

Fragment Tests after MIL-STD 2105 B

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Summary

Explosively formed projectiles (EFP) charges with 16 g liner mass will be very suitable for the fragment impact tests of the MIL-STD-2105 B. They achieve the required velocity of 2530 m/s with about 80 g HE. 3 to 5 EFP generators can be fired simultaneously with less than $\pm 1 \mu\text{s}$ jitter or with any intended time differences. The fragments can be very accurately aimed to the wanted hit position on the test item. These low cost devices do not result in cubic fragments with 12.6 mm side length; they are hemispherically shaped. However, depending on side-on, edge-on or tip-on impacts, cubic fragments have more than a factor of 2 threshold velocity differences. Therefore much more reliable results with a spherical or hemispherical fragment shape on the impact will be achieved.

1. MIL-STD-2105 B Requirements

The MIL-STD-2105 B requires for the acceptance of an “Insensitive Munition” the survivability or at least no violent reactions on fragment impacts⁽¹⁾. Under the preferred test procedure § 5.2.4.2.1. (Figure 1) mild steel cubes of 12.7 mm side length should hit the test item with a velocity of 2530 m/s $\pm$ 90 m/s and with at least two, but not more than five fragments.

In the USA a fragment generator FRAGMAT with 50 kg–90 kg high explosive, Composition B, is used with a central point initiation⁽²⁾, or with the NAWC FRAGMAT launcher five cubic fragments are launched with 18.3 kg Octol and a 5 multipoint initiation (Figure 2)⁽³⁾. Such a high amount of explosives does not only generate an enormous blast effect but will also load additionally the target. Further, such an amount of high explosives cannot be used at many test ranges, at least in Europe. In addition the hit position of the fragments is not controlled very well. For catching the natural fragments, built by the axial confinement originally made of steel, a 75 mm to 100 mm thick Rolled Homogeneous Armour (RHA) shielding is necessary to avoid perforation or to overcome spall fragments from the shield⁽⁴⁾. This problem is drastically reduced by using a special tungsten/epoxy confinement, produced with a special molding process⁽³⁾.

Under § 5.2.4.2.2. an alternative test procedure #1 is described where a “single” 16 g mild steel fragment with 12.7 mm diameter and 14.7 mm cylindrical length and an additional cone of 140° on its front side can be fired from a

powder gun with 1830 m/s. However, this leads to a total different threat level compared to § 5.2.4.2.1.

Under § 5.2.4.2.3. an alternative test procedure #2 is given where the test setup, fragment characteristics and passing criteria shall be designed, based on the threat hazard analysis (THA) to address fragment threats for tactical situations.

The author has the impression that the “trial inventors” had problems to test the different items with the 16 g cubical fragments launched by HE generators with 2530 m/s. On the one hand, this is an extremely high velocity, which may occur on static targets, but at least very seldom. On the other hand, the necessary amount of high explosives to launch such fragments also creates a lot of technical problems.

The alternative test procedure #1 is a practical compromise to reduce drastically the requirement now to the impact by a single mild steel fragment with a cylindrical shape and to launch this fragment from a powder gun with 1830 m/s.

The alternative test procedure #2 gives a further compromise, certainly imposed by the threat hazards analysis.

To conduct the multiple fragment impacts with the required velocities – 2530 m/s $\pm$ 90 m/s and precise impact location – either on the main charge or on the most shock sensitive location of the munitions, the Denver Research Institute (DRI) has designed and used a dual powder gun with two extremely long 40 mm barrels arranged in a special mobile shelter⁽⁴⁾. Special problems arose to achieve the velocities by changing the test site. No remarks are given on the simultaneity of the two fragments. The reactivity of confined high explosive charges changes by the time difference of the fragment impacts⁽⁵⁾.

Four such preformed fragments can also be simultaneously launched by a very special laboratory gun⁽⁶⁾. In general, this is generally also an expensive tool. For the installation, the gun needs a concrete base. The hit positions of the four fragments on the AURs (all up rounds) are relatively well defined.

