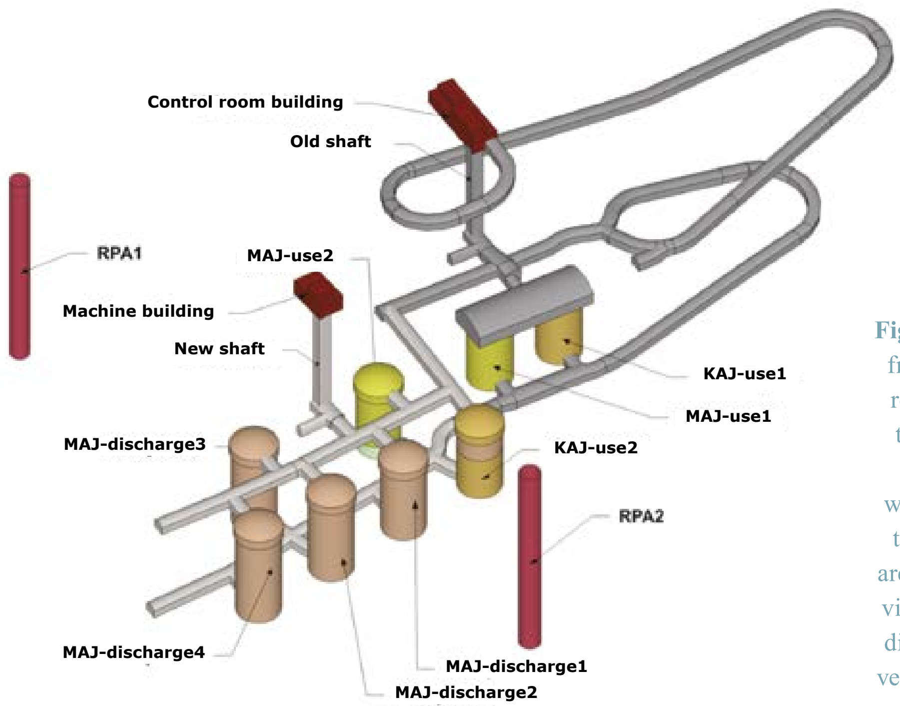


Figure 5. Expanded VLJ facility, viewed from the southwest. The two silos in the rear belong to the currently used part of the VLJ facility. The two silos that will be constructed during the expansion while OL3 is in operation can be seen in the middle. When the power plant units are being decommissioned, the four silos visible on the left will be constructed for disassembly waste, and the two separate vertical shafts will be constructed for the disposal of the reactor pressure vessels.

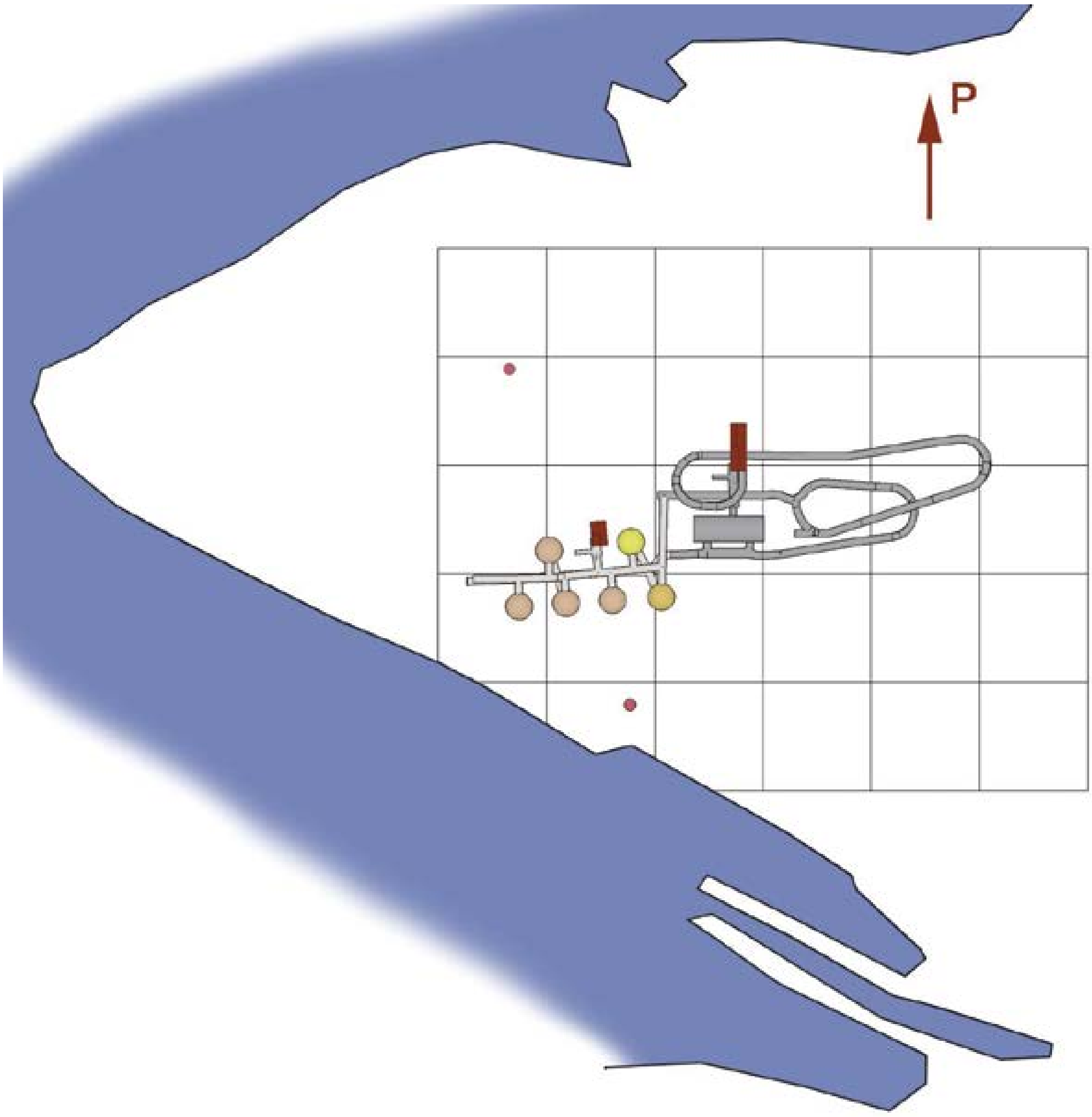


Figure 6. The placement of the expanded VLJ facility on the cape of Ulkopää. The currently operating underground part of the facility is shown in medium grey and the related above-ground control room building, which is approximately 44 metres in length, is shown in red. The map has a grid size of 100 m.

the requirements related to decommissioning. Numerous arrangements useful for the decommissioning are equally important for radiation protection and waste management during the plant operation.

The requirements for radiation safety over the lifecycle of the entire facility have been taken into account in the system design of the Olkiluoto 3 plant unit and their realisation has been separately assessed in the system safety analyses presented by the licensee. The first plan for the decommissioning of the Olkiluoto 3 plant unit will be submitted to the Radiation and Nuclear Safety Authority together with the operating licence application.

6.1 Goals and options for decommissioning

The decommissioning of a nuclear power plant refers to the activities that are taken after the service life of the power plant is complete and that are intended to ensure that the radioactive components remaining inside the plant do not cause harm to the environment. Decommissioning waste can be divided into two groups: activated and contaminated waste. Contaminated components can be further divided into components with surface contamination and components that have absorbed radioactive substances.

