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# Experimental Setup to Assess Blast and Penetration-Induced Secondary Debris in a Military Operations in Urban Terrain (MOUT) Environment

by Paul S Duvall

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# **Experimental Setup to Assess Blast and Penetration-Induced Secondary Debris in a Military Operations in Urban Terrain (MOUT) Environment**

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<b>14. ABSTRACT</b> The purpose of this report is to document the procedures for setting up collection medium in an urban environment to collect secondary debris caused by an explosion. The collection medium allows us to evaluate the possible penetration depths of secondary debris into the Warfighter and assess different types of clothing and protective equipment.					
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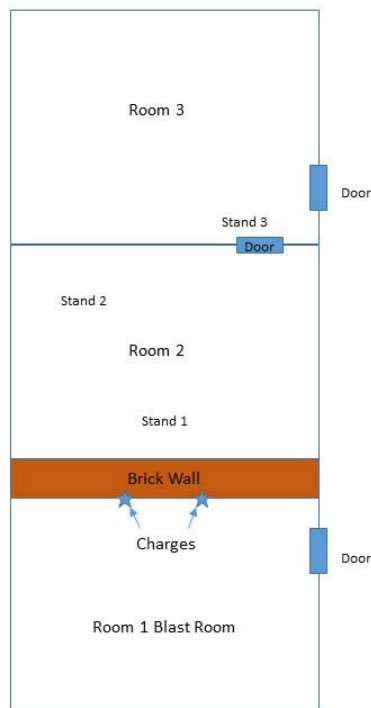
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## 1. Introduction

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As part of an ongoing Project Agreement on Military Operations in Urban Terrain (MOUT), the US Army Research Laboratory's (ARL's) Explosives Effects Branch supported a series of experiments conducted in Meppen, Germany (DEU), to understand loading on personnel protective equipment (PPE) produced during urban weapon attacks. These experiments were conducted by detonating an explosive charge placed on a brick wall to create secondary debris that would impact the US-designed collection medium. The collection packs that were utilized have previously been used in experiments where it was necessary to collect secondary sand debris from buried blast experiments. Because the collection methodology was considered successful for the fine grain sand used in those experiments, the same design was adapted for collecting wall debris. Participating countries in the experimental series included DEU, the Netherlands (NLD), and the United States (ARL and the Air Force Research Laboratory). Each participating country designed a collection medium to understand the effects of failing walls in an urban environment on PPE material and clothing and on associated personnel injury. The experimental area consisted of 3 separate rooms (Fig. 1). The first room was used as the blast room. The second and third rooms contained the collection medium. A double thick brick wall separated rooms 1 and 2 and was used to create the secondary debris.



**Fig. 1** Experimental rooms

## 2. Experimental Setup

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### 2.1 Collection Medium

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A wooden collection stand (Fig. 2) was designed to hold each collection medium that the US provided for testing. Each stand was precut out of 1.90-cm-thick plywood and assembled on-site. The overall measurements were 172 cm high  $\times$  54.61 cm wide. The front window frame was 59.69 cm high  $\times$  54.61 cm wide with an opening 50 cm high  $\times$  45 cm wide. The stand was configured to be generally representative of a Warfighter that is 187.96 cm tall (95th percentile Anthropometric Survey [ANSUR] II study) with a presented chest area of 50.8 cm high  $\times$  45.72 cm wide. When placed in the stand, the center of the collection pack was 142 cm high (Fig. 2). The stand was fabricated to contain a collection pack consisting of neoprene foam and plastic (50.8 cm wide  $\times$  55.88 cm high  $\times$  5.75 cm deep). Each collection pack was 5 layers of neoprene foam (11.43 mm) with 0.002 inches (0.05 mm) of plastic interweaved between each layer (Fig. 3). The front of the pack utilized 2 layers of plastic.



Fig. 2 Collection stand



**Fig. 3** Foam packs

In addition to the foam collection pack, the wooden stand was designed to hold 2 synthetic gelatin blocks or a combination of gelatin soap and synthetic gelatin for use as the collection medium (Fig. 4). Shelves were constructed to support the synthetic gelatin and gelatin soap with dimensions of 25.4 cm wide  $\times$  25.4 cm deep. Each shelf was attached to the side of the stand so that the distance from the ground to the center of the collection medium was 142 cm. The synthetic gelatin is designed to have the penetration resistance of 20% that of ballistic gelatin. The benefit of using the synthetic gelatin is that it is not temperature sensitive in contrast to the 20% ballistic gel. Due to its temperature insensitivity and results of comparative studies, the synthetic gelatin was chosen for shipment from the United States to GEU. The presented area of the gelatin blocks was 20.32  $\times$  20.32 cm. The gelatin soap blocks were provided by the German participants in the experiments and a representative sample is shown in Fig. 5.



**Fig. 4** Collection pack with gelatin soap and synthetic gelatin



**Fig. 5** Gelatin soap

Each foam pack was covered with different types of clothing material provided by the participating countries (Fig. 6). Figure 6 shows 2 types of NLD fabric covering the foam pack. The synthetic gelatin was covered with 2 types of US Kevlar weave cloth.



**Fig. 6** Collection medium

## 2.2 Explosive Blast Experiments

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A double thick brick wall was constructed to separate the blast room from the target room (Fig. 7).



