



Novel Construction Fall Plenary Session 2018

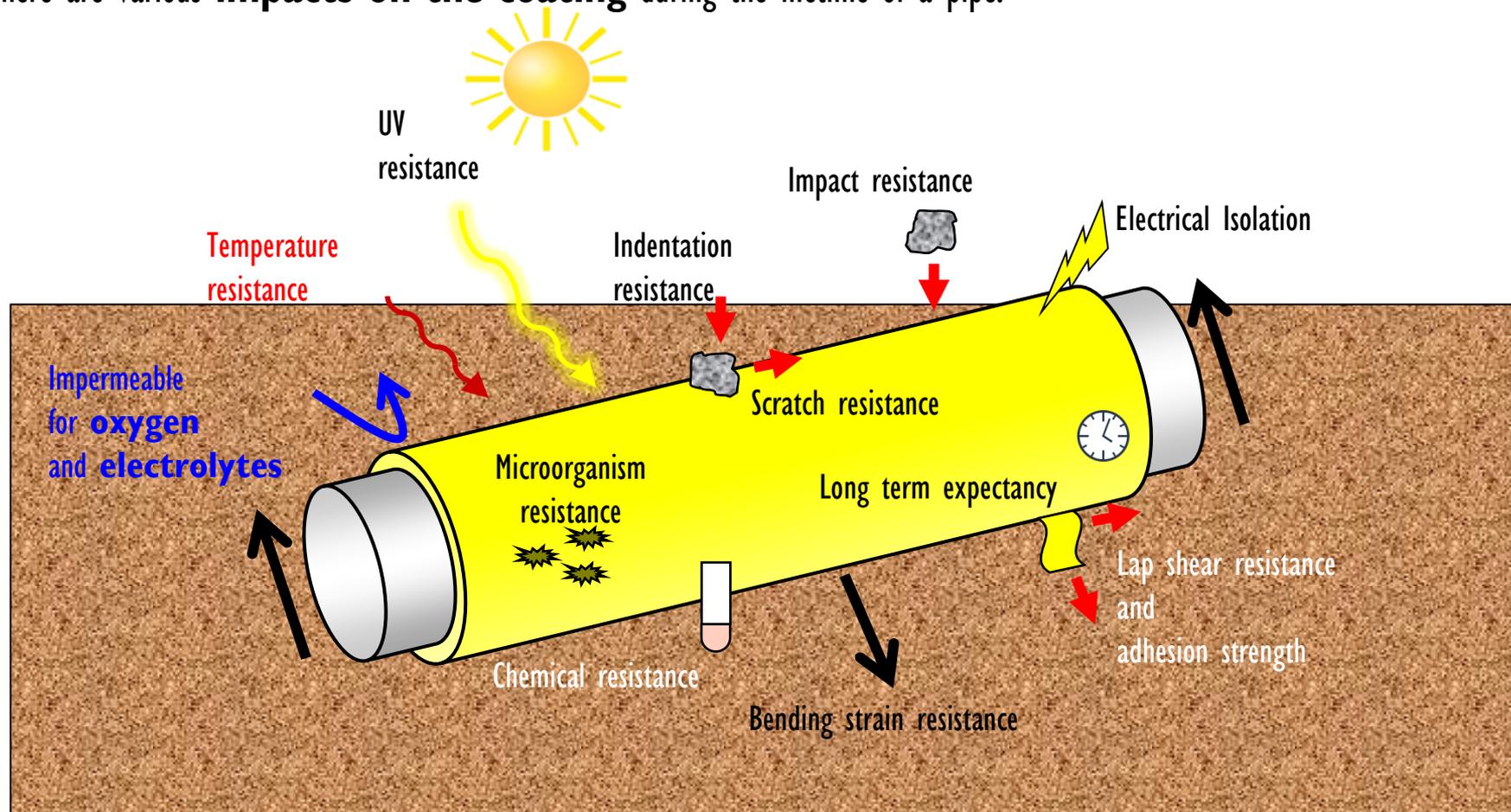
“Shielding” - Coatings or “Non-Shielding” - Coatings?

Geneva, 24./25. October 2018

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DENSO GmbH,
Germany

Challenges to any Coating

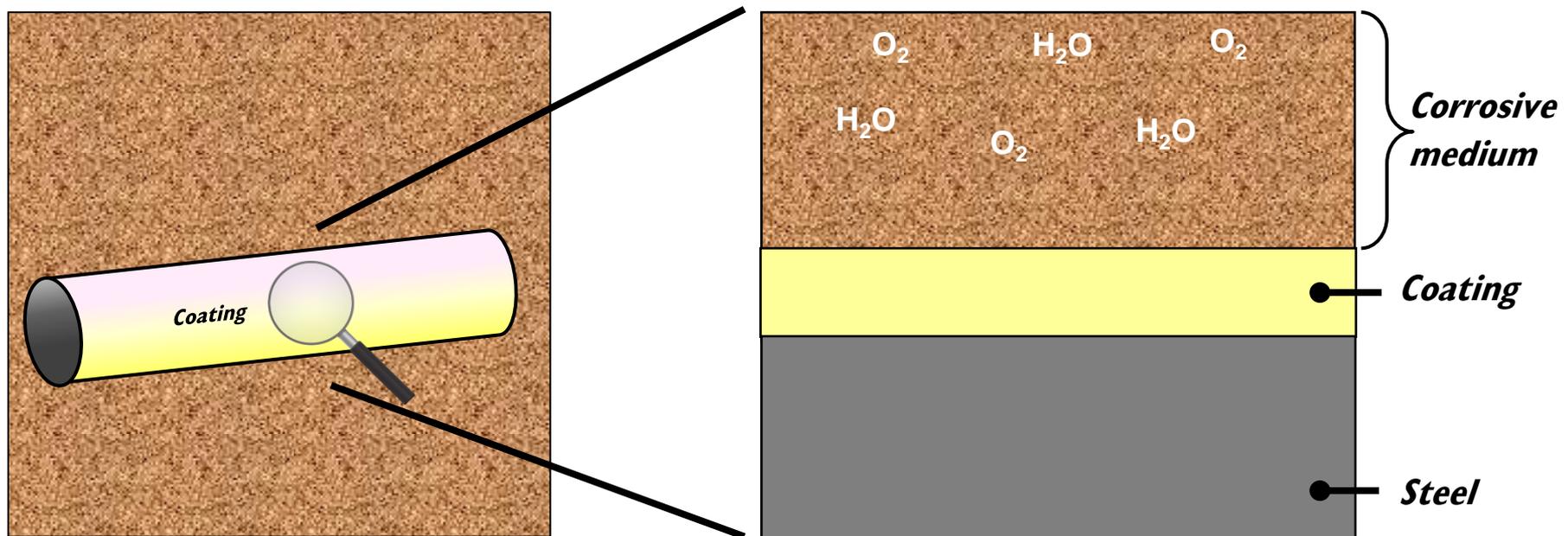
There are various **impacts on the coating** during the lifetime of a pipe.



