JOURNAL OF SCIENCE OF THE MILITARY ACADEMY OF LAND FORCES

Volume 48 Number 1 (179) 2016

DOI: 10.5604/17318157.1201743

STORAGE OF MILITARY EQUIPMENT – THEORETICAL CONSIDERATIONS

Zbigniew CIEKOT*

* *Military Institute of Armored and Automotive Technology (WITPiS)*
e-mail: zbigniew.c1@wp.pl

Received on March 10th 2015; accepted after revision in January 2016

Abstract:

The article presents various aspects of temporary protection of military equipment that has been withdrawn from active service. It contains the analysis of the temporary protection methods used by the Polish Armed Forces, and describes their impact on the technical condition of the equipment (vehicles) stored. In addition, explanations of the basic storage-related terms used in the military are provided. The causes of corrosion and its types are considered as well. Due to the fact that temporary protection schemes play a vital role in the operation of military equipment, an attempt has been made to systematize the area. Hence, a proposal determining the structure of the temporary vehicle protection system has been put forward.

Keywords: *corrosion, temporary protection, military equipment*

INTRODUCTION

Modifications affecting the organizational structure of the Polish Armed Forces, caused by the implementation of the defense doctrine, resulted in temporary withdrawal of certain amounts of military equipment[1] (ME) from active service and in its storage. It

[1] Military equipment (ME) comprises special-purpose equipment designed or adapted specifically for military use and intended to serve as weapons, munitions or war supplies. In order to ensure the use of unified terminology, it has been decided that the term "military weapons and equipment" is equivalent to the term "military equipment" - Decision 72/MON of the Minister of National Defense dated 25 March 2013 on acquisition of military equipment and services for the Polish Armed Forces (Official Journal of the Ministry of National Defense dated 25 March 2013, item 78), pp. 4. [See:] De-

needs to be noted that storage should be perceived as a set of activities related to ensuring proper conditions in which supplies and technical equipment are kept, safeguarding their fitness for use and enabling their operation, in line with the intended purpose, within a specific time period[2]. It is assumed that temporary storage of military equipment aims primarily to reduce its cost- and labor- intensiveness. Another important factor is maintenance of the equipment's technical parameters. Hence, protection of the technical equipment against the negative impact of the elements is one of the priorities of the structures and the personnel responsible for the overall operating processes[3]. The main objective is to protect the equipment from corrosion and ageing, as well as to ensure that its operational readiness is maintained. A divide has been introduced for the purpose of the present article, assuming that the study will focus on vehicles with military registration only.

1. GENERAL TERMS

Conservation of military vehicles is by no means a new concept. It may be assumed that as soon as motorized vehicles (cars, trucks, tanks, armored vehicles) entered military service, the problem of protecting them against the negative impact of the elements and the environment in which they (dust, sand) had to be tackled as well. The 'Tank Conservation Manual' issued in 1928,[4] which provided a dozen-page description of the methods to be used in order to conserve the Renault FT-17 tank, or the 'Armored and motorized equipment maintenance manual' [5]of 1938 addressing the entire spectrum of problems related to conservation and storage of wheeled and tracked vehicles of the era may serve as good examples here. It also needs to be noted that storage-related issues were given consideration in the Polish Armed Forced in the West as well, as exemplified by the 'Vade-Mecum of the Driver Soldier, Part II'[6] – a textbook containing a chapter devoted to the storage of motor vehicles. While searching the resources of the Central Military Library (Centralna Biblioteka Wojskowa), the author of this work has failed to come across any publications of the Polish Army in the East devoted to the issue in question. First manuals providing detailed instructions to

cision No. 435/MON of the Minister of National Defense dated 24 December 2013 on determining the roles and responsibilities of custodians of and central logistic authorities exercising control over military equipment within the Ministry of National Defense (Official Journal of the Ministry of National Defense dated 27 December 2013, item 390).

2 M. Brzeziński, *Zabezpieczenie logistyczne oddziałów i pododdziałów wojsk lądowych w oddziałach taktycznych. Podręcznik*, MON, Warsaw 1996, General Staff no. 1490/98, p. 31.

3 Military weapons and equipment. General technical requirements, control and test methods. Methods for testing total resistance to elements, Defense Standard NO-06-A107:2005, MON, Warsaw 2005.

4 *Instrukcja Konserwacji Czołgów*, Szkoła Czołgów i Samochodów, Warsaw 1928, Approved for internal use in the Tank and Vehicle School by its Commander, Major Naspiński on 1 June 1928.

5 *Instrukcja o utrzymaniu sprzętu pancernego i samochodowego*, MS Wojsk, Dowództwo Broni Pancernej, Warsaw 1938.

6 *Vade-Mecum Żołnierza-Kierowcy Część II*, Wydawnictwo 1. Brygady Strzelców 1941, Reprint (3rd edition) by Sekcja Wydawnicza Dowództwa Bazy i Etapów Armii Polskiej na Wschodzie, Palestine, September 1943.

be followed while protecting military equipment against corrosion were issued in 1962. These were updated on a regular basis, once a decade, until the end of the 1980s. The latest publication entitled 'Organization and principles governing storage and conservation of weapons and military equipment DD/4.22.8' was issued by the Inspectorate for Armed Forces Support in 2013.

