Results of Recent Tests of GNS Transport and Storage Casks for Nuclear Waste – 15285

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ABSTRACT

State of the art dimensioning of casks for nuclear waste is changing rapidly in recent years. Therefore even established packages that serve the market for many years have to face new type testing programs that implements changes to its designs. The paper shows some of the recent testing programs for existing packages and provides an outlook to future casks solutions and its testing programs.

INTRODUCTION

For some decades the casks and containers of GNS have been serving as a reliable solution for the disposal of low- and intermediate-level waste of the operational phase of NPP in Germany. Due to the German phase out of nuclear energy additional waste streams from the dismantling and decommissioning of NPP have to be considered and taken into account during cask design. Recently the operating experience with casks and containers was broadened to foreign markets like the UK. Similar waste characteristics and comparable requirements for transport, interim storage and final disposal necessitate only slight changes in safety cases and elected technical solutions.

The longtime experience ensures consistent cask designs suited for the needs of transportation, interim storage and final disposal. Therefore several variants of the casks were introduced and fitted to different wastes and its handling and treatment in- and outside of the casks. The current product range of GNS includes Type IP-2, Type A and Type B packages for different activity levels. In particular the MOSAIK®[1] casks and the GNS Yellow Box®[2] containers provide a wide range of options for different waste streams like activated and/or contaminated (core) components, resins, sludges, gravel and filters. In the segment of low level waste the cask portfolio is enlarged by the GNS Cladded Concrete Shielding to be used as Type IP-2 or Type A package and by the SBoX®[3] containers. The GNS Cladded Concrete Shielding cask is mainly suited for waste pre-packed in drums, while the SBoX® containers are designated for similar waste streams as the GNS Yellow Box® containers with the advantage of an entirely open-able lid side.

[1] MOSAIK is a registered trademark of GNS Gesellschaft für Nuklear-Service mbH (Frohnhauserstraße 67, 45127 Essen, Germany)
[2] GNS Yellow Box is a registered trademark of GNS Gesellschaft für Nuklear-Service mbH (Frohnhauserstraße 67, 45127 Essen, Germany)
[3] SBoX is a registered trademark of GNS Gesellschaft für Nuklear-Service mbH (Frohnhauserstraße 67, 45127 Essen, Germany)

Since state of the art dimensioning especially of Type B packages has been improving rapidly in recent years the design of the well established packages is going to be enhanced. Therefore GNS performed some 9 m drop tests according to IAEA requirements [1] with a newly designed shock absorber for the MOSAIK® casks. These tests were performed at different temperatures and orientations and result in larger safety margins and reliability in terms of sustainable further usage of the packages for many years to come. The motivation for the newly designed shock absorber and the results of these drop test are presented in section "9 m drop tests with MOSAIK® cask".

The variety of license guidelines for interim storage and final disposal facilities that partly exceed the safety case scenarios of transportation imposes additional challenges to the casks' designs. Especially fire tests with subsequent leak tightness requirements are complex scenarios for every cask design. GNS performed a fire test with an average flame temperature of 800 C and a duration of one hour. After a cooling period of 24 h the leak tightness requirements were achieved. Technical solutions and results of a recently performed fire test with a MOSAIK® cask are sown in section "Fire test (800 C, 1 h) with MOSAIK® cask".

Both numerical calculations and experimental proof illustrate the fulfillment of several storage requirements and lead to numerous approvals for interim storage and final disposal for different types of casks. Further developments in waste disposal and enhanced requirements in the license processes for transportation, interim storage and final disposal are the next challenges. Therefore new cask designs are being developed, that cover all waste streams expected in future dismantling and disposal projects. The newly designed cask MOSAIK® II-S is presented with the projected tests that are intended to cover all license fields in section "MOSAIK® II-S".

9 m Drop Test with MOSAIK® Cask

MOSAIK® casks made from ductile cast iron (DCI) have been featured a valid type B approval certificate for many years. The required type tests including 9 m drop tests were successfully performed in the past. To meet expected future demands in various licensing procedures a new shock absorber that significantly reduced deceleration under the test conditions and opens design margins was developed.