Coating: The First Line of Defense



The task of the Coating is to **keep corrosive elements away** from the pipe at all times.



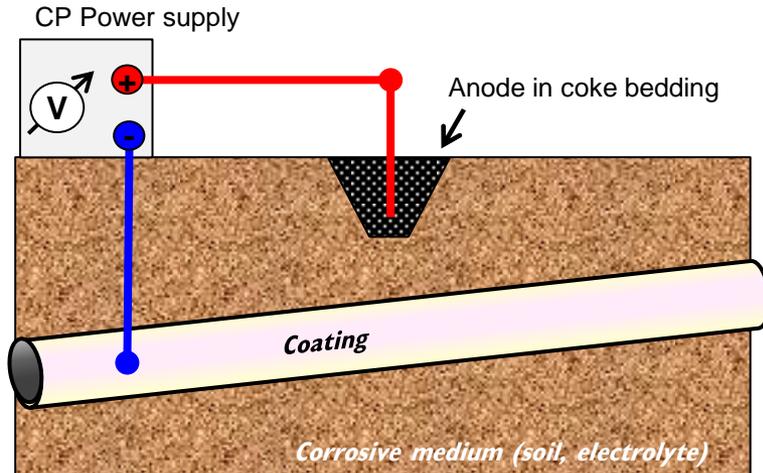
No Corrosion – The Coating is The First Line of Defense

