

Инжиниринговый дивизион государственной корпорации по атомной энергии «РОСАТОМ»

# Требования зарубежных заказчиков к проектам АЭС, выполняемых на основе информационного моделирования (на примере АЭС «Ханхикиви-1»)

Группа компаний ASE

Директор по науке и инновациям  
АО ИК «АСЭ» - С.В. Егоров



# АЭС – СЛОЖНЫЙ И ОПАСНЫЙ ОБЪЕКТ



- Зданий и сооружений – 100
  - Оборудование - 1 млн. шт.
  - В проекте листов А4 – более 200 тыс. (12 основных зданий)
  - срок выполнения – 10 лет
  - срок эксплуатации – 60 лет
  - до 1000 подрядчиков на Проект,
  - Мультиязычность, мультидисциплинарность
- 
- ТЗ на проектирование – 400 листов А4
  - Количество требований – порядка 10 000\*к

# УПРАВЛЕНИЕ КОНФИГУРАЦИЕЙ И ТРЕБОВАНИЯМИ ЯДЕРНОГО ОБЪЕКТА



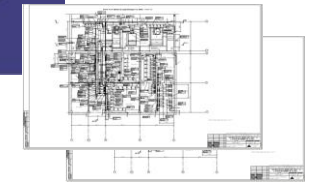
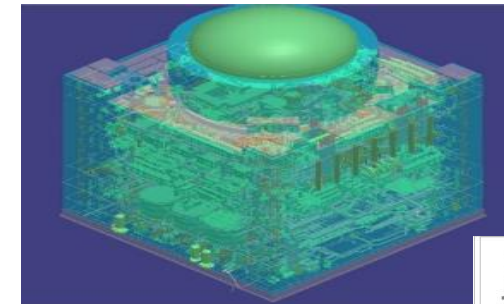
Технические требования  
Типовой проект



Должны  
соответствовать

Должны соответствовать

Проектная и исполнительская  
модель (3D|2D)