The options for decommissioning can be divided into three main categories:

- Immediate disassembly
- Delayed disassembly
- Isolation.

During immediate and delayed disassembly, all of the radioactive material is taken out of the plant site and radiation monitoring is no longer required. Isolation refers to placing the decommissioning waste inside the interior of the reactor building and blocking any access and leak paths. TVO's plans do not cover the isolation option.

The starting point for TVO's plans has been that the plant units are disassembled during decommissioning to a degree where radiation monitoring is no longer required. According to the completed analyses, the decommissioning can be safely carried out by utilising modern technology. Both immediate disassembly and delayed decommissioning are feasible alternatives. The choice of method depends on whether the site area will be used for industry or nuclear energy generation after the service life of the plant. In the latter case, the area will continue to be under constant radiation monitoring and physical protection for dozens of years, which means that the immediate disassembly of the decommissioned facility is not necessary for the clearing of the area from supervision.

The decommissioning plan for the Olkiluoto 3 plant unit covers the disassembly and disposal of the plant, an estimate of the radiation doses from the decommissioning work and a safety case for the disposal. It also presents an estimate of the decommissioning costs. The starting point for the plan is the disassembly, packaging, transport and disposal of material that has become activated and contaminated during 60 years of operation.

According to the completed analyses, TVO's power plant units can be disassembled by using modern technology and the decommissioning waste can be safely disposed of in the bedrock of the plant site, together with the power plant waste.

6.2 Performing the decommissioning

Immediate disassembly is the default scenario for the decommissioning of the Olkiluoto 3 plant unit. According to this strategy, the decommissioning will take place at the same time as the decommissioning of the Olkiluoto 1 and Olkiluoto 2 plant units, which are scheduled for disassembly after a controlled storage period of 30 years. The simultaneous disassembly of three plant units yields synergy benefits for the organising of the decommissioning, for example.

In terms of power plant waste disposal, preparations are made for expanding the facilities for decommissioning waste and used reactor internals, as well. According to the performed analyses, this waste can be safely disposed of in the silos constructed next to the VLJ facility.

According to the main option for decommissioning, the disassembly of Olkiluoto 3 will begin after 60 years of operation and last for approximately nine years. The work is divided into a preparation stage that lasts approximately six years and a three-year disassembly and disposal period. The expansion of the VLJ facility for the disassembly waste and used reactor internals is done as part of the preparation stage.

Performing the decommissioning of the nuclear power plant requires using methods and equipment developed for different purposes. Radiation is the most limiting factor in terms of working methods, which is why remotely operated equipment is used in the disassembly whenever possible and necessary. The basic work phases include the removal of piping and equipment, for example. In order to facilitate packing and improve packing density, the piping and equipment is cut or sectioned. The planned methods are the same as those planned for use during the decommissioning of the OL1 and OL2 plant units.

The work in the preparation stage includes transferring the fuel from the reactor to the refuelling pool and storing the fuel until it can be moved to the interim storage for spent fuel. The primary circuit is purged and the wastewater is treated. The different systems are decontaminated in order to minimise radiation doses and the amount of waste placed in disposal. The buildings are modified in order to enable the disassembly and transfer of large components and the various systems. Facilities are arranged for the decontamination, sectioning and packaging of contaminated equipment. Transportation methods are built and tested for the transfer of equipment – the entire pressure vessel in particular – into the disposal facilities.

The expansion of the VLJ facility, intended for use as a disposal facility for the decommissioning waste, is planned and implemented. A separate disposal shaft is constructed for the pressure vessel, which is disposed of as an entire unit. Each of the disposal shafts is dimensioned for two pressure vessels. The pressure vessels of the OL1 and OL2 plant units are placed inside the same shaft.

The main components of the activated material are the reactor pressure vessel, reactor internals and concrete from the biological shield. The most important work phases during the disassembly of a pressure vessel are the removal, transport and disposal of the vessel. The activated reactor internals are processed and packed inside the pressure vessel. In order to simplify the transport of the pressure vessel, the packing may be performed near the disposal facility. For the most part, the concrete from the biological shield has a fairly low activity level, but protection from activated dust must be considered during its disassembly. Remotely controlled equipment is used for cutting the concrete of the biological shield.

The other material activated during operation includes control rods, control rod guide tubes and core instrumentation. The assumption is that the control rods will be disposed of inside disposal capsules in Posiva's disposal facilities for spent fuel, together with the spent nuclear fuel. The control rod guide tubes and core instrumentation will be packed inside the reactor pressure vessel for disposal.

6.3 Disposal of decommissioning waste

Decommissioning waste will be disposed of by using largely the same methods as are used for the disposal of power plant waste generated during operation. A preliminary plan for the expansion of the VLJ facility has been drawn up, and it also considers the disposal of decommissioning waste from Olkiluoto 3. Approximately 15,000 m3 of silo volume has been reserved for the decommissioning waste from Olkiluoto 3.

The volume of contaminated decommissioning waste is estimated to be 7,500 m3. If the waste is packed inside 200-litre drums, the packing efficiency is approximately 60%. In practice, the packing efficiency can be improved by using different compacting methods. By using the conservative assumption presented herein, the disposal space required for the contaminated waste is approximately 12,500 m3. When the volume of concrete from the biological shield, 450 m3, is added to this volume, the estimated amount of waste will fit inside the reserved disposal space with a fair margin. The activated waste, with the exception of the concrete from the biological shield, is packed inside the pressure vessel, which is then disposed of as an entire unit inside a separate disposal shaft.

7. COSTS AND ADVANCE PREPARATION

7.1 Cost estimate

Table 1 presents a cost estimate for TVO's nuclear waste management according to the price level in 2012, exclusive of authority supervision costs or taxes; the estimate assumes that Olkiluoto 3 is operated for 60 years and the spent fuel is placed in interim storage for a maximum of 100 years. The cost estimate only covers TVO's share of the management of spent fuel from TVO and Fortum which is managed by Posiva. The cost estimate for decommissioning also includes the disassembly of non-activated structures and systems.

7.2 Preparation for future costs

TVO has prepared for the future waste management of its current plant units in accordance with the Nuclear Energy Act and Decree. The preparation ensures that the funds for the safe treatment of all nuclear waste and the decommissioning of the nuclear power plants are always available in the form of reserves or securities.

OL3 is included in TVO's preparation arrangements in accordance with the Government Decision 165/1988 concerning the preparation for the costs of nuclear waste management in a manner where only the additional costs created by OL3 are included in OL3's share of TVO's liabilities. According to the above decision, OL3's share of the liability can be collected over a maximum of 25 years from the start of operation of the plant unit.

In the waste management diagram from 2013, where OL3 is included from 2017 onwards, the accumulated future costs of waste management, plant unit decommissioning and the required research, development, administration and authority work are estimated to be EUR 420 million at the end of the said year according to the additional cost principle presented above.

The waste management diagram is reviewed every three years on the basis of the progress of the actions, changes in the cost level and any possible changes in plans and cost estimates. The financial preparations made by TVO ensures that the funds required for the safe implementation of nuclear waste management are available.

Table 3. Cost estimate for TVO's nuclear waste management. The service life for Olkiluoto 3 is 60 years and the service life of the KPA storage is 100 years.

