DANISH EMERGENCY MANAGEMENT AGENCY

DANISH HEALTH AUTHORITY
Radiation Protection

Topical Peer Review II on Fire Protection

National Assessment Report of Denmark

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0. Preamble/Foreword

Background.

The Council Directive 2009/71/EURATOM of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations as amended by Council Directive 2014/87/Euratom of 8 July 2014, requires as per article 8e 3., that Member States undertake national assessments of specified topics (Topical Peer Reviews) related to matters of nuclear safety. A first topical peer review was carried out in 2017. The member states, acting through the European Nuclear Safety Regulators Group (ENSREG), have decided that the topic for the second TPR is fire protection.

For this review, national assessments of fire safety is performed by member states and the results presented in National Assessment Reports (NAR). The NAR´s are subjected to peer review from all other member states, with the Commission as observer. As part of the review process, member states will define appropriate follow-up measures to be taken, in accordance with the relevant findings from the peer review process. Reports and outcomes of the review are to be made publicly available once finalized.

The Danish National Assessment Report (NAR) has been developed in accordance with the Technical Specification for the National Assessment Reports published by WENRA.

The NAR was compiled by the nuclear regulatory authorities (Danish Health Authority (DHA) and Danish Emergency Management Agency (DEMA)), with contributions from Danish Decommissioning (DD) as the responsible licensee for the nuclear installations in Denmark. DD's contributions include descriptions of the installations and aspects of the fire safety protection concept and its implementation.

National Assessment Report

All nuclear installations in Denmark are located at one site, where installations were in operation from the late 1950´ies until 2002. All installations have since been in "safe care and maintenance" or under decommissioning.

In this report, the fire safety of two selected installations is reviewed. The review shows that the fire protection concept applied to the Danish nuclear facilities has evolved over the transition from the operational to the post-operational period, and as decommissioning activities have progressed. Whereas fire protection during operations strongly relied on the presence of a dedicated, on-site fire service, fire safety in the post-operational period has relied to a higher degree on passive safety features, in particular with respect to detection and alarm measures.

It is concluded that the level of fire protection for nuclear facilities in Denmark is considered satisfactory, and that the fire protection concept and its implementation has proven adequate. However, it is also recognized that ensuring coordination between regulatory authorities at different hierarchical levels and with reference to different legislative requirements is challenging. Furthermore, the transition from the operational into a post-operational stage of decommissioning, has resulted in gradual erosion of fire safety competences available to the licensee. This presents a risk that the (fire) safety culture erodes over time, leading to poor implementation of the fire protection concept.

These lessons will be included in the continuous development of the fire protection concept for the remaining ongoing decommissioning activities and in the definition of a new fire protection concept for a planned long term storage facility at the Risø site.

1. General information

1.1 Nuclear installations identification

All nuclear installations in Denmark are located at the former Risø National Laboratory on the Risø site, north of the city of Roskilde. The Risø National Laboratory was a state-owned research institution, tasked to undertake research related to the peaceful use of atomic energy. Operations at the Risø site were initiated in 1955 and ceased in 2002 when all installations apart from those related to the waste management plant were placed in "care and maintenance" prior to dismantling.

The Risø National Laboratory included three research reactors (DR1, DR2 and DR3), a hot-cell facility, a fuel fabrication plant, a waste management plant, and storage facilities holding all radioactive waste generated from operations (and later also decommissioning activities) at the Risø site and resulting from research, industrial and medical applications of radioactive materials in Denmark. A total of four storage facilities for solid radioactive waste and one purpose-built container for liquid radioactive waste are currently operated on the site.

In 2003 the Danish Parliament decided to permanently shut down the Risø National Laboratory and to initiate decommissioning of all nuclear installations and associated facilities on the site with the aim of releasing buildings and land areas from regulatory control. For this purpose, a state-owned organisation named Danish Decommissioning (DD) was established as a new licensee with the main purpose of decommissioning the nuclear installations and facilities at the Risø site and to ensure continued reception and management of radioactive waste generated from institutional use in Denmark. Figure 1 shows a map of the Risø site with the nuclear installations. The numbering corresponds to the numbering in Table 1 where the nuclear installations and associated facilities, including waste storage facilities, are listed.

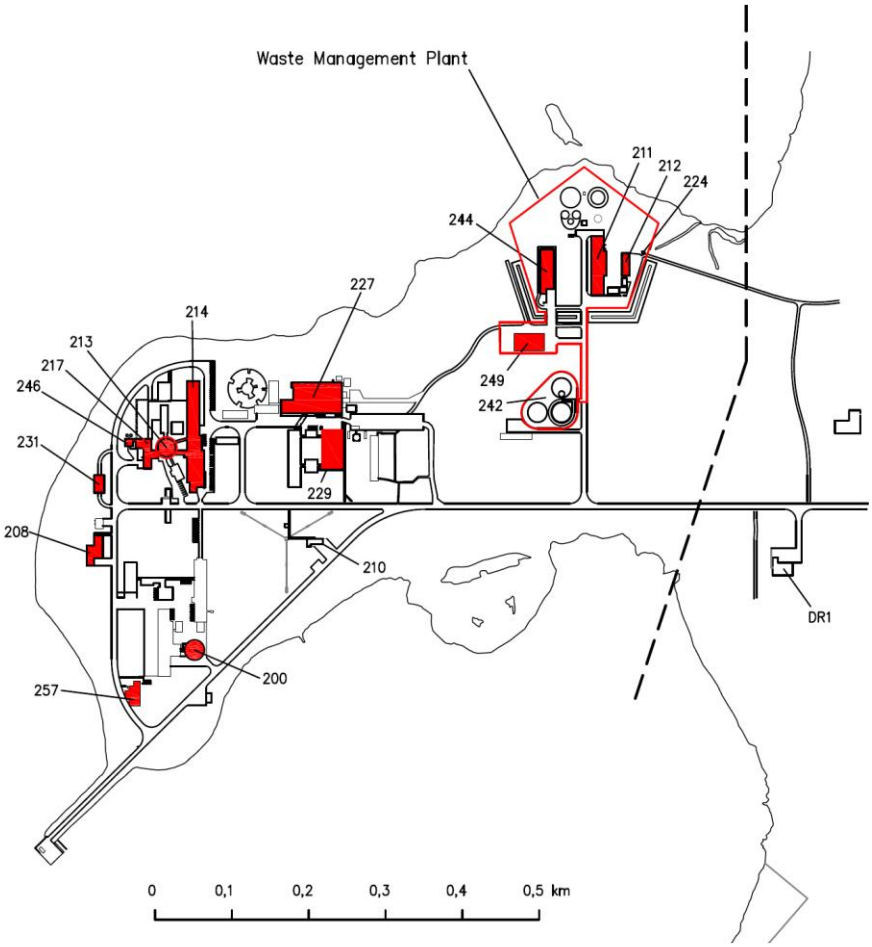

Figure 1. Map showing the Risø site. The buildings marked in red are managed by DD. The numbers refer to the building numbers in Table 1.

Building number	Installation/facility description
200	DR 2 Reactor Containment Hall
208	Radiological Characterization Laboratory
211	Waste Management Plant (main building)
212	Drum Storage (including drum press facility)
213	DR 3, Reactor Containment Hall
214	Office building and DR 3 Active Handling Hall
217	DR 3 (auxiliary building) Radioactive water treatment
224	Storage of Radioactive Liquids
227	Hot Cell Facility
229	Fuel Fabrication Plant
231	Centralvej Storage
242	Tailings pools and ore heap (Pools for tailings and ore)
244	Low Level Waste Storage
246	Building including tanks for radioactive waste water
249	Intermediate Storage
257	Clearance Laboratory

Table 1. List of buildings managed by DD. The location of each building on the Risø site is shown in figure 1.

1.1.1 Qualifying nuclear installations

Nuclear installations which have already been decommissioned and released from regulatory control are out of the scope for the TPR II review. The remaining Danish installations which hereafter are considered qualifying installations for the national assessment are:

- The Danish Reactor 3 (DR3, under decommissioning)
- The Hot Cell Facility (under decommissioning)
- The Waste Management Plant (main building) (under decommissioning)

Also identified as qualifying installations are the four radioactive waste storage facilities, which are all in operation:

- Drum Storage
- Low Level Waste Storage
- Intermediate Storage
- Centralvej Storage

1.1.2 National Selection of installations for TPR II and justification

Denmark has no nuclear installations in operation. Hence, the installations to be represented in the TPR II review must be selected from the list of waste storage facilities and installations under decommissioning. Within the scope of the TPR II review, there are four nuclear installations under decommissioning and four storage facilities for radioactive waste that are on the same site and are directly related to the nuclear installations at the Risø site.

For these installations and facilities, radiological assessments of the consequences of a fire point toward limited levels of exposure, but some scenarios still warrant the consideration of protective actions to limit exposures and the risk of contamination to the surroundings environment in case of fire.

Due to the advanced stages of dismantling of installations under decommissioning, the radiological consequences of a fire in an installation under decommissioning are assessed to be of less significance than those from a fire in a storage facility for radioactive waste.

The criteria considered in the selection process for "candidate" and "represented" installations or facilities are as follows:

- The selection of "candidate installations" must include one installation under decommissioning and one storage facility.
- For installations under decommissioning, the installation with the assessed largest potential for dispersion of radioactive material in the case of a fire has been selected. Aspects considered include the radioactive inventory contained in the installation, the potential for mobilization of (parts of) the inventory as well as level of containment in case of a fire.
- For waste storage facilities, the facility with the largest potential for exposure due to the magnitude of the inventory and the risk of spread of contamination in case of fire has been selected. Aspects considered are the stored inventory, whether the radioactive waste is combustible, if the radioactive waste is conditioned in a fire-resistant manner and whether the facility provides containment in case of a fire.

Below, the national selection of 'qualifying installations' for the TPR II review is listed, including indication of whether the installations are considered 'candidate' or 'represented' installations:

Installations under decommissioning

The Hot Cell Facility (candidate installation): The installation is under decommissioning. The ongoing activities include robotic cleaning of surfaces resulting in possible radionuclide contamination within the installation, and in contaminated blasting materials. The installation may provide some

level of containment of radioactive materials in case of a fire. The Hot Cell Facility is considered having a larger potential for dispersion of radioactive materials, and hence contamination of the environment in the case of a fire than other installations under decommissioning on the Risø site. The installation is not used for storage of radioactive waste. The installation is identified as a 'candidate installation'.

Danish Reactor 3 (DR3): The decommissioning of DR3 is at an advanced stage (Table 2). The remaining inventory is primarily associated with H-3 contaminated concrete. The containment functions of the building are still in operation. The risks of exposure and potential for spread of contamination are deemed very limited. The installation is not suited as 'candidate installation' and is hence identified as a 'represented installation'.

The Waste Management Plant: The decommissioning of the original main building of the plant (building 211) is at an early stage. The main radioactive inventory in the building stems from the former distillation facility for radioactively contaminated water. New distillation equipment has been moved to a different facility on-site, but the storage tanks for distillation sludge in building 211 are still in use. The waste management plant is considered as having a low source term for dispersion of radioactive materials to the environment in the case of a fire, and hence the plant is identified as a 'represented installation'.

Radioactive waste storage facilities

Drum Storage (candidate installation): The Drum Storage and the reception facility for radioactive waste generated from institutional uses are both placed in building 212. The storage area consists of concrete walls and floor in a "tub"-like construction covered with a metal roof. Radioactive waste of historical origin is stored in 210 L steel drums, mostly in unconditioned form. A comparative assessment of the consequences of incidents leading to release of radioactive materials (not necessarily caused by fire) in DR3, the Hot Cells Installation, the Low Level Waste Storage and the Drum Storage, respectively showed that releases from the Drum Storage holds a larger potential for exposures to the public and workers than releases from other storage facilities[1]. Some drums contain combustible bitumen and a some contain asphalt. The installation is expected to provide limited containment of radioactive materials in case of a fire. Also, the conduct of daily activities related to reception of radioactive waste in the building may impact the risk of or consequences of a fire. The facility is identified as 'candidate installation'.

Centralvej Storage: The facility consists of an underground concrete storage block with circular pits wide enough to accept 210 L waste drum sizes and smaller cylindrical steel containers, respectively, as well as larger square compartments for large waste items. The storage block is covered by a light metal structure. All pits and compartments in the storage block are sealed with concrete lids. The facility contains mainly metallic radioactive waste items with higher activity contents compared to the other waste storage installations. Radiological impact assessment of scenarios for atmospheric spread of small fractions of the inventory, consistent with the nature of the radioactive waste, demonstrate assessed exposures amounting to less than 10 % of that resulting from fires in the other storage facilities, i.e. the Drum Storage. Due to the concrete containment, the facility is considered less prone to damage by a fire than e.g. the drum storage. The storage is identified as a 'represented installation'.

