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KOREAN NUCLEAR SOCIETY

KNS 2018 Autumn Meeting, October 24-26, Yeosu Expo Convention Center

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Design of Spent Fuel Storage Facilities for the Load Cases of Earthquake and Aircraft Impact

Technical Specifications, Methods and Examples for Wet and Dry Storage

KNS 2018 Autumn Meeting, Yeosu, 10/25/2018,

Session 3A, Radioactive Waste Management

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Introduction

Climate change and its consequences are obvious

A climate-neutral energy production is more important than ever and nuclear energy can help to generate energy in a climate-neutral way

The nuclear fuel cycle involves safety risks that need to be minimized

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Introduction

IAEA's Specific safety guide SSG-15 provides guidance and recommendations on the design, safe operation and assessment of safety for wet and dry spent fuel storage facilities:

- **Preferably passive, inherently safe systems (§6.3)**
- **The concept of defense in depth should be applied (§6.14)**
- **A multi-barrier approach should be adopted (§6.4b)**

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Introduction

- **The facilities should maintain their structural integrity in all operational states and accident conditions (§6.15)**

- **Subcriticality, heat removal, containment of radioactive material, radiation protection and retrievability of the fuel should be fulfilled**

- **Structural and mechanical loads such as earthquakes are to consider properly (§6.25-§6.46)**

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Introduction

The situation in several countries is characterized by an uncertainty, how to specify and qualify spent fuel storage facilities:

When will a final repository be operational?

How to bridge the period until a final repository is available?

What is the expected service lifetime of the storage facility?

Which type of storage facility is the most appropriate – wet or dry?

Design Procedures

A basic requirement for interim storage facilities is the robustness of the building structure against the load cases earthquake (DBE) and airplane crash (APC)

The applied procedures during the design phase are similar for both DBE and APC:

A. Consideration of soil-structure-interaction (for soils differing from rock conditions)

B. Linear dynamic analyses

C. Evaluation of design floor response spectra

Common Design Procedures DBE and APC

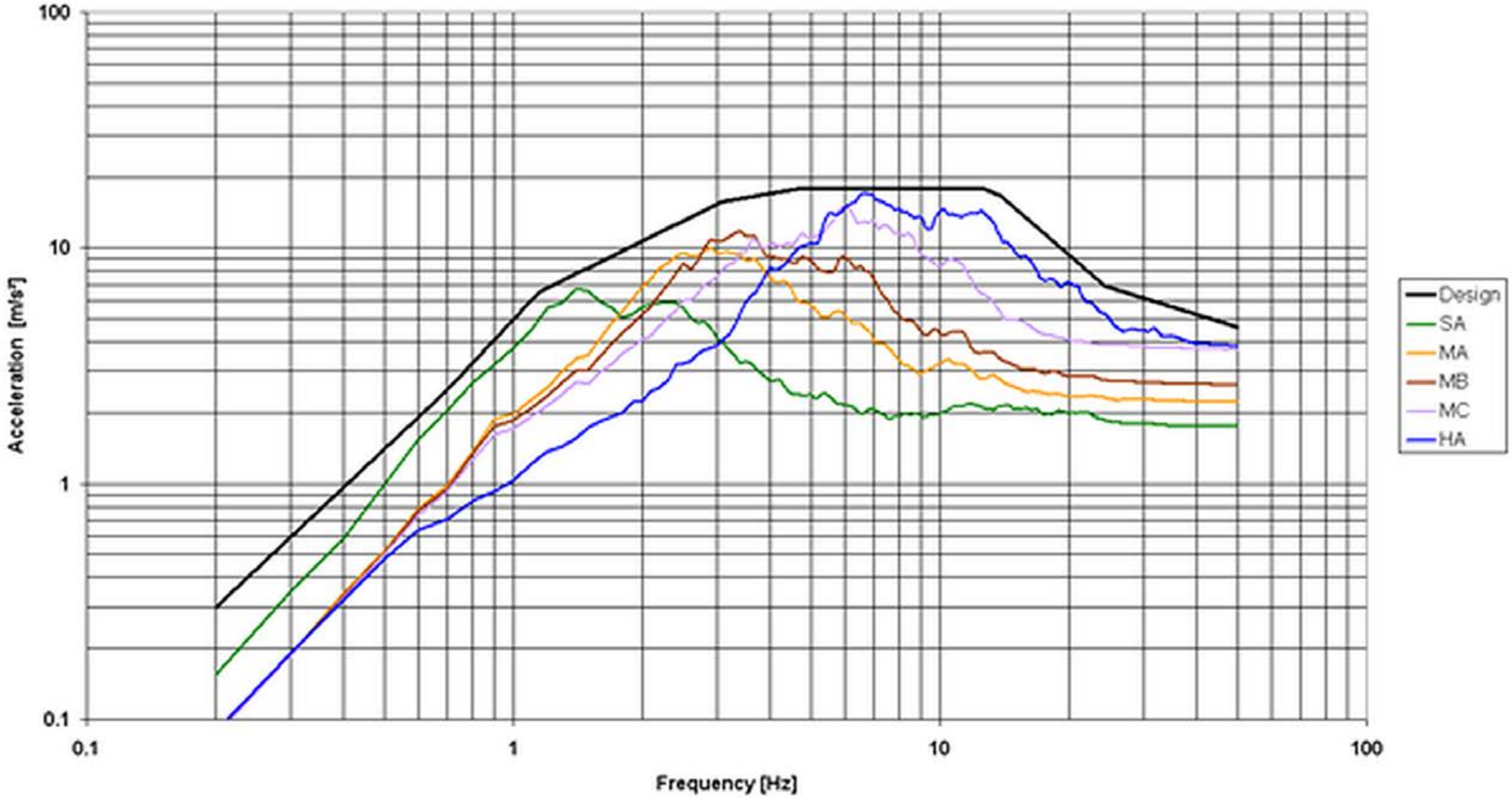

Figure 1: Evaluation of design floor response spectra (calculation by Max Aicher Engineering)

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Design Procedures for the Load Case DBE

The design of the building structure…

…is performed on the basis of response spectrum method calculations for consideration of the DBE

…taking into account soil-structure-interaction and load case combinations with forces due to permanent and variable static loads

…has to be verified regarding uplift criteria in case of dynamic excitation

Design Procedures for the Load Case APC

Figure 2: Impact of a fighter plane on a concrete wall, © Sandia National Laboratories

Design Procedures for the Load Case APC

More and more regulatory commissions require a verification that the nuclear facilities, designed on the basis of DBE, are capable to resist aircraft impact

Although the load function for a military aircraft is standardized and publicly available, there is no standardized load function for large passenger airplanes

Design Procedures for the Load Case APC

The definition of the load function for large passenger airplanes is subject to an agreement between operator and regulatory commission

For different nuclear facilities, huge differences of the prescribed APC load functions are present, depending on the selected aircraft parameters and primary on the adopted impact velocity, as shown in fig. 3

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Design Procedures for the Load Case APC

