31 May 2013

BULLETIN

ZINKOMAG

Galvanized Steel Sheet with Improved Corrosion Resistance

ABSTRACT

U. S. Steel Košice Company is an integrated steel plant located in the Eastern Slovakia. Under the name **ZINKOMAG** the company offers progressive steel sheets with zinc-magnesium-aluminum coatings. These sheets are manufactured by hot dip galvanizing of steel in zinc alloy containing 0.8 to 1.0% Mg and 0.8 to 1.0% Al.
The main advantages of the **ZINKOMAG** are excellent corrosion resistance, excellent coating adhesion, high scratch resistance, low friction coefficient, good weldability, good paintability and extended lifetime of final products. **ZINKOMAG** in non-passivated and passivated state exhibits much better anti-corrosion properties than traditional GI (galvanized) coating and allows achieving a comparable or better corrosion resistance with only half of the coating weight. **ZINKOMAG** is an excellent choice in all industries where the traditional galvanized materials are used, particularly in environments prone to corrosion, e.g. in construction, engineering, consumer and automotive industry.

INTRODUCTION

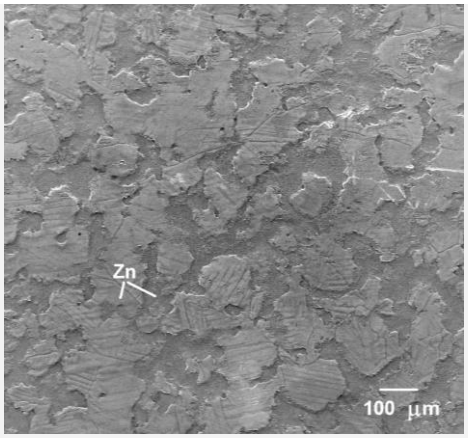
U. S. Steel Košice Company is an integrated steel plant located in the Eastern Slovakia. In the area of hot-dip galvanized sheets, its production program consists of production of the traditional hot dip galvanized sheets (galvanized – GI), sheets with iron-zinc coating (galvannealed - GA) as well as also progressive steel sheets with zinc-magnesium-aluminum coatings **(ZINKOMAG).** These sheets are produced by hot galvanizing in zinc alloy containing 0.8 to 1.0% Mg and 0.8 to 1.0% Al.

BASIC INFORMATION ABOUT PRODUCT

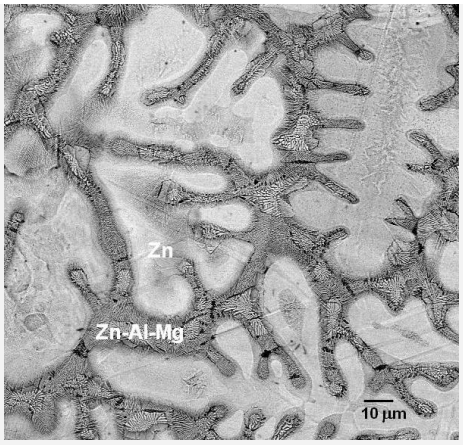
One of the most important features of galvanized steel sheets is their resistance to corrosion. Long-term corrosion protection of galvanized material is determined predominantly by coating thickness. Significant improvement in corrosion properties of the coated steel material can be also achieved by adjusting the chemical composition of the zinc coating. The presence of elements such as Mg and Al significantly increases the corrosion resistance of coatings.

Chemical composition of coating

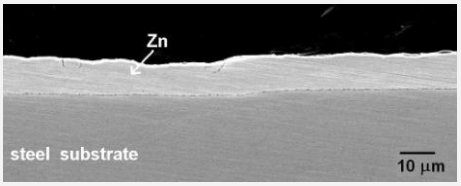
Zinc-magnesium-aluminum coatings are produced by hot dip galvanizing in zinc alloy containing 0.8 to 1.0% Mg and 0.8 to 1.0% Al. Compared to traditional zinc coatings, ZINKOMAG contains the areas enriched by the magnesium and aluminum, ***Fig. 1.*** Elements Mg and Al form protective stabilizing coating layer on the surface, thus providing the natural protection of the coated material and the slowing of material oxidation (corrosion) process.
Corrosion resistance of the coatings can be additionally increased by chemical passivation. The main task of chemical passivation is to provide temporary protection of galvanized steel surface against initial oxidation (white rust formation) during transportation and storage.



