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CRITERIA FOR EVALUATION NEW GENERATION OF ARMORED VEHICLES

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Summary

The current Polish Regulation of the Minister of Internal Affairs and Administration of 7 September 2010 distinguishes three types of armored vehicles: A, B and C, where type A is characterized by the most stringent set of requirements. This article discusses the regulatory requirements and the drafted assessment criteria proposal for new generation of armored vehicles (type A). The compliance of armored vehicles with regulatory requirements is certified by accredited bodies on the basis of testing.

A proposal has been put forward to classify new generation armored vehicles into 5 groups. A1 – standard, A2 – standard plus, A3 – professional, A4 – professional plus and A5 – extra. Also a proposal has been made to prepare the so-called "armored vehicle evaluation index" calculated as a weighted average of the seven subindices. Based on the sample of an armored vehicle constructed as a prototype by the consortium of PIMOT, WAT, ITS and AMZ Kutno under a research project of the Ministry of Science and Higher Education an assessment of the class was carried out and an overall evaluation index for armored vehicle was calculated. The assessment methods for type A armored vehicles described in the article may be very useful in the development and comparative studies of new vehicles and for product offers presented to customers on the market.

Keywords: armored vehicles, vehicle testing, anti-theft protection

1. Introduction

Ensuring a high level of safety for people and valuables in transit results in demand for armored vehicles, i.e. vehicles with enhanced theft-resistance. These vehicles, in addition to the transport of valuables, which include: money, silver, gold, platinum and precious

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stones, can also carry documents crucial for state security, for instance, documents containing classified information. Simultaneously, a tendency can be observed, where the most frequent users of this type of vehicles, in particular, banks and security companies [4, 8, 11, 12], have been increasing the requirements for their operational safety.

In accordance with the currently applicable Regulation of the Minister of Internal Affairs and Administration of 7 September 2010 on "the requirements for safeguarding valuables stored and transported by entrepreneurs and other organizational units" (Polish Journal of Laws 2010.0166.1128) three types of armored vehicles have been differentiated: type A, type B and type C. The most stringent requirements are in place for type A armored vehicles. Vehicles of this type provide a high level of security for the guards and the transported values. However, this level is a level required by regulations for the general public. Some specific solutions that allow the increase in the level of security above the security provided by type A armored vehicles will be discussed in the further sections of the article. The present discussion will focus on type A armored vehicles [7, 11, 15].

Compliance with regulatory requirements is certified by accredited testing bodies on the basis of testing [5, 6]. PIMOT, classified as one of these bodies, from 2000 to 2010 has issued approx. 400 certificates (diagram in Fig. 1). This number applies to individual vehicles.

The article discusses the legally valid requirements valid law and presents additional assessment criteria developed for type A armored vehicles.

Testing the armored vehicles that have already met the minimum regulatory requirements for compliance with the specified criteria should allow for a thorough, qualitative (comparative) assessment of these products.

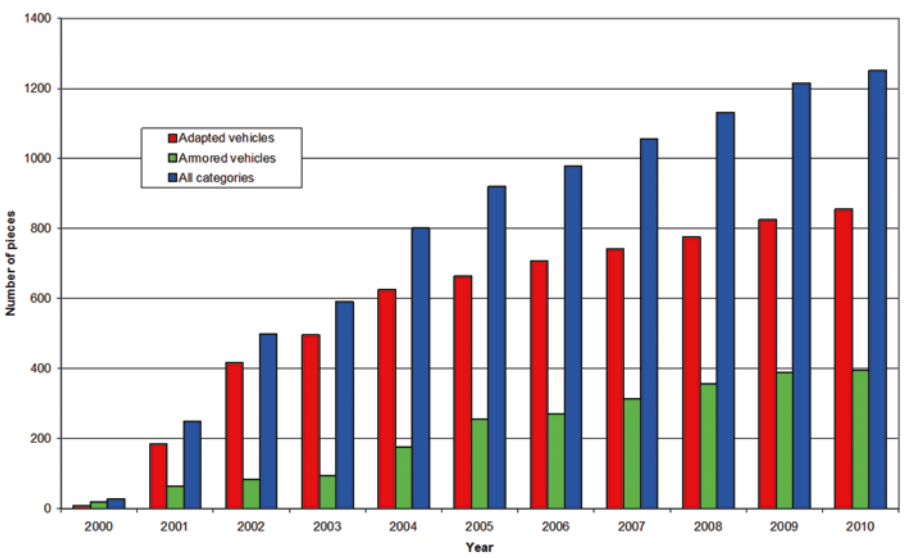

Fig. 1. The Number of Certificates Issued by PIMOT (cumulative) in the years 2000–2010

