What is the relationship between Current and Corrosion Control ?

A tutorial presentation
by
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to demonstrate in 4 steps
the relationship between
current and
corrosion control

Step 1 : What is current

Step 2 : Relationship between current and steel potential

Step 3 : Electrons and steel

Step 4 : Effect on corrosion

STEP 1 : What is Current ?

Electric current is a flow of electric charge.

According to physical laws :

Ampere is the unit of current,
Coulomb is the unit of electric charge.

AND

1 Coulomb per second = 1 Ampere .

STEP 1 : What is Current ?

How much charge is 1 Coulomb ?

According to SI (International System of Units) :

A charge of 1 Coulomb is equal to

$6{,}25 \times 10^{18}$ negative particles or electrons.

STEP 1 : What is Current ?

So what does it mean if I have a current of 1 Ampere ?

It means every second an amount of $6{,}25 \times 10^{18}$ negative particles or electrons pass through a cross section of the wire.

In case of mAmps the amount is still high : $6{,}25 \times 10^{15}$ electrons.

STEP 2 : Relationship between current and steel potential

STEP 2 : Current and potential

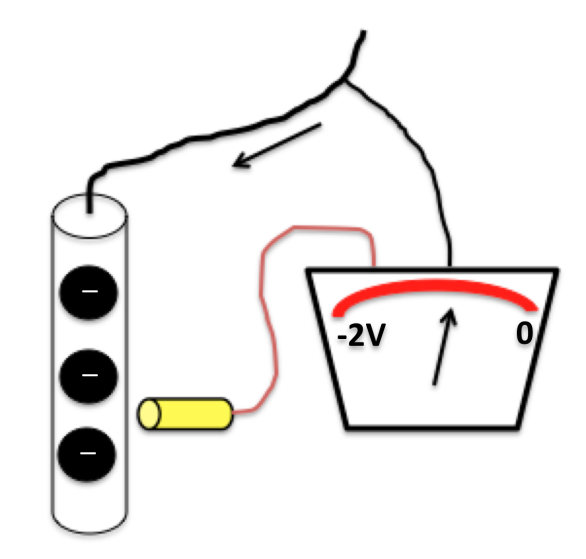
Now we know what current is –a flow of negative particles- we would like to know the effect on a steel structure.

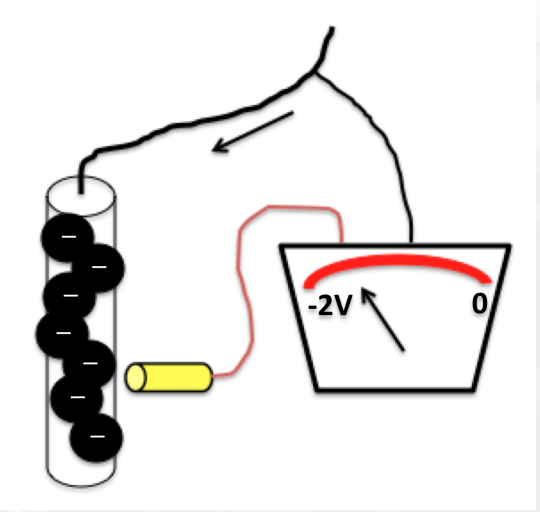
Imagine a steel bar which is charged with a current of several mA's.

Basically this steel bar is filled with millions and millions of negative particles every second.

STEP 2 : Current and potential

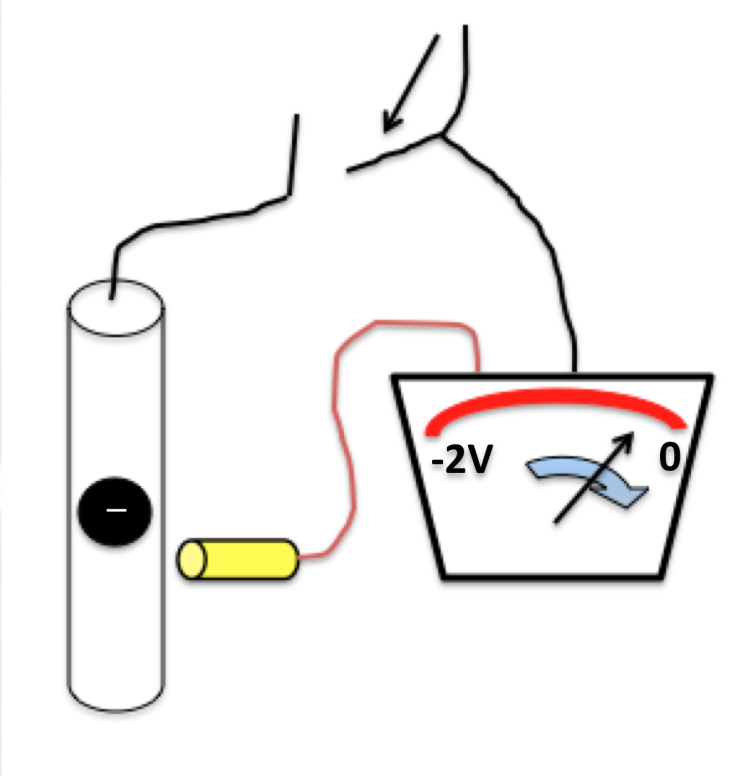
When filling up or charging this steel bar with millions and millions of negative particles it is not so difficult to understand that the more particles are flowing into my bar the more negative the potential of this steel bar will be. This is called polarisation.