Intermediate Storage: The facility consists of a concrete floor and a steel superstructure covered with corrugated metallic boards. The facility contains radioactive waste from the decommissioning of the installations at the Risø site and repackaged radioactive waste units (drums) from other storage

[1] P. H. Jensen, Memorandum: "Vurdering af behov for et helsefysisk beredskab for radiologiske uheld på Risøområdet" 2007, rev. 2016.

facilities. The radioactive waste is packed in ISO containers (299 cm x 244 cm x 130 cm – Material: 2 mm steel, bottom 5 mm), custom-made steel containers (DD-type 2) (212 cm x 147 cm x 139 cm - Material: 10 mm steel) and two so-called "Jumbo Containers" (313 cm x 313 cm x 213 cm - Material: 65 mm steel) for unique, odd-size and large metallic radioactive waste items with high surface dose rates. The main part of the inventory of radioactive waste is present in metallic and concrete matrices and as such less prone to mobilisation during a fire. The Intermediate Storage Facility is identified as a 'represented installation'.

Low Level Waste Storage: The facility stores low level radioactive waste in cement-lined and uncemented steel drums. The radioactive waste originates from both the operations at Risø site and from external users of radioactive materials. Some steel drums contain bitumen. The inventory of radioactive waste at the Low Level Waste Storage represents only a small fraction compared to the inventory present in the Drum Storage and activity concentrations are significantly lower. The storage is identified as a 'represented installation'.

1.1.3 Key parameters per installation

All installations at the Risø site are now either fully decommissioned, released from regulatory control, under decommissioning or in preparation for decommissioning. The four main storage facilities are still in operation and will be decommissioned at a later stage. Table 2 shows the status of each of the nuclear installations.

Nuclear installation/facility	**Type**	**Taken out of operation**	**Decommissioning status**
Danish Reactor 1 (DR1)	Small homogeneous 2 kW reactor mainly used for educational purposes	2001	Fully decommissioned. Released from regulatory control in 2006
Danish Reactor 2 (DR2)	5 MW research reactor of the open pool type	1975	Reactor is fully decommissioned. Reactor Containment Hall is used for handling of waste objects.
Danish Reactor 3 (DR3)	10 MW heavy water research reactor of the PLUTO type	2000	Biological shield is being removed. Following this the final decommissioning stages of the reactor hall can commence.
Hot Cell Facility	Installation for post irradiation investigations of nuclear fuel	1989	Initial remote cleaning of all 6 cells is complete, and each cell is ready for secondary robotic cleaning.
Fuel Fabrication Plant	Fuel Fabrication Plant for DR 2 and DR 3	2002	Fully decommissioned in 2022. Released from regulatory control in 2023
Waste Management Plant	Radioactive waste management facilities	2019	Decommissioning plan approved in 2019. Preparatory work and initial dismantling of building 211 has started.

Table 2. Nuclear installations and facilities at the Risø site.

Table 3 shows the main storage facilities at the Risø site and inventories of stored radioactive waste. The storage facilities all contain radioactive waste generated at the Risø site as well as radioactive waste generated from research, industrial and medical applications of radioactive materials in Denmark.

Storage facility	Mass (tons)	Activity (TBq)	Conditioning
Low Level Waste Storage	~1,100	6 LLW	3930 Double layer 210 L steel drums with a 5 cm concrete lining between steel layers and concrete plug under a steel lid. 196 Single layer steel drums. 23 drums with bitumen 849 280 L drums containing 210 L drums (repackaged)
Drum Storage	~29	* ILW	98 Double layer 210 L metal drums with a 5 cm concrete lining between metal layers and concrete plug under a metal lid. 1 drum with bitumen and 6 drums with asphalt
Centralvej Storage	~100	424* ILW	255 Single layer 210 L metal drums or smaller diameter stainless steel cylinders, all placed in underground pits. Large, single solid radioactive waste items are stored in individual packaging (concrete containers, plastic wrapping etc.) in larger square underground compartments.
Intermediate Storage	1,605	234 LLW	49 ISO containers 214 DD steel containers and 2 DD "jumbo" containers. Deteriorated drums from the Low Level Waste Storage repackaged in DD steel containers with loose carbonate / concrete backfill.

* The total inventory of the two facilities, Drum Storage and Centralvej Storage is reported. The largest activity fraction is stored at Centralvej Storage.

Table 3. The waste storage facilities at the Risø site, including inventories and information on conditioning. Radioactive waste classification (LLW or ILW) according to IAEA GSG-1.

A new upgraded storage facility

In 2018, the Danish Parliament adopted Parliamentary Resolution B90/2018 on a long-term solution for radioactive waste management in Denmark. B90/2018 stipulates the national policy for management and disposal of radioactive waste. This includes the establishment of a new upgraded storage facility, which is presently under planning and to be constructed at the Risø site. Radioactive waste which is currently managed by DD and which in future will be received by DD, will be transferred to the upgraded storage facility for storage. In 2073 at the latest, a disposal solution for all Danish radioactive waste must be available.

The new upgraded storage facility is still in the planning stages, and construction approval has not been granted. As such, the facility does not fall under the scope of the TPR II review.

1.1.4 Approach to development of the NAR for the national selection

The Danish TPR-II review reported in the NAR is compiled by the nuclear regulatory authorities (Danish Health Authority (DHA) and Danish Emergency Management Agency (DEMA)), with contributions

from DD as the responsible organisation for the nuclear installations on the Risø site. DD's contributions include descriptions of the installations and aspects of the fire safety protection concept and its implementation.

1.2 National regulatory framework

The legal and regulatory framework concerning fire safety of nuclear installations is a composite of provisions from four bodies of law covering nuclear installations, radiation protection, fire safety and emergency management. Legal requirements are specified in several legislative documents in each of the four areas. Note that regulatory authorities operate at national-level in matters concerning nuclear safety and radiation protection and primarily at municipality-level in matters concerning general fire safety.

Nuclear installations

According to the Nuclear Installations Act DHA and DEMA constitute the Nuclear Regulatory Authorities. The two authorities jointly carry out the regulatory functions regarding nuclear safety pursuant to The Nuclear Installations Act and its underlying Executive Order on Protective Measures against Accidents at Nuclear Facilities.

- Act no. 170 of 16 May 1962 on Nuclear Installations (The Nuclear Installations Act)[2]
- Executive Order no. 278 of 27 June 1963 on Protective Measures against Accidents at Nuclear Facilities[3]

Moreover, provisions regarding the task and mandate of the Nuclear Regulatory Authorities are specified in Circular no. 9450 of 9. July 2020 on the regulatory control exercised by the nuclear regulatory authorities regarding the nuclear safety of nuclear installations.

Radiation protection

The DHA carries out its duties in accordance with the Radiation Protection Act in addition to the duties performed in accordance with the Nuclear Installations Act. Provisions for fire safety in relation to radioactive materials, including radioactive waste are specified in the executive orders issued by the DHA, pursuant of Act no. 23 of 15 January 2018 on Ionising Radiation and Radiation Protection (the Radiation Protection Act):

- Act no. 23 of 15 January 2018 on Ionising Radiation and Radiation Protection (the Radiation Protection Act)[4]
- Executive Order no. 669 of 1 July 2019 on Ionising Radiation and Radiation Protection[5],
- Executive Order no. 670 of 1 July 2019 on Use of Radioactive Substances[6].

Building Regulation

Many issues relating to fire safety in buildings are regulated by The Building Act and its underlying Executive Order on Building Regulations 2018 (BR18). These regulations apply to construction of new buildings, additions and significant changes to existing buildings and demolition of buildings. The legal framework falls under the responsibility of the Danish Authority of Social Services and Housing.

[2] Nuclear Installations Act

[3] Executive Order no. 278

[4] Radiation Protection Act

[5] Executive Order no. 669

[6] Executive Order no. 670

- Act no. 1178 of 8 June 2021 (The Building Act)[7]
- Executive Order no. 1399 of 12 December 2019 on Building Regulations 2018 (BR18)[8]

A fundamental principle of the Danish Building Regulations is that it is not possible to regulate buildings retrospectively. This principle is in place to ensure the rights of the building owner not to be bound by binding, costly regulations after the building is established.

The nuclear installations at the Risø site is thus regulated by the building regulation requirements that existed at the time of the construction. New modifications to the installations will be bound by the current building regulations.

In general, the Building Regulations consists of all requirements for buildings including fire safety requirements, where the Emergency Management Act (see below) is an overall supplement to the Building Regulations providing more specific regulation of situations where there is a particular risk of fire hazard.

The Building Regulations does not contain specific requirements to installations that store dangerous substances, but it contains a procedure for ranking of buildings in risk and fire categories, which enables more strict requirements for some buildings that constitutes a higher risk in terms of fire safety.

With regards to the Building Regulations, a risk assessment must be conducted in order to asses which of the requirements in the Building Regulations are applicable. The installations at the Risø site have to comply with the requirements for fire safety in the Building Regulations.

The requirements in the Building Regulations does not contain any specific regulation or guidance regarding especially fire hazardous storage or use of dangerous substances, since this is regulated in the Emergency Management Act.

Emergency Management Act

The Emergency Management Act issued by the Ministry of Defence inter alia defines the purpose and competences of fire and rescue services in Denmark and hence contains elements of relevance to fire safety and nuclear installations. In addition, and pursuant to the act, DEMA has issued Executive Order No. 1762 on Security Measures for Nuclear Material and Nuclear Facilities and Drafting of Security Plans which to some extent can affect operations at the nuclear facilities at Risø.

- Consolidated Act. No. 314 of 3 April 2017 (The Emergency Management Act)[9]
- Executive Order No. 2341 of 09 December 2021 on Fire Inspection[10]
- Executive Order No. 1762 of 27 December 2016 on Security Measures for Nuclear Material and Nuclear Facilities and Drafting of Security Plans[11]

In regard to fire safety, The Emergency Management Act functions as an add-on to the requirements in the Building Regulations.

The Emergency Management Act, article 33, section 1 provides the legal basis for regulating the location, design and use of facilities that store, use or produce liquid or gaseous fire hazardous or explosive substances or other substances, which in relation to fire or other damage results in a risk of harm for persons, property or the environment and therefore constitutes a risk for the public safety. The term "other substances" is considered by DEMA to include radioactive and nuclear material. The specific regulation in the Emergency Management Act is thus relevant for the storage or use of radioactive and nuclear materials at the Risø site.

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[7] Building Act

[8] Building Regulation BR18

[9] Emergency Management Act

[10] Executive Order no. 2341

[11] Executive Order no. 1762

The Emergency Management Act article 34, section 2 provides the legal basis for the local municipality to issue specific requirements to the design and use of the facilities in order to minimize the risk of fire as much as possible and to secure the possibility of safe rescue and extinguishing efforts, where no other regulation exists. In a situation where special properties of the materials that are stored or used increase the fire hazard or complicate the rescue and extinguishing efforts, the local municipality can determine how to design and regulate the use of the facility in a specific manner in order to reduce the risk of fire and explosion.

Storage of radioactive and nuclear materials is thus not specifically regulated by The Emergency Management Act, but if deemed needed it provides a legal basis for regulating nuclear facilities according to article 34, section 2.

The Executive Order on Fire Inspection is issued pursuant to the Emergency Management Act. This provides a legal basis for the local municipality to conduct fire safety inspections of specific buildings, where many persons assemble or which constitutes a specific fire hazard.

1.2.1 National regulatory requirement and standards

Nuclear Installations Act:

The Nuclear Installations Act provides the overarching legal framework for maintaining nuclear safety. The Nuclear Regulatory Authorities have established Operational Limits and Conditions (OLC[12]) concerning the safety of operation and decommissioning of the nuclear installations and facilities at the Risø site. The OLC are issued in accordance with the provisions of the Nuclear Installations Act. The OLC are continuously updated to reflect the operation and decommissioning activities of the nuclear installations and facilities at the Risø site

The specific provisions to ensure nuclear safety in relation to fire, are detailed in the OLC for the activities of DD. The OLC includes specific chapters on emergency preparedness in general and fire protection in particular, including on-site emergency preparedness and requirements regarding fire prevention and response. The OLC further specifies, that fire inspections must be carried out at least every two years by fire safety expertise approved by the local emergency services. As part of the inspection, the current fire prevention level is reviewed and suggestions of improvement hereof (c.f. firefighting equipment and fire sectioning) are to be given. When making changes to installations (e.g. during decommissioning), which may have an effect on the fire safety, fire safety expertise must be consulted.