2. Legal requirements for armored vehicles

General and detailed legislative issues concerning armored vehicles as vehicles for the transport of valuables are set out in:

- Act of 22 August 1997 "on the protection of persons and property" (Polish Journal of Laws 1997.0114.0740, as amended),
- Act of 30 August 2002 "on the conformity assessment system" (Polish Journal of Laws 2010.0138.0935, as amended)
- Regulation of the Minister of Internal Affairs and Administration of 7 September 2010 on "the requirements for safeguarding valuables stored and transported by entrepreneurs and other organizational units" - (Polish Journal of Laws 2010.0166.1128).

The requirements of the permit for entry into service in the road traffic movement (approval requirements), as for special vehicles, are set out in the following documents:

- Directive of the European Parliament and Council Directive 2007/46/EC of 05 September 2007 establishing a framework for the approval of motor vehicles and their trailers, systems, components and separate technical units intended for such vehicles (Official Journal EU L263 of 09 October 2007, as amended),
- Act of 20 June 1997 on "Traffic Law" (consolidated text of the Polish Journal of Laws 2012.1137.1448),
- Regulation of the Minister of Transport, Construction and Maritime Economy of 25 March 2013 on the approval of motor vehicle and trailer types and their equipment or parts (Polish Journal of Laws 2013. item 407).

Act of 22 August 1997 on "the security of people and property" is the main legal reference regulating issues connected to the transport and storage of valuables. The Act specifies the areas, objects, equipment and transports subject to mandatory protection (Art. 5), which include, among others, banks and enterprises producing, storing or transporting valuables in significant quantities.

Section 12 of the currently applicable Regulation of the Ministry of Internal Affairs and Administration of 07 September 2010 states:

1. *Entrepreneurs and managers of other agencies make use of storage or transport containers for valuables that have:*
   1) *a certificate of conformity issued by an authorized certification body or a declaration of conformity issued either by the manufacturer or importer, confirming compliance with the general or specific requirements as defined by the regulations on the conformity assessment system, provided such requirements have been specified for any particular product,*
   2) *If no requirements as set out in Item 1 have been specified for the product - it is necessary to present and issue them by a certification body accredited by the Polish Centre for Accreditation.*

Transport of valuables in excess of 1 value unit is carried out with the use of armored vehicles. Value unit is understood as 120 times the average salary in the previous quarter

as announced by the President of the Central Statistical Office in the Dziennik Ustaw Rzeczypospolitej Polskiej (Journal of Laws of the Republic of Poland) „Monitor Polski".

Transport of valuables in excess of 24 value units is carried out with the use of a type A armored vehicle. Transport of valuables up to 8 calculation units is carried out with the use of a type C armored vehicle.

3. Technical Requirements for Armored Vehicles

Technical requirements for motor vehicles for the transport of valuables were developed based on the legal references discussed in the preceding item and are attached to these documents or provided as separate documentation (technical conditions) [14, 15].

The new Regulation of the Ministry of Internal Affairs and Administration of 07 September 2010 has introduced a number of changes in relation to the technical requirements set out in the previous regulation of the Ministry of Internal Affairs and Administration of 14 October 1998. The analysis of the changes is presented in the article [5].

In accordance with the current Regulation of the Ministry of Internal Affairs and Administration all vehicles for the transport of valuables have been defined as armored vehicles and, depending on the design and security, classified into types: A, B and C.

A new category has also been introduced – security vehicles for guards protecting the transport of a high number of value units. The most stringent requirements for the protection of the transport of valuables must be meet by armored vehicles of type A.

General Technical Requirements for type A armored vehicles (in accordance with Appendix No. 3 are as follows:

1. *Type A armored vehicle must meet at least the following general technical requirements:*
   1) *design including a separate load compartment,*
   2) *passenger compartment with five seats and a fuel tank guard of FB 5 rating in accordance with DIN EN 1522 (fuel tank, side walls) and at least FB4 class in accordance with DIN EN 1522 (floor, roof),*
   3) *passenger compartment of BR 5 rating in accordance with PN-EN 1063 without the possibility of opening,*
   4) *must be equipped with air-conditioning and ventilation of the interior,*
   5) *cargo compartment reinforced with steel sheet, at least of "45" grade of 1 mm thickness in accordance with PN-EN 10083-1, with only one access door (specifically in the form of latched double-wing rear door with interlocking function and the possibility of attaching to the walls of the compartment in the open position) with hinge pins protected against removing and equipped with an additional lock, of class A at least in accordance with PN-EN 1300,*
   6) *wall, floor and ceiling lining and cladding as well as equipment and fittings inside the cargo compartment must have flammability grade of B = 0, in accordance with PN-ISO 3795 (or an equivalent document),*

