

The Metal That Reacts Most Readily Is the One That Does Not Corrode

— Aluminium sits at -1.66 V, baser than iron, yet its film is **4** nm, **1/125** of iron's **500** nm — the ordering is reversed — what separates them is not the potential but whether the film can cover what lies beneath — [Paper 441]

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— *From thinking to syncing.* —

Abstract

A metal that reacts more readily is expected to corrode sooner. This paper shows that the ordering is reversed—the basest metal is protected by the thinnest film. No new theorem or law is claimed. First, aluminium sits at -1.66 V, baser than iron at -0.44 V (Section 2). Second, this is the core of the paper. And yet its film is only **4 nm, **1/125** of iron's **500** nm. The ordering is reversed (Section 2). Third, what separates them is not the potential but whether the volume ratio of the film lies between **1** and **2** (Section 3). Fourth, aluminium at **1.28** and chromium at **1.99** fall inside; iron at **2.14** and magnesium at **0.81** fall outside (Section 3). Fifth, below **1** gaps open and above **2** compression cracks it. It fails on both sides (Section 3). Sixth, the separator is readiness to react against the volume ratio of the film (Section 4). Keywords:** passivity, corrosion, oxide film, standard electrode potential, Pilling-Bedworth ratio.

Scope of this paper (scope note): No new theorem or law is claimed—standard electrode potentials, passivity and the Pilling--Bedworth ratio are all standard (since 1923). The volume ratio is not made the sole criterion—the range from 1 to 2 is a guide, and metals satisfying it are not all passive. It is treated as close to a necessary condition. The structure of the film is not discussed—crystalline or amorphous, the distribution of defects and the kinetics of growth are not the subject. The environment is not fixed—chloride breaks passivity. Pitting and crevice corrosion are not the subject. The film thicknesses are not asserted as measurements—4 nm, 3 nm and 500 nm are representative and move with conditions. Alloys are not treated—why stainless steel resists corrosion is touched only through the contribution of chromium. Relation to earlier papers: Paper 440 showed that protection requires something to dissolve first—there the potential fixed the direction; here it does not. Paper 300 showed that common root and distinct root can be decided—“reacts readily” and “corrodes readily” are distinct roots by that criterion. Paper 432 showed that the strongest period in a record is the weakest in the forcing—there too the ordering was reversed; this is a second instance. Paper 419 showed that the same material differs in strength by orientation—here too, another quantity hides inside the name of the material. What is added is setting potential against film thickness to put the reversal into numbers, giving the ratio of films as 1/125, tabulating the volume ratio for four metals, showing two different modes of failure below 1 and above 2, confirming that the ordering by potential is not the ordering by volume ratio, and placing the separator at “readiness or volume ratio”.

1. Notation and the Question

Setting: When a metal reacts with oxygen, take the volume of oxide formed divided by the volume of metal consumed.

$$PB = \frac{V_{\text{oxide}}}{V_{\text{metal}}}$$

Below 1 the film cannot cover what lies beneath; above 2 it is said to crack under compression.

Observation 1.1

A metal that reacts more readily is expected to corrode sooner. The baser the potential, the more easily it oxidises—a natural thought.

Observation 1.2

But the objects say otherwise. Aluminium window frames last decades while iron railings rust in a few years—and aluminium is by far the baser of the two.

Question: What reverses the ordering.

2. The Basest Metal Has the Thinnest Film

Computation 2.1: Set potential against oxide film thickness for three metals.

Metal	Potential [V]	Film [nm]
Aluminium	−1.66	4
Chromium	−0.74	3
Iron	−0.44	500

Observation 2.2

Aluminium is the basest of the three.—1.66 V—the readiest to react.

Observation 2.3

And its film is only 4 nm.**1/125** of iron’s 500 nm—thin, and stopped.

Observation 2.4

Iron’s 500 nm is not “thickly protected”.It is the result of never stopping—thickness is not the strength of the protection but the record of the progress.

Observation 2.5

So the ordering is reversed.The basest by potential is the thinnest by film—the same shape as Paper 432, where the orderings on the cause and effect sides did not agree.

3. What Separates Them Is Whether the Film Can Cover

Computation 3.1: Take the volume ratio of oxide to metal for four metals.

Metal	Volume ratio	Can it cover?
Magnesium	0.81	no; gaps open
Aluminium	1.28	yes
Chromium	1.99	yes
Iron	2.14	cracks under compression

Observation 3.2

Only aluminium and chromium fall between 1 and 2.1.28 and 1.99—and these are the two that passivate.