**Fig. 7** Double thick brick wall

Two explosive charges were placed on the wall, on the side of room 1,142 cm off the ground with a spacing of 49.5 cm from the center point of the wall to create the secondary debris. Three collection stands were used for the blast test (Fig. 8).

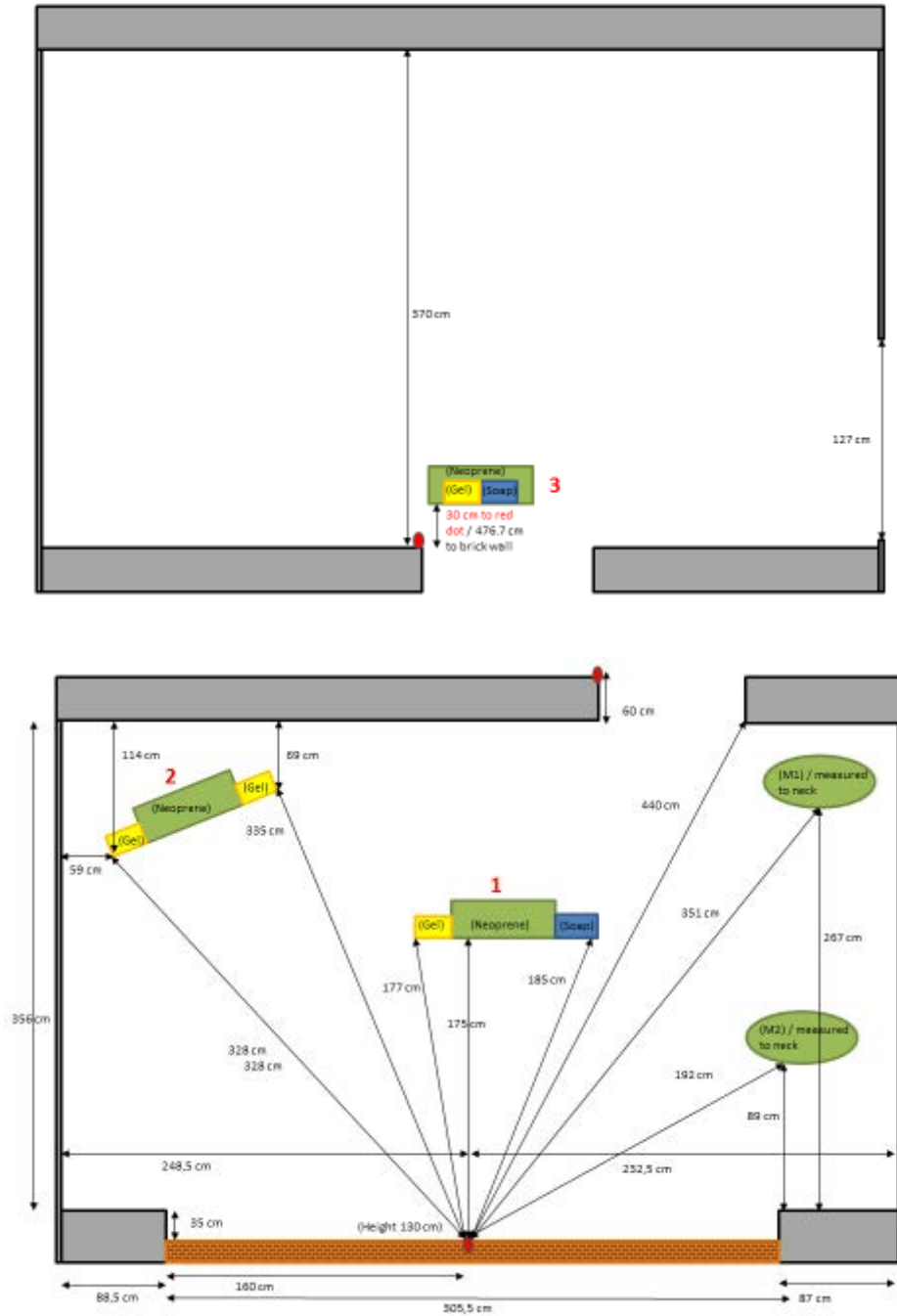


Fig. 8 Test configuration

The first stand was located 175 cm from the brick wall in room 2. The foam pack was covered with an NLD fabric. Half of the pack was also covered with NLD undergarment material under the first layer of fabric (Fig. 9). The soap block and gelatin block of the first stand were covered with a DEU pug material.



**Fig. 9 Collection stand**

The second stand was located 328 cm from the brick wall (Fig. 8). The foam was covered half with NLD fabric and half with defender undergarment. The 2 side targets on this stand were synthetic gel blocks covered with a single US weave material of various thicknesses (Fig. 6).

The third stand was located 476.7 cm from the brick wall (Fig. 8) just behind the doorway of room 3. Half of the foam pack was covered with NLD fabric and the other half was bare. Both the gelatin and soap were bare.

High-speed videography was used to obtain measurements of wall debris velocity and document wall debris spray.

### **3. Conclusion**

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Through these experiments, the collection medium design proved to be a valuable way to understand the impact from secondary debris. The stands provided a simple, yet effective way of containing each collection medium.

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