

TESTING OF „MAMUT” THE EVACUATION & TECHNICAL RECOVERY WHEELED VEHICLE

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Abstract

This paper provides characteristics of the evacuation and technical rescue heavy vehicles. Heavy tactical evacuation and technical rescue vehicles are built on the chassis of tactical vehicles with high loading capacity, generally with 8x8 driving system. In each analysed case, the vehicles are one of the family members of the tactical heavy-duty vehicles. Evacuation equipment of such vehicles is as follows: main winch, arm or towing device, and lifting equipment. A domestically manufactured vehicle, developed under the project No. 356/BO/I, was presented. The testing process that such type of vehicles, including the above mentioned, are subject to have been discussed herein. Revision of parameters received and as specified in the requirements and relevant standards enforces an adequate scope of testing. In the case of the MAMUT vehicle, the following requirements have been checked: structural design, engine, driving system, cab, main winch, auxiliary winch, winch for self-recovery, hydraulic crane, hydraulic hoisting and towing equipment, power generator, electrical system, safety, ergonomics and technical aesthetics, specialist equipment, secret camouflage, and transportability.

Keywords: *evacuation, technical rescue, recovery vehicle, driving system*

1. Special character of evacuation and technical rescue vehicles

Armoured evacuation and technical rescue vehicles – are tracked or wheeled vehicles built on the basis of tanks or armoured combat vehicles (ACV) intended to carry out recovery missions, such as: using a winch to pull out tanks or ACV that got bogged down in mud, sand or some other soft ground; to tow away a damaged vehicle to a place from which it can be evacuated to its repair point; to perform simple repairs of the above types of vehicles under the conditions of combat operations.

The main tasks of armoured heavy evacuation and technical rescue vehicles include:

- to evacuate vehicles that are incapable to move independently as a result of enemy operations, mechanical damage, or bogging down in the field;
- to tow damaged vehicles to a place where they can be repaired or loaded on a transportation flatbed and moved to the place where their repair will be possible;
- to replace basic subcomponents of the damaged vehicles, such as: engine or turret;
- to make repair works by using set of tools carried;
- to carry out spare parts;
- to perform welding works;
- to pump fuel out from the damaged vehicles and pump it into operable vehicles;
- to execute earthworks using the blade, such as: grading of ground, trenches, back-filling of shell-pits, or removal of rubble (ruins);
- to remove obstacles (fallen branches of trees, wrecks, etc.);
- to evacuate and first aid to the injured.

Over the past few years, many armies have implemented their programs to acquire new equipment, which aimed to add new tactical vehicles with high load capacity, capable of carrying a load of 15 tons or more, to their already existing fleet of transport vehicles. Those four-or-five-axle vehicles, with total weight between 30 and 40 tons and providing good mobility both on paved roads and off-road, are used in particular for transporting large and heavy cargo (palletized, containerized, and bulk). The vehicles are also used as mobile platforms for missile launchers, heavy electronic equipment, etc., as well as engineering equipment transporters (transporter of expandable bridges, transportable systems of expandable roads, etc.). An important operational role that is meant for the vehicles resulted in a need to introduce a vehicle that would secure operational performance of those vehicles. This gap has been filled in by heavy tactical evacuation and technical rescue vehicles.

According to numerous operational considerations, tactical recovery vehicles should be among the first varieties of vehicles from new families of tactical vehicles being introduced as equipment of troops. According to the definition and the development of that variety, the tactical evacuation and technical rescue vehicle that is built on the basis of the family of tactical high-load-capacity vehicles should:

- have at least the same level of mobility (both on a paved road and off-road) as the vehicle whose operation it is to secure;
- be able to pull the damaged vehicle out to the place where from it can be evacuated to the repair point;
- be capable to independently pull out a vehicle that was stuck in the mud, sand, or some other soft ground, without causing its damage;
- be equipped with a set of tools that allows for performing simple repairs.

In addition to the above-mentioned features, the equipment applied to that vehicle should ensure that activities related to the coupling of vehicles on pulling out and towing were as simple and as quick as possible in order to mitigate the risk of exposure of the crew to enemy fire.

If the tactical evacuation and technical rescue vehicle is equipped with the rotative jib crane, it can additionally be used for handling containers, pallets, vehicle bodies, armament modules and systems both in the field and in storages (lifting of engines or turrets, etc.). Modern heavy tactical evacuation and technical rescue vehicle must be an optimal combination of proper chassis and proper evacuation equipment.

