

APARATURA BADAWCZA I DYDAKTYCZNA

Selected aspects of corrosion protection testing on the example of salt spray chamber and components of grassland machinery in SaMASZ

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SUMMARY:

The paper presents selected aspects of corrosion protection testing of machine elements. The salt spray chamber is discussed, which is used in the method of checking anti-corrosion coatings. Sodium chloride was sprayed into the chamber. Its task is to show which coating meets the requirements and which should be further refined (find the reason causing the negative test result). This is a test that is performed at 35°C and 5% NaCl in the atmosphere. Tests in atomized neutral brine (NSS) are carried out according to PN-EN ISO 9227 and ISO 3574. The paper presents test results of sample measurements which were divided by surface preparation technologies, shot blasting, paint manufacturer, coating thickness and degree of detachment.

Wybrane aspekty badań pokryć antykorozyjnych na przykładzie komory solnej i elementów maszyn łąkarskich w przedsiębiorstwie SaMASZ

Słowa kluczowe: komora solna, ubytki korozyjne, procesy technologiczne

STRESZCZENIE:

W pracy zaprezentowano wybrane aspekty badań pokryć antykorozyjnych elementów maszyn. Omówiono komorę solną, która jest wykorzystywana w metodzie sprawdzania pokryć antykorozyjnych. W komorze rozpylony został chlorek sodu. Jego zadaniem jest pokazanie, która powłoka spełnia wymagania oraz która powinna zostać jeszcze dopracowana (znalezienie przyczyny odpowiedzialnej za negatywny wynik badania). Jest to badanie, które wykonuje się w temperaturze 35°C i 5% NaCl w atmosferze. Badania w rozpylonej obojętnej solance (NSS) prowadzone są wg PN-EN ISO 9227 oraz ISO 3574. W pracy przedstawiono wyniki badań pomiarów próbek, które zostały podzielone ze względu na technologie przygotowania powierzchni, śrutowanie, producenta farby, grubość powłoki oraz stopień odwarstwienia.

1. INTRODUCTION

Corrosion is the process of destruction of material due to chemical or electrochemical impact of the environment.

The corrosion phenomenon occurs on various materials, both metallic and many others. Destructive effects of the environment on ceramic materials, plastics and composites can be observed. The mechanism of corrosion of different materials depends on the type of electrical conductivity at the interface between the material and the environment and on the type of environment. Corrosion is electrochemical by nature mainly for high conductivity materials, whereas in the case of low conductivity or lack of conductivity, corrosion takes place as a chemical or physicochemical process [1], [2]. Where ion conductivity is not present, the destructive process takes place according to the chemical mechanism. The environments causing chemical corrosion of metals include: hot flue gases, oil and its derivatives, molten sulphur, a series of organic compounds and dry gases.

Corrosion resistant materials are those which may be used in aggressive environments without introducing additional protective treatments. The degree of resistance depends both on the composition and structure of the material and on the type of environment. Acidic environments are considered more aggressive in action on metals and their alloys, but some anions may strongly inhibit corrosion [3].

The methods of corrosion protection may include, inter alia, the salt spray chamber, which is used for early detection of losses.

2. DESCRIPTION OF SALT SPRAY CHAMBER SAMPLE TESTING

The salt spray is a test used to evaluate whether a tested product, and more specifically its coating or material (e.g. metal or organic coating), has corrosive properties. The purpose of the sodium chloride spray in the chamber is to indicate which coating meets the requirements and which coating should be further developed. This is an accelerated test (it takes place 100 times faster than the tests performed in natural environment), since it is usually performed at 35°C and 5% of NaCl in the atmosphere. After a certain time has elapsed, the samples are removed and analysed. The

analysis defines appearance, defects, number of defects, how defects are distributed and other aspects. Microscopic analysis is performed.



Figure 1 Photograph of the salt spray chamber in SaMASZ.
Source: own study

This allows the determination of the time after which the first changes on the sample begin to occur. The chamber is equipped with a heating control system that maintains the temperature under predefined conditions and in a device where brine is sprayed. This device has a pure air supply system with pressure control (within the range of 98 kPa \pm 10 kPa) and a NaCl spray tank. Compressed air supplied to nozzles should be cleaned from residues of oils and solids. Tests in neutral salt spray (NSS) are performed according to PN-EN ISO 9227. This standard includes the procedure for performing the test, the description of the instrumentation and the reagents used. The types of methods for evaluating the corrosivity of environments used for various tests can also be found there [5].