Launching of 16 g fragments with an EFP-design to velocities of 2530 m/s is no problem at all. Mild steel for the fragments can also be used. Only the shape will not be cubical. But a cubical shape is also changed to a conical or hemispherical front after perforation, also of thin target material. The orientation of a cubical fragment on a HE surface has a very great influence on the threshold values for the initiation and for the light covered high explosives (Figure 3)⁽⁷⁾. More reliable results can definitely be achieved by a hemispherical front face of the fragment.

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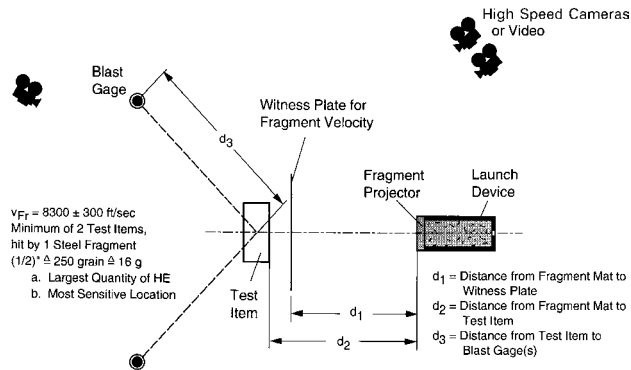


Figure 1. Sketch in MIL-STD-2105 B (Navy) for the fragment impact tests after the procedure § 5.2.4.2.1.

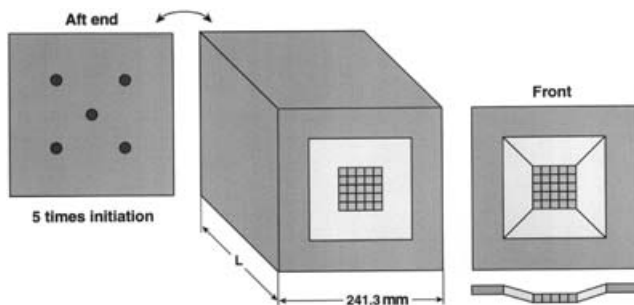


Figure 2. FRAGMAT fragment projector. To launch 16 g cubic fragments to 2530 m/s velocity 18.3 kg Octol and 5 initiation points on the rear side and a special radial confinement around the fragments are necessary^(2–4).

A large number of tests were conducted by the author with 40 g heavy EFP-fragments to find the threshold values of confined high explosive charges with different barrier or cover plate thickness at 2.400 m/s impact velocities⁽⁵⁾.

2. Fragment Threat

The author criticized this unrealistic requirement in his presentations on the “Propulsion and Energetic Panel, 78th A Specialists’ Meeting” held 1991 in Bonn, Germany, which is published in the AGARD-CP-511⁽⁸⁾ and at the binational German/French Workshop at the Institute Saint Louis in November 1992⁽⁹⁾.

Boggs showed in his paper “Hazards of energetic materials and their relations to munitions survivability” the fragment threat as a function of fragment mass and velocity and in a rough way their probability of occurring⁽¹⁰⁾. His diagram shows that the 16 g fragment with 2530 m/s is beyond the threat range (Figure 4). A fragment of exactly 2050 m/s with 73 g has a higher frequency of appearing. A further critical

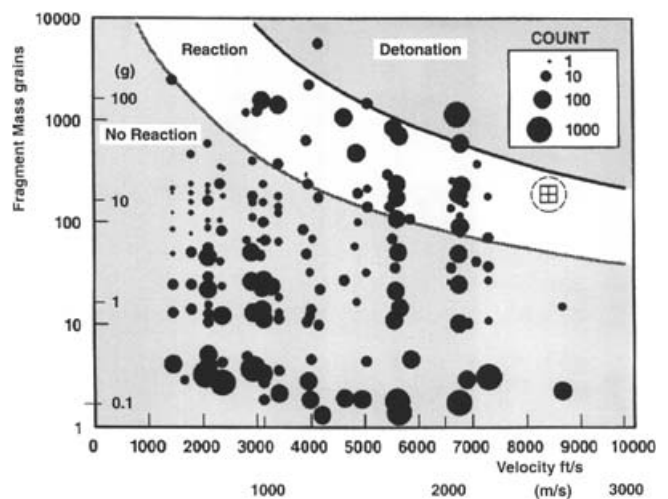


Figure 4. Fragment threat on a response plot⁽¹⁰⁾.