In its colloquial meaning, the term 'conservation means preservation (Latin conservare – to preserve; conservatio – preservation)[7]. Conservation of a vehicle, in turn, comprises all activities that need to be performed in order to temporarily protect a motor vehicle against corrosion. The manner in which motor vehicles used in the military are protected against corrosion is determined by the following factors: combat readiness, service life and reliable operation, material and labor costs, labor-intensiveness of the conservation-related processes, availability of the materials used for conservation on the domestic market, as well as by the simplicity of the conservation processes[8].

Storage, in turn, should be understood as withdrawal of a given vehicle from active service, for a specific period of time. Once conserved, vehicles should be stored at a specified location and in pre-determined conditions. Preparation of a vehicle for conservation - a process including all activities of technical and organizational nature that need to be performed in order to begin conservation - is therefore of vital importance. De-conservation is another of the important issues that must be taken into consideration while discussing the broadly understood notion of 'storage'. It consists in removal of conserving agents and preparing the vehicle for regular use. The term *de-conservation* covers also the activities that need to be performed after the expiry of a specified storage period. Such activities consist in replacement and replenishment of the conserving agents, as well as in preparing the vehicle for prolonged storage.

It needs to be stressed that the technical condition and maintenance of the military equipment assigned to a given unit is the responsibility of its commander. The personnel in charge of operating the equipment, in turn, exercise overall supervision over the process. Users of military equipment are obliged to abide by the applicable operational, safety (fire protection and transportation) as well as environmental protection regulations[9].

2. THE ROLE OF STORAGE IN THE SERVICE LIFE OF MILITARY EQUIPMENT

Research conducted by the Military Institute of Armored and Automotive Technology in the 1980s and 1990s indicated that the technical readiness of equipment varies over time, in line with the following formula:

---

[7] W. Kopaliński, *Słownik wyrazów obcych i skrótów obcojęzycznych*. 20th edition, Państwowe Wydawnictwo „Wiedza Powszechna", Warsaw 1990, p. 276.

[8] *Encyklopedia techniki wojskowej*, MON, Warsaw 1978, p. 278.

[9] *Regulamin Ogólny Sił Zbrojnych Rzeczypospolitej Polskiej,* Decision no. 445/MON of the Minister of National Defense dated 30 December 2013 (Official Journal of the Ministry of Defense of 2013, item 398), p. 27 (clauses 138, 140, 142).

$$\alpha(t) = \alpha_1 \cdot e^{-k(t-1)}$$

where:

α_1 – technical readiness factor during the first year of service life,

k - factor describing the intensity of quality indicators' fluctuations over time.

Particular attention needs to be drawn to the fact that as the technical readiness factor decreases the costs of maintenance, repairs, fuel consumption and spare parts grow. It has been determined that several out of over a dozen thousand parts making up a given vehicle impact the quality of indicators describing that vehicle, with 150 ÷ 300 of them limiting its reliability, and 80 ÷ 100 determining the safety of its use[10]. In the light of the above, equipment storage needs to be considered one of the very important aspects. Considering the fact that storage constitutes a part of military equipment's operation, one needs to note that the equipment's availability for the recommended maintenance is also an important issue. According to literature, operation is understood as a set of purposeful activities of organizational, technical and economic character, involving a technical object, as well as the interrelations between these activities, from the moment the object is taken over for its intended use until its liquidation. Therefore, operation of military equipment aims primarily to achieve the intended operational and training objectives, maintain the readiness (availability) for use, and restore such readiness (availability) by servicing the military equipment[11]. It is estimated that storage is located within the maintenance of military equipment, aiming to ensure its readiness (availability) for use, as presented in Figure 1.

The environment is a very important factor requiring military equipment to be stored properly, as it causes the corrosion of metals[12] and ageing of non-metallic elements. As far as metals are concerned, their corrosion may be, depending on the processes involved, of the chemical or electrochemical nature. In both cases metallic surfaces are[13] degraded by corrosion.

[10] *Sprawozdanie Nr 55/ZE/2004 „Wpływ czasu i warunków przechowywania pojazdów na proces starzenia jego elementów (szczególnie polimerowych) i wywołanych w nich zmian własności eksploatacyjnych"*, WITPiS, Sulejówek 2004, p. 4.

[11] M. Brzeziński, *Zabezpieczenie…, op. cit., p*. 105.

[12] Corrosion (Lat. corrodere – eat away), consists in gradual degradation of material that is exposed to the elements.

[13] Corrosive wear is caused by ageing processes occurring as a result of complex physical and chemical reactions between the environment and the elements of motor vehicles, Hebda M., Wachal A., *Trybologia* , Wydawnictwo WNT, Warsaw 1980, p. 60.

