BAM

Bundesanstalt für
Materialforschung
und -prüfung

Sicherheit in Technik und Chemie

EXPERIMENTAL TESTING OF CONTAINERS FOR RADIOACTIVE MATERIAL

FOCUS AREA
ENERGY

Portfolio

Container design testing is performed for national and international package approval and license procedures for the transport and storage of radioactive material. Physical testing of containers and their components is part of the package safety evaluation.

Mechanical and thermal tests are conducted at the drop and fire test facilities at BAM Test Site for Technical Safety. Planning, preparation, performance, analysis and evaluation of the experimental investigations are realized by BAM.

Main work competencies are the definition of test goals according to package safety cases, the planning of measurement concepts as well as the evaluation of complex loading situations of packages. BAM operates state-of-the-art high-speed video systems and data acquisition systems for strain, acceleration and temperature measurements. BAM staff carry out leakage-testing and investigate complex deformation states of package components with modern optical measurement techniques.

Furthermore, BAM develops methods for safety evaluation of package containments and integrity for operational and accident conditions. Research activities focus on the investigation of package component materials and the scientific understanding of the behaviour of packages under transport and storage conditions. The connection between physical testing and BAM competencies in numerical simulation and analysis is the basis for our comprehensive package safety evaluation.

The BAM experience resulting from testing, assessment and research work is incorporated in international standards and the development of the International Atomic Energy Agency (IAEA) regulations.

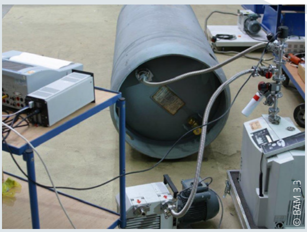
Overview

200-t Drop Test Facility
S.6

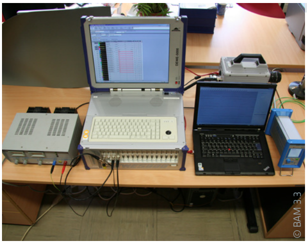
Guided Drop Test Tower
S.8

55-t Drop Tower
S.7

Fire Test Facility
S.9



Leakage Testing
S.10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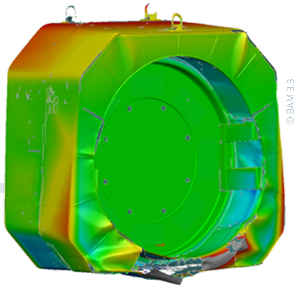
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200-t Drop Test Facility

The 200-t drop test facility consists of a steel tube construction drop tower of 36 m height. It is equipped with a 200-t winch on top, an unyielding target in accordance with IAEA requirements and an assembly hall with an 80-t overhead crane. There are control and measuring rooms and a massive building for safe observation. The momentum free drop release of test objects between 2-t and 200-t is realized by electro-mechanical or electro-hydraulically cable released detaching devices.

Technical Specification

max. drop mass:	200,000 kg
max. drop height:	30 m

Unyielding Target

Reinforced concrete block with anchored steel plate as a rigid surface.

total mass:	approx. 2,600,000 kg
target area:	14 m x 14 m x 5 m
impact pad (steel plate):	10 m x 4.5 m x 0.22 m

The construction ensures fulfillment of the requirements for unyielding targets in accordance with the IAEA regulations for packages and test models up to 200-t.

55-t Drop Tower

The open-air drop tower allows testing of various test objects, especially liquid-filled containers. The test system consists of a drop tower with spiral staircase, a 55-t winch on top with a double hook, a reinforced concrete foundation with an embedded steel plate as rigid surface of the impact pad, and a control and measuring room.

Technical specifications

max. mass of test object:	55,000 kg
max. drop height:	18 m

Unyielding Target

Reinforced concrete block with anchored steel plate.

total mass of foundation:	approx. 600,000 kg
target area:	10 m x 10 m x 2.5 m
impact pad (steel plate):	7 m x 4 m x 0.21 m

The construction ensures fulfillment of the requirements for unyielding targets in accordance with the IAEA regulations for packages and test models up to 55-t.

Guided Drop Test Tower

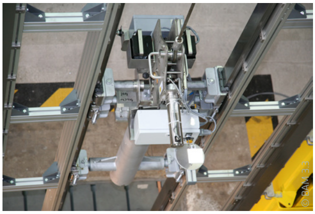
The guided drop test tower consists of a 14-meter high steel frame structure with a maximum load capacity of 1,000 kg, a rigid foundation and steel impact pad equipped with a T-slot system to realize variable test setups. The maximum drop height provided by the adjustable frame results in sled velocities at impact of up to 15 m/s. The combination of drop height and mass depends on the tolerable kinetic energy of the test bench. A drop weight interception system (DWIS) has been developed by BAM to avoid a second impact of the drop weight on the primary loaded component or specimen.

