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Topical Peer Review II on Fire Protection

National Assessment Report of Austria

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Executive Summary

According to Article 8e of Directive 2014/87/EURATOM amending Directive 2009/71/EURATOM, EURATOM Member States are obliged to review the nuclear safety of relevant nuclear installations on their territory, at least every six years based on a specific topic related to nuclear safety. This provision was transposed into § 51 of the Austrian Radiation Protection Act 2020 (Strahlenschutzgesetz 2020).

In November 2020, the European Nuclear Safety Regulators Group agreed on “Fire Protection” as a topic for the second Topical Peer Review (TPR II) at its meeting. TPR II covers – among other nuclear installations – research reactors regardless of their type and thermal power.

The Technical University of Vienna (TU Wien) operates a pool type TRIGA Mark II research reactor. It has a maximum continuous thermal power output of 250 kW and pulsing capabilities up to 250 MW. This research reactor is the only nuclear installation in operation in Austria and falls within the scope of this peer review.

Fire protection is regulated in a wide variety of legal provisions in Austria. The building codes of the respective federal provinces form the core of the fire protection regulations. For the research reactor operated in Vienna, the Viennese Building Code is the relevant provincial legislation. In addition, federal laws as well as (inter)national standards and guidelines are taken into account with regard to fire protection.

The research reactor operated in Austria is continuously adapted to the state of science and technology in the area of fire safety. The effectiveness of fire protection measures is being checked as part of regular inspections.

In summary, this approach ensures a high level of safety regarding fire protection for the TRIGA Mark II research reactor.

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1 General Information

According to Article 8e of Directive 2014/87/EURATOM amending Directive 2009/71/EURATOM, EURATOM Member States are obliged to review the nuclear safety of relevant nuclear installations on their territory, at least every six years based on a specific topic related to nuclear safety. This provision was transposed into § 51 of the Austrian Radiation Protection Act 2020 (Strahlenschutzgesetz 2020).

The first Topical Peer Review took place in the years 2017/18 on the topic of "Ageing Management" for nuclear power plants and research reactors with more than 1 MW thermal power. Austria did not participate in the first Topical Peer Review as it fell outside the scope (the only research reactor has a thermal power of less than 1 MW).

The second Topical Peer Review (TPR II) will be carried out in 2023/24. The European Nuclear Safety Regulators Group (ENSREG) agreed on "Fire Protection" as a topic for TPR II at its meeting in November 2020. TPR II covers – among other nuclear installations – all research reactors regardless of their type and thermal power.[1]

The only nuclear installation in operation in Austria is a pool type TRIGA Mark II research reactor operated by the Technical University of Vienna (TU Wien).[2] It has a maximum continuous thermal power output of 250 kW and pulsing capabilities up to 250 MW. The reactor is located in the second district in Vienna. TRIGA type research reactors are inherently safe for reactivity insertion events due to the large, prompt negative temperature coefficient of the UZrHx fuel. In the event of a complete loss of water, the reactor will automatically shut down. The fuel elements would reach a maximum temperature of 275°C and would not be damaged. Post-decay heat would be removed by natural air convection from the uncovered core.

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[1] With the exception of the critical, sub-critical assemblies, homogeneous zero-power reactors and accelerator driven systems are covered by the term "research reactor".

[2] In the past two additional research reactors have been operated in Austria: The ASTRA research reactor with a thermal power of 10 MW at the Austrian Research Centre Seibersdorf and the Siemens ARGONAUT research reactor with a thermal power of 10 kW at the Reactor Institute in Graz. However, their life cycles ended in 2006, when both reactors were successfully decommissioned. Therefore, they are not subject of this report anymore.

The TRIGA Mark II research reactor is classified as a reactor with a lower risk profile according to the Technical Specifications[3] due to the low nominal power, the safety features of the research reactor and the lack of significant additional risks.

1.1 Nuclear installations identification

Besides the TRIGA Mark II research reactor at the TRIGA Center Atominstitut of the TU Wien, there are no other nuclear installations as defined in the Technical Specifications in Austria, such as nuclear power plants, spent fuel storage facilities, enrichment facilities, nuclear fuel fabrication facilities or reprocessing facilities at any stage of the life cycle.

Storage facilities for radioactive waste fall within the scope of TPR II if they are on the same site and directly related to other types of nuclear installations. The only storage facility for radioactive waste in Austria is located in Seibersdorf whereas the TRIGA Mark II research reactor is located in Vienna. Consequently, it is not on the same site and it is not directly related to the TRIGA Mark II research reactor. Therefore, it does not fall within the scope of TPR II.

1.1.1 Qualifying nuclear installations

In conclusion, due to the scope of TPR II, the Austrian National Assessment Report (NAR) will cover the TRIGA Mark II research reactor in Vienna.

1.1.2 National selection of installations for TPR II and justification (brief summary of)

The NAR will provide information on the TRIGA Mark II research reactor operated by the TU Wien, as it is the only nuclear installation in Austria and falls within the scope of TPR II.

[3] WENRA, Report Topical Peer Review 2023 Fire Protection Technical Specification for the National Assessment Reports, 21 June 2022.

1.1.3 Key parameters per installation

The key parameters for the TRIGA Mark II research reactor are:

- Name: TRIGA II Vienna
- Licensee: TU Wien, Karlsplatz 13, 1040 Vienna, Austria
- Type of reactor: TRIGA reactor
- Thermal power: 250 kW
- Date of first criticality: 7th of March 1962
- Scheduled end of operation: 2040

The TRIGA Mark II research reactor was installed by General Atomics (San Diego, California, USA) in the years 1959 through 1962, and went critical for the first time on the 7th of March 1962. Since then, the operation of the reactor has averaged 220 days per year without any long outages. The TRIGA-reactor is a research reactor of the swimming-pool type that is used for training, research and isotope production (**T**raining, **R**esearch, **I**sotope **P**roduction, **G**eneral Atomics = TRIGA). There are 37 TRIGA reactors in operation worldwide, with eight of them in Europe.

The installation has a maximum continuous power output of 250 kW (thermal). The heat produced is dissipated via a primary cooling circuit (deionized, distilled water at temperatures between 20°C and 30°C) and a secondary coolant circuit (ground water at temperatures between 12°C and 18°C). The two circuits are separated by a heat exchanger.

The reactor core consists of 83 fuel elements (each of them 3.75 cm in diameter and 72.24 cm in length), which are arranged in an annular lattice. Two fuel elements have thermocouples implemented, which allow to measure the fuel temperature during reactor operation. At nominal power of 250 kW, the center fuel temperature is about 200°C. Because of the low reactor power level, the burn-up of the fuel is very small. Most of the fuel elements loaded into the core in 2012 are still in use.

Inside the fuel element cladding (steel), the fuel is in the form of a uniform mixture of 8 % uranium, 1 % hydrogen and 91 % zirconium, with the zirconium-hydride being the main moderator. Since the moderator has the special property of moderating less efficiently at high temperatures, the research reactor in Vienna can also be operated in a pulsed mode (with a rapid power rise to 250 MW for roughly 40 milliseconds). The power rise is accompanied by an increase in the maximum neutron flux density from $1x10^{13}$ $cm^{-2}s^{-1}$ (at

250 kW) to $1x10^{16}$ $cm^{-2}s^{-1}$ (at 250 MW). The negative temperature coefficient of reactivity consequently brings the power level back to lower values after the pulse. The maximal pulse rate is twelve per hour, since the temperature of the fuel elements rises to about 300°C during the pulse.

The reactor is controlled by three control rods, which contain boron carbide as absorber material. When these rods are fully inserted into the reactor core, the neutrons continuously emitted from a start-up source (Sb-Be photo-neutron source) are absorbed by the rods and the reactor remains sub-critical. If the absorber rods are withdrawn from the core (two of them are driven by an electric motor and one pneumatically), the number of fissions in the core and the power level increases. The start-up process takes roughly five minutes for the reactor to reach a power level of 250 kW from the sub-critical state. The reactor can be shut down either manually or automatically by the safety system. It takes about half a second for the control rods to fall into the core.

Fire protection is implemented through the interaction of several institutions:

- The Bundesimmobiliengesellschaft (BIG) is the building owner and responsible for commissioning, maintenance, repairs and renovations to the building.
- The TU Wien, Department of Buildings and Technology (GUT), is responsible for all infrastructural matters. They are responsible for providing optimal conditions for research and teaching and the infrastructure necessary for staff and students.
- The TRIGA Center Atominstitut operates the research reactor. It is their responsibility that their staff is instructed accordingly as well as that the Fire Protection Regulations of TU Wien are executed accordingly.