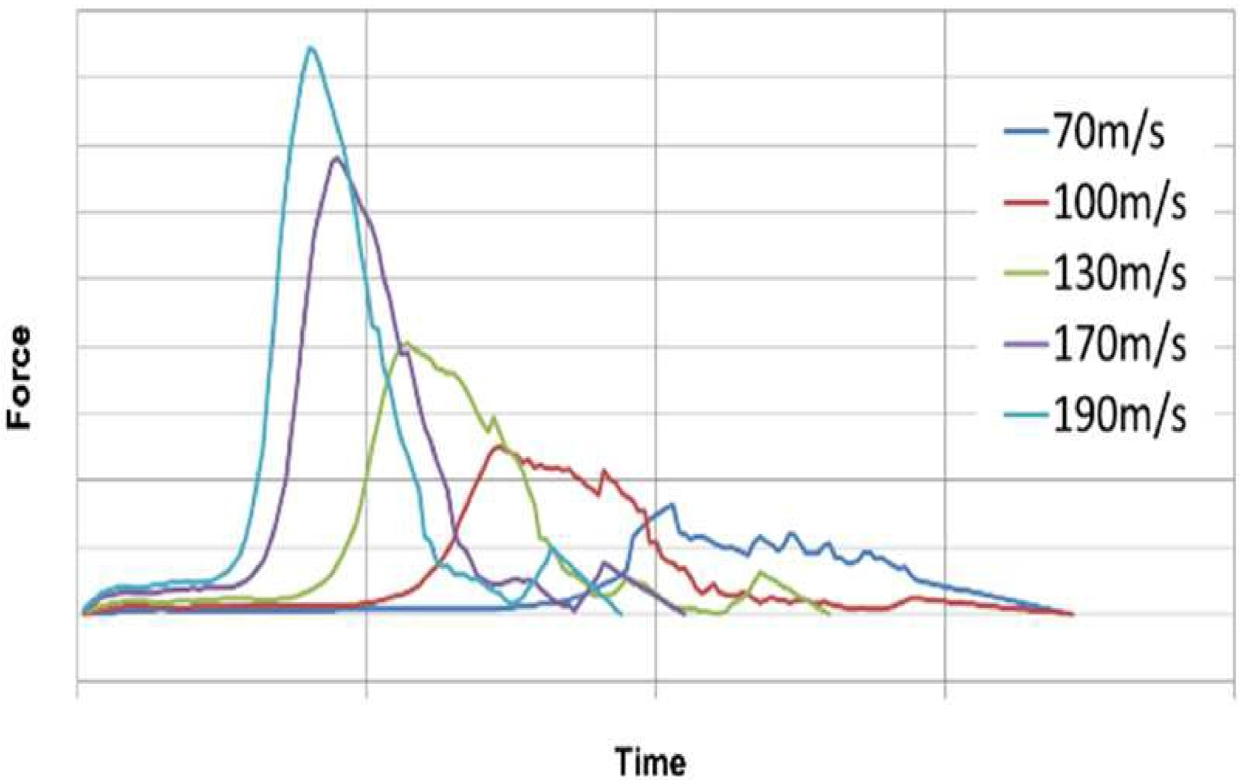

Figure 3: Influence of the impact velocity of a large passenger airplane on induced force, Calculation of Max Aicher Engineering for an Airbus A380

