

IM HE-T[®] Final Hazard Classification

1.0 IM HE-T[®] Background

The IM HE-T[®] cartridge was developed as a joint effort between General Dynamics- Ordnance and Tactical Systems based in St Petersburg, FL and Nammo based in Raufoss, Norway. Nammo developed the projectile assembly based on their 120mm Mk 1 HE-T round, fielded by Swedish Defense Forces in 1998. The IM HE-T[®] is currently qualified for both the L44 gun system in the Leopard II tank and the M256 gun system in the M1A1/A2 Abrams tank. IM HE-T[®] has capability against a target set that includes bunkers, reinforced concrete walls, light armor, and personnel.

The IM HE-T[®] consists of a propulsion/ignition system combined with an IM explosive filled projectile. The IM HE-T[®] propelling charge is 7-perf hybrid ball powder and utilizes an electric primer for ignition. The projectile consists of a forged steel body filled with PAX-48 explosive. The fuze on the forward end contains a booster charge and lead charge of PBXN-5. The fuze has two electric detonators, one for super quick mode and one for delay mode. A supplementary charge consisting of PBXN-5 is placed between the fuze and the PAX-48 main charge. The assembled cartridge is packaged in a standard PA171 vented ammunition container. See Figure 1.1 and 1.2 below.

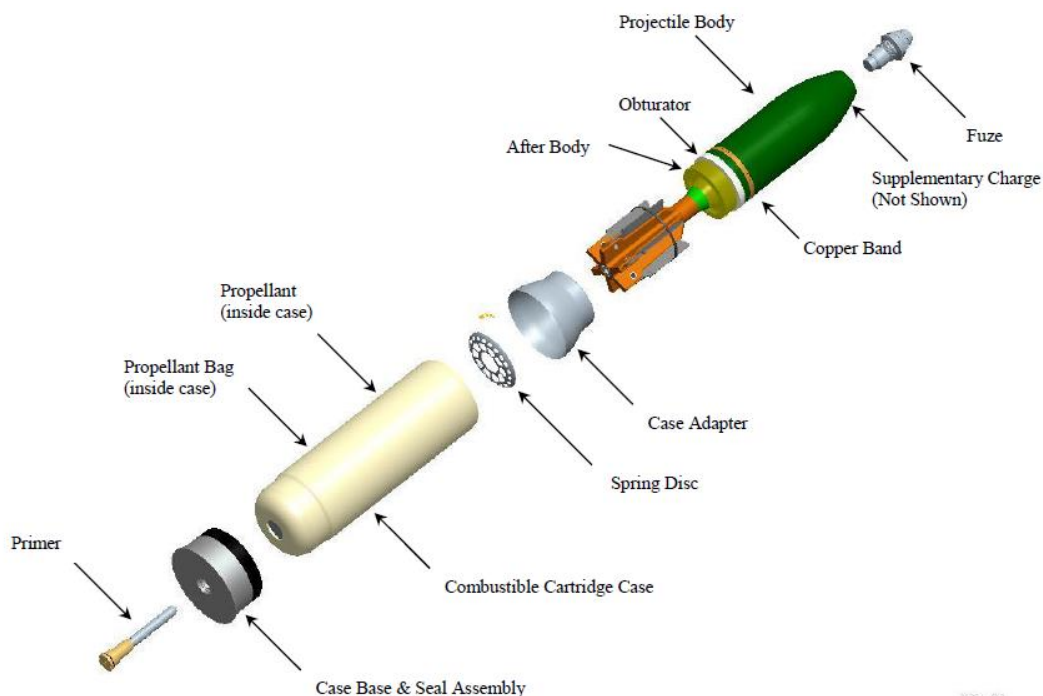


Figure 1.1- IM HE-T[®] Cartridge Diagram

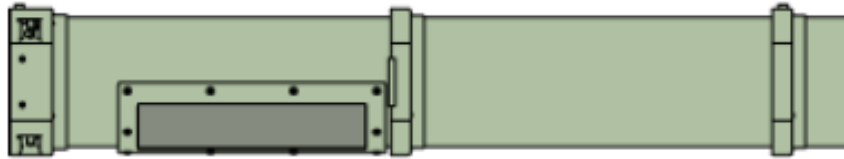


Figure 1.2- PA171 Ammunition Container

2.0 DOD Final Hazard Classification Testing

IM HE-T[®] Qualification testing in support of Final Hazard Classification was performed by the USG in 2013. To determine the Final Hazard Classification of the packaged IM HE-T[®] cartridge, a test plan was devised that included testing in accordance with UN Series tests per 49 CFR and the Joint Technical Bulletin (TB) 700-2, 30 Jul 2012, Department of Defense Ammunition and Explosives Hazard Classification Procedures. A summary of test results is provided in Figure 2.1 below. Figure 2.2 and 2.3 show the set up and an acceptor cartridge from the Sympathetic Reaction test.

| Test | Standard | Results |
|----------------------------|----------------------|----------------|
| Thermal stability | UN Series 4 (a) | Performed |
| 12-meter drop | UN Series 4 (b) (ii) | Performed |
| Single Package | TB 700-2 | Not performed |
| Sympathetic Reaction | TB 700-2 | Performed |
| Liquid Fuel/ External Fire | TB 700-2 | Performed |

Figure 2.1- DOD FHC Test Results



Figure 2.2- Sympathetic Reaction Test Set Up



Figure 2.3- Acceptor Projectile from Confined Test

The Department of Defense Explosive Safety Board (DDESB) reviewed the results of the testing and assigned the IM HE-T® a Hazard Classification of 1.1E. A slightly modified version of the IM HE-T cartridge had been classified as 1.2E as produced for GD-OTS Canada and Nammo by their cognizant transportation authorities. The IM HE-T as produced in the US was expected to carry the same Hazard Classification.

