Methodology and Experiences of Experimental Drop and Fire Testing of Radioactive Waste Containers for Final Disposal - 14478

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ABSTRACT

The paper gives an overview of methodologies and experiences in experimental drop and fire testing of radioactive waste containers for final disposal performed by the German Federal Institute for Materials Research and Testing (BAM) over more than twenty years.

The drop test setup is predominantly defined by the rigidity of the impact target. Depending on the approval strategy an adequate impact target for drop testing of waste containers might be the unyielding IAEA target made of a mild steel plate fixed on a massive reinforced concrete block. In addition to this essentially unyielding target a concrete slab can be adapted in order to simulate the hard but yielding real ground of a storage facility more accurately. Further important item of the test setup is the drop orientation of the container which is mostly derived from the requirement of maximum damage in regard to the safety criteria to be reviewed.

Strain and acceleration measurements are accepted standard measurement methods to investigate container's mechanical behavior caused by drop testing. With strain gages the time dependent magnitude of any deformation and the associated stresses can be determined. Accelerometers are used for measurement of motion i.e. speed or the displacement of the cask body, vibration and shock events. These results constitute the main basis for the validation of a finite-element analysis (FEA) of the test scenario. Both, measurement and FEA complement each other and draw a comprehensive picture of container's impact loading. In this context, optical 3-d measurements of the deformed geometries of container and target in combination with high-speed video of the impact event constitute an additional data basis for FEA validation and the evaluation process.

Within container Type VI safety assessment according to the requirements for the German Konrad repository a full scale fire test with an original cubic container made of ductile cast iron filled with a representative (inactive) ion exchanger resin was performed. The test was carried out at the BAM open propane gas fire test facility. By means of the one hour 800°C fire test concerning the German repository "Konrad" requirements, it was demonstrated that the distribution of inner temperatures and pressure is a complex issue not only during the fire but also during the cooling down phase.

INTRODUCTION

During the last twenty years the German Federal Institute for Materials Research and Testing (BAM) has been involved in drop and fire testing of a wide variety of containers for disposal of radioactive waste in several national as well as international licensing applications.

The German Konrad repository for radioactive waste with negligible heat generation is suitable for disposal of the established categories of low-level and to the majority of intermediate-level radioactive waste [1], [2]. Three main types of Konrad standardized waste containers made of steel sheets, reinforced concrete or ductile cast iron were drop tested in accordance with the relating disposal requirements. Figure 1 shows some examples of those container designs (from left to right): Steel sheet container Type II, Cylindrical reinforced concrete cask Type II, Cubic ductile cast iron container Type VI, Cubic reinforced concrete container Type IV, Cubic reinforced concrete container Type IV filled with eight steel drums (not finally assembled in the figure), and Steel sheet container Type VI.
In order to cover the Konrad test requirements in a conservative manner the container drop tests were performed mostly onto the unyielding IAEA target of BAM's large drop test facility instead of a more representative foundation of the repository.

Steel sheet container Type II

Concrete cask Type II


Ductile cast iron container Type VI


Concrete cask Type IV

Concrete cask Type IV


Steel sheet container Type VI

Figure 1: Examples of drop tested national waste containers made from steel sheets, concrete or ductile cast iron

Especially Konrad cubic container designs made of ductile cast iron (DCI) were intensively investigated under the aspect of potential brittle fracture behavior. Mainly during the flat impact onto the bottom side of the container high stresses have been detected at the inner corner edges of the side walls [3], [4]. Drop tests from drop heights of up to 5 m in various drop test orientations of the specimens onto a concrete slab adapted on top of the IAEA target of the drop test facility were carried out. This setup can be considered as a hard but yielding target representing the real ground of the repository.

In context with Japanese waste container safety assessment for radioactive waste disposal at intermediate depths, BAM performed drop tests contracted by Kobe Steel, Ltd., Japan [5]. The tests were carried out at the 200-tons drop test facility situated on the BAM Technical Test Site (BAM TTS), Germany. The drop tested containers are designed for low-level waste (LLW) such as channel boxes, control rods of boiling-water reactors as well as burnable poisons and control rods of pressurized-water reactors (Figure 2, left).

Furthermore design tests of single and double steel sheeted ILW containers up to drop heights of 15 m onto an unyielding target were conducted by BAM (Figure 2, right).