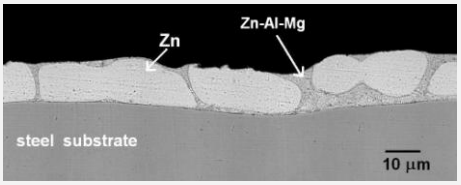
GI coating - surface



ZINKOMAG - surface



GI coating – cross-section



ZINKOMAG - cross-section

Fig. 1 *Structures of traditional GI coating and ZINKOMAG coating*

Hardness of coating

To measure coating hardness Knoop hardness test is usually used. This test is suitable for thin, or very brittle materials, where only a small indentation may be made for testing purposes (it is a microhardness test). A pyramidal diamond point is pressed into the polished surface of the test material with a known force, for a specified dwell time and the resulting indentation is measured using a microscope.

By this method it was found out, that while GI material has Knoop hardness about 40HK, microhardness of ZINKOMAG is about 70HK (5g load and LECO AMH 43 microscope were used). The increased microhardness of ZINKOMAG results in the higher scratch resistance in comparison to GI material.

Corrosion tests

Corrosion tests were carried out in aggressive atmosphere of neutral salt spray according to international standard STN EN ISO 9227. In the test the time till zinc coatings got rusted through was observed and the results were mutually compared. ***Fig. 2*** shows testing equipment, in which the corrosion tests were carried out.

Fig. 2 *Corrosion chamber SKBWF-1000A TR*

Corrosion test of chemically non-passivated surface

Non-passivated galvanized material is mainly used in those cases where it is intended for subsequent application of organic and inorganic layers. Therefore in the corrosion tests the attention is usually paid to the resistance of the coating to red rust appearance.