Должны  
соответствовать

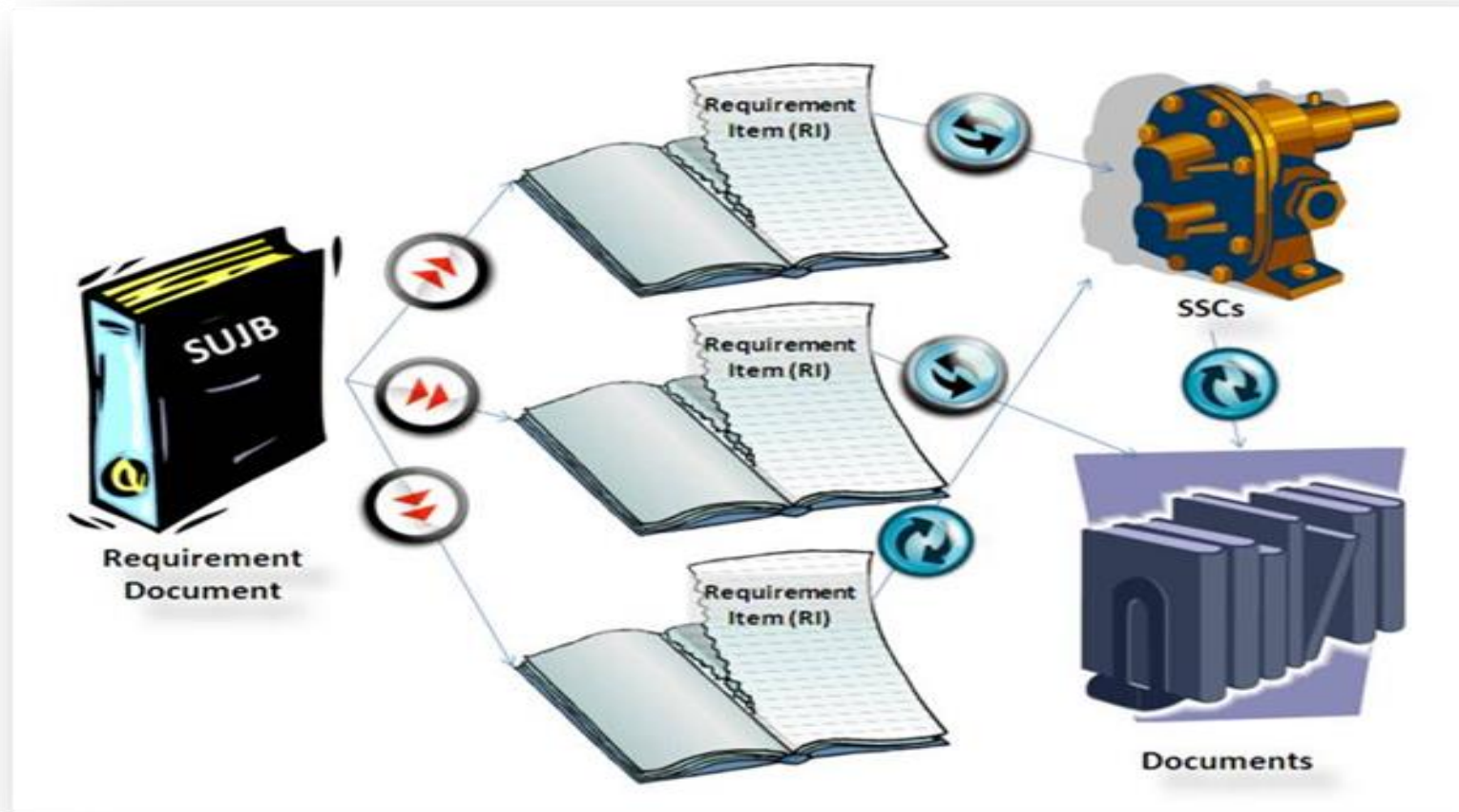
Физическая конфигурация  
объекта



Согласно IAEA-TECDOC-1335 функция управления конфигурацией должна обеспечивать что:

- Элементы конфигурации соответствуют друг другу на протяжении всего ЖЦ
- Все изменения авторизованы
- Соответствие верифицируемо

# РАБОТА С ОТДЕЛЬНЫМИ ТРЕБОВАНИЯМИ, А НЕ С ДОКУМЕНТАМИ



В каждом проекте сооружения АЭС количество требований исчисляется  $k \cdot 10\,000$