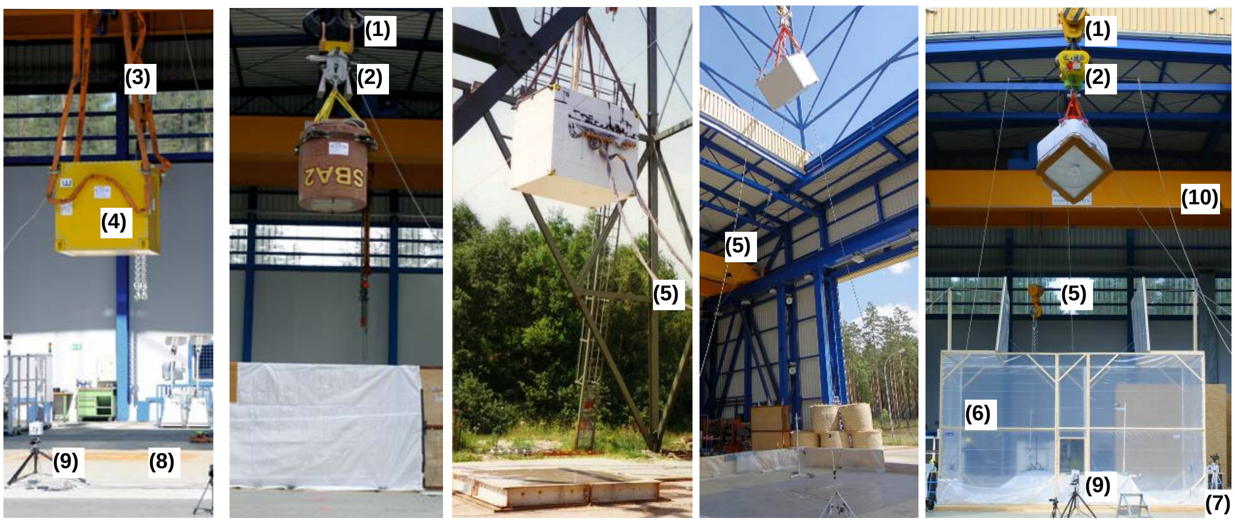
Figure 2: Examples of drop tested international waste containers made of cast steel (left) **and steel sheet** (right)**.**

DROP TEST FACILITY

Since 2004 drop tests of waste containers or transport casks for radioactive materials are performed at the 200-tons drop test facility located at BAM's Test Site for Technical Safety (BAM TTS) near Berlin [6]. Until then drop tests were performed at an open air drop tower for masses up to 80 tons with a corresponding IAEA- target near Braunschweig [6].
The larger drop test facility is characterized by three main components, namely the drop tower with its hoist on top, the assembling hall with movable roof and the IAEA- impact target. The drop tower, a 36-meter high steel frame construction, is placed over the assembling hall on four separate pile foundations. The hoist is located in a height of 33 meter. The lifting capacity is limited to a mass of 200 000 kg - the maximum lifting height belongs to 30 meters. An overhead crane with a lifting capacity of 80 000 kg is available for all kinds of handlings in the assembling hall. The movable roof has the dimension of 10 m x 12 m. The release of a specimen is always performed by momentum free working release systems. An electro-hydraulical system for masses between 20 and 200 tons and an electro-mechanical system for masses up to 50 tons can be used.

Figure 3 shows some examples of test setups for waste container drop testing. In context with the German Konrad repository a side-wall drop test with a steel sheet container and a drop test with a cylindrical concrete cask onto its lid side both with drop heights of 5 m onto the unyielding IAEA-target as well as a 5 m drop test with a DCI container onto a concrete target are shown on the first three figures.
The next two figures show a 15 m drop onto the IAEA-target of a steel sheet container with its

lid sided long corner edge downwards and an 8 m drop onto a concrete target of a Japanese cast steel container with its lid sided corner edge as impact point. A specific feature in this test setup was the closed volume construction built with closable roof and two dust-samplers for the particle release measurement in case of lid opening due to the drop test. In order to simulate the particle size of the real content the container was partly filled with ferrite powder. Further features of the test setups are explained in Figure 3.



legend: hoists crane hook (1), momentum free release system (2), nylon slings for the specimen attachment to the release system (3), specimen (4), measuring cables (5), closed volume construction for particle release measurements (6), dust sampler (7), IAEA- target (8), concrete slab (9), high-speed video camera (9), 80-tons gantry crane (10)

Figure 3: Examples of test setups for waste container drop testing

IMPACT TARGETS

Impact targets for drop testing of waste containers can be targets simulating the real ground at individual storage facilities, or an essentially unyielding target representing requirements of the IAEA regulations for safety demonstration according to hypothetical accident conditions of transport.

