

Principles OME Essay

by James Cawte

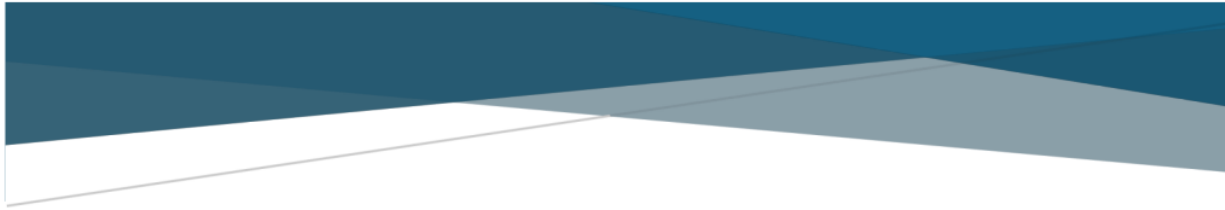
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PRINCIPLES OF OME

Fuse Design for a Medium Calibre Free Flight
Rocket

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Introduction

The item required is a mechanical nose fuse for a medium calibre 90mm-130mm and free flight rocket with an HE/fragmentation warhead during service life. This essay will cover the ways in which this could be achieved and explore the suitability of them.

Requirement

The following are requirements provided in the brief:

- The fuse will be mounted on the nose of the munition
- The fuse will be entirely mechanical
- The fuse will have at least 2 safety breaks
- The fuse will be capable of achieving an airburst predictably
- The fuse must be safe for intended use

The following are basic functional requirements of the weapon:

- The weapon will be safe to store
- The weapon will be safe to transport
- The weapon will be safe to handle
- The weapon will be safe to arm
- The weapon will be safe for intended use
- The weapon will destroy the intended target
- The weapon will detonate when intended

Non-Mechanical Fuzes

Non-mechanical fuzes range from burning safety fuze, electric detonators and radar/sonar proximity based. All these alternatives may have provided the same functionality but will not be considered due to the requirement for a mechanical fuze.

Safety Considerations

Medium Calibre (90mm-130mm)

With conventional munitions that are fired from a barrel using propellant there is a very large acceleration in a small amount of time. This causes set-back as the components within the munition are all 'jolted' by the sudden change in velocity. Consequently, a consideration is that the functionality of the fuze is not impeded by the set-back. If the munition is fired through a rifled barrel then it needs to withstand rapid rotational forces as well.

Free Flight Rocket

Rockets burn using either solid fuel rocket motors or liquid fuel. Solid fuel is predominantly used as it cuts down on the complexity and allows for a more even burning front. The duration of flight is dependent on the rate of burn of the propellant. A rocket in flight produces a large amount of heat so the materials in the explosive train and components of the fuze must not be inadvertently initiated or degraded by the rise in temperature.

Safety in Storage

There are various conditions a munition may be stored within such as caves, buildings and containers. These range vastly in temperature, humidity and other environmental factors. A clear understanding of all intended and probable storage situations is required before considering the design.

Electrical storms pose a risk to explosives when stored. Appropriate measures need to be taken such as evacuating any storage site while an electrical storm is active. Sufficient lighting arresting systems must also be in place to protect buildings containing the explosives.

The weapon being stored must be in a state where it is not vulnerable to activation by aging or corrosion. Because of this the compounds within need be well understood and chosen to reflect this requirement. Corrosion can cause defects in flight for rockets if the casing is damaged then the surface area of the grain may increase leading to unsteady progressive, uneven burn. There must be clear parameters for acceptable conditions that the weapon can be stored in as well as how many and how densely as best efforts should be made to prevent sympathetic detonations leading to mass detonations should the worst-case scenario occur. These parameters should be known to anyone handling the weapons and easily found on packaging.