Radiation Protection Act and associated executive orders:

Executive Order no. 670 of 1 July 2019 on Use of Radioactive Substances specifies that all radioactive materials, including radioactive waste, shall be stored so as to be protected against theft and vandalism as well as fire, flooding and similar environmental impacts. Specifically, such materials may not be stored together with explosive, corrosive or highly flammable substances or other substances that might compromise safety during storage. In addition, the aforementioned executive order stipulates that an emergency response plan shall be established, which shall comprise an alerting plan and precautions in the event of fire, flooding, earthquake, power cut, etc. The emergency response plans shall be kept up to date.

Building Regulations

As noted the facilities at Risø were constructed from the 1960s and onwards. The original building permits can no longer be retrieved but it can be assumed that the buildings lived up to the building

[12] The OLC is available through the following link: https://www.sst.dk/-/media/Viden/Straaling/Radioaktivitet/BfDA-Danish-Decommissioning.ashx

regulations in force at the time of construction. Consequently, it is assumed that fire analyses were carried out according to existing regulations.

It follows from Building Regulations that significant building changes must comply with the current building regulations. This means that during major building changes, e.g. in connection with the transition to decommissioning, a new assessment of fire safety must be carried out according to current building regulations. The principle behind the requirements set forth in the building regulations is an assessment of building type and use which results in a number of requirements that the building must meet. It is the building owner's responsibility to meet the requirements, but it is the municipal authorities who ensure quality and assess whether the building owner meets the requirements before the conversion is carried out.

A new version of the building regulations (BR18) has been published in 2018, to which all significant building changes must now comply. The fire technical requirements in BR18 are decided on the basis of a principle of application category and risk class.

- The categories of use are determined on the basis of the people staying in the building and their ability to bring themselves to safety in the event of a fire.
- The risk classes are based on how complex it is for people to get themselves to safety, evacuate or rescue themselves from a building. The risk classes are also based on the fire load, where relevant, as a particularly large fire load can give rise to a very long fire duration.

The fire class results in the building having to meet a number of requirements. When additions to or conversions of an existing building are carried out, which are of a significant nature, the extension and/or the converted part of the existing building must be placed in fire classes according to the above principles. When classifying the extension or the modified part of the building in fire classes, account must therefore be taken of the complexity of the fire protection in the relevant part of the building as well as the complexity of the documentation method used. In addition, a decision must be made as to whether the addition or conversion has an impact on fire safety in the existing part of the building.

The Danish building regulations only cover conventional buildings and therefore do not directly take the radiological risk of nuclear facilities into account. However, the local fire authorities must assess whether there are additional fire scenarios that are not covered by the requirements in the building regulations, and if this is the case, these are dealt with individually and result in separate requirements.

The Emergency Management Act

Though legal basis for regulating the storage of radioactive materials exists in the Emergency Management Act article 33, DEMA has not issued any specific fire safety regulations or orders regarding the storage of radioactive materials or decommissioning of nuclear facilities at Risø.

The fire service in municipality in Roskilde is responsible for ensuring that the DD meets the fire safety regulations that are applicable to the facilities at Risø. This includes securing that conditions for conducting a safe fire and rescue operation is in place.

The local fire service performs a fire inspection of the Risø facilities once a year, which is a specific interval chosen based on the specific risk assessment conducted according to the Executive Order on Fire Safety Inspection issued by DEMA. During these inspections it is ensured that the use of the building complies with the fire safety requirements that are determined for the specific building in the building permit. Besides this, the use of buildings is inspected according to the requirements in the Building Regulation.

The local municipality has not used the legal basis in the Emergency Management Act to regulate the nuclear installations at the Risø site, and has thus not found it necessary in their assessment of the necessary fire protection strategy to issue specific requirements in order to ensure the public safety.

1.2.2 Implementation/application of international standards and guidance

The following standards are listed in OLC as guidelines for the planning, preparation and conduct of decommissioning activities as well as operational activities related management of radioactive waste:

- IAEA Specific Safety Guide No.SSG-47, Decommissioning of Nuclear Power Plants and Research Reactors and Other nuclear Fuel Cycle Facilities
- IAEA General Safety Guide No. GSG-3, Safety Case and Safety Assessment for the Predisposal Management of Radioactive Waste
- IAEA Safety Reports Series No. 45, Standard Format and Content for Safety Related Decommissioning Documents

The standards present aspects related to fire safety relevant for decommissioning, predisposal management and documentation of decommissioning activities, which Danish Decommissioning through the provisions of the OLC is obliged to take into consideration.

2. Fire safety analysis

The fire safety analysis provides a means of assessing the adequacy of defence in depth regarding fire safety (prevention, detection, control and mitigation of a fire). The term fire safety analysis covers both deterministic fire safety analyses such as a Fire Hazard Analysis (FHA) as well as probabilistic fire risk analysis (called Fire PSA). For waste storage facilities and installations during decommissioning, requirements for conducting fire safety analyses primarily refer to the conduct of an FHA. For the installations and facilities discussed below, a simplified approach for FHA is described, in line with the graded approach, considering the particular Danish national circumstances with relatively low amounts of radioactive waste and facilities in advanced stages of decommissioning.

Fire protection at the Risø site

Storage facilities and installations currently under decommissioning at the Risø site were originally designed and constructed in accordance with building codes and regulations in force at the time of construction, i.e. dating back to the mid-1950s. All subsequent modifications to building constructions or construction of new buildings have been established in line with building codes and fire protection provisions in force at the time of modification or construction. Throughout the operational lifetime of the facilities and installations, an on-site fire department was maintained. However, in the years 1998 – 2000, operational activities at the Risø site had significantly decreased, and a fire safety analysis was carried out with the purpose of investigating the possibility of disbanding the on-site fire department and instead relying on the nearby fire department in the municipality of Roskilde.

The fire safety analysis focused on the DR3, which at the time was considered the main potential source of radioactive releases in the case of a fire. The analysis identified areas/rooms where Systems, Structures and Components (SSC) necessary for safety could be affected by a fire or where a fire could directly lead to the release of radioactive material. Additional areas where SSC necessary for safety could be affected by a fire, but where the function of the SSC in question was ensured through additional auxiliary or back-up systems, were also identified. For each area, the inventory of flammable and combustible materials was assessed. On this basis, a set of recommendations regarding the building structure (primarily regarding fire sectioning and cable conduits), operational procedures (reduction of flammable and combustible materials) and detection systems and fire alarms (direct alerting of fire department) were developed as compensatory measures for the absence of an on- site fire department. In the analysis it was concluded that closing down the on-site fire department would result in an increased response time from 5 minutes to 10-15 minutes. The analysis further concluded that implementation of all recommended improvements would result in an overall increase in fire safety, primarily due to the increase in passive safety features; enhanced fire sectioning and automated detection and alarm systems. In consequence, it was decided to close the on-site fire department.

Based on the conclusions of the analysis, fire preventive and firefighting measures were enhanced by increasing the number of fire sections and through making firefighting equipment more readily available within each facility or installation. All sectioning was established in accordance with requirements in building codes and as specified by the fire department of the municipality of Roskilde. In addition, automated fire-detection and -warning systems with direct links to the fire department of the municipality of Roskilde were installed in all facilities and installations, apart from the Centralvej Storage and the Low Level Waste Storage, where risk of fire and amounts of flammable and combustible material was deemed low. In the Drum Storage, only one automated fire detector was installed based on the assessed amounts of flammable and combustible material balanced against the potential exposures to workers required to install and service a more comprehensive detection and alarm system.

Fire protection during decommissioning

Shortly after these activities, the Danish Parliament decided in 2003 that operations at the Risø site were to end, and that decommissioning of all facilities was to be initiated. The requirements for safety of "care and maintenance" operations and decommissioning at the Risø site, including fire safety, have been maintained through implementation of general fire safety provisions, requirements regarding radiation protection and specific provisions in the OLC, which since then has been continuously adapted to the activities on site. During 20 years of decommissioning, the radiological risks associated with fire have been continuously and significantly reduced through dismantling of facilities and packaging of radioactive waste representing sizeable fractions of the combined inventory to be considered as a source term in the event of a fire. Operational fire safety during decommissioning has been addressed through the general planning requirements specified in the OLC and referring to international standards. Radioactive waste of historical origin, for which the radioactive waste inventory, conditioning and waste package integrity may be less well documented, is primarily stored in facilities dedicated to that purpose. Radioactive waste from decommissioning activities is stored in other facilities constructed for that purpose. The fire hazard related to radioactive waste of historical origin is therefore mainly defined by the properties of the radioactive waste itself, packaging and the storage environment.

All structural changes to any nuclear installation and facility on the Risø Site have been subject to the Danish Building Regulations which specify the requirements of the Building Act, including fire safety. The OLC specifies, that all planned changes to installations which may have an effect on the fire safety (e.g. during decommissioning), must be reviewed by a certified fire safety expert. During the review, the certified fire safety expert reviews and assesses compliance with applicable specific requirements as well as general fire safety issues (see also sections 2.1.5).

I-2.1 Waste storage facilities

Drum Storage

I-2.1.1 Types and scope of the fire safety analyses

Fire safety objective

The fire safety objective for the drum storage facility is to assure the safety of persons within or in the immediate surroundings of the facility in case of a fire. From a radiological point of view, the added objective is to ensure that the contents of waste packages stored in the Drum Storage Facility is contained within individual waste packages to the best practicable level, and that protection against releases to the surrounding environment is optimized in the event of a fire.

The safety objective must be achieved through the collective contributions from the safety functions of the different components of the Drum Storage Facility.

The safety function for persons within or in the immediate surroundings of the Drum Storage Facility is the provision of early detection, alert and safe exit from the facility.

The main safety function for the confinement of the radioactive material within the Drum Storage Facility, relies on confinement within individual waste packages. Therefore, the arrangements for fire safety are focused on the prevention of radioactive releases from the stored waste containers rather than e.g. to protect structures, systems and components from fire effects. The protection against releases to the environment in the event of fire is to a large extent relying on early detection and rapid extinction of fire in order to limit the potential for releases into the surroundings.

The Drum Storage Facility is an integrated part of the waste reception building for the reception of external waste (building 212). The general activities, equipment and materials in building 212 and

adjoining attached buildings may contribute to the fire risk of the Drum Storage Facility and these activities contribute to the importance of early detection and rapid response.

Fire safety analyses

The requirements for fire safety at the Drum Storage reflect the outcomes of safety analyses related to the need to ensure human (i.e. "conventional") fire safety, and the effects of potential releases of radioactive material (radiological safety).

Conventional fire safety

The storage facilities and installations currently under decommissioning at the Risø site were originally designed and constructed in accordance with building codes and regulations in force at the time of construction in the late 1950s. All subsequent structural changes to nuclear installations and facilities on the Risø Site have been subject to the Danish Building Regulations which specify the requirements of the Building Act, including fire safety (see chapter 1 and section 2.0 above).

The main changes carried out at the Drum Storage over the last two decades have been subject to the provisions of Building Regulations 2010 (BR10) and Building Regulations 2018 (BR18), focusing on the assurance of human safety. The analyses supporting these regulations have centered on ensuring fire detection, fire alert and evacuation, supported by passive means for mitigating fire spread.

Radiological fire safety

In the comparative assessment of the consequences of incidents from 2016 mentioned in section 1.1.2, the radiological effects of potential releases of radioactive materials from different facilities at the Risø site were assessed. For the Drum Storage, the scenario presented a scalable assessment of the effects of the release of radioactive materials from the storage in the event of an explosion followed by a fire. The assessment showed that an event causing damage to the integrity of waste units and to the release of radioactive material to the surroundings, either through damaged structures of the building, or due to firefighting activities, might necessitate on-site as well as off-site mitigating measures to be carried out. Realistic scenarios lead to assessed exposures that may exceed dose limits for members of the public, but which are below limits for occupational exposures.

As the Drum Storage has a "tub-like" construction, there will be no imminent need to control the flow of the extinguishing media (water) to limit the spread of contamination, although subsequent management steps will need to address management and treatment of extinguishing water. Consequently, the main potential source of contamination is from airborne spread of evaporated or particulate-carried radionuclides released from damaged waste units.

