Subject Review

PRINCIPLES AND CRITERIA FOR THE EVALUATION OF THE CORROSIVITY OF ATMOSPHERIC ENVIRONMENTS ON STEEL STRUCTURES

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ABSTRACT

The paper presents the environmental impact on steel structures and the corrosivity of atmospheric environments. It defines the principles and criteria for the evaluation of atmospheric-corrosivity classes, according to European standard, which were introduced in the new technical national regulations in the field of corrosion protection of steel structures. It shows the equivalence between the new corrosivity classes and the old aggressivity classes according to Romanian standard, still in force. The examples of typical environments corresponding to the corrosivity classes are also presented.

Keywords: corrosivity classes; aggressivity classes; corrosion rate.

REZUMAT

În lucrare se prezintă impactul mediului asupra structurilor din oțel şi corozivitatea mediilor atmosferice. Se definesc principiile şi criteriile de evaluare a claselor de corozivitate atmosferică, în conformitate cu prevederile standardului european, care au fost introduse în noile reglementări tehnice naționale în domeniul protecției împotriva coroziunii a structurilor din oțel. Se arată echivalența între noile clase de corozivitate şi vechile clase de agresivitate în conformitate cu standardul românesc, in vigoare. Se prezintă, de asemenea, exemple de medii tipice corespunzătoare claselor de corozivitate.

Cuvinte cheie: clase de corozivitate; clase de agresivitate; viteză de coroziune.

1. INTRODUCTION

1.1. General

It is known that the *protection against corrosion* of constructions is an essential component part of durability, which expresses the capacity of the construction to preserve the initial performances during its whole lifetime. Durability is implicitly contained in all six essential requirements from Construction Products Directive (CPD) 89/106/EEC (EC, 1989), directive transposed in our country through HG 622/2004 which establishes the conditions of introducing the construction products on the market (Government of Romania, 2004). Internationally, the implicit requirement regarding durability and corrosion of the steel constructions under the action of aggressive agents is reflected in UE norms as follows:

- CPD, Interpretative Documents for the application of CPD and Guide F of European Commission on durability;
- SR EN 1993 (Eurocode 3), for the design of steel structures (ASRO, 2006), which contains one subchapter of durability, where there the factors to be referred to are stipulated, among which the environmental conditions, for adequate protection of materials;
- European standards series SR EN ISO 12944 (ASRO, 2002), which include the new corrosivity classes for steel constructions;
- European standards in the field of protection against corrosion, recently adopted internationally, and also the standards in progress.

On July 1, 2013, Regulation (EU) No. 305/2011 shall come into force, laying down harmonised conditions for the marketing of construction products that explicitly contained the durability of the construction works in one of the seven basic requirements for constructions, namely the fundamental requirement 7 "Sustainable use of natural resources" (EC, 2011).

In the last few years, some technical regulations in the field of protection of constructions against corrosion have been issued in Romania and some others, existing before 1989, have been revised, with the purpose of creating the normative frame to implement them.

The issue of these technical regulations has been processed in phases, depending on the necessities on the national plan. There have also been adopted some European standards in this field, through translation or through confirmation sheet.

In this context, the new technical regulation GP 111 (MTCT, 2005) aims to revise, modify and complete the technical national regulation GP 035 (MLPAT, 1998), in order to align and correlate it to the European standards series SR EN ISO 12944 regarding the protection of steel structures against corrosion. Some of these European standards were initially adopted in our country by *reproduction of the official version (confirmation sheet).* Subsequently, some of these European standards have been translated.

One of the important innovations in the European standard SR EN ISO 12944-2 (ASRO, 2002) is the introduction of the corrosivity classes, for the classification of the aggressive atmospheric environments on steel structures.

This paper presents the principles and criteria for the evaluation of atmospheric-corrosivity classes on metallic structures, according to European harmonised standard SR EN ISO 12944-2, by comparing them with the old aggressivity classes from the Romanian standard STAS 10128 (ASRO 1986), still in force, and shows the equivalence between these two types of classification. The examples of typical atmospheric aggressive environments corresponding to the corrosivity classes are also presented.

2. EVALUATION OF THE CORROSIVITY CLASES

In the European approach, according to the European harmonized standard SR EN ISO 12944-2, the intensity of atmospheric environments action on steel constructions and on their members is classified into six atmospheric *corrosivity classes*:

- C1 - very low;
- C2 - low;
- C3 - medium;
- C4 - high;
- C5 - I - very high (industrial);
- C5 - M - very high (marine).

To determine the *corrosivity classes*, the main criterion is based on corrosion rate measurement of standard metallic specimens, expressed as mass or thickness loss, according to SR EN ISO 9226 (ASRO, 2012 a).

Table 1 presents, for each corrosivity class, the corrosion rates after one year of exposure, for low-carbon steel and zinc.

