

Marek Ł. GRABANIA

Maciej KOCHEL

## OBJECT DEMONSTRATOR

**Abstract.** The article presents the design of an object demonstrator, special stand for ballistic testing of additional armour. A short review of stands for gunfire testing of armour and special plates. The features of the developed structure allowing its use to carry out a wide range of tests for compliance with applicable NATO standards, STANAG 4569 and AEP-55, are discussed. In conclusion, suggestions for broadening the range of applications of the described object/stand in the studies and ballistic tests at authorized military laboratories.

**Keywords:** armour, additional armour, ballistic tests, test stand.

### 1. INTRODUCTION

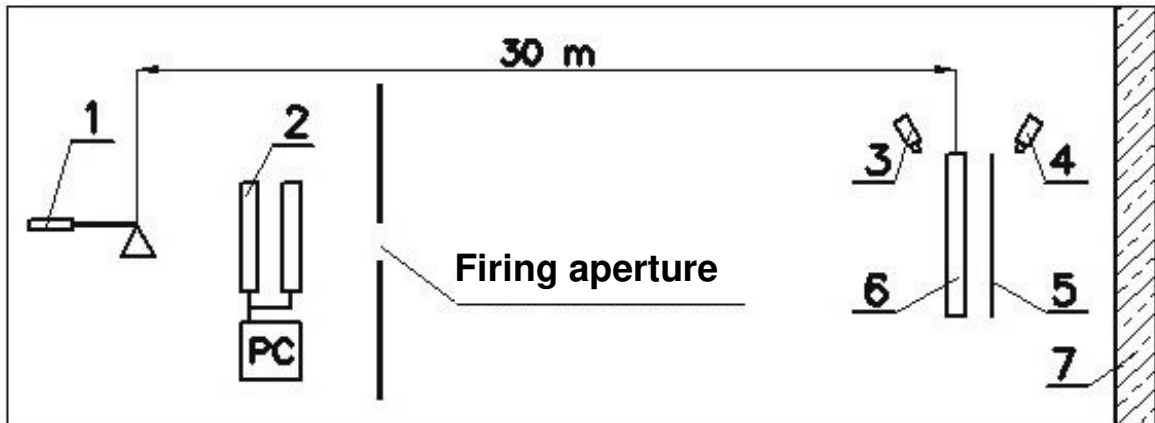
The key issue in the research work and projects on the design of vehicles for military that require increased protection against projectiles or of vehicles for civilian purposes (e.g. vehicles for the transport of valuables), is the selection of appropriate construction materials to ensure the desired level of protection. The design is usually verified during ballistic tests and trials [1] to check the resistance to gunfire. Such tests are carried out in specialized laboratories that provide both infrastructure as well as appropriate instrumentation.

Such laboratories are usually located within military installations that have indoor shooting ranges and/or indoor shooting tunnels, as well as access to the infrastructure of open-air proving grounds. The scope of gunfire testing depends on the advancement of the design and the subject of testing. The latter may include individual armour plates (manufacturer certification testing), fragments of vehicle armour (exploratory research), complete vehicles (testing to verify the adopted level of protection, e.g. qualification tests).

In the case of military equipment the protection level verification is based on standard specifications (STANAG 4569 [2]) and the provisions of NATO document AEP-55 [3].

### 2. TEST STANDS

A typical configuration of a test stand [3], [4] set up for ballistic testing is shown in Fig. 1. The muzzle to target distance (Fig. 1) specified in the figure is an example distance. The actual distance to the tested object is defined in standards [2]. Often, when conducting tests at reduced distances, a technique is used of weighing the powder charge to obtain the required muzzle velocity and provide the required kinetic energy of the projectile.