The test stand foundation of BAM's drop test facility is built according to the IAEA regulations as an essentially unyielding target for specimens up to 200 000 kg [8], [9], [10]. It consists of a concrete block (German concrete grade B25/B35) with the geometrical dimensions of 14 m x 14 m x 5 m and an embedded steel plate as impact pad. This 220 mm thick, 4.5 m wide and 10 m long steel plate is form- and force-fitted fixed by means of 40 pieces of M36 anchor bolts to the concrete block. The total mass of the target is 2 600 000 kg.

For drops tests according to legal regulations for interim storage or final disposal it is often necessary to use a target which represents the real ground of the storage facility. In such cases the container hits directly onto a well-defined concrete slab on top of the IAEA target. Within a comprehensive research project, funded by the German Federal Ministry of Education and Research and in co-operation with industrial partners, the impact behavior of cubic containers made of cast iron was systematically investigated with considerable effort to develop a suitable target construction simulating the real ground of storage facilities [11]. For the example of hypothetical container drops in the Konrad repository, an adequate target construction was found (see Figure 4).

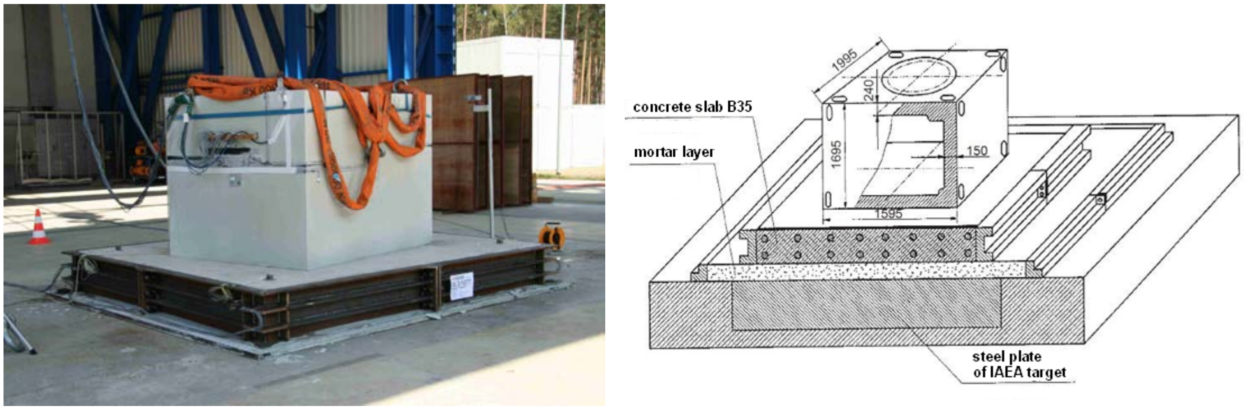


Figure 4: Impact target for drop testing of a DCI container built of a concrete slab adapted with a mortar layer to the IAEA target.

Hereby, the determination of suitable material properties especially for the concrete slab and selection of proper contact conditions between concrete slab and IAEA target were important aspects. The concrete grade of the slab is chosen in compliance with the applicable regulations. For the Konrad repository, the compression strength of 35 MPa must be met. Additionally the slab is reinforced to prevent failure by tractions inside the slab during the impact event. The slab is connected to the underlying IAEA impact pad (steel plate with a thickness of 220 mm and massive concrete block beneath and around) of the drop test facility by a quickly hardening mortar. The mortar is liquid during the preparation of the target and is filled between concrete slab and impact pad like glue. A small steel frame prevents a run-out of the liquid. In order to avoid the subsidence of the concrete slab into the fresh liquid mortar some small flagstones are used as distance holders placing them onto the impact pad. Hardening of the mortar layer results in a very stiff connection between both parts with negligible energy dissipation during impact. The thickness of the layer is approximately 30 mm. For each drop test a new target setup must be installed. This experimental setup fulfils the legal requirements for testing of containers for final disposal in the Konrad repository [2].