Design Procedures for the Load Case APC

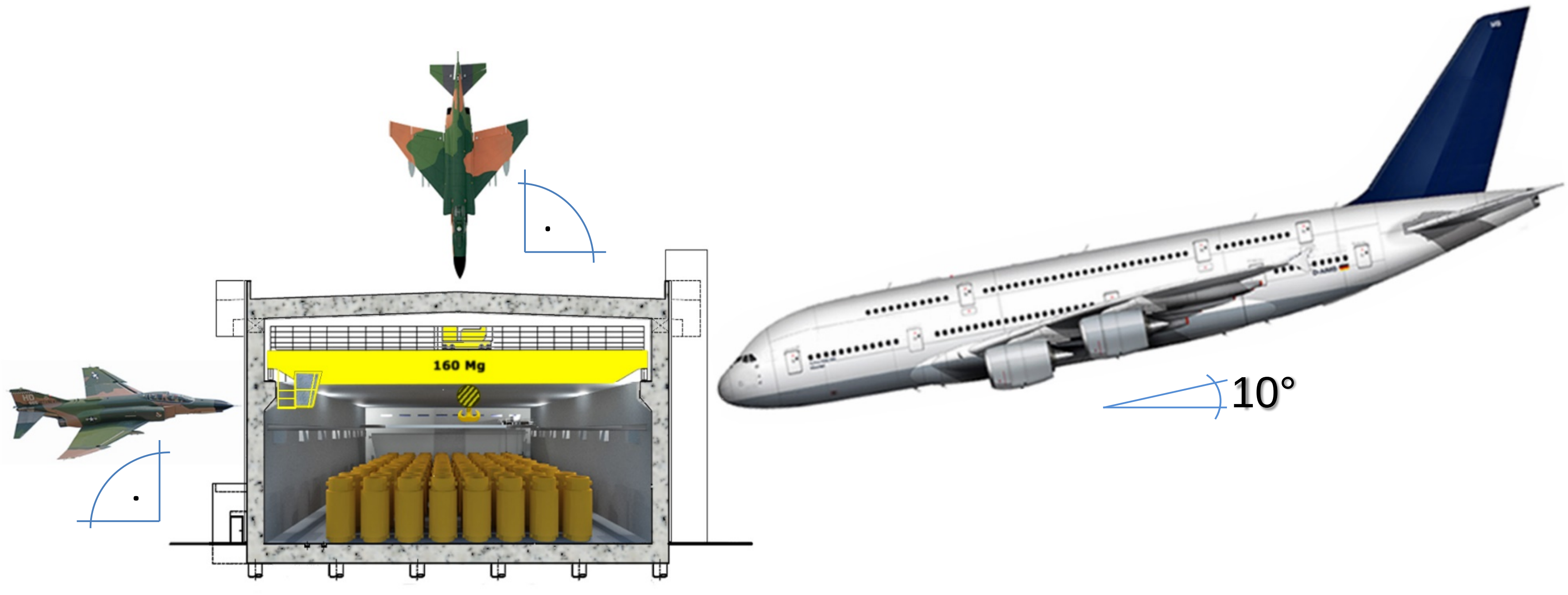

Figure 4: Maximum impact scenarios in case of an airplane crash – military aircraft and large passenger aircraft

Design Procedures for the Load Case APC

The verification of APC resistance consists of following steps:

- Nonlinear calculations for design check of bending capacity at most unfavorable impact locations
- Design check of shear resistance
- Design check of resistance against penetration, scabbing and perforation

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Contemporary Storage Facilities - Proven Safety for 40 – 60 years

Dry storage casks like CASTOR © offer a high level of safety against an airplane crash

Therefore a storage building might not be necessarily safe against an airplane crash, but…

> **…the aircraft fuel needs to be drained to avoid an overheating of the casks**

> **…for the recovery of the casks, the operation of the overhead crane in the building has to be secured**

