Scientific Journal of the Military University of Land Forces
ISSN: 2544-7122 - print, 2545-0719 - online
2018, Volume 50, Number 3(189), Pages 155-165
DOI: 10.5604/01.3001.0012.6234

Original article

Storage as an important element in maintaining technical serviceability of military equipment

Leszek Jaskula*, Jedrzej Dzida

Department of Logistic Support, Stefan Czarniecki Land Forces Training Center in Poznan, Poland,
jaskula@echostar.pl

INFORMATIONS

Article history:

Submited: 11 January 2018

Accepted: 21 May 2018

Published: 30 September 2018

* Corresponding author

ABSTRACT

The article presents the methods of storing equipment used in the Polish Armed Forces and the description of their application. The overall scope of maintenance works performed on the equipment during storage preparation, as well as the scope of checks and inspections executed during the equipment storage and after removal from storage are outlined. Moreover, the causes of corrosion, its effects and ways of prevention are discussed.

KEYWORDS

corrosion, storage methods, dynamic dehumidification, static dehumidification, greaseless method, technical maintenance

Introduction

Corrosion is the gradual process of destruction occurring on the surface of metals and their alloys as well as non-metallic materials (e.g. concrete, wood) due to chemical or electrochemical reactions with the environment. The name comes from the Latin word *corrodere* – to eat. Chemical corrosion consists in the chemical interaction of the center with the material (e.g. formation of metal compounds with elements of the environment). Electrochemical corrosion, which most often damages metals, is caused by the flow of electrostatic charges across the metal-electrolyte boundary. Due to the physicochemical character of the environment, there are distinguished:

– gas corrosion,
– electrolytic corrosion,
– non-electrolytic corrosion,
– atmospheric corrosion,
– soil corrosion,
– biological corrosion (bio corrosion).

The corrosion process can also occur as a result of the simultaneous operation of the environment and other factors, such as *fretting corrosion* – metal corrosion caused by simultaneous environmental impact and friction.

Data from the statistics show that costs resulting from corrosion damage and the need for corrosion protection exceed 4% of GDP in industrialized countries. For example, according to the Government Accountability Office (GAO-03-753), the US Armed Forces spent about $ 23 billion for corrosion problems in 2011. Rusting of iron, tarnishing of brass and copper and blackening of silver belong to the most recognizable examples of corrosion.

Consequently, it is important to ensure appropriate organization and proper storage of large quantities of armaments and equipment in order to protect them against corrosion. This affects significantly their high technical efficiency and, ultimately, the relevant combat readiness of a military unit.

1. Corrosion protection measures

1.1. Overview of storage methods

Commonly applicable methods of protecting metals against corrosion include:

1. The right selection of material in conjunction with appropriate construction solutions.
2. The modification of the corrosive environment by:
   a) oxygen removal,
   b) elimination of acid by neutralization, e.g. with lime,
   c) water demineralization.

   In case of atmospheric corrosion:
   d) dehumidification of the environment, e.g. silica gel,
   e) reduction of local humidity by raising the temperature by 6-7 degrees above the ambient temperature.
3. The use of corrosion inhibitors – chemical compounds added in low concentrations to the aggressive environment cause a significant reduction in metal corrosion rate.
4. The application of paint coatings (paints and varnishes) [Jaskula et al. 2008].

A great number of methods of technical equipment storage are used in the military practice. Their variety and overview is illustrated in Figure 1. It should be noted that grease-based and greaseless methods belong to the oldest ones and currently they are often called traditional methods. The others are based on the static (using silica gel) or dynamic (through drying devices) dehumidification methods.

The grease-based method, one of the oldest methods of corrosion protection, involves the insulation of the metal surface from atmospheric agents by applying protective layers, i.e. organic materials mainly based on crude oil. The effectiveness of this method is problematic due to the life of these oils and grease, and the lack of grease coating refreshment even leads to the accelerated corrosion process.