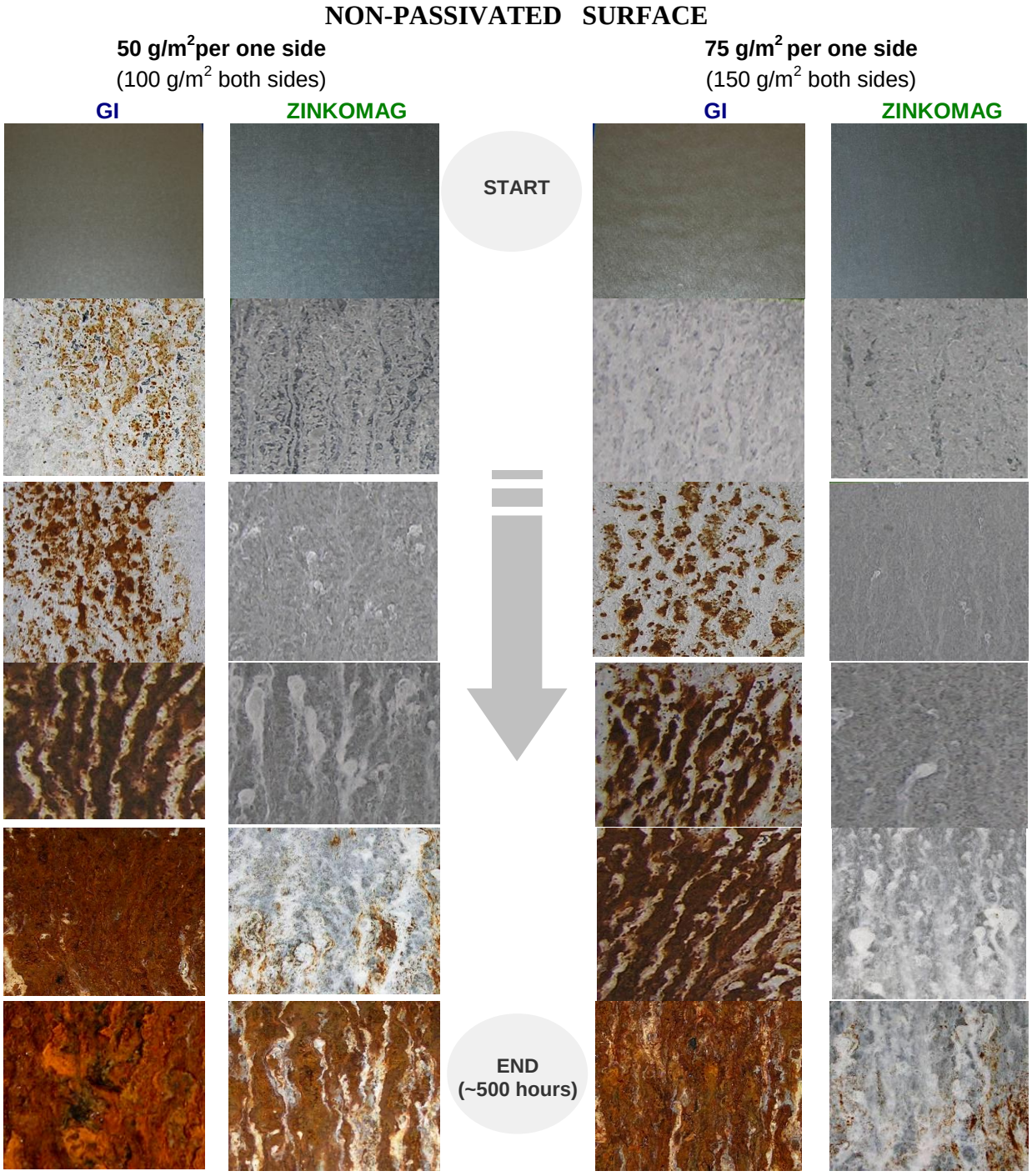


Fig. 3 *Illustration photo of corrosion attack on GI and ZINKOMAG coatings over time. Surface without chemical passivation treatment. Corrosive environment - a neutral salt spray.*

Fig. 3 shows kinetics of corrosion attack on two types of coatings (GI vs. ZINKOMAG) without chemical passivation protection. Both types of coatings had coating thickness of 50 and 75 g/m^2 per one side (100 and 150 g/m^2 both sides) and were exposed to corrosive environment in neutral salt spray according to STN EN ISO 9227 standard.

Corrosion test of chemically passivated surface

Corrosion resistance of the coatings can be additionally increased by chemical passivation. Specific corrosion resistance always depends on several factors, especially the actual coating thickness, type of passivation protection and content of present corrosion inhibitors, as well as the corrosive environment in which the sheet is located.

Indicative comparison of corrosion resistance of two types of zinc coatings (GI vs. ZINKOMAG) at two different coating weight - 50 and 75 g/m^2 per one side - without and with chemical passivation in corrosive environment of a neutral salt spray is shown in ***Fig. 4.***

.