7) *cargo compartment must be equipped with lighting,*
8) *access doors with central lock as well as ajar and unlocked door signaling systems. Door locking and unlocking from outside the vehicle with the use of a radio remote control or an equivalent device, opening only one door and simultaneously closing all the remaining vehicle doors. The ability to lock and unlock particular doors from the level of vehicle dashboard. At least 3 door in the passenger compartment or the driver's compartment and the passenger compartment equipped in exits in the form of doors, windows or hatches, allowing, if necessary, to leave the vehicle (in the number specified under relevant regulations on the technical conditions for vehicles and the scope of their obligatory equipment),*
9) *must be equipped with an immobilizer, compliant with the requirements of Council Directive 74/61/EEC of 17 December 1973 on the approximation of the laws of the Member States relating to devices to prevent the unauthorized use of motor vehicles (O.J. EU Polish Special Edition, Chapter 13, Volume 2, p. 49), hereinafter referred to as "Directive 74/61/EEC," or Regulation No. 116 of the United Nations Economic Commission for Europe - Uniform Technical Requirements Relating to the Protection of Motor Vehicles against Unauthorized Use, hereinafter referred to as "UNECE Regulation No. 116",*
10) *must be equipped with an externally monitored satellite tracking system and an intrusion detection system.*

2. *The engine compartment should be equipped with an automatic fire extinguishing system and the fuel tank should be provided with an explosion protection system.*
3. *Type A armored vehicle should be equipped with a modular car alarm system compliant to the requirements set out in Directive 74/61/ EC, or UNECE Regulation No. 116, that has the following minimum features:*
   1) *panic function activated and deactivated with a single switch on a radio operated remote controller and one additional switch inside the passenger compartment,*
   2) *backup power supply,*
   3) *backup siren alarm,*
   4) *interior security sensors,*
   5) *engine operation interlock,*
   6) *service mode,*
   7) *signaling the alarm with all indicator lamps.*
4. *Type A armored vehicle should be equipped with an alarm transmission system transmitting the following minimum information:*
   1) *vehicle position and speed,*
   2) *cargo compartment and passenger door closed and opened,*
   3) *the vehicle alarm system alarm status,*
   4) *vehicle engine activation and deactivation.*
5. *Within the scope of electromagnetic compatibility the electrical and electronic equipment fitted to the vehicle should meet the requirements as set out in Council Directive*

72/245/EEC of 20 June 1972 on the approximation of the laws of the Member States relating to the suppression of radio interference produced by spark-ignition engines for use in vehicles motor (0. J. EU Polish Special Edition, Chapter 13, Volume 1, p. 226) or UNECE Regulation No. 10 - Uniform provisions concerning the approval of vehicles with regard to electromagnetic compatibility.

6. *Additional electrical installation for the vehicle (after superstructure completion) should meet the requirements of PN-S 76021 (types and scope of testing In accordance with item 4.1.b, Table 2, column 4 of the norm).*
7. *Vehicle wheels should be manufactured with inserts or other solution that allows driving for 15 km at a speed of 50 (± 5) km/h following tire puncture.*
8. *Type A armored vehicle is not allowed to be equipped with any type of LPG fuel system.*

Technical requirements for the remaining armored vehicle types (type: B and C) for the transport of values are less stringent, specifically within the scope of required armor, however please also consider that these vehicles are intended for transport of much smaller number of value units.

Certification testing for vehicles carrying valuables are performed at PIMOT on the basis of WT/107/PIMOT/10 technical conditions, that provide further details for the requirements specified under the regulations of the Ministry of Internal Affairs and Administration.

4. New Generation Armored Vehicles Classes

Technical requirements for type A armored vehicles set out in the Regulation of the Ministry of Internal Affairs and Administration of 7 September 2010 form the basis for the certification of these vehicles and must be assumed as minimum requirements.

Considering the long years of experience of the authors of this article in the area of research on the discussed vehicles and the observation of the market trends for the evaluation of the so called *new generation* armored vehicles, the following increased requirements for armored vehicles have been proposed that affect the security of both the escorting personnel and the transported cargo. New generation should be understood as referring to armored vehicles compliant to the requirements of the Regulation.

