



The present invention relates to a safety mechanism for missiles. More particularly it relates to a protective slow cook-off mechanism for providing an automatic protection by ignition of munition components, selected from the group consisting of rocket motors and warheads, to be non-explosive and non-propulsive.

BACKGROUND OF THE INVENTION

The slow cook-off test is a well known test included in the Insensitive Munition (IM) program. The purpose of this program is to develop munitions which fulfill their performance and operational requirements, while minimizing the violence of the reaction and subsequent damage when subjected to any undesired event.

The slow cook-off test is used to determine the reaction temperature and to measure the overall response of major munition subsystems to a gradually increasing thermal environment. The test consists of subjecting the respective item to be tested to a gradually increasing temperature at a rate of 3.3°C/h until a reaction occurs. The item to be tested may be preconditioned at the munition's upper environmental temperature limit for about eight hours prior to the start of the test.

Reduced smoke composite propellants, used in rocket motors, are based on ammonium perchlorate and an elastomeric plastic such as urethane cured polybutadiene, which burn vigorously at low pressure and are difficult to extinguish. Moreover, the composite propellants tend to react very violently in

the slow cook-off test itself, even with minimal confinement. The reaction involves an explosion deflagration which destroys the case and breaks up the steel oven walls to fragments.

A method to prevent the violent reaction of rocket motor containing a metallic housing during the slow cook-off test was suggested in the US Pat. No. 4,961,313. According to this method, the slow cook-off trigger mechanism is thermally coupled to a bimetallic snap action disc spring.

Another method, described in recent US Pat. No. 5,044,154, suggests a casing made of segments which are attached together. A retaining member which extends circumferentially thereabout, possesses sensitivity to a predetermined initiated temperature. This temperature is higher than the ambient one, but lower than the ignition temperature of the propellant material in the rocket motor. In this manner, it will loose its strength when the retaining member is released and thus the rocket motor may safely be rendered non-propulsive during slow cook-off test.

In the European Patent Application No. 900816, a slow cook-off protection is suggested for a rocket motor having a metallic housing. The safety apparatus comprises a trigger working by a bimetallic snap-action spring to sense the temperature of the ambient environment and generate a mechanical response. It is claimed that the safety apparatus prevents slow cook-off hazard of a rocket.

The main disadvantage of the known devices is based on the fact that the violent reaction of composite propellant rocket motors during the slow cook-off test is almost independent of the casing and therefore splitting the casing does not provide a good protection against slow cook-off test hazards in such

rocket motors. The extreme violence with which ammonium perchlorate and an elastometric binder composite propellant react under the slow cook-off test, is mainly due to the partial decomposition of the propellant and particularly to that of ammonium perchlorate. As known, ammonium perchlorate undergoes a partial decomposition, generating a porous, metastable product. This porous material tends to explode or undergo a chemical reaction producing a vigorous evolution of heat and flame which travels through the material, upon ignition at high temperature.

A typical weapon system contains a warhead, which includes an encased charge and fusing subsystem for activating the charge. Warheads, in general, are divided into three categories: shaped charges, fragmentation warheads and penetrators. With respect to their ability to pass the IM tests, warheads are classified as light, medium and heavily confined warheads. Penetrators are usually heavily and totally confined. This confinement causes problems in relation to thermal stimuli, and especially to slow cook-off tests.

It is also known that missile warheads and especially penetrators are totally confined. This confinement causes problems in relation to thermal stimuli, and especially to a slow cook-off test.

In order to avoid a violent reaction during a slow cook-off test, generally penetrators are filled with insensitive explosives, such as Insensitive Plastic Bonded Explosives (IPBX), that are isolated from the casing by a cavity liner. In addition to the IPBX explosive, a special design of venting holes in the warhead casing is suggested in order to avoid an undesired reaction, thus resulting in a burning of the explosive instead of its explosion during the temperature rise.

Several options of venting designs for warheads are mentioned in the literature. One option relates to a warhead aft plate made of a composite material, which is softened and removed at a high temperature and provides a full venting aft. Another suggestion, known as the "composite overwrap design", is to cut holes into the aft portion, to serve as venting means and to use a filamentary composite material to wrap the warhead. However, the above suggestions failed to avoid a violent reaction of the explosives during the slow cook-off test, due to the high pressure and temperature which generally prevail in the confined casing.

It is an object of the present invention to a device for imparting protection during a slow cook-off test for missile rocket motors whose casing is made of composite materials and warheads with heavy metal casing by rendering them non-explosive and non-propulsive properties under said test conditions. It is yet another object to provide an active such device that would initiate burning of the rocket motor propellants or of the warhead charges under predetermined conditions so as to avoid a violent reaction of the item to be tested under a slow cook-off test.