The greaseless method that has developed particularly intensively in the industry is the most modern version of the above. Chemical agents of various functional properties (mostly multi-purpose) such as Multakor-WD or W-68 concentrate are used in this

method to protect metal surfaces against corrosion. Equipment protected with such preservatives requires additional packaging (e.g. LIK-7 paper, microfiber paper, plastic foil, etc.) when stored for a long time.

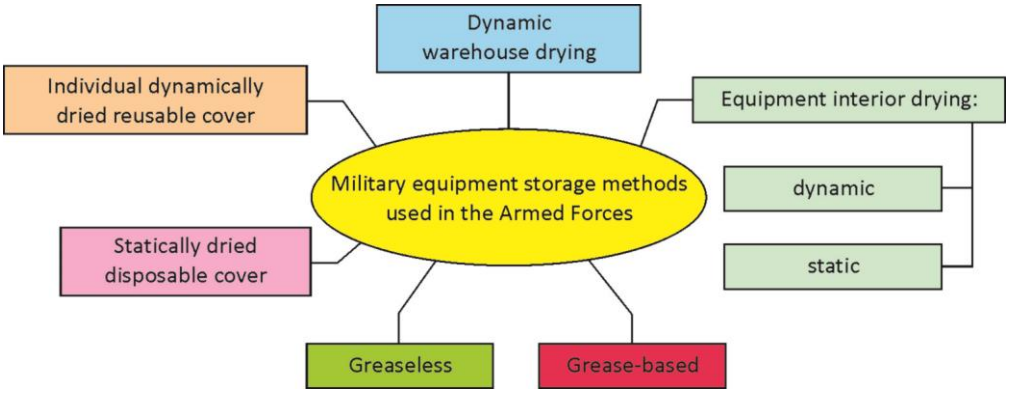

Fig. 1. The methods of storage and corrosion protection
Source: [Own study based on: [Przechowywanie… 2000]].

In recent years, a significant number of methods that use modern corrosion protection measures have appeared, including the VCI (Volatile Corrosion Inhibitor) method that applies corrosion inhibitors to create a protective environment in the immediate vicinity of the stored equipment (Fig. 2). This method uses special anti-corrosion papers and foils, VCI heat-shrinkable foils and VCI emitters. Examples of the application are shown in Figures 3-5.

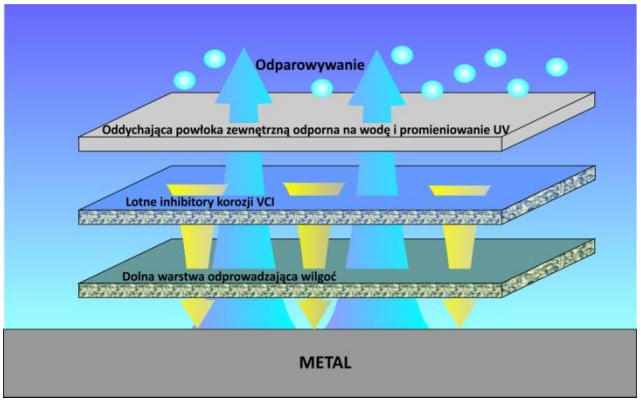

Fig. 2. Diagram of operation of the cover with the corrosion inhibitor
Source: [Own study].

Fig. 3. Examples of weapon protected in the VCI foil and placed in the chest
Source: [Maverick promotional materials].

Fig. 4. Examples of the use of VCI foil and paper
and VCI heat-shrinkable foil to protect equipment of large dimensions
Source: [Maverick promotional materials].

In both of these methods, the effectiveness of protection depends to a large extent on strict adherence to the maintenance technology and, above all, the proper cleaning and preparation of the treated surface. It should be pointed out that measures employed in these methods (that are widely accessible on the market) frequently have a very short lifetime that does not exceed 18-24 months from the date of manufacture (ot from the date of opening of a container!).

Fig. 5. M1A1 Abrams main battle tank and M198 howitzer protected with ENVELOP cover
Source: [Megmar Logistics & Consulting promotional materials].

