ALLEGATO 1

Pagine estratte dal testo

Handookof Weaponery
della

Rheinmetall
Waffentechnisches Taschenbuch 1972 -1982
Tradotto in inglese

1.4.6.2 Fragmentation Charges

Fragmentation charges consist of an explosive body, the surface of which fits against a casing of metat (usually steel). When the explosive detonates, the metal casing is splitted up and the resulting fragments are accelerated at a relatively high velocity. This charge is used in HE-projectiles, HE-bombs, HE-mines, hand grenades, etc.

The metal casing is generally homogeneous, but it can be provided with predetermined fracture points or be composed of separate elements. Predetermined fracture occurs through variation in wall thickness at specific points, or through a reduction in material strength in certain narrow zones, e.g. through electron beam treatment. Fragments resulting from predetermined fracture during detonation are referred to as preshaped fragments.

Fragmentation charges work in the following way. The fragments are hurled outward, and penetrate or perforate objects within a certain distance from the point of burst. In this way damage to the object is attained. The effects of a single fragment at a certain distance from the point of burst are determined by the velocity of the fragment, its mass, shape and position at the time of impact. These characteristics are determined, in turn, by the fragmentation process (mass and shape), acceleration (initial velocity), and the effects of aerodynamic forces (velocity of the fragment when it strikes the object). This means that the fragmentation effects can be divided into four phases, which, taken together, are known as *fragmentation ballistics:*

Fragmentation of the casing,
acceleration of the fragments,
loss of speed due to aerodynamic forces (drag).
penetration of the object (damage to the object).

The *fragmentation* of the homogeneous metal casing or envelope is dependent upon the type of explosive, the type of initiation, the caliber, the ratio between the diameters of the explosive charge and the entire charge (shell, grenade or bomb), and the quality of the casing material. The fragmentation of the metal casing can often be improved considerably by selecting the optimal quality of steel for the task. The relationship between the weight of the explosive and the total weight of the charge is between 0.1 and 0.2 for fragmentation charges; in HE-incendiary shells with tracer (small caliber), this ratio can fall to 0.05.

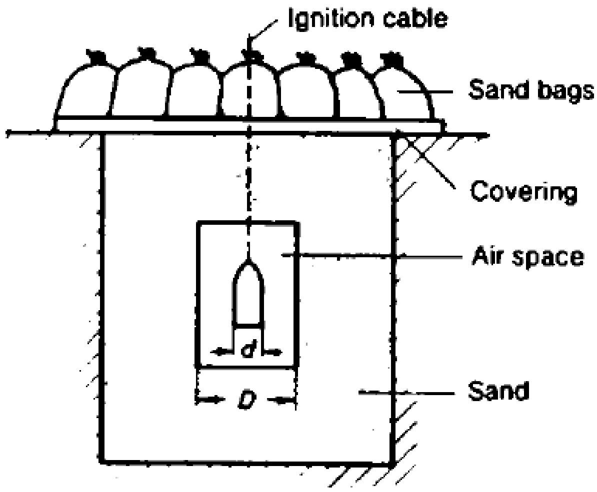

Figure 111. Detonation pit.

Figure 111 shows how the size (that is the size distribution) of fragments is determined using the detonation pit.

The fragmentation charge is surrounded by an air space inside a sand lined pit. The pit is covered and the cover is weighted down with sand bags to dampen the effects of the explosion. The initiation is set off either electrically, or by means of a mechanical fuze with a lanyard.

The air space between the charge and the sand, which is formed by a cardboard cylinder, affects the amount of fragmentation if it is too small. According to H. HANSEL [23], the proper ratio should be *D* % 5 *d*.

The fragments produced by the detonation are trapped inside the pit and can be removed from the sand by using a sieve. A magnet is used to separate the fragments from non-metallic materials (from the fuze or other components). The collected fragments are weighed and sorted according to weight classes.

In order to avoid the sifting required after detonation in a sand filled pit, LINDEIJER and LEEMANS [24] revived an old idea, which called for detonating underwater, and collecting the fragments in a net. Automatic selecting devices are being developed for the sorting of fragments.

Figures 112, 113, 114 and 115 depict typical examples of the *size distribution of the fragments* produced- when 30 mm shells are detonated inside a detonation pit. Figure 112 is a photograph of the fragments of a HE-incendiary shell (arranged according to weight classes).

Figure 113 shows the fragments from a thin wall HE-shell (Minen- geschoss) of the same caliber. Figure 114 and 115 illustrate the number of fragments in each weight class produced by the two projectiles.