Table 1. *Atmospheric-corrosivity classes*

Corrosivity class	Corrosion rate: Mass loss per unit surface/thickness loss (1) (after first year of exposure)			
	Low-carbon steel		Zinc	
	Mass loss g/m^2	Thickness loss μm	Mass loss g/m^2	Thickness loss μm
C1	≤ 10	≤ 1,3	≤ 0,7	≤ 0,1
C2	> 10 to 200	> 1,3 to 25	> 0,7 to ≤ 5	> 0,1 to 0,7
C3	> 200 to 400	> 25 to 50	> 5 to 15	> 0, to 2,1
C4	> 400 to 650	> 50 to 80	> 15 to 30	> 2,1 to 4,2
C5 - I	> 650 to 1500	> 80 to 200	> 30 to 60	> 4,2 to 8,4
C5 - M	> 650 to 1500	> 80 to 200	> 30 to 60	> 4,2 to 8,4

(1) The loss values used for the corrosivity classes are identical to those given in SR EN ISO 9223.

Corrosivity classes can also be estimated by considering the combined effect of the following environmental factors: yearly time of wetness, yearly mean concentration of sulphur dioxide and yearly mean deposition of chloride, according to SR EN ISO 9223 (ASRO, 2012 b). This new classification of atmospheric environments as corrosivity classes was introduced in the new technical regulation on protection against corrosion of steel constructions (GP 111).

3. EVALUATION OF THE CORROSIVITY CLASES

In accordance with the provisions of the Romanian standard STAS 10128, also in force, the action of the aggressive atmospheric environments on steel constructions is classified into four aggressivity classes:

- 1m - non-aggressive;
- 2m - low aggressive;
- 3m - with medium aggressivity;
- 4m - with high aggressivity.

This classification of the aggressive environments has been introduced in the old technical regulation GP 035 regarding the protection of steel constructions against corrosion.

The aggressivity class is established depending on:

- physical state and the nature of the aggressive agents;
- the environment types, justified only in case necessary data are not available for classification according to the first method.

The aggressivity class of the environments with aggressive agents in gaseous state is established depending on the relative humidity of the air, the environment temperature and the aggressive gases characteristic, according to Table 2.

Table 2. Atmospheric-aggressivity class: aggressive gases

Aggressivity class of the environment	Relative air humidity, %	Temperature of the environment, °C	Characteristic of aggressive gases(1)
1m	61…75 ≤ 60	max. 50	without aggressive gases aggressive gases in group A
2m	> 75 61…75 ≤ 60	max. 50	without aggressive gases aggressive gases in group A aggressive gases in group B
3m	> 75 61…75 ≤ 60	max. 50	aggressive gases in group A aggressive gases in group B aggressive gases in group C
4m	> 75 61…75	max. 50	aggressive gases in group B aggressive gases in group C

(1) Aggressive gases in group A: SO_2<0.1; H_2S<0.01; HF<0.01; HCl<0.015; Cl_2<0.03; NH_3<0.50; NO, NO_2<0.05 mg/m^3 air).
Aggressive gases in group B: SO_2-0.1…5; H_2S-0.01…0.5; HF-0.01…0.3; HCl-0.015…0.5; Cl_2-0.03…0.5; NH_3- 0,50…5; NO, NO_2-0,05…1,5 (mg/m^3 air).
Aggressive gases in group C: SO_2-5.1…20; H_2S-0.51…10; HF-0.31…2; HCl-0.51…5; Cl_2-0.51…2; NH_3-5.1…30; NO, NO_2-1.51…10 (mg/m^3 air).

The aggressivity class of the environments with aggressive agents in solid state inside the constructions is established depending on the relative humidity of the air and on the solid characteristic, as shown in Table 3.

Depending on the environment types, the aggressivity class is established according to Table 4.

In STAS 10128, the possibility to establish the aggressivity class, approximately, depending on the value of the penetration (corrosion) index, is also stipulated.

Table 3. Atmospheric-aggressivity class: aggressive solids

Aggressivity class of the environment	Relative humidity of air, %	Characteristics of the solid (1), (2)
1m	61…75 ≤ 60	slightly soluble easily soluble - slightly hygroscopic
2m	> 75 61…75 ≤ 60	slightly soluble easily soluble - slightly hygroscopic easily soluble - hygroscopic
3m	> 75 61…75	easily soluble - slightly hygroscopic easily soluble - hygroscopic
4m	> 75	easily soluble - hygroscopic

(1) Slightly soluble solids: silica powder, calcium carbonate, iron oxide, aluminium oxide, iron hydroxide, etc.
Easily soluble-slightly hygroscopic solids: sodium chloride*, potassium chloride*, ammonium chloride*, sodium sulphate*, potassium sulphate*, ammonium sulphate*, calcium sulphate, potassium nitrate*, magnesium nitrate, sodium carbonate, potassium carbonate, calcium hydroxide, etc.
Easily soluble-hygroscopic solids: calcium chloride, calcium fluoride, magnesium fluoride*, aluminium fluoride*, iron sulphate, magnesium sulphate*, zinc sulphate, ammonium nitrate*, primary phosphates, secondary sodium phosphate, sodium hydroxide, potassium hydroxide, etc.