O_2 = Oxygen H_2O = Water

Cathodic Protection: The Second Line of Defense

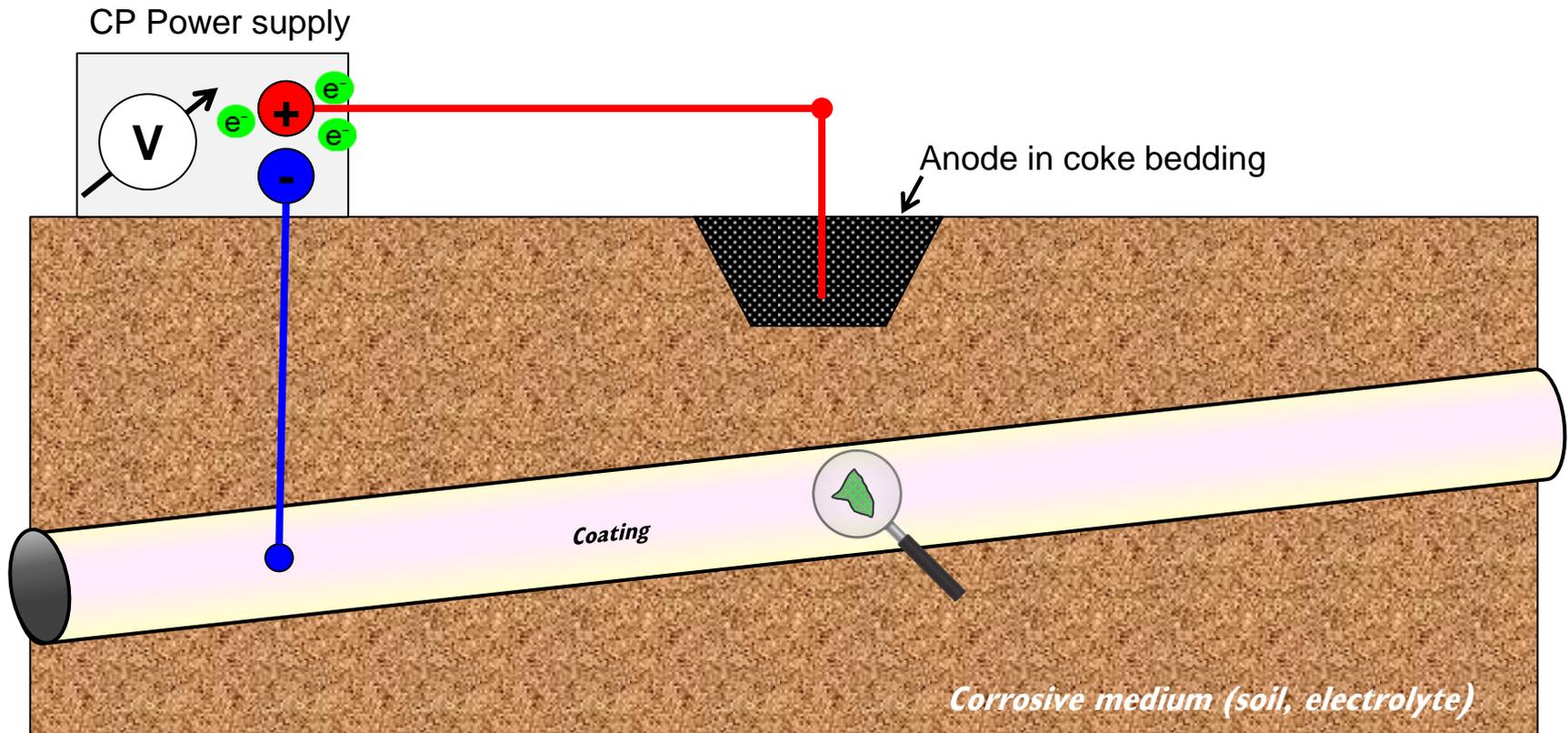


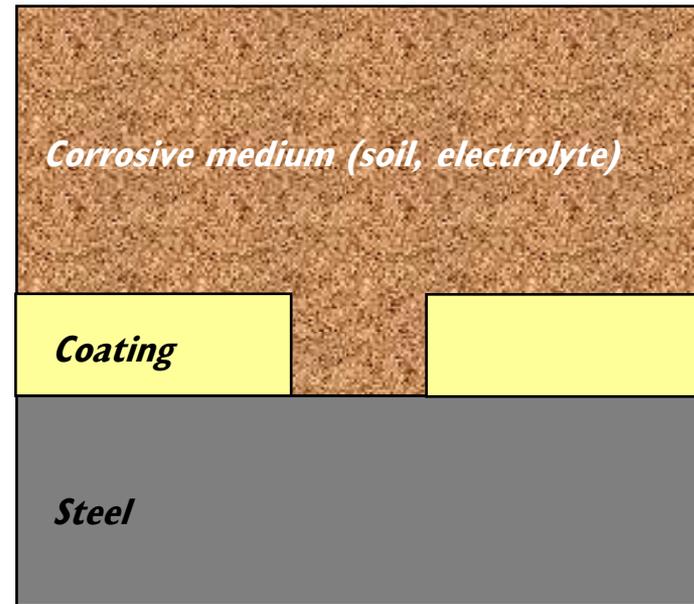
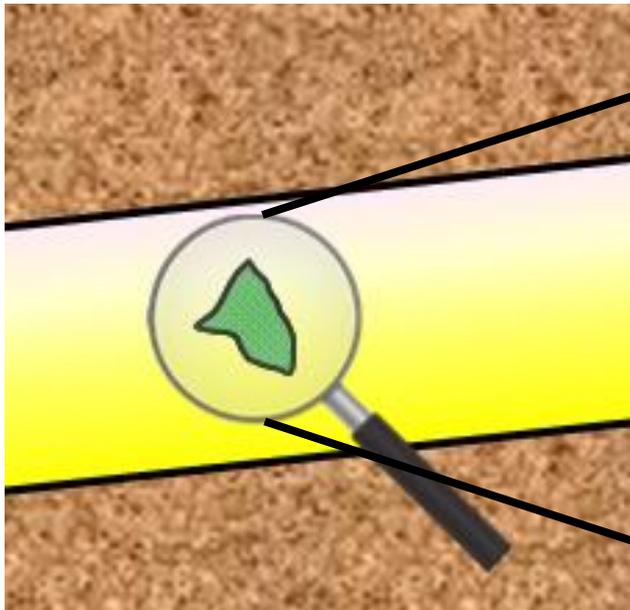
Additional protection is installed by using a Cathodic Protection (CP) system as **Second Line of Defense**. The Cathodic Protection (CP) will only be needed and act in case the Coating is damaged.



The mechanism of CP

In case of a defect in the Coating, the CP will act and supply sufficient electrons to the steel. No corrosion will occur at the defected area.

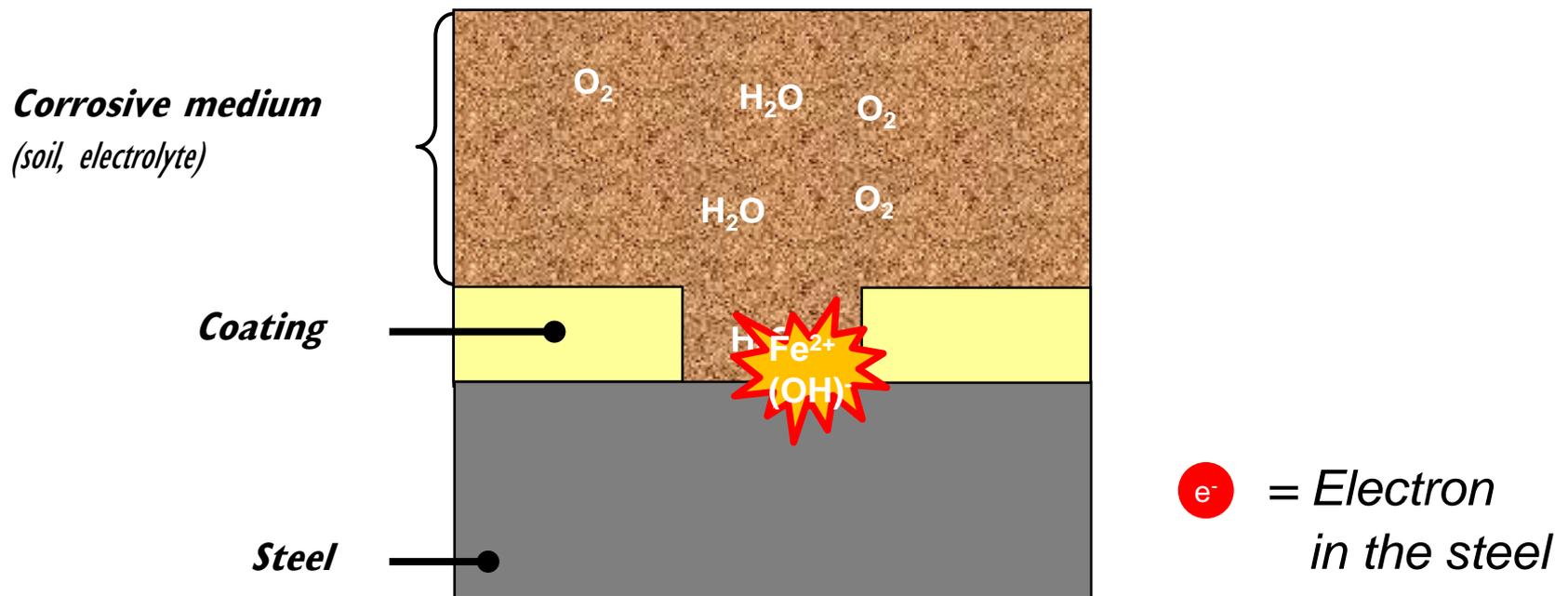






Damaged pipeline Coating **without CP**

Without installed or activated Cathodic Protection (CP), the steel surface would start to corrode immediately.