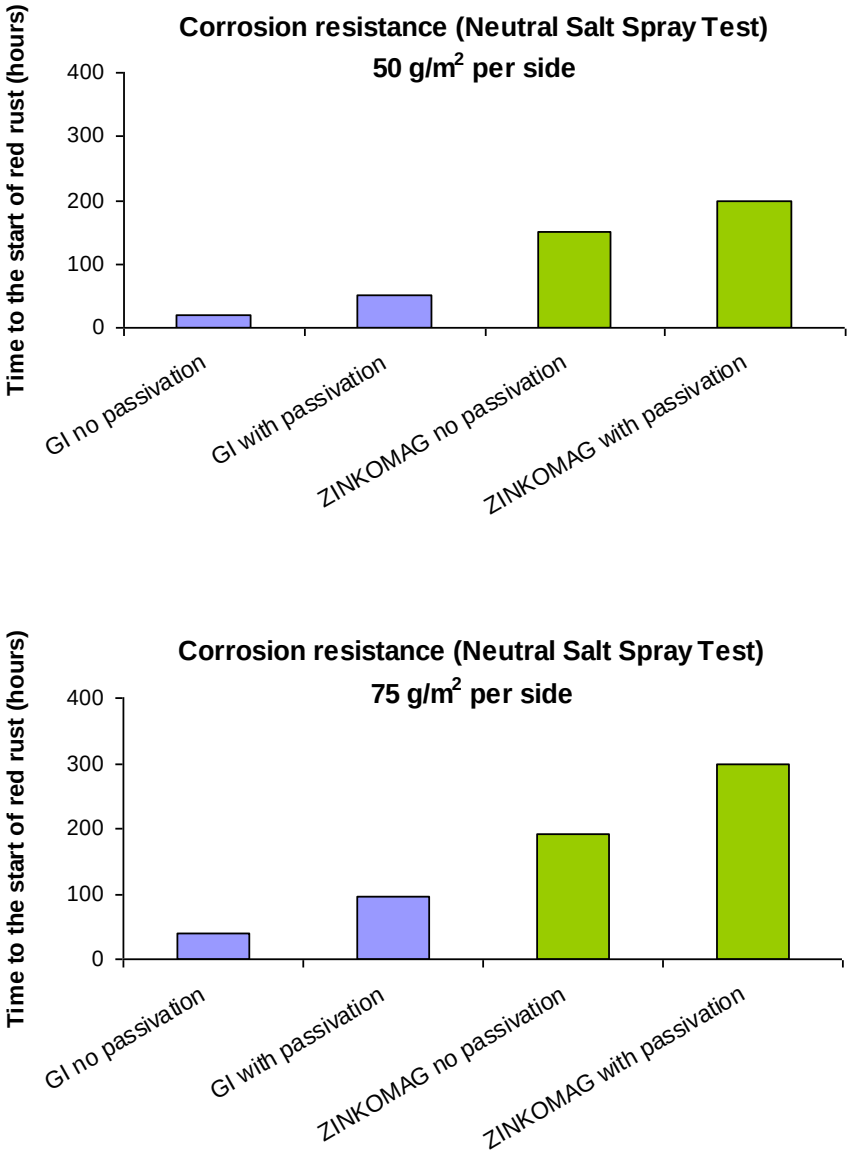


Fig. 4 *Indicative comparison of corrosion resistance of two types of zinc coatings (GI vs. ZINKOMAG) at two coating weights (50 g/m^2 and 75 g/m^2 per one side). Surface without and with chemical passivation treatment. Corrosive environment - a neutral salt spray.*

