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APPLICATION OF UNDERWATER TESTS TO DETERMINE HE-EQUIVALENTS: EXPERIMENTAL AND NUMERICAL STUDY

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Abstract: A technical-safety evaluation of the detonation effects of pyrotechnic compositions can be performed on the basis of TNT/PETN equivalence. The equivalence determination can be carried out by characterization of the blast wave generated from detonations in free field tests, which however can be highly resource intensive and prone to uncertainties. In our contribution, we would like to present underwater ‘small-scale’ experiments for the determination of such equivalents.

Underwater experiments, as described in the European standard EN 13763-15:2004, are performed to test the capability of detonators to initiate explosives by determining the released energy. At BAM this test was modified to compare the energy output of the pyrotechnic mixtures (those used in airbag gas generators and firework flash compositions) and thus to determine their equivalents of high explosives like TNT or PETN. In the modified tests, small cylindrical copper containers were filled with pyrotechnic substances, which were then attached to standard detonators. This explosive charge assembly was then lowered into a water tank of about 1000 Litre capacity. At the same depth as the charge assembly, a piezoelectric pressure sensor was immersed in the water. The horizontal distance between the charge and sensor was about 400 mm. By recording the time-dependent pressure during the test, the shock energy as well as the energy associated with the expanding gas bubble was determined. In addition, energy associated with chemical decomposition was determined using differential scanning calorimetry, DSC method.

The underwater tests were numerically modelled with the hydro-code, APOLLO-BLASTSIMULATOR. Our contribution will compare the results from the numerical simulations with the measured pressure-time characteristics. A detailed parameter analysis is performed with APOLLO to fine tune the simulation model with the experiments. The effects of the water tank-wall reflections and the relative positions of the explosive charge and the sensor is investigated. A detailed analysis of the simulated pressure-time characteristics is used to understand the relationship between charge weight and peak pressure as well as the collapse of the gas bubble. The numerical simulation results together with experimental results enable the comparison of the energy output of pyrotechnic substances with that of TNT and PETN.