Air dehumidification methods ensure much more effective corrosion protection. They consist in placing the prepared equipment in an environment where a continuous atmosphere of relative humidity of 40-50% is maintained by means of different types of technical devices (dynamic dehumidification) or other dehumidifiers (static dehumidification). A warehouse interior, a reusable cover, or a vehicle interior can be such an environment. The latest example of such a way of storage and protection against corrosion is Aircraft Air Dehumidifier (LOP) developed by the Central Military Bureau of Design and Technology (WCBKT S.A.) in Warsaw (Fig. 6) [Stanecki 2012].

With relation to the way of producing a dry environment in the storage place, one can talk about dynamic drying on the principle of sorption (absorption) or freezing. In both cases electronic devices for monitoring climate parameters (thermometers, hygrometers, electronic control units, etc.) are responsible for controlling the proper humidity in the space being dried [Kabza et al. 2005].

Fig. 6. Aircraft Air Dehumidifier
Source: [LOP WCBKT].

In the 1990s most dynamically dehumidifying devices used in the military were made by the Wojskowe Zakłady Uzbrojenia S.A. in Grudziadz (DOS systems). Most of the system solutions used in the military come from that period, and to date a great number of them has been successfully applied.

These methods can take several configurations:

1. Drying of storage facilities:
   a) dehumidification with the use of suspended covers,
   b) dehumidification and heating using an air heater.
2. Equipment interior drying.
3. Dehumidification using reusable covers (Fig. 7).

Fig. 7. Equipment stored in dynamically dried covers
Source: [Own study].

Two dehumidification systems in reusable covers can be distinguished:

– open,
– closed.

Open drying system (Fig. 8) – the process air is drawn from the surroundings of the dehumidifier and is forced through distribution ducts into the space being dehumidified. The wet air is pushed out from the dried space.

Closed drying system (Fig. 8) – is used when the space being dehumidified is relatively tight. The humid process air is taken in by the dehumidifier from the inside of the drained space through distribution ducts and partially from the surroundings, and after drying it is forced back into the being dried space. This ensures minimal installation and operating costs.

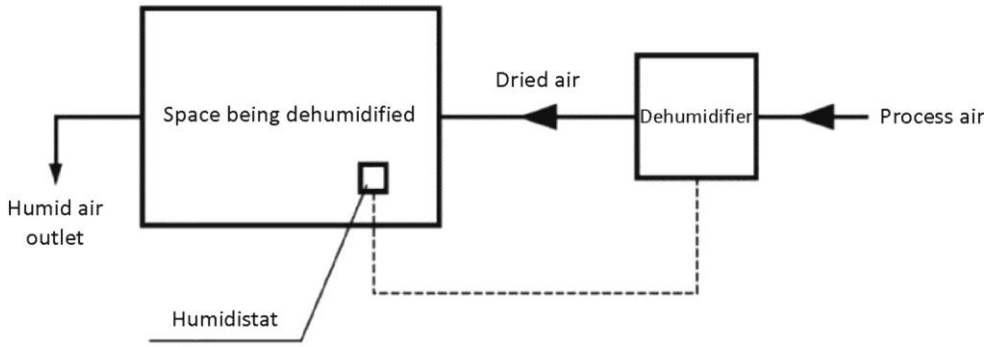

Fig. 8. Diagram of the open system
Source: [Own study].

The air dehumidification methods of storing weapons and military equipment used in place of the traditional maintenance and storage methods bring tangible benefits:

– very effective anti-corrosion protection throughout the storage period of armaments and military equipment,
– the short transition period from storage to use – no need to de-preserve the stored equipment,
– possibility of long-term storage of military equipment in full combat readiness,
– low labor intensity of maintenance and service during storage,
– extending the life span and effectiveness of combat equipment,
– reduction of storage costs.