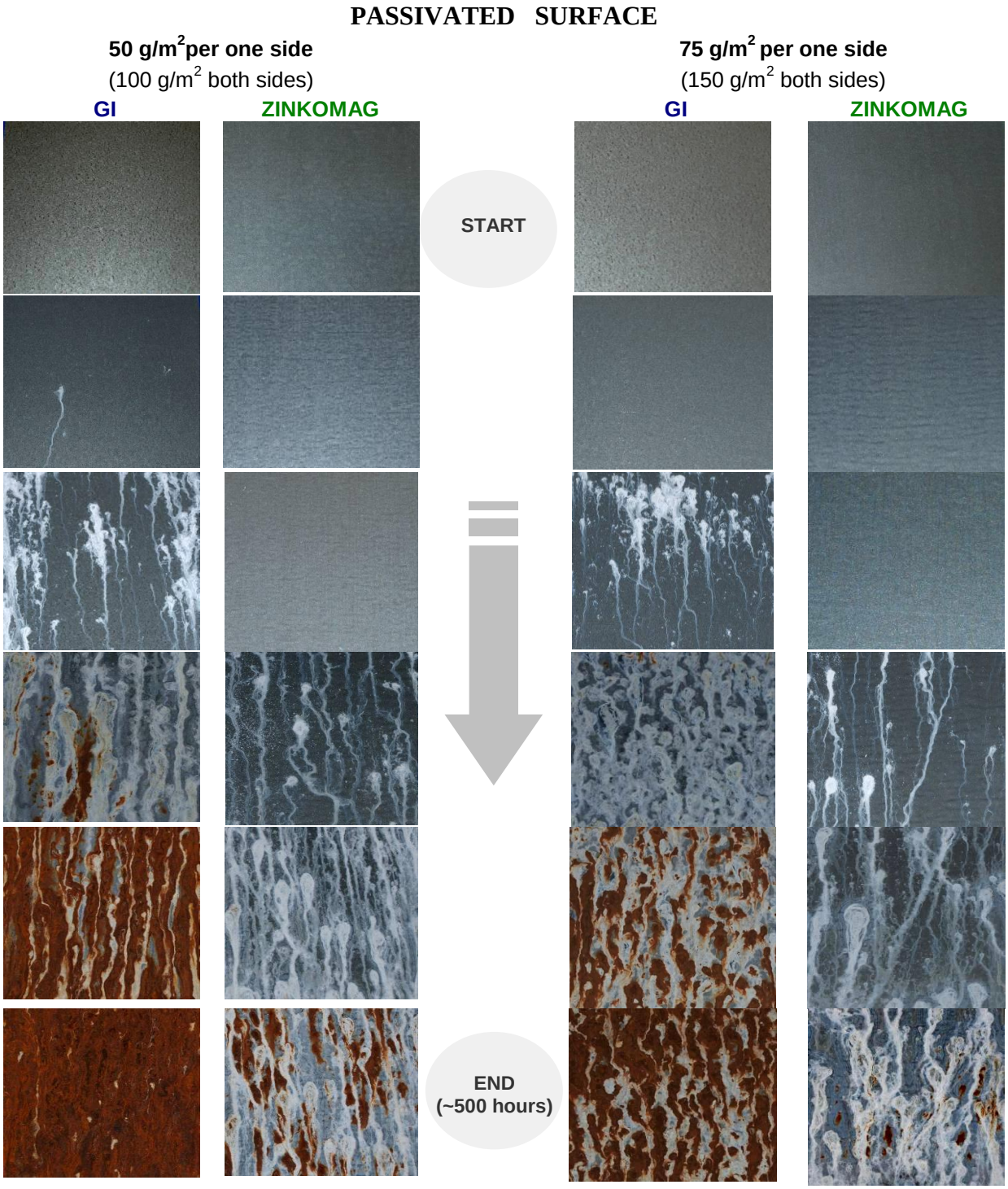


Fig. 5 *Illustration photo of corrosion attack on GI and ZINKOMAG coatings over time. Surface with chemical passivation treatment. Corrosive environment - a neutral salt spray.*

Fig. 5 illustrates the kinetics of corrosion attack on chemically passivated coatings (GI vs. ZINKOMAG) with thickness of 50 and 75 g/m^2 per one side and with the passivation layer with the same Cr^{3+} content in the neutral salt spray.