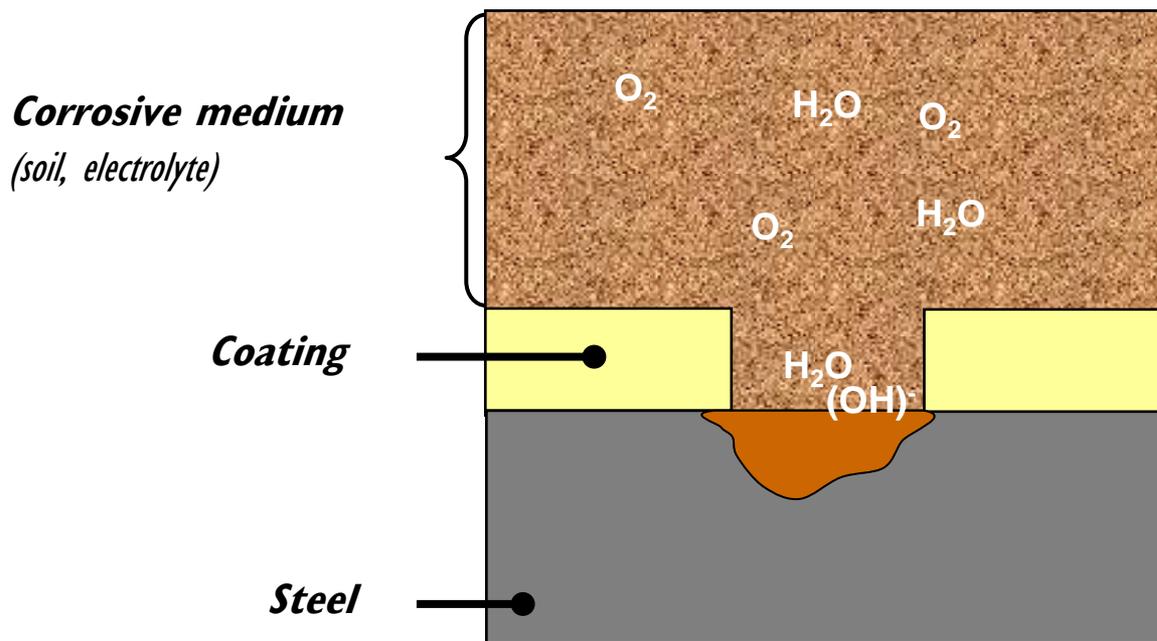


O_2 = Oxygen H_2O = Water OH^- = Alkaline Fe^{2+} = Ferrous



Damaged pipeline Coating **without CP**

Without installed or activated Cathodic Protection (CP), the steel surface would start to corrode immediately.



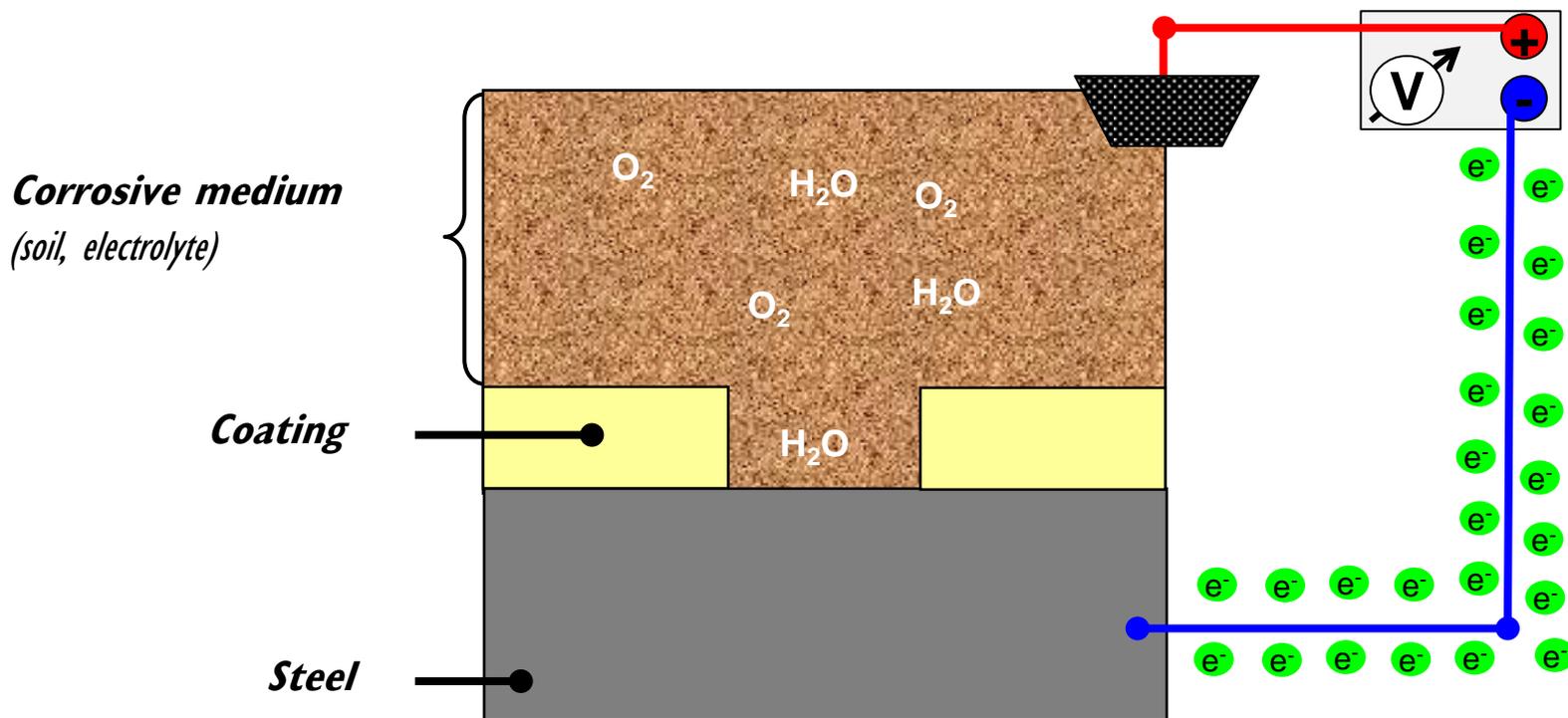
✗ Corrosion !!

O_2 = Oxygen H_2O = Water OH^- = Alkaline Fe^{2+} = Ferrous



Damaged pipeline Coating with CP

With installed CP, sufficient electrons will be provided to the steel. No corrosion will occur at the defected area.