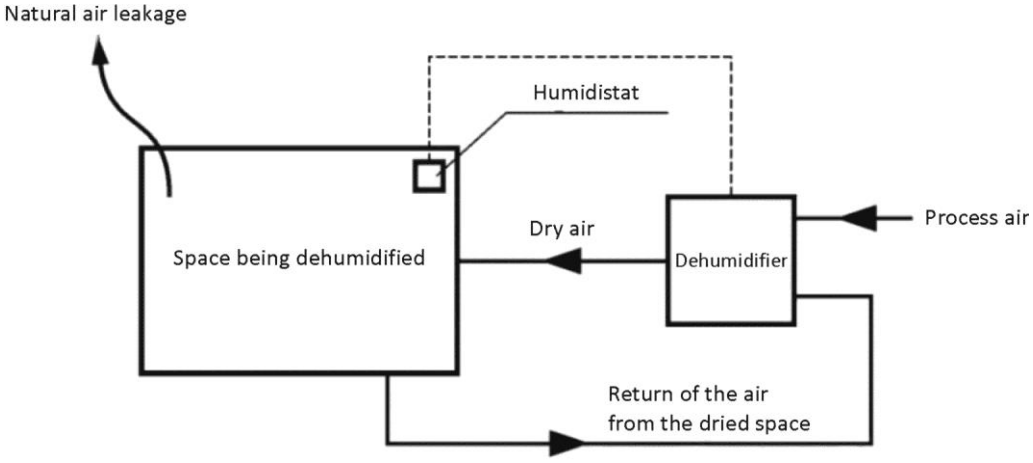

Fig. 9. Diagram of the closed system
Source: [Own study].

1.2. Preparation of the equipment for storage

The scope of service operations before storage, depending on the method used and the type of equipment, includes the following activities:

- delivery of military equipment to the place of storage,
- verification of the military equipment preparation for storage by performing activities that fall within the scope of the inspection without the operation check (IWOC),
- removal of the fixtures and accessories as well as performing possible additional maintenance on them,
- performing maintenance operations that could not be conducted during military equipment service,
- connection and start-up of technical devices to safeguard military equipment storage,
- performing other activities specified by the technology of storing military equipment.

Military equipment designated for storage should:

a) be operational, run in and have the required periodic technical servicing done:
   - equipment intended for short-term storage – the next scheduled periodical technical services,
   - equipment intended for long-term storage – the highest periodical servicing scheduled for this type of equipment;

b) have complete and operational individual equipment (special fixtures);

c) have systems completely filled with liquids (fuels, oils, lubricants, working fluids) in accordance with the relevant standards;

d) have filled in and complete individual operation documentation.

During the preparatory period for having military equipment stored in a military unit, maintenance works should be properly organized taking into account:

- preparation of personnel for performing maintenance works and storing military equipment,
- technologies and technical conditions for military equipment maintenance,
- assistance of the superior level in preparation and storing military equipment,
- means of providing technical devices safeguarding storage and maintenance supplies,
- application of appropriate storage methods and the resulting scope of work,
- preparation of places dedicated for military equipment storage,
- date of commencement and termination of military equipment storage,
- personnel responsible for conducting maintenance works and military equipment storing as well as controllers.

On the example of the PT-91 tank, the full range of maintenance and repair works performed when preparing vehicles for maintenance and storage includes:

1. Highest technical service (for OO-2 tank).
2. Current repair – if needed.
3. Replacement of rubber parts.
4. Replacement of fuel, oils, lubricants and operating fluids.

Properly scheduled, organized and conducted preparation period, including the preparation of equipment for storage (including selection of appropriate corrosion protection method), ensures to a large extent the high level of technical efficiency throughout the storage period.

2. Maintenance of military equipment during storage

In order to maintain the equipment in proper technical condition, the following types of inspections and servicing are carried out during storage:

– daily inspection (DI),
– inspection without the operational check (IWOC),
– inspection with the operational check (IOC),
– special inspection (SI),
– periodic servicing [Instrukcja… 2013].

The algorithm for scheduling and performing individual storage operations is shown in Figure 10.