Five *new generation type A armored vehicle anti-theft protection grades* have been proposed. Depending on the **anti-theft protection grade**, protecting the vehicles against robbery or attack, they have been classified into:

- class A1 – standard,
- Class A2 – standard plus,
- Class A3 – professional,
- Class A4 – professional plus,
- Class A5 – extra.

Armored vehicles of new generation should have higher armor resistance than the armor of the current type A armored vehicles, against:

a - shelling with 7.62 x 39 cal. armor-piercing incendiary bullets from a distance of 30 m,

b - grenade explosion,

c - anti-personnel mine explosion,

d - improvised explosive device explosion.

Departure capability should be the technical possibility of the armored vehicle to depart from the scene using the primary drive system or secondary drive system. Fast departure from the scene, in addition to armor is the best form of protection of persons and property.

Class A1 – armored vehicles compliant to the requirements of the current regulation of Ministry of Internal Affairs and Administration of 07 September 2010;

Class A2 – armored vehicles of a + b protection grade with armor such as in A1 and additional armor for passenger compartment;

Class A3 – armored vehicles of a + b + c protection grade with armor such as in A2 and additional armor for chassis components;

Class A4 – armored vehicles of a + b + d) protection grade with armor such as in A3 and additional engine armor;

Class A5 – armored vehicles of a + b + c + d protection grade with armor such as in A4 and additional armor for chassis and cargo compartment;

Secondary drive system may optionally be used in all armored vehicles, with the exemption that for classes: A4 and A5 additional engine armor is not required. Equipping an A3 class armored vehicle with the secondary drive system may increase its class up to A4.

5. Evaluation indices for new generation armored vehicles

The offers of armored vehicle manufacturers, as well as descriptions of the vehicles in the references – do not constitute a basis for an effective comparison. Evaluation indices for heavy goods vehicles are widely known and thus may be applied to assess the quality of armored vehicles. Based on the analysis of these indices and the remaining characteristics that apply to armored vehicles exclusively the authors have proposed to adopt the following indices for the assessment of type A armored vehicles:

1) vehicle armor (protection class),
2) vehicle energy efficiency,
3) cargo capacity utilization index,
4) vehicle power,
5) journey comfort index,
6) passive safety index,
7) vehicle motion index,
8) general (integrated) armored vehicle evaluation index.

5.1. Vehicle Armor (protection class) (W_o)

To evaluate the armored vehicles armor properties it is proposed to adopt the anti-theft protection classes presented in the previous item. Scored from 1 to 6, each class shall be evaluated with the use of the following scoring.

Class	Points
A1	3.0
A2	3.8
A3	4.5
A4	5.2
A5	6.0

5.2. Vehicle Energy Efficiency

Vehicle energy efficiency is generally calculated as the ratio of consumed fuel to vehicle weight.

After taking into account the fuel consumption levels and: curb weight, payload and fuel, the index can be calculated from the following formula:

$$W_e = R_p \cdot \frac{Z_e \cdot m_z}{m_w + m_u} \tag{1}$$

where:

R_p – constant containing the vehicle and engine type (introducing the constant facilitates acquiring a wide span W_e for small, medium and large vehicles with different engines)

m_z – the weight of tank with fuel [kg]

m_w – vehicle curb weight [kg]

– payload [kg] (the weight of persons and equipment + weight of transported valuables)

Z_e – fuel consumption ratio:

$$Z_e = \frac{Q_p \cdot q}{Q_s} \tag{2}$$

where:

Q_p – vehicle fuel consumption [l/100 km]

Q_s – average fuel consumption for van vehicle family and similar GVW [l / 100 km]

q – multiplication factor containing additional fuel consumption (increased fuel consumption taking into account the specificity of armored vehicle operation, including maneuvering and engine operation without interruptions during loading and unloading valuables)

wherein – W_e and R_p values are dimensionless quantities.

Wherein:

Vehicle energy efficiency class is determined by the calculation of W_e, according to the table below.

Energy Efficiency Class W_e	Numerical values W_e	Points	Comments
A	≤5	6.0	highest
B	〉5 to ≤ 10	5.5	
C	〉10 to ≤ 15	5.0	
D	〉15 to ≤ 20	4.5	
E	〉20 to ≤ 25	4.0	
F	〉25 to ≤ 30	3.5	
G	〉30 to ≤ 35	3.0	lowest

5.3. Cargo Capacity Utilization Index (W_l)

This index determines the utilization of cargo space, as the ratio of cargo space intended for the transportation of valuables to the total space of the vehicle in [m^3]:

$$W_l = \frac{W_w}{W_p} \tag{3}$$

Wherein, in order to simplify the calculations, it is assumed that the total vehicle space forms a cube of the following sides: vehicle wheelbase, vehicle height (-0.3 m), while width (without mirrors), adopted ground clearance - 0.3 m.