The *acceleration* of the fragments produced when the shell body explodes is largely dependent on the weight ratio $\mu = m_{body} : \mu_{\ explosive}$ .The impulse is transferred firstly by the shock wave which is transmitted to the body and repeatedly reflected at its inner surfaces, and then by the exposure of the fragments to the flow of the expanding fumes. The direction of motion of the fragments is roughly at right angles to the surface of the charge.

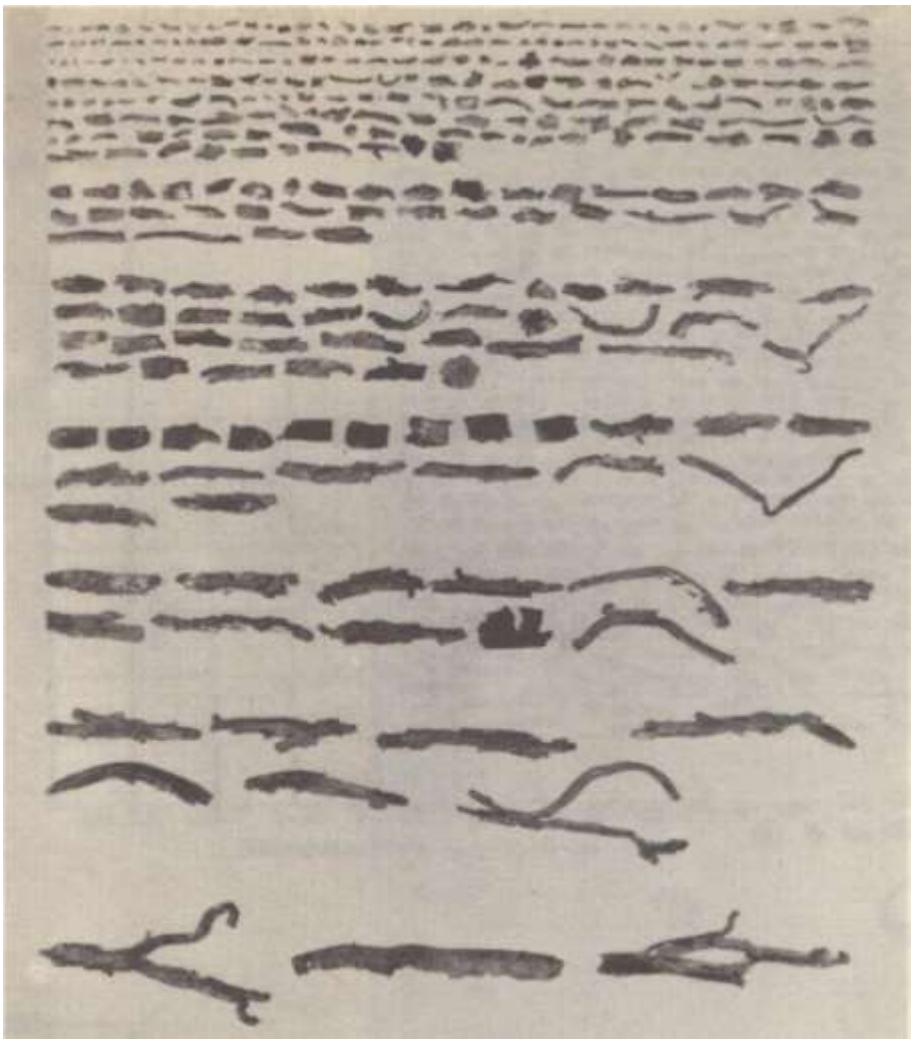

Figure 112._ *Photograph of fragments* from 30 mm HE-incendiary *shell.*

X-ray photographs make it possible to analyse the acceleration of individual fragments. According to new values obtained by M. HELD [25] using a charge with steel balls (pellets), the acceleration process is limited to approximately 6 ps for oblique incidence of the detonation front. The greatest acceleration under the influence of the shock wave takes place within < 1 ps. Figure 116 shows the X-ray photograph of an exploding fragmentation charge.