BRIEF DESCRIPTION OF THE INVENTION

The invention relates to a device for imparting non-explosive and non-propulsive properties to munition components selected from the group consisting of rocket motor and warheads, subjected to a slow cook-off test, wherein said component's casing, or at least some of it, is made of composite

materials, wherein said device consists of using a predetermined pyrotechnic pellet having an ignition temperature of at least 130°C, but below the violent ignition temperature of the propellant or charge of the respective munition component, under slow cook-off conditions, whereby the composite material of said casing loses its strength at the predetermined temperature causing said casing failure and allowing for venting and a non-propulsive burning of the propellants or explosives.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-section of a typical missile containing a rocket motor and a typical embodiment of a safe/arm ignition system

Figure 2 is a cross-section of a typical embodiment of a safe/arm ignition system used to ignite a rocket motor containing a predetermined ignition temperature pyrotechnic ignition device according to the present invention.

Figure 3 is a cross-section of a typical penetrating warhead containing the aft closure and fuse well, venting holes and a typical embodiment of a pyrotechnic ignition device according to the present invention.

Figure 4 is a detailed cross-section of a typical rear part of a penetrating warhead containing the pyrotechnic ignition device and venting holes according to the present invention..

Figure 5 is a cross-section of a typical pyrotechnic ignition device used to ignite a penetrating warhead containing a predetermined ignition temperature pyrotechnic pellet according to the present invention.

DETAILED DESCRIPTION OF THE FIGURES AND THE INVENTION

Figure 1 illustrates schematically a cross-section of a typical missile. The missile illustrated includes a rocket motor (2), an explosive warhead (3) and a safe/arm ignition system (4) which is mounted coaxially in the rocket motor (2). The rocket motor (2) comprises the casing (5), the nozzle (6) and the propellant (7). A venting device (12) to avoid propulsive burning is provided, connecting the rocket motor casing (5) to the nozzle (6). The predetermined pyrotechnic pellet (13) is located in the safe/arm ignition system (4).

In Figure 2 the safe/arm ignition system (4) includes a perforated plastic tube (8) which is threaded in the safe/arm device (9). In the plastic tube (8) there are located igniter common pellets together with the predetermined ignition temperature pyrotechnic pellet which activates the igniter pellets.

The predetermined ignition temperature pyrotechnic pellet must be located in the inner surface of the propellant grain, but its actual location therein is not critical. The arrangement tested in the slow cook-off oven includes the rocket motor and the safe/arm ignition system mounted as illustrated in Fig. 1. When the temperature in the slow cook-off oven reaches the predetermined value, the predetermined pyrotechnic thermal pellet is ignited and activates the

rocket motor igniter pellets. The hot gases and particles produced from the ignition of said pellets exit through the holes of the perforated plastic tube and ignite the propellant material (7). The predetermined pyrotechnic ignition temperature pellet located on the inner surfaces ignites the propellant grain.

When the rocket motor casing is made of a composite material which includes resin and fibers, the resin used is softened at a temperature at a temperature of about 130°C. Thus at a temperature above 130°C the resin is significantly weakened. As a consequence the casing will burst without causing any external effect and thus the propellant will burn non-propulsively at atmospheric pressure due to the full diameter opening of the casing.

A detailed description and data of a typical safe/arm ignition system is hereafter presented, being understood that these are given only for a better illustration of the invention, without limiting its scope as covered by the appending Claims. A person skilled in the art, after reading the present specification will be in a position to insert slight modifications thereof without being outside the scope of the invention as stipulated in the attached Claims.

A typical illustration of a safe/arm ignition system is hereafter presented:

- Internal length of the plastic tube about 77 mm.
- Internal diameter of the tube about 8 mm.
- The tube contains about 60 pellets (4.8 x 4.8 mm) of B-BaCrO₄) and also some pellets of a di-basic pyrotechnic material, with a diameter of about 7 mm and a length of about 20 mm.
- The tube contains about 28 holes of 2 mm diameter divided in 4 rows.

Of course the above data is given only for illustration purposes but no limitation could be understood therefrom.

Figure 3 illustrates schematically a cross-section of a typical penetrating warhead, comprising a heavy casing (11) usually made of steel, an explosive charge (22), an aft closure (23) which contains venting holes (14), the pyrotechnic ignition system (15), the fuse well (16) and a foam ring (17), which separates the explosive charge (12) from the ignition system (15).