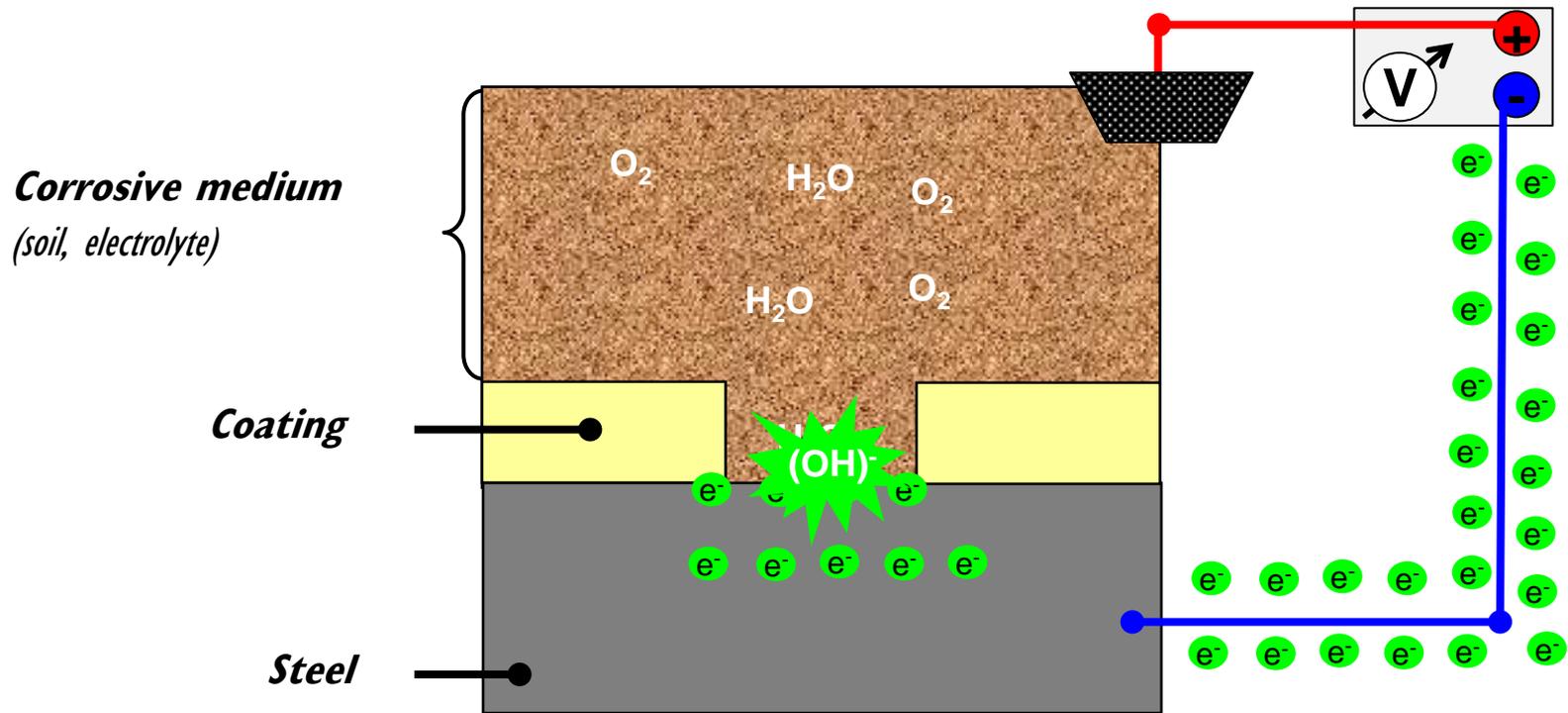


O_2 = Oxygen H_2O = Water OH^- = Alkaline Fe^{2+} = Ferrous



Damaged pipeline Coating with CP

With installed CP, sufficient electrons will be provided to the steel. No corrosion will occur at the defected area.

