

P-OME Assignment MSloan

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CONSIDERATIONS OF THE
FUNCTIONAL DESIGN OF A
MECHANICAL, AIRBURST, NOSE
FUZE FOR A MEDIUM-CALIBRE (90-
130MM), FITTED TO FREE-FLIGHT
ROCKET WITH A
HE/FRAGMENTATION WARHEAD.

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1 Essential purpose and typical components of an artillery fuze

A fuze is a mechanism which initiates an explosive reaction to a stimulus generated by some circumstances or combination of circumstances that the fuze is designed to respond to [1]. Common factors could include target impact, proximity, or time delay, the fuze needs to initiate at the intended point of its trajectory.

An airburst mechanism is one that initiates in flight, as opposed to ground burst which would typically detonate upon reaching their target on the ground. The simplest way this effect is achieved is through the use of a time fuze, in which some form of igniferous compound with a known burn rate is calibrated for the expected flight time.

This timed burn fuze is an example of a mechanical fuze, a non-electrical fuze.

2 Explosive train within the fuze and how it can be stored in a safe condition but brought into an armed state on launch.

2.1 The explosive train

The explosive train describes the act of setting off multiple charges of explosives, from most sensitive to least sensitive, to ensure detonation of the insensitive high explosive main charge.

A primary low explosive is activated by the small stimulus provided by our mechanical fuze. This ignites an intermediate charge of primary high explosive in which the transition from deflagration to detonation takes place. A secondary high explosive intensifies the shock output from the detonation of the intermediate charge, this finally initiates the main charge that produces the desired explosive effect [2].

Each step on the explosive train results in a larger and larger explosion, with the final detonation unlikely to occur in the way required without the aid of the steps prior.

2.2 Description of at least two safety features that could be incorporated into this fuze.

The most important safety feature of a fuze would be a design in which the fuze cannot be armed until firing. This not only would make the fuze safer to handle and store by greatly reducing the chance of accidental initiation. The munition could arm itself during firing or mid-flight, alternatively a firing pin can be manually removed from the munition immediately prior to firing.

This pin solution retains the safety aspects during transportation and storage as the explosive is not armed unless there is intent to use. However, it is best practice to have the weapon armed for as little time as possible, and the advantages to only arming the weapon when it is distanced itself from friendlies and travelling in the opposite direction cannot be overstated.

Once armed a weapon is extremely dangerous. If it misses its target or fails to initiate an air-burst detonation at the right location, a timer in the fuze can be used to self-detonate the explosive, ideally without inflicting any collateral damage. If the timer is set exceed the anticipated flight time of the weapon, then it can be understood that at this point the weapon has missed or failed to activate.

Unexploded ordnances are typically dealt with through the use of committing the explosive material to deflagration. This burns off the explosive in a safe manner, as the gases produced during burning do not build up inside the casing, leading to detonation. A speedometer can be installed in the fuze that, after the previous timer has concluded that the weapon has missed its target, upon hitting a speed of zero and becoming stationary, pops the casing off the explosive and begins a deflagration reaction.

2.3 Consideration of the forces likely to be experienced by the fuze, that could be used to remove safety features.

Immediately after firing, the munition experiences extreme amounts of setback forces as it accelerates. These forces can be taken advantage of in the safe design of a weapon as they are only experienced during firing and not in transportation and storage. A shell encounters 12,000G only during firing, not when dropped accidentally.

The device can self-arm during firing by implementing a system that utilises pins held up by a spring installed at their base. These pins hold in place a locking plate that is also held under tension by springs perpendicular to the pins. As the pins are parallel to the direction of the thrust inertia causes the pins to move out of lock with the plate above them. The tension on the spring for the plate is released and the plate moves out of lock with the pins should they return to their initial relative positions in the fuze. This allows the firing pin to move into position. Once the weapon arms itself this way, the mechanisms have moved into such a configuration that it remains armed.

3 How the fuze might achieve an airburst at a predictable time and position in space.

The simplest (but likely least efficient) way of achieving an airburst at a predictable time and position in space is with a simple hand calculation. When the weight of the munition is known and the thrust acting upon it, the speed can be calculated. If the distance to the target is known then the flight time required for the rocket to reach its destination is easily calculated. A simple timer can be installed that is calibrated for the flight time to achieve detonation at the desired location.

4 The forces and other phenomena in flight and at the target that can be used to initiate the fuze at the desired time and place.

The desired effect of an air-burst weapon is to explode overhead of the target, as this is fragmentation warhead an airburst gives max spread of fragmented projectiles. The simplest initiator for a fuze would be an impact detonator, however by definition this is impossible for an air-burst weapon.

A more complex system than a timed fuze can involve gyroscopes [3] that align only when overhead their target when flying on an arched trajectory. Gyroscopes stabilise themselves and remain level inside of the fuze by freely rotating. A pin can be held in place inside the arm of a gyroscope that releases with the use of springs into a slit that only aligns when the munition has reached the end of its trajectory. For this to function however, careful consideration would be needed in calculating a firing solution to ensure the gyroscope only aligns when desired.

