The vertical placement ultra-thin flameproof baffle of the fuze

C C Sun$^{1,2}$, H B Liu$^{1,2}$ and X Zhao$^{1,2}$

$^1$Xi’an Institute of Electromechanical Information Technology, Xi’an 710065, China
$^2$Science and Technology on Electromechanical Dynamic Control Laboratory, Xi’an Shaanxi, 710065, China

002sc0603@sina.com

Abstract. In order to meet the operational requirements of a new type of intelligent small penetrating submunition fuze with large overload of target base, a new type of ultra-thin vertical fuze flameproof baffle is proposed. Vertical arrangement of fuze ultra-thin flame-proof board uses the three layers of different vertical composite plate structure of metal materials, the overall size for the 1.6mm thickness, the length of vertical is 20mm, upper and lower layer 0.3mm thickness of tungsten-copper alloy plate, respectively, the middle layer of 304 stainless steel. The simulation and test results show that the ultra-thin vertical fuze baffle can resist the penetration overload of 120,000g, and guarantee the safety of 12m dropping and explosion isolation.

Key words. Submunition fuze; Explosion isolation mechanism; Vertical layout; Ultra-thin type flameproof plate

1. The introduction

The development direction of new intelligent miniaturized ammunition has put forward a new military demand for new type of small penetration submunition medicine. Fuze, therefore, in addition to the original function, but also increase the wireless communication module, more sensors and actuators, functional components, such as the miniaturization of the fuze safety system design put forward higher requirements.

Requirements for fuze in fuze limited volume to accommodate more sensors, actuators to perception, ballistic, target detection and processing more environmental information, such as complete more complex instructions and ensure the reliability, meet the demand of the expanded function and
performance improvement of ammunition, but also increased the reliable firing rate of dual redundant detonating sequence. The new generation of intelligent fuze system is far more complex than traditional fuze system, but the fuze volume is limited, fuze must realize miniaturization to meet the increasing functional requirements. The miniaturization of fuze security system can make room for functional components, which is one of the main ways of fuze miniaturization.

At present domestic security system miniaturization has been studied for more than 20 years, the second generation of miniaturization of latest security system in our country, in such aspects as performance, volume has same level with the third generation of miniaturization of security systems[1]. The United States, Russia, France, Israel and other countries have developed the latest fourth-generation miniaturized security system, which is smaller and safer[2].In 2010, the United States announced the development plan of its miniaturized fuze security system, requiring the size of the entire safety system to be smaller than 0.44in³ (about 7.2cm³)[3], the average size of each direction is less than 2 cm. The flameproof plate is an important part of the safety system. In order to adapt to the new type of miniaturized fuze safety system, the size of the flameproof plate structure also needs to be miniaturized.

Because the fuze function of the new type of small penetration submunition is increased and the space is limited, it is necessary to design a double-path explosion isolation mechanism to increase the double-path redundant transmission sequence. Due to the small big overload of penetration submunition to target base to remove flame-proof and trigger delay ignition circuit based on the touch targets at the same time, thus flame-proof institutions need to be used along the elastic axis vertical arrangement to meet requirements.

In order to meet the operational requirements of a new type of intelligent small penetrating submunition fuze with large overloading of the target base, a new type of ultra-thin vertical fuze baffle plate is proposed.

2. Background technology

2.1. Small-sized single-way sliding barrel explosion isolation mechanism arranged vertically by submunition fuse

Figure 1 shows the vertical arrangement of a small penetration bullet fuze with a single slide cylinder type explosion isolation mechanism, made of 45 steel. Because of the small target medicine rely on penetration bullet base big overload lifting and isolation, so the flame-proof sliding barrel along the elastic axis vertical layout, the flame-proof tube size about Ø8mm x 30mm[4].In a safe state, the detonation isolation is carried out through the dislocation relationship among the electric detonator, detonator and booster explosive.
2.2. Properties of tungsten-copper alloys

Tungsten-copper alloy (W-Cu alloy) material has high strength, high density and low thermal expansion coefficient[5], widely used in aviation, aerospace, weapons and other military industries[6]. The higher the density, lower the expansion coefficient, and higher the tensile strength of the metal materials used in fuses flameproof plates, the better the flameproof performance[7]. These properties make W-Cu alloy have good characteristics of absorbing detonation, which is suitable for small size fuse deflector.