The daily inspection (DI), often referred to as supervision, is carried out every morning and additionally at other times, in the case of unfavorable atmospheric conditions (abundant precipitation, strong winds, etc.).

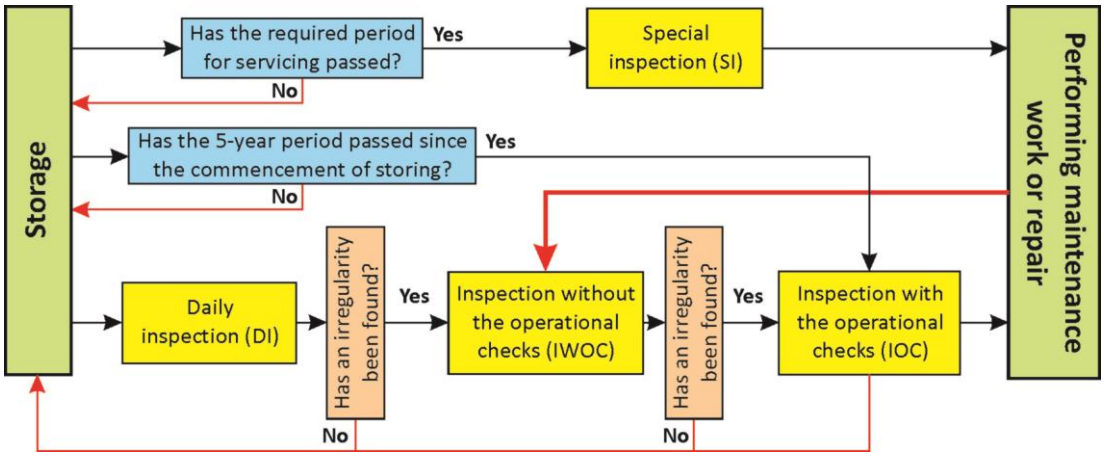

Fig. 10. Algorithm of inspections during military equipment storage.
Source: [Own study].

The scope of the daily inspection, depending on the storage method and technical equipment possessed, covers:

– verification of the humidity level inside military equipment, in the reusable cover or in the warehouse,

– control of the completeness and sealing of military equipment,
– checking the condition of packaging (without opening), tarpaulins and covers,
– controlling the condition of military equipment stored without packaging (maintenance coatings, operating fluid leaks, corrosion traces, etc.),
– controlling the condition of technical devices, racks, cabinets, etc., and possible ventilation of warehouses where military equipment secured by means of grease-based or greaseless method is stored.

The inspection without the operational check (IWOC) consists in verifying the technical condition of all basic mechanisms and systems without starting them up and equipping the military material in accordance with the instructional requirements for a given type of equipment.

The inspection without the operational check is planned by the logistic branch of a military unit and executed by the permanent group assigned by the commander's order.

The inspection without the operational check of military equipment is carried out:
– during the assessment of the quality (verification) of technical service performed during placing military equipment in storage,
– every three months – for military equipment stored for short-term period,
– ad hoc – in relation to the military equipment with deficiencies discovered during daily inspection, taking the form of corrosive or aging changes, damage to seal components, cover damage or relative humidity of above 50% inside the military equipment.

The inspection with the operational check (IOC) includes activities related to the complete diagnostics of the military equipment and the inspection of fixtures and individual equipment.

The inspection with the operational check addresses:
– the military equipment which, as a result of the inspection without the operational check, was negatively evaluated,
– 100% of military equipment after a five-year storage period.

The special inspection (SI) refers to the military equipment that, due to technical and operational conditions, requires periodic activation, control or other activity to maintain the required technical efficiency.

Planning and conducting the special inspection should be in line with the technical and operational documentation of the military equipment. Whenever possible, the special inspection should be combined with the inspection without the operational check.

Depending on the storage method used, the scope of servicing after storage includes:
– disconnection of technical devices securing the storage process,
– removal of maintenance coating and additional safeguards,
– mounting the removed fixtures and equipment.