Examples for High-End Long-Term Storage Facilities for Dry Storage

Safety for > 100 years

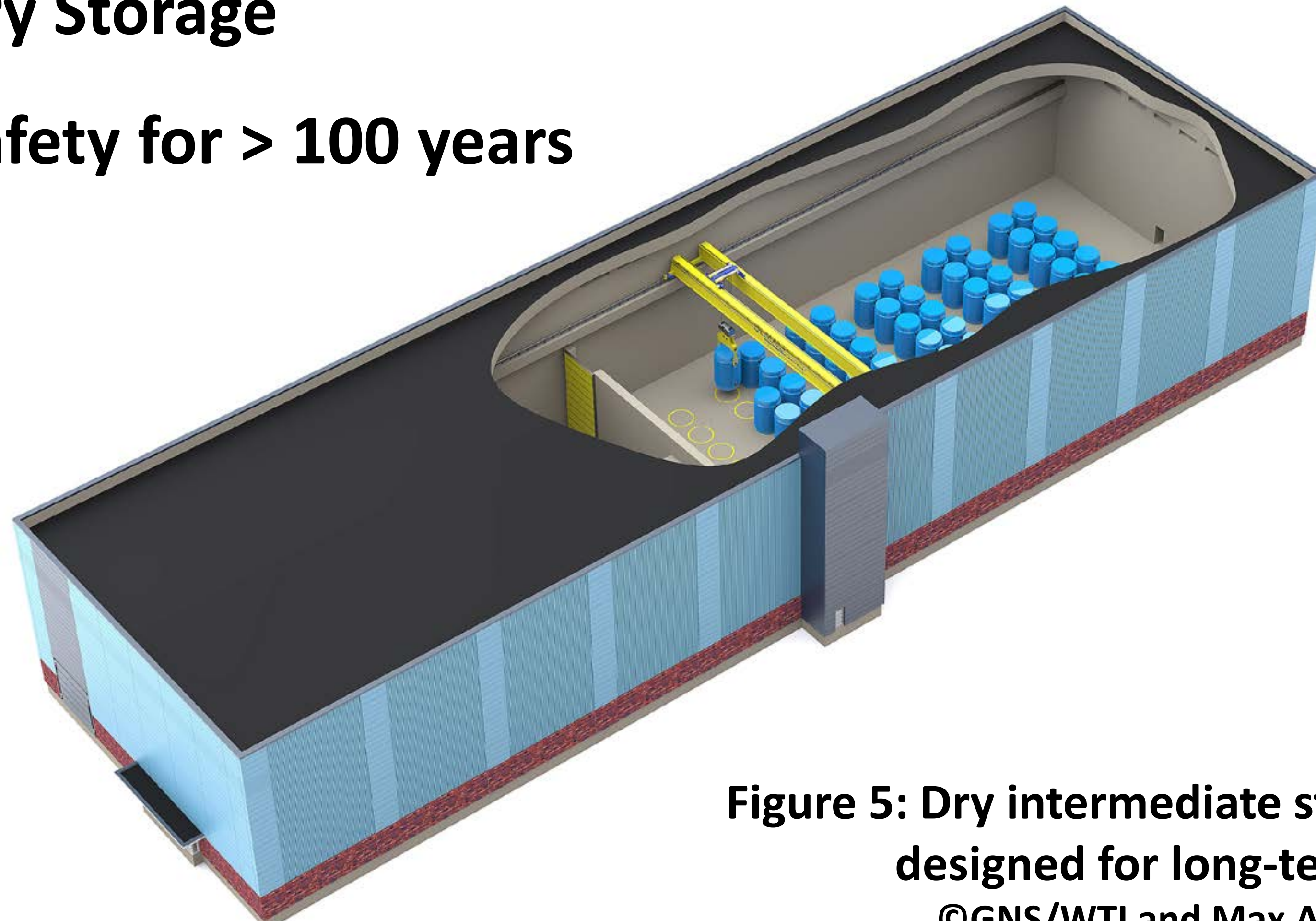

Figure 5: Dry intermediate storage facility, designed for long-term operation,
©GNS/WTI and Max Aicher Engineering

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Examples for High-End Long-Term Storage Facilities for Wet Storage

Figure 6:
Wet storage facility, designed for long-term operation
©Kernkraftwerk Gösgen-Däniken AG

Examples for High-End Long-Term Storage Facilities for Wet Storage

Figure 7:
Wet storage facility, designed for long-term operation
©Kernkraftwerk Gösgen-Däniken AG