	TVO, TOTAL [MEUR]	SHARE OF OL3 [MEUR]
Spent fuel		
Spent fuel interim storage	200	135
Spent fuel transfers from interim storage to the disposal area, encapsulation and disposal of spent fuel	2,800	1,280
Spent fuel in total	3,000	1,415
Decommissioning	560	290
Power plant waste	40	20
Research and development, administration	790	335
Total	**4,400**	**2,060**

8. SUMMARY

TVO has in place plans for the management of nuclear waste originating from all of its nuclear power plant units, including Olkiluoto 3. The plans cover the amounts, treatment, interim storage, decommissioning and disposal of all waste types. The safety of waste management is assessed in the final safety analysis report for the plant units and the VLJ facility and the decommissioning plans for the plant units.

An expansion of the KPA storage has been implemented in order to provide the additional storage capacity required by Olkiluoto 3. Posiva Oy is responsible for the disposal of spent nuclear fuel, research related to the disposal and other expert tasks within its field. The spent fuel disposal solutions and the safety case that were submitted as part of the preliminary safety analysis report for the encapsulation plant and disposal facility received approving safety assessments from the Radiation and Nuclear Safety Authority and the construction licence was granted on 12th November 2015. Posiva's plans and safety case will be specified further before the submittal of Posiva's operating licence application. According to plans, the disposal of spent nuclear fuel will begin in 2024.

Schedules have been made for the nuclear waste management of the different nuclear facilities and their costs have been estimated. The schedules and costs are maintained, for example, in the YJH programmes that are published every three years.

APPENDIX 10

A DESCRIPTION OF

A DESCRIPTION OF THE APPLICANT'S FINANCIAL STATUS, THE PLAN FOR THE ADMINISTRATION OF THE FINANCES OF THE NUCLEAR FACILITY AND THE PRODUCTION PLAN OF THE NUCLEAR FACILITY

1. THE COMPANY'S FINANCIAL STANDING

1.1 The company's shareholders and electricity users

Teollisuuden Voima Oyj (TVO) operates in the fields of power plant construction and the generation, relay and transfer of electricity primarily to the company's shareholders.

The company's shares are divided into series in a manner where the A series shares entitle their owners to the rights and obligations of the OL1/OL2 power plants, the B series shares entitle their owners to the rights and obligations of the OL3 project and the C series shares entitle their owners to the rights and obligations of the Meri-Pori coal-fired power plant. The shares of ownership in the different series are as follows:

The largest shareholder in the company is Pohjolan Voima Oy (PVO), which is owned by Finnish companies from the forestry sector, Finnish municipalities and towns, and energy companies owned by municipalities and towns.

EPV-Energia Oy is mostly owned by electricity distribution companies from municipalities in Southern Ostrobothnia.

Fortum Power and Heat Oy is a part of the Fortum Group, whose largest owner is the Finnish State. The company's areas of business include generation and sales of electricity and heat. Its clients include electricity distribution companies from towns and municipalities, industrial companies and other major electricity consumers. Fortum Power and Heat Oy owns and operates the Loviisa nuclear power plant. Fortum has decided to participate in Fennovoima's nuclear power plant project with a share of 6.6% and on the same terms as the other Finnish companies that are currently committed to the project. Fortum's participation in the project will be implemented via Voimaosakeyhtiö SF. The Kemira group is a chemicals company with three business areas: Paper, Municipal & Industrial and Oil & Mining. Kemira's largest owners are Oras Invest Oy (18.2%) and the investment company Solidium Oy (16.7%), which in turn is owned by the state of Finland.

Oy Mankala Ab is a company owned by Helen Oy, which in turn is owned by the City of Helsinki. It generates and acquires electricity primarily for its shareholders.

Loiste Holding Oy (previously known as Karhu Voima Oy and prior to that Graninge Energia Oy) is a company owned by Kotkan Energia Oy, which in turn is owned by the town of Kotka. It generates electricity for the industry in particular.

According to the articles of association, Teollisuuden Voima Oyj's shareholders are responsible for the variable and fixed annual costs. Each of the company's shareholders is responsible for the company's fixed annual costs, which includes loan interests and payments in proportion to the number of owned shares regardless of whether the shareholder has used their share of the electricity generated by the company. Furthermore, each shareholder is responsible for the company's variable annual costs in proportion to their use of the electricity generated or relayed by the company.

The company sells the electricity it has generated to its shareholders at cost and does not seek profit.

TVO's shareholders and its articles of association ensure its solid financial standing.

	A-series	B-series	C-series	Total
Pohjolan Voima Oy	56.8 %	60.2 %	56.8 %	58.4 %
Fortum Power and Heat Oy	26.6 %	25.0 %	26.6 %	25.9 %
Oy Mankala Ab	8.1 %	8.1 %	8.1 %	8.1 %
EPV-Energia Oy	6.5 %	6.6 %	6.5 %	6.5 %
Kemira Oyj	1.9 %	0.0 %	1.9 %	1.0 %
Loiste Holding Oy	0.1 %	0.1 %	0.1 %	0.1 %

1.2 Financial status of the company

The enclosed financial statements in appendix 11 from 2004-2015 indicate the financial status of the company.

According to the financial statements of 31 December 2015, the total assets of the company were MEUR 6,252. The company had MEUR 1,038 in equity and comparable items, and MEUR 479 in lower-priority shareholder loans. The total amount of long-term and short-term loans was MEUR 3,987. The company's equity also includes a loan of MEUR 1,009 from the State Nuclear Waste Management Fund (YVR) that has been lent further to the company's shareholders.

Approximately MEUR 1,100 have been spent on annual maintenance investments, including infrastructure investments, during the operation of the OL1 and OL2 plant units up to the present day. In May 2013, TVO signed an agreement with Wärtsilä Finland Oy for the delivery of emergency diesel generators and their auxiliary systems to Olkiluoto. There are a total of nine generators, and TVO is responsible for the construction work in the project and the generators' interfaces with TVO's other systems. The aim is to replace the emergency diesel generators, which provide back-up power for OL1 and OL2, by 2022. This is the largest plant modification project in the history of Olkiluoto. In July 2014, TVO signed an agreement with Westinghouse Electric Sweden (WSE) for the replacement of the recirculation pumps at OL1 and OL2. The agreement covers 12 recirculation pumps. The pump replacement is a turnkey delivery. WSE is responsible for the installation of the pumps, the manufacture of special tools and the design of the pumps in cooperation with their manufacturer. TVO is responsible for arranging the support services for the installation in accordance with the agreement. The recirculation pumps will be replaced during service outages between 2016 and 2018.

Approximately MEUR 3,900 of the investment in the OL3 project has been realised by the end of 2015.

The table below presents the development of Teollisuuden Voima Oyj's key figures:

Electricity delivered (GWh)	**2013**	**2014**	**2015**
Olkiluoto 1	7,458	7,254	7,387
Olkiluoto 2	7,148	7,486	6,851
Meri-Pori	725	400	167
Total	15,331	15,140	14,405

TVO's share of funds in the Finnish State Nuclear Waste Management Fund (MEUR)

	1,253	1,324	1358
Turnover (MEUR)	363	325	273
Fuel costs	73	66	59
Nuclear waste management costs	89	51	38
Capital expenditures	61	59	111
Result before appropriations	1	5	7
Investments	303	339	344
Equity	858	858	858
Appropriations	167	173	180
Loans from financial institutions	3,088	3,288	3,509
Shareholder loans	339	439	479
Loan from VYR	932	983	1,009
Total assets	5,572	5,879	6,252
Equity ratio (%)	29.4	30.0	28.9

$$\text{Gearing ratio \%} = 100 \times \frac{\text{equity + appropriations + shareholder loans}}{\text{total assets – loan from VYR}}$$

2. FINANCING MANAGEMENT PLAN

2.1 Investments

The planned write-off periods for the power plants that are a part of the company's fixed assets are as follows:

Olkiluoto 1 and 2	
Basic investment	61 years
Modernisation project investments	21–35 years
I&C investments related to modernisation	15 years
Additional investments	10 years
Buildings and structures	10–40 years
Share of Meri-Pori coal-fired power plant	
Basic investments	25 years
Additional investments	10 years
Wind power plant	10 years
Share of Olkiluoto gas turbine plant	30 years
Olkiluoto 3	
Basic investment	approx. 60 years
Additional investments	10–35 years

The basic principle is that the planned annual depreciation is collected in the price of electricity.