For W_l scoring it is:

W_l	Points
〈 0.1	3.0
0.1 ÷ 0.4	3.8
0.4 ÷ 1	4.5
1 ÷ 2	5.2
〉2	6.0

5.4. Vehicle Power Index (W_m)

The vehicle power index is defined as the ratio of main engine power expressed in kW to permissible gross vehicle weight (GVW), expressed in tons:

$$W_m = \frac{P_s}{m_{GVW}} \tag{4}$$

For W_m scoring it is:

W_m	Points
⟨ 12	3.0
12 ÷ 18	3.8
18 ÷ 25	4.5
25 ÷ 35	5.2
⟩ 35	6.0

5.5. Journey Comfort Index (W_k)

Journey comfort index takes into account the comfort of seats and air conditioning equipment. The lowest scoring is assumed for simple seats without tilt or height adjustment, front and back adjustment – the highest is for seats of full adjustment capability. The number of seats with and without adjustment is taken into consideration.

The lowest sub point scoring is assumed for vehicles with manually regulated air conditioning whilst the highest for vehicles with automatic multi-zone air conditioning.

$$W_k = W_f + W_{kl} \tag{5}$$

For W_k scoring it is:

W_k (sub point)	Points
2 ÷ 4	3.0
4 ÷ 6	3.8
6 ÷ 8	4.5
8 ÷ 10	5.2
10 ÷ 12	6.0

5.6. Passive Safety Index (W_b)

Passive safety index takes into account the number and quality of systems affecting the passive safety of the vehicle. To determine the index, the following equipment is taken into account: air bags, safety belts and safety belt tensioners, head restraints (standard and active).

For W_b scoring it is:

W_b	Points
2AB	3.0
2AB + act. head restraint	3.4
4AB	3.8
4AB + act. head restraint	4.2
6AB	4.5
6AB + act. head restraint	5.2
as above + additional devices	6.0

5.7. Vehicle Motion Index (W_r)

The Vehicle Motion Index takes into account the speed and acceleration properties of the motor. The second parameter is particularly important in armored vehicles with regard to the possibility of fast departure from the attack scene.

For W_r scoring it is:

$$W_r = 0.8\ W_v + 1.2\ W_a \tag{6}$$

It is proposed to assume the W_v scoring based on the top speed, where v = 200 km/h results in 6 sub points, reduced to 1 sub point at 100 km/h or less. W_a scoring assumes 6 sub points for acceleration time from 0 to 50 km/h equal to five seconds, where the increase by each subsequent second results in subtracting 0.5 sub point from the scoring.

For W_r scoring it is:

W_r (sub point)	Points
2 ÷ 4	3.0
4 ÷ 6	3.8
6 ÷ 8	4.5
8 ÷ 10	5.2
10 ÷ 12	6.0

5.8. Overall Assessment Index for Armored Vehicles (W_z)

The overall (integrated) evaluation index for armored vehicles takes into account all of the above indices, with the weights of individual components k1 ..... k7 of 1.0 ..... values 2.5. This index is defined as the weighted average. Percentage weights may assume any value within the above range. When undertaking exact assessment, the value of percentage weights is determined by a team of experts or based on relevant technical conditions.

The weighted average derived from the overall dependency:

$$W_z = \frac{\sum_{x=1}^{n} W_x \cdot k_x}{\sum_{x=1}^{n} k_x} \tag{7}$$

determines the overall evaluation index for armored vehicles

$$W_z = \frac{W_o \cdot k_o + W_e \cdot k_e + W_l \cdot k_l + W_m \cdot k_m + W_k \cdot k_k + W_b \cdot k_b + W_r \cdot k_r}{k_o + k_e + k_l + k_m + k_k + k_b + k_r} \tag{8}$$

6. Example Design of a Type A Armored Vehicle

The vehicle prototype vehicle was funded as a part of a research project funded by the Ministry of Science and Higher Education and developed and constructed by the PIMOT, WAT, ITS and AMZ Kutno consortium.

6.1. Vehicle Design

The armored vehicle design was prepared as a prototype based on the concept set out in [3]. The design was based on the mass produced vehicle — Mercedes Benz 906KA Sprinter 513 CDI. General interior design for the vehicle is presented in Figure 2.