1.1.4 Approach to development of the NAR for the national selection

Several authorities were involved in the preparation of the NAR, according to the responsibilities for nuclear safety and fire protection on the federal and provincial levels. Fire protection in the sense of this peer review concerns mainly two areas: nuclear safety on the one hand and “classical” fire protection on the other.

The Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) is the competent authority for research reactors. The main obligations according to the Radiation Protection Act 2020 are:

1. The protection of individuals, including their progeny, as well as the protection of the environment with a view to ensuring the long-term protection of human health against the dangers arising from ionising radiation,
2. the assurance of a high level of nuclear safety, and
3. the responsible and safe management of spent fuel and radioactive waste.

The City of Vienna is the competent authority for fire protection at the research reactor.

The NAR was prepared by BMK as the competent authority for practices regarding nuclear safety and radiation protection at the federal level and fire protection experts from the City of Vienna and in close coordination with the licensee of the research reactor.

1.2 National regulatory framework

The Austrian legal system is structured in a so-called tier system of laws, which decrees that the norm that is lower in the hierarchy may not contradict, change or cancel a norm that is higher in the hierarchy. In short, EU law and constitutional law rank higher than federal laws. Federal laws rank higher than ordinances or regulations. Still, all of them are legally binding. On the other hand, mere guidelines are of different quality and subsequently not legally binding, unless they are referred to by a legally binding norm such as ordinances.

For instance, constitutional law is given a higher status by virtue of the fact that it is harder to amend. An amendment to a national constitutional provision requires a two-thirds majority in parliament, with at least half of the members present and voting. The provision thereby adopted is then known as a “Constitutional Law”. By contrast, to pass a valid motion in parliament relating to a law that is not constitutional in nature, a simple majority of votes is required, with one third of parliamentary members present and voting.

With Austria's entry into the EU on 1st of January 1995 Austrian constitutional law was joined with EU law as the most fundamental source of law. The general view is that EU law takes precedence in application, over domestic Austrian law and the national constitution with some exceptions.

Austria is a federal state consisting of nine federal provinces (“Bundesländer”). The respective competences of the federal state (“Bund”, i.e. “the federation”) and the federal provinces are laid out in what is referred to as the competence articles of the Federal Constitutional Law. Legislation in relation to construction and fire protection fall within the competence of the federal provinces.

Fire protection is regulated in a wide variety of legal provisions in Austria. The building codes of the respective federal provinces form the core of the fire protection regulations. For the research reactor operated in Vienna, the Viennese Building Code is the relevant provincial legislation.

Some of the provisions in the Austrian legal system have its origin in the Construction Products Directive (Council Directive 89/106/EEC) that was promulgated in 1989. Its goal was to standardise the basic construction requirements in Europe and to achieve a standardised handling of building materials as well as a reduction of trade barriers.

In 2011, the directive was replaced by the Construction Products Regulation (EU) No 305/2011 that is directly applicable in Austria. It states which protection goals have to be met with regard to fire protection. The protection objectives are defined in Annex I of the Construction Products Regulation concerning the basic requirements for construction works as follows:

The construction works must be designed and constructed in such a way that in the event of an outbreak of fire:

1. the load-bearing capacity of the construction works can be assumed for a certain period of time,
2. the generation and spread of fire and smoke within the construction works are limited,
3. the spread of fire to neighbouring construction works is limited,
4. the occupants can leave the construction works or be rescued by other means,
5. the safety of rescue teams is taken into consideration.

Furthermore, protection goals for “mechanical strength and stability”, “hygiene, health and environmental protection”, “safety and accessibility in use”, “sound insulation”, “energy saving and thermal insulation” and “sustainable use of natural resources” are mentioned in Annex I of the Construction Products Regulation.

Relevant fire protection guidelines have been issued by the Austrian Institute of Construction Engineering (OIB) for the first time in 2007. The original versions were divided into OIB Guideline 2 “Fire Protection”, OIB Guideline 2.1 “Fire Protection for Commercial Buildings” and OIB Guideline 2.2 “Fire Protection for Garages, Covered Parking Lots and Parking Decks”. For high-rise buildings, ONR 22000 addressed buildings with special fire protection requirements (high-rise buildings), edition 2007-03-01. It changed in following years into OIB Guideline 2.3 “fire protection for buildings with an escape level of more than 22 m”. Guidelines issued by the OIB are not legally binding. However, they can become legally binding if they are implemented in the respective federal provinces’ building codes or through building technology ordinances.

In the respective building codes of the federal provinces, the requirements for buildings are described by formulating protection goals. These correspond to those of the Construction Products Regulation. The building technology ordinances provide more detailed provisions on how the protection goals can be achieved on a technical level. For instance, the Viennese Building Technology Ordinance 2020 stipulates that the building regulations laid down in certain parts of the Viennese Building Code are complied with, if the OIB guidelines are adhered to. However, if the OIB guidelines are not complied with, it might still be permissible, if the building applicant proves that the same level of protection is achieved as with full compliance of the OIB guidelines.

In brief summary, this means that if the constructional specifications of the OIB guidelines in the respective cited version are complied with, the minimum requirements for the fulfilment of protection goals from the respective building regulations or the EU Construction Products Regulation are met. Deviation from the OIB guidelines is permissible under certain conditions.

Excursus: Overview of the Austrian institutions directly involved in fire protection regulation and standardisation

Austrian Institute of Construction Engineering (OIB)

The Austrian Institute of Construction Engineering was founded in 1993. The following primary tasks are performed by the OIB:

- The OIB issues OIB guidelines in order to enable the federal provinces to standardise the building requirements in the respective building regulations.
- The OIB issues building materials lists as ordinances for the federal provinces.
- The OIB is the European Technical Assessment Body and the national approval body for construction products.
- As the product information centre for the construction industry, the OIB provides information on the technical requirements for construction products applicable in Austria.
- As a market surveillance authority, the OIB ensures that construction products on the market in Austria meet all legal requirements and do not endanger health and safety.

The establishment of guidelines is carried out by the expert advisory boards, which are generally composed of representatives of the federal provinces. The issuing of a completed guideline requires a resolution in the general assembly of the OIB and that it is made available to the federal provinces after its adoption. The federal provinces have to implement these guidelines in the existing building regulation.

Austrian Standards Institute (ASI)

The Austrian Standards Institute, based in Vienna, was commissioned to carry out the Austrian standardisation organisation.

According to the Standards Act 2016, the Federal Minister of Science, Research and Economy grants a non-profit association the authority to create and publish national standards. This association is assigned the task of creating all prerequisites to be able to apply for membership of the European Committee for Standardisation (CEN) and the International Organization for Standardization (ISO) and to become their member.

Experts must be given the opportunity to participate in the development of standards. Any private person or company can submit an application to the ASI for the development or amendment of a standard. If the request is supported to a certain extend a committee responsible for the development will be founded and included in the work programme.

In a democratic process, after the draft has been written, it will be made available for public comments for six months. The comments will be examined and incorporated into the draft. After its adoption the standard will be published. Henceforth, the standard can be applied in practice and, if necessary, the cycle is repeated when a request is made to amend the standard.

ASI issues Austrian standards (e.g. ÖNORM B 3850 regarding fire resisting doorsets and/or smoke control doorsets – requirements and tests for single and multiple leaf constructions) or adopts European standards into the Austrian body of standards (e.g. ÖNORM EN 54 series regarding fire alarm systems). For new or rapidly changing developments, ASI can publish technical specifications (ONR) which do not have to fulfil all requirements of a classical standard. The ONR must not contradict other ONRs or existing ÖNORMs.

Austrian Federal Fire Brigade Association (ÖBFV)

Technical Guidelines for Preventive Fire Protection (TRVBs) are published by the Austrian Federal Fire Brigade Association. The objectives of the ÖBFV are uniform organisation, equipment and training of the Austrian fire brigades, taking into account the federal structure of the Republic of Austria, as well as the representation of those interests of the fire brigades that go beyond the area of a federal province and the federal territory.

After the first version of the guideline has been issued, they are published on the TRVB working group's homepage for comments. The received comments are subsequently processed by the working group and, in justified cases, taken into account into the guidelines. The adapted guidelines are then published by the decision-making bodies.

1.2.1 National regulatory requirements and standards

This chapter will briefly introduce the relevant laws, ordinances, standards and guidelines related to fire protection. Since the research reactor is located in Vienna and parts of the laws containing fire safety provisions are enacted by the respective nine federal states, this report focuses on the legislation of the federal province of Vienna. A few ordinances refer to the OIB guidelines highlighting their importance.