The new shock absorber (see Figure 1) implies considerably different types of construction compared to the previous one. Since the type test for the prolongation of the type B approval was in principal performed by numerical calculations it is obvious that such a different type of shock absorber requires separate validation and benchmarking of the used numerical codes to experimentally measured values. Therefore three separate 9 m drop tests were performed with maximum designated masses on a target according to IAEA requirements at different temperatures and orientations in summer 2013. A side drop and a corner drop were performed at ambient temperatures, while a centric drop on the lid side was performed at a temperature of -40 C. Local decelerations were measured at the cask body, the lid and at selected positions on the shock absorber. A visual measurement of the deceleration via high-speed video recording was performed additionally. Therefore the shock absorber featured a hollow to measure the movement of the cask

body visually as well. Finally four lid screws at each test type and the supporting rods that keep the different parts of the shock absorber together were equipped with strain gauges.

All three drop tests show good agreement with the numerical calculations (exemplary shown in Figure 2). Both in terms of deceleration as well as in terms of deformation of the shock absorbers. Furthermore the measured deceleration served as input parameters for the numerical calculations of stresses and strains of the cask body and the lid system. These numerical calculations were already benchmarked and validated by other drop test with MOSAIK® casks and CASTOR®[4] casks for spent fuel.

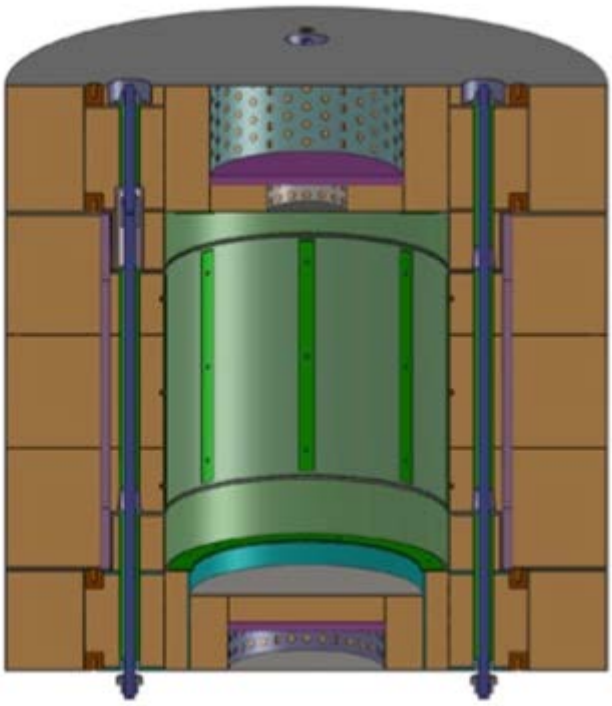

Figure 1: Basic construction of the newly invented shock absorber for MOSAIK® casks**.**

[4] CASTOR is a registered trademark of GNS Gesellschaft für Nuklear-Service mbH (Frohnhauserstraße 67, 45127 Essen, Germany)