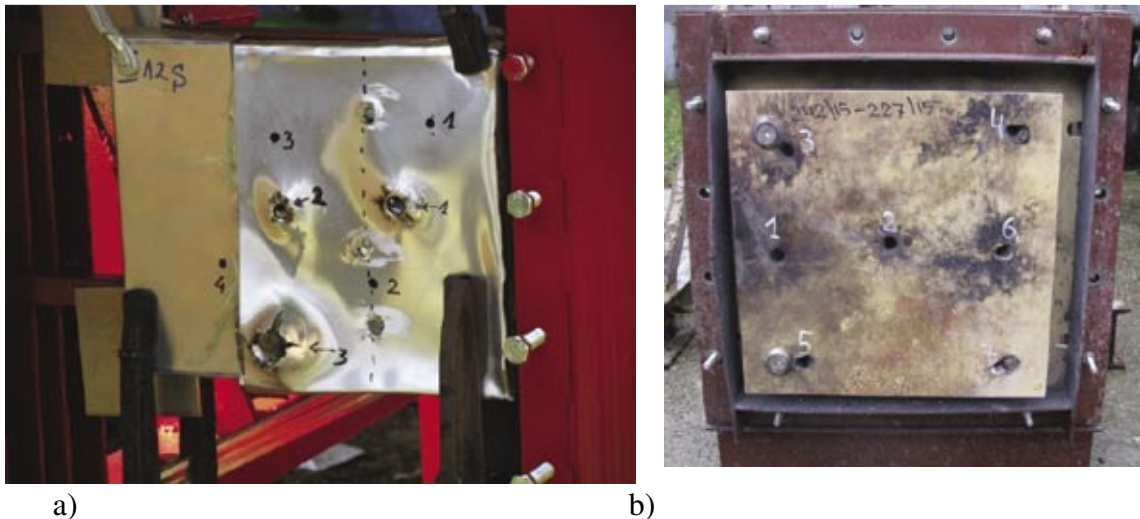


**Fig. 1. Block diagram of a firing test stand**

1 – firing position; 2 – gate for muzzle velocity measurement with computer; 3 – front camera; 4 – rear camera; 5 – witness plate; 6 – tested element; 7 – backstop

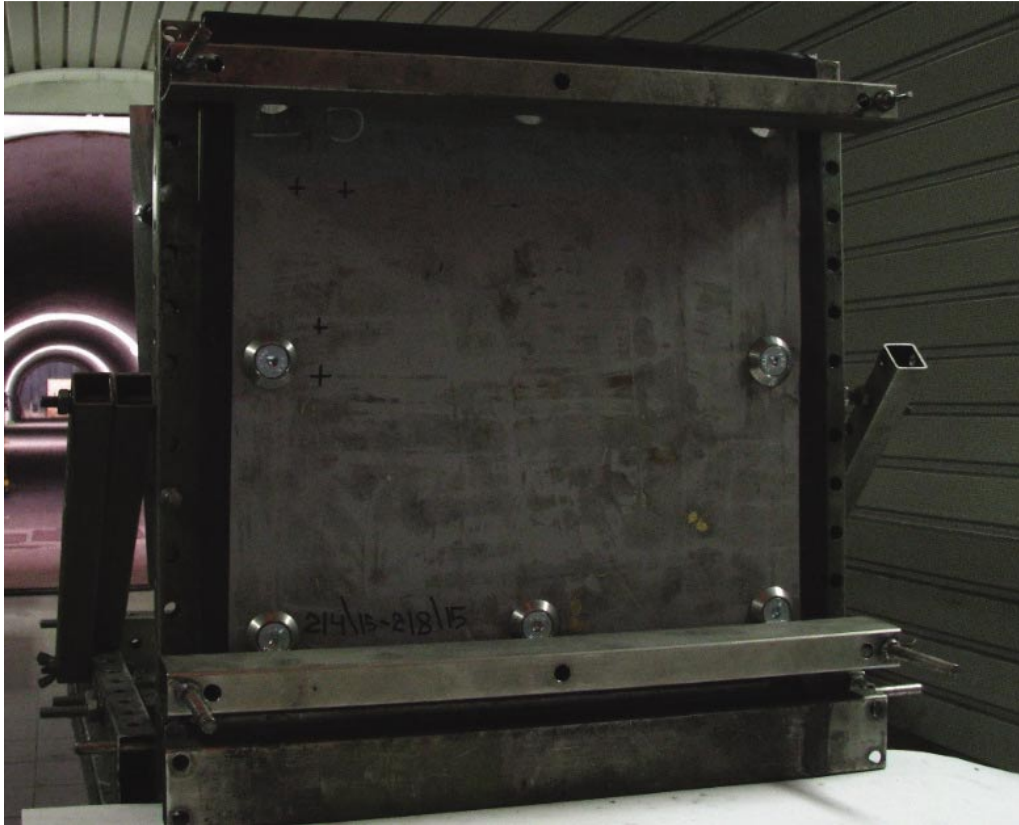
The piece of armour under test (armour module, armour sample) is installed in a special fixture (item 6) to keep it in a fixed position and prevent it from moving when hit by one or more projectiles.