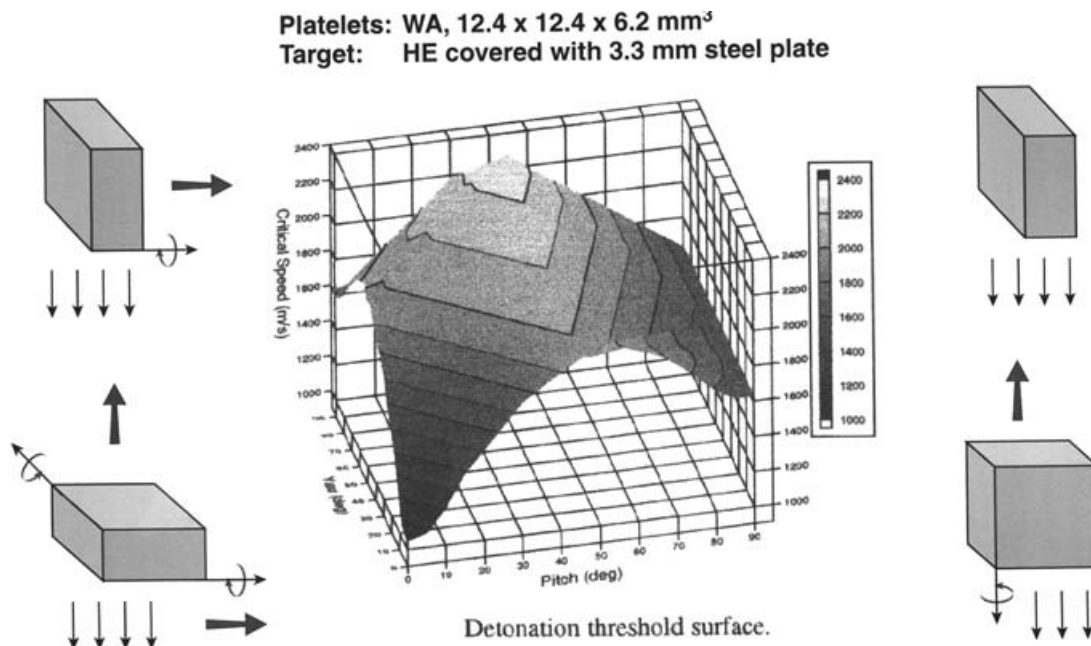


Figure 3. Effect of impact orientation on the critical velocity for initiation of a slightly covered explosive charge⁽⁷⁾.

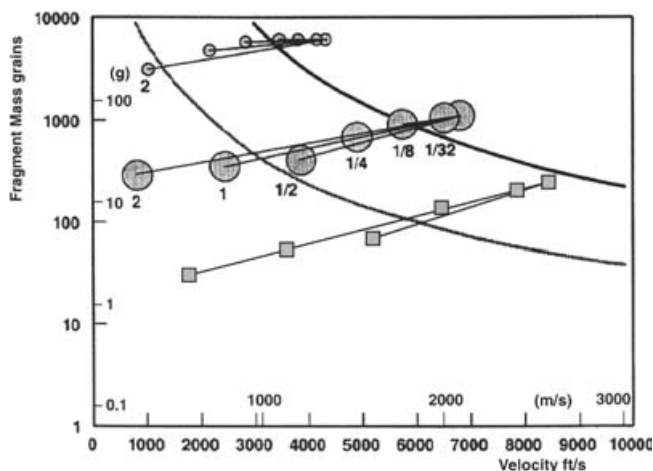


Figure 5. Using THOR equations for the degradation of example fragments as a function of barrier thickness⁽¹¹⁾.

fragment but roughly around 1% of the frequency compared to the 73 g fragment, is a fragment with 430 g with a velocity of 1280 m/s. These two fragments represent a much higher threat to our munitions compared to the unrealistically fast fragment, as Figures 5 and 6 after Wagenhals show in which the perforation of steel barriers of different wall thicknesses are additionally presented with two different perforation equations (THOR, respectively FATE)⁽¹¹⁾.