Figure 4 depicts the detailed rear part of the penetrator. The aft closure (13) is mounted coaxially inside casing (11) by an aft nut (18). The venting holes (14), located in the aft closure are covered by plates (19) made of a composite material.

Figure 5 illustrates the pyrotechnic ignition system (15) of the present invention used in a warhead which includes a plastic tube (20) which is threaded in the aft closure (13). The plastic tube contains a pyrotechnic pellet (21) possessing a predetermined ignition temperature, which when ignited exerts hot gases and particles that ignite the explosive charge of the warhead.

When temperature rises during the slow cook-off test the explosive material expands axially while the foam ring (17) shrinks. The explosive expansion and the resulting foam shrinkage decrease the distance between the explosive material and the pyrotechnic ignition system. When the temperature in the slow cook-off test reaches the predetermined value, the pyrotechnic thermal pellet is ignited. The hot gases and particles resulting from the pellet burning ignite the explosive material. the venting hole (14) covers are made of a composite material which includes resin and fiber, the resin having a softening point at about 120°C. In this manner, at a

predetermined temperature of above 120°C, the resin will be significantly weakened. As a consequence the explosive material will burn non-propulsively at a pressure close to atmospheric due to the sufficient venting area which prevails therein.

A design description of a typical ignition system will be as follows:

- Internal diameter of the tube about 10 mm.
- Internal length of the tube about 30 mm.
- The tube contains one pyrotechnic pellet with the above dimensions, consisting of a suitable pyrotechnic or propellant material.

Hereafter follows an example illustrating the present invention, regarding an embodiment suitable for warheads:

Several slow cook-off tests were conducted to verify the present invention. The test were carried out in various dimensions. Eight half-scaled tests, where the warheads contained about 8 kg of explosive, were successfully performed. In all tests three safety devices were mounted at the aft closure. The explosive was initiated and started to burn when the aft closure temperature was in the range of 130-140°C. After completion of the sub-scaled tests, two full-scale tests were performed. A full-scale warhead was used, 1500 mm long, about 300 mm in diameter, weighing about 250 kg. Both warheads passed the slow cook-off tests successfully, with the explosive starting a mild burning reaction at about 140°C (aft closure temperature).

Again, detailed description and data of a typical safe/arm ignition system are presented, being understood that these are given only for a better illustration of the invention, without limiting its scope as covered by the appending Claims. A person skilled in the art, after reading the present specification will be in a position to insert slight modifications thereof without being outside the scope of the invention as stipulated in the attached Claims.

Most preferred pyrotechnic pellet materials are selected from double-based propellants, such as a mixture of nitroglycerin and nitrocellulose and additives, black powder, mixture of magnesium powder with teflon powder, boron-barium chromate and any other known solid propellants which comply with the above requirement for the ignition temperature. Optionally, in order to improve the physical and chemical properties of the double-based propellants, small amounts of additives may be incorporated as stabilizers.



CLAIMS

1. A device for imparting non-explosive and non-propulsive properties to munition components selected from the group consisting of rocket motor and warheads, subjected to a slow cook-off test, wherein said component's casing, or at least some of it, is made of composite materials, wherein said device consists of using a predetermined pyrotechnic pellet having an ignition temperature of at least 130°C, but below the violent ignition temperature of the propellant or charge of the respective munition component, under slow cook-off conditions, whereby the composite material of said casing loses its strength at the predetermined temperature causing said casing failure and allowing for venting and a non-propulsive burning of the propellants or explosives.
2. The device according to Claim 1, wherein the predetermined pyrotechnic pellet has an ignition temperature in the range of 130-140°C.
3. The device according to Claims 1 and 2, wherein said predetermined pyrotechnic pellet is located in a perforated plastic tube.
4. The device according to Claim 3, wherein the perforated plastic tube contains common igniter pellets together with the predetermined ignition temperature pyrotechnic pellet.



5. The device according to Claims 1 to 4, wherein said predetermined pyrotechnic pellet is made of double-based propellants.
6. The device according to Claim 5, wherein said double-based propellants are selected from: mixture of nitroglycerin, nitrocellulose and additives, black powder, mixture of magnesium powder and teflon powder, and boron-barium chromate.
7. The device according to Claims 1 to 4, wherein the hot gases and particles resulting from the ignition of said pellet exit through the holes of the perforated plastic tube causing the ignition of the propellant or explosive material.
8. A device for imparting non-explosive and non-propulsive properties to union components selected from the group consisting of rocket motors and warheads, subjected to a slow cook-off test, substantially as described in the specification, the drawings and in any one of Claims 1 to 11.