2.2 Sources of financing

The company has no project-specific financing; the investments to the power plants are financed as part of the company's overall financing. According to TVO's financing policy, the company aims to maintain an IFRS capital ratio of at least 25%. The shareholders have invested the amount of new share capital required for the investments and issued shareholder loans. Loan financing has been arranged entirely by commercial means.

TVO has diversified its external financing by using different sources. The company uses both direct bank loans and the capital markets in its financing, while taking into account the market situation.

2.3 Repayment of loans

As a result of the OL3 investment, the total amount of external funding, excluding the loan from the Finnish State Nuclear Waste Management Fund, will increase to approximately MEUR 5,300 by the end of 2018 (including shareholder loans).

According to the financing plan based on the company's forecast investment needs, the net amortisation of the loans will be MEUR 100 per year. By the end of 2025, the amount of external funding is estimated to be approximately MEUR 4,600.

3. PRODUCTION PLAN

Over the past five years, the amount of electricity sold from the OL1 and OL2 plant units has varied between 14.1 TWh and 14.7 TWh. The net electrical output is 890 MW per unit. Going forward, the annual production goal for the plant units will be approximately 7.3 TWh.

Based on the anticipated capacity factor for the first years, the annual production goal for the OL3 plant unit being constructed is 12–13 TWh.

APPENDIX 11

THE APPLICANT'S FINANCIAL STATEMENTS FROM 2004–2015

TEOLLISUUDEN VOIMA OYJ'S ANNUAL REPORTS CAN BE FOUND ON THE COMPANY'S WEBSITE.

APPENDIX 12

A DESCRIPTION OF

HOW THE PROVISIONS IN THE CONSTRUCTION LICENCE HAVE BEEN COMPLIED WITH

Contents

The following presents the implementation of the conditions related to the construction licence granted on 17 February 2005. The wording of the licence conditions follows that included in the construction licence and they are written in italics below.

1. Report on the fulfilment of the conditions of the construction licence

The Olkiluoto 3 plant unit construction licence, which the Government has granted on 17 February 2005, reads as follows:

By virtue of the Nuclear Energy Act and the Nuclear Energy Decree, the Government has decided to grant to Teollisuuden Voima Oy the licence referred to in section 18 of the Nuclear Energy Act

> *for the construction, on the island of Olkiluoto located in the municipality of Eurajoki, of a nuclear power plant unit of the pressurised water type with a rated thermal output of 4,300 MW, intended for electricity production, which corresponds to the general characteristics and the essential features related to ensuring safety proposed in the application for a construction licence.*

This licence ceases to be valid, unless the construction of the nuclear power plant unit is started within two years from the beginning of the le-gal validity of the licence.

The Olkiluoto 3 plant unit is still a nuclear power plant unit of the pres-surised water type, intended for electricity production, and constructed on the island of Olkiluoto located in the municipality of Eurajoki. The rated thermal output of the plant unit is 4,300 MW.

The technical solutions of the Olkiluoto 3 plant unit are presented in Ap-pendices 5–6 to this operating licence application. During the power plant project, the technical implementation has been specified, but the essential features of the plant have not changed during this time.

The construction work to build the power plant unit was started in 2005, which is why the condition governing the expiry of the licence has not become applicable.w

The following discusses the fulfilment at the present moment of the con-ditions set out when the construction licence was granted which were processed when granting the construction licence.

2. Conditions for the granting of a construction licence under section 19 of the nuclear energy act

1) the plans concerning the nuclear facility, its central operational systems and components entail adequate safety and protection of workers, and the population's safety has otherwise been taken into account appropriately when planning operations

Grounds of the safety analysis of the Finnish Radiation and Nuclear Safety Authority (STUK)

The Finnish Radiation and Nuclear Safety Authority (STUK) has compared the applicant's plans with the requirements presented in the "Decision of the Council of State on the General Regulations for the Safety of Nuclear Power Plants" (395/1991). The view of STUK is that the Decision of the Council of State mentioned above is for the most part still up-to-date. The acutest updating needs concern a severe reactor accident and handling of aircraft crashes, as technology with their respect has developed dynamically since the beginning of the 1990s. STUK has evaluated these matters not included in the decision-in-principle on the basis of the Nuclear Power Plant Guidelines.

The meeting of the safety requirements that are currently in force has been demonstrated in Appendix 6 to the operating licence application.

According to the above, the condition laid down in the construction licence is met.

The Finnish Radiation and Nuclear Safety Authority (STUK) states that, in order to demonstrate the fulfilment of the safety regulations, the plans of the construction licence stage concerning the Olkiluoto 3 nuclear power plant unit have been adequately analysed by means of both an accident analysis and a Probabilistic Safety Analysis. STUK regards the research and development activities related to the plant incident and accident processes as adequate.

There still remain some tests or calculation analyses needed for justifying detailed solutions. As the project progresses and plans become more specified, supplementing the analyses will also be continued correspondingly, as part of the licensing process of the technical solutions of the power plant unit.

The analytical and experimental verification of the safety of the Olkiluoto 3 nuclear power plant unit is discussed in Appendix 6 to the operating licence application that assesses the meeting of the requirements laid down in the Radiation and Nuclear Safety Authority's regulation on the safety of nuclear power plants (STUK Y/1/2016, 1st January 2016).

According to the above, the condition laid down in the construction licence is met.

Design requirements for nuclear safety

The Finnish Radiation and Nuclear Safety Authority (STUK) has also examined how the design requirements for nuclear safety presented in the decision 395/1991 and the requirements presented in the Nuclear Power Plant Guidelines concerning nuclear safety have been fulfilled in the design of Olkiluoto 3 nuclear power plant unit. STUK states that adequate levels of protection against disturbances and accidents have been designed for the Olkiluoto 3 nuclear power plant unit and that the nuclear power plant unit has adequate technical barriers to spreading of radioactivity.

The levels of protection applied at the Olkiluoto 3 nuclear power plant unit and the technical barriers to the spreading of radioactivity are discussed in Appendix 6 to the operating licence application that assesses the meeting of the requirements laid down in the Radiation and Nuclear Safety Authority's regulation on the safety of nuclear power plants (STUK Y/1/2016, 1st January 2016).

The implementation meets the requirements set. I&C modifications have been made after the construction licence stage.

According to the above, the condition laid down in the construction licence is met.

Furthermore, the Finnish Radiation and Nuclear Safety Authority (STUK) has stated that the integrities of the nuclear fuel, primary circuit and the containment building of the Olkiluoto 3 power plant unit are adequately secured. The safety functions of the power plant unit have been adequately secured, avoiding human errors has been taken into account in the design of the nuclear power plant unit and in design of its operations, the safety classification is appropriate and the plans concerning the supervision and control of the plant unit are adequate in view of the construction licence. The acceptability of detailed solutions and procedures is evaluated as part of the licensing process of systems that continues during the construction, in so far as the design becomes more specified.

