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TESTING BfR COMBAT BOOTS SUBJECT TO UNDERFOOT ANTI-PERSONNEL MINES

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AIM

The aim of this trial was to conduct the testing of combat boots under the sponsorship and direction of BfR. The boots were subject to anti-personnel underfoot mines and the events were recorded by still, video and high-speed video photography. Standard in-service combat boots were also subject to underfoot mines to provide a comparison.

CONFIGURATION

The two mine types used in this trial are illustrated below.

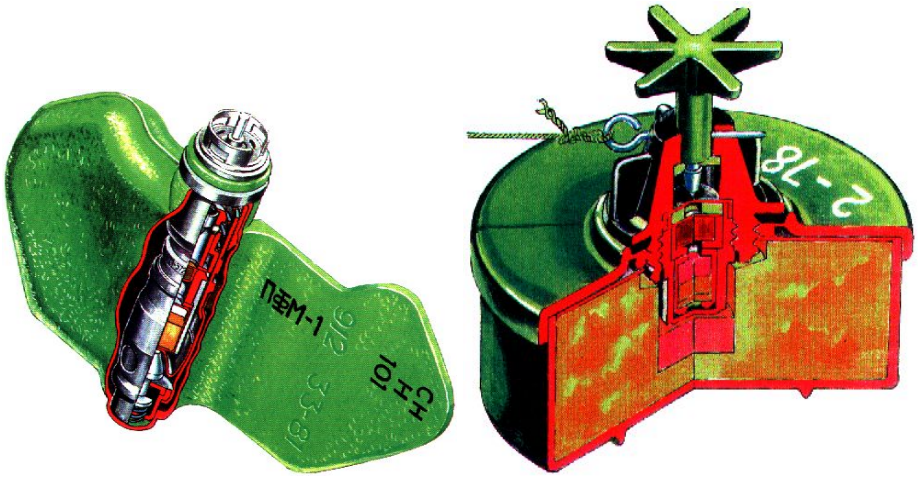

Illustration of the underfoot anti-personnel mines type PFM-1 and PMA-2.

Mine specifications:

PFM-1 mine		PMA-2 mine	
Length	120mm	Diameter	68mm
Width	60mm		
Thickness	19mm	Total height	61mm
Weight	73.5mm	Weight	135g
Explosive	35-40g	Explosive	100g
Operating force	5kg	Operating force	5kg

For the purposes of this trial alternative explosive fills were used.

The PFM-1 mine was filled with 30g and 40g of plastic explosive type PE4.

The PMA-2 mine was filled with 30, 40, 50 and 70g of plastic explosive type PE4.

The in-service fill of the PFM-1 is liquid explosive; the use of plastic explosive (PE4) in these trials is expected to provide effectively identical performance on detonation. Similarly, the PE4 used to fill the PMA-2 will perform near identically with the in-service fill of TNT. In service the PMA-2 is completely filled, but this trial required progressive charge sizes, so the charges of 30g, 50g and 70g were formed around the central fuze, and the annular void then filled with sand. The mines were initiated remotely using detonators inserted into the mine bodies.

No standard is known for proper physiological simulation of lower limbs versus underfoot mines, so conventional manikin legs were used rather than prosthetic limbs. The criteria for damage assessment was patent breaching of the sole and comparative visual damage relative to the standard issue army boot. No attempt was made to assess the extent of potential skeletal, soft tissue or other injury to the limb tissues.

The 'soil' type used was dry sand completely filling a large container (>40L) which was be supported by burial to the brim in soil. In the absence of a sand packing standard, the sand was simply pressed by foot to provide maximum fill prior to implanting each mine. The scatterable mines (PFM-1) were laid on the sand surface in a depression sufficient for the upper surface of the mine to be flush with the sand surface. The buried mine (PMA-2) were implanted with minimal overburden to leave the actuator exposed.

Each boot was mounted on a manikin leg with sock. Each manikin was ballasted with sand to 15kg to represent lower leg mass (note the inertial mass of the limb is largely unrelated to the force to initiate a mine). The manikin legs were tethered in a vertical position by horizontal elastic cords extended to four surrounding poles.

FIRING PROGRAMME

The criterion used to judge the effectiveness of the boot was the patent breaching of the sole/heel. This criterion is also relevant because breaching of the sole is a key process in underfoot mine attack which then allows penetration of disruptive gases and contaminated debris into the tissues of the lower limb. Prevention of breaching of the sole is a crucial requirement of 'mine boot' design. Prevention of sole breaching does not preclude skeletal fractures, stress wave damage to soft tissues, or collateral missile injury, but is of clear profound benefit — except for the incidence of traumatic amputation, retained and uncontaminated tissues have prospects of surgical repair which would otherwise be non-existent.

The trial programme was as follows:

Firing	Boot	Mine position	Mine body	HE fill
1	UKCBH	Ball	PFM-1	30g
2	UKCBH	Heel	PFM-1	30g
3	BfR	Ball	PFM-1	40g
4	BfR	Heel	PFM-1	40g
5	BfR	Ball	PMA-2	30g
6	BfR	Heel	PMA-2	50g
7	BfR	Ball	PMA-2	50g
8	BfR	Heel	PMA-2	70g

Photographs were taken before and after each firing: note that the BfR-V50 boot was, for the purposes of this trial, labelled "BfR-VT50". Each firing was filmed by high speed video, and handheld standard (Digital-8) video was used to add relevant observations before and after each firing.

Comments on the firing programme:

The manikins used here lacked the compliance of live tissues so, although traumatic amputation is a real threat to underfoot mine victims, the detachment of the foot in these firings will have been due to the brittle nature of the manikins; therefore no relevance should be placed on the incidence of foot detachment in these firings.

The BfR-V50 boot has a laminated construction with structural metal plates below the aramid casing. The metal plates tended to be detached and distorted by the mine blast, giving the appearance of considerable damage, but if the aramid casing above survived without breaching then the boot was deemed to have provided effective protection.

Firings 1-4. Although the charge size in the PFM-1 is relatively small, this scatterable mine remains on the ground surface, so the target boot will be subject to the severe threat of an explosive device in direct contact. The UKCBH (firings 1 & 2) has no 'mine boot' qualities and so was expected to be severely disrupted by the 30g charge — these firings were conducted to illustrate the disruption of a conventional combat boot. It was hoped that the BfR-V50 would survive the PFM-1 with full 40g charge (firings 3 & 4), but the severity of the in-contact device proved to be overwhelming.

Firings 5-8. In light of the destructiveness of the in-contact PFM-1, the first firing using the PMA-2 used a conservative explosive fill of 30g to ensure against entirely negative results. However, the BfR-V50 boot sole was not breached and so provided effective protection. The primary cause for the difference in result between firing 5 and firing 3 was that the PMA-2 actuating plunger provides a stand-off comprising a light overburden (about 1cm) of sand plus an airspace of about 1cm. The degree of protection afforded must allow for the stand-off due to the various underfoot mine types. The success of firing 5 prompted 50g charges for firings 6 & 7, and their success in turn prompted the 70g charge for the final firing, in which the BfR-V50 boot heel again survived without breaching. During some firings, rending of the uppers did occur, it is not known what resultant injury to the foot would occur.