Technical specifications

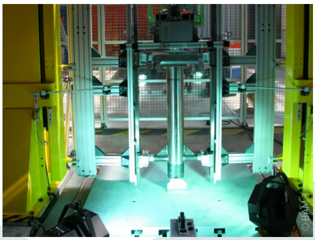
max. mass of drop weight:	1,000 kg
max. drop height:	12 m
DWIS:	500 kg (expandable)

Unyielding Target

Reinforced concrete block with embedded steel plate and machine table.



Overall mass of foundation:	approx. 18,000 kg
area of steel impact pad:	2 m x 2 m



Fire Test Facility

The fire test facility allows the experimental performance of an IAEA fire. Equivalent thermal loads on packages as required by the regulatory pool fire can be ensured. Propane is pumped via underground pipelines from a central storage tank to the fire testing rig. Here, the arrangement of nozzles in the circulating ring burner together with the gas release rate are adapted to the required heat input for the test object.

Technical specifications

max. mass of test object:	200,000 kg
Heat flux:	mean 75 to 110 kW/m^2

Test area

Concrete foundation with cooling water circuit and wind protective shields.

Dimensions: 12 m x 18 m x 2.8 m

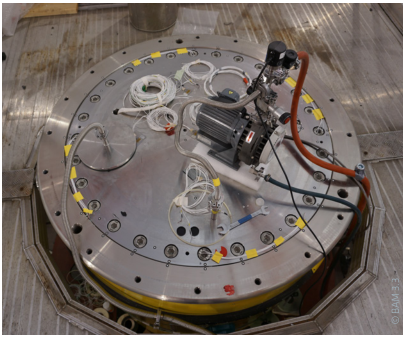
Fuel

Propane (liquid)

max. mass flow: 6,000 kg/h

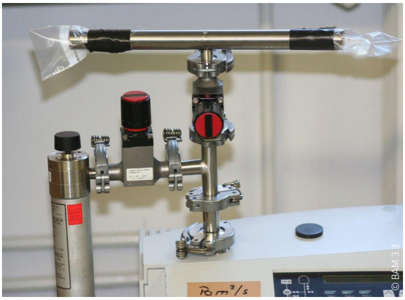
Leakage Testing

Leakage testing as a non-destructive test method is an essential part for meeting the requirements for the leak-tight enclosure of transport and storage containers for radioactive material and sealed radioactive sources. The leak testing methods are used not only to determine a required permissible standard leak rate before and after mechanical or thermal tests, but also for the localization of leaks.



The leak testing procedures are carried out according to ISO 20485. Leak tests on enclosed radioactive material is carried out according to ISO 9978.

Depending on the detection limit, different leak testing methods are used as overpressure or vacuum method:
Bubble test method, pressure change method, sniffing method, tracer gas method (Helium leak-tightness tests).



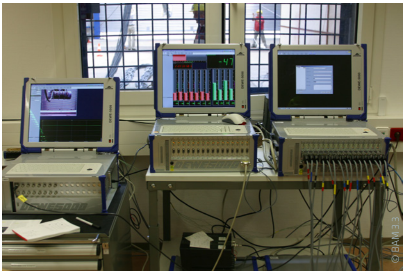
Measurement Techniques

BAM operates a wide variety of measurement techniques. Multi-channel data acquisition systems are available for time dependent measurements of all test-relevant data such as deceleration, strain, force, and temperature. The test specimens are instrumented locally with strain gauges and accelerometers in order to determine strain-time and deceleration-time functions, respectively.

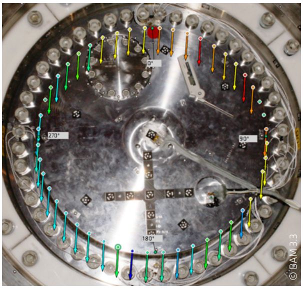
Sample rate:	up to 2 MHz
Memory depth:	up to 24 Bit
Measuring channels:	up to 128

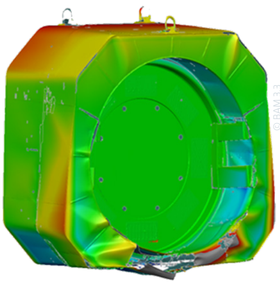
Multi-channel detection devices are also available for monitoring and measurement of test temperatures.

