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LEAKAGE TESTING DURING LATERAL DISPLACEMENT OF METALLIC SEALS UNDER MECHANICAL ACCIDENT IMPACT

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ABSTRACT

In context with approval design tests, the IAEA regulations for the safe transport of radioactive material specify tests for demonstrating ability to withstand normal and accident conditions of transport. For 9-m drop test onto an unyielding target the drop orientation of the package must be chosen in a manner so that maximum damage occurs with regard to the safety criteria.
With respect to leak tightness after drop test impacts a horizontal or slap-down orientated test model can cause a lateral displacement of the packaging’s lids, affecting the leakage rate of the closure lid system strongly.
In Germany dual purpose casks with double lid sealing system composed of primary and secondary lid with bolts, metallic seals as well as cask body sealing surfaces are mainly used.
Besides free drop tests with full-scale and half-scale models within licensing approval procedure BAM develops experimental testing methods to simulate defined stresses and deformations by means of components testing.
In order to investigate the relation between lateral lid displacement and leakage rate, BAM performs impact tests with small scaled flange-lid systems of transport packages in a drop test machine for guided drop tests.
The test setup is realized in a way that the flange part is fixed while a drop weight is impacting onto the lid’s edge. The dynamic displacement of the lid is measured simultaneously.
Because of capturing the drop weight after first impact during a short rebound phase by pneumatic arrest mechanism a secondary impact on lid’s edge is excluded.
The guided drop tests were accompanied by various measurements such as leakage rate recording during and after impact, identification of lateral shifting by electro-optical displacement transducer as well as decelerations of the lid and the impacting weight.
This paper describes the test setup, the test and measurement techniques as well as first results concerning the relation between lateral lid displacement and leaktightness.

INTRODUCTION

In context with approval design tests, the IAEA regulations for the safe transport of radioactive material specify tests for demonstrating ability to withstand normal and accident conditions of

transport.
At drop tests of packages onto an unyielding target with a horizontal or slap-down orientation a lateral displacement of the packaging's lids can be observed.
In order to investigate the relation between lateral displacement and leakage rate of the closure lid system, BAM performs impact tests with scaled flange-lid systems in a drop test machine for guided drop tests. Additional information on this area of investigation is given in [1].

EXPERIMENTAL TEST SETUP

The impact tests with scaled flange-lid systems performed at the BAM Test Site Technical Safety, more precisely at the drop test facility. Among a free fall drop tower, there is a drop test machine for guided drop tests.
“The drop test machine enables a clearly specified component load by a precisely positioned falling test object or drop weight. Loading rates corresponding to a drop velocity up to 15.3 m/s can be achieved at maximum drop energy of 118 kJ. Test objects with a width up to 1600 mm can be tested with the help of two adjustable guide rails.” [2]
The positioning device for the flange-lid systems (figure 1) was fitted on to the unyielding base (heavy impact foundation with steel plate) of the drop test machine.