Figure 5: Setup of the impact target for the drop tests with the KOBELCO waste container built of a reinforced concrete block adapted with mortar to the IAEA- target (left, middle) **and the target locally destructed by the impact** (right)**.**
Legend of schematic view: : (a) concrete slab, (b) mortar, (c) steel impact pad (IAEA-target), (d) reininforced concrete block (IAEA-target), (e) ground, (f) anchor bolts

The basic setup for a yielding target can also be adapted for other drop test scenarios. In context with drop tests simulating the ground of a Japanese storage facility, an impact target built of a large reinforced concrete block adapted to the IAEA target was used [5]. The concrete block was fixed to the IAEA target as described above (see Figure 5). The dimensions of the concrete block were 3 m x 2 m x 0.8 m (length x width x thickness). The compression strength of the used concrete was greater than 100 MPa.

DROP ORIENTATION AND DROP HEIGHTS

The drop orientation of the container, defined by its impact point and impact angle in the drop test, is mostly derived from the requirements of maximum damage in regard to the safety criteria to be reviewed. Drop height and orientation may be derived from possible effects on a handling incident (crashing or toppling down) in the storage or repository facility.
Therefore various drop orientations and drop heights had been experimentally implemented. Common impact areas in context with cubic containers are the lid sided edge or corner edge in order to affect i.e. the lid closure system directly by the impact. Other drop orientations are the plane impact onto a container's wall (i.e. bottom) introducing very short impact durations with highest decelerations to the container. Analogues impact areas can be found with cylindrical containers. In order to achieve a maximum amount of impact energy the impact angle may be chosen in a way that the centre of gravity lays perpendicular over the target and the contact area - the centre point of the drop test facility.

The exact positioning of a container into drop orientation and the adjustment of the defined drop angles often cause complex handling operations (Figure 6). For setting the container into various drop orientations as mentioned above it has to be rotated in most cases which usually is performed using two cranes – i.e. the overhead crane of the facility and in addition a mobile crane. After the rotation the container has to be set stable into a test stand, mostly a steel frame construction, which predefines and keeps the drop orientation of the container for connecting it by nylon slings to the release system. Now, the fine adjustment of the container's drop angle can be started using i.e. adapters of variable length.

Figure 6: Cask handling, positioning and adjustment of the container into the defined drop orientation.

TEMPERED SPECIMENS

Low temperature drop tests can be performed with specimens cooled down in a large cooling box (dimensions 4 m x 4 m x 4 m) made of wooden composite plates and double walled with isolation material between inner and outer walls using liquid nitrogen as refrigerant. The box is directly charged by cryogenic nitrogen (LN_2) with a temperature of - 196°C and circulated inside by ventilators, placed in the top of the cooling box. The entry of LN_2 is carried out regulated in dependence of the defined goal temperature of the specimen measured by thermocouples and the inner temperature of the cooling box. The temperature measurements comprised the whole cooling process and the following drop test preparation time until the specimen impacts during drop test.

STRAIN AND ACCELERATION MEASUREMENTS

Instrumented measurements especially transient strain and acceleration measurements are one of the accepted standard measurement methods in drop testing of packages and waste containers for radioactive materials [13]. These methods are dedicated to answer questions in regard to the structural integrity of a package, the behaviour of package's components (closure lid, lid bolts, handling parts, etc.) as well as of the content's behaviour under impact conditions. Strain and acceleration measurements as well as their analysis are often very complex and extensive also because they are in turn embedded in complex drop test experiments having to consider difficult boundary conditions as for example very low specimen temperatures, large drop heights and sophisticated drop orientations of the specimen. In every case special instruments and adequate technical equipment is required to measure strains and accelerations under these and transient shock conditions which are characterized by impact times in the range of a few milliseconds up to several tens of milliseconds naturally depending on container design and drop test conditions as drop height and target.

Test results as deceleration-time and strain-time functions constitute a main basis for the validation of assumptions in the safety analysis and for the evaluation of calculations based on finite-element methods. Strain gages are useful to determine the time dependent magnitude of any deformation and the associated stresses. Accelerometers are widely used for the measuring of motion i.e. speed or the displacement of the rigid cask body, vibration and shock events.