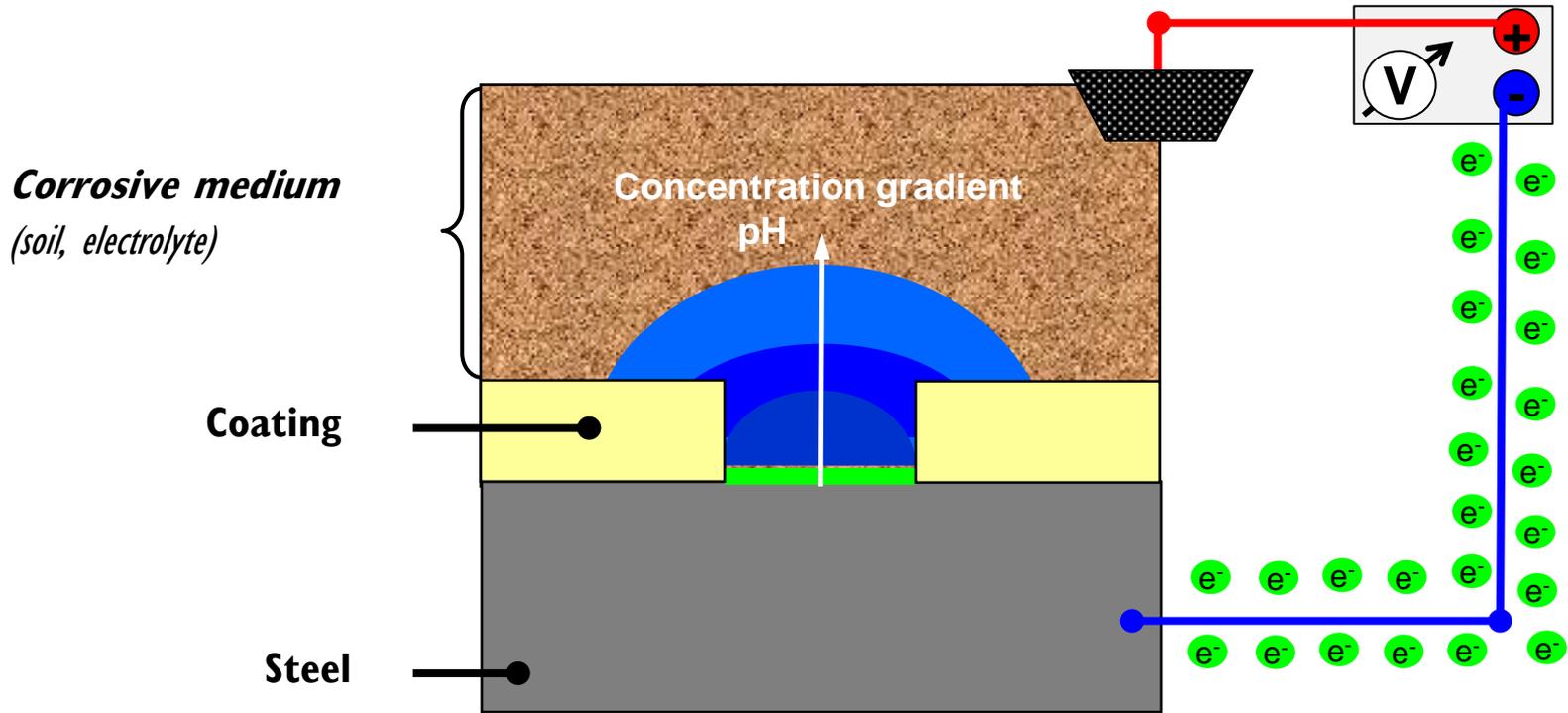


No Corrosion

O_2 = Oxygen H_2O = Water OH^- = Alkaline Fe^{2+} = Ferrous

CP and its activation polarization

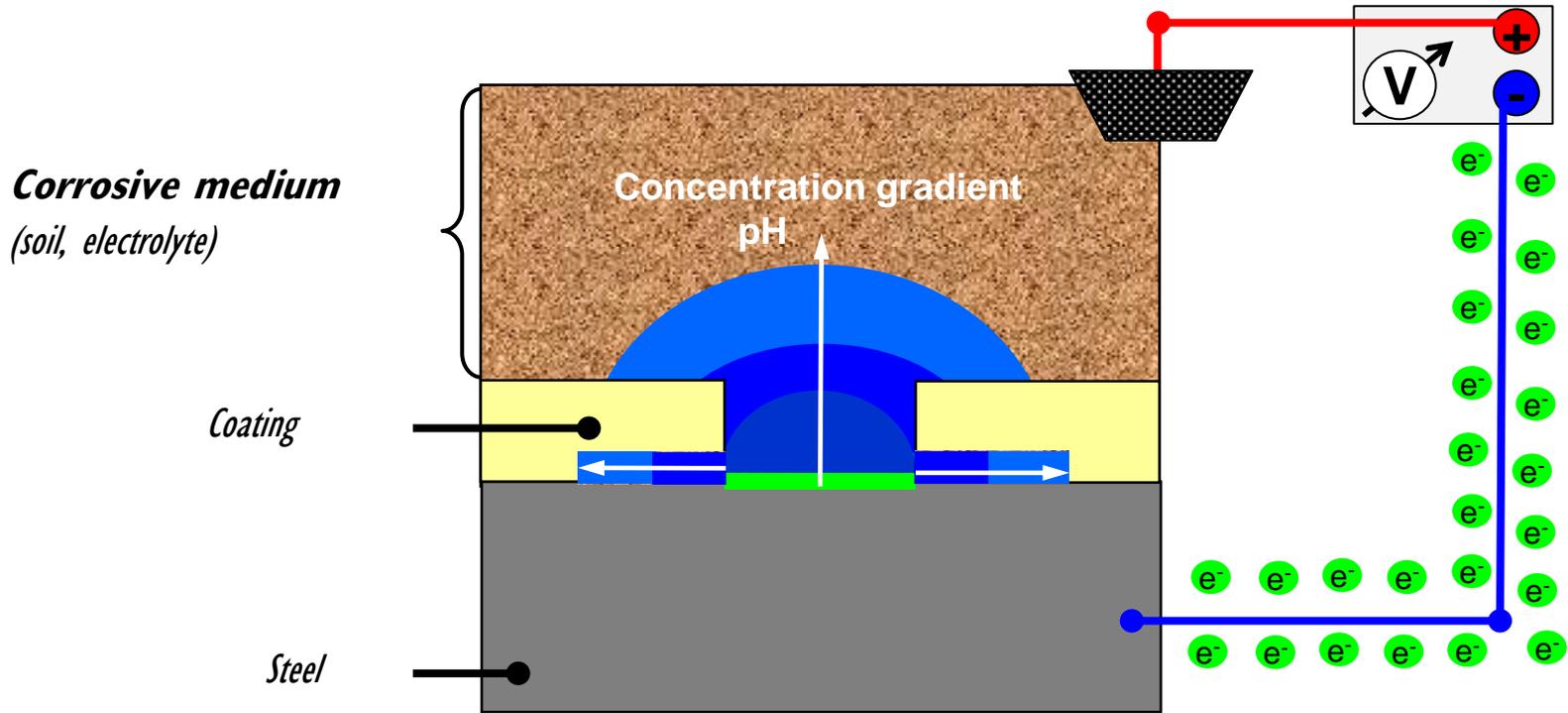
By supplying sufficient electrons to the steel, the pH-level increases to an alkaline level, protecting the defected area.



— No Corrosion – due to activation polarization

CP and its concentration polarization

Even in case of disbonded Coating areas, the pH-level increases to an alkaline level, protecting these areas.



Green bar No Corrosion – due to activation polarization

Blue bar No Corrosion – due to concentration polarization (increase of pH)

Limitation factors for CP protection

Some factors might influence the current flow of the Cathodic Protection, such as

- Metallic structures in the path,
- Interferences from nearby structures, or
- Shorted casings.



But the most influencing factor are high resistance or non-conducting materials, such as

- Rocky terrains and
- Dry ground...

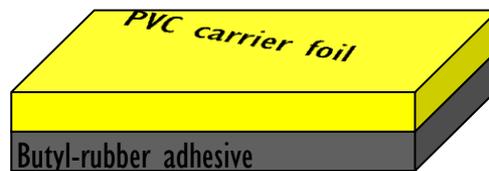
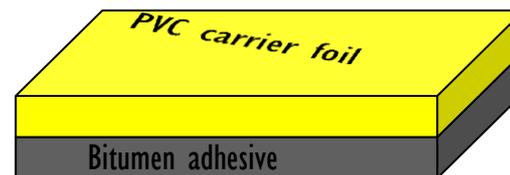




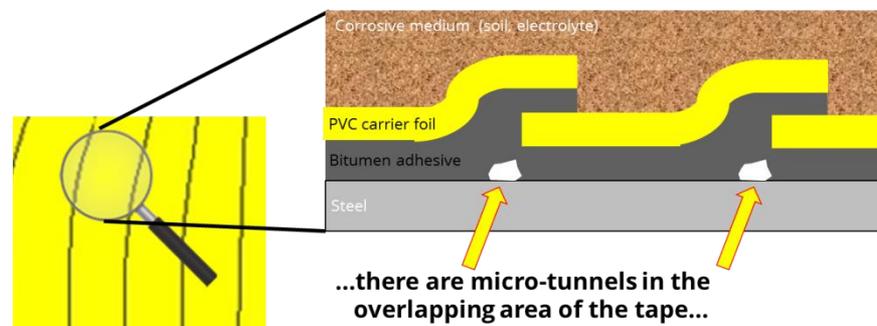
How the discussion about
“Shielding” - Coatings
or
“Non-Shielding” - Coatings
started at all:

How it all started

What happens if you use a 2-ply tape, no matter what material it is based on (bitumen, PVC, Butyl-rubber, PE, ...)?