Corrosivity is evaluated to check the repeatability and reproducibility of the test results in a given chamber. To determine them, special reference samples made of CR4 steel, in accordance with ISO 3574, are tested in the salt spray chamber. After a reasonable time of exposure in the salt spray chamber, the reference samples are removed and appropriately cleaned, and then the loss of metal mass per square metre of the reference sample is determined. The instrumentation operates satisfactorily if, after a reasonable time, the loss of mass per surface of the reference sample falls within the standard ranges for each test. For the NSS test, it is (70 \pm 20) g/m² over 48 hours; for the AASS test, it is (40 \pm 10) g/m² over 24



Figure 2 Salt spray tank.
Source: own study

hours; and for the CASS test, it is (55 ± 15) g/m². PN-EN ISO 9227 also provides the methods of placing samples in the test chambers. The samples should be placed with the test surface facing upwards at an angle close to 20° relative to the vertical and in such a way, so that they do not come into contact with each other or with the chamber walls. The samples may be placed in the chambers at different levels, but care should be taken to prevent the solution or corrosion products from flowing out of the samples or holders from higher levels onto the samples underneath them. The salt spray tests are used only for comparative tests to determine whether the quality of the tested metal material is maintained with or without corrosion protection after a specified time [5]. Such measurements do not allow for comparison and division of different materials by their corrosion resistance. Tests intended to evaluate the behaviour of the samples in humid atmospheres are described in PN-EN ISO 6270-2:2006 [6].

3. INTERPRETATION OF TEST RESULTS

The method of exposing test samples in atmospheres with condensation water was used. Test atmospheres containing condensation water facilitate condensation on the test sample surfaces the temperature of which is lower than the temperature of saturated air in the humidity chamber. The reason for this condition is radiation of heat to the chamber walls or cooldown of the tested sample. The test atmosphere may be either constant humidity (CH) atmosphere, alternating humidity and temperature (AHT) atmosphere or

alternating temperature (AT) atmosphere. If, in addition to the condensation water, the test samples are affected by changes in temperature and humidity, it is recommended to select the alternating atmosphere. The amount of condensation water is significantly influenced by the ambient temperature in the chamber room and the temperature of the test sample [4]. Condensate dripping from the test samples consists of condensation water and, in some cases, solid and liquid components of exposed coatings, dissolved in or mixed with condensation water. In the case of a condensing atmosphere with alternating humidity and temperature, the entire test, which lasts 16 h including cooldown, should be carried out in an open or ventilated humidity chamber. For the same test period, but in an atmosphere with alternating air temperature, a closed humidity chamber should be used. For testing in warm and humid atmosphere, a vapour-tight climate chamber is required. It is usually equipped with a tray in the floor, serving as a water reservoir, the heating of which controls the climatic conditions within the chamber. Heating time depends to a significant extent on the type and number of samples as well as on the ratio of the water surface in the floor tray to the surface of the walls of the humidity chamber and to the water temperature. The test samples are exposed at any angle, not less than 60° from the horizontal, in such a way that they are not in close contact with each other and may adequately radiate heat energy [5], [6].

Table 1 presents the results of tests of samples of components of grassland machinery located in the salt spray chamber at different times. These test plates were divided by surface preparation methods, shot peening, paint manufacturer and coating thickness. Samples No 2–5 were prepared using zinc phosphating + cathodic coating (KTL) + powder coating and were tested over 1580 h. Non-shot-peened plates have much lower coating thickness and a higher degree of delamination as compared to the shot-peened samples. Components No 7–8 have surfaces made by means of iron phosphating + passivation, whereas samples No 10–11 were prepared using zinc phosphating + KTL + powder coating; they were immersed for the period of 1600 h. The samples made using iron phosphating + passivation have much thicker coating than the plates 10–11. Sample No 7 has the greatest degree of delamination (5.4 mm) from among the components No 7–11.

Table 1 Testing of coatings in the salt spray chamber according to PN-EN ISO 9227 (NSS).

