Corrosivity measures

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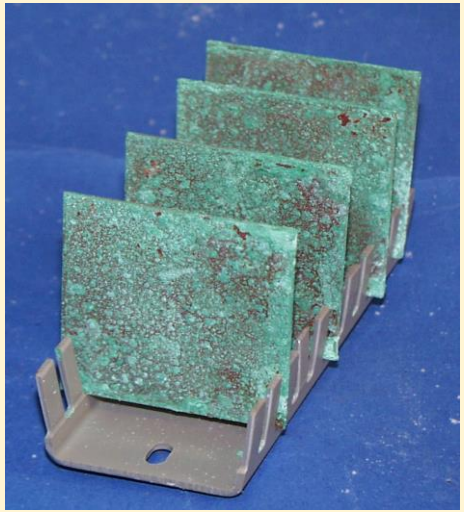
Corrosivity measures – *using:*

- ***Metal coupons***
- *Aircorr (will be presented by D. Thierry, RISE)*
- *Mobile testing (will be presented by C. Schneiker, RISE)*

Metal coupons:

- ✓ **Mass loss (balance)**
- ✓ **Weight increase (balance)**
- ✓ Cathodic Reduction (electrochemical set-up)
- ✓ Corrosion Products Analysis (XRD/SEM-EDX/FTIR)/…



Estimate *Lifetime of products* from field exposure values to using accelerated test methods:

- ***Metal loss values***
- *weight increase values*

To calculate exposure time in an accelerated corrosion test method:

here: **ISO 21207 method B:**

1. Estimate life-time in a standard environment (requirements from customer)
   ex. C3, according to ISO 9224
2. *In all calculations regarding corrosion rate, according to ISO 9224, a span of ± 50% in mass loss must be taken into account !!*
3. Estimate life-time in your specific environment
   → calculate from ex. 1 year exposure to desired time

Methodology:

Metal loss

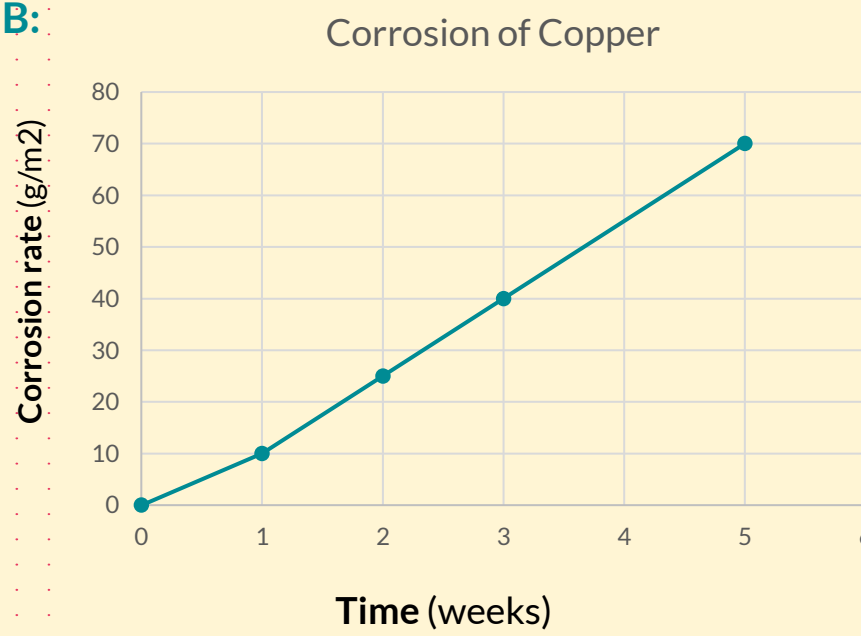
ISO 21207 method B

According to Corrosion rate in ISO 21207, method B:

- **Three weeks is equal to = 40 g/m^2:**

What is the estimated years in

C3 or C4 (according to ISO 9224)?



According to ISO 9224:2012

40 g/m^2 metall loss is reached after:

- *Ex. C4 → 2 years*
- *Ex. C3 → ca. 6 years*

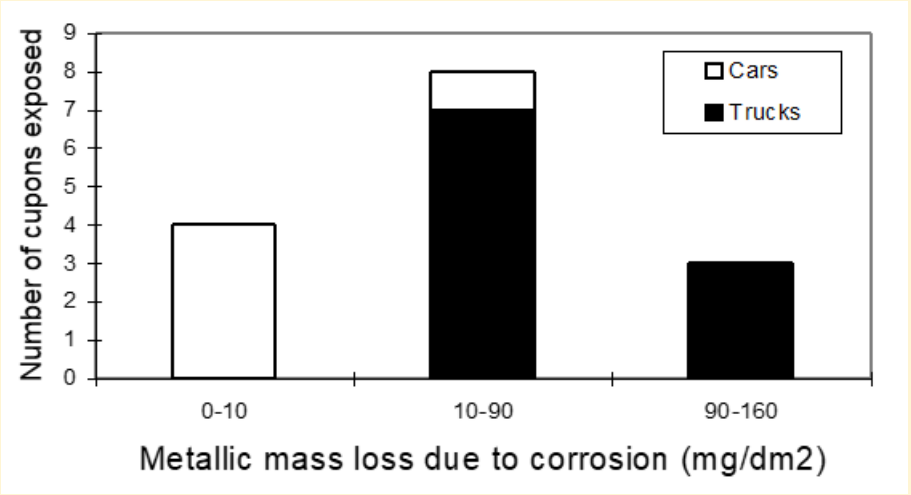
Metal	Corrosivity category	Exposure time years					
		1	2	5	10	15	20
Copper	C1	0,9	1,4	2,6	4,2	5,5	6,6
	C2	5	8	20	23	30	37
	C3	12	19	35	56	73	88
	C4	25	40	73	116	152	184
	C5	50	79	146	232	304	368
	CX	90	143	263	418	548	664

(the table shows maximum corrosion in resp. corrosivity class!)

Metal loss

2. Estimate life-time in your specific environment
- extrapolating from 1 to 10 years

Copper exposed in vehicle – 1 year



Corrosion (1 year) = 5000 mg/m^2

Calculating 10 years corrosion after 1 years exposure

$$Corr\ (t) = Corr_{1\ year} \times t^{x} \qquad (Eq.1)$$

Calculation of 10 years

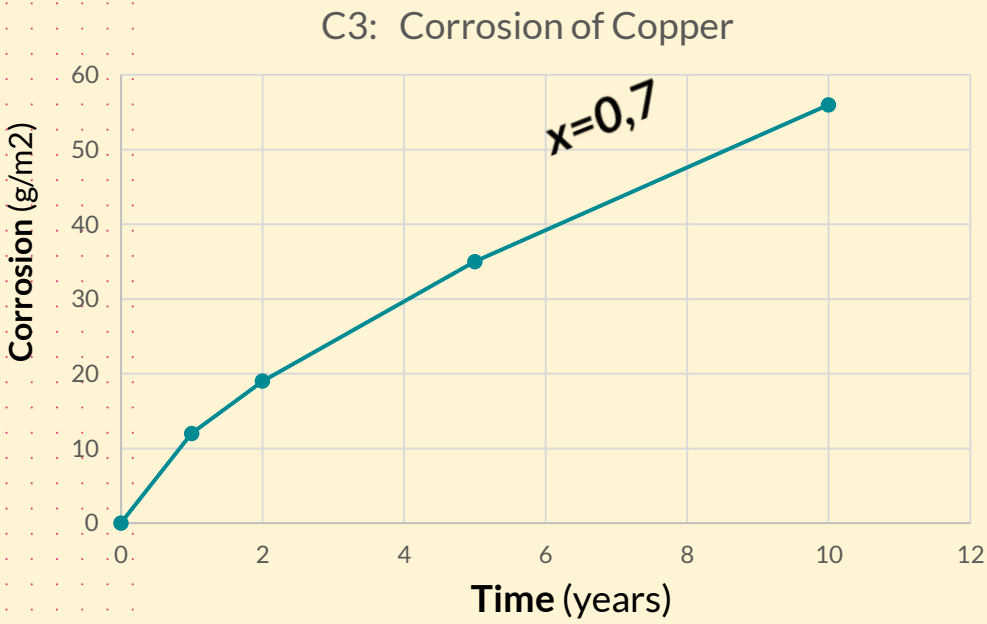
Corr (10 years)= corrosion after 10 year = **??**