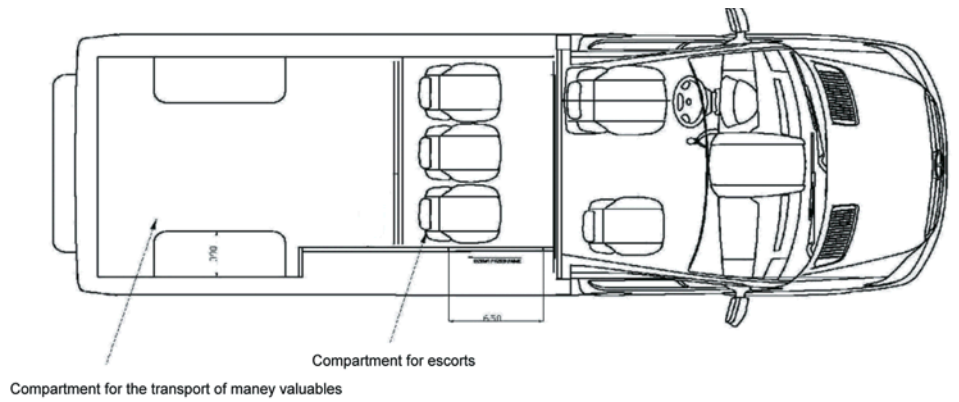

Fig. 2. General Interior Design

In addition to standard steel armor components, laminate aramid plate LIM [10] was used for the construction of the vehicle armor.

The materials for the protective layer their distribution in the vehicle is shown in Tables 1 and 2.

Table 1.

CLASS/MATERIAL	FB 4	FB 5	COMMENTS
Steel armor plate	32 kg/m^2	48 kg/m^2	FB 4 – 4 mm FB 5 – 6 mm
Light protective layer/ aramid laminate LIM/	10 kg/m^2	25 kg/m^2	

Table 2.

ELEMENT	SURFACE	STEEL	LAMINATE
Floor and ceiling	8.0 m^2	256 kg	80 kg
Vehicle sides	5.1 m^2	245 kg	127 kg + 50 kg with the use of load bearing elements
Doors	1.7 m^2	82 kg	43 kg

Also the weight of security glazing was reduced by approximately 15 % with the use of the state-of-the-art technologies.

Fig. 3. General View of the Type A Armored Vehicle Prototype

Fig. 4. Type A Armored Vehicle Prototype (With Side Door Open)

Figures 3, 4 and 5 present the photographs of the armored vehicle manufactured under the scope of development project, based on the above mentioned mass-produced van of gross vehicle weight equal to 5 tons.

Fig. 5. View of the Cargo Compartment of the Type A Armored Vehicle

Essential design parameters of the vehicle are shown in Table 3:

Table 3.

Maximum gross vehicle weight:	5000 kg
Engine manufacturer:	Daimler AG
Engine Code:	651955
Engine Type:	Compression ignition engine with direct injection and turbocharging
Maximum Engine Power:	95 kW (129 HP)
The number and arrangement of cylinders	4R
Displacement:	2143 cm^3
Transmission (type):	TSG 360-6
Tires and Wheels:	axle 1: 205/75 R 16C, axle 2: 205/75 R 16C
Number of axles:	2
Number of wheels:	6
Traction axles:	1, rear
Wheelbase:	3665 mm
Axles track:	1708 mm / 1521 mm
Length:	5910 mm
Width:	1993 mm
Height:	2510 mm
Maximum speed:	90 km/h

6.2. Secondary Drive System

The prototype in question makes use of an electric auxiliary drive system, referred to as the Secondary Drive System, developed at PIMOT, that allows fast emergency departure of the vehicle.

The secondary drive system allows fast departure of the vehicle from the scene, e.g. after an improvised explosive device or grenade explosion when the combustion engine powered drive train system is damaged. The possibility of fast departure from the scene of the attack on the armored vehicle is one of the features presented under the new vehicle design recommendations, differentiating the current solution from the previous solutions. A range of 15 km was assumed – in accordance with the regulation of the Ministry of Internal Affairs and Administration, as in the case of damage to the wheel resulting from bullet penetration.

It is very likely that in the event of an attack, both events (damage to the drive train system a wheel penetrated with a bullet) will occur simultaneously. For construction reasons, the Secondary Drive System weight and dimensions cannot be significant as this could affect the functionality of the armored vehicle. With the assumed vehicle speed (50 to 60 km/h) a reduction of the Secondary Drive System power was achieved in comparison to the Main

Drive System. Based on the calculations, a Secondary Drive System of 4 x 14 power with the use of 4 DC engines and a belt drive was developed. The schematics of the Secondary Drive System is presented in Fig. 6.