5 Possible failure modes of the functional design and how 'failure to function as intended' would be mitigated.

Environmental testing of the equipment would be a priority. A mechanical fuze contains moving parts, more so than an electrical fuze would. Variation in temperature can have an effect of the dimensions of metals and other matter, with small moving mechanical parts at large risk of no longer moving smoothly at extreme temperatures.

Movement could also be hindered by freezing of water vapour present in the atmosphere. This can be mitigated by designing the munition to be airtight or coated in a waterproofing material. Construction of the munition would need to be performed in a controlled low-humidity environment.

A Rheinmetall ABM/KETF 30MM x173 ammunition/PMC308 has an operational temperature range of between -46°C and +63°C [4], DefStan 00-035 [5] states that this temperature range would be exceeded by many desert or equatorial climates and polar regions. A failure to function as intended could be likely in these conditions, a different munition rated for these temperatures would have to be used.

The ambient temperature inside an ISO container under the midday sun can be far greater than the temperature of the surrounding area, so considerations in storage techniques must also be taken.

References

- [1] The Franklin Institute, "Design considerations," in *AMCP 706-179*, Washington, D.C., Headquarters, U.S. Army Materiel Command, 9 March 1965, p. 62.
- [2] The Franklin Institute, "Explosive charges as components of weapon systems," in *AMCP 706-179*, Washington, D.C., Headquarters, U.S. Army Materiel Command, 9 March 1965, pp. 1-3.
- [3] J. Brothers, "Air-burst fuze system for projectiles". United States of America Patent 3,434,423, 26 June 1967.
- [4] Rheinmetall, "Rheinmetall - First in airburst technology," [Online]. Available: <https://www.rheinmetall.com/Rheinmetall%20Group/brochure-download/Weapon-Ammunition/B306e0921-ABM-Rheinmetall-first-in-airburst-technology.pdf>. [Accessed 6 December 2024].
- [5] Ministry of Defence, Defece Standard 00-035 Issue 5 Environmental Handbook for Defence Materiel Part 4 - Natural Environments, 2018.

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GRADEMARK REPORT

FINAL GRADE

30/100

GENERAL COMMENTS

Engagement with Literature Skills

The student has shown engagement with a limited range of sources. For further marks, the student should engage with a much wider range of sources such as research papers etc.

Knowledge and Understanding Skills

The student has shown gaps in the knowledge of the basic underlying concepts and principles. There was very little attempt made to discuss how unintended detonation might be prevented during the storage, handling, and transportation of a munition.

The student states that Def Stan 00-035 states that the temperature range of -46C to +63C falls would be exceeded by many desert or equatorial climates or polar regions. However, the student does not even begin to explain why these temperatures may be problematic for a munition.

Cognitive and Intellectual Skills

The student's work on how safety mechanisms could be removed in sequence to arm the fuze was wholly descriptive.

The student only provided one example of a safety mechanism, with the guidance clearly stating that a minimum of two should be discussed.

There was a failure to develop any kind of argument or judgement. The student quotes from some of their reference documents, but rarely goes on to explain what the quote means in context. In the section titled "Description of at least two safety features that could be incorporated into this fuze" they do not describe any safety features. They mention the possibility of incorporating a speedometer in the fuze to indicate when the munition has come to a halt, thus showing that they do not really understand that a rocket might be travelling in the region of Mach 1 or higher and that the only

time it will come to rest is on impact with a target or the ground, and the incorporation of an impact firing mechanism is common practice.

Overall, the language and depth of discussion used is poor and does not meet the guidance requirement to "...be able to present, evaluate and interpret qualitative and quantitative data, in order to develop lines of argument and make sound judgements in accordance with basic theories and concepts of your subject(s) of study."

Practical Application Skills

With no figures provided, the student has shown a flawed appreciation of the context of the application of the safety features within the fuze. For further marks, the student could provide diagrams that show the safety features they would implement.

The student has chosen not to include any diagrams to support their explanations, despite a clear suggestion in the assignment guidance: "The assignment should include diagrams to illustrate safety features in SAFE and ARMED modes and where these are removed in the launch sequence." This guidance was repeated during lectures. The explanations themselves are generally insufficient to provide the reader with a sense of how the safety mechanisms operate in sequence during the ARMING process and it was expected that diagrams would enable the student to illustrate this complex sequence of events and movements.

Transferable Skills for Life and Professional Practice

The student's work was mostly structured with relevant ideas reasonably presented. Work lacked coherence in some places with some areas of minor weakness throughout.

The student has not shown that they understood the Task Description and could/should have come to the lecturer for 1-to-1 advice, during the periods when the lecturer stated at the end of teaching sessions that they would be available in the OME Lab for that purpose.

The quality of the writing was poor, showing scant appreciation that the role of a professional engineer in the drafting of specifications/designs is to be able to explain the underlying concepts, science, technology and engineering principles in detail to other engineers and in simpler, yet sufficiently technical, language to managers and customers.

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