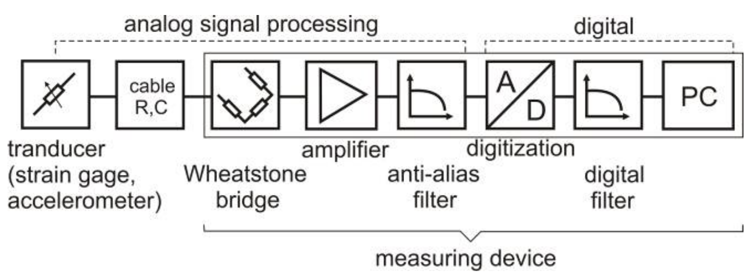


Figure 7: Typical measurement chain for strain and acceleration measurements

Figure 7 shows a typical measurement chain for strain and acceleration measurements. Basically, it is the procedure of an electrical signal processing which can be subdivided into an analogue and digital stage. The transducer – strain gage and accelerometer (piezoresistive or piezoelectric with integrated electronics, e.g. ICP®) – which is applicated or mounted on the container at defined points of interest converts the mechanical transient impact response (strain, acceleration) into an electrical voltage change, which can be regarded as the output signal of the transducer. The signal transmission between transducer and measurement device is realized by long distance measuring cables. As signal conditioner for strain measurements and for acceleration measurements with piezoresistive accelerometers high quality DC-amplifiers are used. Amplifiers with analogues bandwidths of 100 kHz up to 1 MHz are commercially available depending on use and requirements. The data acquisition i.e. the analogue to digital conversion of the analogue measuring signal and its transient recording is provided by A/D-cards. Commercial cards offer sample rates up to 500 Msamples/s per channel, 16-bit resolution or more, high fast on-board memory and trigger functions. The sampling of all input channels must be simultaneously performed by one A/D converter for each channel in order to avoid time delays between the channels and therewith misinterpretations in signal analysis of container drop testing.

Strain Measurements

In context with drop testing of containers typically used strain gages for experimental stress analysis are foil strain gages, which are generally built of an open-faced constantan grid pattern on a thin polyimide-layer. These strain gages are very rugged and safe in use without any problems also under difficult outdoor conditions, naturally provided an appropriate use. Preferably used in experimental stress analyses are 120 Ohms-strain gages - grid lengths between 3 mm and 6 mm are appropriate in the majority of application cases. The application of strain gages is of particular importance for the quality of measured strain signals and the validity of the results of experimental stress analysis, respectively.

Different arrangements of the bridge circuit, such as full-bridge, half- and quarter-bridge circuits are in use for various strain measurement challenges. In experimental stress analysis a commonly used arrangement for the connection of single strain gages is the 3-wire Wheatstone Quarter-Bridge circuit.

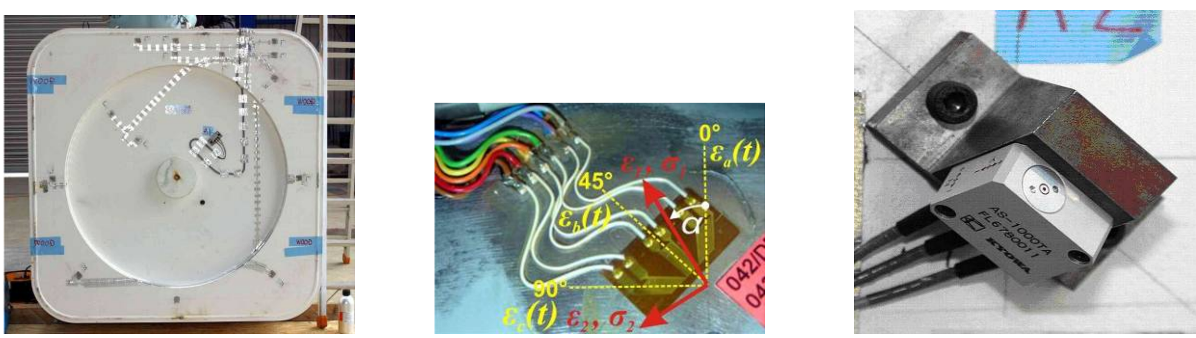


Figure 8: Waste container instrumented with strain gages and accelerometers (left). Detail of an applicated rectangular strain gage rosette (middle) and a mounted accelerometer (right)

The aim of experimental stress analysis is the determination of significant stresses in the container and/or components of the container under impact conditions. The influence of various loading variables such as e.g. tension/compression and bending or torsion and bending, etc. create the common case of a general biaxial stress state in the container's surface. This state is defined by the principal stresses and their principal direction. As a result of the combination of various loading parameters the principal direction can not be assumed as known in such a way as for example in other cases like cylindrical pressure vessels under inner pressure or an axle under pure torsion loading, etc. But it can be shown that only three independent strain measurements – namely in three different directions – are required to determine the principal strains and stresses. This request can be solved by strain measurements using so-called three grids strain gage rosettes, whereby its installation on the surface of the test object can be done without any regard to orientation. The equations for the interpretation of three-gage strain rosettes measurements in regard to principal strains and their orientation (principal direction) can be deduced from the Mohr's cycle of strain [14].