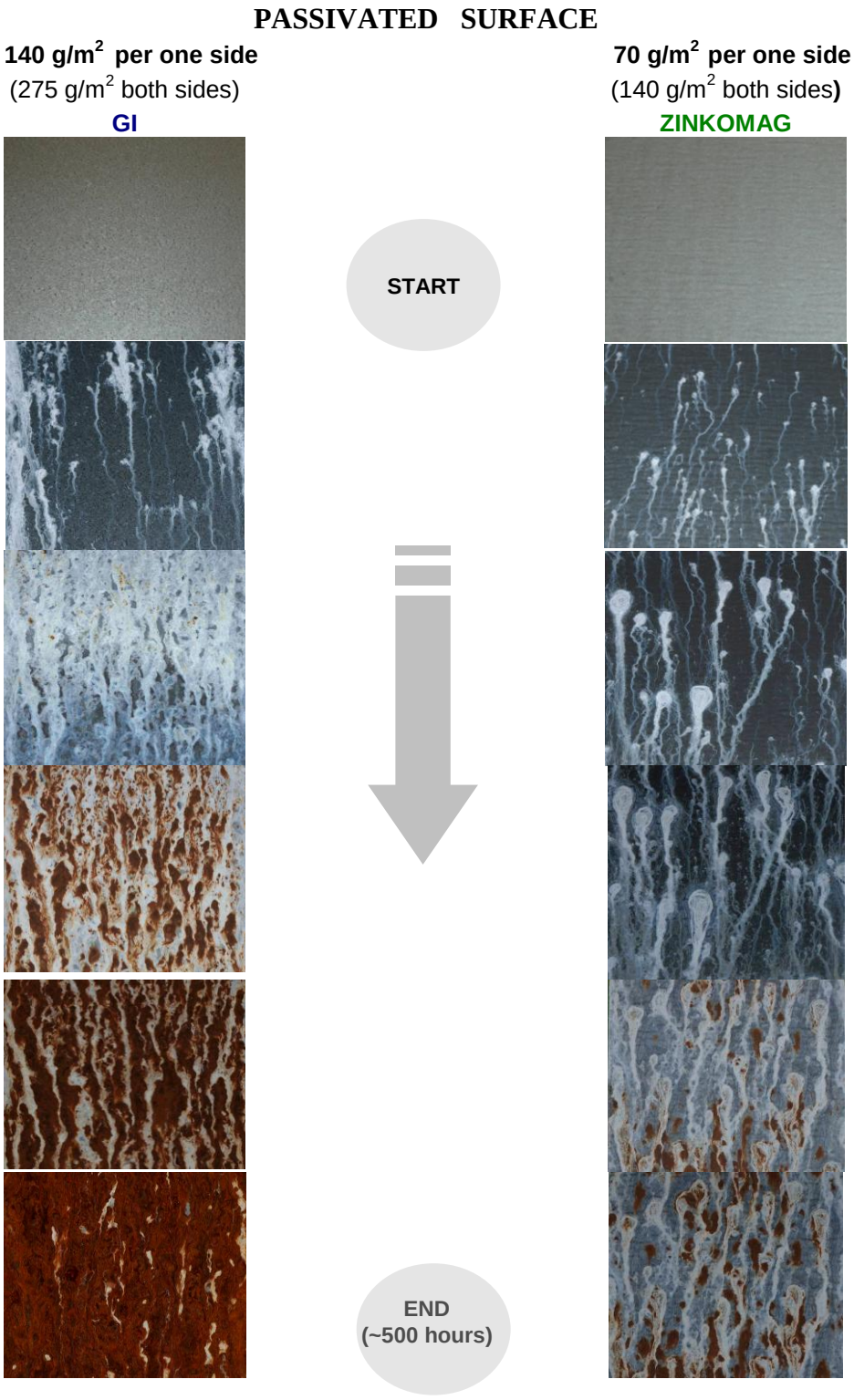


Fig. 6 *Illustration photo of corrosion attack on GI coating with thickness of 140 g/m^2 per one side (275 g/m^2 both sides) and on ZINKOMAG with thickness of 70 g/m^2 per one side (140 g/m^2 both sides) over time. Surface with chemical passivation treatment. Corrosive environment – a neutral salt spray.*

Perfect corrosion resistance of ZINKOMAG, in comparison with traditional GI coating, offers a possibility to reduce the typically used GI coating weight to half weight with ZINKOMAG, while keeping the same or better corrosion resistance of galvanized sheet. Results of corrosion test in neutral salt spray of GI coating with thickness of 140 g/m^2 per one side (275 g/m^2 both sides) and ZINKOMAG with thickness of 70 g/m^2 per one side (140 g/m^2 both sides) are documented in ***Fig. 6*** and ***Fig. 7.***

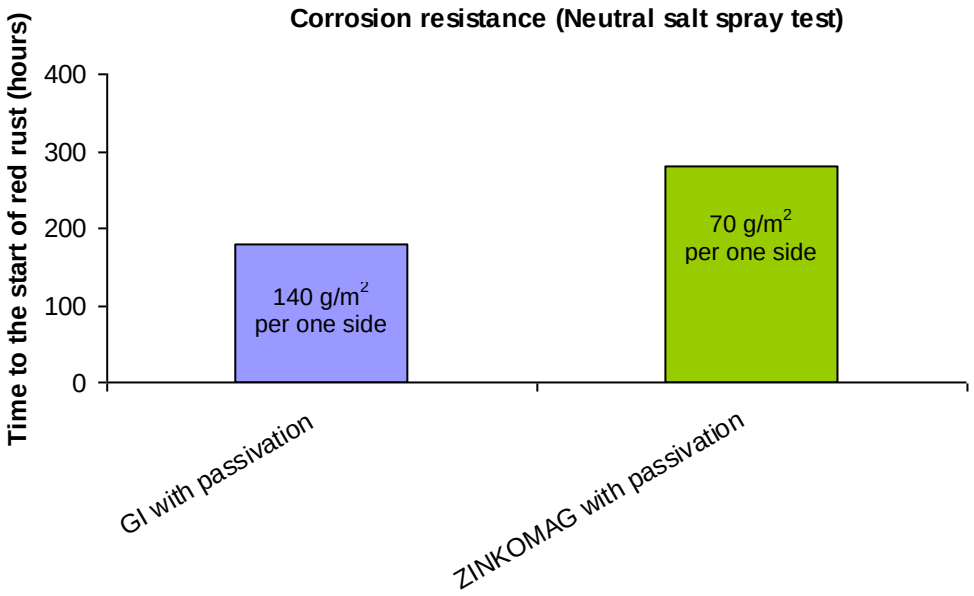


Fig. 7 *Informative comparison of corrosion resistance between two types of zinc coatings (GI vs. ZINKOMAG) at different coating weights – GI coating with thickness of 140 g/m^2 per one side (275 g/m^2 both sides) and ZINKOMAG with thickness of 70 g/m^2 per one side (140 g/m^2 both sides). Surface with chemical passivation treatment. Corrosive environment – a neutral salt spray.*

CONCLUSION

The main advantages of the **ZINKOMAG** are excellent corrosion resistance, excellent coating adhesion, high scratch resistance, low friction coefficient, very good weldability, good paintability and extended lifetime of final products. **The coating type ZINKOMAG in non-passivated and passivated state shows significantly better corrosion properties than GI-type coating and allows achieving a comparable or better corrosion resistance with only half of the coating weight, compared to traditional GI coatings.**

ZINKOMAG is an excellent choice in all industries where the traditional galvanized materials (GI) are used, particularly in environments prone to corrosion, e.g. in construction, engineering, consumer and automotive industry.