# Трудная задача: Как принять сложный инженерный проект с N\*1000 требованиями и M\*1000 проектными материалами?

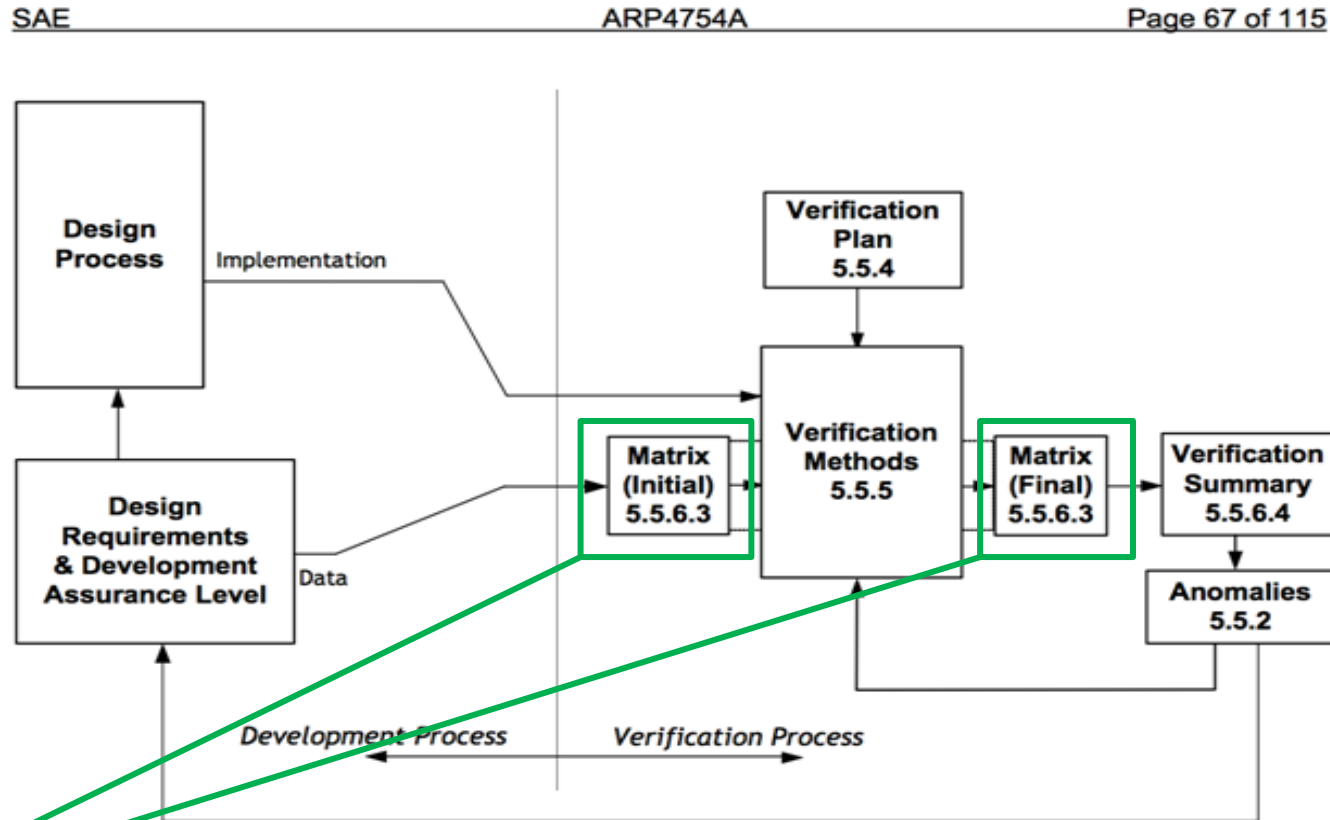


FIGURE 13 - VERIFICATION PROCESS MODEL

ARP 4754-1996  
ARP 4754A-2010

P-4754-2011 «Руководство по процессам сертификации высоко-интегрированных сложных бортовых систем воздушных судов гражданской авиации» - российская версия.

Под матрицей (*Matrix*) здесь понимается связь между требованиями, проектными документами, и критериями и программами приемки и выводами о выполнении требований.



# Пример выделения требований в EUR (version D)

## Volume 2 Chapter 9 CONTAINMENT SYSTEM

Revision D State 08 October 2012

Section	Requirement	Section comment	Last change
C	<p>The loads shall be combined and corresponding acceptance criteria shall be defined, on the basis of:</p> <ul style="list-style-type: none"><li>• probability of occurrence,</li><li>• operating experience,</li><li>• engineering judgment.</li></ul>	<p>C1 For general guidance an indicative list of load conditions to be considered is presented in Table 1 for PWR and BWR design. All of the loads are not applicable to all of the structural elements. Operational transients' loads, not included in Table 1, are design specific and will be defined in Volume 3.</p> <p>C2 See Chapter 2.9 Section 2.9.3.1.4.1.1.</p>	
D	<p>Loads for each structural element shall be identified and evaluated with account of the conditions to which that particular structural element may be subjected.</p>		
E	<p>Load combinations for each structural element shall be identified and evaluated with account of physical ability of simultaneous action of loads.</p>	<p>E1 For example maximum pressure and maximum temperature physically could not act simultaneously and therefore could not be included in one load combination.</p>	
F	<p>The liner shall be designed to withstand the effects of imposed loads and actions to accommodate deformation of the concrete without jeopardising its leaktightness.</p>	<p>F1 Depending on the specific design solution, load list and load classification can be different. The liner will be designed to withstand against the following loads and actions, such as:</p> <ul style="list-style-type: none"><li>• jet impingement,</li><li>• construction loads, especially if used as formwork,</li><li>• loads resulting from prestressing (for prestressed containment).</li></ul>	
G	<p>For serviceability analysis the liner shall be used as a structural element.</p>		
H	<p>The liner should not be used as a structural element for DBC.</p>		



EUROPEAN UTILITY REQUIREMENTS FOR LWR NUCLEAR POWER PLANTS

# Примеры оформления требований в нормативных документах Венгрии

## *2.3.2. Satisfaction of interested parties*

2.3.2.0100. The expectations of the interested parties, in order to enhance their satisfaction, shall be considered by the top management during the activities and interactions of the processes of the management system while ensuring that safety is not compromised.