The following specific information can be achieved from strain measurements during container drop testing namely continuous strain-time histories at the monitored locations (container walls, wall junctions, closure lid, lid-bolts, weldings, etc.), structural response of the container due to impact (waves, vibrations and quasi-static deformations), the principal strains/ stresses and their principal directions at the monitored locations, the vibration of strains/stresses (amplitude, frequency), impact duration of the tested container as well as propagation and amplitude of stress waves.

Acceleration Measurements

Acceleration measurement is also one of the accepted standard measurement methods in container drop testing. The acceleration measurement can provide important information for the analysis of the impact behavior as continuous acceleration-time histories at the monitored locations of the container and target, rigid-body impact acceleration or force, rigid-body impact kinematics of the container during impact (velocity- and displacement history), impact duration, vibration frequencies and response spectra, respectively. In container drop testing with measuring of accelerations mostly piezoresistive transducers are used but also piezoelectric transducers are applied (Figure 7). Because of long distance measuring cables in container drop testing the electrical connection between accelerometer and amplifier is ideally realized by a six-wire Wheatstone Full-Bridge circuit with sense wiring of the excitation supply – 2 wires additional to the current voltage supply (2 wires) and signal output (2 wires). The major advance of piezoresistive accelerometers is that they have a frequency response extending down to DC (0 Hz) or to steady state accelerations for measurements of long duration transients, respectively, along with a relatively good high-frequency response [15].

OPTICAL 3-D DEFORMATION MEASUREMENT

The determination of a container's geometry after the drop test especially the directly by the impact affected and deformed zones of the container as well as the impacted target are often of interest in context with the evaluation process i.e. as data basis for FEA validation, etc.. Mechanical measurements are mostly unsuitable for this purpose due to the geometrical complexity of the deformations occurred. Therefore, in recent years optical three-dimensional surface digitisation methods are in service. More specifically, the fringe projection method in combination with close range photogrammetry allows a precise and overall measurement of the container [16]. The measuring data can be provided i.e. in IGES file-format for digital exchange of information and further analysis with Computer-aided design (CAD) systems and FE-postprocessing software.

An example using the results of a container's 8 m corner drop onto a concrete plate as impact target is shown in Figure 9. The complex deformation geometry of the specimen's impacted corner edge as well as the crater demolition of the concrete slab are determined using optical 3-d measurement methods [5]. The photo on the left shows a 3-d digitization of the deformed corner edge. This digitization allows the comparison to the original geometry obtained by zero-measurement before the drop test so that for any shape the divergence and therefore the deformation can be determined. The blue line in the left photo represents the original geometry and the red curve the deformed. The calculated maximum deformation belongs to 14 mm and

the maximum bending to 18 mm.
In Figure 9 the photos on the middle and right show the deformation over the whole specimen as fringe plot and the digitization of the concrete plate.

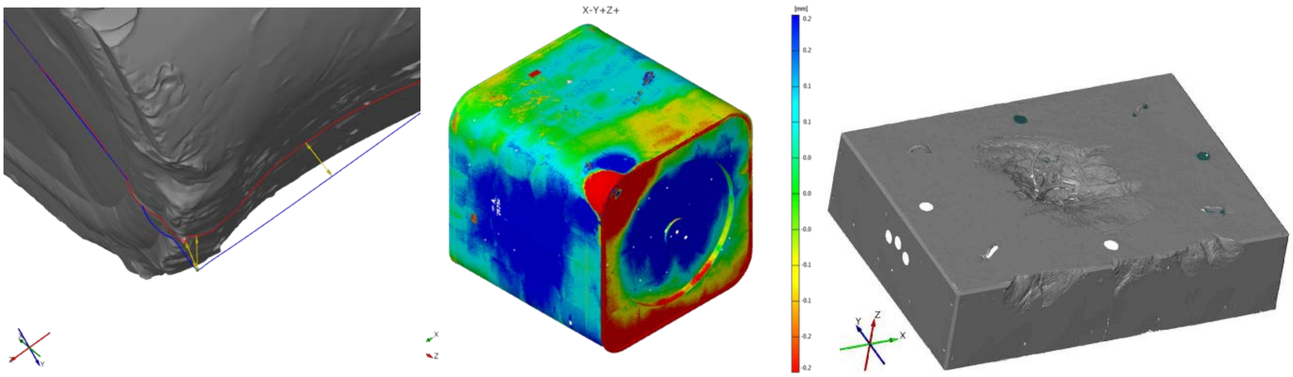


Figure 9: Results of optical 3-d measurements. Visualization of specimen deformations at corner edge due to impact and the penetration into the target.