STEP 2 : Current and potential

When switching off the current I am discharging the steel bar and the potential will become more positive. This is called depolarisation.



STEP 3 : Electrons and steel

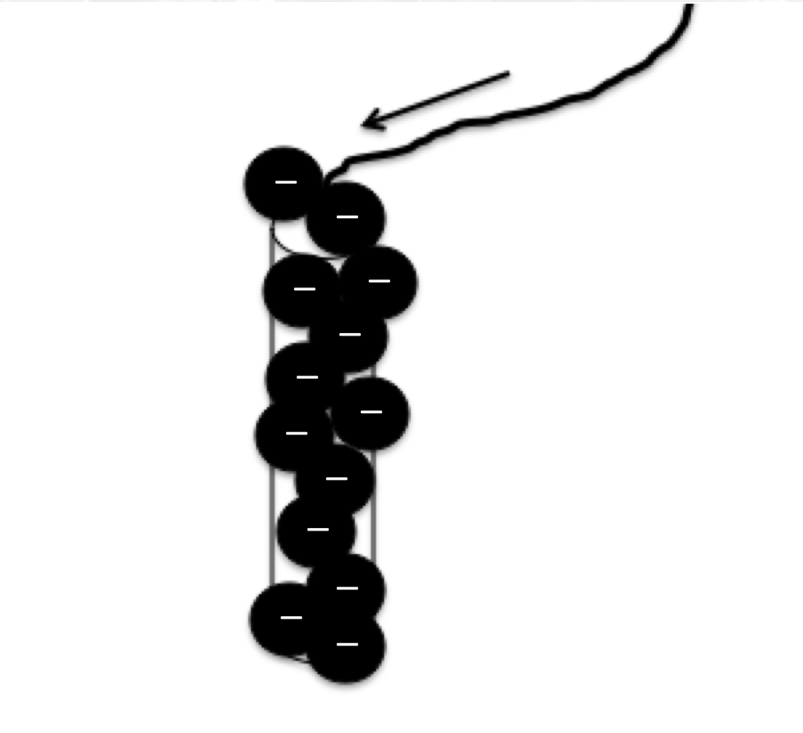
STEP 3 : Electrons and steel

1. Charging the steel bar with millions and millions of negative particles will cause a situation in which I am pressurising the bar with these particles.

2. Fundamentally electrons cannot leave the electrode as these particles need a conductor to flow.

STEP 3 : Electrons and steel

What is happening in that particular situation :



These particles feel squeezed in.

And charged particles whose charges have the same sign repel one another.

STEP 3 : Electrons and steel

What happens exactly ?

Imagine yourself on a remote island in the middle of the ocean, higly populated and its population increasing by the second. You want to flee but you cannot, because you will drown when jumping in the ocean.

The only option you have is building a boat jumping in it and rowing away from the island. Thus you need something which carries you.

When you cannot find a boat, you need to construct one, which means you need material available.

When constructed the boat
you charge the boat (carrier)
with your weight and row away.

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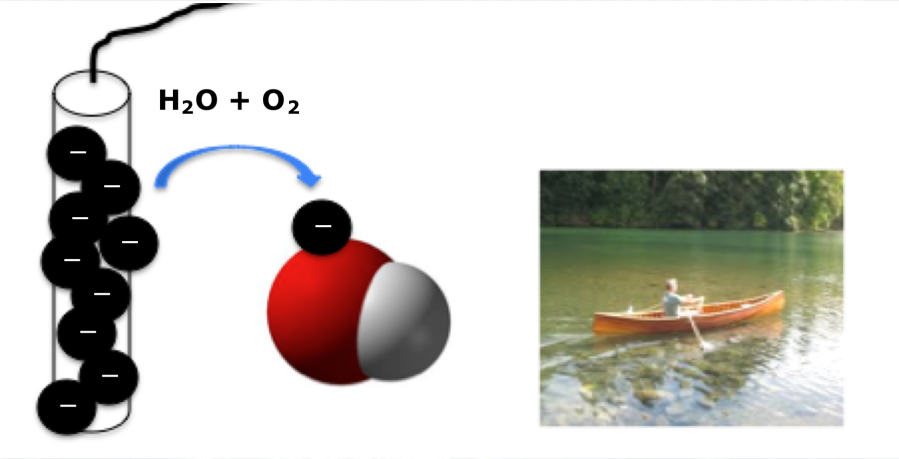
STEP 3 : Electrons and steel

This process applies exactly the same to these particles.