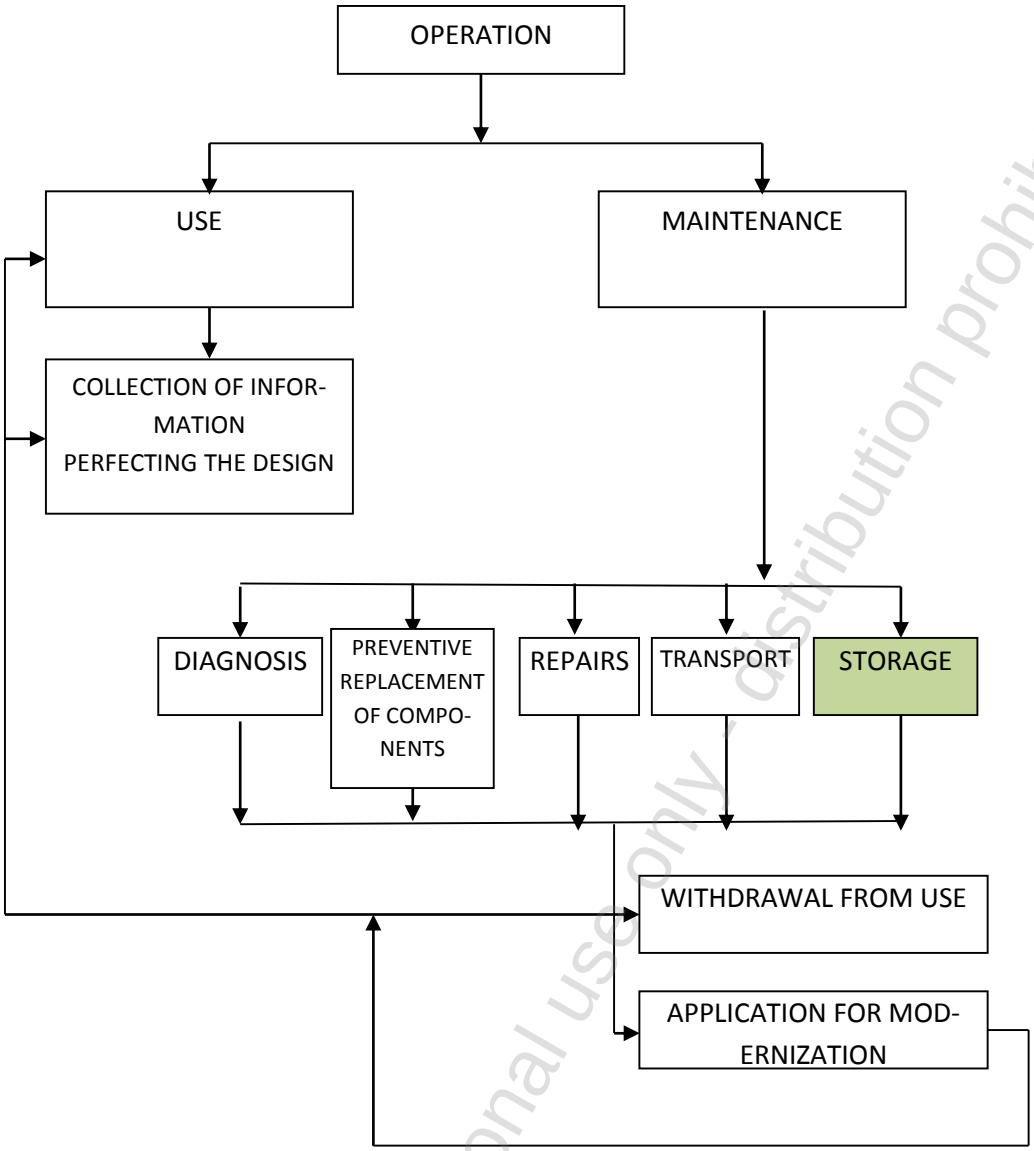

Fig. 1. The position of storage in the process of operation [10 p. 7]

In the first case, chemical corrosion consists in the impact that dry gases or liquid organic compounds in which no ions may be created exert on metals at high temperatures. Chemical corrosion comprises primarily gas corrosion that takes place at elevated temperatures. In most cases it has the form of oxidization of metals. It needs to be noted that the intensity of gas corrosion depends on the type of metal, temperature and protective properties of various oxides. Electrochemical corrosion, in turn, is a metal degradation process that occurs in electrolytes, due to the flow of electric current. The analysis of source materials indicates that galvanic cells are created in electrolytes between the following:

- two different combined metals;
- components (phases) or crystals of metal;

- metallic coating (regenerative, protective or decorative layer) and the core of a given component;
- inclusions (impurities) and metal;
- layer of oxides and metal.

Relative humidity and impurities contained in the atmosphere are two other important factors facilitating corrosion. The situation presented in figure 2 is a good example here.