3. Ultra-thin fuse flameproof plate arranged vertically

In order to improve the firing rate of the new type of small penetration submunition, the double-path explosive isolation mechanism should be designed to increase the double-path redundant transmission sequence. The vertical layout of the detonation isolation mechanism is required because of the large overload of the target base. At the same time new small penetration submunition fuze explosion mechanism is to meet the requirements of flame-proof and to meet the requirement of high penetration overload and, in this paper, the vertical arrangement of fuze ultra-thin flame-proof board proposed composite structure with three layers of different metal materials (Figure 2), flame-proof institutions within the very narrow space using symmetric dual vertical arrangement, to meet the demand of the two-way combustion and flame-proof (Figure 3).

![Figure 2. Ultra-thin fuse deflector arranged vertically.](image)

![Figure 3. Schematic diagram of double channel layout of fuze ultra-thin type flameproof plate arranged vertically.](image)

Its single overall size is 1.6mm thick, the vertical length is about 20mm, the upper and lower two layers are respectively 0.3mm W-Cu alloy plate, the middle layer is 304 stainless steel, between the three layers by riveting connection. In order to resist high penetration overload in the process of penetration, the bending Angle structure at the upper end of the middle layer was designed. The whole design of the flameproof plate has a detonation guide hole, and the electric detonator transmits the detonation charge through the detonation guide hole. Compared with Figure 1, the vertical placement of fuze ultra-thin type flameproof plate can reduce the detonation sequence of the first-order detonator, and replace it with the detonation hole, the structure can be more than doubled.

4. Simulation and test verification
4.1. Simulation verifies the capability of the ultra-thin vertical fuze flameproof plate against high penetration overload

Due to the small penetration submunition in the process of penetration by as much as 120,000 g of penetration overload, so the vertical arrangement of fuze ultra-thin flame-proof plate by simulating the resistance to penetration overload capacity, the overload curve as shown in Figure 4 [8]. If the maximum stress of the flameproof plate is less than the yield limit of the materials used (Table 1), the flameproof plate meets the requirements of high penetration overload. The finite element model is shown in Figure 5. The simulation unit system is mm-ms-g-MPa.

The material parameters used in the simulation are shown in Table 1:

| Diaphragm material         | Density (g/mm³) | Elastic modulus (MPa) | Poisson's ratio | Tensile strength (MPa) | Yield limit (MPa) | Shear modulus (MPa) |
|----------------------------|-----------------|-----------------------|-----------------|------------------------|-------------------|---------------------|
| 304 stainless steel        | $7.93 \times 10^{-6}$ | $194 \times 10^3$     | 0.3             | 520                    | 205               | $58 \times 10^3$    |
| Tungsten copper alloy      | $19.3 \times 10^{-6}$ | $410 \times 10^3$     | 0.33            | 1200                   | 2000              | $136 \times 10^3$  |

Figure 4. Penetration overload curve.

Figure 5. A simplified finite element model for calculation.

Under the condition of maximum penetration overload of 120,000 g, the forces of the vertically arranged fuze ultra-thin explosion-proof plate were simulated respectively. The simulation results are shown in Figure 6. The maximum stress appears at the inner bend of the upper end of the hook structure in the middle layer of the flameproof plate, which is 17.6 MPa, less than the yield limit of 304 stainless steel used in the middle layer, which is 205 MPa, and the structure will not fail.
Maximum stress throughout the ultra-thin flame-proof plate are less than the yield limit of material used, so the vertical arrangement of fuze ultra-thin flame-proof plate can meet the small penetration ammunition drug resistance of 120,000 g penetration overload work requirements.