3. EFP Fragment Generator

Assistance was given by Weimann for the layout of the fragment generator as an EFP charge with the liner and charge geometry⁽¹²⁾. A mild steel liner (ARMCO-Iron) with a mass of exactly 16 g was used (Figure 7). To ensure that no liner mass is lost by the launch process, a radial confinement or a so-called spalling is used with a hexagonal shape to get also a very well controlled rear or base formation. The weight of the cast high explosive charge of Comp. B-3 is only about 80 g. By firing 2 to 5 charges the

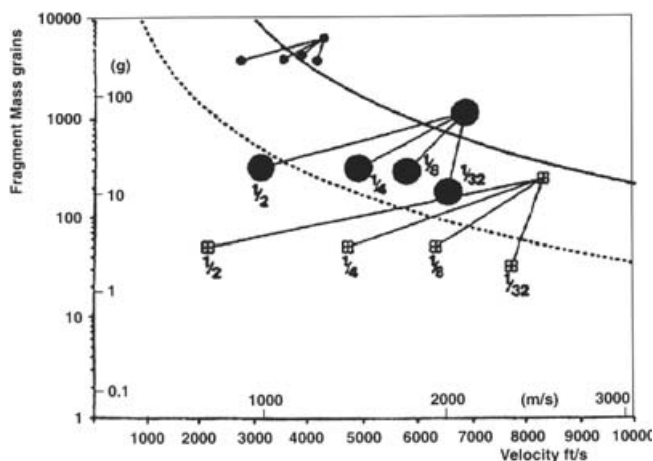


Figure 6. FATE equations for the degradation of example fragments as a function of barrier thickness⁽¹¹⁾.

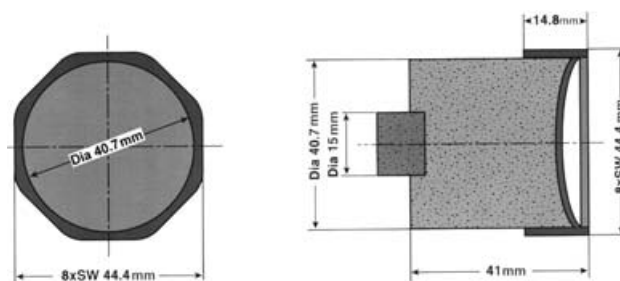


Figure 7. Typical layout for the 16 g fragment generator.

total amount of detonating high explosive is 160 g to 400 g which is extremely less compared to FRAGMAT generators of 18 300 g to 50 000 g. This does not give any blast load at all to the test item in one or a few meters distance.

Two 16 g EFP-fragment generators were fired simultaneously in front of a flash X-ray unit with a delay time of 500 μ s (Figure 8). The axial distances of the two fragment generators were 160 mm. A plywood was installed on the rear side between the two 16 g EFP-fragment generators. They were glued in plastic tubes which were fixed in a 19 mm thick plywood (Figure 9). Then they were individually oriented to the target by a laser.

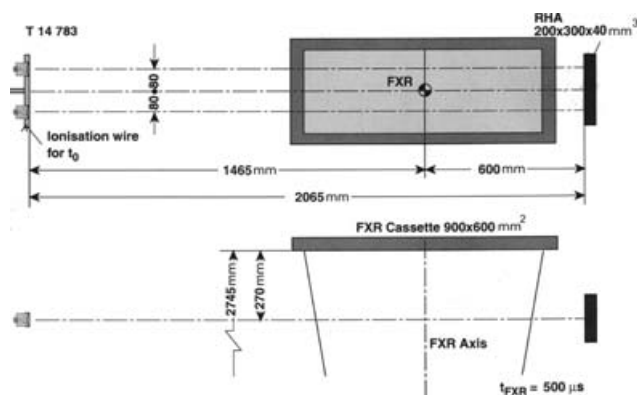


Figure 8. Test setup to get the velocities and shape of the 16 g EFP fragments by flash X-ray.