2. Key solutions for heavy evacuation and technical rescue vehicles

The following heavy tactical evacuation and technical rescue vehicles are used in major NATO countries:

- French Renault TRM 10000 CLD (Fig.1);
- German FAUN BKF 30.40 (Fig.2);
- British Foden (Fig.3);
- U.S. M984A1 (Fig.4).



Fig. 1. Renault TRM 10000CLD



Fig. 2. FAUN BKF 30.40



Fig. 3. Foden



Fig. 4. M984A1

Heavy tactical evacuation and technical rescue vehicles are built on the chassis of tactical vehicles with high loading capacity, generally with 8x8 driving system. In each analysed case, the vehicles are one of the family members of the tactical heavy-duty vehicles. Evacuation equipment of such vehicles is as follows: main winch, arm or towing device, and lifting equipment. Additionally, some support devices are used, such as auxiliary winch, anchoring device and stabilizers. Main winches that are used in heavy tactical evacuation and technical rescue vehicles have their towed mass ranging from 180 up to 270 kN and a length of rope over 100 m. Only in M984A1, the M984A1 vehicle, the length of the rope is 56 m. For towing a vehicle damaged in half-suspension, two types of devices are used in modern heavy tactical evacuation and technical rescue vehicles. One of them is a towing arm (Faun, Foden and M984A1 vehicles) equipped in a crossbar that is attached to the tow hitches of the damaged vehicle. Lifting of the damaged vehicle front or rear is made either by the main winch rope (Faun and Foden vehicles) or by hydraulic servomotors (M984A1 vehicle). The solution provides elevation from 113 to 130 kN. The second type of a towing device is a rigid tow-rod of „A” type that when connected to the damaged vehicle is lifted by a hoist mounted on the vehicle (TRM10000 CLD vehicle). This solution provides elevation of 75 kN.

There are two types of lifting devices that are used for reloading works in heavy tactical evacuation and technical rescue vehicles: cranes and folding lifts. The cranes that are used have a lifting capacity of 150 -153 kN. The folding lifts have a lifting capacity ranging from 65 to 125 kN. In order to make it easier for the crew to unroll the rope from the main winch, auxiliary winches are used in those vehicles with pulling capacity from 3 to 10 kN and their rope length between 200 - 240 m.

As each vehicle is able to maximize traction of its main winch by using blocks, the anchorage devices are used to secure the vehicle from any moves. For anchoring the recovery vehicle, the following types of devices are used: independent anchors pulled out hydraulically or manually (Foden, M984A1); blade attached in the rear of the vehicle (Faun); removable anchors attached to stabilizers (TRM10000).

There is a general rule and a standard that heavy tactical evacuation and technical rescue vehicles are equipped in winches for self-recovery with a pulling capacity from 80 up to 100 kN.

Additional equipment of such vehicles is as follows:

- sets of tow adapters for different types of vehicles;
- kits for welding works;
- toolkits to carry out simple repairs.

Modern heavy tactical evacuation and technical rescue vehicles may tow vehicles as heavy as 30 and up to 40 tons of weight.

3. Polish vehicle „MAMUT”

A prototype of the heavy evacuation and technical rescue vehicle "MAMUT" has been developed under the project. Its parameters are summarized in Table 1, and in addition, Table 2 summarizes the parameters of a hydraulic crane that is integral equipment to this vehicle. The vehicle is presented in Fig. 5.



Fig. 5. Wheeled Evacuation and Technical Rescue Vehicle

Tab. 1. Basis Technical Parameters

Parameter	MAMUT
Origin:	Poland
Cab Armour	Level 2
Base Vehicle	Tatra 7Z0R9T-37A
Running gear	8x8
Cab	4
Total weight	35 tons
Length	Without blade
Width	2.55 m
Height	To the cab
Clearance	0.39 m
Wheelbase	1 950 + 3 660 + 1 450 mm
Entry/descent angle	45°/without blade
Maximum velocity	90 km/h
Fording	1.20 m without preparation
Engine power	440 kW / 12,5 kW/t
Tire size	16.00 R20
Crane	12 000 kg per 3.5 m = 43.9 Tm
Main winch	2x 28 tons 100 m

Tab. 2. Hydraulic Crane Parameters

	Parameter Name:	HIAB 477 EP-2 Hi Pro
1.	Maximum moment of load capacity force [Tm] :	43.9
2.	Maximum radius [m]:	8.4
3.	Number of expansion components:	2
4.	Maximum load capacity at maximum radius [kG]:	5 200
5.	Maximum load capacity at minimum radius [kG]:	12 000 [3.5m]
6.	Extension turn angle [°]:	400
7.	Height [mm]:	2404
8.	Curb weight [kg]:	4440

