framatome

DEVELOPMENT OF VVER-1000 FUEL ASSEMBLY SHIPPING SOLUTION BY FRAMATOME: PROJECT OBJECTIVES AND STATUS

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VVER-1000 container project manager

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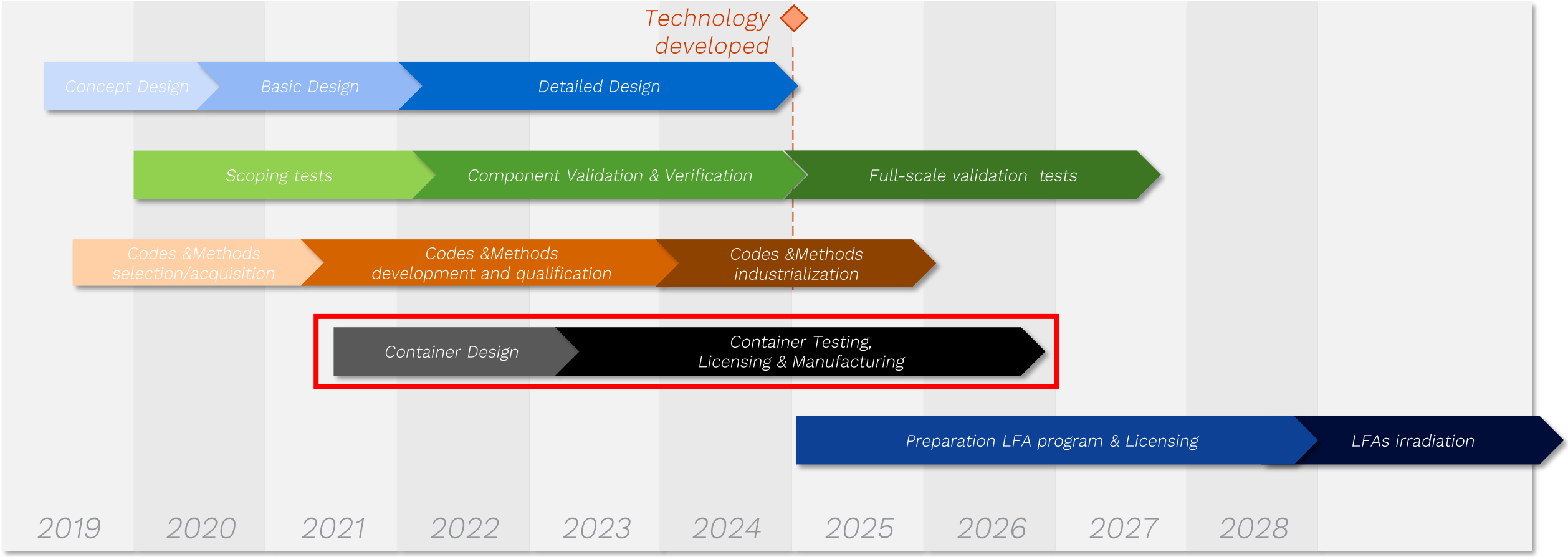
Roadmap

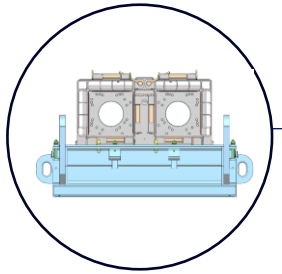
VVER-1000 Framatome own-design



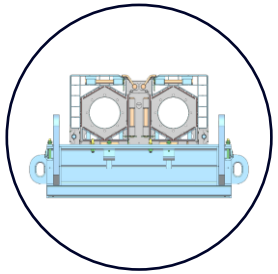
Framatome VVER-1000 container

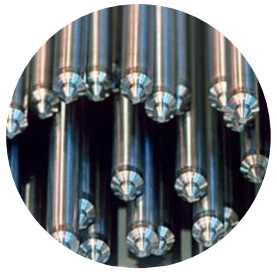
Project definition

Proven high-quality design
Modified version of the existing PWR fuel transport container ANF-18, which has demonstrated safety and reliability over the past 25 years



IAEA Test Series for VVER
Demonstration of Robustness and Safety of the Modified Container (VVER) through FEM Calculations and IAEA Test Series with German authorities (BAM / BASE)





IAEA licensing standard
Licensing on-going according to international standards of IAEA (SSR-6)

European Sovereignty
Design and manufacturing supply chain fully European

ANF-18 container

Key numbers

2000

Licensed for the first time

The ANF-18 container has been developed at ANF and tested (IAEA Test series) with the German authorities in 2000.