Interfaces between conventional and radiological fire safety

Some aspects of conventional safety may impact on features relevant for radiological fire safety and reversely. For instance, the need to ventilate smoke and ensure means of escape may conflict with priorities to limit releases of radioactive materials to the surroundings. As the potential range of assessed radiological consequences from a fire in the Drum Storage point to significantly smaller consequences than the potential life-threatening scenario for a person within or in the immediate surroundings of the facility in case of a fire, the conduct of life-saving actions, as deemed necessary by emergency response units, is given priority.

I-2.1.2 Key assumptions and methodologies

Conventional fire safety

The Drum Storage has been in operation since the late 1950´s. The main changes carried out at the Drum Storage over the last two decades have been subject to the provisions of BR10 and BR18, focusing on the assurance of human safety. The analyses supporting these regulations have centered on ensuring fire detection, fire alert and evacuation, supported by passive means for mitigating fire spread. The facility is not considered covered by pre-accepted fire safety solutions specified in the

BR, but is subject to general provisions for fire safety, including fire sectioning corresponding to the general use of the building, maximum allowable fire loads, ignition sources, combustible materials etc., all derived on the basis of generic fire safety analyses.

Radiological fire safety

The radiological modelling assumes an explosion as the initiating event, followed by a fire. The explosion causes damage to the integrity of waste units and the ensuing fire causes release of radioactive material to the surrounding environment. No specific assumptions regarding safety functions or particular SSCs to be protected against fire have been made, as the fire safety objective for the Drum Storage specifically relies mainly on maintaining waste package integrity. The assessment does not explicitly consider the impact of the permanent or transient presence of combustible material since the inventory of such materials is significantly smaller than the inventory of stored radioactive waste.

I-2.1.3 Fire phenomena analyses: overview of models, data and consequences

No specific model for fire phenomena for the Drum Storage has been applied.

The analytical basis for the standard requirements in the BR assumes predefined sets of bounding parameters regarding fire loads, development of smoke, robustness of fire compartments, access routes for escape, etc., corresponding to various types of buildings, their intended uses and likely scenarios for onset and development of fires. See also section 2.1.1.

Radiological modelling assumes an explosive initiation and allows for the development of fire, either as a result of addition of fire propellants or due to the properties of the contents of waste units. No specific modelling of fire development, fire spread or timing of events leading to releases have been carried out.

I-2.1.4 Main results / dominant events (licensee´s experience)

Spontaneous initiation of a fire within the Drum Storage is considered unlikely and spread of fire from other parts of the building into the storage area likewise – mainly due to the layout of the building, regulatory restrictions on use of various parts of the buildings (c.f. OLC) and the limited inventory of combustible material. As such, requirements for conventional fire safety and the assessed very low fire hazard for the Drum Storage dictates an external event as the most likely initiating event.

I-2.1.5 Periodic review and management of changes

The use of the Drum Storage has remained unchanged for decades, and involves only very limited activities related to the storage area. Changes to the surrounding building parts are subject to regulatory provisions for assessment of fire safety (c.f. OLC). So far, the scope of changes has had limited effect on fire safety, and actual re-assessment of the adequacy of fire safety analyses has not been deemed necessary, primarily due to provisions for maintaining operational fire safety.

At the operational level, a fire protection inspection is carried out every year of all DD's facilities by external independent certified experts (RMG) who are accredited (DS/EN ISO/IEC 17020:2005). The purpose of the inspection is to provide a description and condition assessment of the fire technical conditions at the time of the inspection, as well as to increase the focus on fire safety.

Prior to the inspection, the fire-technical documentation is reviewed and during the fire protection inspection itself, the fire-technical conditions at the facility are reviewed, including:

- Order and tidiness
- Signage
- Electrical installations
- Organization for fire safety and emergency plans
- Fire sectioning in relation to the use of the building

- Accumulation of materials that increase the fire load beyond what the facility is approved for.
- Assessment for gas, flammable liquids and other high-risk elements.
- Ignition sources are assessed in the same way as fire load. But it is assessed whether the source meets a standard, e.g. CE marking (right down to coffee machines).
- The location of the ignition source in relation to combustible surfaces.
- Review and guidance on hand-held extinguishing equipment, types and location (follows a standard)
- Assessment of whether the automatic fire alarm system covers the entire building
- Comes with fire safety recommendations in addition to applicable legal requirements

The nuclear regulatory authorities are invited to participate in an inspection every second year, where the local fire authority also participates, with the report from the inspection subsequently forwarded to the nuclear supervisory authorities for their information.

The automatic fire alarm system (ABA) at all DD's facilities is checked and tested twice a year by an external certified company. DD carries out a monthly self-inspection of the ABA system in all of DD's buildings.

DD carries out an additional 1 to 2 annual internal reviews of the facility with a focus on conventional safety, including fire safety and fire load.

An annual external inspection of all manual fire-extinguishing equipment is carried out.

I-2.1.5.1 Overview of actions

DD has not reported any actions, due to the fact that there have been no structural changes.

I-2.1.5.2 Implementation status of modifications/changes

DD has not reported any status of modifications/changes.

I-2.1.6 Licensee's experience of fire safety analyses

The strength of using experienced external experts is that it ensures an objective assessment and a high standard of fire safety.

It can be considered a weakness that DD itself does not have competences in fire safety, but as DD is a relatively small organisation, it will be very difficult to maintain internal accredited and experienced competences. Therefore, DD has chosen to outsource this task.

I-2.1.6.1 Overview of strengths and weaknesses identified

DD has not reported on strengths and weaknesses identified, as there have been no structural changes or other reasons for identifying such.

I-2.1.6.2 Lessons learned from events, reviews, fire safety related missions, etc.

DD has not reported on lessons learned from events, reviews, fire safety related missions, etc.

I-2.1.7 Regulator's assessment and conclusions on fire safety analyses

General for all represented Danish nuclear installations:

The original fire safety analyses for these 60-year-old buildings is no longer available, but following the decision in 2003 to cease operations at the Risø site, the general approach has been to refer to analytical basis supporting the general building code, valid at any given point in time. Additional regulatory requirements have been imposed when deemed necessary from a nuclear safety or radiation protection perspective.

During the design process for newer buildings and building modifications, the nuclear regulatory authorities have been consulted for further requirements within their respective areas of responsibility.

The range of assessed radiological consequences from a fire in the Drum Storage point to significantly smaller health risks than the potential life-threatening scenario for a person within or in the immediate surroundings of the facility in case of a fire. Therefore, provisions for conventional fire safety, i.e. life-saving provisions and actions are given priority, while potential additional provisions for nuclear safety are added for particular circumstances on a case-by-case basis.

I-2.1.7.1 Overview of strengths and weaknesses identified by the regulator

General for all represented Danish nuclear installations:

A strength of this approach has been that all general procedures are identical to those used for all other (dangerous activities) buildings in the country, and deviations become distinct. Practical experience has proven the approach fit for purpose, considering a graded approach in a setting where the radiological risks are continuously being reduced. A potential weakness may rest with the fact that fire safety at nuclear facilities is regulated according to several legislative instruments and is subject to regulatory oversight by several regulatory authorities. This necessitates coordination across ministerial areas and at different hierarchical administrative levels and thus introduces risks of omissions or inaccuracies in the identification of applicable regulatory requirements and of inconsistencies in enforcement actions. In practice, only minor issues relating to these risks have been identified. These findings also apply to experiences gained in relation to the Drum Storage.

I-2.1.7.2 Lessons learned from inspection and assessment as part of the regulatory oversight

General for all represented Danish nuclear installations:

The biannual fire safety inspections the local fire authorities and with the presence of the nuclear regulatory authorities provides for a dedicated walk down of all rooms of buildings at each nuclear facility or installation. This has, in a few cases, led to identification of (generally minor) non-compliances with fire safety provisions in the OLC and fire safety requirements specified in Danish BR.

Particular for the Drum Storage

The Drum Storage is located in a building, where other rooms are used for changing purposes. In some instances, rooms have been found in use for other purposes than specified in OLC or by the nuclear regulatory authorities. In general however, specified conditions are complied with.

I-2.1.7.3 Conclusions drawn on the adequacy of the licensee's fire safety analyses

No conclusions regarding the fire safety analyses in the far past can be drawn. The approach used in recent years, where the nuclear regulatory authorities are consulted throughout the process, as they have been for the numerous changes implemented at this installation is generally considered sound.

II-2.1 Facilities under decommissioning

Hot Cells

II-2.1.1 Types and scope of the fire safety analyses

Fire safety objective

The fire safety objective for the Hot Cell Facility is to assure the safety of persons within or in the immediate surroundings of the facility in case of a fire. From a radiological point of view, the added objective is to ensure that the extent of potential releases is minimized in the event of a fire.

The safety objective must be achieved through the added effect of safety functions of the different components and operational fires safety procedures of the Hot Cells facility.

The safety function for persons within or in the immediate surroundings of the Hot Cell Facility is the provision of early detection, alert and safe exit from the facility.

The main safety function from the facility for the minimization of potential releases, relies on operational planning and development of procedures adapted to the particular operational state, including relevant dismantling activities of the Hot Cells Facility at any given point in time. The arrangements for fire safety focus on the operational aspects of ensuring that the presence of flammable and combustible materials as well as ignition and oxidisation sources are kept at the lowest practicable level. The protection against releases to the environment is based on the principle of defence in depth (prevention, detection, control and mitigation of a fire)

Fire safety analyses

The requirements for fire safety at the Hot Cells facility reflect the outcomes of safety analyses related to the need to ensure human (i.e. "conventional") fire safety, and the effects of potential releases of radioactive material (radiological safety).

Conventional fire safety

The storage facilities and installations currently under decommissioning at the Risø site were originally designed and constructed in accordance with building codes and regulations in force at the time of construction in the late 1950s. All subsequent structural changes to nuclear installations and facilities on the Risø Site have been subject to the Danish Building Regulations which specify the requirements of the Building Act, including fire safety (see chapter 1 and section 2.0 above).

The Hot Cell facility has been exposed to a number of structural modifications e.g. in connection with the transition from operations to post-closure activities and again when dismantling activities were initiated. The specific building regulations applying at the time of the most recent changes to the Hot Cell facility are the BR10 (the building regulations in force in 2010). As for the Drum Storage, the analyses supporting these regulations have centered on ensuring fire detection, fire alert and evacuation, supported by passive means for mitigating fire spread.

Radiological fire safety

In the comparative assessment of the consequences of incidents rom 2016 mentioned in section 1.1.2, the radiological effects of potential releases of radioactive materials from different facilities at the Risø site were assessed. For the Hot Cell facility, the effects of a potential release of radioactive materials during decommissioning of the Hot Cell facility were assessed. The assessment showed that an event leading to the release of radioactive material to the surroundings, either through failure of the confinement/ventilation system, or due to firefighting activities, could potentially necessitate on-site mitigating measures, whereas off-site mitigation will likely not exceed reference levels for such activities to be initiated. The scenario leads to assessed exposures that do not exceed dose limits for members of the public, nor limits for occupational exposures. Since the time of the study, decontamination activities have reduced contamination levels of individual hot cells with up to 85%. Exposures resulting from a fire today would be reduced proportionally.

Interfaces between conventional and radiological fire safety

Some aspects of conventional safety may impact on features relevant for radiological fire safety and reversely. For instance, the need to ventilate smoke and ensure means of escape may conflict with priorities to limit releases of radioactive materials to the surroundings. As the potential range of assessed radiological consequences from a fire in the Hot Cell facility point to significantly smaller consequences than the potential life-threatening scenario for a person within or in the immediate surroundings of the facility in case of a fire, the conduct of life-saving actions, as deemed necessary by emergency response units, is given priority.

II-2.1.2 Key assumptions and methodologies

Conventional fire safety

The Hot Cell facility was taken out of operation around 1990 and after initial dismantling activities, the facility was left encased with gypsum board walls. Therefore, the conclusions of the fire-technical analysis carried out in 1998-2000 were only applied once dismantling activities at the facility resumed in the late year 2000´s to early 2010´s.

When the Hot Cell facility was prepared for decommissioning in 2010, the conversion had to meet the requirements in force at the time, i.e. be in accordance with the national building regulations 2010 (BR10). The facility was deemed in accordance with pre-accepted fire safety solutions specified in the BR, in which predefined sets of bounding parameters regarding fire loads, development of smoke, robustness of fire sections, access routes for escape, etc., corresponds to various types of buildings, their intended uses and likely scenarios for onset and development of fires. The Hot Cell facility falls within "Category of use" 1, which includes building sections for day stays, where people who normally stay in the building section are all familiar with the building section's escape routes and are able to get to safety with their own help.