The military equipment should be removed from storage based on a technology card developed for a specific type(s) of equipment.

Conclusion

The selection and application of appropriate storage methods is a particularly important element in the proper military equipment operation. The grease-based method can be used to store military equipment if it has a simple, homogeneous construction without complex electrical and electronic systems. However, the effectiveness of protection is very low in this method – approximately 50% in the five-year storage period [Przechowywanie… 2000]. In the industry it has been effectively taken over by the greaseless method and static drying, which, along with the emergence of new protective measures, especially VCI, are effective in long-term storage. Nonetheless, in both cases some technological limitations exist and hence they are mainly suitable for storage of components and parts in warehouses. Unfortunately, the least efficient grease-based method has still been cultivated in the military.

It seems that the most comprehensive and universal way of storing military equipment is provided by the dynamic dehumidification method, which, coupled with the greaseless method, enables the storage of large-size military equipment with a high technical complexity with advanced electronics.

Lastly, an important part of the military equipment storage process is to control its technical condition, carried out on a regular basis in the scheduled cycle of inspections, as well as on an ad hoc basis in emergency cases. This aspect shows the great advantage of the dynamic dehumidification method, where control and registration of climatic parameters (temperature and humidity) take place automatically. Adding the high level of effectiveness of protection in this method – 95% [Przechowywanie… 2000], it is clear that it is a method worth using and disseminating in the Polish Armed Forces.

Acknowledgement

No acknowledgement and potential founding was reported by the authors.

Conflict of interests

The author declared no conflict of interests.

Author contributions

All authors contributed to the interpretation of results and writing of the paper. All authors read and approved the final manuscript.

Ethical statement

The research complies with all national and international ethical requirements.

ORCID

Leszek Jaskula – The author declared that he has no ORCID ID's

Jedrzej Dzida – The author declared that he has no ORCID ID's

References

Instrukcja o zasadach i organizacji przechowywania oraz konserwacji uzbrojenia i sprzetu wojskowego. DD/4.22.8. (2013). Bydgoszcz: Inspektorat Wsparcia Sil Zbrojnych.

Jaskula, L., Jankowiak, R. and Dzida, J. (2008). *Przechowywanie uzbrojenia i sprzetu wojskowego*. Poznan: Centrum Szkolenia Wojsk Ladowych.

Kabza, Z., Kostyrko, K., Zator, S. et al. (2005). *Regulacja mikroklimatu pomieszczenia*. Warszawa: Agenda Wydawnicza PAK.

Przechowywanie uzbrojenia i sprzetu wojskowego wojsk ladowych. (2000). Warszawa: Dowodztwo Wojsk Ladowych, Szefostwo Sluzb Technicznych.

Stanecki, M. (2012). Lotniskowy osuszacz powietrza z WCBKT. *Technika Wojskowa*, no. 9, pp. 2-4.

Biographical notes

Leszek Jaskula – MAJ, DSc Eng., Senior Lecturer in the Department of Logistic Support; Graduate of the Faculty of Mechanical Engineering at the Military Academy of Technology in Warsaw and the Poznan University of Technology; Area of interest: construction and operation of motor vehicles; Co-author of articles on the strength of thin-walled multi-layer coatings and specialist textbooks on the construction and operating rules (including storage) of military vehicles.

Jedrzej Dzida – MAJ, MSc. Eng., Head of the Department of Logistic Support; Graduate of the Faculty of Mechanical Engineering at the Military Academy of Technology in Warsaw; Area of interest: construction and operation of motor vehicles; Co-author of specialist textbooks on the construction and operating rules (including storage) of military vehicles.

How to cite this paper

Jaskula, L. and Dzida, J. (2018). Storage as an important element in maintaining technical serviceability of military equipment. *Scientific Journal of the Military University of Land Forces*, vol. 50, no. 3(189), pp. 155-165, http://dx.doi.org/10.5604/01.3001.0012.6234