8

Licensed in 8 countries (IF)

- Germany
- Switzerland
- Poland
- Spain
- France
- Netherland
- Sweden
- Finland

70

Fleet of 70 ANF-18 container

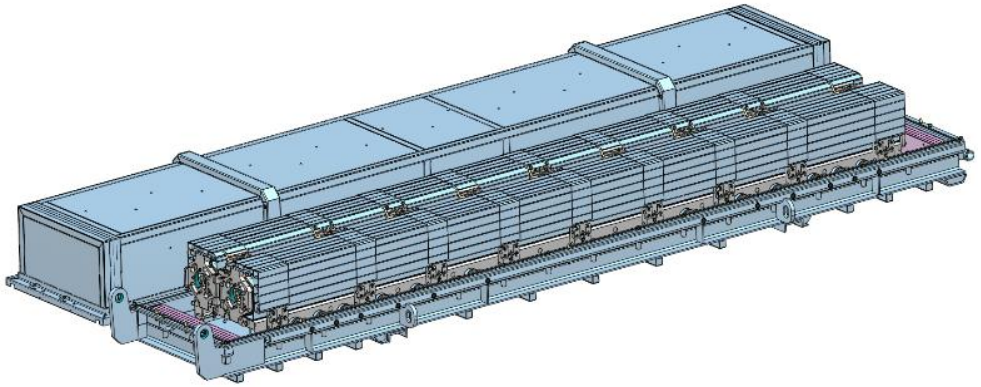
Currently 58 ANF container available

- 12x new VVER container in manufacturing
- 12x VVER modification sets in manufacturing (upgrade of current ANF-18 fleet)
- 24x ANF-18 VVER container planned for VVER-1000 transports

2

Different type of products

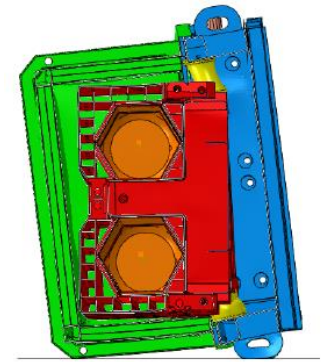
Typ: 14x14; 15x15, 16x16, 17x17, 18x18 and VVER-1000
ANF-18 VVER can transport 2 VVER-1000 fuel assemblies

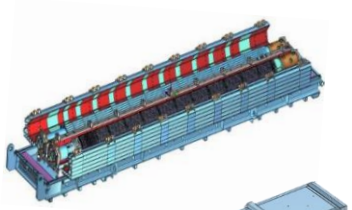


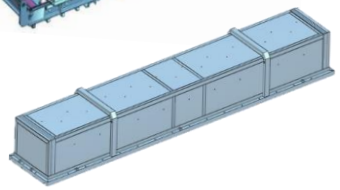
Measurements:
Height: 794 mm
Width: 1.136 mm
Length: 5.866 m
Cavity length: 4.890 mm
Empty Weight: 2.860 kg
Gross Weight: 4.700 kg

Preparation of the IAEA test series

- Determination of the worst **drop orientation**
  - Set up of a complex FEM model
  - Calculation of various drop orientations
  - Evaluation of these orientations with accompanying criticality calculations
- Preparation of test series related documentation
- Manufacturing of ANF-18 VVER container
- Manufacturing of dummy FA
- Manufacturing of the counterweight
- Design and purchasing of specific handling tools & fixtures
- Design and purchasing of vacuum test chamber for helium leakage test