For employees, the following fire protection objectives apply under the **Workers Protection Act 1994**:

- Employers have to take appropriate measures to avoid the occurrence of a fire and, in the event of a fire, to avoid endangering the life and health of workers.
- Employers have to take appropriate measures necessary for firefighting and evacuation of workers.
- Employers have to take appropriate precautions to prevent explosions and limit the consequences of an explosion.

The **Workplace Ordinance** – as an ordinance to the Workers Protection Act – regulates, among other things, the requirements for workplaces. From the perspective of occupational health and safety, the OIB guidelines represent the state of the art in the field of construction technology and structural fire protection. The fire protection design of a structure in compliance with the applicable provisions of the OIB guidelines is a suitable substitute measure for exceptions from the provisions of the Workplace Ordinance. This means that deviations from provisions of the Workplace Ordinance are permitted, if the corresponding provisions of an OIB guideline are complied with.

For civil servants similar provisions apply under the **Federal Civil Servants Protection Act 1999**.

The **General Radiation Protection Ordinance 2020** stipulates fire protection in the following respects:

- as part of the operating rules,
- specific record-keeping and notification obligations of the licensee,
- as part of the safety report,
- as part of the training for personnel in the field of nuclear safety.

According to § 91 of the **Viennese Building Code**, buildings have to be planned and constructed in such a way that the risk to life and health of persons due to fire is prevented and the spread of fire is effectively limited. From this generally formulated protection goal, the following requirements for buildings with regard to fire protection are specified in §§ 92 to 96 of the Viennese Building Code:

- Maintaining the load-bearing capacity of the structure for a sufficient period of time in the event of fire, to enable the escape/rescue of occupants and to ensure access for rescue teams, as well as avoiding major damage to permitted development on neighbouring properties in the event of fire-related building collapse.
- Limitation of the spread of fire and smoke within the structure to protect adjacent units of use, to secure escape routes and to enable effective firefighting.
- Prevention of the spread of fire to neighbouring structures via the external walls, roofs and roof superstructures.
- In the event of fire, occupants shall be enabled to leave the structure or be rescued quickly and safely.
- The safety of firefighters and rescue teams during firefighting and the possibility of effective firefighting operations shall be ensured.

According to § 68 of the **Viennese Building Code**, exceptions to legally defined building regulations are permitted. This is of great importance e.g. regarding the protection of existing buildings.

The **Viennese Building Technology Ordinance 2020** stipulates that:

- The building regulations laid down in […] the Viennese Building Code are complied with, if the guidelines of the OIB […] insofar as they regulate building regulations, are adhered to.
- The OIB guidelines […] may be deviated from if the building applicant proves that the same level of protection is achieved as with the application of the OIB guidelines.

Fire protection regulations are available in various types of guidelines and standards. The OIB guidelines issued by the Austrian Institute of Construction Engineering form the basis for building technology. They provide basic technical building guidelines for standard buildings such as residential and office buildings, hospitals and nursing homes, educational institutions, garages, company buildings.

How the technical requirements, formulated in these OIB guidelines, can be implemented according to the state of the art, is subsequently described in the TRVB (Technical Guidelines for Preventive Fire Protection). For instance, TRVBs concern special utilisation of buildings, such as sales premises larger than 3,000 m² or sales areas with more than three floors in open connection or prisons as they lie outside of the scope of the OIB guidelines.

There are no separate OIB guidelines or TRVBs for the construction of new research reactors. Instead, generally applicable fire protection standards such as for laboratories or educational institutions would be applied for the construction of new research reactors in case of comparable reactor specifications.

1.2.2 Implementation/Application of international standards and guidance

The IAEA safety standard regarding the Safety of Research Reactors (SSR-3) has been taken into account. The fire protection components are specified according to their type and origin. Where international or European standards are relevant, these have been adopted into the Austrian standards system. For instance, the ÖNORM series EN 54 is relevant for the fire alarm system. EN indicates that this standard has its origin in the European Committee for Standardization. Another example of a European standard that was adopted into the Austrian standards system is ÖNORM EN 13501 regarding the fire classification of construction products and building elements.

2 Fire Safety Analyses

2.1 Research reactors

The TRIGA Mark II research reactor is a swimming pool type research reactor used for training, research and isotope production. The reactor has a maximum continuous power of 250 kW. More detailed information on the research reactor can be found in chapter 1.1.3.

2.1.1 Types and scope of the fire safety analyses

The analyses of the impact of fire to the safety of the research reactor is part of the safety report. The fire protection concept must meet conventional requirements for the protection of property and persons, which are derived from the applicable building regulations as well as the specific requirements regarding radiation protection. In the event of a fire, radiation exposure or contamination of persons, property or the environment must be avoided or minimized.

The effects of fire are part of the deterministic safety analysis. The reactor hall is designed as a separate fire compartment. There are regularly tested fire detectors in the reactor hall. Fire incidents are automatically forwarded to the fire brigade. In case of an alarm of the fire alarm system during the operating hours of the reactor, the reactor operation must be stopped immediately. Specific rules regarding the behaviour and responsibility of personnel in the event of fire are in place.

The scope of the analysis depends on the hazard potential of the installation. Due to its low maximum continuous power output of 250 kW and the inherent safety of its fuel the research reactor has a low hazard potential (see chapter 1.1.3.). The failure of the cooling system, complete loss of the primary cooling water during reactor operation, rupture of the cladding of a fuel element or, as a worst-case scenario, rupture of the cladding of all fuel elements as a result of external force were taken into account.

Overall, the analysis of the impact of fire to the safety of the research reactor concludes that the effects of a fire in the reactor hall or the reactor control room are low.

In order to keep the building up to date in terms of fire protection, a fire protection evaluation including a risk assessment was performed in 2021 by a company specialized in fire protection on behalf of BIG. The main focus of the risk assessment was the protection of persons, i.e. the safe escape of persons inside the building in case of fire. The fire-safety risk assessment was carried out based on the relevant requirements for the building with regard to its use as an educational facility.

2.1.2 Key assumptions and methodologies

In the event of a complete loss of cooling water, it would not result in a meltdown of the core or lead to a fire. Instead, natural air convection would be sufficient to keep the temperature of the core cool enough to not damage the fuel or to release fission products. Due to the low power density of the TRIGA reactor, the decay heat will be dissipated by natural air convection with an uncovered core.

The worst-case scenario of the safety report is a simultaneous rupture of all fuel element claddings as a result of an external force (e.g. crash of a large aircraft onto the reactor hall). This would of course also destroy the reactor hall itself. In this extremely unlikely case, radioactive material would be released into the environment. In the main wind direction, an accumulated dose of up to 0.37 mSv after one day (also after 50 years) could be expected at a distance of 105 m to 210 m after such an incident.

The worst conceivable (albeit extremely unlikely) scenario resulting from a fire would be the collapse of the reactor hall. Due to the design of the reactor (massive primary cooling water pool and water column above the reactor core), the collapse of the hall will not generate enough energy to cause the worst-case scenario described above. This also underlines the low hazard potential of the reactor. In terms of fire protection, it is therefore justified to consider the reactor hall as a laboratory or engineering room.

The fire protection evaluation (including a risk assessment with the main focus on protection of occupants) is exclusively a safety-related assessment, which was created on the basis of the available planning material and after on-site inspections of the building. For the risk assessment, the burning of storage material, room inventory or technical equipment was considered depending on the use of the room; model calculations going beyond that were not carried out.

In terms of fire protection, it is justified to consider the reactor hall as a laboratory or equipment room, because the research reactor has a low hazard potential due to its design (inherent safety), the existing safety equipment, the operating procedures, and low activity inventory.

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

Due to the low fire load in the reactor hall, merely the fire of equipment (e.g. tables or europallets), measurement set-ups (e.g. measuring instruments, technical racks) or the electrical installations (e.g. fuse boxes, switch cabinets, etc.) are conceivable.

Such fire events will not provide enough energy to endanger the integrity of the reactor shielding, the primary coolant tank or the reactor hall until the fire brigade arrives. However, it is conceivable that the glazing of the reactor hall could be broken as a result of burning bearings and that activated air or vaporised cooling water could escape into the open air as a result (however, these would be extremely low activities). In order to minimize the risk of destruction of the reactor hall glazing, the TRIGA Center Atominstut operating personnel make sure that the area in close proximity to the glazing is free of combustible bearings.