Radiological fire safety

The radiological modelling does not invoke a particular initiating event, but assumes that parts of the inventory of the most contaminated cell are mobilised (e.g. in a fire) and that failure of the ventilation system leads to release into the surrounding environment. As such, the containment function of the ventilation system is compromised. No assessment of the impact of permanent or transient presence of combustible material has been made.

II-2.1.3 Fire phenomena analyses: overview of models, data and consequences

The analytical basis for the standard requirements in the BR assumes predefined sets of bounding parameters regarding fire loads, development of smoke, robustness of fire sections, access routes for escape, etc., corresponding to various types of buildings, their intended uses and likely scenarios for onset and development of fires. See also section 2.1.1.

Radiological modelling sets as a pre-condition, the failure of the containment properties of the facility. No initiating event for this is specified, but the situation may arise either as a result from general technical breakdown, the impact of the fire itself or as a result from fire suppression activities, subject to decision by emergency response units.

II-2.1.4 Main results / dominant events (licensee´s experience)

It is DD's experience that the approach to fire safety is comprehensive and applies a graded approach and that it is therefore not necessary to further specify or re-assess fire technical analyses. The approach can also be considered a very conservative approach, as the national requirements cover many more conceivable incidents and experiences. The approach therefore covers a wider range than what a specific analysis for the individual plants will arrive at and more specific requirements are covered under the local requirements.

II-2.1.5 Periodic review and management of changes

No periodic review of the fire safety analyses with respect to type, scope, assumptions, methodologies etc. are carried out.

A fire protection inspection is carried out every year of all DD's facilities by external independent certified experts (RMG) who are accredited (DS/EN ISO/IEC 17020:2005). The purpose of the inspection is to provide a description and condition assessment of the fire technical conditions at the time of the inspection, as well as to increase the focus on fire safety.

Prior to the inspection, the fire-technical documentation is reviewed and during the fire protection inspection itself, the fire-technical conditions at the facility are reviewed, including:

- Order and tidiness
- Signage
- Electrical installations
- Organization for fire safety and emergency plans
- Fire sectioning in relation to the use of the building
- Accumulation of materials that increase the fire load beyond what the facility is approved for.
- Assessment for gas, flammable liquids and other high-risk elements.
- Ignition sources are assessed in the same way as fire load. But it is assessed whether the source meets a standard, e.g. CE marking (right down to coffee machines).
- The location of the ignition source in relation to combustible surfaces.
- Review and guidance on hand-held extinguishing equipment, types and location (follows a standard)
- Assessment of whether the automatic fire alarm system covers the entire building
- Comes with fire safety recommendations in addition to applicable legal requirements

The nuclear regulatory authorities are invited to participate in an inspection every second year, where the local fire authority also participates, with the report from the inspection subsequently forwarded to the nuclear regulatory authorities for their information.

The automatic fire alarm system (ABA) at all DD's facilities is checked and tested twice a year by an external certified company. DD carries out a monthly self-inspection of the ABA system in all of DD's buildings.

DD carries out an additional 1 to 2 annual internal reviews of the facility with a focus on conventional safety, including fire safety and fire load.

An annual external inspection of all manual fire-extinguishing equipment is carried out.

II-2.1.5.1 Overview of actions

No particular actions regarding approaches to the safety analyses have been identified.

II-2.1.5.2 Implementation status of modifications/changes

New assessments are regularly made by external advisers when changes are made that may have consequences for fire safety. DD sends these changes to the nuclear regulatory authorities for approval or information, depending on the scope. It is further DD's responsibility to document these changes and seek other relevant approvals.

II-2.1.6 Licensee’s experience of fire safety analyses

The strength of using experienced external experts is that it ensures an objective assessment and a high standard of fire safety.

It can be considered a weakness that DD itself does not have competences in fire safety, but as DD is a relatively small organisation, it will be very difficult to maintain internal accredited and experienced competences. Therefore, DD has chosen to outsource this task.

II-2.1.6.1 Overview of strengths and weaknesses identified

The strength of using seasoned external experts is that it ensures an objective assessment and a high standard of fire safety.

It can be considered a weakness that DD itself does not have competences in fire safety, but as DD is a relatively small organisation, it will be very difficult to maintain internal accredited and experienced competences. Therefore, DD has chosen to outsource this task.

II-2.1.6.2 Lessons learned from events, reviews, fire safety related missions, etc.

DD has good experience of using external experts to carry out the necessary fire technical assessments, analyses and inspections. It happens that after the annual fire technical review it is necessary to make minor adjustments, such as installing an extra fire detector. This shows that an annual review with an impartial fire expert is relevant and when it is only a question of minor things, the frequency is also appropriate.

It is also DD's assessment that it works well to follow the national standard for fire safety, supplemented by local requirements, since compared to a graded approach, the radiological consequences of a fire in DD's facility are relatively low.

II-2.1.7 Regulator's assessment and conclusions on fire safety analyses

General for all represented Danish nuclear installations:

The original fire safety analyses for these 60-year-old buildings is no longer available, but following the decision in 2003 to cease operations at the Risø site, the general approach has been to refer to analytical basis supporting the general building code, valid at any given point in time. Additional regulatory requirements have been imposed when deemed necessary from a nuclear safety or radiation protection perspective.

During the design process for newer buildings and building modifications, the nuclear regulatory authorities have been consulted for further requirements within their respective areas of responsibility.

The range of assessed radiological consequences from a fire in the Drum Storage point to significantly smaller health risks than the potential life-threatening scenario for a person within or in the immediate surroundings of the facility in case of a fire. Therefore, provisions for conventional fire safety, i.e. life-saving provisions and actions are given priority, while potential additional provisions for nuclear safety are added for particular circumstances on a case-by-case basis.

II-2.1.7.1 Overview of strengths and weaknesses identified by the regulator

General for all represented Danish nuclear installations:

A strength of this approach has been that all general procedures are identical to those used for all other (dangerous activities) buildings in the country, and deviations become distinct. Practical experience has proven the approach fit for purpose, considering a graded approach in a setting where the radiological risks are continuously being reduced. A potential weakness may rest with the fact that fire safety at nuclear facilities is regulated according to several legislative instruments and is subject to regulatory oversight by several regulatory authorities. This necessitates coordination across ministerial areas and at different hierarchical administrative levels and thus introduces risks of omissions or inaccuracies in the identification of applicable regulatory requirements and of inconsistencies in enforcement actions. In practice, only minor issues relating to these risks have been identified. These findings also apply to experiences gained in relation to the Drum Storage.

II-2.1.7.2 Lessons learned from inspection and assessment as part of the regulatory oversight

General for all represented Danish nuclear installations:

The biannual fire safety inspections the local fire authorities and with the presence of the nuclear regulatory authorities provides for a dedicated walk down of all rooms of buildings at each nuclear facility or installation. This has, in a few cases, led to identification of (generally minor) non-compliances with fire safety provisions in the OLC and fire safety requirements specified in Danish BR.

Particular for the Hot Cells facility:

Due to the decommissioning process, several modifications of installations inside this building have been implemented. These have been approved by the nuclear regulatory authorities before their implementation. The changes are in accordance with the Building Code in force at the time of the modification and with other appropriate standards. The implications on fire safety have been evaluated by the nuclear regulatory authorities, resulting in minor changes, or acceptance of deviations from standard requirements, when these were not deemed significant from a safety point of view.

II-2.1.7.3 Conclusions drawn on the adequacy of the licensee's fire safety analyses

No conclusions regarding the fire safety analyses in the far past can be drawn. The approach used in recent years, where the nuclear regulatory authorities are consulted throughout the process, as they have been for the numerous changes implemented at this installation is generally considered sound.

3. Fire protection concept and its implementation

The following is a review and analysis of the elements in the fire protection concepts applied to selected installations covering the three levels of defence in depth with regard to fire safety; Fire prevention, Active fire protection, Passive fire protection

3.1 Fire prevention

Drum Storage

I-3.1.1 Design considerations and prevention means

The building was constructed around 1960 according to the then applicable fire strategy. There have been no changes to the building since the time of construction.

The Drum Storage is located inside building (212) that is also used for receiving and handling external waste as shown in the section below:

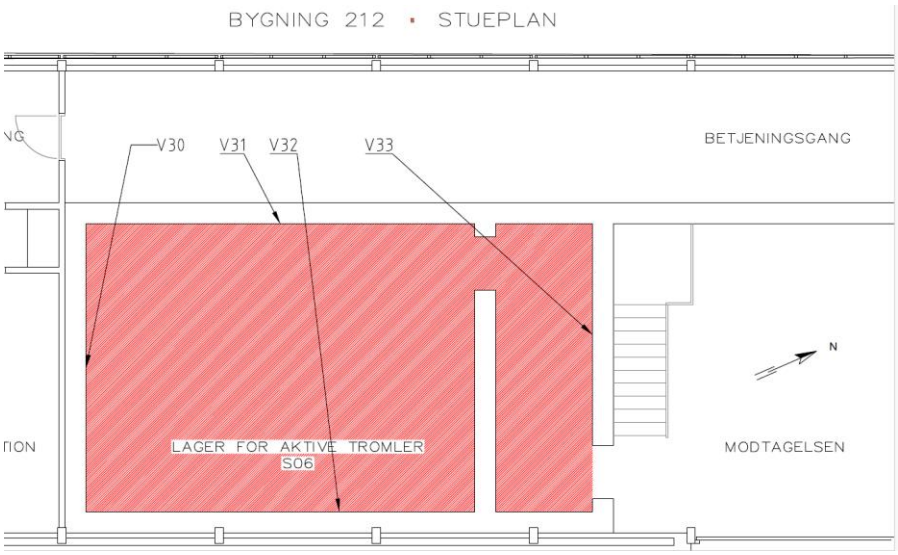


Figure 2. Section of building 212 containing the Drum Storage (red shaded area)

The Drum storage itself is built of 44 cm thick concrete walls, which have a height of approx. 3.5 m high and is finished at the top with windows with fixed frames. The ceiling is made of concrete and consists of a 5 cm concrete layer and 12 cm of lightweight concrete layer. The floor is made of concrete. There are no doors in the Drum Storage, but a 1 m wide opening into an antechamber (right part of the red shading in the drawing), through which the drums can be moved into the storage. This antechamber acts as a labyrinth to avoid direct radiation from the drums inside the Storage.

Due to their thickness, the Drum Storage's walls are to be regarded as fire walls, but as there is an opening in one wall, it is not a separate fire compartment.

In the room with the opening into the Storage itself, Reception, there is a gate that can be opened to the outdoors and a door to the adjacent room, which, among other things, contains a glove box in which waste is pressed into barrels. In Reception, waste from external customers is accepted and

here this waste must be stored for a short time (up to 4 days) until it is moved to another storage facility.

Other rooms in building 212 are used for radioactive waste management purposes, including sorting and compaction of received radioactive waste.

I-3.1.2 Overview of arrangements for management and control of fire load and ignition sources

A complete list of measures and periodic checks can be found in sections 2.1.5.

For all activities at the Drum Storage Facility, the focus is on minimizing the fire load, e.g. through continuous cleaning, not storing waste at the facility and not using flammable transport units (e.g. wooden pallets).

Waste items received from external customers can only be stored for a few days and is to be moved before the end of each week.

A statutory workplace assessment (APV) is always made (national legal requirement) for the work tasks at the facility, which assesses conventional safety, including fire safety.

Written work instructions are made for receiving of waste from external customers and for specific tasks carried out at the facility, in which it is assessed whether further measures should be taken to increase fire safety.

Periodic inspections regarding functionality and fire safety are carried out on equipment at the facility.

In order to prevent a fire from starting at the facility, the following measures are implemented:

- All electrical installations at the plant are carried out by authorized electricians
- All electric equipment must be CE marked
- Charging batteries is done outdoors or in a ventilated area.
- It is ensured that no easily flammable construction materials are used
- Materials/waste that can unnecessarily increase the fire are not stored within the facility

The room immediately to the east of the Drum Storage, to which there is an exit from the Drum Storage, is used for receiving waste from external customers, but only solid waste and non-flammable liquids. The flammable liquids that DD receives as waste are placed in an ATEX-approved container that is not connected to building 212.

No gas-evolving or flammable materials are stored or worked on in the building, and the fire load is kept to a minimum.