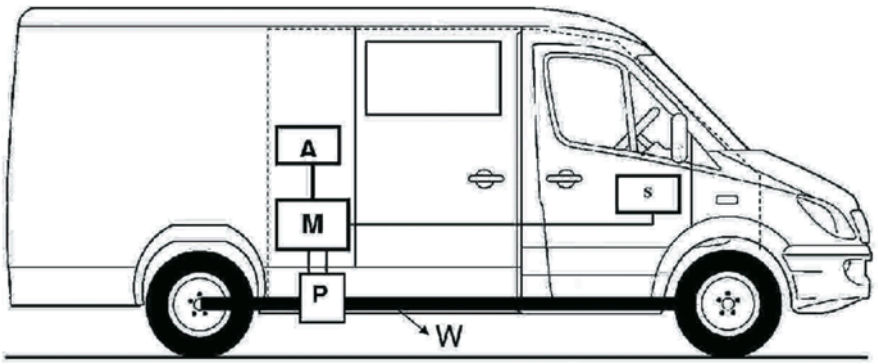

Fig. 6. Schematics of the Secondary Drive System (description provided in the text)

Such setting in the vehicle in question is preferred for structural reasons, and particularly because of the favorable weight distribution of the vehicle units.

Placing a secondary drive system inside an armored vehicle requires a new regulation of the Ministry of Internal Affairs and Administration (passenger compartment), although it slightly limits the functionality of the compartment, but has a significant positive impact on the levels of protection against explosions and external damage. When using this type of secondary drive system arrangement it is possible to significantly reduce the degree of vehicle engine protection, which also has a beneficial effect on the load placed on the front axle of the vehicle, especially if the structure used for the armored vehicle is a conventional utility vehicle.

Three secondary drive system construction alternatives have been considered to be utilized in the vehicle:
1) electric,
2) combustion,
3) pneumatic.

After analyzing the three alternatives the elective drive solution was adopted.

The drive system consists of the following equipment and systems: electric motor M power controller S, battery A and gear P connected to the drive shaft W.

Any failure of the internal combustion engine of the vehicle will result in closing the circuit of battery A with electric motor M via the power controller S.

After the activation of the circuits the driver controls the speed of motor M and the vehicle

with the use of a speed referencing-unit. The vehicle can travel forward as well as backward. The change of direction of motor M rotation M, and hence the vehicle travel is also facilitated with the use of P system.

The vehicle is able to travel until the battery power is depleted. The power reserve should allow to travel 15 km at nominal power of engine M.

7. Armored Vehicle Assessment Testing

The results of testing and assessment are for the type A armored vehicle described in Item 6.

The type and scope of testing for the sample type A armored vehicle according to [15] is described in Table 4.

Table 4.

#	Requirements	Scope of Testing for Particular Classes					Requirement No. according to WT-T	Test Description according to WT-T
		A1	A2	A3	A4	A5		
1.	Body	RW	+	+	+	+	4.3.1	RW
2.	Vehicle Armor	RW	+	+	+	+	4.3.2	P
3.	Engine and Power Supply System	RW	-	+	+	+	4.3.3	P
4.	Cooling System	-	-	+	+	+	4.3.4	P
5.	Drivetrain System	-	-	+	+	+	4.3.5	4.4.1
6.	Steering System	-	-	-	+	+	4.3.6	4.4.2
7.	Braking System	-	-	-	+	+	4.3.7	4.4.3
8.	Suspension	-	-	-	+	+	4.3.8	4.4.4
9.	Road Wheels	RW	+	+	+	+	4.3.9	4.4.5
10.	External Lighting and Signaling	RW	+	+	+	+	4.3.10	4.4.6
11.	Electrical & Electronic Equipment	RW	+	+	+	+	4.3.11	4.4.7
12.	Passive safety	-	+	+	+	+	4.3.12	4.4.8
13.	Additional Equipment	D	D	D	D	D	4.3.13	P
14.	Traction Testing	-	+	+	+	+	4.3.14	P

RW – Regulation of the Ministry of Internal Affairs and Administration of 7 September 2010 and WT/107 / PIMOT/10

P – Testing in accordance with testing procedures of an accredited laboratory

D – Optional Equipment

7.1. Evaluation of Test Results

The result of conformity should be considered positive if the vehicles have passed all tests in accordance with their class as set out in the Technical-Tactical Conditions (WT-T) and testing scope specified in Item 4.4 [15]. The above WT-T have been developed on the basis of the current requirements set out in the Regulation of the Ministry of Internal Affairs and Administration of 2010 and the results of research and development project. [13]

7.1.1. Armored Vehicle Class

Based on the criteria defining the armored vehicle class set out in section 4, the sample armored vehicle was classified as A3 - PROFESSIONAL.