2.1.4 Main results / dominant events (licensee's experience)

Since the licensing of the research reactor on 7th of March 1962, continuous improvements were made in the area of preventive fire protection, such as the retrofitting of a fire alarm system in the entire institute building, or the fire protection separation of the stairwells and the formation of separate fire compartments for the reactor hall, lecture hall, offices and laboratory areas. A detailed list of the construction activities for continuous improvement of the fire protection measures can be found in chapter 2.1.5.1.

In the past, General Atomics carried out extensive tests on the fuel elements that are in use at the TRIGA Mark II research reactor in Vienna. The findings were incorporated, among other things, in the internal safety report of the TRIGA Center Atominstitut of the TU Wien, which have been continuously compiled and expanded since 1961. The latest safety report was prepared in 2022 and includes the following topics, amongst others:

- location and topographical, as well as geographical position of the TRIGA Center Atominstitut,
- meteorological factors,
- geological, hydrological and seismological conditions,
- building structure and components (referring to the reactor hall),
- description of the reactor plant including operating conditions, control systems, safety systems and monitoring systems,
- ventilation of the reactor hall,
- operational management and operational safety of the reactor,
- security status (access authorisations and security personnel),
- safety and accident analysis and
- an overview of the current status of the decommissioning concept.

Under the topic of safety analysis and emergency planning, various scenarios are dealt with without going into detail about the probability of occurrence:

- extreme external, natural hazards,
- extreme external, unintentional man-made hazards,
- extreme external, deliberate man-made hazards,
- abnormal operation and malfunction,
- loss of coolant accident,
- reactivity transient,
- failure of the crane during fuel assembly transport,
- rupture of the crane support cable or other load-bearing component
- and jet pipe B – white jet.

Among other things, scenarios such as complete loss of cooling water or rupture of the cladding of a fuel element or all fuel elements as a result of external force effects were considered and their respective radiological effects on the environment were calculated (the latter in 2010). In particular, the analysis of an extremely improbable accident (worst-case scenario) should be mentioned here. Namely, the complete destruction of the reactor hall and the reactor shielding. Thereby the destruction of all fuel elements and the release of the volatile fission products were assumed under the most unfavourable meteorological conditions (low wind speed). As already mentioned in Chapter 2.1.2, in the worst-case scenario an accumulated dose of up to 0.37 mSv can be expected after one day (also after 50 years) in the main wind direction at a distance of 105 m to 210 m.

The safety considerations show that the research reactor at the TU Wien can be used without special pressure-safe containment due to its special inherent safety characteristics and since minimal risk to personnel, the public and the environment is to be expected during normal operation as well as during accidents.

In the internal safety report of the TRIGA Center Atominstitut of the TU Wien described above, the effects of a fire in the reactor hall, the reactor control room or in the annex are classified as low. Especially since the reactor hall is designed as a separate fire compartment. The reactor hall, reactor control room and annex are monitored by fire detectors and fire alarms are automatically forwarded to the fire brigade.

2.1.5 Periodic review and management of changes

The recurring inspections such as maintenance/revisions of fire protection facilities are based on normative/regulatory requirements. BIG as the building owner is responsible for commissioning maintenance work, repairs and revisions regarding the building. These inspections cover components relevant to fire protection such as the fire alarm system, the closing of fire dampers and conformity with existing guidelines.

The fire alarm system is inspected annually by a certified installation company. During this maintenance, all fire detectors are triggered to check their functionality. Furthermore, the capacities of the emergency power supply of the fire alarm control panel are measured and it is calculated whether the required emergency power supply (72 h or 36 h in the case of permanently present personnel) is maintained. The result of the maintenance is recorded in a protocol that is co-signed by the contracted company and the operator. Any deficiencies found and not immediately remedied are listed in a report. The most recent maintenance report shows all deficiencies that have already been remedied by the licensee.

Additionally, the fire alarm system is inspected every two years by a body authorised to recheck compliance with TRVB 123 /23 (S) (fire alarm systems) and TRVB 114 /22 (S) (connection conditions of fire alarm systems to public fire brigades).

The escape lighting, ventilation systems, smoke outlets in the stairwells and fire doors are being serviced regularly. The last maintenance report shows no deficiencies in that regard.

The portable fire extinguishers are serviced every 2 years, most recently in February 2023. The inspection list and a location list of the portable fire extinguishers are available.

The maintenance of the fire doors was carried out by BIG in September 2022. Whereas maintenance of fire dampers was carried out by BIG in August 2022.

In addition to the maintenance, repairs and revisions of fire protection equipment, inspections of the research reactor are carried out by the competent authority in accordance with § 61 of the Radiation Protection Act 2020. The most recent inspection did not reveal any fire protection deficiencies.

2.1.5.1 Overview of actions

The basic approval for the research reactor was issued on the 12th of August 1959. Subsequently, in 1962, a modification of the construction permit plan was applied for. On the 18th of March 1963, the completion of construction works was notified and the operating permit was issued. Only rudimentary fire protection measures were part of the submission plans and no direct fire protection requirements were issued to the building applicants in the permit.

On the 3rd of October 1980, an application was submitted for the construction of a storage room for reactor components and low-level radioactive material and for the storage of gas. According to the requirements at that time, these rooms on the ground floor and basement were designed as independent fire compartments. An automatic fire alarm system with smoke detectors was installed in these areas in order to automatically close the fire dampers of the ventilation system (supply and exhaust air).

A fire alarm system with full protection was installed in 1984 (see 3.2.1.1).

On the 24th of October 1984, a decision of the competent building authority required the construction of comprehensive building improvements in regards to fire protection. The staircases were separated with respect to fire protection in order to ensure safe evacuation of personnel. Furthermore, the reactor hall, the lecture hall, office and laboratory areas had to be constructed as separate fire compartments. The physical separation between the corridor and the reactor hall on the ground floor was realised in form of a fire protection glazing.

In 1991, the renovation of the north facade – the outer wall of the reactor hall – was approved. In 1993, the renovation of the south facade was approved. In 1995, organisational fire protection measures as well as facilities for first response to fires were prescribed by the building authority.

On the 29th of December 2005, a building permit was issued for the modification of the room layout on the ground floor of the south-east wing in the area of laboratories and work rooms. In addition, a steel construction including a catwalk was attached to the flat roof on the inner courtyard side for the arrangement of the heat exchangers of the air conditioning system. An escape ladder into the courtyard was required.

In 2008, remediation measures of the staircases A and B were implemented. The change entailed a partial renewal of the fire doors to EI_2 30-C (fire-resistant for 30 minutes and self-closing), the renewal of the flooring to B_{fl}-s1 (flame resistant with very limited contribution to fire, low smoke development), railing adjustments and the renewal of the handrail.

In 2010, room reallocations and changes to the room layout were implemented in the course of restructuring measures. To provide light for a newly created laboratory area in the basement of the building, a light trench was constructed on the north side and new windows were installed on the north and west facades. Furthermore, two insertion openings were made in the roof area of the building for the insertion of ventilation and air-conditioning units. In addition, a lift shaft was constructed in the courtyard-side roof area in the north-eastern area of the institute from the 2nd basement to the 1st floor.

In a final step structural changes with regard to a new freight lift were approved on the 19th of August 2014. A storage room for an oil tank was rededicated; henceforth, the entrance to the elevator had been separated in terms of fire protection.

On the 19th of December 2018, a state of the art fire protection concept for the construction of a new institute building on the site was created by a qualified company. This additional building was constructed next to the main building. It is free-standing on all sides and has an escape level of approximately 12 m. It was constructed in accordance with the latest fire protection regulations. The distance from the main building is large enough to minimize the mutual influence of the buildings in case of fire.

In 2021, a fire protection risk assessment with regard to the primary protection goal of protection of building occupants was commissioned from the owner of the building. Based on this risk evaluation a results matrix with a priority ranking of the necessary fire protection measures was prepared.

2.1.6 Licensee's experience of fire safety analyses

Based on the low hazard potential of the TRIGA Mark II research reactor and the inherent safety of the fuel, as well as the internal safety and incident analysis (see Chapter 2.1.4), the existing fire safety analysis as part of the safety report is sufficient for the TRIGA reactor in Vienna.

Nevertheless, fire protection is of enormous importance to ensure the safety of students, staff and the public. Numerous improvements over the past decades have shown that there is a constant effort to keep up with the state of the art.