## *2.3.3. Organizational policies*

2.3.3.0100. The top management shall develop the policies of the organization. The policies shall be in accord with the activities of the nuclear facility and the licensee.

## *2.3.4. Design*

2.3.4.0100. The top management

- a) shall define the strategies, plans, and objectives that are in accord with the policies of licensee;
- b) shall develop standardized, harmonized policies of the organization, as well as strategies, plans, and objectives in a manner that ensures that their collective impact on safety is clear and manageable;
- c) shall ensure that measurable objectives related to practical implementation of policies, strategies, and plans are established through appropriate processes at various levels in the organization.
- d) shall ensure that the achievement of the objectives is regularly assessed during the implementation of the plans; furthermore
- e) shall ensure that, if necessary, measures are taken to address deviations from the plans.



# Примеры оформления требований в нормативных документах Финляндии

GUIDE YVL A.3 / 2 JUNE 2014

S T U K

## 4.2 Responsibility of the management of the nuclear facility

404. The nuclear facility's management is responsible for the nuclear facility's management system. The management shall ensure that the management system is established, implemented, assessed, and continuously improved. Furthermore, the management shall ensure that the operations comply with the requirements specified in the management system.

405. The nuclear facility's management shall designate an individual from the management with the responsibility and authority to

- co-ordinate the development and implementation of the management system
- attend to the regular assessment and continuous improvement of the management system
- report on the management system's functionality and development needs with an eye to safety and safety culture in particular
- resolve conflicts relating to the requirements and processes of the management system.

406. The nuclear facility's management shall demonstrate their commitment to safety as well as

409. Performance of work and the flow of information shall be organised to make the responsible manager continuously aware of all the essential factors affecting the safety of the facility and that they are handled as required by their safety significance.

410. The responsible manager's deputy shall have up-to-date knowledge of the facility's operation and factors affecting safety.

## 4.4 Planning and follow-up of activities

411. The nuclear facility's management shall establish strategies and ways of working as well as set goals that support the implementation of a safety and quality policy. The strategies and ways of working shall be unambiguous and consistent, and they shall be communicated to the personnel. Clear plans of action and procedures as well as adequate resources shall be in place to achieve the goals.

412. The management system shall include procedures for the planning and follow-up of activities.

413. The set goals shall be measurable and their



## Project Requirements (initial requirements)

### STUK Requirements

Finland's regulatory technical documentation on nuclear safety published by STUK

1. YVL-A.1 – YVL-A.12
2. YVL-B.1 – YVL-B.8
3. YVL-C.1 – YVL-C.6
4. YVL-D.1 – YVL-D.5
5. YVL-E.1 – YVL-E.12

**TOTAL STUK Requirements: 6.981**

### Contract Requirements

Parts 1-5 of Appendix 3

- Part 1. General technical and safety requirements
- Part 2. Requirements for structures, systems and components
- Part 3. Requirements for Management, Engineering and Design
- Part 4. Training requirements
- Part 5: Project Site and Construction Site requirements

**TOTAL Contract Requirements: 17.715**

## ПРАВИЛА РАБОТЫ С ТРЕБОВАНИЯМИ В ГК РОСАТОМ



- Единые отраслевые методические указания по формулированию, идентификации, оформлению и оценке качества требований в проектах сооружения АЭС.

[Приказ №1/869-П от 20.09.2016]

- Единые отраслевые методические указания по управлению требованиями в проектах сооружения АЭС за рубежом на этапе предконтрактных работ.

[Приказ 1/1277-П от 28.12.2015]

- Единый отраслевой порядок управления требованиями на различных стадиях ЖЦ АЭС в проектах сооружения АЭС за рубежом.