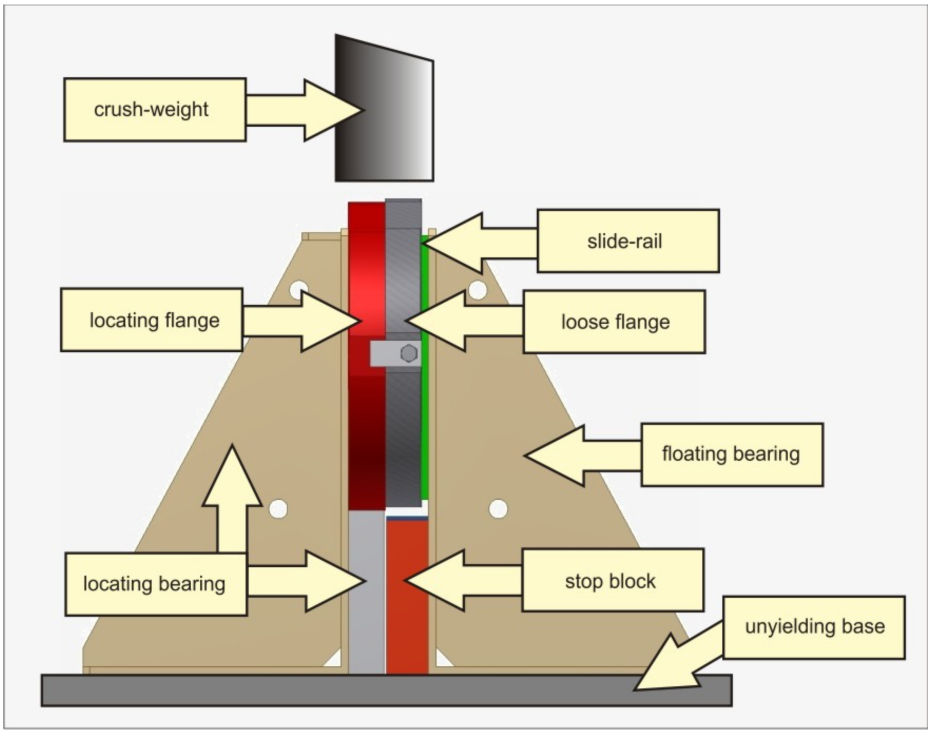

Figure 1. Positioning device with the flange-lid system (sketch)

The measurement equipment and gadgets were arranged around the positioning device with the flange-lid system. At the front side of the device (figure 2 a) similar notches made possible the lateral lid displacement measurement. The glands and fittings for the leakage measurement were fitted at the back side of the positioning device (figure 2 b).

a) front view **b) back view**

Figure 2. Test setup

Lateral, between the positioning device and the guide rails of the drop test machine, the actuator strands of the “Drop Weight Interception System (DWIS)” [3] were located.
The dynamic load of the flange-lid system was performed by an elastic collision of a 212 kg crush-weight on the upper edge of the loose flange. The drop height was 2,80 m.
The lateral lid displacement was limited by a stop block. To dampen the recoil of the loose flange, the upper edge of the stop block was covered with lead. After the first impact of the crush-weight, this was caught before another strike by the DWIS. So, a free swinging of the loose flange has been ensured.

MEASUREMENT OF THE LATERAL DYNAMIC LID DISPLACEMENT

The measurement of the lateral dynamic lid displacement was carried out by three different measurement methods.

Table 1. Applied lid displacement measurement methods

Method	Specification
Electro-optical transducer 100R	non-contact method, high dynamic resolution, severely limited target area
Highspeed video analysis	non-contact method, middle dynamic resolution, quasi-unlimited target area
Acceleration measurement	wired-contact method, high dynamic resolution, stationary assembling

Pilot tests had shown that the maximum value of the lateral lid displacement has a significant influence on the tightness of the flange-lid system. The maximum value of the lateral lid

displacement can be observed approximately in the middle of a half-wave after the impact of the crush-weight. These half-wave has a temporal extension about 2 - 3 milliseconds.
Therefore, the demands on the dynamics of the different measurement methods were high.
The electro-optical transducer and the acceleration sensor were 2MHz sampled. The highspeed video was recorded with 4000 fps.
Typical measured waveforms of different applied measuring methods are shown in Figure 3.