The plans have been submitted to the authority for approval during the pre-inspection stage as part of the licensing process of the systems.

According to the above, the condition laid down in the construction licence is met.

The Finnish Radiation and Nuclear Safety Authority (STUK) also states that the design of the Olkiluoto 3 nuclear power plant unit is good in regard to preparedness for external incidents and fires. As for aircraft crashes, certain design particulars will, however, still need final specification, completion of ongoing or supplementary analyses and verification of the analytical results by testing.

The protection against aircraft crashes has been presented to the Radiation and Nuclear Safety Authority in connection with the operating licence application. Experimental research related to the matter is discussed in Appendix 6 to the operating licence application that assesses the meeting of the requirements laid down in the Radiation and Nuclear Safety Authority's regulation on the safety of nuclear power plants (STUK Y/1/2016, 1st January 2016).

According to the above, the condition laid down in the construction licence is met.

Further, the Finnish Radiation and Nuclear Safety Authority (STUK) states that the operating experiences obtained from other plants and the results of the safety research have been taken into account in the design of the new plant unit. The design criteria of the nuclear power plant unit to be built will be continuously evaluated during the construction and operating licence handling by applying the best knowledge available.

The technical design solutions of the Olkiluoto 3 nuclear power plant unit are evaluated from the point of view of operating experience in Appendix 6 to the operating licence application that assesses the meeting of the requirements laid down in Section 21 of the Radiation and Nuclear Safety Authority's regulation on the safety of nuclear power plants (STUK Y/1/2016, 1st January 2016). TVO's standardised routines for the follow-up of operating experience will also be applied to the Olkiluoto 3 nuclear power plant unit during the operation stage.

According to the above, the condition laid down in the construction licence is met.

Regulations on radiation exposure and emissions of radioactive substances

Based on the applicant's plans and analyses conducted, the Finnish Radiation and Nuclear Safety Authority (STUK) has further stated that the threshold values for the radiation exposure and radioactive emissions of the nuclear power plant unit laid down in decision 395/1991 are not reached. Among these are the threshold values of the radiation exposure of the population in normal operation, operational disturbances to be expected, possible accidents and severe reactor accidents. In STUK's view, the Olkiluoto 3 nuclear power plant unit has been designed to be adequately safe in terms of the threshold values of the emissions.

The analyses submitted to the Radiation and Nuclear Safety Authority in connection with the operating licence application meet the acceptability criteria.

According to the above, the condition laid down in the construction licence is met.

Statement of the Advisory Committee on Nuclear Safety

According to the view of the Advisory Committee on Nuclear Safety, the plant project can be implemented as required in sections 6 and 7 of the Nuclear Energy Act. The Advisory Committee agrees with STUK in that the preconditions under section 9 of the Nuclear Energy Act are met in terms of nuclear and radiation safety. The Advisory Committee considers it important that safety issues will be prioritised during the construction and that enough time will be reserved for handling safety issues.

No compromises have been made in terms of the safety requirements during detailed planning and construction. The meeting of the safety requirements is described in Appendix 6 to the operating licence application.

According to the above, the condition laid down in the construction licence is met.

In the Preliminary Safety Analysis Report the applicant has given the 50 MWd/kgU discharge burnup upper limit (megawatt day per one kilogram of uranium). In STUK's view, the acceptability of this value has not been demonstrated in the light of current knowledge, and thus STUK retains the upper *limit of 45 MWd/kgU, unless the applicant can experimentally demonstrate to STUK that the higher value can fulfil all pertinent safety criteria. Similarly, the Advisory Committee on Nuclear Safety requires that the discharge burnup of nuclear fuel be limited to comply with the safety requirements.*

The Government considers that the plans concerning the nuclear power plant unit, its central operational systems and components are adequate in view of safety. At the same time, the Government states that if the applicant wishes to set a upper limit higher than 45 MWd/kgU for the discharge burnup at the operational phase of the plant unit, it shall demonstrate by tests to the Finnish Radiation and Nuclear Safety Authority (STUK) that the higher value proposed will fulfil the safety requirements.

The Radiation and Nuclear Safety Authority has approved the fuel assemblies in the initial fuel configuration of the Olkiluoto 3 nuclear power plant unit up to a maximum burnup of 45 MWd/kgU per assembly. TVO does not intend to change this burnup limit in connection with the operating licence application. The use of a higher discharge burnup (52 MWd/kgU) as the initial assumption for the plant unit's safety analyses is a conservative practice in terms of the end results in the final safety analysis report.

Core operation planning is used to ensure the meeting of the design bases and safety requirements concerning burnup and reactivity management, including the shutdown margins.

The analysis in the OL3 final safety analysis report (FSAR) indicate that the requirements are met. The boundary conditions for the calculation parameters that are applied to the FSAR accident analyses support the following goals:

- A conservative approach is followed in order to demonstrate safety
- This avoids the need for repeating the accident analyses in order to demonstrate the safety of refuelling
- This approach provides flexibility for technical improvements in the future.

The discharge burnup value was increased at this time from the value of 45 MWd/kgU that was licensed for the fuel in the initial configuration to 52 MWd/kgU in the final safety analysis report in order to arrive at a conservative analysis (this also involved increasing the cycle lengths in the calculations). Therefore, the burnup value of 52 MWd/kgU may be considered a limit above which the plant unit's safety analyses shall be reviewed again if a fuel assembly type being used is to be later licensed for a higher burnup.

This maximum value in no way limits the use of the initial fuel assembly licensed currently at the plant unit.

According to the above, the condition laid down in the construction licence is met.

b) Physical protection has been taken into account appropriately when planning operations

The Industrial Safety District of Turku and Pori points out in its statement that along with the Olkiluoto 3 project attention should be paid especially to the teaching and guiding of the employees filling in new vacancies. The Industrial Safety District considers that the objectives and requirements regarding following of a safety culture set out in the application correspond to the objectives of the Occupational Health and Safety Act (738/2002).

Occupational safety during the Olkiluoto 3 project has been compliant with the requirements. New personnel have been trained in occupational safety and guidance has been provided. Special attention has been paid to safety culture. The operating and maintenance instructions of the plant are reviewed in terms of occupational safety requirements. Training and guidance are provided in relation to operation and maintenance and the process separations and safety isolations related to them.

According to the above, the condition laid down in the construction licence is met.

According to the Finnish Radiation and Nuclear Safety Authority (STUK), the Olkiluoto 3 nuclear power plant unit has been designed to be adequately safe in view of limiting the radiation exposures of the workers. As for operation and maintenance, the design of the plant has also observed the target of keeping the radiation dose of the workers as low as practically possible.

The radiation safety of workers at the Olkiluoto 3 nuclear power plant unit is discussed in Appendix 6 to the operating licence application that assesses the meeting of the requirements laid down in Section 7 of the Radiation and Nuclear Safety Authority's regulation on the safety of nuclear power plants (STUK Y/1/2016, 1st January 2016).

According to the above, the condition laid down in the construction licence is met.

The Government states that health and safety at work has been appropriately taken into account in the planning of operations.

Occupational safety meets the requirements. Special attention has been paid to structural occupational safety throughout the construction in order to allow the plant to meet the requirements of the Occupational Health and Safety Act from a structural point of view. The correct placement of working platforms and access to the platforms, ladders and their placement and structure, lifting and lifting rails, sufficient dimensioning of access ways and transport routes and the sufficient dimensioning of exit routes have been among the aspects studied. Risk analyses have also been prepared concerning lifting and related crushing hazards.