A hydraulic station which supplies pressure to the hydraulic press is placed in the passage behind the Drum Storage.

Since the waste stored in the Drum Storage primarily consist of metal parts contained in concrete-lined steel drums, the fire load inside the Drum Storage is deemed low. The only source of ignition inside the Drum Storage is the remote-controlled crane (figure 2). During operation the crane is followed from outside mirrors. Since the crane is rarely in use there are effectively no sources of ignition inside the storage room.

The fire conditions in the building are reviewed regularly - see appendix 2 (Fire safety inspection) and appendix 4 (ABA inspection) and comply with BR18.

A fire protection inspection is carried out every two years of all DD's facilities by external impartial experts (certified by the national accreditation body in Denmark, DANAK) in which the nuclear regulatory authorities participate. Subsequently, the inspection report is forwarded to the nuclear regulatory authorities for information.

I-3.1.3 Licensee's experience of the implementation of the fire prevention

I-3.1.3.1 Overview of strengths and weaknesses

Due to the level of radiation the Drum Storage itself is constructed in a way that it is difficult to access. This means that the current conditions are fire-technically stable. New drums are only rarely added to the storage, as the facilities producing the type of waste the storage was designed for is no longer in use. The stored drums will not be removed until decommissioning of the storage. Till then, the fire load inside the storage will not change.

The disadvantage is that, should a fire still occur, the area is very difficult to access for extinguishing due to the construction. The drum Storage has been in operation for over 60 years, and there have been no cases of fire.

Against this background, fire prevention in and around the Drum Storage is considered to be sufficient.

I-3.1.3.2 Lessons learned from events, reviews fire safety related missions, etc.

In the 60 years that the Drum Storage has been in operation, there have been no fire-related incidents, neither in the Drum Storage itself nor in the remaining part of building 212, nor have there been any false alarms.

The annual fire inspections have also not resulted in any measures, either in the form of orders or suggestions for improvement.

In 2019, the back passage to the west of the Drum Storage (shown in figure 2) was emptied of various materials that could potentially pose a fire risk.

Apart from annual fire inspections, no reviews focused on fire safety have been carried out.

Experience from events show that fire safety is predominantly underpinned by adherence to operational procedures and work instructions.

I-3.1.3.3 Overview of actions and implementation status

Actions in response to annual fire inspections are continuously implemented. Most actions relate to reduction of fire loads and possible ignition sources.

I -3.1.4 Regulator's assessment of the fire prevention

Fire preventive measures in the Drum Storage rely in part on the structural and layout features of the building itself, and partly on the adherence to operational procedures specified in the OLC, including provisions for detailed instructions for work activities and periodic inspections by technical staff. The observations below relate to assessments from the nuclear regulatory authorities, as findings from certified fire safety inspections are addressed elsewhere in this report.

I-3.1.4.1 Overview of strengths and weaknesses in the fire prevention

Structural and layout features:

The building consists of concrete floors, concrete and brick wall and a concrete roof. As such, fire load of the building itself is low. Rooms are not everywhere separated by doors, in particular the storage area does not have a door. However, the spatial arrangement of the storage area relative to the surrounding rooms in the building in combination with the limited fire load contribute to reducing the risk of a fire starting or spreading to the storage area. There are a limited number of potential ignition sources which contribute to the level of passive safety, and limit the potential for onset of a fire. The main structural and layout features are generally considered to contribute positively to fire prevention.

Operational features:

The storage area is not accessed by staff, and waste units are not routinely added or removed from the storage area. Activities carried out in other parts of the building may in particular circumstances add to the risk of fire, and fire prevention in these cases rely on the adherence to operational procedures.

I-3.1.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

Inspection activities focus on operational means for preventing fires, as the structural features of the buildings leave few things to be inspected. For operational safety, keeping ignition sources and fire loads at the lowest practicable level has proven a theme of reoccurring importance, particularly in periods of time where work activities in the building are low. Strict compliance with provisions specified in OLC as well as work instructions and manuals for inspection of facilities outside working hours is crucial is this regard.

Fire prevention could be strengthened through a higher degree of segmentation between parts of the building where different activities are carried out, or through stricter limitations on the types of activities allowed within the building.

Hot Cells

II-3.1.1 Design considerations and prevention means

The Hot Cell facility is an integrated part of building 227 which formerly housed DTU offices and laboratories (figure 3). In 2022 all DTU activities were relocated and presently the only activities in the building relate to DD and the decommissioning of the Hot Cell facility.

Figure 3. Schematic overview of building 227 containing the Hot Cell facility showing ground level and 1. Floor respectively. The Hot Cell facility placement in the building is shown in red.

The original Hot Cell facility consists of 6 interconnected concrete block cells. The walls were constructed of 1.7 m reinforced concrete. The block of Hot Cells is located along the central axis of the building and constitutes a massive concrete structure, with limited access routes. The surrounding building is constructed from concrete and brick. The majority of room separations are made from gypsum board walls. No flammable items remain within individual Hot Cells nor in the now vacated rooms of the surrounding building. Office spaces used for current decommissioning activities (planning and supervision) are separated from the row of Hot Cells by gypsum board walls. No ignition sources have been identified within the row of Hot Cells. In the work areas surrounding the row of Hot Cells, equipment as well as fixed installations that may act as ignition sources are present. The following is an assessment of potential sources of ignition in the areas surrounding the row of Hot Cells.

- Construction switchboards
- Electric Truck
- Control panel for ventilation systems
- Health physical equipment (iCAM) with associated laptops
- Various lamps with battery for emergency lighting
- Cart with battery for retrieving equipment from the cells
- Cart with battery + robot for cleaning cells
- Control panel for cyclone vacuum cleaners

- Video surveillance with associated computers

The following is an assessment of fire-prone materials at the facility itself:

- Work clothes
- Covering plastic
- Waste racks
- Ventilation filter boxes in operation
- New ventilation filters

II-3.1.2 Overview of arrangements for management and control of fire load and ignition sources

A complete list of measures and periodic checks can be found in sections 2.1.5.

For all activities at the facility, the focus is on minimizing the fire load, e.g. through continuous cleaning, not storing waste at the facility and not using flammable transport units (e.g. wooden pallets). A statutory workplace assessment (APV) is always made (national legal requirement) for each work task at the plant, which assesses conventional safety, including fire safety. Work plans are drawn up (local requirement) for specific tasks carried out at the facility, in which it is assessed whether further measures should be taken to increase fire safety (for example, when welding or flame cutting).

Periodic inspections regarding functionality and fire safety are carried out on equipment at the facility.

In order to prevent a fire from starting at the facility, the following measures are implemented:

- All electrical installations at the plant are carried out by authorized electricians
- All electric equipment must be CE marked
- Chemical liquids are stored in a chemical cabinet designed for that purpose
- Gas for e.g. health physics monitors is stored outside the building
- Charging batteries is done outdoors or in a ventilated area.
- Hot work (welding, flame cutting) must not be used without a specific assessment
- It is ensured that no easily flammable construction materials are used
- Materials/waste that can unnecessarily increase the fire are not stored within the facility

II-3.1.3 Licensee’s experience of the implementation of the fire prevention

II-3.1.3.1 Overview of strengths and weaknesses

It is a strength that the fire technical reviews described above are carried out by impartial parties with extensive experience and knowledge of fire safety. It can be a disadvantage that DD itself does not have the skills to carry out the fire technical assessments. However, this disadvantage is of a minor nature, as there are rarely comments and corrections during the fire technical reviews described above. It is therefore DD's assessment that the current scope of control and focus on not increasing the fire load on the facility is working well.

II-3.1.3.2 Lessons learned from events, reviews fire safety related missions, etc.

DD has not had any fire-related incidents at the Hot Cell facility, but there have been several false alarms due to e.g. dusty work.

II-3.1.3.3 Overview of actions and implementation status

There are no outstanding items from the fire technical reviews that have not yet been implemented.

Comments about fire safety following fire technical reviews, most often relates to a lesser extent flammable material which is unnecessarily stored at the facility. It is therefore important to constantly focus on this.

II-3.1.4 Regulator’s assessment of the fire prevention

Fire preventive measures in the Hot Cell facility rely to a higher degree on the adherence to operational procedures specified in the OLC etc. than on the structural and layout features of the building itself. The observations below relate to assessments from the nuclear regulatory authorities, as findings from certified fire safety inspections are addressed elsewhere in this report.

II-3.1.4.1 Overview of strengths and weaknesses in the fire prevention

Structural and layout features:

The block of Hot Cells is located along the central axis of the building and constitutes a massive concrete structure, with limited access routes. Feed-throughs for cables and tubes in the cell structure are numerous, but the majority remain sealed, and only a limited number may be opened for remote work activities within the cells. The risk of start of a fire inside the now vacated cells is limited, as is the risk of spread of a fire from the surrounding areas to the cell blocks. The potential exception to this is the ventilation system, which may act as a conduit for fire spread through the system of air ducts.

Operational features:

Individual cell units are not readily accessible, and work activities inside the cells have largely only been through remote means. Access to surrounding working areas, from where remote work inside the cells are carried out is restricted to periods where particular tasks are to be carried out. Operational procedures dictate thorough planning of conduct of activities as well as post activity clean up, focussing inter alia on fire safety, including provisions for reducing ignition sources, the amount of combustible materials and fire load in general. Non-compliance to such procedures may enhance risks of fires starting.

II-3.1.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

Inspection activities focus on adherence to operational procedures concerning fire safety, in particular in relation to initiation of new work activities or when changes to the structures surrounding the block of hot cells are carried out. The continually changing layout of the surrounding (gypsum wall) structures affects access points and -routes and may change the number and types of potential ignition sources, conduits for fire spread and fire loads in general, if not registered and monitored carefully.

3.2 Active fire protection

For all DD’s facilities:

There is no automatic fire-extinguishing equipment at DD's facilities, but instead there is equipment for manual fire-fighting at all the facilities, as required by BR18.

DD's technical employees, including those working at Hot Cells and the Drum Storage are trained in elementary firefighting, as required according to OLC, chapter 11.4.

Decisive firefighting is carried out by the local emergency services (Roskilde Fire Brigade). All fire alarms from nuclear facilities go directly to Roskilde Fire Brigade, as well as to Risø gatekeeper function, which is also manned 24 hours a day.

DD has, as part of the preparedness, an on-duty health assistant on 24-hour duty in DD's area. In this way, the health assistant can be available at the scene of the fire at all times within a short time and guide the extinguishing emergency team (Roskilde Fire Brigade) about the health and physical conditions when they arrive at the scene of the fire.

For renovations and new constructions, DD follows the national requirements in the building regulations, BR18, regarding fire safety, and this assessment is carried out by the external company, RMG, which is accredited by DANAK. This is further described in chapter 2.

All fire installations are permanent installations.

Drum Storage

I-3.2.1 Fire detection and alarm provisions

I-3.2.1.1 Design approach

The Drum Storage is exempt from the requirement for the number of fire detectors in the coverage area, as there is a low fire load, and due to dose considerations for installers.

Therefore no fire detectors are installed in the Drum Storage itself. In the surrounding rooms in building 212, there are a total of 8 fire detectors.

I-3.2.1.2 Types, main characteristics and performance expectations

The fire detectors installed in the surrounding rooms are all permanently installed fire detectors. All alarms from the ABA facility at the nuclear facilities on Risø go directly to the municipal fire brigade, as well as to DD's technical guard (comparable to a control room) and Risø gate guard. These alarm connections are wired.

I-3.2.1.3 Alternative/temporary provisions

In the event that the alarm lines should be out of service, manual rounding will be done at least every 4 hours instead of according to internal procedures until automatic fire monitoring is restored.

DD does not perform manual fire inspection during normal operation. If there is a fault with the automatic fire alarm system (ABA) in other parts of building 212 or it is out of order, a manual fire call is made according to an internal procedure.

I-3.2.2 Fire suppression provisions

I-3.2.2.1 Design approach

According to the OLC, it is required that fire-extinguishing equipment must be available to the extent necessary at the nuclear facilities, and that the equipment must be checked and inspected by an authorized company in accordance with the applicable regulations in the area (OLC 11.2).

There is no extinguishing equipment in the storage area itself, nor in the reception room where the opening is. In the surrounding rooms in building 212 there are a total of three carbon dioxide extinguishers. The fire extinguishing equipment is placed according to instructions from the fire technical advisers who carry out fire inspections for DD.