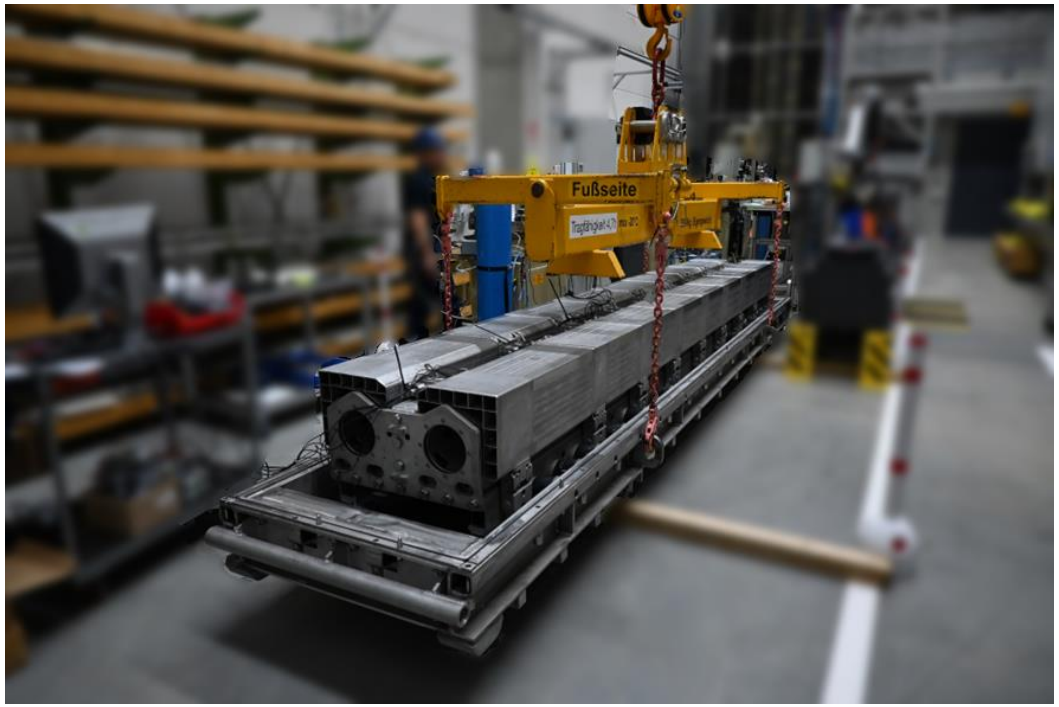


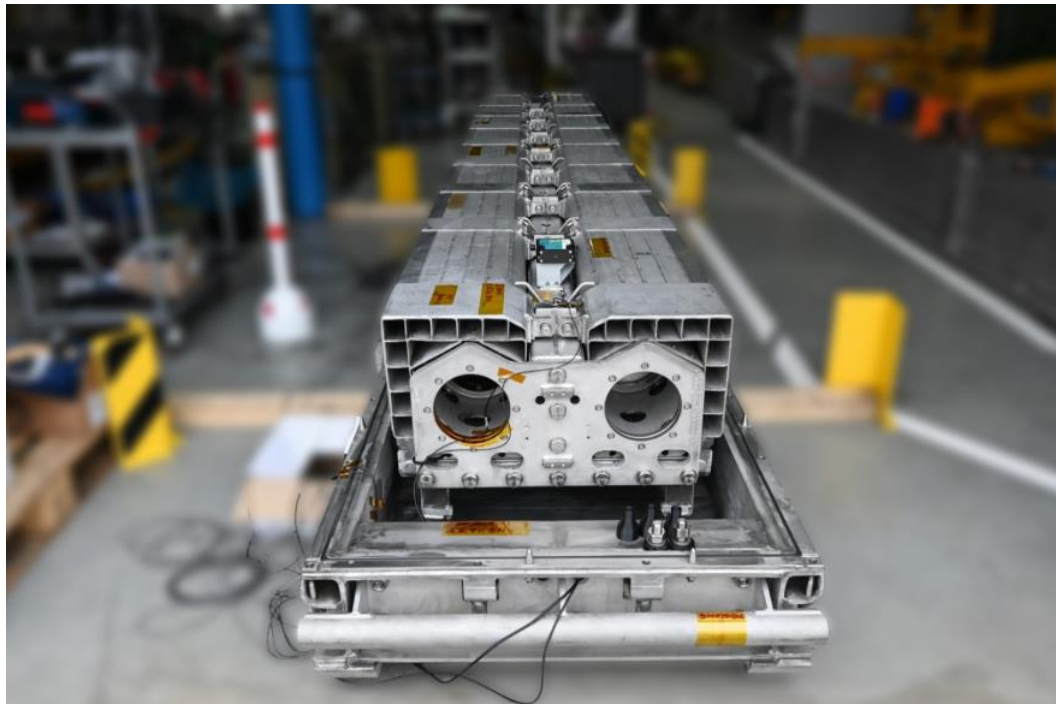




Preparation of the test sample

- Manufacturing of a **drop test container ANF-18 VVER**

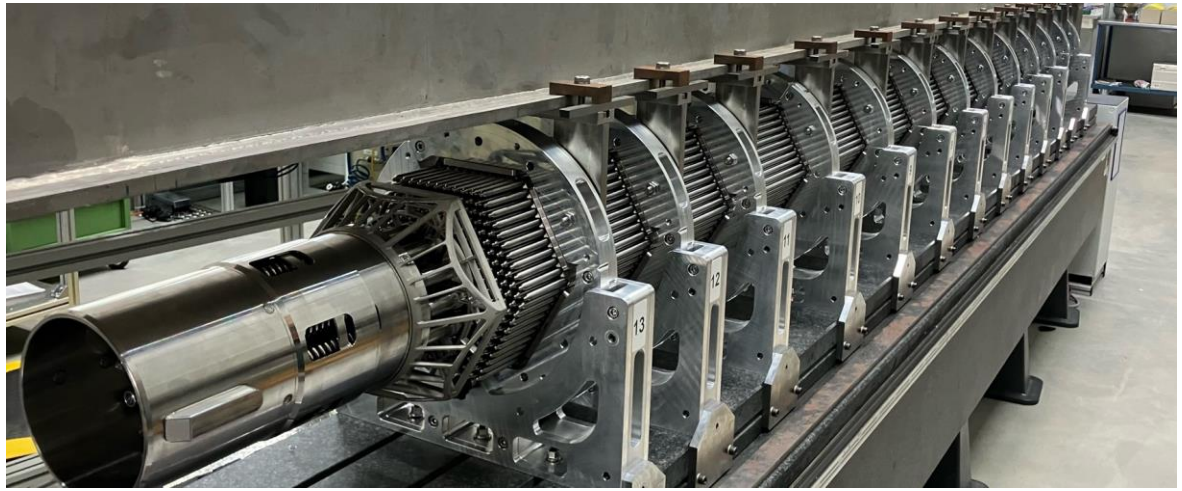




- The ANF-18 VVER was manufactured based on the new design under the supervision of the German authority (BAM) and is representative of the performance of the IAEA test series.
- Together with the dummy FA and the counterweight, they form the test model, which is completely measured, inspected, and subsequently evaluated based on the criticality-relevant dimensions.