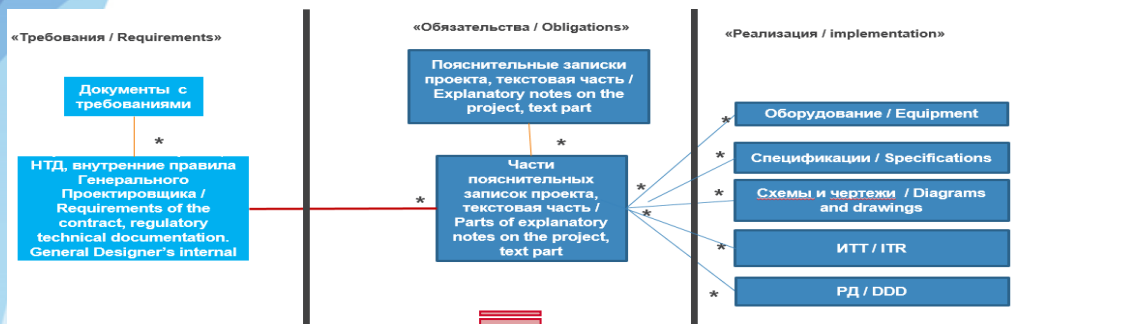
[Приказ 1/636-П от 11.07.2017]

- Единый отраслевой порядок управления требованиями на различных стадиях ЖЦ АЭС в проектах сооружения АЭС на территории Российской Федерации.

[Приказ 1/759-П от 10.08.2017]

- Учебные курсы в Корпоративной Академии Росатома.

# СИСТЕМА УПРАВЛЕНИЯ ТРЕБОВАНИЯМИ



Database Explorer: Project requirements, Appendix 1.1

ID	Number of req	Requirements	Type of requirement	Specialization	Reference to App 1.
1	2.1	2.1 Safety and design basis requirements	H - Heading	Проектирование, анализ безопасности	
2	2.1-0005-N	The technical and safety requirements in this document correspond to the requirements of the Hungarian Nuclear Safety Code and are in accordance with the European Utility Requirements (EUR). The lessons learned from the early and recent nuclear power plant accidents (including the most recent Fukushima events) are incorporated into the requirements, even if some of them are not required by the Hungarian Nuclear Safety Code (NSC) or by EUR.	N - Not requirement	Проектирование, анализ безопасности	02-01-03-01
4	2.1-0010-T	The design features corresponding to the lessons learned from the past nuclear power plant accidents are required to be taken into consideration in the application, nevertheless it is demanded that a separate section in the Tender documentation will be devoted to this topic with detailed information about feedback.	T - Technical requirement	Проектирование, анализ безопасности	02-04-01
5	2.1.1	2.1.1 Fundamental safety criteria and objectives	H - Heading	Проектирование, анализ безопасности	
6	2.1.1.1	2.1.1.1 Fundamental safety criteria	H - Heading	Проектирование, анализ безопасности	
7	2.1.1.1-0010-T	All practical efforts shall be made to prevent and mitigate nuclear or radiation accidents and it shall be ensured that the likelihood of an accident having harmful consequences would be extremely low.	T - Technical requirement	Проектирование, анализ безопасности	02-01-03-07
8	2.1.1.1-0020-T	It shall be ensured that in normal operation radiation exposure within the plant and radiation doses due to any release of radioactive material	T - Technical requirement	Проектирование, анализ безопасности	02-03-01-01

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Rational software

# Карточка требования

Main Requirements Contractors Documents Traceability matrix Verification Analytics References



## Requirement versions card: [YVL-B.2-3.2-314](#)

Sequence: 24

Version: 2013-11-15

**Text:** 314. The following part of systems belonging to Class EYT shall be allocated to Class EYT/STUK if the system 1. has facility-specific risk importance in consequence of the initiating events caused by its failure 2. protects safety functions, such as fire protection systems, against internal or external threats 3. monitors the radiation, surface contamination or radioactivity of the plant, instruments, workers or the environment (e.g. the environmental radiation monitoring network) but is not assigned to Safety Class 3. 4. is necessary for bringing the facility to a controlled state in case of an event involving a design basis category DEC combination of failures (DEC B) or a rare external event (DEC C).