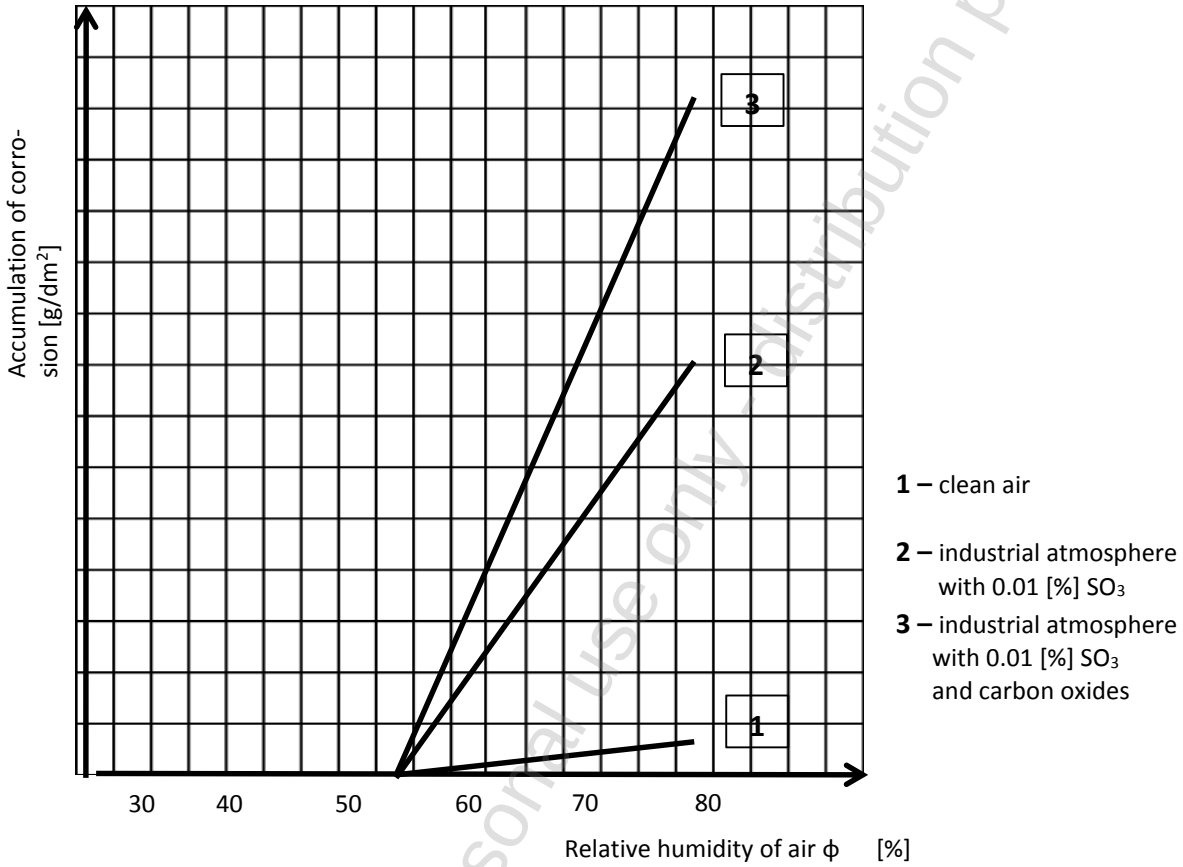

Fig. 2. Factors influencing the occurrence of n corrosion of steel

Source: Chachulski A., *Dobór parametrów systemu ochrony czasowej czołgów opartego o dynamiczne osuszanie powietrza*, Zeszyty Naukowe WITPiS no. 7, Sulejówek 1999 p. 7

It needs to be reminded that the conserving effect of dry air consists in almost total prevention or at least in slowing down the corrosion of steel. Such results may be expected if the relative humidity of ambient air is kept below the threshold value of approximately 55%.[14] A galvanic cell created between two different types of metal is the more active the further apart both metals in the voltage series are.

[14] Chachulski A., *Dobór parametrów systemu ochrony czasowej czołgów opartego o dynamiczne osuszanie powietrza*, Zeszyty Naukowe WITPiS vol. 7, Sulejówek 1999, p. 6.

The process of non-metallic components' ageing is another of the issues that determine technical readiness of equipment. This process causes unfavorable chemical changes, affects the structure of materials and adversely impacts their physical properties. It is triggered by oxygen, ozone, high - energy radiation or other substances. The process is facilitated by heat, light and ions of certain metals. The structure of cross-links between the individual polymer chains is the element that is most susceptible to the unfavorable effects of the factors referred to above. The nature of changes affecting the physical properties depends on the type of polymer. In the case of rubber, the impact of atmospheric conditions is manifested in two ways. The first of those processes is oxidization, catalyzed mainly by sunlight, heat, humidity and mechanical stress. The other process consists in cracking.

One has to note that during peacetime armies are required to store military equipment taking into account a regular surplus or war supplies at the same time. Thus, it is indispensable to include various storage methods - both of the low-cost (with or without the use of greases) and cost-intensive character (the dynamic storage method). Preliminary assessment of the literature dealing with the problem, discussions held with the staff of the Inspectorate for Armed Forces Support, military units, employees of the Military Institute of Armored and Automotive Technology, as well as personal experience gathered over the many years of service at various positions within the military have enabled to formulate a research problem specified as follows:

What actions need to be taken to improve the effectiveness of military equipment storage in order to maintain its technical readiness for further use?

In order to provide an answer to the problem, specific research methods need to be employed, e.g.: the analysis of documents and statistical data, as well as observation. It must be noted that storage of equipment requires proper management and operational structures of relevant capability[15], effectiveness and[16] efficiency[17]. In line of the above, a conclusion can be drawn that regardless of whether the Polish Armed Forces operate domestically or abroad, the military equipment storage methods used should be adapted to the specific environmental conditions.

[15] Capability (Polish: *wydolność*), (med.) is the ability of a complete living organism, or of its individual parts, to function normally, *Słownik języka polskiego PWN*, Wydawnictwo Naukowe PWN, Warsaw 2007, p. 1188; As far as storage of military equipment is concerned, efficiency is ensured by proper organizational structure (management and execution), technical personnel possessing relevant skills and equipped with gears enabling the tasks performance.

[16] Effectiveness (Polish: *efektywność)* is a positive result, capability, efficacy, performance *Słownik wyrazów obcych*, Wydawnictwo Naukowe PWN, Warsaw 1995, p. 269; [see:] Effectiveness is the ability to achieve the intended result in an economical way, i.e. at the lowest cost required to achieve the objective (workload, financial expense, time), Jałowiec T., *Efektywność w wojskowym systemie logistycznym. Zarys problemu*, Wyd. BEL Studio Sp. z o.o., Warsaw 2013, p. 10.

[17] Efficiency (Polish: *skuteczność)* is a feature of a medicine or a means that enables it to render the expected, positive and favorable result *Mały słownik języka polskiego*, Wydawnictwo Naukowe PWN, Warsaw 1997, p. 854.