Preparation of the test sample

- Manufacturing of a **dummy fuel assembly + counterweight**



- The Dummy Fuel assembly is fully representative of the VVER 1000 design and was manufactured by Framatome prototyping lab.
- The Dummy Fuel assembly was characterized to provide inputs for the counterweight manufacturing.

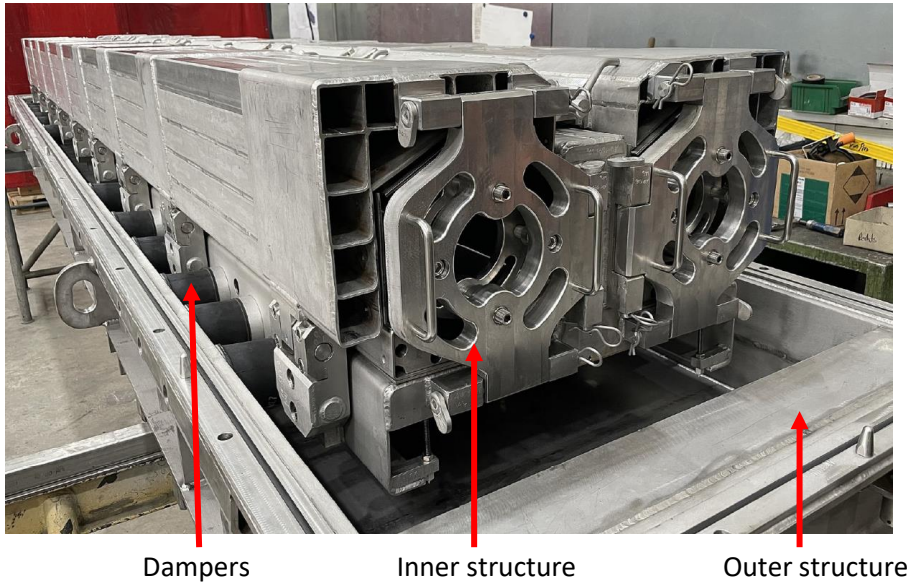
- The counterweight was calculated and designed based on the VVER-1000 design and corresponds in its essential characteristics to the design.
- Calculations regarding bending stiffness, weight, and center of gravity have been carried out.