HIGH-SPEED VIDEO

The high-speed video technique with motion analysis of an impacting specimen under drop test conditions can be an advantageous tool for the analysis of the impact event and the kinematic behavior of the container, and seeks to complement measurements of acceleration [13].

The chronological synchronization of high-speed video recording with corresponding acceleration time histories using adequate signal analysis software gives the opportunity for better mechanical interpretation and understanding analysing acceleration signals, but also strain signals. Significant signal parts of the acceleration time curve during impact can be possibly related to visual mechanical events occurring at the impacting container or the target. A containers adjusted drop orientation can be validated by the high-speed video e.g. in the moment just before impact and possible deviations from that orientation can be quantified. Besides other aspects, this could be one important aspect in context with the validation of numerical calculations of drop tests using the method of finite elements considering that already small deviations from the defined impact orientation can change expected results significantly.

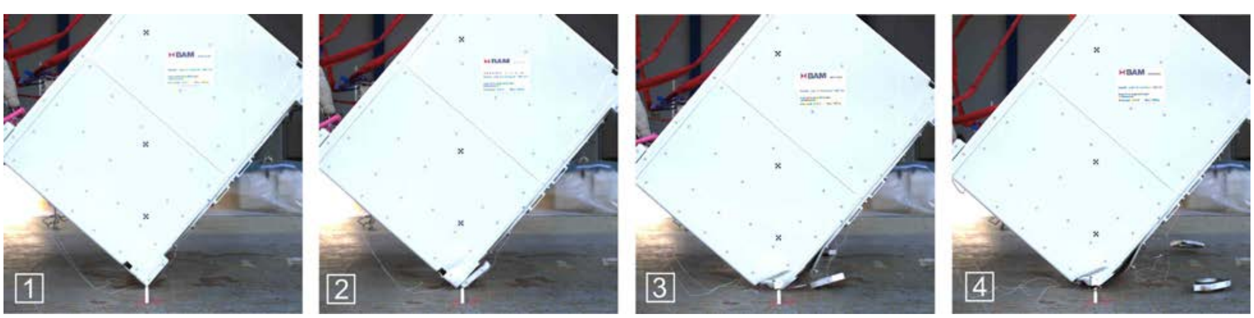


Figure 10: Impacting waste container onto the IAEA-target. High speed filmed with 2000 frames per second. Photo 1 shows the first contact and confirms the exact impact orientation. Photos 2 to 4 show the first Milliseconds of the impact.

Today, digital high-speed video technique with the possibility of a couple of thousands of frames per second by acceptable resolutions and colour picture can provide an appropriate and easy to handle data basis for motion analysis. Current movement analysis software supports the automatic tracking of objects via pattern recognition. The results are displacement time histories of selected points at the surface of a specimen (e.g. high contrast markers were approved) which can be transferred by derivative with respect to time into velocity and deceleration time curves. Thereby and in contrast to measurements with accelerometers the much lower bandwidth and the higher uncertainties should be considered. Figure 10 shows an example of an impacting waste container dropped from a height of 15 m onto the IAEA- target.

FIRE TESTING

The thermal test requirements for type B transport packages are based on a liquid hydrocarbon pool fire. BAM performed thermal tests on a corresponding test facility by the year 1990. Because of problematic air pollution by heavy smoke emission using the fuel oil pool fire BAM had to develop an alternative test method. Since 1991 BAM uses a propane gas fired test facility. The equivalency of this new test method has been proved by various investigations, so that compliance with the IAEA-thermal requirements is given [17].