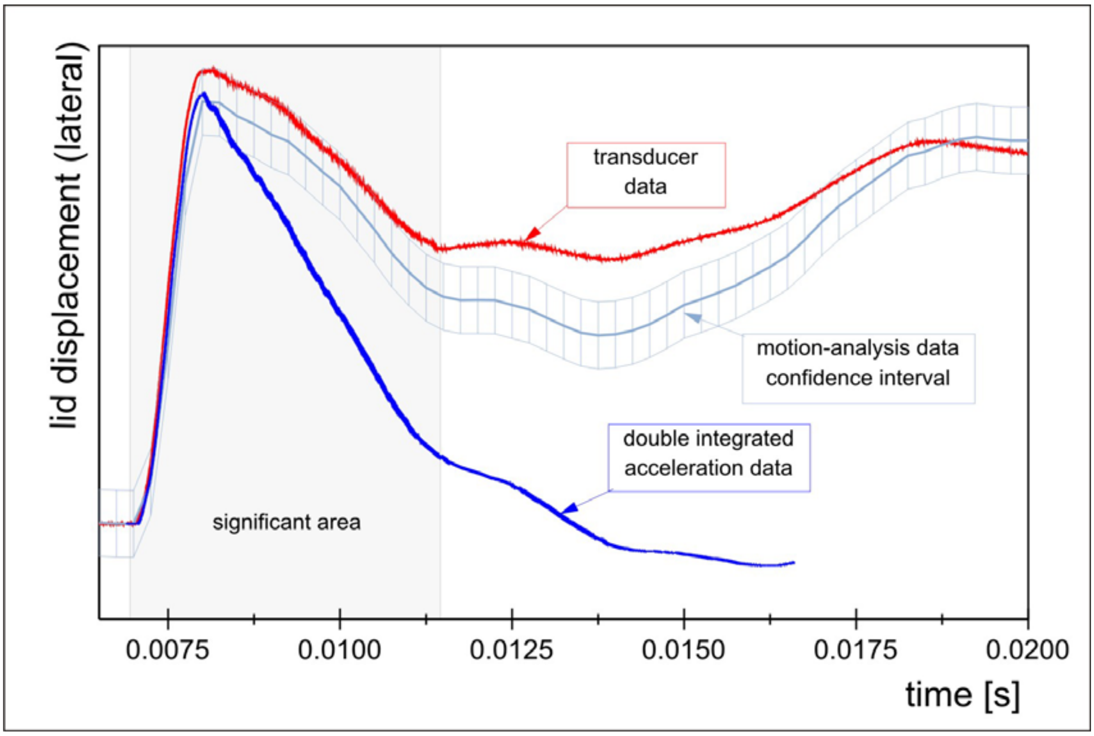

Figure 3. Lid displacement waveforms of different measuring methods

Determination of maximum dynamic lid displacement is possible in various ways.
The whole course of the lid displacement will be well measured by the sensor 100R.
Also, the video analysis gives satisfactory results.
An advantage of the video analysis method is to create various motion analysis of other measurement points afterwards when these are in the visible range of the video-record.
By the acceleration sensor (mounted on the backing flange) shall register the maximum lid displacement redundant.
In addition to measurements of the lateral displacement of the loose flange, the fixed flange was observed for inclination. Measuring equipment was a 200 kHz laser vibrometer. The measured inclinations were negligible.

MEASUREMENT OF THE HELIUM LEAKAGE RATE

In addition to the measurement before and after the dynamic lid displacement test, measurement of the Helium leakage rate was carried out simultaneously with the dynamic lateral load according to the method A1 (DIN EN 1779). Measuring equipment was a Phönix L300.
In this case, the He-leckare rate was plotted and recorded (10 kHz) for the duration of the first 10 seconds after the trigger event.
It was found that a plotter is not really suitable for registration of such short event signals.
Because the He-pressure wasn't measured simultaneously, the detector signal (response) in the following only is considered.
Typical 10 second detector responses are shown in Figure 4.