The complexity of the fixture depends on test requirements and the laboratory, as well as on the location of the firing tests. Figs. 2 and 3 show examples of structures for fixing the element to be tested.



**Fig. 2. Auxiliary gunfire testing instrumentation**

a) Photo IMN OML, Skawina b) Photo OBRUM sp. z o.o.



**Fig. 3. Gunfire testing stand installed in a shooting tunnel**

(photo IMN OML, Skawina)

In the project titled "Additional modular armour for wheeled armoured personnel carriers and tracked platforms" (codenamed MODPANC) [5], carried out by a consortium of five companies, including OBRUM, testing of the protection level of the additional armour under development is one of the major elements designed to verify the results obtained. The ballistic tests conducted as part of the MODPANC project were performed using the instrumentation provided by the institutions where the firing tests were carried out (Military Institute of Armour and Vehicle Engineering, Military Institute of Armament Technology) and instrumentation developed and fabricated at OBRUM.

Two stands were designed for firing tests for the purposes of the project to be used at different stages of research in the MODPANC project:

1. A test stand [4] for testing samples (Fig. 4) of additional armour of the following dimensions:
  - 250 x 250 mm; 250 x 500 mm and 500 x 500 mm.
2. A test stand [6] for testing (Fig. 5):
  - consolidated add-on armour modules 500 x 500 mm;
  - test objects – two consolidated add-on armour modules  
500 x 500 mm affixed to the primary armour by means of a fastening arrangement.

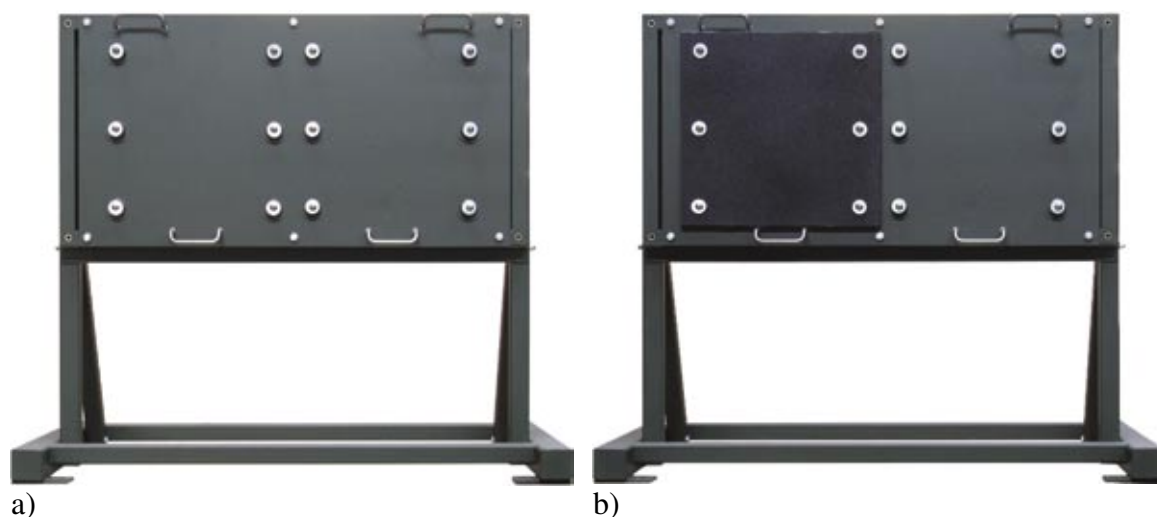
The stands are shown in Figs. 4 and 5.