The Drum Storage is both physically difficult to access and there is a high dose rate level in the storage area. The poor access conditions impose limits to manual fire suppression activities. However, the reception room is easy to access.

No fixed water supply for fire suppression is present in the building, but fire hydrants are located along local paved roads at the Risø site.

The tub-like construction of the storage area enables retention of water or other extinguishing media, providing both cooling and some level of containment of contamination.

I-3.2.2.2 Types, main characteristics and performance expectations

The local emergency services, Roskilde Fire Brigade, carries out firefighting for DD. The choice of extinguishing agent is decided upon by the Roskilde Fire Brigade depending on the nature of the specific fire and on the type and layout of the facility.

Fire safety at DD's facilities is discussed with Roskilde Fire Brigade as necessary, in particular during inspections and when new staff at the Roskilde Fire Brigade are introduced.

As the nuclear facilities at Risø are being decommissioned, the conditions in some of the buildings change over time. This is the reason why a health assistant always attends the scene of the fire, so that they can advise the firefighters about the specific conditions in the building in question.

I-3.2.2.3 Management of harmful effects and consequential hazards

The storage area in building 212 is designed as a tub-like structure that can retain potentially contaminated extinguishing agent.

DD is responsible for management for any contaminated extinguishing media after the intervention.

I-3.2.2.4 Alternative/temporary provisions

There are currently no such provisions for DD.

I-3.2.3 Administrative and organisational fire protection issues

I-3.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

There are local instructions for DD's own staff on how to act in the event of a fire in a nuclear facility. Depending on the specific circumstances, actions may include evacuation, first aid and basic fire suppression.

DD's technical staff are trained in basic firefighting, which is refreshed every two years. Roskilde Fire Brigade, which is the local rescue service, makes up the mobile fire-fighting units. DD's own staff will never try to put out a fire in the Drum Storage itself, but always wait for the fire brigade to arrive on the scene.

DD's firefighting equipment is reviewed at the required intervals and replaced as necessary. This is done by external partners with this expertise.

DD holds annual preparedness exercises, which may also include firefighting. The local emergency services also take part in these exercises, so that the interaction is trained. These exercises are evaluated among the participating parties and an exercise report is drawn up.

I-3.2.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

The local rescue service, Roskilde Fire Brigade, has supreme responsibility for firefighting at the nuclear facilities on Risø and is the holder of the necessary skills and equipment for this. Roskilde Fire Brigade has full responsibility for providing off -site assistance.

On-site assistance is provided by Risø port guard (DTU) in collaboration with DD's on-duty health assistant.

DD's emergency preparedness includes a command centre, which is also staffed by DTU staff. Through this, efforts are also coordinated with the local emergency services.

I-3.2.3.3 Specific provisions, e.g. loss of access

As the owner of Risø buildings, it is the Danish Building Agency that is responsible for keeping the access roads to the nuclear facilities at Risø clear. The Technical University also at the Risø site has the necessary equipment to clear the access roads, if needed.

Hot Cells

II-3.2.1 Fire detection and alarm provisions

II-3.2.1.1 Design approach

Building 227 of which the Hot Cells facility is a part is fully covered by an automatic fire alarm system "ABA". Alarms from ABA go directly to the municipal fire service and the local guard. When the ABA system is activated, there will be an auditory alarm throughout the building, and a loudspeaker call will be made from the local guard informing all other buildings about the fire alarm. The local health and physical preparedness will then prepare to receive and guide the municipal fire service. In addition, a contingency group from DD will be gathered and prepared to assist the health and physical preparedness.

It should be mentioned that it has been assessed that it is not necessary to have fire detectors in the cells themselves, where the largest part of the contamination in the facility is located. The basis for this is that there are no sources of ignition in the cells and since the cells are built of concrete with internal steel lines, there is no fire load. If a fire should still occur, heat development of over 40 degrees in the ventilation system will result in an alarm going to the local guard, who can then respond.

II-3.2.1.2 Types, main characteristics and performance expectations

Only permanently mounted detectors are used. The number and location of the automatic smoke detectors has been assessed by an external certified company. DD is not familiar with all the principles for this assessment, but basically there must be at least one fire detector per closed room or ceiling section where smoke can collect. As a starting point, mainly optical smoke detectors are used, but thermal detectors are used in places where this can result in false alarms.

Overall, the building is 4680 m² divided into 40 individual groups, with 299 smoke or individual thermal detectors and 38 manual alarm activation points (glass breaks). The division into groups ensures that it is possible for the fire brigade to quickly localize the fire in the building.

The entire ABA system in the building is connected via cable to a single control panel, which sends a signal via cable to a central control panel. The main board sends the signal via cable to 2 different local guard units and the municipal fire service. All parts of this connection are provided with UPS and if the connection disappears for any reason other than fire it is considered a fire alarm.

II-3.2.1.3 Alternative/temporary provisions

In the event that the alarm lines should be out of service, manual rounding is carried out every 4 hours until automatic monitoring is restored.

II-3.2.2 Fire suppression provisions

II-3.2.2.1 Design approach

The Hot Cell facility is composed of a series of fire cells enabling fire suppressions efforts to be focussed on specific parts of the facility in case of a fire. No particular further provisions for enabling access to fire cells are provided.

No fixed water supply for fire suppression is present in the building, but fire hydrants are located along local paved roads at the Risø site.

II-3.2.2.2 Types, main characteristics and performance expectations

If a fire is detected at the facility, the municipal fire service will be alerted as soon as possible, either via the automatic fire alarms or alarm pressure by people in the area.

Fire-extinguishing equipment is available to facilitate suppression of small fires. The equipment must be checked and inspected by an authorized company in accordance with the applicable regulations in the area (OLC 11.2). Larger fires are suppressed by the fire brigade.

At the central ABA system in the building, the fire service has the opportunity to see where in the building an alarm is coming from. At the ABA facility, there are drawings of the access roads and the shortest possible route to the individual fire cells. The extinguishing capacity of the fire brigade must be sufficient at all times.

No fixed extinguishing equipment is installed in the facility.

All manual fire-extinguishing equipment is dimensioned and placed according to the instructions of the fire technical advisers who carry out fire supervision. At the Hot Cell facility itself, it is estimated that there must be a CO_2 extinguisher in each of the 6 fire cells.

DD has no influence on the extinguishing medium that the fire brigade chooses to use, but the fire brigade has access to local fire hydrants and if the capacity of the fire hydrants is not sufficient, there is access to the fjord, which is approx. 50m from the building.

II-3.2.2.3 Management of harmful effects and consequential hazards

There are no direct measures to prevent the spread of radioactive substances during a fire. DD does not handle the extinguishing agent after the intervention, but will carry out a clean-up afterwards. If contaminated extinguishing media is collected in the sewer, this ends up at a local treatment plant where it is possible to temporarily interrupt further discharge.

DD has a 24/7 emergency service with a guard with health physics competences, who will meet with the external emergency services (fire brigade) to guide them regarding radiation. In addition, there is also a health physicist on duty who will arrive at the facility after no more than 45 minutes.

II-3.2.2.4 Alternative/temporary provisions

If it is assessed that a work process (e.g. welding) requires special temporary fire-extinguishing equipment, this will appear in the statutory workplace assessment APV, which is always drawn up before the execution of the work.

II-3.2.3 Administrative and organisational fire protection issues

II-3.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

Local staff are trained in basic firefighting, which is refreshed every two years. All fire-fighting equipment is reviewed by external certified partners at the required intervals and replaced as necessary.

Annual preparedness exercises are held, which may also include firefighting. The municipal fire brigades are also invited to participate in these exercises, so that the interaction is trained.

The automatic fire alarm system (ABA) at all DD's facilities is checked and tested twice a year by an external certified company. DD carries out a monthly self-inspection of the ABA system in all DD's buildings.

DD conducts an additional 1 to 2 annual internal reviews of the facility with a focus on conventional safety, including fire safety and fire load.

An annual external inspection of all manual fire-extinguishing equipment is carried out.

II-3.2.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

The municipal fire service has supreme responsibility for firefighting at the nuclear facilities on Risø and is the holder of the necessary skills and equipment for that. However, it can be mentioned that

there is an expected response time of less than 10 minutes, from when they receive an alarm until they are in the area.

II-3.2.3.3 Specific provisions, e.g. loss of access

As the owner of Risø buildings, it is the Danish Building Agency that is responsible for keeping the access roads to the nuclear facilities at the Risø site clear. The Technical University also at the Risø site has the necessary equipment to clear the access roads, if needed.

3.3. Passive fire protection

Drum Storage

I-3.3.1 Prevention of fire spreading (barriers)

I-3.3.1.1 Design approach

The drum Storage is constructed as a bathtub with high sides and is located inside a room in building 212, as shown in figure 2. It has very thick walls (44 cm) facing the other rooms in the building, whose primary function is as radiation shielding, but at the same time are effective fire walls. Due to the staggered openings into the drum Storage, the Storage itself does not constitute a fire compartment.

I-3.3.1.2 Description of fire compartments and/or cells design and key features

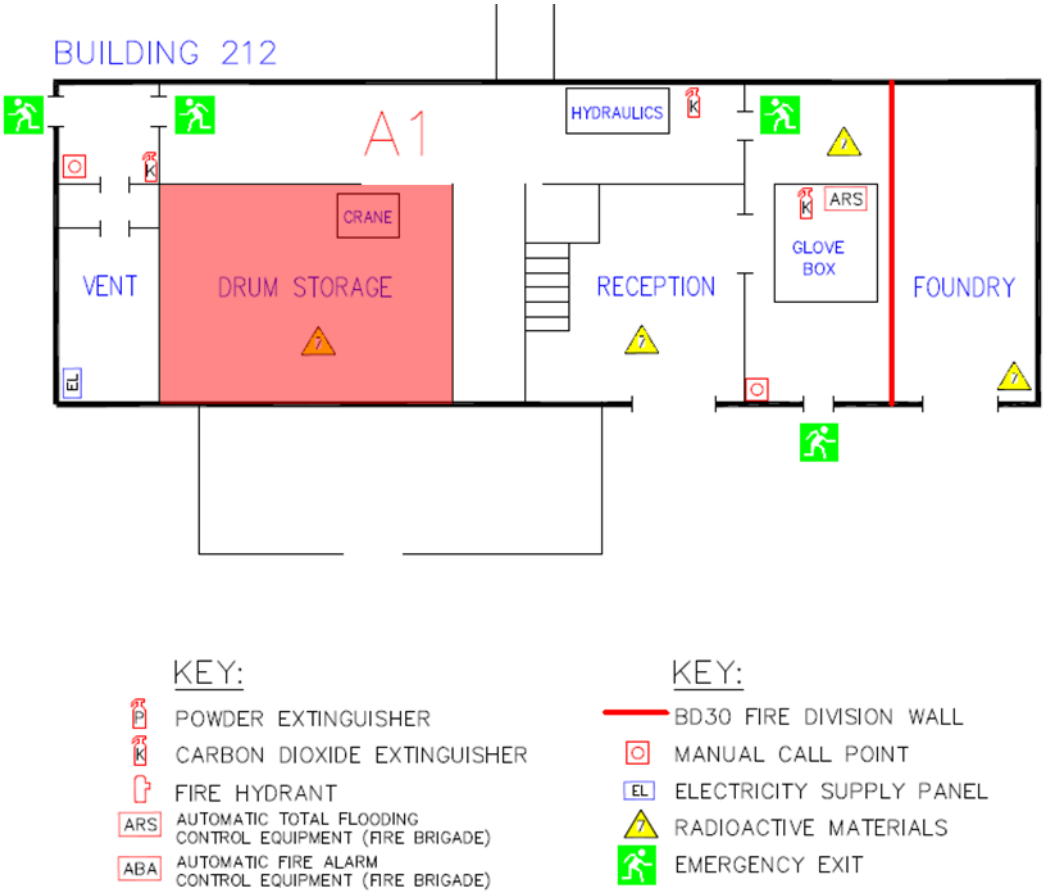


Figure 4. Schematic overview of building 212 containing the Drum Storage facility. The location of the storage area in the building is shown in red.

The storage area itself is not designed as a fire compartment, as the walls do not go all the way to the ceiling. The room at the north end of the building ("Foundry" in figure 3.3.1) is separated from the rest of the building by a brick wall which divides the building into two Fire Compartments (marked with at red vertical line in figure 4).

I-3.3.1.3 Performance assurance through lifetime

There have been no building changes, or changes in the use of the storage and the surrounding rooms, in the more than 60 years the storage has been in use.