The towing extension system, the so-called "Lift" – the device for lifting and fixing towed vehicles is mounted at the rear part of the frame. "Lift" is composed of two fixed vertical columns of rectangular cross-section, permanently mounted to the auxiliary frame. Inside the fixed poles, there are movable poles, which, by fastening the top of the crossbeams, are lifted by a pair of hydraulic servomotors. At the top part, the poles are permanently locked together using a special bracket with mounted support rollers to hold the ropes of the main capstan winches. The "tow extension" is mounted on special supports to the movable poles. Inside the movable poles, there are servomotors mounted for the tow extension folding to its transportation position (by 90° upwards); all swivel joints equipped with greasing points. Hydraulic hoisting and towing device provides safe towing of vehicles with their total weight above 26 tons on a dirt road surface at a speed of 15 km/h and on a paved road at velocity of 35 km/h.

The structure design of the tow extension does not exclude a tow hitch mounted at the manufacturers as is the case in other designs.

Unique Features of MAMUT Vehicle:

1. DEUTZ TCD 2015 V08 engine originating from the line of military engines with power of 440 kW (585 BHP), not requiring the use of any additional substances (Ad blue).
2. Spatial (closed) frame of the vehicle instead of a standard one based on channel irons, greater rigidity and strength of the vehicle against overload resulting from off-road towing.
3. Independent suspension of all axles.
4. Single tires (16.00 R20) with Run Flat type of inserts on all axles (analogical structures are forced to use twin tires on the rear axle), which limits the off-road abilities.
5. The possibility of holding the blade in front of the vehicle for reopening of crossings, temporary back-filling of holes in the road (other vehicles have no such possibility, in particular when maintaining the angle of attack of min. 21°) with the steering system from the driver's seat.
6. The possibility of using the main capstan winches to work at the back and one in the front of one vehicle (similar structures can only use the capstan winches backwards).
7. Angle of attack without a mounted blade of 45° (in MB Actros 4151 AK) is only 28°.
8. The vehicle is equipped with two capstan winches of SEPSON H350PX type with integrated stacker and additionally with the rope pusher, (those are the only capstan winches with a stacker that prevents rope tangling on the drum).
9. Capstan winches are equipped with 100 m of rope of a smaller diameter (Ø 22 mm instead of 28 or 26 mm) which makes it more flexible and of less weight – thus it is easier to handle when the competitors use only the ropes with Ø 26 and of the same strength parameters as applied in KWZT.
10. The vehicle is equipped with two fuel tanks (2x320L) armoured to Level 2 according to STANAG 4569 (similar structures do not have this type of solution).
11. Application of the biggest transportable crane in this type of armoured vehicles categories [43.9 Tm] without losing its ability to be transported by rail (upon earlier preparation).
12. The 4-person cab armoured to Level 2 according to STANAG 4569 and as the only one in this type of vehicles has been tested by Polish Research Unit (Military Institute of Armour and Automotive Technology).
13. The vehicle has a roof over the capstan winches and designed for transporting special equipment, safe movement inside the vehicle.
14. Capable of fording, without preparation of 1.2 m (Other vehicles need some preparation).
15. Specific solution design of the vehicle structure, which resulted in a relatively small height of the vehicle, and thus the low positioned centre of gravity – such configuration ensures high stability of the vehicle especially while operating main capstan winches.
16. This is the only vehicle that uses a tow-rod for towing via original tow seat of the vehicle (vehicle towing capacity of DMC > 26 tons) without a need for using any adapters or other solutions.

17. The ability to run on a common battlefield fuel F-34.
18. Thanks to some devices, mounted on the vehicle (front blade, rear spade lugs), there is a possibility to self-lift the entire vehicle, e.g. to replace the wheel or perform a small repair.

Other Characteristic Features:

1. Central Tire Inflation System (CTIS) for all wheels and controlled from the cab.
2. The vehicle is equipped with independent heating and air-conditioning system.
3. Automatic Drives Management (ADM) system.
4. The cabin is equipped with a filtering and venting system in view of ABC weapon danger.
5. The cab is equipped with a roof hatch fit for mounting of armament.
6. Road range over 650 km.
7. It has evacuation auxiliary equipment: double-block with anchorage handle, thimbles, shackles, adapted to evacuate all types of vehicles of the Armed Forces and also NATO military vehicles, in compliance with STANAG 4019.
8. It enables one operator to control both capstan winches simultaneously.
9. The vehicle provides manual control over the towing device, capstan winches, and the crane itself from one desktop of the operator's seat as well as a standard radio-remote control from a distance of min. 50 m from the vehicle contour.
10. The military chassis while other structures are based on modified civilian vehicles.
11. In the rear part of the middle frame, there are shields of support spade lugs, hydraulically extended; the spade lugs are ending with tooth blades, allowing for punching into the ground and effectively immobilizing the vehicle; when using the spade lugs as support on the asphalt their blades are shielded with covers to prevent surface against damage.