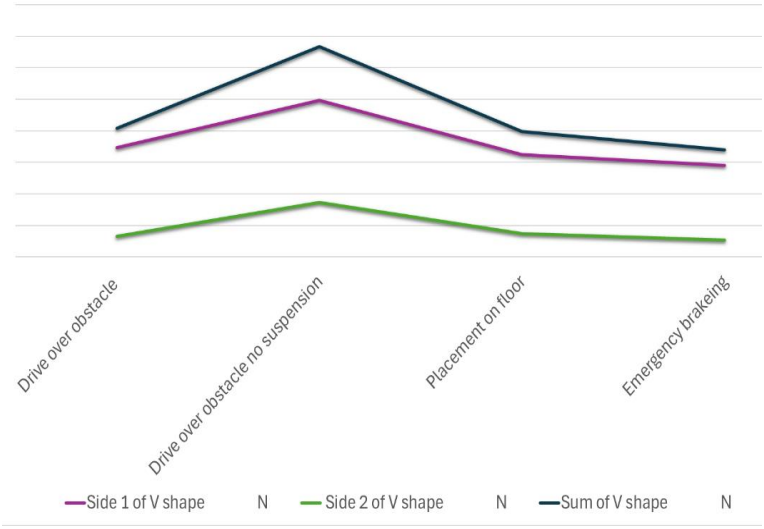
Transport test in real conditions

Transport testing of ANF-18 VVER for VVER 1000 own design

Before the IAEA test series, a transport load test with the ANF-18 VVER test sample was performed:

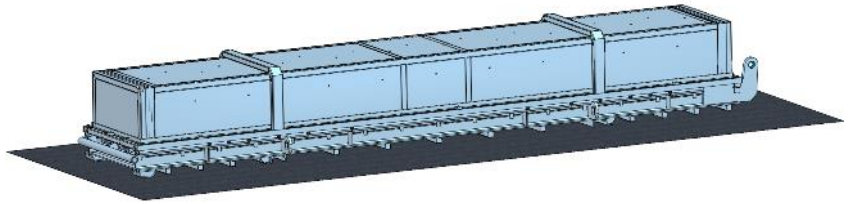
- Special load cases like speed bumpers, rolling over obstacles, suppression of truck suspension, emergency braking
- Handling load cases (crane and forklifted handling with “hard” placement on floor)



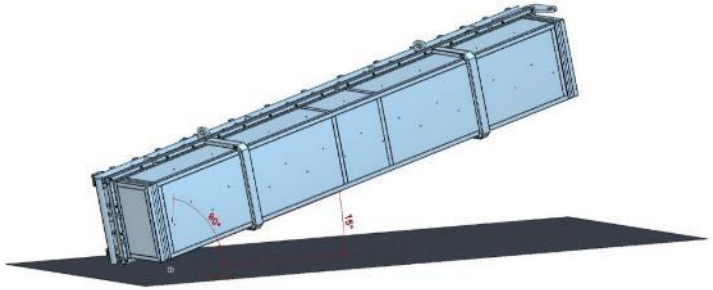


Transport load case shows excellent behavior of ANF-18 VVER for VVER 1000 own design!

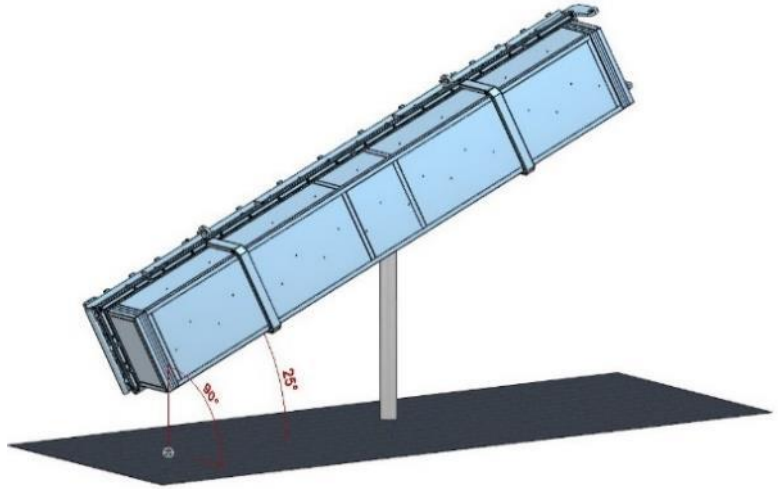
Steps of the IAEA testing series



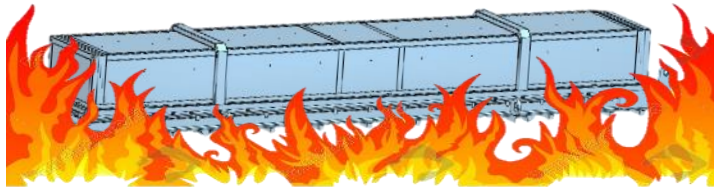
Drop of the container from 1.2 m height onto the bottom structure