Baseline: CB0

File: /Hanhikivi/DataFiles/YVL\_B\_2\_-\_Classification\_of\_systems,\_structures\_and\_components\_of\_a\_nuclear\_facility-2016\_05\_09-12\_32\_33.xml

### Traced documents

**Functional safety class:** EYT / STUK

**ID Location / DOORS ID:** FI-STUK-YVL-197D

**ID of version:** 2013-11-15

**Licensees verification type:** Analysis; Review

**Licensing step:** OL; CL

**Lifecycle phase:** Plant Modifications; Preparation for CL; Construction

**Regulatory verification type:** Review / Assessment

**SAR classification:** General Design Basis; Accident Analyses

**Source Government Decree:** VNA 717 4 §

Document	Version	Name	Contractor
<a href="#">FH1.B.P000.1.050705.020501.054.CA.0001</a>	0.0	System functions and design bases (KPF)	<a href="#">Atomproekt</a>
<a href="#">FH1.B.P000.1.050705.020601.054.CA.0001</a>	0.0	System functions and design bases (KPK)	<a href="#">Atomproekt</a>
<a href="#">FH1.B.P000.1.050705.0303&amp;&amp;.062.DP.0001</a>	0.0	Drawings of Solid Radioactive Waste Handling Systems	<a href="#">Atomproekt</a>
<a href="#">FH1.B.P000.1.110501.&amp;&amp;&amp;&amp;&amp;.078.HE.0001</a>	1.0	11.5.1 Design Bases(rev.1, Atomproekt development)	<a href="#">Atomproekt</a>
<a href="#">FH1.B.P000.1.110502.&amp;&amp;&amp;&amp;&amp;.078.HE.0001</a>	1.0	11.5.2 System Description(rev.1, Atomproekt development)	<a href="#">Atomproekt</a>

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### Verification result

Status	Comment	Document
Yes		<a href="#">FH1.B.G000.1.05&amp;&amp;&amp;&amp;.021.HE.0001.R</a>

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# Управление требованиями / пример трассировки документов



Main Requirements Contractors Documents Traceability matrix Verification Analytics References