3.0 SMS Series 6 Testing

In an effort to relax the initial Hazard Classification without changing the design, testing was recommended by Safety Management Services (SMS) to be performed to requirements of both the UN Series 6 (a) Single Package Test and to the UN Series 6 (b) Stack Test. Testing was performed in two phases, starting with one initial Stack Test and followed by two more trials with an altered pallet configuration and one Single Package Test. DOT provided feedback prior to initial testing and following the results of the first phase. Results of testing are summarized in Figure 3.1 and further detailed in the sections below.

| Test | Conditions and Results | Pass/Fail |
|-----------------------------------|--|--|
| UN Series 6 (a) Single Package | Reaction effects were not contained within the packaging; reaction effects could cause propagation of adjacent packages as evidenced by a crater at the test site, a hole in the witness plate, measurement of a blast, and disruption and scattering of the confining material. | FAIL (mass explosion of the warhead) |
| UN Series 6 (b) Stack | In all three trials, the crater was not appreciably larger than that given by a single package, damage to the witness plate beneath the stack was not appreciably greater than that from a single package, and measurement of blast did not significantly exceed that from a single package. In the last two trials there was not a violent disruption or scattering of most of the confining material. In the first trial, there was violent disruption and scattering of most of the confining material since the test was conducted on a thicker witness plate with the donor cartridge higher up in the stack (i.e. one layer off of the witness plate). | Pass (no evidence of explosion of the contents of more than one package) |

Figure 3.1- SMS Series 6 Test Results

3.1 Single Pack Test

The Single Pack Test was recommended by DOT for comparison to the results of the Stack Test for the witness plate, pressure, and distances of debris including UXO. A single packaged donor cartridge was placed directly on the witness plate with 5 sand-filled PA171 metal containers around the donor. The test set up was covered with loose earth with a minimum thickness of confinement in every direction of 0.5 meters. The donor was initiated into the main explosive charge of the warhead. See Figure 3.2 and 3.3 below for test set up and witness plate results.



Figure 3.2- Single Package Test Set Up



Figure 3.3- Single Package Test Witness Plate

3.2 Stack Test

Three trials of the UN Series 6 (b) Stack Test were conducted. The first trial was performed to determine the feasibility of reducing the hazard classification. A donor was surrounded by 4 adjacent acceptors above, below, and one to each side as shown in Figure 3.4 below. Witness plate and recovered debris from this trial are shown in Figure 3.5 and 3.6.



Figure 3.4- Stack Test Trial 1 Set Up



Figure 3.5- Stack Test Trial 1 Witness Plate



Figure 3.6- Stack Test Trial 1 Recovered Donor and Acceptor Debris

Following completion of the first trial, a second and third trial were proposed with some modifications from SMS and DOT input. Cartridges and ammo cans were painted different colors to discern the pallet position of recovered debris. The donor was placed directly on a thinner witness plate than the initial trial to better assess the reaction in comparison with the single package test. Blast overpressure was also recorded at 30, 40, and 50 feet for comparison to the single package test. The quantity of acceptors was increased from four to seven. Acceptors were placed in every position surrounding the donor and an additional two rounds placed two pallet positions away to determine if the reaction would lessen as the distance from the donor increased. Test set up configuration can be seen in Figure 3.7 below.



Figure 3.7- Stack Test Trial 2 & 3 Set Up

The reactions of Trial 2 and 3 were very similar in the deformation of the witness plate (Figure 3.8) and the distances, quantity, and condition of recovered debris (Figure 3.9). The furthest any debris was recovered from on either trial was approximately 40 feet. Pressure sensor readings for both trials did not exceed that of the single package test. Cartridges two positions away from the donor were mostly still intact in their ammo cans with the exception of the burning of the propelling charge and combustible cartridge case.



Figure 3.8- Stack Test Trial 3 Witness Plate



Figure 3.9- Stack Test Trial 3 Recovered Donor and Acceptor Debris

4.0 Final Hazard Classification Determination

Based on the results of the test, explosion of the contents of more than one package did not occur instantaneously when initiating the warhead as evidenced by the following:

- There was not a crater at the test site appreciably larger than that given by a single package.
- Damage to the witness plate beneath the stack was not appreciably greater than that from a single package.
- Measurement of the blast did not significantly exceed that from a single package.
- There was not a violent disruption or scattering of most of the material.

Results of the testing initially performed by the USG along with UN Series 6 (a) and (b) testing performed by SMS was submitted to DOT. The IM HE-T[®] cartridge as packaged in a PA171 ammo cans was assigned a 1.2E Hazard Classification by US DOT on August 23rd, 2019.

5.0 Lessons Learned

- Stack/Sympathetic Reaction Testing setup is open to interpretation and input from the approving authority.
- Test Plans to be reviewed and agreed upon by all involved parties prior to testing.
- Mark acceptors with different colors to better determine effects of reaction.
- Perform Single Package Test in advance for comparison.
- Perform initial trial in advance before committing resources to testing.