Drop of the container from 9 m height onto the worst position (on the side with 15°)



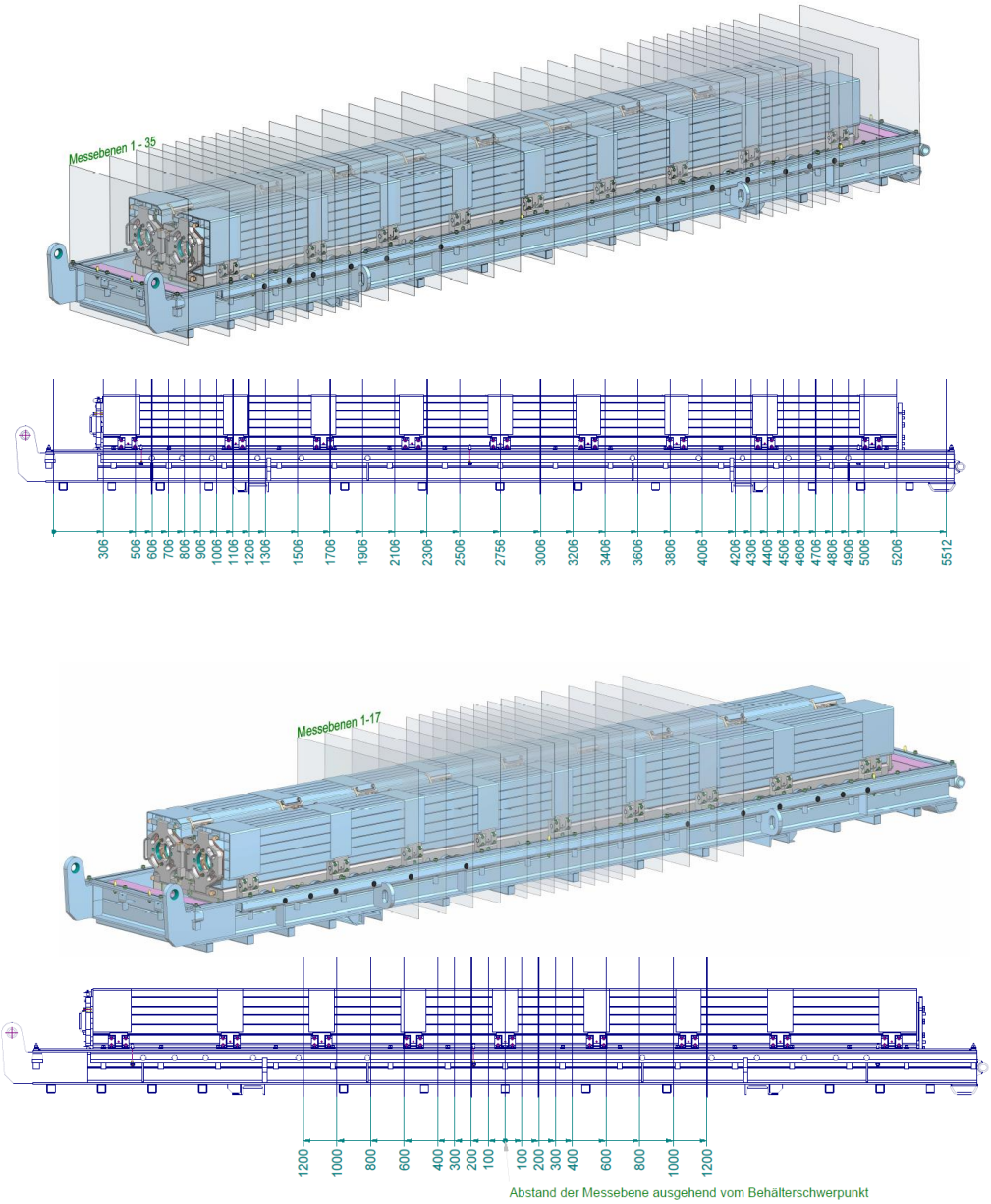
Drop of the container onto a spike on the side with 30° ≈ 1 m drop height