Examples for High-End Long-Term Storage Facilities for Wet Storage

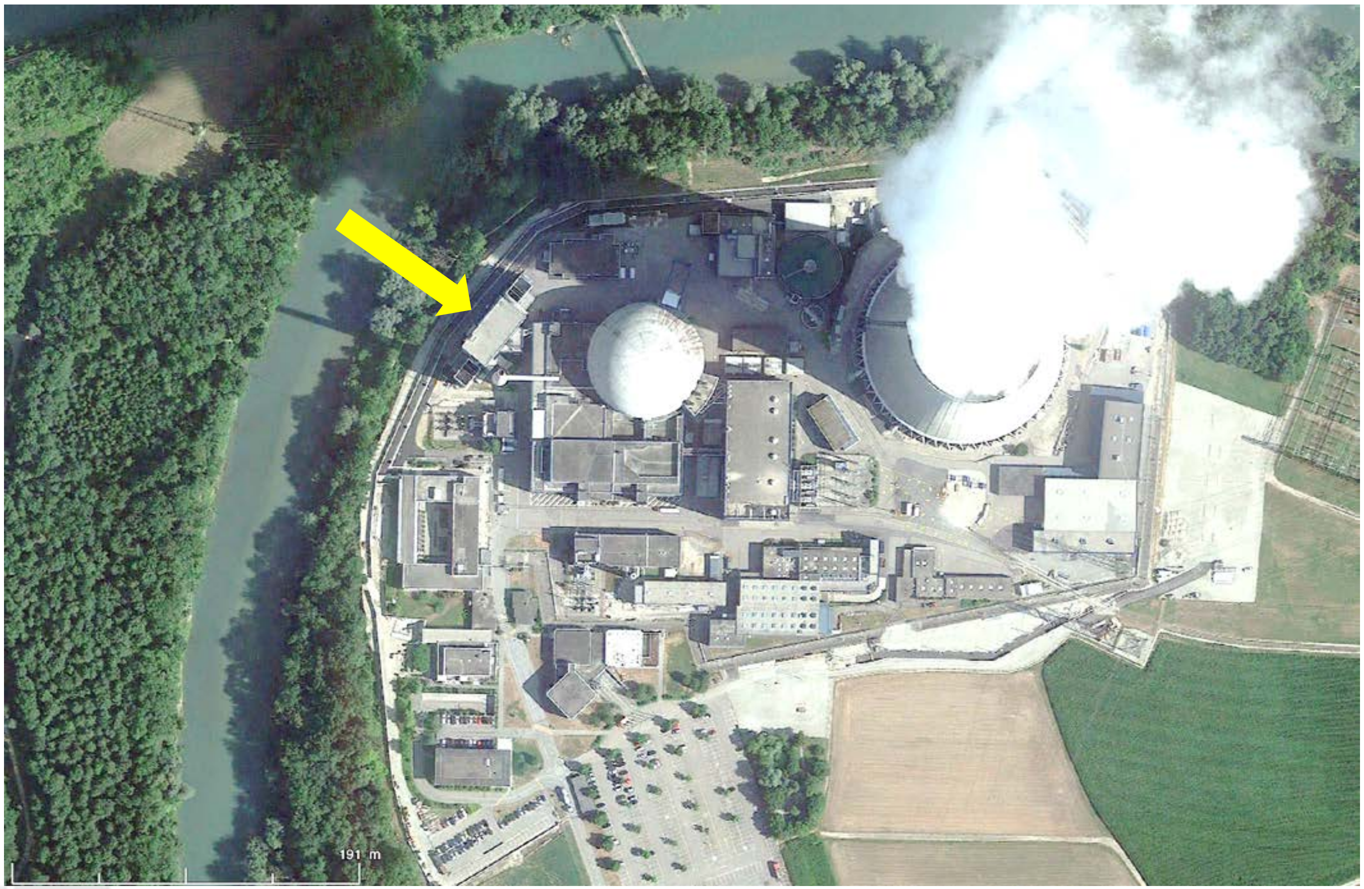

Figure 8: Aerial view NPP Gösgen, Switzerland

Source: **Google Earth**

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Examples for High-End Long-Term Storage Facilities for Wet Storage

Figure 9: Wet storage facility, designed for long-term operation

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Conclusions

The application of modern calculation methods results in sufficient resistance against eartquakes and aircraft impact

Depending on the availability of final repositories, the lifespan of interim storage facilities will increase in the future

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Conclusions

The design of the building structure has to take into account the longer service period to ensure radiation protection

Max Aicher Engineering offers adequate and affordable solutions,

- Designed with Building Information Modeling (BIM),

- Failsafe and Reliable

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감사합니다!

Thank You for Your Attention

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We would love to answer your questions.
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