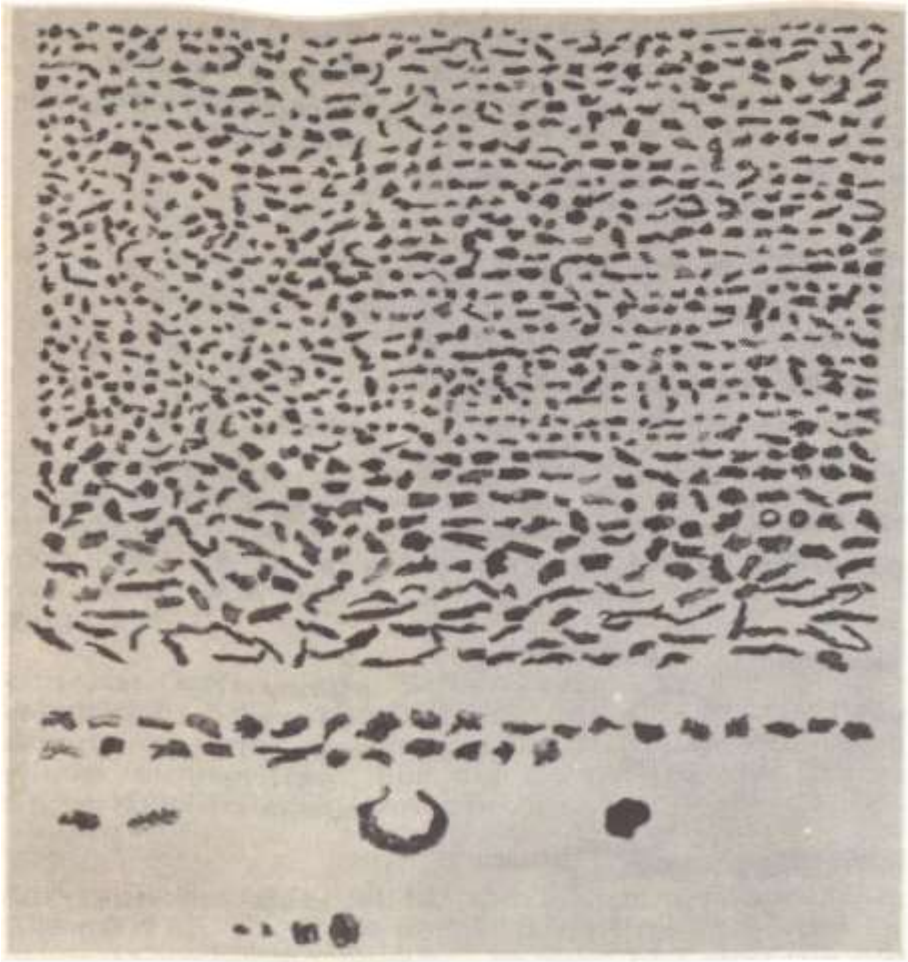

Figure 113. *Photograph of fragments from 30 mm thin wall HE-shell (Minengeschoss).*

At the end of the acceleration phase, the fragments attain velocities of between 1000 and 1500 m/s. For rounds detonated in flight, this velocity must be added (as a vector) to the velocity of the projectile. Due to the velocity of the projectile at the time of detonation, the trajectories of most of the fragments form a cone that opens away from the projectile. The angle of the cone depends on the ratio of the velocity of the projectile to the velocity of the fragments (determined when the projectile is at rest).

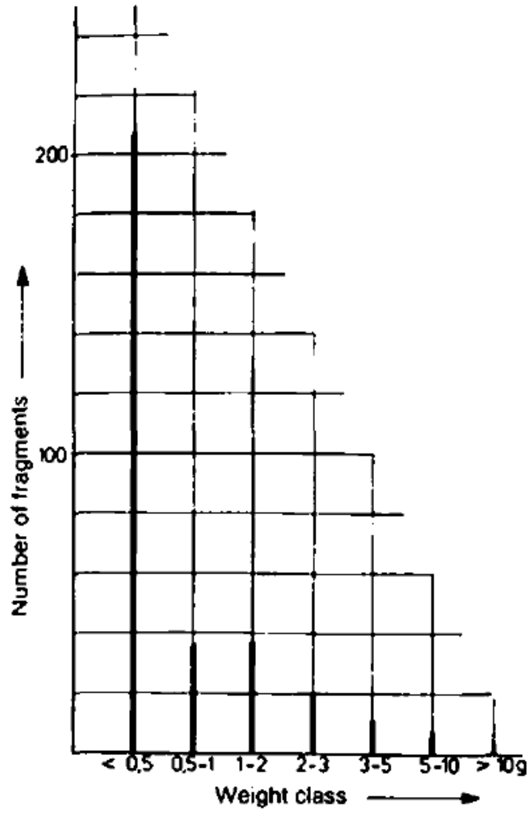

Figure 114.

