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Environmental Simulations for EOD Shaped Charges

This article describes the methodology and importance of environmental simulations and testing of shaped charges used for the disposal of explosive remnants of war and landmines. The author discusses a single sequence of tests conducted on a specific product as an example of the depth to which environmental factors should be investigated in order to address them before final production and manufacture.

by Reto Liechti | Saab Bofors Dynamics Switzerland Ltd.

Vibration caused by transportation, temperature changes and the natural aging process, as well as other environmental factors, can impair the safe operation of a product. Assessing environmental effects on a product can be time-consuming and expensive. However, in the case of explosive-ordnance-disposal equipment, environmental simulations and testing are basic tools for the scientific investigation and production of safe new products.

The Need for Environmental Simulations

When handling explosives, safety and reliability are key factors for a successful mission. In demining operations with in-situ disposal, shaped charges are often used, especially when inducing deflagration of submunitions (cluster bomblets). Thus, using shaped charges speeds up operations and minimizes hazardous risks to deminers.

Many shaped charges are available on the market. Any of these charges used in the field can cause harm if not used properly. The shaped charges referred to in this article are proven through a program of extensive environmental tests, not only in their development phase but also throughout the manufacturing stage. These environmental test programs include assessment, clearance checks to ensure operators can handle (and) transport-vibration checks (to test for worst-case land, sea and air conditions). Environmental tests also consider extreme environmental aggression such as rapid and extreme changes in temperature, pressure, humidity and adverse immersion environments such as sand, dust storms and water. These tests guarantee the product can withstand different circumstances and provide full performance until the end of its anticipated life cycle.

Development Phase

Environmental simulations are often performed either before a product is in its early development phase or when a product is about to enter the market and go into service. Development phases are usually detailed procedures and individual phases that some companies refer to as a series of Design Definitions. The content for each DD phase varies from one project to another but generally takes the form as illustrated in Figure 1.

Sequence

In order to discuss a sequence for environmental testing, one sequence of the tests will be more closely examined now. Each test is dependent on its predecessor. With this dependence, potential failures can be summed; this summation results in better estimates than the product’s mechanical limit of the product (see Figure 3 page 72).

Standards and Specifications

Test results should be according to certain test-method-type standards such as:
- MIL STD 314: Department of Defense Test Method Standard for Fuze and Fuze Components, Environmental and Performance Tests
- STANAG 4700: Environmental Testing (AECTP 300 & 400)
- IEC 6068-2-20: Environmental Testing

Vibration Tests

High-cycle fatigue materials performance is commonly characterized by an S-N curve (S = stress, N = cycles to failure), also known as a Weibull-curve. A vibration test simulates the effect with vibrations often experienced during transportation and operation. The test attempts to cover all occurrences the product will encounter during its product lifecycle. In the case of explosive charges, the more intense the vibration environment, the faster the aging process occurs and the higher the possibility of discovering cracks and gaps in between the explosive filling and the mechanical body.

X-ray Inspection

X-ray inspection will prove if the vibration tests had any influence (see Figure 3). In this illustrated example, the procedure is undertaken according to MIL STD 810E, MIL standard 314.4, category one (basic transportation) with the following characteristics:
- Vibration test specifications:
- Configuration: Products in original packaging
- Vibration V 964: Horizontal, transversal and vertical axis vibrations
- Frequency: 10 - 300 Hz/10 g
- Testing time: 1 hr per axis (5 axis)
- MIL STD: MIL-STD 810E, MIL 314.4, Fig. 314.4-1
- Number of test pieces: n = 30 – batch no. 2050 - 2079
- Packing: Wooden box no. 047 with polystyrene foam
- Temperature: Room temperature

The rain test determines the effectiveness of seals and cases in preventing water penetration. The test also shows the product capability to satisfy performance during and after exposure to water.

Rainfall test specifications:
- Test order-No: 10139682 and 4135 0990
- Used facility: Rain plant No. 80
- Frequency: 10 - 500 Hz/1.04 g
- Type of test: Rain test unpaired
- MIL STD: According to MIL, method 502.2
- Rain quantity: 100 mm/hr, wind velocity 18 m/s
- Duration: 30 min.
- Rotary table: Turning

The rain test determines the effectiveness of seals and cases in preventing water penetration. The test also shows the product capability to satisfy performance during and after exposure to water.

X-ray Inspection

An X-ray inspection is performed after each individual environmental test in a sequence. It is a real-time nondestructive subsurface inspection and shows the product’s internal characteristics. The inspection is a dynamic 360-degree live image where the object is rotated in front of the X-ray source. During a visual inspection by trained operators, the X-ray can indicate any hidden cracks or air gaps.

The advantage of the X-ray inspection is that no harm will reach the product, but it will provide full information about the object’s density, which is directly linked to quality and performance. Any cracks or gaps detected would essentially have a negative impact on product performance and accuracy.

Performance Test

In addition to all previous tests, a final performance test simulates a mine or unexploded ordnance disposal operation where, for instance, a mine body or artillery shell requires penetration before deflagration or detonation. The setup for such a performance test with a defined target can utilize multiple cycled homogeneous armor plates as shown in the images 4 and 5. The penetration will show any performance problems such as variation, dispersion or inadequate penetration of the jet’s tip that may not be detectable in any of the previous tests. The requirements for the performance penetration test are that it must be reproducible and permit comparisons to identify penetration performance, which is the most important testimony of a high-quality product. In the field, high accuracy and reproducibility will permit fast intervention and safe and successful operations.
In the early development phase of most products, environmental simulations and testing can uncover potential future risks and reduce the eventual time to market. Simulations and testing can improve designs and ensure the product is safe and reliable throughout its full life cycle. These environmental assessments can be time-consuming and expensive, but assessment prior to product use in the field is more economical and ethical than marketing untested products that may result in considerable damages and loss of life.  

See endnotes page 83.