These electrons need a carrier and look what is available to flee their precarious condition.

Generally water and oxygen is available in many electrolytes.

From water and oxygen these particles create their carriers.



STEP 3 : Electrons and steel

This process is an electrochemical reaction in which water and oxygen are consumed to form hydroxide-ions as electron carriers.

So every time a negative particle needs te leave the electrode, it initiates an electrochemical reaction to create a carrier for itself.

STEP 4 : Effect on corrosion

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We know now what current is and what effect it has on steel.

But what is its effect on corrosion ?

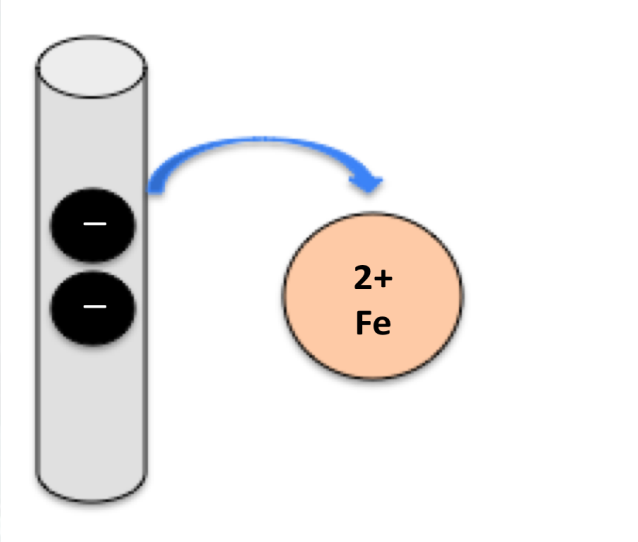
There are several factors which contributes to the inhibition of the corrosion process :

STEP 4 : Effect on corrosion

A) Every corrosion reaction initiates with an electrochemical reaction of the substrate (steel).

It starts with the simple corrosion reaction :

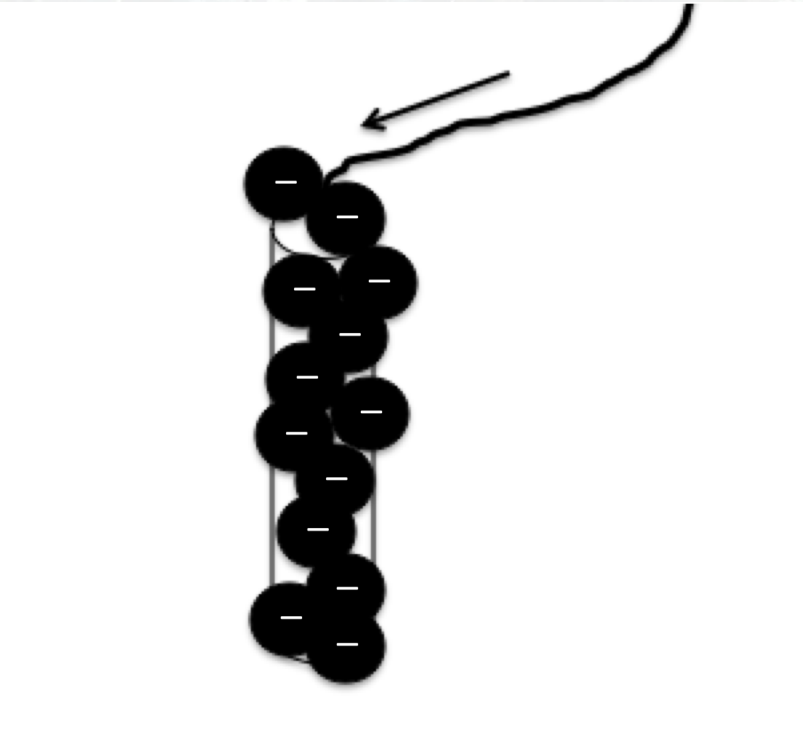
Fe (substrate) → Fe^{2+} + 2 e⁻



As can be seen the corrosion reaction charges the steel bar with negative particles, such as the current does.

STEP 4 : Effect on corrosion

We have seen our steel bar when charged by current.



Millions and millions of electrons per second squeezed together.

The corrosion reaction will be hindered because :

The steel bar is already fully charged with electrons.

STEP 4 : Effect on corrosion

B) And as previous seen the hydroxide-ions formed (to become the electrons carriers) :

$(H_2O) + (O_2) + e^- \Rightarrow (OH)^-$

will create an alkaline environment around my steel bar.

This alkaline environment will passivate steel.

Through logic steps we have shown by use of normal physic laws that current is a fundamental requirement to keep corrosion under control.