The new fire test facility which was built for testing transport packages and waste containers is located close to the drop test facility on the BAM Test Side Technical Safety [18].
The test object is located inside a flat concrete trough with an operation area of 12 m x 8 m. The fire engulfment is produced by burning propane which is released in liquid state from a multitude of gas nozzles in a pipe that surrounds the test object in form of a ring burner. The pipe can be adapted to the various dimensions of the packagings and containers to get in every case full fire engulfment. The intensity of heat can be regulated by variation of pressure and quantity of the propane and the number of nozzles. The fire peak temperatures reach 1100°C. In order to eliminate wind effects the concrete trough is surrounded by a wall made of steel sheets. A permanent water circulation system cools the concrete base.

In order to fulfil the required fire conditions for large full-scale test containers, the parameters of the burner configuration and the amount of propane consumption have to be determined in advance. The determination is done by a calorimeter test using a full-scale model of the container to be tested, which is made of welded steel sheets and filled with water. A detailed description of the verification of the fire conditions can be found in [17].

Naturally, in the fire test the low level waste (LLW) must be replaced by an adequate inactive surrogate representing the LLW’s thermal heat transfer properties and decomposition behaviour. This requires e.g. a corresponding characterization of the LLW’s thermal decomposition behaviour which can be solved by thermal analyse methods like thermogravimetry (TGA) coupled with an evolved gas analysis (EGA).

It should be noted that instead of an open air fire test facility also a furnace can be used for the fire test. An advice to fulfil the fire conditions in furnace tests can be found in the ASTM standard practice E2230 [19].

Example
The fire test requirements for the German Konrad repository are defined by the responsible German Federal Office for Radiation Protection (BfS) [2], [20]. Containers for example which are classified as accident safe waste containers followed by increased barrier properties with a

specified leakage rate must fulfil the following acceptance criteria. According to a conservative approach, the container has to withstand an fully engulfing 800°C fire over one hour including the subsequent cooling phase. The leakage rate must be lower than $1.0 \cdot 10^{-5}$ Pa m^3/s before, and lower than $1.0 \cdot 10^{-4}$ Pa m^3/s after the thermal test. During and after the fire a possible pressure raise inside the container should be maximal equal or below 1500 kPa.

With numerical calculation methods using finite element codes, the maximum container and seals temperatures can be computed quite well. In contrary the temperature distribution of the content (more or less wet bulk material) inside the container is hardly to predict, because the thermal properties of the content as a function of temperature are mostly unknown. Secondly, besides heat transfer by conduction of heat also heat transfer by mass transfer has to be taken into account. The maximum pressure inside the container is the sum of the water vapour pressure and the partial pressure of the evolved decomposition gases [21]. Either of them can be calculated if the temperature distribution inside the content is unknown. For the estimation of the partial pressure of the evolved decomposition gases the nature and amount of the evolved gases must be known additionally.

For that reason and in context with the regulatory assessment of the cubic DCI container Type VI according to the requirements for the German Konrad repository a full scale fire test with an original container filled with ion exchanger resin was performed [22]. The test was carried out at the BAM propane-burning open gas facility with flame temperatures in the vicinity of the container surfaces of approximately 800°C in average.

Figure 11. Full scale one hour fire test with a cubic DCI container filled with ion exchanger resin (left and center; BAM Lehre))**; calorimeter test** (right) **with a cubic container (1.6 m x 2 m x 1.7 m) on the new open gas fire test facility (BAM TTS) with an achieved heat input of 75 kW/m² by low wind and a propane output rate of 2100 kg/h.**

The thermal test has demonstrated that the distribution of inner temperatures and pressure seems to be complex not only during the fire but also during the cooling down phase. The effects of water and shape of the exchanger resin (powder or sphere) are of great importance for the heat transfer mechanisms and thus for the thermal distribution inside the container content. Subsequent autoclave tests were carried out in order to assess and compare the pressure build-up of other commercial types of ion exchanger resin with the one used in the fire test [22].

CONCLUSIONS

Over more than 20 years BAM accumulated experiences in performing huge numbers of drop tests with various designs of containers for disposal of non-heat-generating radioactive waste. The drop testing methodology and applied measurement techniques had been continuously improved and developed. Fire testing experience and appropriate facilities are also present. Applicants or contractors who provide their test specimens for testing to BAM have to specify accurately the test conditions with respect to drop height, container drop position, impact target specification, fire duration and maximum or average flame temperatures. These test conditons and the acceptance criteria are usually defined on basis of the relevant national storage facility or repository requirements. A mutually agreed test program and quality assured test performance of the accredited BAM test laboratory ensures reliable results for further safety assessment and licensing of the container design.

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