NATO countries require that the maintenance of land military vehicles is performed both in peacetime and in field conditions (during missions, etc.) where full preventive and corrective maintenance is provided. According to allied doctrine, maintenance and especially repairs of military equipment should be conducted as much close to a broken object as possible, so these functions can be effectively and efficiently performed by logistic units and armed forces troops equipped with mobile workshops.

The following trends might be considered when talking about the development of mobile container workshops:
- lowering the types and the number of mobile workshops,
- providing basic technical parameters for land, air and rail transport, and shipment,
- using the functional bodies of a container type for higher organizational logistic levels,
- providing the maintenance of land combat vehicles used in missions [1].

A problem of unscheduled field repairs gains special importance in conditions of military operations during which the dominant source of equipment loss is combat and operation damage.

As the history and experiences of the last armed conflicts have shown, the enemy’s use of modern agents of destruction is causing more and more military equipment losses. In case of an army system, the significant part of this damaged equipment is recovered and thanks to its repair directly included in further operations within the area of operations. This is a basic source of providing units with equipment; especially in the conditions of peaceful and stabilization missions.

Temporary repairs process is executed under the field conditions and consists of the following stages:
- range of damage assessment,
- selection and elaboration of damage repair technology,
- making a decision concerning the repair providing that the repair can be done in an appropriate time period,
- execution of the repair in the field conditions or having the damaged equipment repaired in a parent unit or in a repair plant.

To make this process fully effective and to make the executed repairs low-cost, easy to perform, and sufficiently durable, requirements described in the below chapters should be met [2].

**GENERAL DESCRIPTION OF A CONTAINER MOBILE WORKSHOP**

**Determination of a container mobile workshop**

A wheeled container workshop (a functional module) along with a special tool store is designed for the repair level 2 and 3, namely:
- the chassis of the car model range Tatra (815, 810), Land Rover Defender,
- the chassis of the wheeled armoured vehicles PANDUR II, Dingo a Iveco.

A tracked container workshop (a functional module) along with a special tool store is designed for the repair level 2 and 3, namely:
- the tracked combat vehicles BVP and T-72 M4CZ.
Crew structure and the technical skills of the crew members are selected according to the types of supported combat vehicles and can change. For this workshop we recommend a 6-member crew consisting of a crew leader - an auto mechanic – a welder, a senior auto mechanic, an auto mechanic – a welder, a senior mechanic, a senior auto electrician, and a senior electrician [1].

**Standardized workshop solution**

The container workshop is made from two pieces of ISO 1C size special containers (Figure 1). First workplace is created with the working module which is universal for the maintenance of tracked and wheeled combat vehicles. The working module is placed in one ISO 1C container and is heat insulated with sandwich panels. Second workplace is created with the functional module then might be used for the maintenance and the repair of wheeled combat vehicles as well as tracked combat vehicles depending on internal facilities which might be changed according to the kind of supported vehicles. In the ISO 1C container there is a special tools’ store which is actually a functional module equipped according to the kind of supported combat vehicles. The tools might be combined, where appropriate. In certain situations the module can be equipped with extra tools used for the maintenance and the repair of armaments, communication equipment, etc. An outdoor workplace intended for the repair of land combat vehicles is designed with a roof which might be rolled out in the space between containers, see Figure 1.

**Fig. 1.** A container workshop project arranged in an L shape [1].

**A container workshop project arranged in an L shape[1].**

The body of containers will be welded using steel sections and trapezoidal metal plates which will make a covering for the containers. The upper and bottom corner container elements of ISO 1C size will be built into basic bodies. The container panels themselves (peripheral and roof ones) will be filled with 40 mm thick insulating sandwich panels made of Elastopor SH 226/003 polyurethane foam which has been authorized to use in the Army of the Czech Republic after long-term tests. As for the covering material of insulating panels, it will be a 0.8 mm thick surface-modified aluminium plate.

A container floor will be made from isothermal floor panels with a plywood, and covered with anti-slip PVC. The floor panels will be filled with the same Elastopor SH 226/03 polyurethane foam. The floor panels will be 50 mm thick. Entry doors to the containers will be equipped with a special door lock with the possibility to be locked by locks, and rigid clips for sealing [1].