When preparing for commissioning, TVO will be performing occupational safety reviews before the actual commissioning inspection. These reviews will be used to check the actions that will be taken at the locations in question during operation and maintenance, and whether the conditions for the safe performance of work exist. This means that the machinery and equipment located in a room do not cause an immediate risk to its operator, the planned service and maintenance activities can be performed on the machinery and equipment, and the machinery and equipment are accessible and their surrounding work platforms are safe to use. TVO has provided instructions for these reviews.

According to the above, the condition laid down in the construction licence is met.

(c) The population's safety has otherwise been taken into account appropriately when planning operations

After having received from the Ministry of the Interior the statement required under section 37 of the Nuclear Energy Decree, the Finnish Radiation and Nuclear Safety Authority (STUK) has checked the preliminary emergency plan of the Olkiluoto 3 nuclear power plant unit, which concerns the planned emergency arrangements for the operation of the Olkiluoto 3 nuclear power plant unit, and found it adequate at this stage.

As a summary, the Finnish Radiation and Nuclear Safety Authority (STUK) states that, in view of emergency arrangements, the design of the Olkiluoto 3 nuclear power plant unit and the related measures and those related to its construction, as well as the plans for measures on the site, are adequate and meet the regulations under the Decision of the Council of State 397/1991.

The Government considers that – on top of the plans for the nuclear power plant, its central operational systems and components that have been examined in point 1(a) above and the safety arrangements in point (3) below, the safety of the population has otherwise appropriately been taken into account in operational planning.

Appendix 6 to the operating licence application contains analyses regarding the meeting of the requirements laid down in the Radiation and Nuclear Safety Authority's regulation on emergency response arrangements at nuclear facilities (STUK Y/2/2016, 1st January 2016) and security arrangements in the use of nuclear energy (STUK Y/3/2016, 1st January 2016).

According to the above, the condition laid down in the construction licence is met.

2) The location of the nuclear facility is appropriate with respect to the safety of the planned operations and environmental protection has been taken into account appropriately when planning operations

(a) The location of the nuclear facility is appropriate with respect to the safety of the planned operations

The Government considers that the location of the power plant is appropriate in terms of the safety of its planned operations.

The extreme weather phenomena that have been considered possible at the location of the nuclear facility have been taken into account in the design and, in particular, in the safety analyses submitted to the Radiation and Nuclear Safety Authority.

According to the above, the condition laid down in the construction licence is met.

(b) Environmental protection has been taken into account appropriately when planning operations

As the coordinating authority defined in the Act on Environmental Impact Assessment Procedure (EIA), the Ministry of Trade and Industry considered in its statement on the EIA report that the report on the environmental impact assessment on the Olkiluoto site is, given the stage of the project, wide-scoped and detailed enough and that it fulfils the requirements *of the Act and Decree on Environmental Impact Assessment Procedure and that it meets the objectives set in the assessment programme.*

The Ministry of the Environment considers in its statement that the applicant does not clearly state how it will take the comments and measures presented in the EIA procedure into account in the implementation of the project. Further, it states that the impacts of radioactive waste on living organisms are handled only in broad outline in the EIA report.

In its response the applicant points out that the aspects put forth in the statements given on the EIA report have been, and will be, taken into account as the project progresses and describes the implementation stage of the ancillary projects mentioned in the coordinating authority's statement as well. It is also stated in the response that the Olkiluoto power plant already has today a comprehensive and versatile control programme for monitoring ambient radiation, which also covers important species other than those that are important for the food chain of humans. In the framework of the programme, sensitive measurements are carried out to identify radioactive substances from the power plant in the organisms near the power plant. The contents are so low that they have no discernible impacts, and the new plant unit will not change this situation.

The statement of the coordinating authority does not present any actual remarks or measures. As for the impacts of the spreading of radioactive emissions, it states that the impacts are presented in the manner approved at the EIA programme stage. The EIA procedures concerning power lines have already been completed, but the EIA procedure concerning the reserve power plant is still in progress. The road to the Olkiluoto power plant was improved during 2004.

The EIA procedure for the Olkiluoto 3 project has been completed in accordance with the Act on Environmental Impact Assessment Procedure (468/1994), and the aspects that were brought up have been observed during the later planning and implementation of the project. Environmental impacts have been assessed in more detail during the environmental permit procedure of the project and in the permit procedure conducted under the Water Act that have been discussed in Appendix 7 to the operating licence application.

The environmental monitoring programme at Olkiluoto has been expanded to also cover the operation stage of the OL3 plant unit. Environmental monitoring is discussed in Appendix 7 to the operating licence application.

The EIA procedure for the Olkiluoto gas turbine plant, which acts as the reserve power plant, was completed in 2005. The gas turbine plant has been constructed and commissioned upon application by Fingrid Oyj pursuant to the conditions of the environmental licence and the licence for the storage of dangerous chemicals that were granted in 2006.

According to the above, the condition laid down in the construction licence is met.

Environmental impacts during construction

In its response the applicant states that, in order to supervise and manage the implementation of the construction stage, an environmental plan, which it would be ready to deliver to the environmental authorities for their information, should be drafted. The applicant is also ready to hear and consider the opinions and comments of the environmental protection surveillance authorities on its contents. The plan comprises the environmental aspects and impacts related to the application of the Environmental Protection Act and the Water Act and, as necessary, the possible joint effects with the Onkalo project of Posiva Oy during the construction. The plan will be supplemented, when necessary, as the construction progresses.

The environmental aspects of the Olkiluoto nuclear power plant are managed by means of an environmental management system that also covers the construction stage of the Olkiluoto 3 plant unit. The environmental management system is discussed in Appendix 7 to the operating licence application.

The environmental monitoring programme at Olkiluoto covers the construction stage of the Olkiluoto 3 plant unit. During the construction stage, the monitoring has been expanded in terms of water construction effects and noise, for example. The monitoring programme is discussed in Appendix 7 to the operating licence application.

The applicant has drawn up an environmental plan concerning the construction of Olkiluoto 3 that takes into account the joint effects of the different activities in the Olkiluoto area. The plan has been appended to the environmental management system.

According to the above, the condition laid down in the construction licence is met.

Taking environmental protection into account

The County Government Board of Western Finland considers in its statement that the handling of the environmental licences subject to the Environmental Protection Act related to the projects and the handling of the licence for the intake of the cooling water are in progress. The Board expects the decisions on the applications to be made during 2005.

The County Government Board of Western Finland has granted the Olkiluoto 3 plant unit an environmental licence for its operation and the intake of cooling water. The licences in question are discussed in Appendix 7.

According to the above, the condition laid down in the construction licence is met.

The Finnish Radiation and Nuclear Safety Authority (STUK) considers that the environmental impacts of the placing on Olkiluoto of the Olkiluoto 3 nuclear power plant unit have been adequately taken into account in view of the issues belonging to STUK's sector. It also considers that the arrangements planned for the control of the emissions and contents of the radioactive substances from the Olkiluoto 3 nuclear power plant unit in the environment are efficient enough.

The radiation monitoring programme of the vicinity of Olkiluoto also covers the operation of the Olkiluoto 3 nuclear power plant unit. The radiation monitoring programme is discussed in Appendix 7.

According to the above, the condition laid down in the construction licence is met.