Safety in Transit

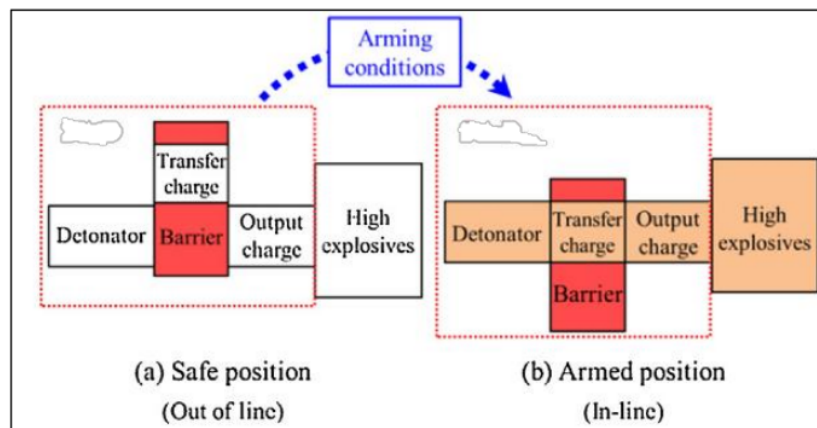
In transit there are different requirements for the safe existence of a weapon. While in transit an explosive may be exposed to vibration from engines of a vehicle or terrain, rapid temperature change from differences in altitude or gradual temperature change as it is geographically transported.

The modes of transport allowed are best restricted to ship and metalled road transport as these offer the least vibration and no drastic temperature and pressure changes.

Safety During Intended Use

When intending to detonate the weapon there should be at least 2 safety breaks required to be removed before the fuze will detonate the payload. The main fill will be a high explosive material however should not be easy to initiate without a fuze. Ideally, The weapon would qualify as Insensitive Munition (IM).

There are a variety of different safety break designs which usually involve a physical disconnect between the fuze and the main fill. There can be pins to hold part of the explosive train out of alignment in order to prevent function. Using pins is a good extra layer of safety for storage and transportation.



Representation of the Arming Process¹

Another method is to have a shutter block the striker from being able to make contact with the flash composition. This shutter protects the device so that even if the striker were to function without intention, then no consequence would come from it.

These safety breaks can be an automatically disengaged when the munition is fired by using either the set-back or rotation during flight (presuming the munition rotates). These require that the munition has been intentionally fired and traversed a minimum distance before it arms.

Another safety break is to detach the fuze from the munition unless necessary for imminent use

Common Artillery Fuze Components

One common method mechanical fuzes initiate the primary explosives (e.g. Lead Azide) is to use a striker needle to concentrate a large amount of energy onto a

¹ Ref [4]

piece of stab sensitive flash composition which will then react. This reaction is funnelled down the channel the booster where the explosive train progresses.

The explosive train within the fuze begins with a tiny quantity of primary explosive. Once initiated by an external stimulus the energy initiates the booster material which subsequently detonates the high explosive main fill. The materials for all of these components vary but some are much more widely used such as RDX or TNT. [1]

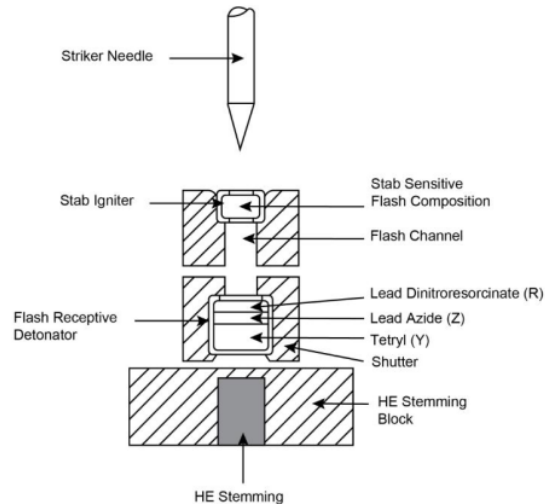


Diagram of a Stab Ignitor²

Achieving Airburst

Impact

An impact fuze is the simplest mechanical design and only requires the striker strike the primary explosive when it impacts onto a solid. The design needs to withstand the set-back of firing/launching the weapon though. This can be achieved by using a spring with high stiffness as to only allow high speed collision with an object overcome it. This option will not be of use in this scenario as it is impossible to achieve airburst with an impact fuze unless the impact fuze is at an impractical distance in front of the main fill. This solution makes the final article bulky and aerodynamically problematic.

Timer

A time fuze can be configured before firing the munition using calculations based on flight times to produce an air burst above the intended target. This gives the most

² Ref [3] – Chapter 6, Page 20

reliable way to produce an air burst above an intended target because of the functioning of the fuze irrespective of external factors. The timed fuze would be used in conjunction with range data to quickly calculate the duration required on the timer to get an optimum airburst.