3. STORAGE OF MILITARY EQUIPMENT – GENERAL ASSUMPTIONS

Depending on the manner in which it is used, the Polish Armed Forces' military equipment is classified into the following groups[18]:

a) in use – the group E;

b) in storage – the group K.

The **E** group includes equipment that is in daily use (DU) for training and implementation of objectives. This group includes also training equipment, cross-sections, etc. As far as the **K** group is concerned military equipment represents war supplies[19] (WS) and/or daily use equipment that is not planned to take advantage of over the period of at least 30 days, as well as military equipment that constitutes a surplus over the staff-related or other requirements of a given unit. The above indicates that depending on the period of time over which the military equipment is to be withdrawn from use, the following storage methods need to be applied:

a) short-term storage – STS;

b) long-term storage – LTS.

It is estimated that short-term storage will apply to equipment that is not planned to use over a period of 30 days up to one year. Long-term storage, in turn, is a procedure that refers to the aforementioned war supplies or equipment that is planned to use up to one year. Military equipment bound for storage should meet the criteria:

a) it should be in good technical order and all periodic maintenance (PM) procedures should be completed, in line with the following assumptions:
   - equipment bound for short-term storage – the next planned PM,
   - equipment bound for long-term storage – the most detailed PM envisaged for the specific type of equipment;

b) its technical and supervision certificates (if required) should be valid;

c) its equipment and accessories should be complete and operable;

d) its systems should be filled with the relevant substances (fuel, oils, lubricants, fluids), in line with the applicable standards;

e) its technical documentation should be up-to-date.

The study of source materials, as well as experience gathered during military service indicates that the following military equipment storage methods may be used:

---

[18] *Zabezpieczenie techniczne Sił Zbrojnych Rzeczypospolitej Polskiej. Zasady funkcjonowania (Technical back-up of the Polish Armed Forces. Operational principles) DD/4.22*, MON, Bydgoszcz 2012, Logis Ref. No. 10/2012, p. 29.

[19] War supplies constitute the difference between the staff-related requirement of war time (W) and peace time (P), *Instrukcja zarządzania eksploatacją uzbrojenia i sprzętu wojskowego w Siłach Zbrojnych Rzeczypospolitej Polskiej. Zasady ogólne DD/4.22.13,* MON, Bydgoszcz, Logis Ref No. …/2013, p. 23.

a) grease-based - GB;

b) greaseless - GL;

c) reusable covers:

   –- dynamically dried - RC-D,

   –- statically dried - RC-S;

d) disposable covers, statically dried - DC-S;

e) drying the interior of equipment:

   –- dynamic - DDI,

   –- static - SDI;

f) dynamic drying of warehouses - DDW.

The above means that the personnel in charge of performing conservation should be properly trained on the job, familiar with the design of the equipment and its maintenance processes, and also applies adequate storage methods. Availability of the military infrastructure required to store the equipment is of equal importance. The priority should be to store it in properly prepared garages or under umbrella roofs. Storage in the open should be avoided by all means. It is estimated that in order to protect the military equipment that is not used on daily basis, the Polish Armed Forces should continue to store it relying on the modern methods available. Depending on the infrastructure existing at individual military units, the conserved equipment (vehicles) may be stored:

- in air-conditioned warehouses;
- in closed warehouses without air conditioning;
- under umbrella roofs;
- in natural warehouses (in the open).

It is assumed that warehouses used for storing conserved vehicles must meet the following criteria[20]:

- their roofs, gates and windows should be in a good technical condition and water tight;
- should be equipped with a working air conditioning system enabling to maintain a specific, minimum humidity level;
- should enable the vehicles to be moved out in an efficient and defect-free manner.

[20] The detailed criteria are presented in the *"Instrukcja o zasadach i organizacji przechowywania oraz konserwacji uzbrojenia i sprzętu wojskowego* DD/4.22.8, Ministry of Defense, Armed Forces' Support Inspectorate, Bydgoszcz 2013.

It has to be borne in mind that adequate vehicle storage conditions depend, to the greatest extent, on the atmospheric conditions (in the case of vehicles stored outdoors and under umbrella roofs), ambient temperatures, and, primarily, air humidity. The optimum parameters to be maintained indoors, where vehicles are stored, are given below:

- temperature - approx. 10 - 25°C;
- relative humidity - approx. 40 - 60%.

Contrary to appearances, these parameters are not easy to reach, as in the vast majority of cases the adaptation of the garage space to the needs of storing vehicles requires considerable financial expenditure.

4. THE ANALYSIS OF THE MILITARY EQUIPMENT STORAGE METHODS USED

At present, the Polish Armed Forces store its equipment relying practically on all the methods available. Based on observations made at selected military units of the Inspectorate for Armed Forces Support, three main variants of the Temporary Protection System (viewed as a set of inter-related rules and packaging (barrier-forming) materials (both of primary and auxiliary character)), developed at the Military Institute of Armored and Automotive Technology, may be distinguished depending on the character and kind of the materials used. These include the barrier, inhibitor-based and dried variants. The analysis of the literature on the subject allows the conclusion that the classification of the temporary protection system applicable to vehicles is ambiguous and depends on the current needs. Conservation methods and procedures are not fully systematized and ordered. The division into three conservation methods is quite common[21]:

- the loose cover method, relying on the use of a loose cover characterized by vapor- and water-tight properties;
- the cocoon method that consists in creating a plastic cocoon formed by spraying film-forming materials onto a supporting net stretched over the object to be protected;
- the encapsulation method, used primarily in the military, and relying on the armored vehicles' ability to easily and effectively air-seal their tubs and turrets, thus creating a barrier that separates the vehicle's interior from the adverse impact of the elements.