4.2. **Simulation verifies the safety of ultra-thin fuses arranged vertically when 12m falling**

In the service process, because the fall is likely to lead to the vertical arrangement of fuze ultra-thin flame-proof board security failure occurs, so drop of simulation verification, if the flame-proof board of maximum stress is less than the yield limit of material used (Table 1), the flame-proof plate meet the security requirement 12m falls. In the most dangerous case, the sag overload can be simulated by a curve whose peak value is 12,000 g and the corresponding time is 230μs. The curve of sag overload is shown in Figure 7.

![Figure 7. The overload curve of 12m falling.](image)

The simulation results as shown in Figure 8, the maximum stress in the middle tier of the flame-proof institutions within the top hook structure of bend, 2.1 MPa, the material yield limit of 304 stainless steel is far less than the middle layer 205 MPa, so fall effect of overload of flame-proof board is minimal.
Throughout the ultra-thin flame-proof board maximum stress is less than the yield limit of material used, so the vertical arrangement of fuze ultra-thin flame-proof board hook upper middle tier structure in the bend of the safety of the 12m fall in dealing with the satisfied service.

4.3. The test verifies the explosion isolation safety of the ultra-thin fuses arranged vertically

Vertical arrangement of fuze ultra-thin flame-proof board's primary function is to ensure that the detonator in occasional case the advanced ignition, will not set off at the next lower level booster column, so as to avoid bullets medicine early burst and cause damage to our personnel and equipment. Therefore, the explosion isolation performance of the explosion isolation mechanism is tested and verified.

Test is new small drug penetration ammunition Ø 2.5mm size distribution by electric detonator, the electric detonator can effectively pierced the 3mm steel plate. In electric detonator with high overload resistance of ultra-thin fuze flame-proof $\approx 0.1$mm agency clearance under the conditions of explosion-proof test, if the third layer of tungsten copper alloy plate is in good condition, the isolation plate of flame-proof performance meet the safety requirements.0.1mm

After the detonation of the electric detonator, the explosion isolation mechanism is disassembled layer by layer. The first layer of W-Cu alloy sheet, the middle 304 stainless steel sheet and the third layer of tungsten-copper alloy sheet are respectively shown in Figure 9 from left to right. It can be seen that the first layer of W-Cu alloy sheet is seriously damaged, and the middle 304 stainless steel layer has a slight dent caused by detonation of the detonator. The third layer of tungsten-copper alloy sheet is intact without any trace.

Figure 8. Stress clouds under 12m falling.

Figure 9. Details of each layer of the flameproof plate after the test.
(a) The upper layer plate; (b) The inter layer plate; (c) The under layer plate.

Test results show that although the high overload resistance of ultra-thin fuze explosion mechanism of the first layer is fragile, but absorption detonation energy effect is good, can effectively reduce the
next layer of 304 stainless steel plate have been hit. Therefore, the whole vertical layout of the fuze ultra-thin type flameproof plate has good performance.

Comprehensive above the results of simulation and experiment results, which can be concluded that the overall size is about 1.6mm×20mm vertical arrangement of fuze ultra-thin flame-proof board, can resist 120,000 g penetration overload, 12m falling at the same time meet the explosion-proof security and safety.

5 Conclusion
In this paper, the vertical placement of the fuze ultra-thin type flameproof plate, the overall appearance of which is three layers of different metal materials vertical composite sheet structure, its overall size is 1.6mm thickness, vertical length about 20mm. The middle layer is made of 304 stainless steel, and the bend at the upper end of the middle layer is designed to resist penetration overload. The upper and lower layers are made of 0.3mm thick W-Cu alloy plates to absorb detonation energy of detonators. Verified by simulation, the vertical arrangement of fuze ultra-thin flame-proof plate can resist 120,000 g penetration overload, and satisfy the security of the 12m falls, and experiments verify its meet new small drug penetration ammunition flame-proof required by the security. Direction of further research for the vertical arrangement of fuze ultra-thin flame-proof plate can be applied to other ammunition fuze, at the same time, with the continuous development of material technology, the future may be a new kind of material, adopting the new materials of the vertical arrangement of fuze ultra-thin flame-proof plate to the structure of the smaller size and better flame-proof security.

6. Reference
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