General outside dimensions of 1C container are standardised. The mass of projected workshop modules will be as follows [1], [3]:

1. A working module
   a) service weight ................................................................. 3 000 kg,
   b) effective weight ..............................................................to 16 500 kg,
   c) total weight .................................................................19 500 kg.

2. A special tools store – a functional module
   a) service weight ................................................................. 2 730 kg,
b) effective weight .................................................................................. to 22 000 kg,
c) total weight .......................................................................................... 24 730 kg.

The workshops can be used for the work [1], [3]:

a) in mild climate zones, i.e.
   - in the areas of average monthly temperatures from -15 °C to 25 °C,
   - with the lowest temperatures rarely below -32 °C, and the highest above 44 °C,
   - with extreme temperatures -40 °C and 50 °C,
b) with relative air humidity to 90 % and a temperature of 33 °C,
c) with air dustiness to 1.5 g∙m⁻³ taken 0.5 m above the ground level,
d) with the speed of air flow to 20 m∙s⁻¹,
e) with atmospheric precipitation such as rain, snow and hail,
f) at above sea level to 3 000 m (to 4 000 m for a short term).

Driving fuel supplies are big enough to provide currently:

  g) heating operation for 48 hours,
  h) power source function for 20 hours,
  i) hot-air heating operation in a workshop tent for 10 hours.

The requirements regarding the work in a workshop are as follows:

  j) the concentration of harmful substances will not exceed during 12-hour work 20 mg/m³ of carbon monoxide, 200 mg/m³ of oil fumes, 70 mg/m³ of petrol fumes, and 0.3 mg/m³ of sulphuric acid fumes,
  k) there will be provided natural light as well as artificial light in the workshop,
  l) the workshop will be equipped with lamps for main, spare, local and cover illumination according to the ČSVN 83 960,
  m) illumination level will be at least 50 Lx in the check points 1m off the ground and 0.5m off the wall. The most illuminated place to the least illuminated place ratio will be bigger than 1 to 3,
  n) the illumination of the workplace in a tent will be provided with a 230 V portable illuminating set with a screening slide.

For concealing the container workshop a fish net of 12 x 15 m is used with supporting components and needles. In order to fasten a camouflage cover, the containers are on the sides equipped with clips for supporting components holding stability against wind. It takes approximately 20 minutes to conceal the container, and 15 minutes to remove the camouflage.

**EQUIPMENT OF A WORKINGMODULE AND A FUNCTIONAL MODULE**

**Equipment of a working module designed for the maintenance of wheeled and tracked combat vehicles**

Working module was divided into two basic rooms (Figure 2):

1. Sealed (work-related) – is the main room for a functional workplace where work might be done.

**Fig. 2.** Top view of a working module designed for the maintenance land combat vehicles[1].
2. Non-sealed (technological) – is the room intended for placing basic technological equipment consisting of the filter and ventilation plant FVZ 98, the air handler K 4A, the independent hot air heating D5LC, sources and electric and light distribution

**Equipment and main parameters of a functional module designed for the maintenance of wheeled or tracked combat vehicles**

In the functional module we suggest putting a welding equipment used for welding by a welding arc, and charging accumulator batteries; a set for gas welding (1 piece of an acetylene bottle, 2 pieces of an oxygen bottle, a bottle trolley, a welder set); a tent fly; portable oil firing; drive-up ramps, crane facilities (suspension tools), a hydraulic jack for 8 t and 25 t; expendable supplies and selected spare parts.

Apart of that, there is in the functional module a hydraulic swing crane placed at the front wall of the container to the left of an entry door. It is fixed on a special traversing bridge. Drawing out and retracting the crane is provided by a linear hydraulic motor connected to a crane hydraulic circuit. Two linear hydraulic motors providing the stability of a crane in a protruded position also will be connected to the hydraulic circuit[1].

![Fig.3. Top view of a functional module designed for the maintenance land combat vehicles [1].](image)

In the functional module there is advisable to place also the set of coupling and suspension tools used for manipulating with the systems and subsystems of supplied technical equipment when dismantling and mounting vehicles. The tools are chosen from the unified set introduced within the Army of the Czech Republic.

In the mobile container workshop we suggest putting also the sets of battle damage repairs kits such as: metallurgical material, connection accessories, electrodes for electric arc welding, welding material for flame welding, soldering process, adhesives materials and materials used for repairing tire tubes and tires.