2.1.7 Regulator's assessment and conclusions on fire safety analyses

2.1.7.1 Overview of strengths and weaknesses identified by the regulator

The design of the TRIGA Mark II research reactor and the structure of the fuel result in a low hazard potential overall. In addition, the preventive fire protection measures in place correspond to the technical state of the art, both structurally and operationally, as well as to Austrian specifications and international standards.

Furthermore, the operator analysed the potential risk associated with fire as part of their safety report and conducted an extensive safety and incident analysis (see chapter 2.1.4).

Additionally, a fire protection evaluation including a risk assessment was conducted for the institute building with a focus on the protection of building occupants (see chapter 2.1.1) in 2021. Minor improvements will be made in a timeframe that is acceptable to the risk associated.

Thus, the implemented measures and the existing analyses are considered adequate in relation to the low hazard potential.

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

In the course of the regular inspections of the TRIGA Center Atominstitut according to § 61 of the Austrian Radiation Protection Act 2020, a fire protection inspection is carried out. If deficiencies relating to fire protection are identified, they must be remedied within a reasonable period of time. The remediation of deficiencies is being checked afterwards by the fire protection experts of the City of Vienna.

2.1.7.3 Conclusions drawn on the adequacy of the licensee's fire safety analysis

Overall, both the structural and the operational measures of preventive fire protection correspond to the current state of the art. Furthermore, fire protection was adequately analysed by the licensee. The documents prepared by the licensee contain all relevant information in relation to fire protection.

Inspections are carried out regularly. Prescribed measures are implemented in appropriate periods of time in order to meet all fire protection requirements.

In conclusion, the licensee's fire safety analysis is deemed adequate.

3 Fire Protection Concept and Its Implementation

3.1 Fire prevention

3.1.1 Design considerations and prevention means

In general, the measures and rules of conduct with regard to preventive fire protection in the premises of TU Wien (but especially for occupants of laboratory premises) are laid down in the Fire Protection Regulations of the TU Wien. They include:

- the responsibility and competence,
- the training of university employees of the TU Wien (as fire safety officers or fire safety wardens),
- general duties to cooperate (applies to all occupants of university properties),
- duty to cooperate in preventive fire protection,
- behaviour in case of fire,
- assembly points, and
- behaviour after a fire.

Further requirements for general behaviour regarding preventive fire protection are regulated in the Fire Protection Regulations of the TRIGA Center Atominstitut. In this document, all relevant people and their responsibilities for fire protection are laid down (see chapter 3.4 for further details).

The most important procedures for the behaviour in the event of a fire are available on clear notice boards, to support the people in the TRIGA Center Atominstitut in case of an emergency.

Further guidelines that must be followed by the employees of the TRIGA Center Atominstitut in the event of a fire – such as the triggering of the alarm (if this does not happen automatically) and the behaviour in the event of a fire – are defined in the House Rules of the TRIGA Center Atominstitut (last version 2021).

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

In order to keep the fire load in the reactor hall low, there is almost no combustible storage there, apart from a few worktables whose work surfaces are made of fibreboard. Furthermore, only euro pallets made of flame retardant plastic are used in the reactor hall and any wooden transport boxes must be removed from the reactor hall as fast as possible after delivery.

General rules of conduct are defined in the Fire Protection Regulations of the TRIGA Center Atominstitut, for instance

- handling of combustible waste,
- storage of flammable material,
- use of electrical equipment,
- use of machinery,
- use of vehicles,
- smoking ban,
- work activities involving fire,
- keeping escape routes clear,
- the closing mechanism of fire doors must not be blocked,
- securing of work rooms after completion of work.

The mandatory fire safety instructions for staff and students and their documentation, as well as provisions on the general duty for cooperation are written in the Fire Protection Regulations of the TU Wien.

The implementation of prescribed fire protection measures and the provisions of the Fire Protection Regulations of the TU Wien are monitored by the responsible persons defined in the Fire Protection Regulations of the TRIGA Center Atominstitut (fire safety officers, fire safety wardens, fire safety team).

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

The fire protection monitoring of the TRIGA Center Atominstitut is carried out by a fire alarm system with full protection in accordance with TRVB 123 /23 (S). The building is divided into different fire compartments in compliance with Austrian standards. All fire detectors installed throughout the building correspond to the fire load for the respective area.

The fire alarm system is serviced by a specialised company once a year. Any defects are documented and forwarded to the BIG or GUT for repair. A siren test is also carried out in the entire building as part of the maintenance. If structural measures require adjustments, these are also implemented. In addition to the annual maintenance, the fire alarm system is inspected by testing the fire alarm centre every two years.

Structural measures were carried out in 2008, when the entire building was renovated based on the newest fire protection standards. The staircases of the institute building can be mentioned as an example here: All wooden materials used were replaced by flame retardant aluminium components. In addition, the ventilation of the staircases was changed from manual operation to automatic operation. The opening of the ventilation for the stairwell is done automatically by the fire alarm system now. In order to reduce the fire load, especially on the escape routes, any fire loads (e.g. empty packaging material) are removed daily. In the reactor hall in particular, all previously used wooden materials were replaced by flame retardant plastic (pallets, etc.).

Since the fire alarm system was put into operation in 1984, there have been no significant fire incidents in the institute building or the reactor hall.

3.1.3.1 Overview of strengths and weaknesses

The ventilation in the reactor hall is equipped with temperature sensors, which means that the fire dampers are closed only when the temperature in the ventilation duct is very high, which always gives maximum priority to the rescue of persons. In both the reactor control room and the safety service, the ventilation of the reactor hall can be switched to "emergency mode". If the radiation warning system detects an increase in measured values in the reactor hall, the supply air can be switched off and the exhaust air halved by switching to emergency mode. This always guarantees that there is negative pressure in the reactor hall and that the deposition of possible radioactive isotopes on the activated carbon filters in the exhaust air is reduced. Overall, no weaknesses have been identified.

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

The direct connection to the fire brigade means that the emergency services can be expected to arrive very quickly in the event of a fire alarm. The fire station assigned to the research reactor has a good local knowledge due to repeated visits to the site. The personnel of the fire brigade in charge is trained in the field of radiation protection. In addition to the fire alarm system, there are 103 hand-held fire extinguishers distributed throughout the building, which also provides an opportunity for direct on-site firefighting by institute staff. The fire extinguishers are adapted to the respective fire load. They are numbered consecutively and checked annually. In addition, all fire doors are inspected by the BIG once a year.

If external companies have to carry out work in the institute, they must fill out a release form for fire hazardous activities before starting their work. The institute's security service switches off the fire detectors in the affected area, enters it into the control book of the fire alarm system and switches the affected detectors back on as soon as the external company has finished their work. This prevents a fire detector from being activated by possible dust or smoke development in the affected area. The contracted companies must ensure alternative fire safety measures for the duration of their work. Through release certificates and the associated assumption of responsibility, the number of false alarms caused in the course of work by external companies could be considerably reduced.

Due to the evacuation drills, an annual instruction of personnel and the special structural features of the institute building, necessary evacuations in the event of a fire alarm are carried out very quickly and without difficulty. The institute's staff assemble at the institute's car parking lot within a few minutes, thus ensuring unhindered entry into the building by the fire brigade.

3.1.3.3 Overview of actions and implementation status

The structural fire protection measures implemented so far have already been listed in chapter 2.1.5.1.

Minor improvements - identified in the frame of the risk assessment in 2021 - will be remedied in a coordinated manner within a timeframe that is proportional to the risk associated.

3.1.4 Regulator’s assessment of the fire prevention

3.1.4.1 Overview of strengths and weaknesses in fire prevention

Since the research reactor was constructed, both the structural and organisational fire protection measures have been continuously improved and adapted to the current state of the art. During 60 years of operation of the research reactor at the TRIGA Center Atominstitut, there has been no fire incident.

In the course of the prescribed annual emergency drills at the TRIGA Center, Vienna’s Professional Fire Brigade is frequently involved in the exercise operations. As a result, the personnel of the responsible fire stations have good local knowledge of the installation and have an overview of the existing measurement possibilities on site. The Vienna Professional Fire Brigade is well equipped to handle fires at the institute due to their special training in radiation protection.

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

Deficiencies detected during regular inspections and revisions of the existing fire protection equipment are remedied within reasonable timeframes. This is being supervised in the course of regular inspections in accordance with § 61 of the Austrian Radiation Protection Act 2020. For instance, in 2021, during the course of an inspection wooden transport boxes were placed in the first floor corridor in front of the reactor hall. Since these boxes increased the fire load and since they were placed in such a way that the prescribed escape route width could not be maintained, the licensee was ordered to remove them. They were removed within the prescribed period.