30 mm HE-incendiary shell, number of fragments by weight class.

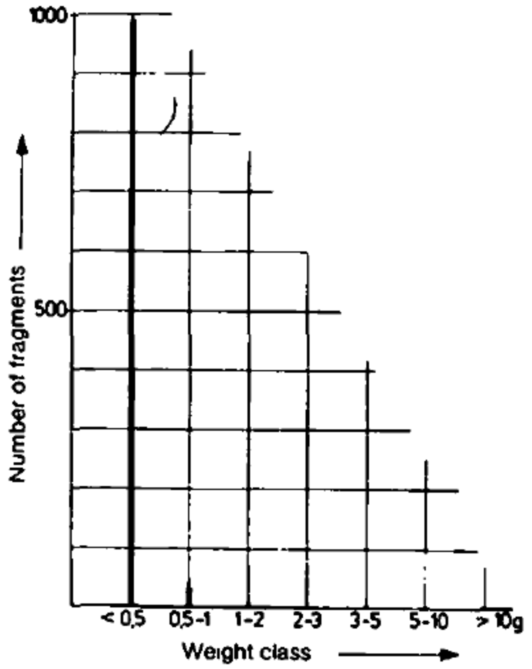

Figure 115.

30 mm thin wall HE-shell (Minengeschoss), number of fragments by weight class.

It is difficult to estimate how much the fragments will be retarded by air resistance, because the fragments have very complex geometric shapes, and tumble several times during their flight (since they do not fly with great stability). In any event, the deceleration is so great, that small fragments (less than 0.5 g) lose their effectiveness within a few meters, despite the high initial velocity.

The ability to penetrate the target or to damage the object is characterized by the concept of the *"effective fragment"*, which is defined as follows: *A fragment is effective if it perforates a steel sheet, 1.5 mm thick.*

The number of *effective fragments*, dependent on the distance from the point of burst, can be determined in a fragmentation test area.

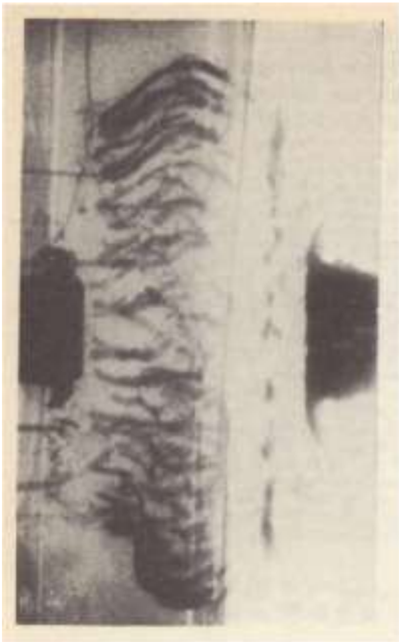

Figure 116. *X-ray photograph of an exploding fragmentation charge.*

This device consists of several sheets of 1.5 mm steel plate arranged at various distances from a central point (as shown schematically in Figure 117). The fragmentation charge is detonated in a lying position at the center.

By counting the number of fragments perforating each of the sheets, one can derive the number of effective fragments at each of the different distances, as well as their spatial distribution.

Since most fragmentation charges are symmetrical about their axis of rotation but are shaped differently front and rear (e.g. an HE-projectile), it is necessary to carry out two detonation tests. In the second one, the nose and base of the projectile are reversed, that is to say, the projectile is rotated 180° from the position shown in Figure 117.

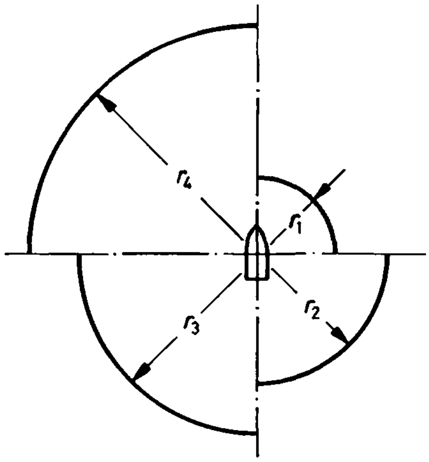

Figure 117. *Fragmentation test area (schematically).*

Figure 118 illustrates as an example the number of effective fragments from a 30 mm HE-shell, as a function of the distance from the burst point.