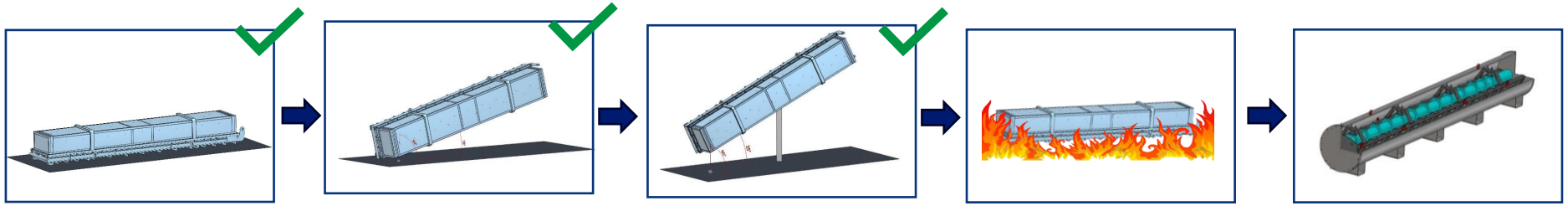
Heating test with 800 °C for 30 minutes

IAEA test series

- **Measuring** of all criticality relevant dimensions before, between and after all individual tests
  - Definition of measuring concept
  - Definition of sensors, cables and planning of their instrumentation for the tests
- Definition, design and manufacturing of **handling equipment & testing equipment**
  - Set up of a handling concept
  - Design of several handling equipment to handle the container and the dummy FA during the tests
  - Test of dummy-FA regarding helium leakage
  - Puncture test of all fuel rods after the test series