Observation 3.3

Magnesium falls below 1.0.81—the oxide is smaller than the metal, so it cannot cover and gaps open.

Observation 3.4

Iron rises above 2.2.14—the oxide is too large, so it presses against itself and flakes.

Observation 3.5

It fails on both sides. Too small and too large are both bad—there are two boundaries, and only between them is anything protected.

Observation 3.6

And the ordering by potential is not what decides. What decides is whether the value falls inside a range, not whether it is large or small—even where two lists run in the same order, the judgement is made by a different rule.

4. The Separator

The separator: readiness to react, or the volume ratio of the film.

Observation 4.1

Readiness settles the beginning. How fast the oxidation starts—aluminium starts instantly.

Observation 4.2

The volume ratio settles whether it stops. If the film covers what lies beneath, it stops there—aluminium starts instantly and stops at 4 nm.

Observation 4.3

These are distinct roots by the criterion of Paper 300. Both are called “liability to corrode”—one about rate, one about stopping.

Observation 4.4

So “it reacts readily, therefore it is at risk” is half right. Right about the beginning—whether it stops is settled by an entirely different quantity.

Observation 4.5

Stainless steel resists not because the iron changed. Chromium is added and a chromium film forms—whose volume ratio of 1.99 lies inside the range.

Observation 4.6

To be honest—falling inside the range does not guarantee passivity. The structure of the film, its defects and the environment all act—the ratio is treated here as close to a necessary condition, not as a sufficient one.

Observation 4.7

One last thing—chloride breaks this protection. Aluminium near the sea pits—a 4 nm film can be pierced locally under the right conditions. Being protected is not being protected absolutely.

5. Roll Call and Closing

1. Aluminium sits at -1.66 V (Computation 2.1): **the basest.**
2. Its film is 4 nm (Computation 2.1): **the thinnest.**
3. That is $1/125$ of iron's 500 nm (Observation 2.3): **the core.**
4. Thickness records progress, not protection (Observation 2.4): **what did not stop.**
5. Aluminium's volume ratio is 1.28 (Computation 3.1): **inside.**
6. Chromium's is 1.99 (Computation 3.1): **just inside.**
7. Magnesium's is 0.81 (Computation 3.1): **below.**
8. Iron's is 2.14 (Computation 3.1): **above.**
9. It fails on both sides (Observation 3.5): **two boundaries.**
10. The separator is readiness or volume ratio (Observation 4.3): **distinct roots by Paper 300.**

Closing: A metal that reacts more readily is expected to corrode sooner—the baser the potential, the more easily it oxidises—but the objects say otherwise: aluminium window frames last decades while iron railings rust in a few years, and aluminium is by far the baser. In numbers, the ordering is reversed—aluminium sits at -1.66 V, the basest of the three, and yet its oxide film is only 4 nm, $1/125$ of iron's 500 nm. Iron's 500 nm is not thick protection but the result of never stopping: thickness is not the strength of the protection but the record of the progress. It is the same shape as Paper 432, where the orderings on the cause and effect sides did not agree. What separates them is not the potential—it is whether the volume ratio of oxide to metal lies between 1 and 2. Aluminium at 1.28 and chromium at 1.99 fall inside; magnesium at 0.81 and iron at 2.14 fall outside. Below 1 the oxide is smaller than the metal, so it cannot cover and gaps open; above 2 it is too large, presses against itself and flakes—too small and too large are both bad, there are two boundaries, and only between them is anything protected. One thing separates them—readiness to react, or the volume ratio of the film. Readiness settles the beginning, and aluminium starts instantly; the volume ratio settles whether it stops, and aluminium starts instantly and stops at 4 nm. They are distinct roots by the criterion of Paper 300, one about rate and one about stopping. So “it reacts readily, therefore it is at risk” is half right—right about the beginning, while whether it stops is settled by an entirely different quantity. Stainless steel resists not because the iron changed but because chromium is added and a chromium film forms, whose volume ratio of 1.99 lies inside the range. To be honest—falling inside the range does not guarantee passivity.

The structure of the film, its defects and the environment all act. The ratio is treated here as close to a necessary condition, not a sufficient one. One last thing—chloride breaks this protection. Aluminium near the sea pits, and a 4 nm film can be pierced locally under the right conditions. Being protected is not being protected absolutely.

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