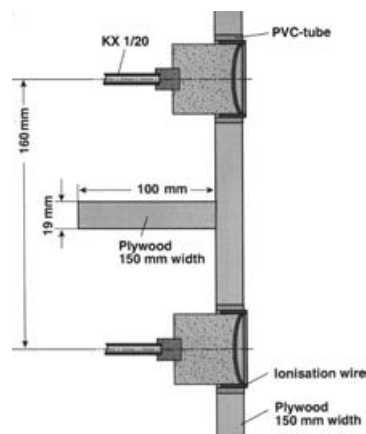


Figure 9. Holding fixture of two 16 g EFP-fragment generators. For aiming generators a laser, fixed on the target, is mirrored on the liners of the EFP-fragment generators.

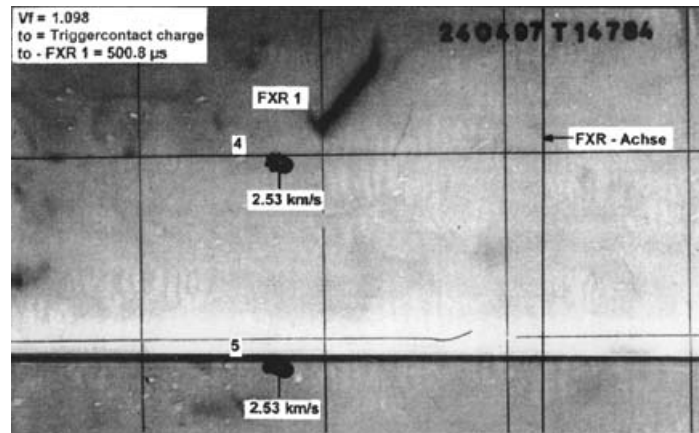


Figure 10. The two fragments with the analysed velocity of 2530 m/s after 500 μ s in 1250 mm travelling distance.

As the 500 μ s FXR-picture shows the EFP-projectiles are a little tilted at 1270 mm distance (Figure 10). The impacts on the mild steel target plate at 2100 mm standoff are very accurately at the desired aiming points in 160 mm distance to each other (Figure 11).

4. Conclusion

A 16 g fragment generator can be designed as an EFP charge and can launch a 16 g fragment with 2530 m/s. The liner material for such EFP generators has to be carefully selected. In case desired, the velocity can also be increased, respectively also easily decreased.

With the same design, also other masses can be launched as already demonstrated with 40 g and 240 g fragment masses at 2.400 m/s velocity⁽⁵⁾. This means that velocity and masses can be changed relatively easily.

However, irrespective of this, these 16 g fragment generators are simple and low cost devices to get one or more impacts on a test item with highly accurate hit positions. With the low explosive weight it is an ideal tool to test the survivability of ammunitions by fragment impacts required in MIL-STD 2105 B.

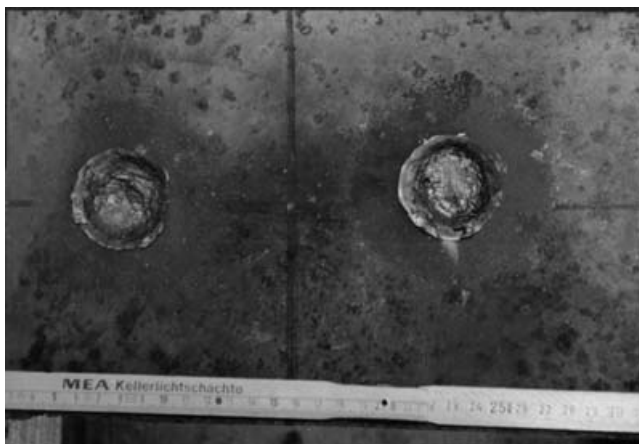


Figure 11. The two impacts of the fragments are exactly on the aimed cross hairs in the mild steel block in 2065 mm distance.

The hemispherical shape of the fragment guarantees high reproducibility of the initiation threshold in contrast to cubical fragments.

5. References

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(Received December 12, 1998; Ms 1998/36)