(2) The environments with solids of increased aggressivity, marked with an asterisk, confer aggressivity class 4m, regardless of the characteristics of the solid and the relative humidity of the air.

Table 4. Aggressivity class - environment type

Aggressivity class of the environment	Environment type
1m	rural
2m	urban
3m	industrial
4m	chemical

4. CORROSIVITY-AGGRESSIVITY CLASSES EQUIVALENCE

Table 5 synthetically presents the *corrosivity classes* stipulated in SR EN ISO 12944-2 and the *aggressivity classes* stipulated in STAS 10128, depending on the corrosion rate of the steel.

Table 5. Corrosivity and aggressivity classes depending on the corrosion rate of the steel

Corrosivity class (SR EN ISO 12944-2)	Corrosion rate of steel, μm/year (SR EN ISO 12944-2)	Aggressivity class (STAS 10128)	Corrosion rate of steel, μm/year (STAS 10128)
C1	≤ 1,3	1m	< 10
C2	1,3…25	2m	11…100
C3	25…50	3m	110…500
C4	50…80	4m	> 500
C5 - I	80…200		-
C5 - M	80…200		-

Table 6 shows the equivalence between the corrosivity classes and the aggressivity classes**,** as results from the comparison of the values of the corrosion rate of the steel shown in Table 5.

Table 6. Corrosivity-aggressivity classes equivalence

Corrosivity class	Aggressivity class
C1	1m
C2	1m….2m
C3	2m
C4	2m
C5 - I	2m…3m
C5 - M	2m…3m
Not stipulated in the SR EN ISO 12944-2	4m

By comparing the values of the corrosion rate of steel corresponding to the corrosivity and aggressivity classes, results the following:

- the values of the corrosion rate are significantly higher in case of the aggressivity classes, as compared to the corrosivity classes;
- the values of the corrosion rate corresponding to the aggressivity class 4m (> 500 μm/year) and, partially, to the aggressivity class 3m (110...500 μm/year), are larger than the values of the corrosion rate corresponding to the corrosivity classes C5 - I and C5 – M (80…200 μm/year).

Consequently, the environments with aggressivity class 4m and, partially, those with aggressivity class 3m, characterized by values of corrosion rate above 500 μm/year, respectively over 200 μm/year, are not stipulated in the European harmonized standard SR EN ISO 12944-2 and, implicitly, in the new national technical regulation, GP 111.

In this context, the cancellation or revision of the Romanian standard STAS 10128 is required, in order to correlate with the harmonized European standard.

5. EXAMPLES OF TYPICAL ATMOSPHERIC ENVIRONMENTS

The examples of typical atmospheric aggressive environments that can be found outside and inside metallic constructions, corresponding to the corrosivity classes, according to European harmonized standard SR EN ISO 12944-2, are presented in Table 7.

Table 7. Examples of typical environments

Corrosivity class	Examples of typical environments (informative only)	
	Outdoor	Indoor
C1 very low	-	Heated buildings, with clean atmospheres, e.g. offices, shops, schools, hotels.
C2 low	Atmospheres with low level of pollution Mostly rural areas.	Unheated buildings where condensation may occur, e.g. depots, sport halls.
C3 medium	Urban and industrial atmospheres with moderate sulphur dioxide pollution. Coastal areas with low salinity.	Production rooms with high humidity and some air pollution, e.g. food-processing plants, laundries, breweries, dairies.
C4 high	Industrial areas and coastal areas with moderate salinity.	Chemical plants, swimming pools, coastal ship-and boatyards.
C5 – I very high (industrial)	Industrial atmospheres with high humidity and aggressive atmosphere.	Buildings or areas with almost permanent condensation and with high pollution.
C5 – M very high (marine)	Coastal and offshore areas with high salinity.	Buildings or areas with almost permanent condensation and with high pollution.

6. CONCLUSIONS

By the introduction of the new corrosivity classes in the national technical regulation, its alignment and correlation with the European harmonized standard in the field of protection of steel structures against corrosion has been achieved.

In order to improve the adjustment /adaptation of the specific national regulations in this field, it is necessary to adopt the harmonized European Standards through integral translation and not by the reproduction of the official version (confirmation sheet).

The activity of adaptation of the national technical regulations, required by the harmonization with the European legislation, has to achieve an agreement between the specific technical regulations and the legal stipulations regarding the introduction of construction products on the market in order to facilitate the application of quality systems in constructions.

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