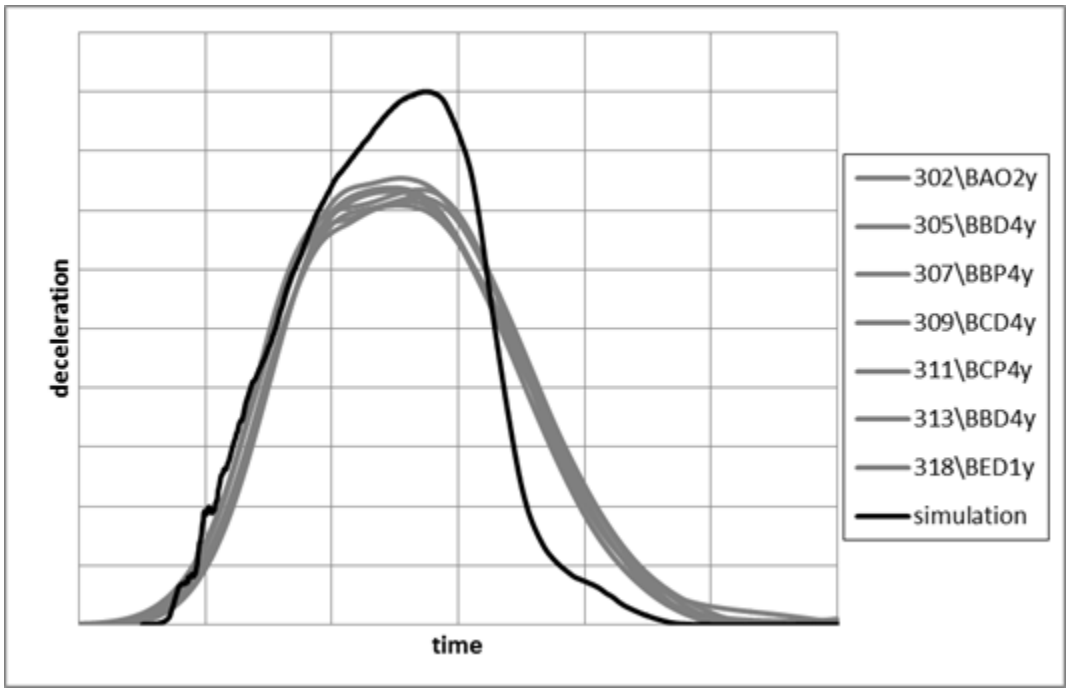

Figure 2: Deceleration over time. In grey the signals of the acceleration sensors and black the numerical simulation of the rigid body deceleration. All curves are shown in the same arbitrary units.

Fire Test (800 C, 1 h) with the MOSAIK® Cask

In the past fire scenarios were mainly considered for safety cases of transport approvals. Therefore the IAEA SSR-6 [1] requirement of a 30 minute fire scenario at a temperature of 800 C was considered in casks developments. In these cases the transport configurations of the package with mounted shock absorbers, serving as insulation, were successfully analyzed for different cask designs mostly by calculations.

The test conditions of a one hour fire scenario at a temperature of 800 C correlates to the requirements of the German disposal facility for intermediate-level waste called Konrad. The most demanding requirements for the disposal license in terms of leak tightness and pressure build up have to be considered for casks that are foreseen for the highest activity levels permitted for the Konrad site. In contrast to the transport configuration the casks have to withstand the fire as such without the help of insulating shock absorbers.

The Konrad-fire scenario prescribes a one hour enveloping fire at a temperature of 800 C with a subsequently following cooling phase of 24 hours. Leak tightness has to be inspected after the cooling phase and may not exceed 10^{-4} Pa/m^{3}s by testing with Helium. An additional requirement covers the pressure build up. During the 25 hour duration of the fire test (including cooling phase) the maximum pressure inside the cask cavity may not exceed 15 bar. Additionally no abrupt drop

in pressure during the 25 hours is permitted. These specifications have to be demonstrated with a conservative waste replica.

Certain maximum temperatures in the sealing area and inside the waste were internally set to meet the above mentioned requirements. Since those maximum temperatures were initially exceeded in calculations with the raw MOSAIK® cask a protective component was invented and later successfully tested. The temperatures in the critical regions are lowered significantly and the internally set maximum temperatures especially in the sealing area were undershot. The calculated seal temperatures provided assurance to meet the leak tightness requirements.

Calculations were proven by an actual fire test in fall 2014 with the newly invented component (see figure 3). The temperature distribution on the surface of the cask was measured to proof the achievement of an average temperature of 800 C as required. Additional temperature measurements inside the cask, especially in the sealing area, on the outer surface of the waste replica and inside the waste replica were taken to benchmark future calculations. Furthermore the internal pressure of the cask was continuously monitored during the fire test and the cooling phase. As a result, the maximum internal pressure was roughly one order of magnitude below the requirement of 15 bar and the measured temperatures even undershoot the satisfactory results of the calculations.

Figure 3: Fire Test of the MOSAIK® cask in fall 2014.

MOSAIK® II-S

To cover all the existing requirements including its current interpretation of type B licensees, of the German disposal Konrad and additionally to meet expected future demands in various

licensing procedures GNS decided to develop a new cask for intermediate level waste. This cask will somehow differ from existing MOSAIK® casks, primarily since it will be made out of steel and not from DCI. This new cask will be suitable for all expected wastes from dismantling and deconstruction.

Currently design subtleties are being ascertained. Nevertheless, the preliminary numerical analysis already proves the accomplishment of the different license requirements and demonstrates design margins. In parallel the manufacturing of a prototype cask was successfully executed with first assembly of the new cask in fall 2014. Furthermore first handling and operating tests will be performed with this prototype cask in late 2014 and early 2015. Thereby uncertainties in the necessary changes of operating procedures will be in an early stage of the design. Further type tests including a first drop test are planned for spring 2015.

CONCLUSION

Current cask designs have been tested with state of the art type testing programs with respect to both transport and storage/disposal requirements. It was shown that even packages with established designs successfully fulfill the currently enhanced interpretations of the various licensee requirements and are fit for future demands. Furthermore new package designs that cover all needs of the upcoming dismantling programs are well on track.

REFERENCES

[1] IAEA Safety Standards, Specific Safety Requirements No. SSR-6, Edition 2012