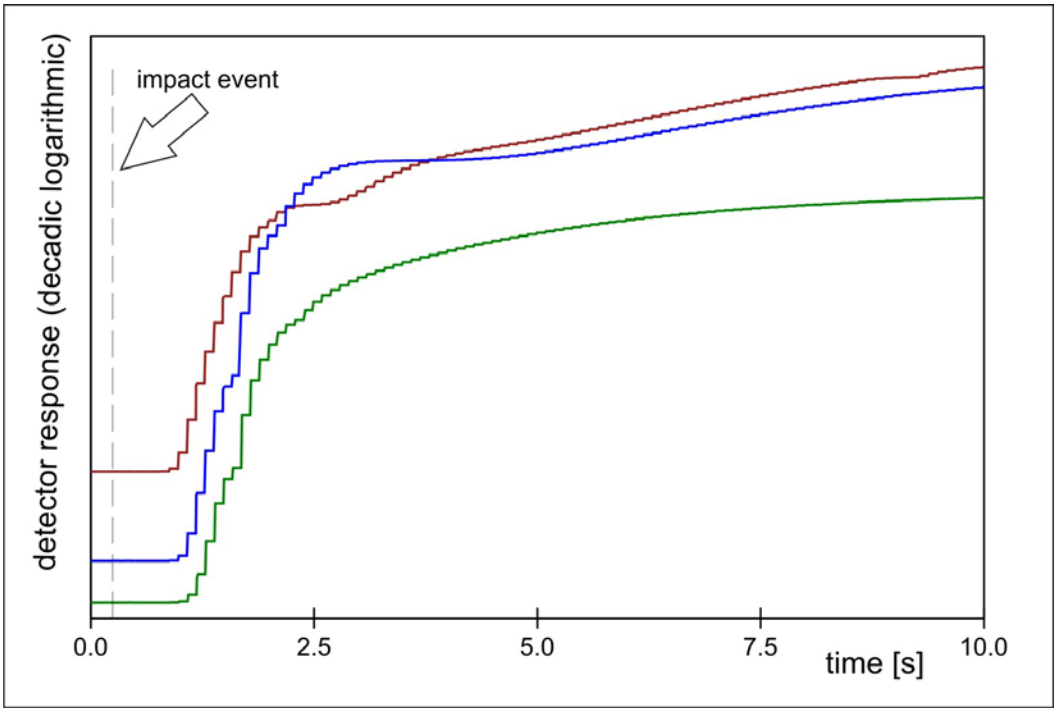

Figure 4. Typical 10 s detector response

Long-term recordings, performed after the dynamic lid displacement tests, showed a steady decrease in the He-leakage rate. The shape of the curves (Figure 4) suggests that this effect occurs in the first minutes after the loading. To determine the timing of the reversal of the trend, it will be necessary to extend the recording time in coming trials. Furthermore, the influence of the transmission behavior of the He-leakage measuring system must be examined in detail. In particular, the influence of the tubing lengths.

DROP WEIGHT INTERCEPTION SYSTEM (DWIS)

For these application and similar tasks, a technical system was developed, that avoid a further impact onto the specimen. This is an electro-pneumatic system which meets the particular requirements of the fast response time of the actuators and the high load equally.
Integral part of the DWIS are fluidic muscle from the company FESTO (Germany).
The system is patented by BAM and well tested.
Special properties are: process-controled triggering, fast and high loadable actuator, no explosive charge, after about 60 second enabled for next power stroke.

CONCLUSIONS

The drop test machine is qualified for dynamic impact tests with scaled flange-lid systems of transport packages. According to prior studies the appropriate measurement method to register the dynamic lid displacement is the electro-optical transducer method with the sensor 100R. Combined with the patented Drop Weight Interception System a defined, dynamic loading of the flange-lid system is possible. The influence of the transmission behavior of the He-leakage measuring system must be examined in detail. In particular, the influence of the tubing lengths. Further investigations are pending.

REFERENCES

1. A. Rolle, „Verification of design leakage rates for artivity release calculation”, PATRAM 2013
2. „drop test machine”, http://www.tts.bam.de/de/pruefeinrichtungen/tts_gefuehrte_fallversuche.htm, 2012
3. patent specification DE 10 2011 056 350 A1, „Fallmassen-Auffangsystem für Fallwerke bzw. Fallprüfstände“, Auster, J., 2012