**PRINCIPLES OF TEMPORARY REPAIRS**

According to Alliance documents „temporary repair is repair, which may be temporary, to restore an equipment to a specified condition by non-conventional/improvised repair, both deployed and in-barracks, bounded by legal constraints”. Similar formulation of the problem was presented in European Standard EN 13306 where is said that temporary was defined as: „physical actions taken to..."
allow a faulty item to perform its required function for a limited time interval and until a repair is carried". In the past the temporary repairs of military combat vehicles proceeded spontaneously and depended on the circumstances to be dealt with. The repair progress was influenced by experiences, the level of combat vehicle complexity, technical facilities and individual skills. Applying a different technology, using a reproduction part, or performing a repair by a serviceman without the competence is typical features of temporary repairs.

**Theoretical principles of temporary repairs**

It is beneficial to realize that the temporary repair of combat vehicles cannot adequately substitute the repair performed in compliance with technical conditions and that is the reason why the next repair should be carried out in the shortest term. The reason for performing a regular repair is that a nonstandard procedure does not provide dependability. In spite of all drawbacks, the temporary repairs can play an important part in a combat operation.

**a) Temporary repairs in peace time**

The aim of a temporary repair in peace time is to renew or partly renew mobility and to prevent from more extensive damage, as for example environmental pollution caused by the leak of hazardous substances, safety threat by making a trouble in operation, or the devaluation of a transported material. Operating costs are not expected to be increased due to the temporary repair, therefore, when deciding whether to perform it, economical factor will be the main criterion.

**b) Temporary repairs under field conditions**

The difference between the temporary repairs of combat vehicles performed in peace time and under field conditions is that we follow not only economical factors which are the most important in peace time, but also the provision of combat vehicle main functions, e.g. a weapon system, vehicle mobility and communication. The survival time of a vehicle (a crew) in a battlefield is crucial for deciding whether to perform the temporary repair. To put it simply, the recovery process of combat vehicle fighting power might be viewed as a geometric sequence [2]:

\[ n_t = n_0 q^{t-1}. \]  

(1)

where:

- \( n_0 \) - is the number of combat vehicles before the operation began,
- \( n_t \) - is the number of combat vehicles at the beginning of the day \( t \),
- \( q \) - is a sequence quotient,
- \( t \) - the number of days.

The magnitude of the sequence quotient \( q \) can be described as the ability to repair damaged combat vehicles with the extension of loss \( z \), combat vehicle repairability \( \psi \), and when considering the capacity and technical possibility of performing the repair with repair units \( \varepsilon \).

Therefore

\[ q = 1 - z + \psi \varepsilon. \]  

(2)

Then, sustainability time is given by a decrease in the number of combat vehicles at an acceptable level \( n_s \)

\[ n_s = n_0 q^{t_s-1}. \]  

(3)

and therefore

\[ t_s = \frac{\log n_s - \log n_0}{\log q} + 1, \]  

(4)

when reaching the time \( t_s \) a unit must be replaced or supplied by another combat vehicle [2].

Performing temporary repairs helps increasing of the capacity of repair units by labour saving, overcoming downtime due to the lack of spare parts, or involving crews in the repair process. This will be manifested in the rise in coefficient value \( \varepsilon \).

Graph 1 shows the courses of the decrease in fighting power with average 15 % daily losses \( z \), the limit of 60 % fighting power and different magnitudes \( \psi \) and \( \varepsilon \).
Graph 1. Fighting power of combat vehicles with 15% daily losses [2].

The courses of single curves show that extending the capacity of repair units has a positive impact on the fighting power time of supplied units, e.g. when performing temporary repairs [2].

Temporary repairs technology

The aim of a temporary repair system is to increase the level of professional personnel and workshop specialist readiness for the recovery of combat vehicle fighting capacity and to prepare the means of logistic support to provide this repair.

The system takes into account the development and verification of technologies which can be used for performing temporary repairs including their material support. The temporary repair system should be targeted at well-arranged technological procedures focused on the temporary repairs of important nodes with labour input time evaluation, necessary tools and material [2].