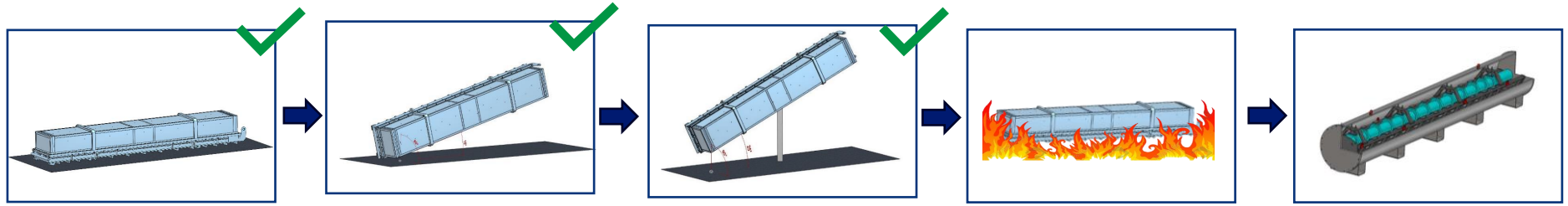


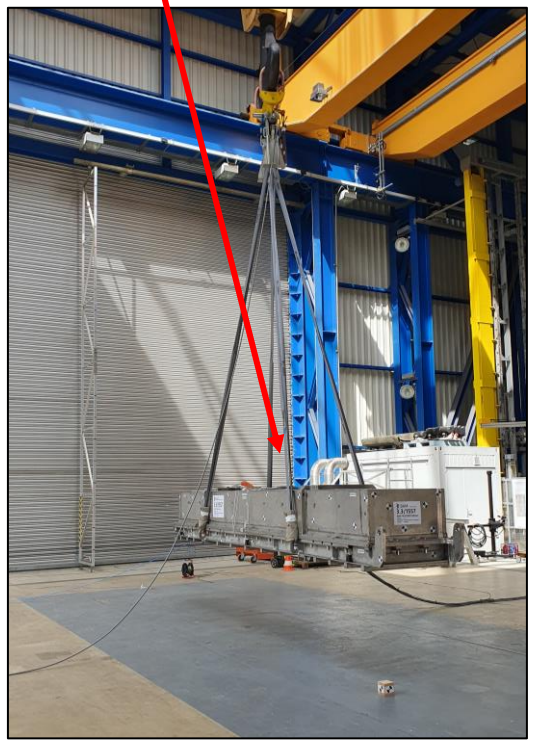
Current Status of IAEA test series

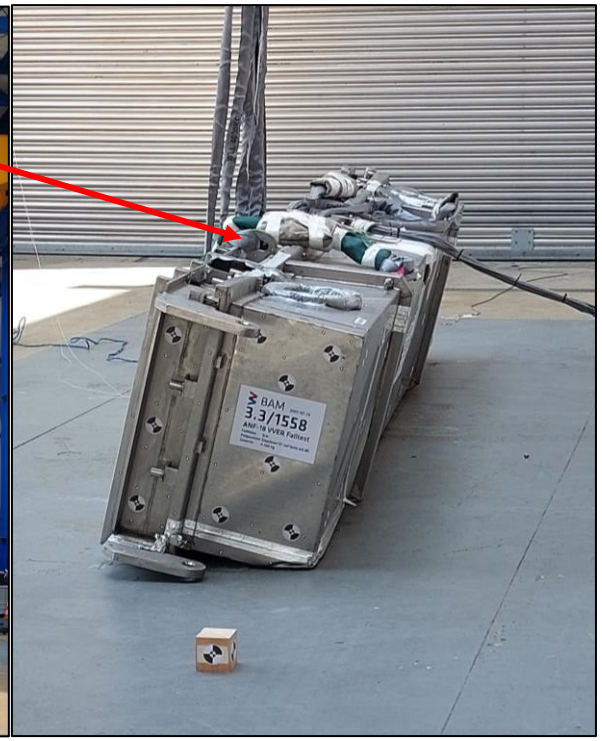


- Drop test out of **1.2-meter**, of **9-meter** and the drop on the **spike** were carried out according to plan, including the measurements and handling.
- The results are consistent with the preliminary FEM calculations, and there were no unexpected events during the drop tests.
- Next month, the heating test will be conducted on the already damaged test sample. Subsequently, the entire dummy FA will undergo a helium leak test, and for verification, all fuel rods will also be punctured and checked for helium content on supervision of German authorities.

Current Status of IAEA test series







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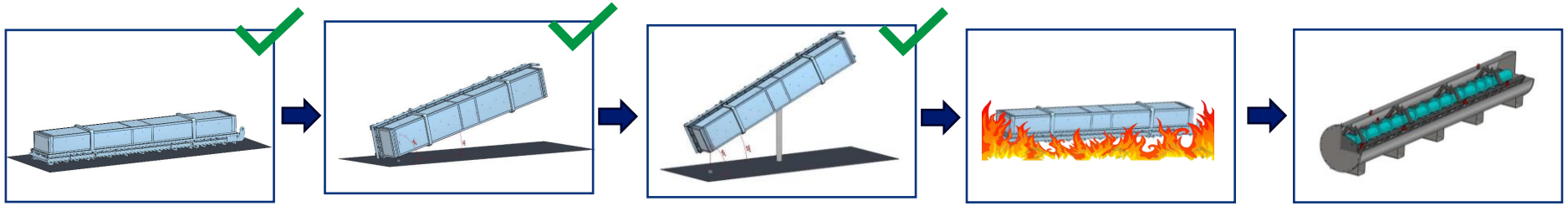
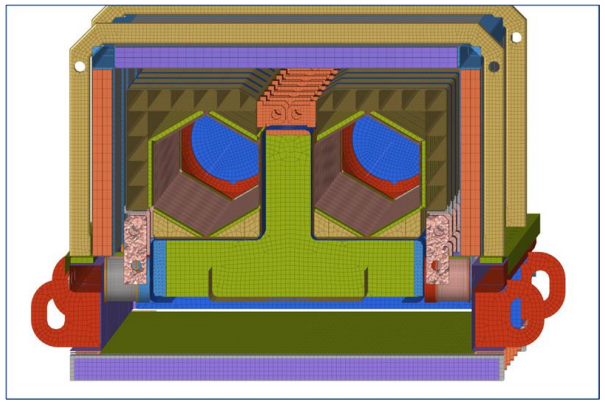


Next steps



- Validation of the FEM model based on the IAEA test series is necessary.
  - A detailed FE Model will be created.
  - Comparison between FE Model damage and real damage on test sample
- After the IAEA testing series, the results will be evaluated, and reports will be written:
  - Criticality analysis
  - Leak tightness analysis
  - Writing of SAR (safety analysis report)
- The SAR will be sent to the authorities to get a license, then this license must be acknowledged by transit countries.
- In parallel the upgrade of existing ANF-18 will take place & manufacturing of new ANF-18 VVER container

Summary

Framatome 100% sovereign European VVER fuel

Framatome develops 100% European sovereign VVER-1000 own-design Fuel Assemblies (FA) and dedicated containers

- VVER-1000 **Lead Fuel Assemblies readiness** targeted for **2028**
- VVER-1000 container is an upgrade of an existing PWR container
- Container IAEA tests campaign progressing well to obtain licensing.

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Thank you