## Traceability matrix

From document to requirements

From requirement to documents

Document	Requirements
<input type="text"/>	<input type="text"/>
<a href="#">FH1.B.G000.&amp;OUJA&amp;&amp;.JEA&amp;&amp;&amp;.021.YS.0013</a>	YVL-B.2-3.1-303; REQ-C5-131; REQ-C5-2576; YVL-E.3-7.6-740; YVL-E.3-1-103; REQ-B4-337; REQ-C5-1274; REQ-C5-182; REQ-C5-60
<a href="#">FH1.B.G000.&amp;OUJA&amp;&amp;.JEA&amp;&amp;&amp;.021.YS.0032</a>	REQ-C5-131; YVL-E.3-1-103; REQ-C5-182; REQ-C5-1274; YVL-E.3-7.6-740; REQ-C5-2576; REQ-C5-60; YVL-B.2-3.1-303; REQ-B4-337
<a href="#">FH1.B.G000.&amp;OUJA&amp;&amp;.JEC&amp;&amp;&amp;.021.CA.0001</a>	REQ-C5-716; REQ-C5-591; REQ-C5-517; REQ-C5-518; REQ-B4-1336; REQ-C5-941; REQ-B3-674; REQ-C5-1311; REQ-C5-574; REQ-C5-1992; REQ-B9-163; REQ-C5-648; REQ-C5-1296; REQ-C5-715; REQ-C5-1315; REQ-C5-590; REQ-C5-1342; REQ-C5-1988; REQ-B9-253; REQ-B4-229; REQ-C5-1262; REQ-B9-248; REQ-C1-736; REQ-C5-1326; REQ-C5-1300; REQ-B4-269; REQ-C5-395; REQ-B4-339; REQ-C5-2719; REQ-B4-397; REQ-C5-876; REQ-B4-1185; REQ-C5-183; REQ-C5-940; REQ-B4-1650; REQ-C5-577; REQ-B4-1184; REQ-C5-185; REQ-C5-558; REQ-C5-736; REQ-C5-737; REQ-C5-448; REQ-B4-337; REQ-B4-376; REQ-C5-333; REQ-B4-1663; REQ-C5-182; REQ-C5-592; REQ-C5-193; REQ-C5-1314; REQ-C5-862; REQ-C5-866; REQ-C5-112; REQ-C5-445; REQ-B4-1183; REQ-C1-774; REQ-C5-947; REQ-B4-377; REQ-B4-1181; REQ-B4-1180; REQ-C5-868; REQ-B4-342
<a href="#">FH1.B.G000.&amp;OUJA&amp;&amp;.JEC&amp;&amp;&amp;.021.DH.0006</a>	REQ-C5-235; REQ-C5-115; REQ-B4-339; REQ-C5-186; REQ-C5-2719; REQ-C5-218; REQ-C5-1307; REQ-B9-30; REQ-B4-1185; REQ-C5-1308; REQ-C5-29; REQ-C5-326; REQ-C5-2576; REQ-B4-1184; REQ-C5-908; REQ-C5-431; REQ-C5-156; REQ-C5-96; REQ-B4-337; REQ-C5-1682; REQ-C5-1248; REQ-B4-376; REQ-C5-113; REQ-C5-182; REQ-C5-99; REQ-C5-862; REQ-C5-866; REQ-C5-112; REQ-C5-61; REQ-B4-1183; REQ-B4-1459; REQ-C5-62; REQ-C5-328; REQ-C5-60; REQ-B4-1181; REQ-B9-510; REQ-B4-342
<a href="#">FH1.B.G000.&amp;OUJA&amp;&amp;.JEA&amp;&amp;&amp;.021.YS.0029</a>	YVL-B.2-3.1-303; REQ-C5-131; REQ-C5-2576; YVL-E.3-7.6-740; YVL-E.3-1-103; REQ-B4-337; REQ-C5-1274; REQ-C5-182; REQ-C5-60

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# ПРИМЕР ОТЧЕТА О ПРОВЕРКЕ ВЫПОЛНЕНИЯ ТРЕБОВАНИЙ НЕЗАВИСИМОЙ ОРГАНИЗАЦИЕЙ



## Consultancy services to support RAOS Project due to the issuance of Hanhikivi-1 NPP Construction License by the Owner

### Report on the Review of Hanhikivi-1 NPP Licensing Document Package

#### Chapter 11 Radioactive Waste Management

106002-99907-TR-REP-EN-0041-R.1.0  
16 March 2016



Reactor AES-2006 NPP/Hanhikivi site, Pyhäjoki, Finland

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## REPORT ON THE REVIEW OF HANHIKIVI-1 NPP LICENSING DOCUMENT PACKAGE CHAPTER 11 RADIOACTIVE WASTE MANAGEMENT

APPENDIX 2:

Requirement ID	Requirement text (exact quote from the document in the original language)	Related sections	Review results		
			Fulfilled	Fulfilled partially	Not fulfilled
	afterwards. According to Section 27 of the Decree, <u>releases of radioactive substances from the plant shall be monitored, and concentrations in the environment controlled.</u>				
<b>YVL A.11</b>	<b>Security of a nuclear facility</b>				
	<b>3.1 The design bases for nuclear security</b>				
YVL A.11# 303	Under Section 4 of Government Decree (734/2008), 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 [2].	All sections of Chapter 11	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
YVL A.11# Table 2	Table 2. Categorisation of nuclear materials and nuclear waste.	11.4 Appendix A	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>YVL B.1</b>	<b>Safety design of a nuclear power plant</b>				
	<b>4.3.5 Other redundancy requirements</b>				
YVL B.1# 456 bul. 3	The following systems performing functions relevant to safety <u>shall satisfy the (N+1) failure criterion:</u>  3. Stationary radiation measuring systems and equipment	11.5.1-5	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>