**Fig. 4. Stand for testing samples of add-on armour**

(photo OBRUM)

The design of the stand for testing individual samples of armour (Fig. 4) has one additional and useful function: it enables changing the position of the plane of armour in relation to the line of fire (shooting at an angle).



a)

b)

**Fig. 5. Stand for testing armour**

(photo OBRUM)

a) stand with fastening arrangement  
ready to receive armour

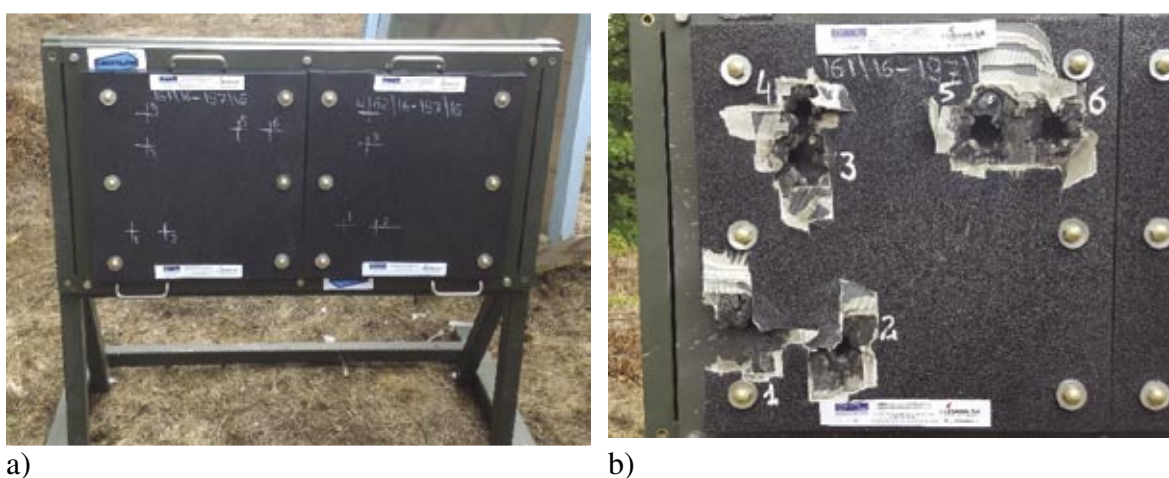
b) stand with one armour module  
fastened

In order to carry out tests in line with the NATO AEP-55 document [3], a standardized size of the armour module (500 x 500 mm) was adopted in the project [5].

Gunfire testing was conducted starting from stage II of the project on the so-called objects for carrying out tests comprising:

- 6, 8 and 10-mm thick primary armour plates 600 x 1100 mm  
(in accordance with Initial Tactical and Technical Specifications [7]) – with carrying handles;
- system for fastening additional armour affixed to primary armour;
- additional armour being tested;
- set of armour bolts.

The object for carrying out tests installed on the test stand is shown in Fig. 6.



