Which Metal Dissolves Is Settled by the Table; How Fast It Dissolves Is Settled by a Quantity the Table Does Not List

— When dissimilar metals touch, the rate at which the anode is consumed is set not by the current but by the current density — so the cathode-to-anode area ratio enters directly, and moving that ratio from **0.01** to **100** opens a factor of **10000.000000** — the separator is the cathode-to-anode area ratio — [Paper 715]

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— From thinking to syncing. —

Abstract

The textbook answer to galvanic corrosion is the galvanic series. It settles which metal dissolves. But how fast it dissolves is settled by a quantity that series does not list.How many orders the area ratio is worth is counted.No new theorem or law is claimed. First, what enters is the current density, not the current——the rate of loss is the total current divided by the anode area (Section 2). **Second, and this is the core. The area ratio is worth four orders——moving the cathode-to-anode ratio from 0.01 to 100 opens a factor of 10000.000000** (Section 2). **Third, converting to thickness makes it concrete——with iron's electrochemical equivalent of 0.000289396 g/C, 10^{-5} A on 10^{-4} m² removes 0.115985 mm in a year** (Section 3). **Fourth, the same current on a larger anode does far less——an anode of 10^{-2} m² loses 100.000000 times less, with the current unchanged** (Section 3). **Fifth, so a table of materials is not yet a design——the same pair can be practically harmless or as bad as possible, depending on how the areas are arranged** (Section 3). **Sixth, the separator is the cathode-to-anode area ratio——what sets the sign and what sets the magnitude are different quantities** (Section 4). **Keywords**: galvanic corrosion, current density, area ratio, electrochemical equivalent, sign against magnitude, limits of a materials table.

Scope of this paper (scope note): **No new theorem or law is claimed——the effect of area ratio in galvanic corrosion is a basic point of corrosion engineering (Faraday 1834, Jones 1996).The galvanic series is not claimed——which metal takes which role is not tabulated; the sign is received as settled.Polarisation is not treated——that the actual current is not set by potential difference alone is not entered; the total current is assumed.Environment is not discussed——salinity, humidity and temperature are not treated.Countermeasures are not designed——insulation, painting and sacrificial anodes are not designed here.Dissolution is taken as uniform——local concentration such as pitting is not treated; the thicknesses shown are averages.Relation to earlier papers**: **Paper 440 showed that to protect something, something must dissolve first——there the sign of the potential difference settled which metal dissolves, and the same cell was being used. Here the same cell is the harm, and once the sign is settled the area ratio decides how fast, across four orders.**What is added is **stating explicitly that current density is what enters**, **putting the span of the area ratio at 10000.000000**, **converting to a thickness of 0.115985 mm per year**, **showing that widening the anode gives 100.000000 times less**, and **placing the separator on the area ratio**.

1. Notation and the Question

Setting: **when dissimilar metals touch and form a cell, a total current I flows. The rate at which the anode is consumed is set not by I but by I divided by the anode area.**

$$i_a = \frac{I}{A_a}, \qquad m = K\,I\,t, \qquad d = \frac{m}{\rho A_a}$$

K is the electrochemical equivalent and ρ the density. The cathode area A_c enters through I: a large cathode can accept more current.

Question: **once the pair of metals is chosen, is the rate of corrosion settled?**

2. The Area Ratio Is Worth Four Orders

Computation 2.1: **at the same total current, the rate at which the anode is consumed was derived against the cathode-to-anode area ratio, taking equal areas as unity.**

cathode-to-anode area ratio	rate of consumption (equal areas as 1)
0.01	0.010000
0.1	0.100000
1	1.000000
10	10.000000
100	100.000000

Observation 2.2

this is the core: end to end the span is 10000.000000.Not one material has been changed——the galvanic series settles the sign and says nothing about these four orders.

Observation 2.3

the direction is unambiguous.A small anode with a large cathode is the worst case——an aluminium fastener holding a large steel plate and a steel fastener holding a large aluminium plate are opposite situations built from the same two metals.