In practice, the grease-based method is also used along with its modified version and with a method that does not require the use of any lubricants.

The presentation of different conservation methods needs to begin with the **grease-based** method in which advantage is taken of protective and insulation properties of

[21] Marczak R., Tybel A., *Konserwacja wojskowych pojazdów mechanicznych za pomocą lotnych inhibitorów korozji (LIK) rozpuszczalnych w olejach eksploatacyjnych*, Zeszyty Naukowe WITPiS vol. 2, Sulejówek 2001, p. 41.

oils and conservation greases. This particular method consists in applying lubricants onto thoroughly cleaned surfaces of metallic objects. It is used for conserving spare parts, tools, small arms, artillery equipment, engines and other military equipment made of steel, colored metals or their alloys, as well as for conserving equipment with surfaces bearing galvanic coatings and non-organic non-metallic coatings. Unfortunately, this specific method is of the low efficiency variety. It is also highly labor-consuming (both during conservation and de-conservation stages) and requires that the conservation procedures be repeated on a regular basis.

Another of the methods, i.e. the **greaseless method,** consists in protecting surfaces with chemical agents offering anti-corrosive properties, without the use of grease. Under this method concentrated or ready-to-use products containing corrosion inhibitors, offering temporary anti-corrosive properties are applied (Multakor WD, W-68 concentrate, LIK version 7, etc.). This is a low-cost method, the chemical can be applied easily, and the conservation agents used do not have to be removed prior to recommissioning of the equipment. The disadvantage of this particular method is that it may be applied only in relation to selected assemblies, mechanisms or elements. It can only be used for conserving complete pieces of machinery and equipment if these are stored in closed warehouses. In addition, the inhibiting agents cause the corrosion of colored metals.

In turn, the static and dynamic drying methods incorporate the usage of disposable covers (DC), reusable covers (RC), as well as static drying of the equipment interior (SDI) or dynamic drying of warehouses (DDW).

The disposable cover method consists in placing the pre-treated piece of equipment (assembly, subassembly, system, etc.) in a loosely fitted cover adapted to the shape of the protected device and made of light plastics of various types. A precisely calculated quantity of silica gel is then inserted inside the cover and the item of equipment to be stored. This method is only used to provide anti-corrosion protection for small items stored inside warehouses. The expected duration of storage with the use of the disposable cover method is 5 years.

Under **the reusable cover method** a pre-treated item of equipment is placed inside a cover, in which atmosphere with the relative humidity level of approx. 40-50% is maintained. This specific level of humidity is achieved owing to the use of technical equipment (dynamic drying) or drying agents (static drying). The expected duration of storage with the use of the reusable cover method is 5 years. The following types of reusable covers may be distinguished:

- the individual reusable cover, dynamically dried - IRC-D;
- the individual reusable cover, statically dried - IRC-S;
- the frame-stretched cover, dynamically dried - FST-D;
- the suspended cover, dynamically dried - SC-D;
- the vacuum reusable cover - VRC.

Vehicles stored under all types of reusable covers should have their key systems additionally protected with the use of greaseless conserving agents. If these are not available, grease-based conserving agents should be taken. The above applies in particular to on-board mounted weapon systems.

Another of the methods, i.e. the **equipment interior drying method** assumes that the relative humidity of the air inside the object (vehicle) will be reduced to 40-50% by the design-inherent ability to air-seal the vehicle. This method works when equipment is stored in open warehouses (under a water-proof cover), as well as under umbrella roofs. The best results, however, are achieved in closed warehouses.

The **dynamic warehouse drying method** consists in maintaining the relative humidity of 40-50% inside the closed premises on which the equipment is stored. The air inside the warehouse is dried with the help of stationary air driers. This method may be used practically in relation to all types of equipment, irrespective of its design. However, an air –tight warehouse is necessary for this method.

The review of the equipment storage methods presented above clearly indicates that when excluding the first two ones, the remaining methods may be used only upon prior financial investment. Therefore, the basic methods (grease-based and greaseless) are among the most popular in the military, while the methods relying on the use of covers or warehouse drying are applied based on the current potential. The latter methods ensure a much better technical condition of the equipment stored, thus boosting its technical reliability. It has to be borne in mind that activities currently being undertaken are aiming to enable practical application of dynamic drying of interiors of vehicles stored, or of entire warehouses. It seems, however, that the pace of the changes fails to match the actual requirements. The correctness of the solutions indicated is confirmed by the analysis of the summaries relating to the equipment storage methods used (which were compiled before 2010)[22]. Although four years have already passed since that time, the condition of the majority of that equipment is still less than satisfactory.

As mentioned earlier, the source literature fails to provide a precise categorization of the temporary protection methods. Therefore, it seems reasonable to suggest a division into the specific categories, as presented in figure 3. The idea behind the new division is the necessity to systematize the terms used and to assign methods applied to specific areas. It seems that there is no need to include the cocoon method in the classification, as it is considered uneconomical, labor-intensive and is practically not used in the military. It was considered an innovative solution back in the 1950s and 1960s when no covers were available. NATO armies commonly used the said method y. In light of the above, the following question may be asked:

Isn't the cocoon method considered in our Armed Forces the same as the methods relying on disposable and reusable covers?