7.1.2. Assessment Index for Armored Vehicles (Integrated)

Based on the dependencies described in Item 5 an overall index for the quality of the sample armored vehicle was calculated for the subindices based on the equation (8).

The following values of subindices from 1 to 6 were adopted for the calculation:

W_o – vehicle armor – class A3

4.5 pts.

W_e – vehicle energy efficiency index based on formulas (1) and (2)

$$W_e = 5000 \cdot \frac{1.26 \cdot 100}{4500 + 500} = 12{,}6$$

where:

$$Z_e = \frac{10.1 \cdot 1.2}{9.6} = 1.26$$

5.0 pts.

W_l – cargo capacity utilization index based on formula (3)

$$W_l = \frac{6{,}7}{3.7 \cdot (2.5 – 0.3) \cdot 2} = 0.41$$

4.5 pts.

W_m – vehicle power index based on formula

$$W_m = \frac{95}{5} = 19$$

4.5 pts.

DMC = 5t due to the use of a van vehicle type which has the above specification in the approval documents.

W_k – journey comfort index (5)

$$W_k = 2 + 2 = 4$$

3.8 pts.

W_b – passive safety index

$$W_b = 4AB$$

3.8 pts.

W_r – Vehicle Motion Index calculated based on the formula (6)

$$W_r = 0.8 \cdot W_v + 1.2 \cdot W_a \text{ and vehicle specifications}$$

$$W_r = 0.8 \cdot 1 + 1.2 \cdot 2 = 3.2$$

3 pts.

The assumed weighted values from 1.0 to 2.5 are:

$$k_o = 2.5; \quad k_e = 2; \quad k_l = 1.5; \quad k_m = 2.0; \quad k_k = 1.6; \quad k_b = 2.0; \quad k_r = 1.5$$

The above scores are and weighted values are put in the formula (8):

$$W_z = \frac{4.5 \cdot 2.5 + 5.0 \cdot 2 + 4.5 \cdot 1.5 + 4.5 \cdot 2.0 + 3.8 \cdot 1.6 + 3.8 \cdot 2.0 + 3.0 \cdot 1.5}{2.5 + 2.0 + 1.5 + 2.0 + 1.5 + 2.0 + 1.5} = 19$$

The sample armored vehicle has obtained the overall evaluation index of:

$$W_z = \frac{55.1}{13} = 4.25$$

8. Conclusion

The article discusses the selected key issues related to the requirements and assessment of new generation type A armored vehicles.

In accordance with the Minister of Internal Affairs Regulation of 7 September 2010 currently applicable in Poland three types of armored vehicles are distinguished: A, B and C, where type A is characterized by the most stringent set of requirements. The article discusses the regulatory and technical requirements and presents the drafted assessment criteria proposal for new generation armored vehicles (type A). Compliance with regulatory requirements is certified by accredited testing bodies on the basis of testing which gives the possibility to establish the minimum requirements. A full qualitative assessment of new generation armored vehicles should produce assessment results in accordance with the proposed criteria.

A proposal has been put forward to classify new generation armored vehicles into 5 groups. A1 - standard, A2 - standard plus, A3 - professional, A4 - professional plus and A5 - extra.

Also a proposal has been made to prepare the so-called "armored vehicle evaluation index" calculated as a weighted average of the seven subindices. Based on the sample of the armored vehicle constructed as a prototype by the consortium of PIMOT, WAT, ITS and AMZ Kutno under a research and development project of the Ministry of Science and Higher Education an assessment of the class was carried out and the overall armored vehicles evaluation index was calculated.

The assessment methods for type A armored vehicles described in the article may be very useful in the development and comparative studies of new vehicles and for product offers presented to customers on the market. The prepared protection classes and evaluation indices for type A armored vehicles should be useful for technical developers and users.

Companies with the most involved in the use of vehicles for the transport of valuables include: security companies, banks (including cooperative banks), vehicle manufacturers, transport companies and the postal service. These entities should also be interested in research and assessment of armored described in the article.

The most important effect of the emergence of the new generation of armored vehicles is a significant increase in safety transport of valuables.

The full text of the article is available in Polish online on the website http://archiwummotoryzacji.pl.

Tekst artykułu w polskiej wersji językowej dostępny jest na stronie http://archiwummotoryzacji.pl.

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