**Fig. 6. The object for carrying out tests installed on the test stand**  
(photo OBRUM)

a) prior to gunfire testing

b) a fragment after gunfire testing

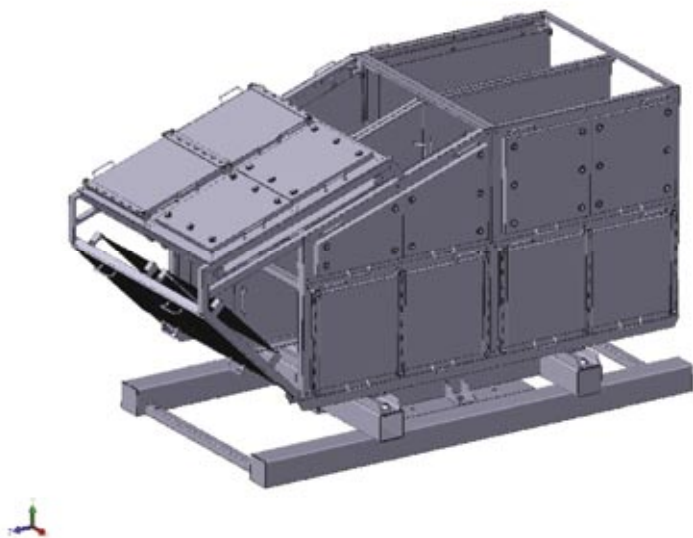
### 3. OBJECT DEMONSTRATOR

The MODPANC project [5] envisages carrying out final tests to verify the adopted protection levels defined in the Initial Tactical and Technical Specifications [7] using a special test stand named "Object Demonstrator". That stand should reproduce the geometrical features of the body of the wheeled personnel carrier and should enable fastening (with the use of the developed fastening arrangement) of all of the designed additional armour modules to carry out ballistic tests. The conceptual design of the Object Demonstrator developed at OBRUM is shown in Fig. 7.

For the purposes of the MODPANC project the dimensions of the main objects for carrying out tests were standardized to 600x1100 mm and 600x600 mm. The object for carrying out tests comprises a set/subassembly consisting of:

- primary armour (ARMSTAL 500 steel 6, 8 or 10 mm thick) with carrying handles;
- fastening arrangement with armour bolts;
- two add-on armour modules 500 x 500 mm.

An example view of the object for carrying out tests in the IMN OML version, affixed to the test stand, which will also be affixed to the object demonstrator, is shown in Fig. 6 a.



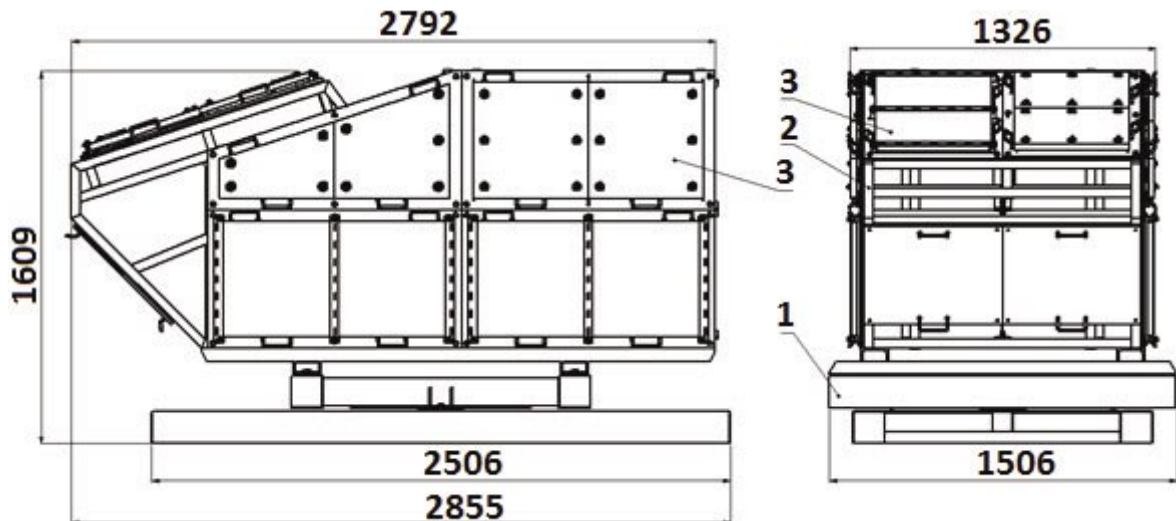
**Fig. 7. Test stand – Object Demonstrator (view)**

The Object Demonstrator – stand for gunfire testing, which is the subject of this article, consists of three main subsets (Table 1).

**Table 1. Main subsets of the Object Demonstrator**

1	Base	1 set
2	Body with partitions-backstops and "witness" plates	1 set
3	Objects for carrying out tests	12 sets

Overall dimensions of the gunfire test stand – Object Demonstrator are shown in Fig. 8.