Barometric

Another possible design would incorporate barometers to measure the altitude of the munition and use a calibrated preset to decide at which altitude it would detonate. This comes with the issue of trajectory. Most munitions travel in a parabola unless in flight propellant is available. Due to this the munition has a high likelihood of being at the same altitude at 2 points of its flight: at the beginning and near the target. To overcome this a safety break could be implemented to require the setback from firing then after a specified time in flight the barometric system was armed. This solution would likely be too complicated and expensive for mass production when there are simpler solutions that achieve the purpose of an airburst

Solution

One possible solution is to have a nose mounted time fuze. Having it be nose mounted rather than in the base makes adjusting the duration before detonation simpler for operators. There is historical precedent for this type of fuze as well, so the mechanism and technologies are well established [2].

For redundancy, there should be 2 safety breaks. Firstly, a pin that holds the striker in place so that until it is intentionally removed it cannot initiate the main fill. Secondly, a shutter should be placed blocking the flash material. This will only be moved once the munition has completed a set number of revolutions ensuring it is well clear of those operating the weapon before it is even possible for detonation to occur. When the munition is not in use the fuze should be removed from the nose. This minimizes the chances of detonation in storage or transport.

Failure Modes

Failure to Function

There is danger that the fuze will not initiate the main fill at all. This would result in a hazard in the form of an unexploded munition. This would need to be treated very carefully and disposed of by experts.

Unintended Function

An unintended functioning of the fuze would be an initiation in a storage facility or during transit. The unmitigated consequences of this could be severe so the safety breaks in place should eliminate this as a possibility due to having the fuze detached from the main munition.

Inconsistent Function

The fuze has a possibility to function before or after it is at the intended point of detonation. This could in a best-case scenario prevent the target from being defeated or in a worse case threaten damaging something other than the intended target. The way to mitigate this is to ensure that the fuzes are batched and tested for defects at the manufacturing stage.

Conclusion

In conclusion, the technology and fuzes identified in this essay as the best option already exist and are used. The mechanical time fuze offers a simple solution to the requirements laid out.

Bibliography

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Principles OME Essay

GRADEMARK REPORT

FINAL GRADE

37 / 100

GENERAL COMMENTS

Dear James,

This is probably not the best piece of work you have ever produced.

Engagement with Literature Skills

There is little evidence of wider reading with only four sources presented by the student. The student is heavily reliant on information gained through class contact.

Knowledge and Understanding Skills

Gaps in knowledge of the basic underlying concepts and principles, with flawed or superficial understanding. Some significant inaccuracies and/or irrelevant material. The student appears to know the basic underlying principles of how the intended effect is achieved at the target, but a disappointing level of depth of understanding provided when discussing how to prevent unintended detonation.

The 'Safety in Storage' section describes general storage issues but there is no mention of safety due to the fuze.

'Safety in Transit' does not mention the fuze and is scant on any other details.

Cognitive and Intellectual Skills

A limited attempt at the description of the rudimentary safety features chosen. For further marks, I would expect to see a greater level of detail applied when describing the safety features.

What is the cognitive link between the title "Medium Calibre (90mm-130mm)" and the subsequent paragraph that describes forces experienced by munition fired from a rifled barrel?

The section titled "Free Flight Rocket" is entirely about rocket fuels but there is no link to the brief.

In 'Safety in Storage' the student describes a possible effect of corrosion on the motor casing but does not explain how the consequence described comes about.

Very shallow coverage and no evaluation in 'Safety in Transit'

Practical Application Skills

An adequate awareness to provide some diagrams showing a basic appreciation for the context. For further marks, refer to the diagrams in text and use them as a point of discussion. Do not simply leave them on the page and assume that the reader will link diagram to text.

Transferable Skills for Life and Professional Practice

Work was mostly ordered with relevant ideas expressed, however, lacked coherence in places.

Incorrect spelling of 'fuze' throughout the paper. An adequate structure which followed the layout of the task description. Most of the descriptions, while accurate if the reader knows the subject, would not give either another explosives engineer or a client the information they need to make an informed opinion or decision.

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