The Government considers that environmental protection has been appropriately taken into account in operational planning and that the cooling water solutions chosen can be regarded as at least as good as the other options brought up in the environmental impact assessment report. It also considers that it is not justified to connect to the licence to be granted a condition concerning an environmental protection plan to be submitted to the environmental authorities for their approval, as the environmental impacts of the construction of the plant do not include any special features arising from the use of nuclear energy and thus there is no need for exceptional regulation in view of the objectives of nuclear energy legislation

TVO views that the conditions in the construction licence concerning the safety of the location and environmental protection have been appropriately considered during the planning of operations.

According to the above, the condition laid down in the construction licence is met.

3) Safety arrangements have been taken into account appropriately when planning operations

After having received the statement required in section 37 of the Nuclear Energy Decree from the Ministry of the Interior, the Finnish Radiation and Nuclear Safety Authority (STUK) has checked the preliminary safety arrangement plan, whose procedures are aimed at preventing unlawful actions against the Olkiluoto 3 nuclear power plant unit after the commissioning of the plant unit, and found it adequate.

STUK has also checked and approved the current safety plan of the Olkiluoto nuclear power plant, in which the construction site of the Olkiluoto 3 nuclear power plant unit has been taken into account in view of the safety arrangements of the existing nuclear power plants. According to STUK, the Olkiluoto 3 nuclear power plant unit and its safety arrangements have been adequately planned to sustain external threats and illegal actions, and they have been found to meet the provisions of the Council of State's Decision-in-Principle 396/1991.

The Government considers that the safety arrangements have been taken into account appropriately when planning operations.

The meeting of the requirements laid down in the Radiation and Nuclear Safety Authority's regulation on security arrangements in the use of nuclear energy (STUK Y/3/2016, 1st January 2016) is assessed in connection with the operating licence application (Appendix 6).

According to the above, the condition laid down in the construction licence is met.

4) A site has been reserved for the construction of a nuclear facility in a local detailed plan in accordance with the Land Use and Building Act (132/1999), and the applicant has possession of the site required for the operation of the facility

The Government considers that the applicant has the governance of the region required by the operation of the plant and that the town plan in force in the area allows the construction of the Olkiluoto 3 nuclear power plant unit.

The local plan in the area remains unchanged.

According to the above, the condition laid down in the construction licence is met.

5) The methods available to the applicant for arranging nuclear waste management, including final disposal of nuclear waste and decommissioning of the facility, are sufficient and appropriate

Handling of spent nuclear fuel

The intermediate storage of spent fuel depends both administratively and process-technologically on the Olkiluoto 1 and 2 nuclear power plant units, and its operating licence is tied to the operating licences of the Olkiluoto 1 and 2 nuclear power plant units, which will be valid until the end of the year 2018 (granted on 13 August 1998).

The expansion of the KPA storage has been completed and TVO has started the process for the renewal of the operating licence of the Olkiluoto 1 and 2 plant units.

According to the above, the condition laid down in the construction licence is met.

On 17 January 2002 the Government made a decision-in-principle that the Olkiluoto final repository could be extended in such a way that the spent nuclear fuel from the operation of the new nuclear power plant unit can also be treated and disposed of at the repository. On 24 May 2002 Parliament decided that the decision-in-principle would remain in force. According to the decision, final disposal facilities corresponding to approximately 2,500 tonnes of uranium at maximum can be built for the needs of the new plant unit.

For the Olkiluoto 3 nuclear power plant unit, the estimated amount of uranium used in the applications for a decision in principle is 2,500 tU. Appendix 4 to the operating licence application presents a more detailed estimate of the amount of spent fuel accumulated at the Olkiluoto 3 nuclear power plant unit as a result of 60 years of operation; the amount is 4,069 assemblies, corresponding to 2,165 tonnes of uranium.

According to the above, the condition laid down in the construction licence is met.

Treatment of power plant waste

According to the application, the power plant waste accrued during operation can be disposed of at the final repository of power plant waste on the site. It can also be stored temporarily in separate intermediate storage of medium-active waste and intermediate storage of low-active waste. When necessary, more space can be excavated in the final repository of power plant waste near the present facilities

As a result of the disposal of power plant waste from the Olkiluoto 1 and 2 nuclear power plant units, the KAJ silo in the VLJ facility was 51% full and the MAJ silo was 60% full at the end of 2014. The preliminary plan for expanding the capacity of the VLJ facility is discussed in Appendix 9 to the operating licence application.

At the end of 2015, the KAJ storage contained 23 m3 of waste and the MAJ storage contained 5 m3. The capacities reserved for the Olkiluoto 1 and 2 nuclear power plant units in the operating licence conditions are 5,000 m3 for the KAJ storage and 3,000 m3 for the MAJ storage. According to the operations licence, the storage capacity of the component storage is 9,300 m3. Therefore, there is sufficient capacity available for the interim storage of power plant waste from the Olkiluoto 3 nuclear power plant before the expansion of the VLJ facility. The interim storage capacity can be considered sufficient when taking into account the estimate of 3,000–6,000 m3 presented for the total volume of waste accumulated from 60 years of operation.

According to the above, the condition laid down in the construction licence is met.

Both the intermediate storage of medium-active waste and the intermediate storage of low-active waste will be used for the needs of the Olkiluoto 1 and 2 nuclear power plant units for the intermediate storage of nuclear waste. This may continue until the end of 2018 based on the operating licence of the existing plant units. The final repository of nuclear waste was taken into use in 1992 and the operating licence runs until the end of 2051 (granted on 9 April 1992).

This operating licence application applies for permission to use the KAJ and MAJ storages for the interim storage of power plant waste originating from the Olkiluoto 3 nuclear power plant unit. For the time being, it is appropriate to use the same length of the operating licence term for the interim storage as is used for the Olkiluoto 3 nuclear power plant unit. The Government made a decision on 22nd November 2012 to amend the conditions of the VLJ facility operating licence to also cover the disposal of power plant waste originating from the Olkiluoto 3 plant unit in the VLJ facility. Extending the operating licence term until 2080, which is the postulated closing time of the VLJ facility in the new final safety analysis report, is also considered appropriate.

According to the above, the condition laid down in the construction licence is met.

Statement by the Radiation and Nuclear Safety Authority

The Finnish Radiation and Nuclear Safety Authority (STUK) considers in its Statement of Position that both the plans for the final disposal of power plant waste and the plans and arrangements for the final disposal of spent fuel in Finland are adequate in view of the construction licence.

Appendix 9 to the operating licence application presents an analysis of the current state of nuclear waste management. A construction licence was granted for an encapsulation plant and disposal facility of spent nuclear fuel on 12th November 2015.

According to the above, the condition laid down in the construction licence is met.

In STUK's view, the decommissioning of the Olkiluoto 3 nuclear power plant unit and the final disposal of the decommissioning waste can be implemented in the same way as in the case of the existing nuclear power plant units.

The decommissioning plans are discussed in Appendix 9 to the operating licence application. TVO has also drawn up a separate analysis on decommissioning for the Radiation and Nuclear Safety Authority. According to the plan, the decommissioning of the Olkiluoto 3 nuclear power plant unit and the disposal of the disassembly waste will, where applicable, be implemented by means of the same methods and solutions that were presented in the decommissioning plan of the Olkiluoto 1 and 2 plant units.

According to the above, the condition laid down in the construction licence is met.

Furthermore, it states that the applicant's safety analysis of the final repository of power plant waste is to be revised in 2007. In connection with the revision, the final disposal of the power plant waste created from the operation of the Olkiluoto 3 nuclear power plant unit should also be examined, as the current safety analysis covers only the power plant waste from the Olkiluoto 1 and 2 nuclear power plant units.