**Fig. 8. Overall dimensions of the Object Demonstrator.**

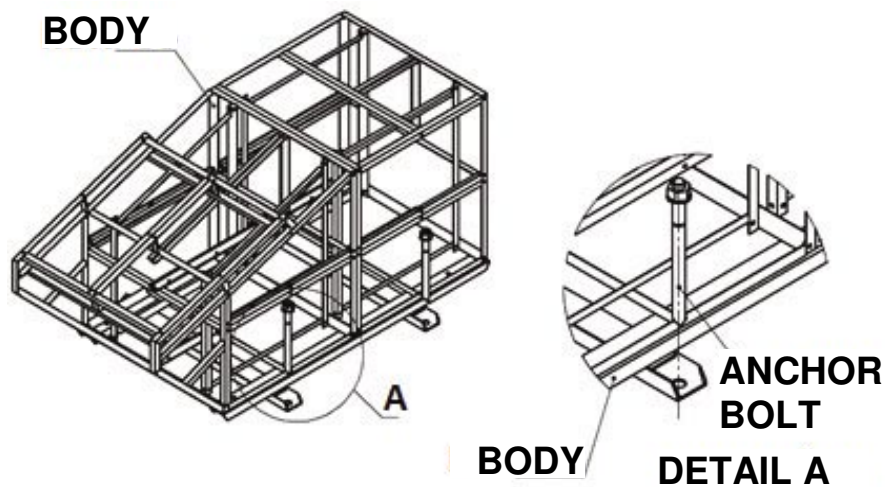
The design documentation of the Demonstrator [9], depending on the scope of testing, including the adopted programme and methodology, provides for two options of Demonstrator application:

### 3.1. Option 1 - simplified.

**(Demonstrator body positioned directly on ground).**

In this case the stand used comprises body with partitions and objects for carrying out tests affixed thereto. In this option the body with partitions is placed directly on the ground. The Demonstrator is secured by anchoring the body (see Fig. 9) by means of expansion bolts (concrete floor) or ground bolts (grassy ground).

This option does not allow rotating the body. Mounting to the ground is shown in Fig. 9.

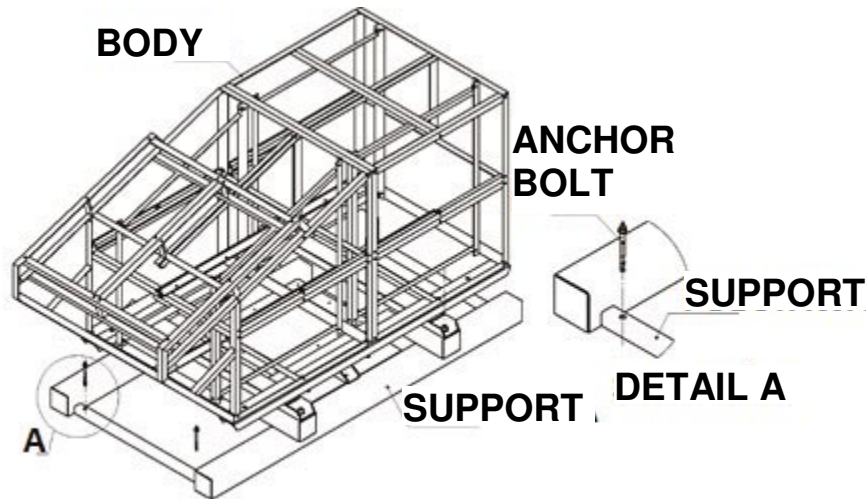


**Fig. 9. Mounting the body directly on the ground**

### 3.2. Option 2 - complete.

(Demonstrator body positioned on a support with a rotation bearing.)

In this option the Demonstrator body of option 1 (Fig. 9) is provided with a rotating support. Prior to gunfire testing the Object Demonstrator support must be secured (Fig. 10) by anchoring the Demonstrator to the ground using expansion bolts or ground bolts. Mounting to the ground according to this option is shown in Fig. 10.



**Fig. 10. Mounting of the complete version of the Demonstrator – anchoring to ground**

In both options mounting to a hard substrate (concrete, rock) is effected by means of expansion anchor bolts M16x160 mm (M12x160 mm).