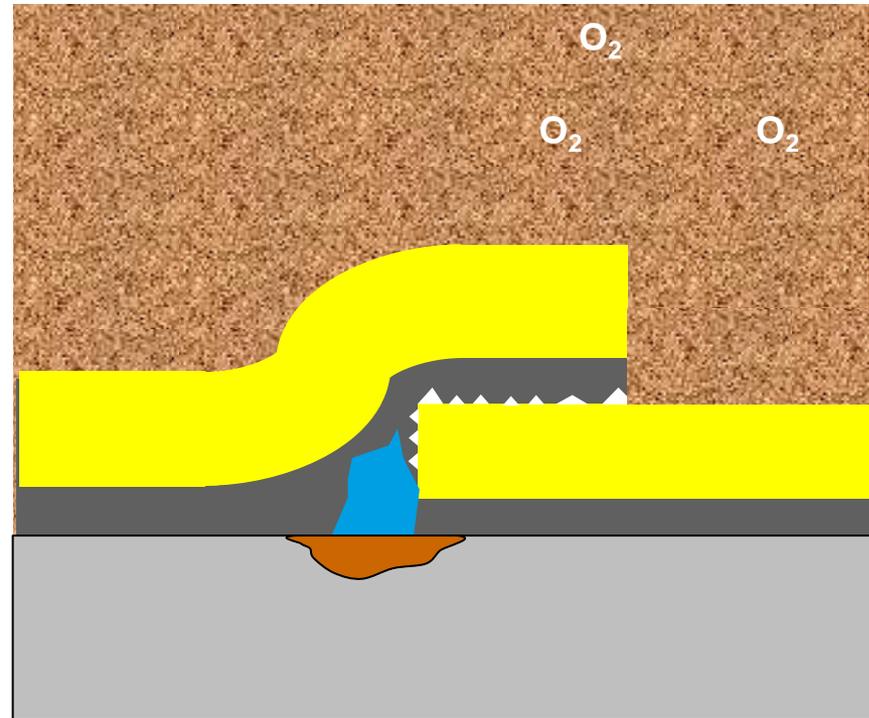
Micro-tunnels may remain in the overlapping area of the wrapped tape, because the carrier foil and the adhesive layer do not form a hose-like coating since they are not able to amalgamate.





How it all started

When wrapped around the pipe, the tape just bonds with the inner-layer (adhesive) on the outer-layer (carrier film) in the overlapping area. It does not build a close hose-like coating and therefore allows O_2 from the environment to diffuse to the steel.

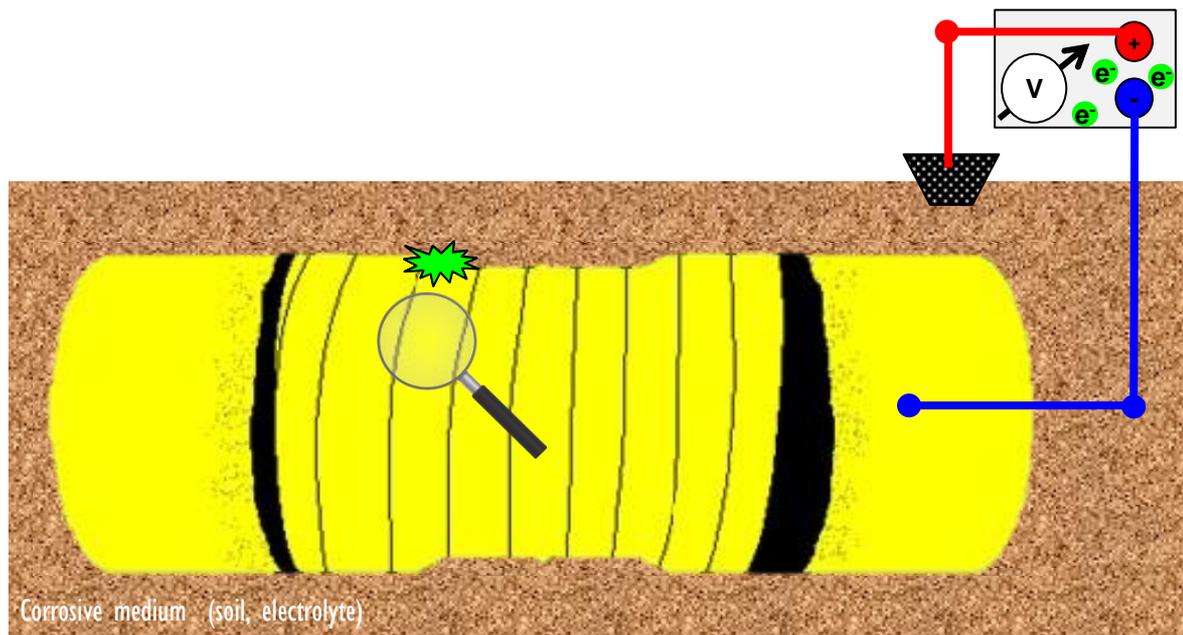


Corrosion is the result



How it all started

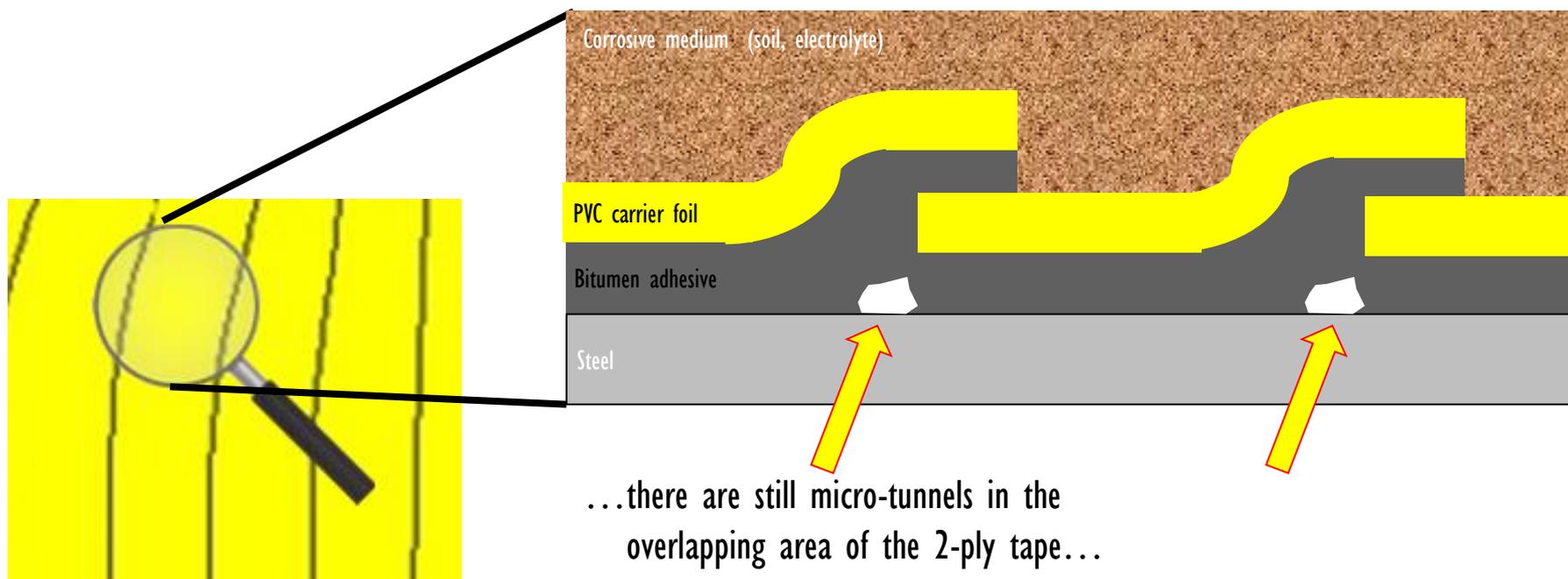
In case of defect at this 2-ply tape, for instance by mechanical loading (indentation), water and oxygen enter the defected area. Now the CP works as a second line of defense and there will be no corrosion near the defected area.