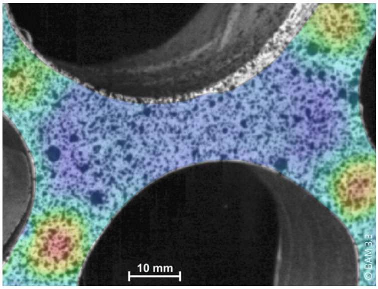
Temperature range:	-70 °C to 180 °C
Measuring channels:	up to 64



Optical 3-D Measuring Methods







Different camera-based coordinate measuring methods are used in the context of experimental stress investigations for the analysis of packages and its components with regard to geometric, mechanical or kinematic parameters. The combination of the measuring methods results in a high degree of metrological flexibility.

Combinable measurement methods
Multi-image photogrammetry; fringe projection; point- or area-supported stereo-photogrammetry; optical stylus

Typical quantities to be determined
Digital all-around shape determination of containers, shock absorbers or functional surfaces as well as their load-related deformation, target-actual or pre-post comparison with CAD data or a reference measurement; point-based displacement and ovalization; strain field

Parameters

Coordinate uncertainty:	from approx. 20 μm/m^3
Scan point density:	typ. 0.3 mm @ 700 mm x 530 mm measuring field
Time regime:	before-after; quasi-static; dynamic typ. 20 kfps @ 1 MPx (stereo arrangement)

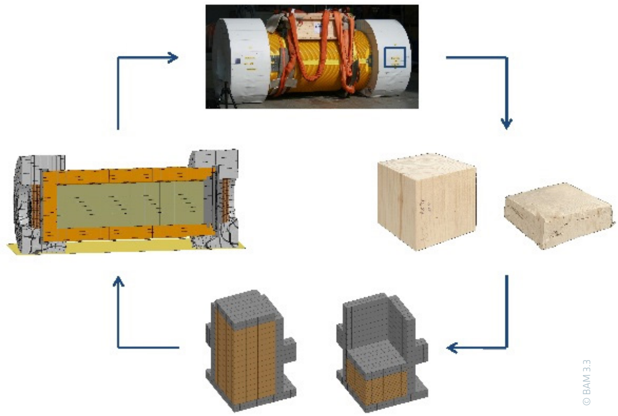
High-Speed Video

Full-HD video technique and several high-speed camera systems are available. High-speed video recording and motion analysis of impact kinematics and component deformations during an impact of a container drop test can be detected and analyzed.

High-speed camera systems
Photron FastCam SA-1:
Full resolution 1,024 x 1,024 Px up to 5,400 fps
CMOS-Sensor with 36 Bit (RGB) and 12 Bit (B/W)

Photron FastCam SA-X2:
Full resolution 1,024 x 1,024 Px up to 12,500 fps
CMOS-colour sensor with 36 Bit

Mechanical Behaviour of Shock-Absorbing Materials

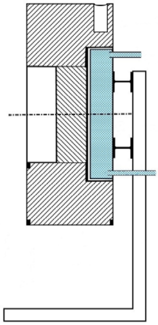


For the package safety assessment numerical simulations are often used to evaluate the behaviour of the involved components. Basis for the numerical calculations are material models with their specific material property parameters. The correct physical understanding of the behaviour of package impact limiters are an essential part for the safety evaluation.

Therefor BAM conducted systematic material tests of wood filled shock absorbing structures to understand the compression phenomenon.

Dynamic compression and penetration tests were performed at the guided drop test machine as part of a resarch project. Load displacement characteristics for the materials spruce wood and damping concrete were determined under different loading rates and temperatures. Spruce wood is often used for the energy absorption in impact limiters of transport casks. The determined characteristics were applied for the development of a new material model in the FEM-code LS DYNA. The results support the estimation of the energy absorption during the impact on a damping concrete foundation and the verification for applicability of an existing material model.

Burning Behaviour of Impact Limiters



While impact limiting components absorb energy during the mechanical tests, they might emit energy during the fire test and afterwards. To fulfill the safety requirements, it is important to understand the burning behaviour of impact limiters and its influence on package safety during the thermal test. With the mechanical pre-damage of the package, caused of drop testing, the impact limiters are exposed to a 30-minute fire and supsequent natural cooling phase.

Within the scope of the research project a large-scale fire test was designed in a way to determine the effective heat load of a typical impact limiter during the thermal test. A modular test stand was designed for testing of different impact limiter sizes. With this test stand a wood filled impact limiter with a diameter of about 2.3 m was exposed to a fire in accordance with IAEA requirements. The burning behaviour and the heat flux to a generically designed package test specimen was measured and recorded. The results will be used for the safety evaluation of packages by BAM.

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