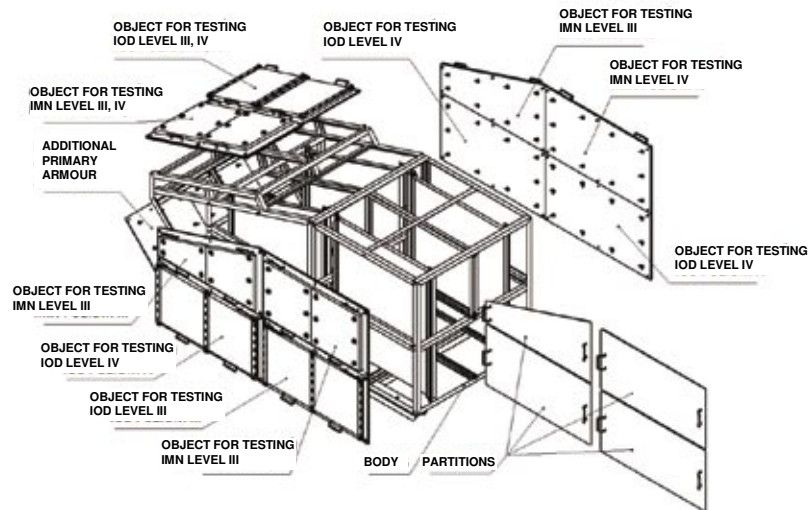
In case of a soft substrate (soil) ground anchor bolts or cable bolts are used.

## 4. BALLISTIC TESTS

The objects for carrying out tests are mounted onto the body with partitions depending on the adopted gunfire test programme and on the sequence of ballistic tests. The arrangement of the objects is shown in Fig. 11. The design of the structure enables multi-variant ballistic testing. The aluminium witness plates installed inside the body of the Demonstrator control primary armour fragmentation, if such should occur. Additional steel partitions positioned in the longitudinal axis of symmetry of the body protect the armour of the opposite side in case of penetration of the armour on the side being tested.

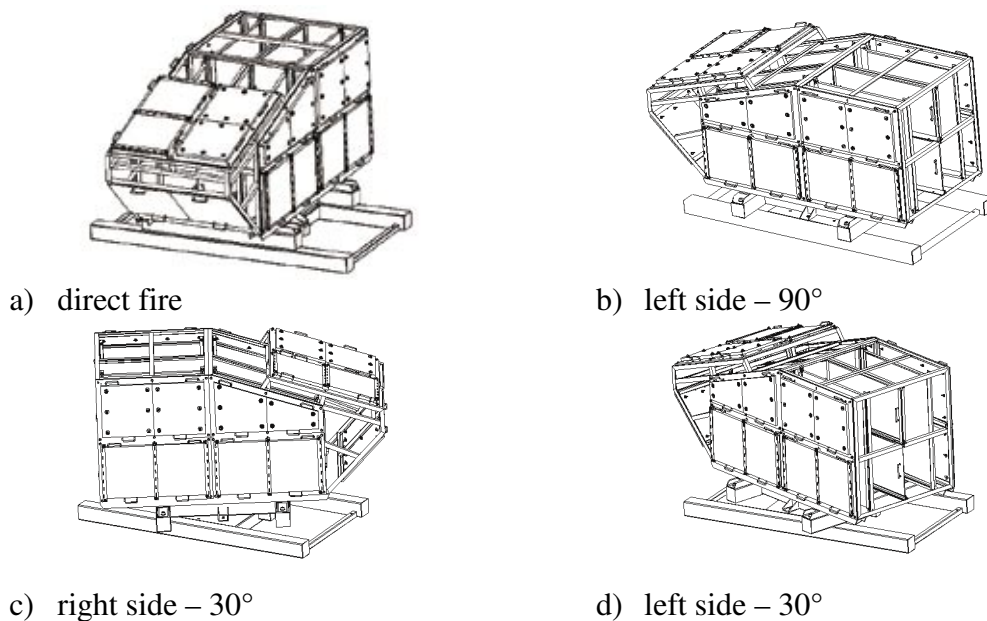
The objects for carrying out tests can also be provided with spall liners (see Fig. 13), enabling gunfire testing of the configuration: **additional armour – primary armour – spall liner.**