The number of false alarms of the fire alarm system as a result of work carried out by external companies has been significantly reduced by the introduction of release certificates for fire hazardous activities. In this context, the external companies must register such work with the safety service or, if necessary, with the fire safety officer and comply with the specified fire prevention precautions of the TU Wien. Due to the fire prevention precautions taken during necessary shutdowns of fire detectors, appropriate fire protection can still be provided.

3.2 Active fire protection

3.2.1 Fire detection and alarm provisions

The task of an automatic fire alarm system is to report an incipient fire at the earliest possible time, while avoiding false and deceptive alarms as far as possible, so that

- early evacuation of the hazardous area is possible to minimise personal injury,
- damage to property is kept to a minimum,
- suitable fire-fighting measures can still be initiated.

3.2.1.1 Design approach

The research reactor and the institute building in question are equipped with a fire alarm system with full protection in accordance with TRVB 123 /23 (S) (fire alarm systems), with automatic alarm forwarding to the public alarm receiving agency (Vienna Professional Fire Brigade) in accordance with TRVB 114 /22 (S)(connection conditions of fire alarm system to public fire brigades). In this context, full protection means that the monitoring area extends to the entire institute building, with the exception of areas defined according to TRVB 123 /23 (S) (e.g. rest rooms, porches without significant fire load, false ceilings with a fire load < 25 MJ/m² ...). In addition to automatic alarm forwarding to the Vienna Professional Fire Brigade and triggering of fire controls, an acoustic alarm is sounded throughout the entire institute building.

The fire brigade's infrastructure is located at the main entrance of the institute building and is equipped with an orange flashing light at the entrance. The fire brigade control panel, the fire brigade plan box (containing the management documents for the fire brigade) and the external detector for alarm transmission bypassing the fire alarm control panel (e.g. in the event of a defect in the fire alarm control panel) are located in the porter's lodge directly next to the main entrance. The central control unit of the fire alarm system is also located in the porter's lodge.

3.2.1.2 Types, main characteristics and performance expectations

The fire alarm system according to TRVB 123 /23 (S) currently has approximately 600 fire detectors, whereby individual detector identification is possible via the existing fire alarm control panel. In detail, there are 8 heat detectors, 567 smoke detectors, 25 push-button detectors, 2 linear smoke detectors and 6 ventilation duct detectors. Due to the room height, two linear smoke detectors are located in the reactor hall, although optical smoke detectors are also installed in areas of lower heights in the reactor hall. Ventilation duct detectors were installed to monitor specific ventilation systems in order to enable the earliest possible detection of smoke in the ventilation ducts or, under certain circumstances, in the ventilation control centres. Heat detectors are used in some areas, as there would be an increased risk of false alarms with conventional smoke detectors (e.g. in the weld shop).

To ensure the safety of occupants, an automatic siren alarm is provided as an acoustic warning of persons present. The positioning of the sirens ensures a minimum audibility level of 65 dB throughout the entire institute building. In addition to the fire controls for alarm forwarding to the fire brigade, flashing beacon and key safe, the following fire controls are available:

- alarm
- ventilation system shutdowns
- release of escape doors
- closing of fire doors
- release of lifts
- activation of emergency lighting
- smoke extractors in the staircases

Depending on the conceptual design of the research reactor, a control of the system to a common alarm is installed or a specific reaction of the above mentioned controls is executed.

At the fire brigade's main point of action in the porter's lodge, a control book of the fire alarm system is available. It contains information on events concerning the fire alarm system, such as alarm activations (false, deceptive, alarm activations), shutdowns, maintenance/servicing or revisions.

3.2.1.3 Alternative/temporary provisions

If, for example, fire alarms are switched off during planned construction work in order to prevent false alarms caused by dust or steam development, the external companies carrying out work have to sign a release certificate for fire hazardous activities to comply with the fire prevention precautions of TU Wien. Thus, the companies themselves must ensure sufficient monitoring and, if necessary, fire guards for the duration of their work.

In the event of the above-mentioned shutdowns or if needed, the Vienna Professional Fire Brigade can be alerted at any time by telephone via the Austrian fire brigade emergency number 122.

3.2.2 Fire suppression provisions

3.2.2.1 Design approach

Various hand-held fire extinguishers (CO_2 extinguishers, powder extinguishers and foam extinguishers) are available to combat incipient fires by institute staff before the fire brigade arrives.

There are two above-ground hydrants on the grounds of the institute building that can be used by the fire brigade to supply water for extinguishing. These hydrants are connected to the main water supply of the institute building, which is connected to the drinking water network of the city of Vienna. Based on the infrastructure of Vienna, each hydrant will supply approximately 800 – 1000 litres of water per minute (this will, however, only hold true in case of the usage of a single hydrant, as both hydrants are connected to the same supply line).

The institute building can be completely bypassed by vehicles and can thus be reached all around by fire-fighting vehicles, keeping fire-fighting lines short and thus saving valuable time in the event of a fire.

Due to the low hazard potential of the research reactor, the inherent safety of the fuel, as well as the low hazard posed by the other uses of the institute building, no automatic extinguishing system and no plant fire brigade is required. Instead, the Vienna Professional Fire Brigade handles firefighting at the TRIGA Center Atominstitut.

3.2.2.2 Types, main characteristics and performance expectations

103 hand-held fire extinguishers are available for extinguishing incipient fires. They are distributed throughout the building. This also gives the institute's staff the possibility to fight fires directly on site before the fire brigade arrives. The fire extinguishers are adapted to the respective fire loads and uses. They are numbered consecutively and are checked annually.

3.2.2.3 Management of harmful effects and consequential hazards

In the event of a fire in the reactor hall, the extinguishing water would be collected on the ground floor, as the hall floor is designed as a trough with the purpose to hold the entire cooling water of the reactor pool (approximately 20 m^3).

Due to the low fire load in the reactor hall, however, it is extremely unlikely that such amounts of firefighting water will have to be applied in the event of a fire. Water overflow could be expected in the event of a leakage of the entire primary cooling water and a simultaneous fire event. However, the reactor hall floor drains into two tanks with a volume of altogether approximately 23 m^3. The room where the tanks are located can hold an additional volume of approximately 20 m^3 in case of overflow. Hence, there would have to be applied more than 40 m^3 of firefighting water to cause an overflow of the reactor hall floor.

3.2.2.4 Alternative/temporary provisions

The TRIGA Center Atominstitut has its own welding shop for spark-generating work. If work with an increased risk of sparking or high heat generation has to be carried out outside the welding shop, the executing company must fill out and sign a release form for activities involving fire hazards. The fire detector affected by the work will be deactivated by the porter for the required period in agreement with the responsible institute employee. If more than one fire detector needs to be deactivated, permission must be obtained from a fire safety officer. After completion of the work, the fire detectors have to be reactivated by the porter (after prior consultation with the responsible institute employee). During such activities, hand-held fire extinguishers or other suitable extinguishing agents must be kept ready in the immediate vicinity. The executing companies must continuously check the affected areas. The executing companies are also responsible for any fire watches and follow-up checks after completion of their work.

3.2.3 Administrative and organisational fire protection issues

Every fire alarm activation is automatically forwarded to the Vienna Professional Fire Brigade. Alternatively, it is possible to alert the fire brigade at any time by calling the emergency number 122.

In accordance with the house rules of the TRIGA Center Atominstitut and the notices on how to behave in the event of a fire, a push-button detector must first be activated in the event of a fire (if the fire alarm system has not already been triggered) and the fire brigade or the porter must then be notified via the internal house emergency call. The porter shall then make the necessary notifications in accordance with the Work Instructions to Porters of the TRIGA Center Atominstitut. Subsequently, further notifications shall be decided on an occasion basis in accordance with the licensees Emergency, Notification and Response Plan.

As soon as the acoustic warning device sounds, all staff members must leave the building immediately and go to the assembly point. This procedure is monitored by the fire safety guards and the fire safety team in accordance with the Fire Protection Regulations of the TRIGA Center Atominstitut.

If there is an alarm from the fire alarm system during reactor operating hours, the reactor operation must be stopped immediately. The reactor operator is responsible for the subsequent rapid and calm evacuation of all persons present in the reactor hall.

3.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

The TRIGA Center Atominstitut does not have a plant fire brigade. According to the Fire Protection Regulations of the TU Wien and the Fire Protection Regulations of the TRIGA Center Atominstitut, the staff is primarily responsible for evacuating the building and only for initial extinguishing measures in the event of small incipient fires (see chapter 3.4).