I-3.3.2 Ventilation systems

I-3.3.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

There is no direct ventilation in the Drum Storage itself, but the building is equipped with a ventilation system, where the air from outside is sucked into the building and heated via heating surfaces. The heating takes place to avoid freezing in the storage. From the building itself, the air is exhausted to the atmosphere, as it is filtered through a pre-filter and an absolute filter.

I-3.3.2.2 Performance and management requirements under fire conditions

The ventilation system is manually controlled and does not switch off automatically in the event of a fire. The decision to switch of the system manually rests with the emergency services.

Hot Cells

II-3.3.1 Prevention of fire spreading (barriers)

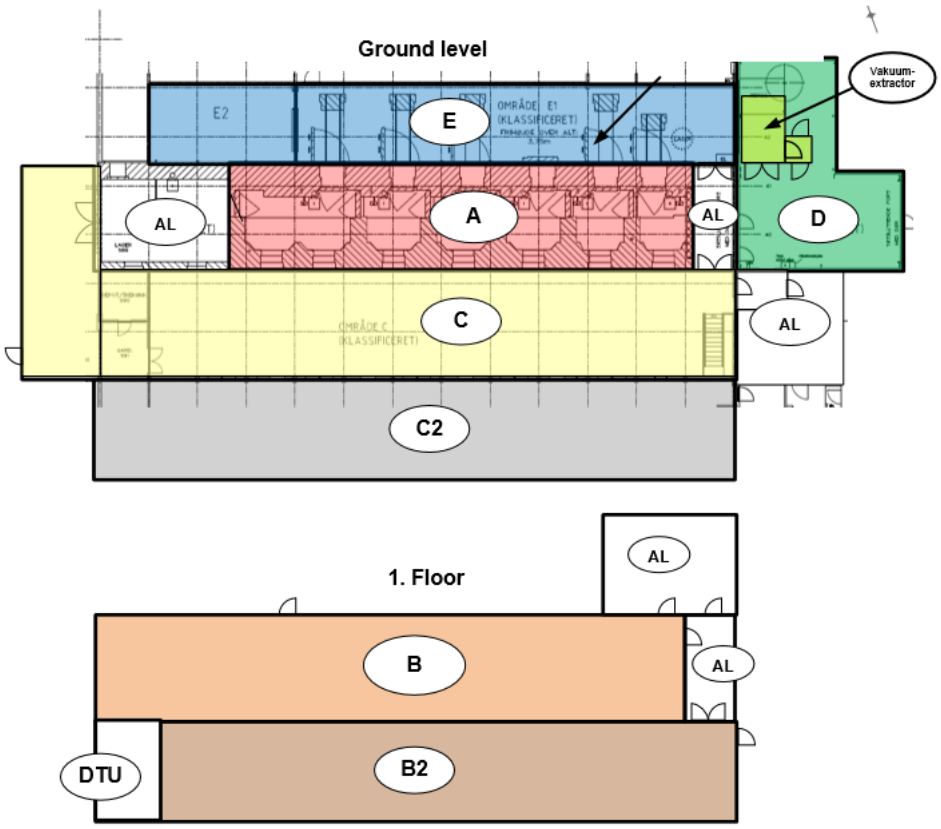
II-3.3.1.1 Design approach

In connection with preparing the facility for decommissioning in 2010, the facility was isolated from the rest of the building with gypsum board walls in fire class BD-60. The entire facility is built in areas around the row of cells, which function as fire cells with BD-30 walls and doors, and which are connected by airlocks.

The remaining part of the building follows Danish building legislation on the construction period and will not be dealt with further in this section, as it is empty and unused.

II-3.3.1.2 Description of fire compartments and/or cells design and key features

Areas that act as fire cells can be seen in the drawing below.



The facility is roughly divided into the following areas, where AL are Airlocks

Floor plan:

A : Save	the cell row
C : Yellow	The front of the cell row
C2 : Gray	Unclassified office corridor
D: Green	Car lock and contains an enclosure with a vacuum cleaner
E : Blue	The back of the cell row

1st floor:

B : Orange	Directly above the cells
B2 : Brown	Technical room with ventilation filters
DTU: White	Part of the remaining building

There is also a crawl space under parts of the above areas, but this is not reviewed here as it is not used.

In the following, the focus is on the 3 areas where a fire has the greatest risk of resulting in a potential radiological risk:

- A : The cell row itself
  - Walls are built in 1.7 m concrete, with an internal 8 mm steel liner. There are quite a few penetrations in the concrete walls, but they are all closed, or part of the ventilation system.
  - All doors to the cells are minimum BD 30 and built as parts of locks (minimum 3 doors before you can enter the cells).

    - Ceilings are min. 0.5m thick in concrete, with 8 mm steel lines. There are larger passages in the ceiling between all cells, all of which are closed with min. 2mm steel plates.
    - The floor is made of concrete, with 8mm steel liners.
- B2 Technical room on the 1st floor with ventilation filters
    - Walls and doors are all minimum BD 30 min
    - Ceilings are made of concrete
    - Floors are made of concrete, with individual penetrations for ventilation (there is a dispensation for not having fire dampers in the channel penetrations, as it was assessed at the time of construction that it was more important to be able to maintain differentiated negative pressures in the areas of the facility).
- D: Containment with a vacuum cleaner located in the area east of the cell row.
    - Walls and ceilings built in mineral wool panels with steel sheets in fire class BD 30 min, with single penetrations for ventilation
    - Doors are mine. BD 30.
    - The floor is made of hollow concrete with an epoxy coating

II-3.3.1.3 Performance assurance through lifetime

New assessments are regularly made by external advisers when changes are made that may have consequences for fire safety. It is the project manager's responsibility that major changes appear in project/subproject descriptions that are sent to the nuclear regulatory authorities for approval or to inform the nuclear regulatory authorities of minor changes through work plans.

It is further the project manager's responsibility to document these changes and seek other relevant national/municipal approvals.

I-3.3.2 Ventilation systems

I-3.3.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

The ventilation system at the Hot Cell facility has been rebuilt in several rounds, of which the latest rebuilt was in 2015-16. The facility is built so that it is possible to maintain differentiated negative pressures in all areas, so that an inward air flow is maintained towards the cell row. The ventilation is divided so that it is possible to regulate and switch off the following separate areas:

- A: The cell row
- C: The area south of the cell row
- E: The area north and east of the cell row
- B: The areas on the 1st floor above the row of cells.
- D: Car lock, with separate control of containment for vacuum cleaner

None of the internal ventilation ducts in the building are fire insulated.

I-3.3.2.2 Performance and management requirements under fire conditions

In the event of a fire, the development of heat will cause the exhaust air in the ventilation system to increase and at a temperature of over 40 degrees an alarm will be activated and the ventilation in the affected area will be switched off automatically.

If the fire brigade deems that the ventilation must be stopped before firefighting, they have the option of doing so by a manual pressure located at the main entrance. Here, the fire brigade can choose to:

- Stop all ventilation in the facility
- Stop all ventilation in the facility, except for the cell row where there is only extraction.

3.4 Licensee's experience of the implementation of the fire protection concept

DD has good experience of using external experts to carry out the necessary fire technical assessments, analyses and inspections. This ensures an objective impartial assessment by experienced accredited experts and ensures a high standard for fire safety. It can be considered a weakness that DD itself does not have competences in fire safety, but as DD is a relatively small organisation, it will be very difficult to maintain internal accredited, experienced competences.

It is DD's assessment that it works well to follow the national standard for fire safety, since compared to a graded approach, there are relatively low radiological consequences of a fire in DD's facility. (Applies to both facilities).

Drum Storage

Based on the fire analysis in the year 2000 and the more than 60 years of operational history of the Drum Storage, it is assessed that the existing level of fire protection measures is at a sufficient level for the Drum Storage in Building 212. The annual fire inspections carried out by accredited experts confirm this statement.

DD has not had any fire-related incidents at the Drum Storage. Over the years, DD has had some false alarms, which have shown that fire preparedness works effectively.

Hot Cells

Based on the fire analysis in the year 2000 and the operational history of the Hot Cells since beginning of the decommissioning, it is assessed that the existing level of fire protection measures is at a sufficient level for the Hot Cells in Building 227. The annual fire inspections carried out by accredited experts confirm this statement.

DD has not had any fire-related incidents at the Hot Cells since beginning of the decommissioning. Over the years a few false alarms related to e.g. dusty work have shown that fire preparedness works effectively.

3.5 Regulator's assessment of the fire protection concept and conclusions

Fire safety competences at the licensee are limited to day-to-day operational fire safety aspects, e.g. assuring through internal inspection procedures that fire loads are low and potential ignition sources are few, etc. Local fire suppression capabilities are modest. However, relevant staff undergo basic fire safety training and furthermore manual fire extinguishing equipment is widely available throughout the facilities, and potentially could be used by all staff, thereby decreasing the risk that fires develop more rapidly and become more widespread before fire suppression can be undertaken by local emergency services.

The moderate level of fire safety competences available to the licensee in general presents a risk that the (fire) safety culture erodes over time, leading to poor implementation of the fire protection concept.

Drum Storage

The drum storage itself is technically unchanged since its construction, but fire protection has been discussed during the biannual walk-downs with the local fire authority and the nuclear regulatory authorities as observers, without any changes to the fire protection concept being implemented.

Hot Cells

The Hot Cell facility has been refurbished several times to accommodate its decommissioning. During the approval processes for these changes, fire protection issues have been addressed, considering nuclear safety on a case by case basis.

3.6 Conclusions on the adequacy of the fire protection concept and its implementation

Bearing the remarks in section 3.5 on assessment of the fire protection concept in mind, the following remarks regarding the adequacy of the fire protection concept for the Drum Storage and the Hot Cell facility apply:

Drum storage

Given that drums are neither added, nor removed from the storage area, and that work activities in the building do not otherwise require access to, or passage through, the area, the protection concept relies to a high degree on operational safety (adherence to instructions concerning all activities in the building etc.), which has proven adequate.

Hot Cells

As decommissioning has progressed, the potential for release of radioactivity into the environment has decreased due to both the reduction in fire load within the row of hot cells and the removal of activity from the cell interiors through decontamination. As such, fire safety today relies mainly on the operator's adherence to provisions for fire safety in building regulations when restructuring or modifying the areas surrounding the row of hot cells, and day-to-day operational provisions for maintaining a low fire load, and a low-ignition environment in the working areas surrounding the row of hot cells. This approach has proven adequate to date.

4. Overall Assessment and General Conclusions

The fire protection concept applied to the Danish nuclear facilities has evolved over the transition from the operational to the post-operational period, and as decommissioning activities have progressed. Whereas fire protection during operations strongly relied on the presence of a dedicated, on-site fire service, fire safety in the post-operational period has relied to a higher degree on passive safety features, in particular with respect to detection and alarm measures. In the transition from an operational to a post-operational regime, specific fire safety analyses allowed for identification of features to enhance passive features of fire safety. The implementation of passive fire safety features and the operator's adherence to procedures for maintaining fire safety during day-to-day operations has provided the basis for fire protection during the last two decades. Historically, a very limited number of fires have occurred at the Danish nuclear facilities at Risø. Over the past twenty years only minor incidents of fire have occurred; none in candidate installations, and no fire has resulted in significant damage to buildings nor in the release of radioactivity to the surrounding environment.

Based on these experiences, the level of fire protection for nuclear facilities in Denmark is considered satisfactory, taking into account that; all nuclear facilities are located at the same site, all facilities are to be decommissioned and the majority of (fire) safety significant facilities are already decommissioned or at advanced stages of decommissioning. As such, the fire protection concept has proven adequate, and experience has shown that it has been implemented in a way sufficient to serve its purpose.

As decommissioning progresses and radiological constraints on fire safety become less significant, general provisions for fire safety in building regulations play an increasingly important role. In this situation, distinct delineation of responsibilities, careful coordination between regulatory authorities and clear communication to licensees become crucial for maintaining and implementing an effective fire protection concept.

It should be recognized that ensuring coordination between regulatory authorities at different hierarchical levels and with reference to different legislative requirements is challenging and presents risks of duplication of work and requirements to the licensee. In addition, risks of insufficient regulation for critical areas might arise. In this regard, clear specification of regulatory requirements regarding fire safety as well as licensee competences in the field of fire safety is key to the effective implementation of a fire protection concept.

These lessons must be included in the continuous development of the fire protection concept for the remaining ongoing decommissioning activities and in the definition of a new fire protection concept for the planned storage facility at the Risø site.