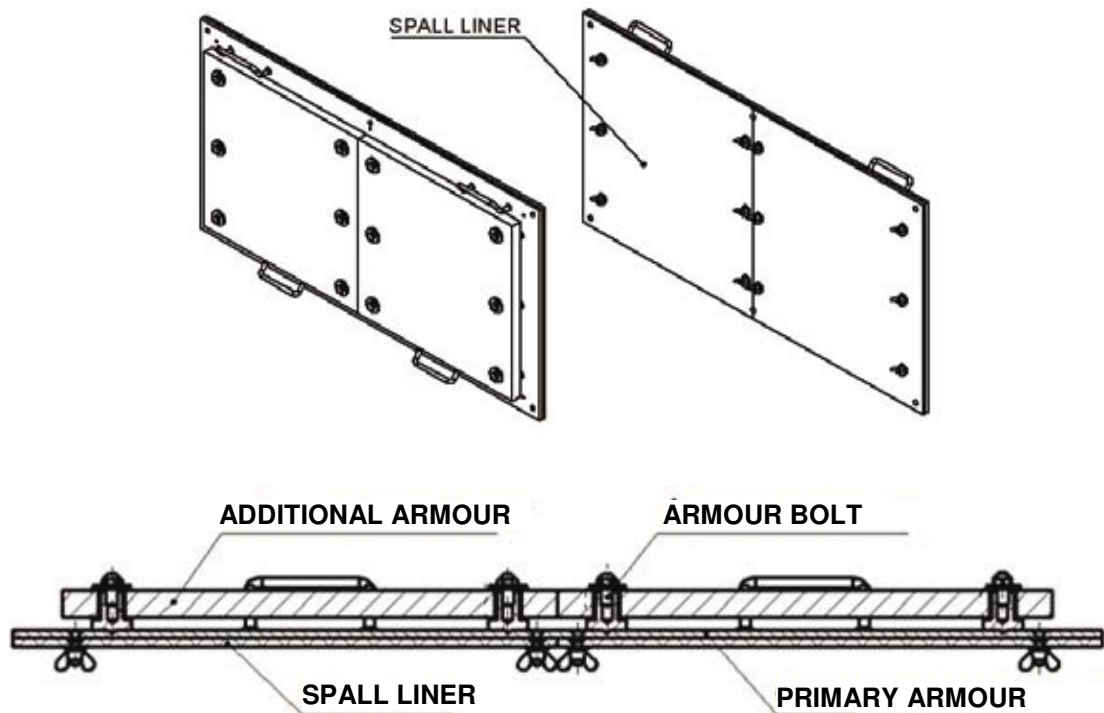
**Fig. 11. Arrangement of armour modules – installation of the Object Demonstrator**

The mounting of the Object Demonstrator of the complete option 2 (with support and rotation bearing) enables conducting testing with gunfire perpendicular to the plane of the additional armour and at angles of 30 and 60 degrees. Examples of the Demonstrator positioning on the gunfire test stand are shown in Fig.14 a, b, c, d.



**Fig. 12. Angles of firing at the Object Demonstrator**

The test stand - Object Demonstrator enables conducting gunfire testing of additional armour modules designed and fabricated as part of the project with the use of technologies of the Foundry Research Institute in Cracow (IOD modules) and of the Institute of Non-Ferrous Metals, Light Metals Division in Skawina (IMN modules) The objects for carrying out tests were additionally modified to also enable testing with spall liners affixed. The manner of installing is shown in Fig. 13.



**Fig. 13. Object for carrying out tests (IMN version) with additional spall-liner.**

## 5. SUMMARY

The developed Object Demonstrator (test stand) enables, in accordance with the guidelines included in the MODPANC project [5] description, to install and assess the protection level of armour for levels II, II and IV in accordance with STANAG 4569 [2] and NATO AEP-55 [3].

The features of the structure designed deviate substantially from those of known test stands (Figs. 2, 3) used in renowned military laboratories (Military Institute of Armour and Vehicle Engineering, Military Institute of Armament Technology).

The design, to be verified during gunfire testing carried out as part of the MODPANC project, should prove the features and usefulness of the stand for other applications.

Successful verification may contribute to the fabrication of more stands for the testing of armour of land vehicles or their fragments being currently developed in Poland, by simulating the silhouette of the vehicle and enabling simultaneous, multi-variant testing on large fragments of protected areas at various firing angles: 90°, 60° and 30°.

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