[22] Source materials kept at the Inspectorate for Armed Forces Support.

It seems that the presentation given above provides a clear description of the temporary protection systems used by the Polish Armed Forces.

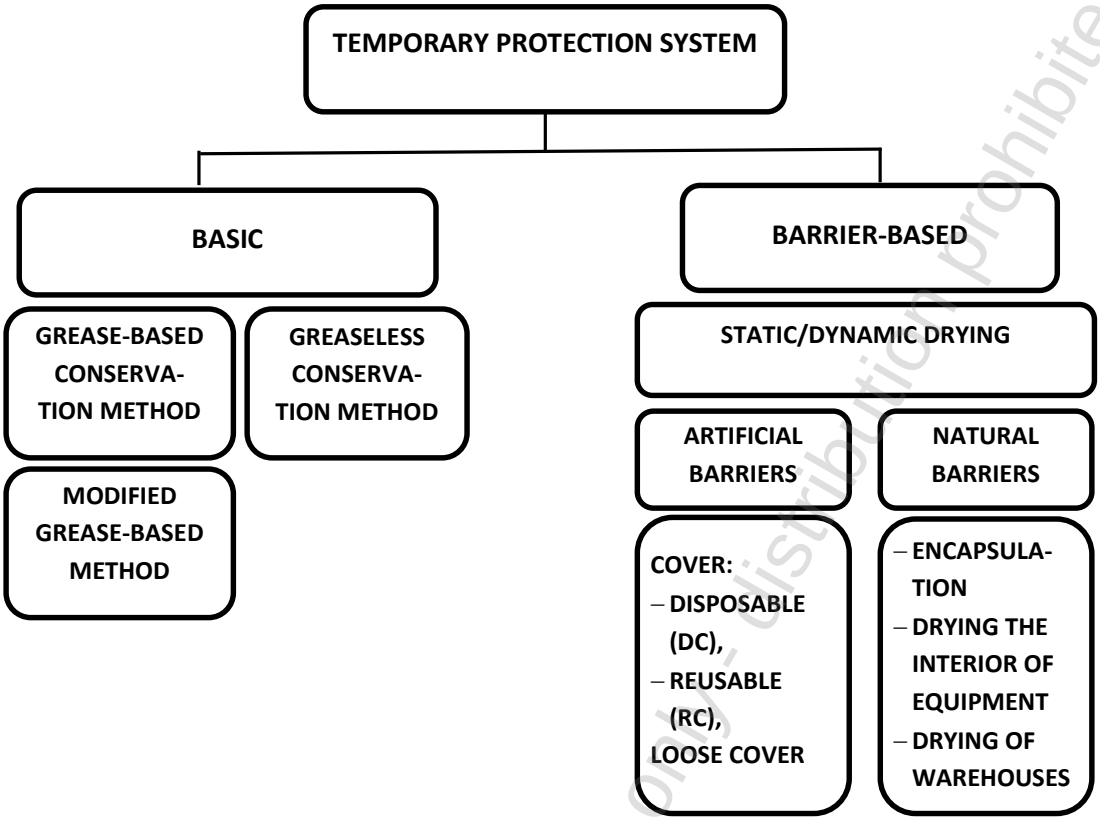

Fig. 3. The temporary protection system of military equipment (a proposal)

Source: Own compilation

CONCLUSIONS

In the Polish Armed Forces equipment (vehicles) is stored with the use of generally available temporary protection methods. In the ideal solution 100% of vehicles that are withdrawn (for a short or a long period of time) from operation are stored dynamically inside warehouses. However, decisions on the use of air drying methods must be based on economic analyses that take into consideration the financial effects of the investment- and warehouse operation-related expenditure, as well as the costs that need to be borne in order to prepare the equipment for storage and to conduct its necessary periodic maintenance.[23] It needs to be stressed that the dynamic drying method is of the most practical variety for vehicles, as it enables to maintain them, without additional labor requirement, in the proper technical condition. In addition, no de-conservation is required if the equipment is to be re-commissioned. Installation of the battery is the only activity that is necessary to make the vehicles road worthy again. Hence, it is recommended to verify the structures in charge of equipment stor-

[23] Sakowicz A., *Problemy podniesienia efektywności systemów osuszających*, Informator WITPiS vol. 46, Sulejówek 1997, p. 127.

age within the Polish Armed Forces. It seems that the role of the Head of the Infrastructure Department of the Inspectorate for Armed Forces Support as the central logistics entity in charge of 'installation of protective systems and of military equipment storage relying on dynamic air drying methods' is limited to the installations used in a specific building (warehouse) only. The entity in charge of organizing the storage system or, to put it more precisely, the military equipment temporary protection system throughout the entire structure of the Polish Armed Forces, is missing. It is recommended to take the necessary decisions as early as possible, so that unnecessary delays may be avoided.