The VLJ facility safety analysis was revised in 2007, taking into account the power plant waste from the Olkiluoto 3 nuclear power plant unit (Olkiluoto VLJ Repository - Safety Case, Fortum Nuclear Services, December 2006). The safety analysis was submitted to the Ministry of Employment and the Economy (TEM) at the end of 2006 as part of the analysis of the safety and operating experience of the VLJ facility and the new packaging and disposal techniques for power plant waste that are required under the operating licence conditions of the VLJ facility. In its statement on 26th March 2008, TEM stated that it has no comments on the analysis.

The safety analysis in its entirety (10 separate reports) is appended to the final safety analysis report of the VLJ facility (VLJ-FSAR). The Radiation and Nuclear Safety Authority has approved the periodic report drawn up under the operating licence of the VLJ facility, the updated safety case of the VLJ facility and its final safety analysis report.

The disposal of the power plant waste from the OL3 plant unit can be implemented safely in the same manner as for the power plant waste from the current (nuclear power plant) units.

According to the above, the condition laid down in the construction licence is met.

STUK also considers that the survey presented in Annex 12 to the application for a construction licence "Report on the applicant's plans and the methods available to arrange nuclear waste management" is very general in nature. The adaptation of Posiva Oy's final disposal plan to the needs of the Olkiluoto 3 nuclear power plant unit should be started so that more detailed plans can be presented in the three-year review of nuclear waste management TKS-2006 to be published in 2006.

Posiva was granted a construction licence for the encapsulation plant and disposal facility on 12th November 2015. The construction licence takes into consideration the Olkiluoto 3 plant unit as detailed in the decision in principle concerning its spent nuclear fuel. The impacts of the Olkiluoto 3 plant unit have been taken into account in the planning of waste management; the waste management plans of the Olkiluoto 3 plant unit have been presented in the 2006 and 2009 TKS programmes and in the 2012 and 2015 YJH programmes.

According to the above, the condition laid down in the construction licence is met.

The Government states that mainly the same nuclear waste management arrangements will be used for the new plant unit as in the case of the existing nuclear power plant units. The methods available to the applicant for arranging the nuclear waste management of the new nuclear power plant unit are adequate and appropriate.

Appendix 9 to the operating licence application presents an analysis of the current state of nuclear waste management.

According to the above, the condition laid down in the construction licence is met.

6) The applicant's plans for arranging nuclear fuel management are sufficient and appropriate

The Government's view is that the availability of uranium at a reasonable price will be possible for many decades. Given this, the Government states that the applicant's fuel management arrangements are adequate and appropriate.

Appendix 4 to the operating licence application presents an analysis of the current state of nuclear fuel management.

According to the above, the condition laid down in the construction licence is met.

7) The applicant's arrangements for the implementation of control by the Radiation and Nuclear Safety Authority (STUK) as referred to in paragraph 3 of section 63 subsection 1, in Finland and abroad, and for the implementation of control, as referred to in paragraph 4 of section 63(1) are sufficient

STUK has approved the report and states in its Statement of Position that enough time should be reserved for the administrative procedures needed to ensure the control possibilities during the construction. STUK is to receive in good time information on the manufacturing schedules of the machinery, structures and systems that will be important for safety, on the basis of which STUK can confirm that the control measures required in the nuclear power plant guidelines will be implemented.

The Government states that the applicant's arrangements are sufficient as regards the regulatory control referred to in Section 63 of the Nuclear Energy Act. At the same time, the Government states that if enough time is not reserved for the control subject to chapter 15 of the Nuclear Energy Act, this will lead to prolongation of the construction period.

The Radiation and Nuclear Safety Authority (STUK) has been provided with supervision opportunities during the construction of the Olkiluoto 3 plant unit and STUK has performed the supervision activities required by the YVL Guides.

According to the above, the condition laid down in the construction licence is met.

8) The applicant has the necessary expertise available

According to the Finnish Radiation and Nuclear Safety Authority (STUK), the applicant has sufficient expertise in completing the construction project. When compiling the project implementing the nuclear power plant unit, the applicant has extended its organisation and recruited experts in various sectors especially for implementing the project. STUK also considers that, based on the inspections and observations it has made in connection with the handling of the application for a construction licence, the consortium in charge of the plant delivery has adequate expertise in the field of nuclear technology.

STUK considers that the applicant has adequate arrangements for recruiting the personnel and organisation needed for a safe operation of the Olkiluoto 3 nuclear power plant unit. STUK requires that the applicant will ensure the sufficiency of its expertise also during the future operation of the nuclear power plant unit. Thus owing to the characteristics of the new plant and the technologies applied in it, the applicant should ensure that its organisation, which will be strengthened during the construction period, will remain competent enough also upon the shift over to the operational stage, particularly in the fields of nuclear safety, mechanical technology and automation technology.

The Government states that the applicant has the necessary expertise available.

TVO has strengthened its expertise concerning the Olkiluoto 3 nuclear power plant unit by means of expertise gained during construction and the training of personnel recruited for the OL3 plant unit. Appendix 8 to the operating licence application discusses in more detail the expertise available to the applicant and the OL3 operating organisation.

According to the above, the condition laid down in the construction licence is met.

9) The applicant has sufficient financial prerequisites to implement the project and carry on operations

The Ministry of Finance has no remarks on the application. It considers in its statement that arranging the financing in the manner proposed by the applicant will be possible so that a satisfactory equity ratio and sufficiently good credit eligibility rating can be ensured for the applicant.

The Government considers that the applicant has adequate financial possibilities of implementing the Olkiluoto 3 nuclear power plant unit and of carrying out the subsequent operations.

Appendix 10 to the operating licence application discusses the applicant's financial prerequisites for implementing the Olkiluoto 3 nuclear power plant unit and engaging in related business operations.

According to the above, the condition laid down in the construction licence is met.

10) The applicant is otherwise considered to have the prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations

The Government states that no such matters have arisen that would question the applicant's prerequisites for engaging in the operations safely. Furthermore, it considers that the Olkiluoto 3 project could otherwise be implemented in accordance with Finland's international contractual obligations.

The obligations from international contracts signed by Finland are fulfilled. .

According to the above, the condition laid down in the construction licence is met.

After the Government's decision-in-principle, an emissions trading system has been taken into use in Finland since the beginning of 2005. In the Government's view, this development will not, however, have any effect on the evaluation of the Olkiluoto 3 project as a project complying with the overall good of society.

The emissions trading system does not affect the Government's assessment of the project's compliance with the overall good of society.

According to the above, the condition laid down in the construction licence is met.

According to the Statement of Position of the Finnish Radiation and Nuclear Safety Authority (STUK), the Olkiluoto 3 nuclear power plant unit can be built safe in accordance with sections 5–7 of the Nuclear Energy Act.

The Olkiluoto 3 nuclear power plant unit meets the requirements of Sections 5–7 of the Nuclear Energy Act.

According to the above, the condition laid down in the construction licence is met.

On the basis of the above, the Government states that the conditions for granting a construction licence are met.

It is the opinion of TVO that the conditions for granting a construction licence have not been deviated from.

3. Conclusions

The reservations of the decision presented in item 1 have been taken into consideration and the requirements presented therein are met.

Olkiluoto
FI-27160 EURAJOKI, Finland
Tel. +358 2 83 811
www.tvo.fi

Helsinki
Töölönkatu 4
FI-00100 HELSINKI, Finland
Tel. +358 9 61 801