The Vienna Professional Fire Brigade then performs the actual firefighting. Depending on the damage situation (fire with or without release of radioactive substances), either a standard firefighting method with the usual protective equipment for firefighting is executed, or the fire brigade officer-in-charge can fall back on existing protective equipment, measuring technology and decontamination capacities of the Vienna Professional Fire Brigade. Regarding protective equipment, the Professional Fire Brigade keeps ready dust- and/or liquid-tight protective suits in combination with circulating air-dependent or circulating air-independent respiratory protection as well as gas-tight protective suits in combination with circulating air-independent respiratory protection. Furthermore, the Vienna Professional Fire Brigade has various measurement systems for the detection of alpha, beta, gamma and neutron radiation. However, in this case, the existing measurement technology and expertise of the personnel of the TRIGA Center Atominstitut is also reverted to. In addition, the Vienna Professional Fire Brigade has equipment for setting up a mobile decontamination line for the personnel deployed.

In the event of a fire, the fire brigade has access to the following command and control equipment in the porter's lodge:

- single detector identification of the fire alarm system,
- fire brigade control panel,
- detector group directory,
- fire protection plans,
- notification lists, and
- evacuation records in form of dosimeter that were handed in by employees.

Furthermore, the Vienna Professional Fire Brigade is repeatedly involved in the annual emergency drills of the TRIGA Center Atominstitut in order to continuously improve the site knowledge of the emergency team of the responsible fire stations.

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

As described in chapter 3.2.3.1, the TRIGA Center Atominstitut does not have a plant fire brigade. Firefighting is covered by the Vienna Professional Fire Brigade.

The responsibilities of the staff are precisely assigned in the Emergency, Notification and Response Plan of the TRIGA Center Atominstitut. It is defined who can declare a radiological emergency and who takes over the command in the event of an emergency. If the decision-makers are not present in the TRIGA Center Atominstitut, they will be contacted by the porter. Furthermore, this document describes the tasks of the incident commander as well as the messages and alarms to be executed. For the duration of the fire brigade operation, the officer-in-charge of the fire brigade takes over the management of the incident. The TRIGA Center Atominstitut's operations manager provides technical advice and information on special hazard areas.

The internal documentation of fire incidents is done in the control book of the fire alarm system (located in the porter's lodge). Repairs, maintenance, recurring inspections and revisions of the fire alarm system are also noted there. The external documentation is prepared by the fire brigade's officer-in-charge in form of the mandatory mission report after completion of the operation activities.

3.3 Passive fire protection

3.3.1 Prevention of fire spreading (barriers)

3.3.1.1 Design approach

The reactor hall is designed as a separate fire compartment. The laboratory rooms (if not directly connected) and the lecture hall are designed as separate fire compartments as well. All components forming fire compartments are solid constructions consisting of reinforced concrete with the prescribed classification (90 minutes fire resistance).

Apart from the entrance area – where a ceiling opening in the area of the stairs exists, which leads to a two-story fire compartment – there is a floor-by-floor fire compartmentation throughout the building.

Inside the building, the walls and ceilings forming the fire compartments have the prescribed classification (90 minutes fire resistance). For a horizontal fire compartmentation in the exterior area, the facade has an exterior wall strip across the ceiling in the prescribed classification (90 minutes fire resistant) with a height of approximately 120 cm.

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

The reactor hall (on all floors), all laboratory rooms, stairwells (with the exception of the stairwell in the entrance area) and the lecture hall are designed as separate fire compartments. Furthermore, individual rooms with an increased risk in case of fire (such as the ventilation control centre, central heating room, pump rooms, transformer room, welding workshop, gas cylinder store, isotope store) are designed as separate fire compartments as well.

The reactor pool has a diameter of approximately 2 m and is surrounded by a concrete shield, which is approximately 2 m thick. Furthermore, there is a water column of about 5 m above the top of the reactor core. A failure of the main power supply results in a reactor fast shutdown. The heat generation in the fuel elements is so low that the natural coolant convection in the reactor tank is sufficient to dissipate the decay heat. Therefore, the reactor can be considered as a separate fire compartment regarding the preventive fire protection.

The stairwells inside the building are designed as separate fire compartments, whereby the stairwell walls and ceilings are of solid construction (reinforced concrete walls and ceilings) of the prescribed classification (90 minutes fire resistant) and the doors are standardised in the prescribed classification (30 minutes fire resistant, according to the Austrian Standard ÖNORM B 3850).

External walls, load-bearing walls and ceilings of the institute building are of solid construction (reinforced concrete) in the prescribed classification (90 minutes fire-resistant).

The fire compartments of the corridors and office areas have been selected in such a way that there are no escape routes longer than 40 m from any area inside the building to the outside or to one of the two staircases.

3.3.1.3 Performance assurance through lifetime

Inspections of the functionality of the (automatically) closing fire doors and fire dampers are conducted annually. Defects are documented and the building owners take appropriate steps to rectify them. Regarding the most recent inspections of the fire protection equipment, please refer to section 2.1.5.

3.3.2 Ventilation Systems

The reactor hall has one supply air system and two exhaust air systems, whereby the exhaust air system (construction part A) has an air flow rate of 12600 m^3/h and the exhaust air system (construction part B) has an air flow rate of 13400 m^3/h. The volume flow of the supply air system is slightly lower than that of the two exhaust air systems, thus ensuring a negative pressure of 10 Pa. This prevents any uncontrolled escape of radioactive gases and aerosols through leaks or door gaps into the vicinity of the reactor hall. A filter system (pocket filters G4, F7 and F9 one after the other) is installed upstream of the supply air system and a filter system (F9, H14, activated carbon and abrasion filter E11 one after the other) is installed downstream of the exhaust air systems in order to separate gaseous contaminants as well. The exhaust air system of construction part A also contains the exhaust air from the ion exchanger room and the jet pipe ventilation.

The reactor control room has its own supply air system with an airflow rate of 1500 m^3/h. The reactor control room does not have its own exhaust air system. An air volume of 1200 m^3/h is extracted through the exhaust air system of construction part A of the reactor hall. The difference of 300 m^3/h ensures that an overpressure prevails in the reactor control room compared to the reactor hall, so that in the event of leaks and door gaps, the flow direction always leads into the reactor hall.

If the airflow for the reactor supply air or the reactor exhaust air (exhaust air system construction part A and construction part B) falls below 50 % of the maximum possible airflow, a reactor fast shutdown is executed. A message will be displayed on both, the graphic monitor and the text monitor via the reactor instrumentation. The proper performance of this reactor fast shutdown is tested during the annual repeated inspections.

The reactor hall exhaust air ducts are monitored with aerosol monitors (collection and measurement of radioactive aerosols for emission monitoring) and NaI scintillation detectors (monitoring of gamma emitters). The measured values are displayed in the reactor control room, the radiation protection office and the porter's lodge.

In the event of an incident with increased release of radioactivity, the ventilation system will be switched from normal operation to emergency ventilation, with an air flow rate of about 4600 m^3/h in the A line and about 3900 m^3/h in the B line. Particularly since the supply air fan will be switched off, there will still be sufficient negative pressure in the reactor hall. The jet tube ventilation will continue to operate in the event of an incident.

The supply air fan to the control room can also only be put into operation if at least exhaust air A is in operation. In the event of a fire, the ventilation continues in normal operation.

Multi-leaf fire dampers of the qualification EI 90 (fire-resistant for 90 min) were set at the entrance and exit of the ventilation centre and integrated into the reactor monitoring system. Additional EI 90 fire dampers are installed wherever the ventilation lines penetrate fire compartment boundaries.

3.3.2.1 Performance and management requirements under fire conditions

This information can be found in chapter 3.3.2.

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

The roles defined below are responsible for fire safety throughout the institute:

- central fire safety officer (ZBSB),
- fire safety officer (BSB),
- fire safety warden (BSW),
- fire safety team (BST).

Fire Safety Officers (BSB)

1. Fire safety officers (BSB) and deputies are appointed for the individual object groups at the TU Wien.
2. The scope of duties of the BSB depends on the respective object conditions and in particular on the relevant provisions of the relevant TRVB. In the area of monitoring compliance with measures for preventive fire protection, the provisions as for the Central Fire Protection Officer (ZBSB) shall apply accordingly.
   The BSB is the contact person for fire prevention officers in their common local or substantive areas of activity. The activities are to be coordinated with the ZBSB.
3. The fire safety officer (BSB) shall in particular have the following general duties:
   a) Participation in possible changes to the fire protection regulations, fire protection plans and alarm regulations.

b) Keeping the fire safety book.

c) Carrying out inspections in accordance with an inspection plan to rectify fire hazard deficiencies.

d) Checking that the necessary markings are complete.

e) Regular inspections of buildings including basements, attics and garages.

f) Recording and keeping records of the names of university officials to be notified in case of fire during night time.