REFERENCES

1. Brzeziński M., *Zabezpieczenie logistyczne oddziałów i pododdziałów wojsk lądowych w oddziałach taktycznych. Podręcznik*, MON, Warsaw 1996, General Staff No. 1490/98
2. Chachulski A., *Dobór parametrów systemu ochrony czasowej czołgów opartego o dynamiczne osuszanie powietrza*, Zeszyty Naukowe WITPiS vol. 7, Sulejówek 1999
3. *Decyzja Nr 72/MON Ministra Obrony Narodowej z dnia 25 marca 2013 r. w sprawie pozyskiwania sprzętu wojskowego i usług dla Sił Zbrojnych Rzeczypospolitej Polskiej (Decision 72/MON of the Minister of National Defense dated 25 March 2013 on acquisition of military equipment and services for the Polish Armed Forces) (Official* Journal of the Ministry of National Defense dated 25 March 2013, item 78)
4. *Decyzja Nr 435/MON Ministra Obrony Narodowej z dnia 24 grudnia 2013 r. w sprawie określenia funkcji gestorów i centralnych organów logistycznych sprzętu wojskowego w resorcie obrony narodowej* (*Decision No. 435/MON of the Minister of National Defense dated 24 December 2013 on determining the roles and responsibilities of custodians of and central logistic authorities exercising control over military equipment within the Ministry of National Defense) (Official* Journal of the Ministry of National Defense dated 27 December 2013, item 390)
5. *Encyklopedia techniki wojskowej*, MON, Warsaw 1978
6. Hebda M., Wachal A., *Trybologia* , Wydawnictwo WNT, Warsaw 1980
7. *Instrukcja Konserwacji Czołgów (Tank Conservation Manual)*, Szkoła Czołgów i Samochodów, Warsaw 1928, Approved for internal use in the Tank and Vehicle School by its Commander, pp. major Naspiński on 1 June 1928
8. *Instrukcja o utrzymaniu sprzętu pancernego i samochodowego (Armored and automotive equipment maintenance manual)*, MSWojsk, Dowództwo Broni Pancernej, Warsaw 1938.
9. *Instrukcja o zasadach i organizacji przechowywania oraz konserwacji uzbrojenia i sprzętu wojskowego (Organization of and principles governing storage and conservation of weapons and military equipment)* DD/4.22.8, Ministry of Defense, Armed Forces' Support Inspectorate, Bydgoszcz 2013

10. *Instrukcja zarządzania eksploatacją uzbrojenia i sprzętu wojskowego w Siłach Zbrojnych Rzeczypospolitej Polskiej. Zasady ogólne (Polish Armed Forces weapons and military equipment operation manual) DD/4.22.13,* Ministry of Defense, Bydgoszcz
11. Jałowiec T., *Efektywność w wojskowym systemie logistycznym. Zarys problemu*, Wyd. BEL Studio Sp. z o.o., Warsaw 2013
12. Kopaliński W., Słownik wyrazów obcych i skrótów obcojęzycznych. 20th edition, Państwowe Wydawnictwo „Wiedza Powszechna", Warsaw 1990
13. *Mały słownik języka polskiego*, Wydawnictwo Naukowe PWN, Warsaw 1997
14. Marczak R., Tybel A., *Konserwacja wojskowych pojazdów mechanicznych za pomocą lotnych inhibitorów korozji (LIK) rozpuszczalnych w olejach eksploatacyjnych*, Zeszyty Naukowe WITPiS vol. 2, Sulejówek 2001
15. Norma Obronna-NO-06-A107:2005, MON, Warsaw 2005
16. *Regulamin Ogólny Sił Zbrojnych Rzeczypospolitej Polskiej (General by-law of the Polish Armed Forces),* Decision No. 445/MON of the Minister of National Defense dated 30 December 2013 (Official Journal of the Ministry of Defense of 2013, item 398)
17. Sakowicz A., *Problemy podniesienia efektywności systemów osuszających*, Informator WITPiS vol. 46, Sulejówek 1997
18. *Słownik języka polskiego PWN*, Wydawnictwo Naukowe PWN, Warsaw 2007
19. *Sprawozdanie Nr 55/ZE/2004 „Wpływ czasu i warunków przechowywania pojazdów na proces starzenia jego elementów (szczególnie polimerowych) i wywołanych w nich zmian własności eksploatacyjnych"*, WITPiS, Sulejówek 2004
20. *Vade-Mecum Żołnierza-Kierowcy Część II*, Wydawnictwo 1. Brygady Strzelców 1941, Reprint (3rd edition) by Sekcja Wydawnicza Dowództwa Bazy i Etapów Armii Polskiej na Wschodzie, Palestine, September 1943
21. *Zabezpieczenie techniczne Sił Zbrojnych Rzeczypospolitej Polskiej. Zasady funkcjonowania (Technical back-up of the Polish Armed Forces. Operational principles) DD/4.22*, MON, Bydgoszcz 2012, Logis Ref. No. 10/2012

BIOGRAPHICAL NOTE

Zbigniew CIEKOT, PhD, Eng. – a graduate of the Vehicle Military School in Piła (1982) and the third degree studies at the National Defense Academy. He served in various positions in the Polish Armed Forces. He ended his military service while working in the Inspectorate for Armed Forces Support. He currently works as a lecturer at the Military Institute of Armored and Automotive Technology in Sulejówek. The areas of his interest include the exploitation of vehicles, technical security of the Armed Forces. He is

the author of about 20 articles related to these areas, and the academic co-editor of several scientific publications in this field. Moreover, he has participated in several research works on technical security in combat operations. Military equipment storage has recently been the area of his concern. He is the organizer / co-organizer of numerous scientific meetings (seminars, symposia) on these issues.

HOW TO CITE THIS PAPER

Ciekot Z., (2016). Storage of military equipment – theoretical considerations. *Zeszyty Naukowe Wyższa Szkoła Oficerska Wojsk Lądowych im. gen. Tadeusza Kościuszki Journal of Science of the gen. Tadeusz Kosciuszko Military Academy of Land Forces*, 48 (1), p.112-127. http://dx.doi.org/10.5604/17318157.1201743