Source: own study

Item / Sample No	Paint polymerisation parameters	Number of hours in the salt spray chamber	Surface preparation method	Sample shot-peened YES/NO*	RAL / paint manufacturer	Coating thickness (µm)	Degree of nation PN EN ISO 4628-8:2005
1/2	SUM – 210 degrees / 40 min PPR – 205 degrees / 65 min	1580	Zinc phosphating +KTL+ powder coating	NO	RAL 6017 INVER	65 µm	1.3 mm
2/3	SUM – 210 degrees / 40 min PPR – 205 degrees / 65 min	1580	Zinc phosphating +KTL+ powder coating	NO	RAL 6017 INVER	45-60 µm	2 mm
3/4	SUM – 210 degrees / 40 min PPR – 205 degrees / 65 min	1580	Zinc phosphating +KTL+ powder coating	YES	RAL 6017 INVER	90 µm	0.9 m
4/5	SUM – 210 degrees / 40 min PPR – 205 degrees / 65 min	1580	Zinc phosphating +KTL+ powder coating	YES	RAL 6017 INVER	100-120 µm	0 mm
5/7	Manual paint shop 195 degrees / 65 min	1600	Iron phosphating + passivation	NO	RAL3000 +podkład FreiLacke	112-134 µm	<u>5.4 mm</u>
6/8	Manual paint shop 195 degrees / 65 min	1600	Iron phosphating + passivation	YES	RAL3000 +podkład FreiLacke	165-195 µm	1.1 mm
7/10	SUM – 210 degrees / 40 min PPR – 205 degrees / 65 min	1600	Zinc phosphating +KTL+ powder coating	YES	RAL 2002 PPG	100-130 µm	1.7 mm
8/11	SUM – 210 degrees / 40 min PPR – 205 degrees / 65 min	1600	Zinc phosphating +KTL+ powder coating	NO	RAL 2002 PPG	110-125 µm	2.5 mm
9/12	Manual paint shop 195 degrees / 65 min	1080	Iron phosphating + passivation	YES	RAL 2008 INVER	105-108 µm	<u>5.7 mm</u>
10/13	Manual paint shop 195 degrees / 65 min	1080	Iron phosphating + passivation	NO	RAL 2008 INVER	110-117 µm	<u>7.3 mm</u>
11/14	SUM – 210 degrees / 40 min	912	Zinc phosphating +KTL	YES	PPG	40 µm	0 mm
12/15	SUM – 210 degrees / 40 min	912	Zinc phosphating +KTL	NO	PPG	20 µm	0.5 mm

Plates 12 and 13, which were prepared by means of iron phosphating + passivation, were placed inside the salt spray chamber for 1080 h. The non-shot-peened sample No 13 has a greater coating thickness and the largest degree of delamination out of the tested samples (7.3 mm). This resulted in delamination of the coating on the edge of the tested sample. Components No 14 and 15 were placed inside the salt spray chamber for 912 h. The plates were coated using zinc phosphating + KTL. Coating thickness of the shot-peened sample No 14 was 40 µm, whereas in the non-shot-peened sample No 15 – only 20 µm. In the plate No 14, the paint coating has not been delaminated, whereas in the sample No 15 it has delaminated to 0.5 mm.



Figure 3 Sample No 15.

Source: own study



Figure 4 Sample No 5.
Source: own study



Figure 6 Sample No 13.
Source: own study



Figure 5 Sample No 11.
Source: own study

4. CONCLUSIONS

The salt spray chamber is used for accelerated tests. This is the most common method used for several decades. It is intended to show in a short period how a given component will react to salt mist. When analysing the test results, it is possible to determine such aspects as appearance, defects, number of defects and the manner of their distribution.

In the examples described above, it can be noted that the tested samples showed minor deficiencies (between 0.5 mm and 7.3 mm) and a blister occurred in the last tested sample. Only two of the tested plates, namely No 5 and 14, met the requirements of the scope of the standards.

The paint manufacturer is not responsible for the occurrence of delamination, since it depends on the method of preparation of the sample for painting and the course of the entire coating application process.

The non-shot-peened plates have higher degree of delamination than the shot-peened samples. The degree of delamination does not depend on the plate thickness.

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