Fire Safety Wardens (BSW)

The duties of fire safety wardens are as follows:

1. The fire safety wardens (BSW) shall undergo relevant training within the framework of the legal provisions.
2. The fire safety wardens shall support the ZBSB and the respective BSB in the performance of their duties and shall monitor fire safety in the local area of operation of the workplaces. The BSW shall report visible deficiencies, sources of danger and grievances to the respective BSB in charge (implementation of the inspection in accordance with an inspection plan). The rectification of deficiencies shall also be monitored and documented.
3. Their main task is to take the necessary initial measures in the event of a fire and to ensure peace and order.
4. In the event of a fire alarm, BSWs shall report the fire to the responsible BSB.
5. In the event of a fire alarm, BSWs shall immediately ensure that the university staff behave in accordance with the Fire Protection Regulations.
6. When the evacuation order is given, the BSW shall ensure,
   a) that occupants leave the buildings in a calm and orderly manner via the nearest escape routes and emergency exits,
   b) the lifts are empty and no longer in use,
   c) the physically handicapped are assisted and no one is left behind in the rooms.

Fire Safety Team (BST)

The duties of the fire safety team are as follows:

1. The fire safety team (BST) shall assist the respective BSB in the performance of duties.
2. Their main task is to take the necessary initial measures in the event of an emergency, to carry out the evacuation and to support the security service, as well as to ensure peace and order.
3. In the event of an alarm, the BST shall immediately ensure:
   a) that the occupants of the TU Wien behave in accordance with the fire protection regulations,
   b) that the occupants of the TU Wien leave the buildings in peace and order via the nearest escape routes and emergency exits,
   c) the doors of the rooms and the corridor doors are closed,
   d) the lifts are not used,
   e) the physically handicapped are assisted,
   f) no one is left behind in the rooms.

Fire safety instructions given by a person with a specific function as defined above shall be followed immediately and all observations of deficiencies in the field of fire safety shall be reported to them immediately.

Persons with a specific function are responsible for monitoring and complying with the fire protection measures prescribed by the authorities and the provisions of the Fire Protection Regulations.

Based on this structure and the general behaviour described in the Fire Protection Regulations of the TRIGA Center Atominstitut (order and cleanliness, no storage of flammable waste, etc.), the outbreak of fires could be effectively prevented in recent years and the evacuation necessary in the course of a false alarm could be carried out quickly and without problems.

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

The fire protection concept has been continuously improved and adapted in the past, so that it corresponds to the current state of the art. It should be noted that the implemented fire protection concept provides a significantly higher level of protection than what was prescribed when the reactor building was constructed. (Note: The Viennese Building Code does not require an adaptation to the current state of the art, since the reactor was constructed in the 1960s and all requirements have been met at the time.) Nonetheless, many improvements have been implemented over the past decades. For instance, in 2021 an independent evaluation of fire protection was conducted at the site, and any potential for improvement that was identified will be implemented in a timely manner. In addition to the independent evaluation of the operator, regular inspections are carried out by the authorities in accordance with § 61 of the Radiation Protection Act 2020.

With regard to fire suppression provisions, fire extinguishing blankets could be provided and distributed throughout the building in addition to the hand-held fire extinguishers as further improvement. Even though fire blankets are not required by law, it could help the institute's personnel to extinguish developing fires with as little damage to the infrastructure as possible.

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

The fire protection concept of the TRIGA Mark II research reactor operated by TU Wien, as well as its design, is deemed appropriate with regard to the low hazard potential of the TRIGA reactor. In some areas, a higher level of safety was implemented than required by law.

The cooperation between the staff of the TRIGA Center Atominstitut and the Vienna Professional Fire Brigade can be positively highlighted. Due to the repeated joint exercises, the fire brigade has good local knowledge of the premises on which the reactor is located.

With regard to fire suppression provisions, as further improvement fire extinguishing blankets could be provided and distributed throughout the building in addition to the hand-held fire extinguishers. Even though fire blankets are not required by law, it could help the institute's personnel to extinguish developing fires with as little damage to the infrastructure as possible.

In conclusion, the fire protection concept and the implementation are consistent and adequate in relation to the hazard potential of the research reactor.

4 Overall Assessment and General Conclusions

The implemented structural and reactor specific measures of preventive fire protection in the TRIGA Center Atominstitut at the TU Wien correspond to the current state of the art and have been implemented in accordance with Austrian laws and standards. Organisational fire protection has also been implemented in accordance with existing regulations.

Inspections are carried out in regular intervals and implementation of prescribed measures as well as remediation of any deficiencies are performed in a timely manner. In addition, structural and organisational adjustments are continuously adapted in order to remain state-of-the-art in terms of fire protection.

One improvement is recommended in the area of fire suppression: fire extinguishing blankets could be provided and distributed throughout the building in addition to the hand-held fire extinguishers. Even though fire blankets are not required by law, it could help the institute’s personnel to extinguish developing fires with as little damage to the infrastructure as possible.

Guidelines and Standards

IAEA Safety of Research Reactors, Specific Safety Requirements, IAEA Safety Standard Series No. SSR-3, STI/PUB/1751, ISBN 978-92-0-104816-5, Vienna, Austria, September 2016, https://www-pub.iaea.org/MTCD/publications/PDF/P1751_web.pdf.

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Abbrevations

ASI	Austrian Standards Institute
BIG	Bundesimmobiliengesellschaft
BSB	Fire Safety Officer
BST	Fire Safety Team
BSW	Fire Safety Warden
CEN	European Committee for Standardisation
EEC	European Economic Community
ENSREG	European Nuclear Safety Regulators Group
EU	European Union
EURATOM	European Atomic Energy Community
GUT	Department of Buildings and Technology
IAEA	International Atomic Energy Agency
ISO	International Organization for Standardization
NAR	National Assessment Report
ÖBFV	Austrian Federal Fire Brigade Association
OIB	Austrian Institute of Construction Engineering
ÖNORM	Austrian Standard
ONR	Austrian technical specifications, ON-Regel
TPR II	Topical Peer Review II
TRIGA	Training, Research, Isotope Productions, General Atomics
TRVB	Technical Guidelines for Preventive Fire Protection
TU Wien	Technical University of Vienna
ZBSB	Central Fire Safety Officer

Laws and Ordinances

English title	German short title	German Long Title
Radiation Protection Act 2020	Strahlenschutzgesetz 2020	Bundesgesetz über Maßnahmen zum Schutz vor Gefahren durch ionisierende Strahlung idF BGBl. I Nr. 50/2020
Workplace Ordinance	Arbeitsstättenverordnung	Verordnung der Bundesministerin für Arbeit, Gesundheit und Soziales, mit der Anforderungen an Arbeitsstätten und an Gebäuden auf Baustellen festgelegt und die Bauarbeiterschutzverordnung geändert wird idF BGBl. II Nr. 309/2017.
Viennese Building Technology Ordinance 2020	Wiener Bautechnikverordnung 2020	Verordnung der Wiener Landesregierung, mit der bautechnische Anforderungen festgelegt werden idF LGBl. Nr. 4/2020
Viennese Building Code	Wiener Bauordnung	Wiener Stadtentwicklungs-, Stadtplanungs- und Baugesetzbuch idF LGBl. Nr. 70/2021
Workers Protection Act 1994	ArbeitnehmerInnenschutzgesetz	Bundesgesetz über Sicherheit und Gesundheitsschutz bei der Arbeit idF BGBl. I Nr. 115/2022
Federal Civil Servants Protection Act 1999	Bundes-Bedienstetenschutzgesetz	Bundes-Bedienstetenschutzgesetz idF BGBl. I Nr. 205/2022
Standards Act 2016	Normengesetz 2016	Bundesgesetz über das Normenwesen idF BGBl. I Nr. 153/2015
General Radiation Protection Ordinance 2020	Allgemeine Strahlenschutzverordnung 2020	Verordnung der Bundesministerin für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, des Bundesministers für Soziales, Gesundheit, Pflege und Konsumentenschutz und der Bundesministerin für Digitalisierung und Wirtschaftsstandort über allgemeine Maßnahmen zum Schutz vor Gefahren durch ionisierende Strahlung idF BGBl. II Nr. 339/2020

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