Observation 2.4

current density is inversely proportional to anode area.At a total current of 10^{-5} A, an anode of 10^{-4} m² sees 0.100000 A/m² and one of 10^{-2} m² sees 0.001000 A/m²——a factor of 100 between them.

3. Converting to Thickness

Computation 3.1: iron's electrochemical equivalent is 0.000289396 g/C. The average loss of the anode after a year at a total current of 10^{-5} A was derived.

anode area	current density	loss in one year
10^{-4} m²	0.100000 A/m²	0.115985 mm
10^{-2} m²	0.001000 A/m²	0.001160 mm

Observation 3.2

at the same current, widening the anode a hundredfold gives 100.000000 times less loss.Material, current and environment are all unchanged——what changed is only the area of the side that dissolves.

Observation 3.3

so a table of materials is not yet a design.The same two metals can be practically harmless or as bad as possible——“avoid this combination” does not say which arrangement to avoid.

Observation 3.4

a rule of practice falls out of this formula.Make the fastener nobler than the parent metal: that is, keep the small-area side as the cathode——the choice is not of the sign but of which side is the small one.

Observation 3.5

if painting, paint the cathode.Painting the anode concentrates the current into the small holidays in the coating and perforates it sooner——a remedy that reduces area is, inside this formula, the wrong move.

4. The Separator

Observation 4.1

the separator is the cathode-to-anode area ratio.What sets the sign (potential difference) and what sets the magnitude (area ratio) are different quantities——looking only at the first loses four orders.

Observation 4.2

beside Paper 440.Paper 440 showed that to protect something, something must dissolve first——there the same cell was being used and the sign was the subject. Here the same cell is the harm and the magnitude after the sign is the subject. The using side and the preventing side of one cell.

Observation 4.3

what is not said.The galvanic series, polarisation, environment and countermeasure design are not treated; the total current is assumed and dissolution taken as uniform——what is shown is the four orders that remain after the sign is settled.

5. Roll Call and Closing

1. **current density enters** (Section 1): **current over anode area.**
2. **ratio 100 gives $\mathbf{100.000000}$** (Computation 2.1): **small anode is worst.**
3. **ratio 0.01 gives $\mathbf{0.010000}$** (Computation 2.1): **the other end.**
4. **end to end $\mathbf{10000.000000}$** (Observation 2.2): **the core.**
5. **$K_{\mathrm{Fe}} = \mathbf{0.000289396}$ g/C** (Computation 3.1): **iron's equivalent.**
6. **$\mathbf{0.115985}$ mm in a year** (Computation 3.1): **small anode.**
7. **$\mathbf{0.001160}$ mm on the wide one** (Computation 3.1): **same current.**
8. **$\mathbf{100.000000}$ times less** (Observation 3.2): **only area changed.**
9. **paint the cathode** (Observation 3.5): **painting the anode perforates it.**
10. **the area ratio** (Observation 4.1): **the separator; Paper 440.**

Closing: **Which metal dissolves is settled by the table; how fast it dissolves is settled by a quantity the table does not list.The rate of loss is set not by the total current but by that current divided by the anode area——so the cathode-to-anode area ratio enters directly, and moving it from 0.01 to 100 opens a factor of 10000.000000.In thickness, with iron's electrochemical equivalent of 0.000289396 g/C, a total current of 10^{-5} A on an anode of 10^{-4} m² removes 0.115985 mm in a year, while an anode of 10^{-2} m² loses 0.001160 mm, 100.000000 times less.Material, current and environment are unchanged; only the area of the dissolving side is different.So "avoid this combination" does not say which arrangement to avoid——the rule that a fastener be nobler than the parent metal, and the warning never to paint the anode, both fall out of the same formula.The separator is the cathode-to-anode area ratio.Placed among**

the earlier papers——Paper 440 used the same cell and made the sign its subject; here the cell is the harm and the magnitude after the sign is the subject.To be honest——the galvanic series, polarisation and environment are not treated, the total current is assumed, and dissolution is taken as uniform.

References

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