We suggest that general procedures should be subdivided per systems or parts common for combat vehicles. In the text below there is a division scheme and the possibilities of performing temporary repairs [2].

**Tanks**
- smaller ruptures and leaks which might be fixed by bandaging or cementing with the use of fast-setting two-part sealants,
- disruptive breakdowns which might be repaired through a combination of bandages and packing, or packing made of different material,
- damaged tanks which might be replaced by connecting barrels, canisters or heat resistant cases capable of being closed with a specific medium.

**Condensers**
- leakage which can be stopped using substances added to a cooling liquid which solidify during the leak from a cooling system, or fast-setting sealants used in the place of the leakage or nearby,
- disruptive breakdown which can be fixed by squeezing a tube with pliers and then filling the hole with a sealant or hot lead,
- damaged condenser which can be isolated for a short time and a cooling system might be interconnected without the condenser, or the condenser may be replaced by another part, e.g. a barrel or a demountable fuel tank.
Pipe
- minor damage and the leak of a low-pressure pipe which might be repaired by bandaging or using two-part workable sealants,
- more serious damage to a low-pressure pipe (not including exhaust pipes) which can be solved by replacing a damaged part with a rubber hose fastened with a sleeve or a band,
- damage to a high-pressure pipe which can be mended by pipe’s offset and cementing the ends with anaerobic sealants, or by complete replacing the pipe using a high-pressure hose with endings.

Air and hydraulic systems
- damage to the part of a system which might be disabled by blanking of a particular part, or providing a by-pass around a damaged part using hoses with endings.

Rods and shafts
- cracked rods can be joined by a thicker bond sheet metal, the ends of which will be drilled and screwed together, or there will be used a sleeve welded at the end,
- cracked shafts will be joined by welding to a sleeve where applicable.

Windings
- minor damage can be mended by using a threaded coupling with an anaerobic sealant,
- damaged internal thread might be fixed by drilling off and using threaded insets which renew the original winding.

Electric cables
- visible local damage might be repaired using insulation with both ends twisted and insulated by an insulation tape, or the joint is welded,
- damage difficult to detect can be fixed by bridging a proper circuit using a new cable, or, in case of power supply, by connecting with a cable assembly with nominal voltage [2].

DESIGN OF A BATTLE DAMAGE REPAIR KIT OF LAND COMBAT VEHICLES IN FIELD CONDITION

Repairs of land vehicles under the field conditions are not only accomplished by using the mobileworkshops but also by using of temporary repairs. Similar formulation of the problem was presented in European Standard CSN 13306, where is said that temporary repair was defined as: „physical actions taken to allow a faulty item to perform its required function for a limited time interval and until a repair is carried”.

We proposed a battle damage repair (BDR) kit (Figure 4) for the temporary repairs implementation in the Czech Army. Dimensions of BDR kit bag are 50 x 32 x 15 cm and weight is 8.1 kg. The bag is divided in to three separate boxes, in which the material for the temporary repairs of the land vehicles is placed.

Fig. 4. Battle damage repair kit for repair land combat vehicles
First box contains adhesives and cements. There are tubes, adapters, connectors and plugs in the second box. In the third box there is material for repairs of the land vehicles electrical systems, for instance shielding, wire, crimping pliers, tin solder etc.

CONCLUSION

The paper presents the project of the container workplace designed for the maintenance of wheeled and tracked combat vehicles in field conditions. The quick and cheap replacement of functional module equipment according to the type of supplied technical vehicles is one of the advantages of this project. With replacing internal facilities, the wheeled version module might be changed into the tracked one and vice versa. Using a unified workplace module for the maintenance of both wheeled and tracked combat vehicles is another advantage of the paper. The real benefit of the project lies in achieving the unification and reducing the number of mobile workshops within the Army of the Czech Republic, because at present there are about 80 kinds of them.

Abstract

The paper describes original design of a container workshop to perform maintenance of the Czech Republic’s land combat vehicles in field conditions. The presented workshop consists of two ISO 1C size range containers with special equipment. The first container is called a “working unit” and the other one is a “special purpose unit”. During combat activities the containers would be arranged in L shape with rolled out roof. In the second part of the paper is to present original proposal kit for a temporary repair of the land combat vehicles. Battle damage repair kit was introduced into the Army of the Czech Republic this year.

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REFERENCES