4. Vehicle testing

Revision of parameters received and as specified in the requirements and relevant standards enforces an adequate scope of testing. In the case of the MAMUT vehicle, the following requirements have been checked: structural design, engine, driving system, cab, main winch, auxiliary winch, winch for self-recovery, hydraulic crane, hydraulic hoisting and towing equipment, power generator, electrical system, safety, ergonomics and technical aesthetics, specialist equipment, secret camouflage, and transportability.

Testing related to the evacuation of damaged vehicles was crucial because of the tasks performed by the vehicle. Sample tests were demonstrated in Fig. 6 and 7.



Fig. 6. View of the vehicle while performing the test to measure traction force of the winch for self-evacuation



Fig. 7. View of the hydraulic hoisting and towing device in the vehicle while performing the load position stability test (protection against self-lowering when loaded with a damaged AMV Rosomak vehicle in its base version with a turntable)

As part of the requirements check for the ability to carry out the technical back-up support tasks of the subunits, equipped with wheeled vehicles and for the implementation of technical rescue tasks and using devices mounted to the vehicle, the following tests were performed:

- towing of a damaged AMV Rosomak vehicle in its base version with a turntable using the tow-rod Fig.8;



Fig. 8. View of the vehicle while performing a towing test of a damaged AMV Rosomak vehicle in its base version with a turntable using the tow-rod

- towing of a damaged AMV Rosomak vehicle in its base version with a turntable using the tow triangle Fig. 9;



Fig. 9. View of the vehicle while performing a towing test of a damaged AMV Rosomak vehicle in its base version with a turntable using the tow triangle

- towing of a damaged AMV Rosomak vehicle in its base version with a turntable using the lifting and towing device at the front of the damaged vehicle, Fig.10;



Fig. 10. View of the vehicle while performing a towing test of a damaged AMV Rosomak vehicle in its base version with a turntable using the lifting and towing device by the front of the damaged vehicle

- towing of a damaged AMV Rosomak vehicle in its base version with a turntable using the lifting and towing device by the rear of the damaged vehicle Fig.11;



Fig. 11. View of the vehicle while performing a towing test of a damaged AMV Rosomak vehicle in its base version with a turntable using the lifting and towing device by the rear of the damaged vehicle

- Towing of a D-46-type of damaged biaxial trailer, using a towing hook Fig.12;



Fig. 12. View of the vehicle while performing a towing test of a D-46-type of damaged biaxial trailer, using a towing hook

- towing of a damaged N-60W-type of flatbed, using the lifting and towing device by the front of the damaged vehicle Fig.13;



Fig. 13. View of the vehicle while performing a towing test of a damaged N-60W-type of flatbed, using the lifting and towing device by the front of the damaged vehicle

- pulling out a bogged down damaged AMV Rosomak vehicle in its base version with a turntable using the main winch Fig.14;



Fig. 14. View of the vehicle while performing an evacuation test of the bogged down damaged AMV Rosomak vehicle in its base version with a turntable using the main winch

Tests were performed to evacuate vehicles with defective running gear Fig.15 and to check possibilities for carrying our works to reload 1C containers Fig. 16.



Fig. 15. View of the way to join hydraulic hoisting and towing device to Star 266 vehicle by using tow-hitches for wheels slipped-on a cross bar (traverse) and the tow-hitches for (opposite) wheels before a towing test is performed



Fig. 16. View of the container sized 1C lifted by the crane from the ground

5. Summary

At present, Polish Armed Forces (WP) have only tracked evacuation equipment that allows for securing combat operations of armoured subunits and those of mechanised infantry.

There are no tactical wheeled evacuation and technical rescue vehicles on stock of Polish Armed Forces. Wheeled evacuation tractors (CKE) that occur in the tables of duty may only tow a damaged vehicle using a tow-rod. Such evacuation technique allows for evacuating 8 - 12% of the damaged vehicles only.

The heavy wheeled evacuation and technical rescue vehicle MAMUT designed and built by domestic industry from the state budget funding, gains technical parameters that place it among the top world leading vehicles of this type in terms of evacuation possibilities.

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