$Corr_{1\ year}$ = corrosion after 1 year = $5\ g/m^2$

t = time, in years = 10 years

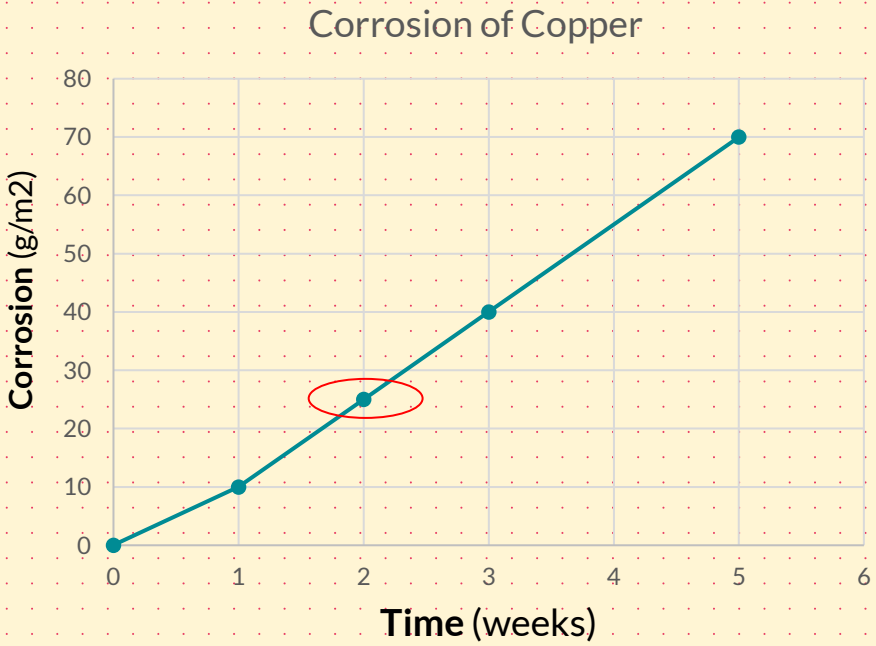
x = curvature of the corrosion curve = 0,7

$$Corr\ (10\ years) = 5\ g/m^2 * 10^{0,7} = 25\ g/m^2 \qquad (Eq.1)$$



How many weeks in ISO 21207, method B is this equal to?

A. According to ISO 21207, ***Table 1.***



B. Calculating from Eq.1

In general:

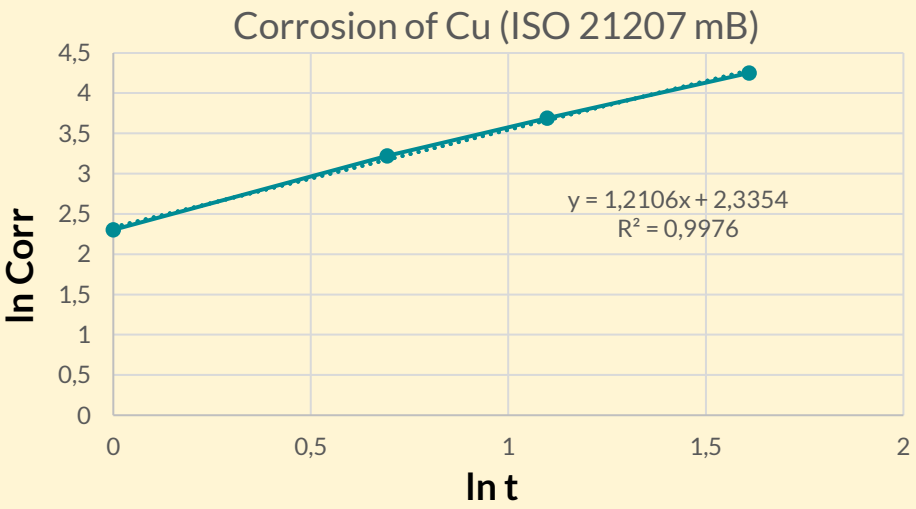
$Corr\ (t) = Corr_{1\ year} \times t^{x}$ ***(Eq.1)***

$\ln Corr\ (t) = \ln Corr_{0} + x \ln t$

Calculate the corrosion equation for the corrosion in question

How many weeks in ISO 21207, method B, is this equal to….?

B. Calculating from Eq.1



In general:

$Corr\ (t) = Corr_{1\ year} \times t^{x}$ *(Eq.1)*

$\ln Corr\ (t) = \ln Corr_0 + x \ln t$

Calculate the slope (x) for the corrosion in question

For ISO 21207 method B:

X= 1,21

The corrosion curve for ISO 21207 method B

$Corr\ (t) = C_o * t^{1,21}$; $C_o = 10\ g/m^2$

Estimate time in corrosivity class (in field) from exposure in an accelererated corrosion test:

- *metal loss values*
- **Weight increase values**

Ex. IEC 60068-2-60, method 4

Three weeks is equal to = 180 mg/m^2/day x 21 days = 3800 mg/m^2

- *What is the estimated years in C2 (according to ISO 11844-1:2006)?*

Estimation of years in C2

ISO 11844-1:2006

Calculation of $Corr_{cu}$ (t) = $Corr_{1\ year}$ x t^x

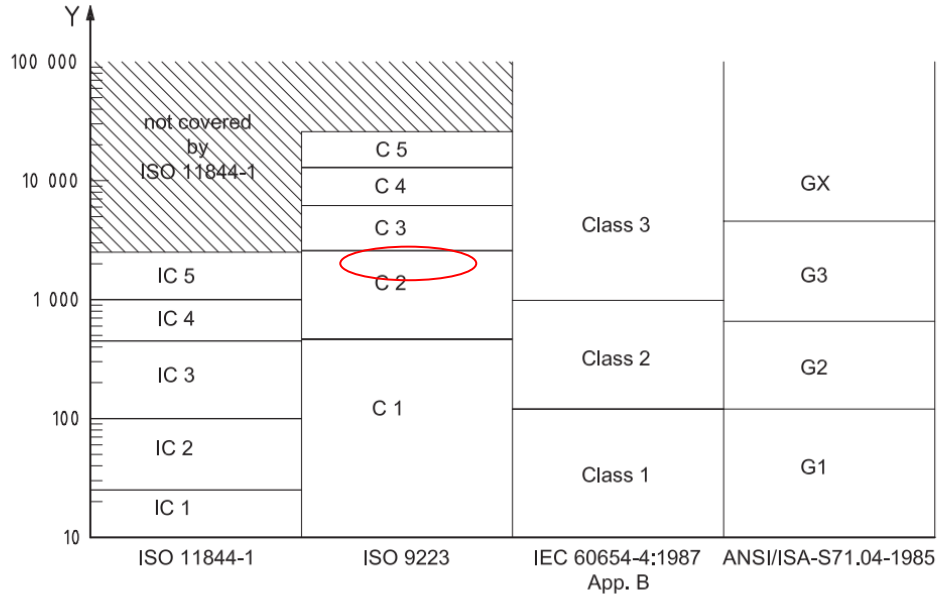
For 3800 mg/m²

$t = e^{(\ln((Corr,tot) / (Corr, 1\ year)) / x)}$

Where:

Corr.tot = 3800 mg/m²
Corr, 1 year = 2000 mg/m²
X = 0,7

Time (t) = $e^{[\ln(3800/3000))/0,7)]}$ = 1,8 years



Key
Y Mass increase after 1 year of exposure (mg/m²)

Figure A.2 — Copper corrosivity classification according to ISO, IEC and ISA

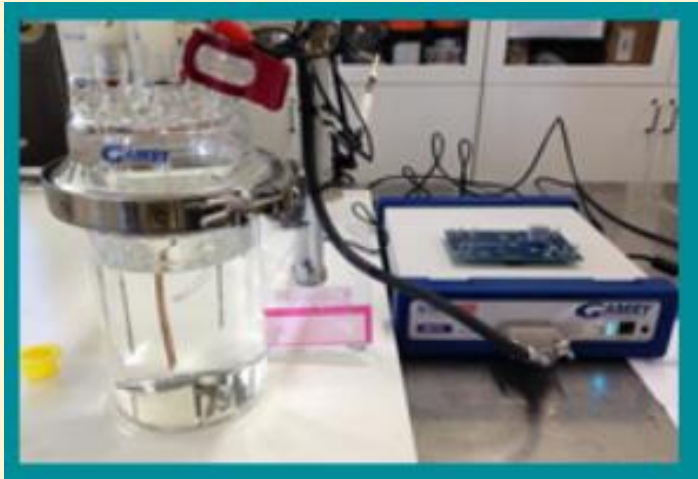
methodolgy: **Cathodic reduction**

- This method is used when the corrosion rate is very low (consequently thin corrosion products layers)!

- Used in the standard **ANSI/ISA-71.04-2013**

(ANSI = American National Standards Institute)

(ISA = International Society of Automation)



methodolgy: Cathodic reduction

The corrosion layer after 30 days is measured using

$$x1 = x(t1/t)^{A}$$

Where:

x1 = is the equivalent film thickness after 30 days

x = is the measured film thickness after time t

t1 = is thirty days

t = is the actual test time (days)

A = is equal to 0.3 for G1, 0.5 for G2, and 1 for G3 and GX

methodolgy: Cathodic reduction

The corrosivity is thereafter decided according to the G-classification:

Severity level	G1 - Mild	G2 - Moderate	G3 - Harsh	GX - Severe
Copper reactivity level (in angstroms)*	< 300	< 1000	< 2000	≥2000
Silver reactivity level (in angstroms)*	< 200	< 1000	< 2000	≥2000

*Normalized to a 30-day exposure. 1 angstrom = one hundred-millionth of a centimeter, or 10^{-10} meter.

Field values – can be find in the following standards:

- *ISO 9224 (metal loss)*
- *ISO 11844 (weight increase)*
- *ISA 71.04 (cathodic reduction)*