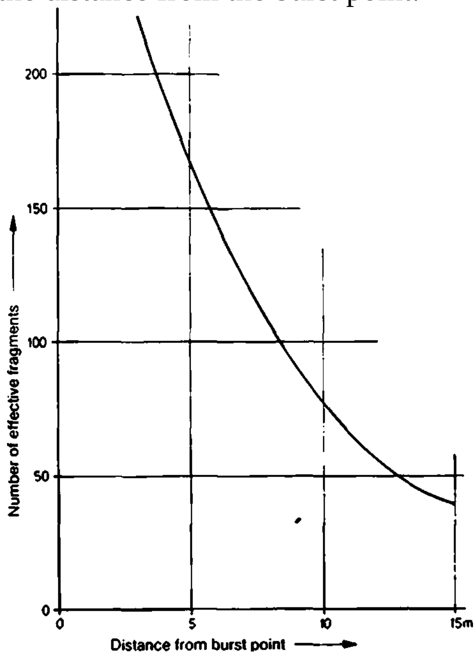

Figure 118. *Number of effective fragments as a function of the distance from the burst point for a 30 mm HE-shell.*

Of particular importance in the effectiveness tests is the number of effective fragments hitting per unit area as a function of the distance from the point of burst. This number is known as the *fragmentation density.*

The fragmentation density decreases with the distance, because of the energy loss of the fragments due to air resistance and because of the simple geometric fact, that the greater the distance from the point of burst, the greater the area hit by the fragment spray. The decrease in the fragment density determined geometrically is proportional to $r^{'1}$ for cylindrical charges with no fragmenting material other than the cylindrical cover, and proportional to r^2 for spherical charges initiated centrally.

The distance for fragment density "1" is often used as a simple way for describing a charge effectiveness. The fragment density "1" means that there is *one* effective fragment for each m^2.

The effectiveness of fragmentation charges such as HE-projectiles used in anti-aircraft defenses are of particular interest. Today, low flying planes are engaged with 20 to 40 mm automatic guns as well as rockets. These guns fire special projectiles which have an impact fuze with a delay mechanism. The fuze is activated when the ^hell hits the skin of the plane, but does not initiate the detonation until the shell has penetrated to a depth of some 5 calibers.

The number of hits which are required to knock out a given plane depends upon the projectiles fired, the type and size of the plane, and the location of hits. In general, one can add up (accumulate) the damage caused by individual hits to determine when the plane will be knocked out; this means that the kill effect of each hit can be defined by the following expression:

$$P_{klh} \times N_k = 1. \qquad (41)$$

In this expression, p_{klh} stands for the kill probability of an individual hit, and N_k is the number of hits required to achieve the kill.

For $p_{t|h}$, various functions have been stated depending on the weight of the projectile, the weight of the explosive, and on the type of aircraft involved. Here we shall use the function suggested by MOLITZ which takes the weight of the explosive as the independent variable:

$$p_{k|h} = 1 - e^{-(m/m_0)\lambda}, \qquad (42)$$

where m = weight of the explosive
m_0 = standardizing factor

and

$$\lambda > 1.$$

Figure 119 plots the function described by Equation (42)

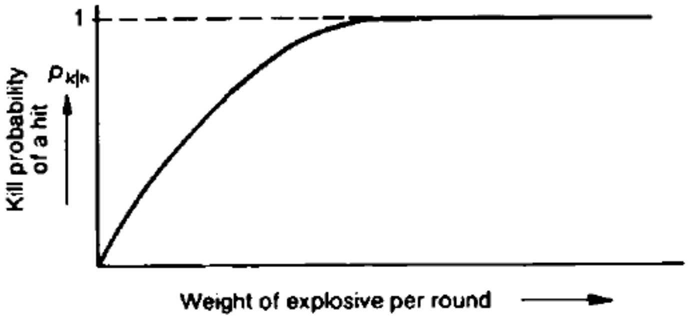

Figure 119. *Relationship between the kill probability of a hit and the weight of explosive per round.*

Figure 119 shows that, according to Equation (42), with increasing explosive weight, $p_{k|h}$ tends towards the saturation value of "1”. Just when this saturation value is reached, so that an increase in the explosive weight per projectile would lead to ‘'overkill", remains a matter of debate. The reason for the lack of reliable values for $p_{k|h}$ can be traced to the extremely high costs involved in carrying out the necessary trials. In addition, any such values, as far as they are known, are likely to be regarded as military secrets.