No corrosion near the defect!

How it all started

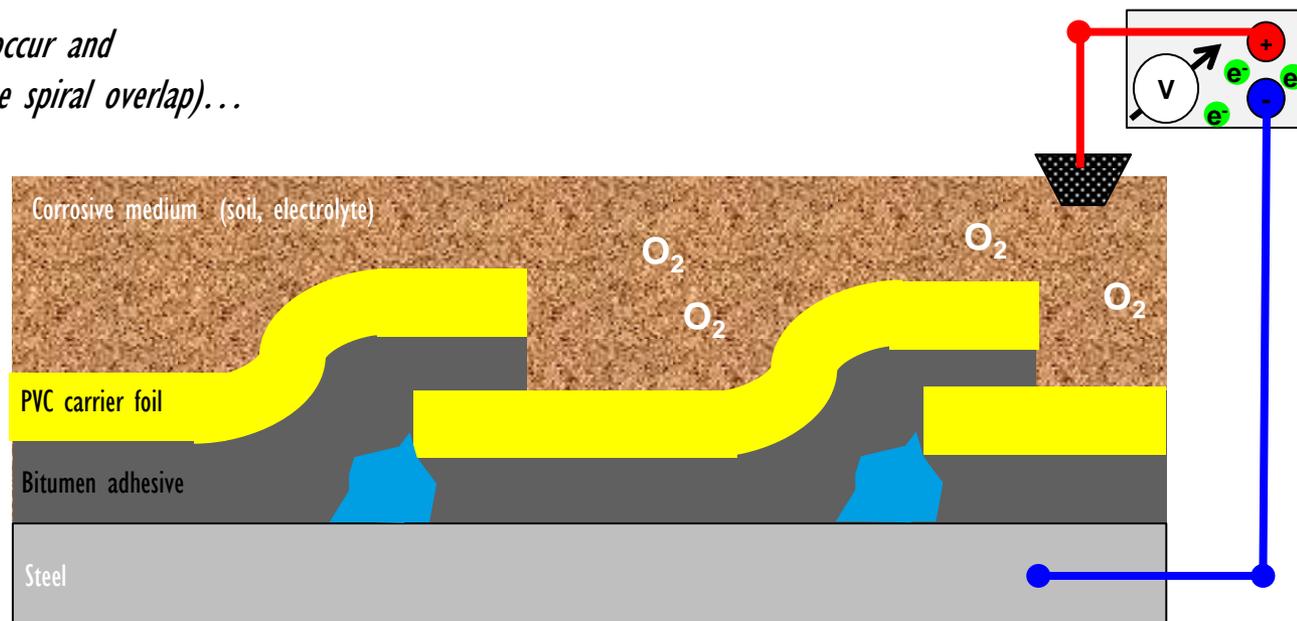
... at first glance a good protection is achieved, but...



How it all started

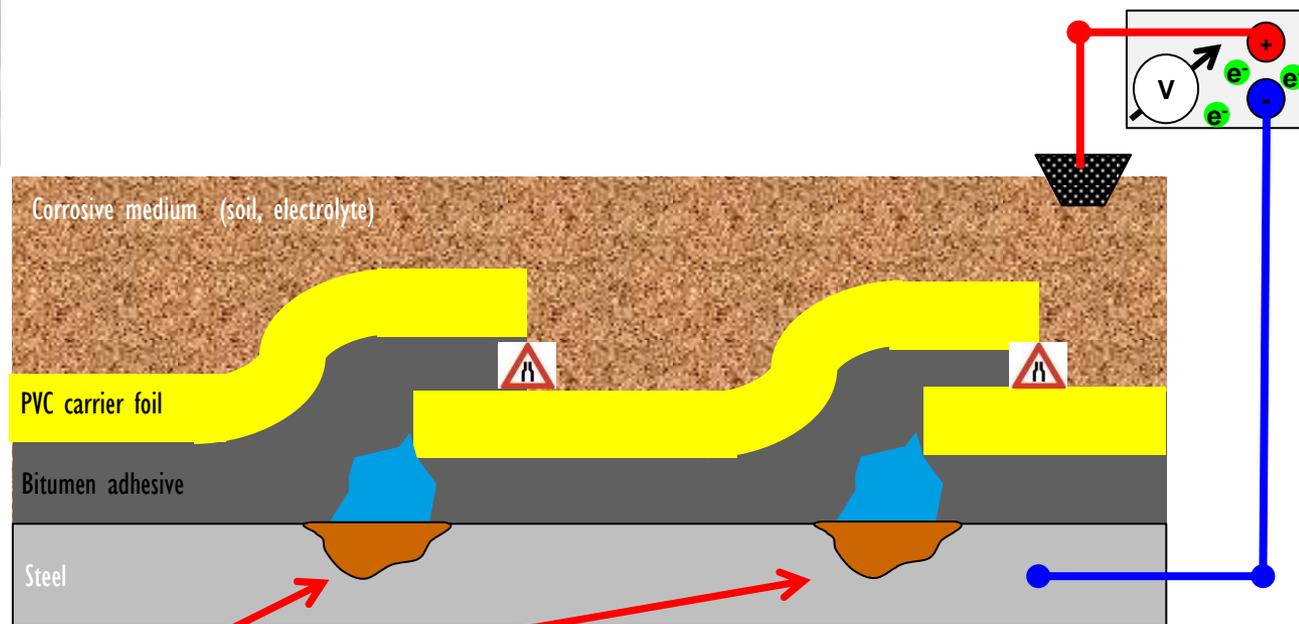
... enabling water and oxygen to access from the defected area...

- 1) **water** and dissolved **oxygen** will enter from the defected area into **the microtunnel...**
- 2) Progressive **disbondment** will occur and a **channel** is formed (following the spiral overlap)...
- 3) O_2 diffuses **continuously** into the channel at each overlapping area...



How it all started

... resulting in Spiral Corrosion!

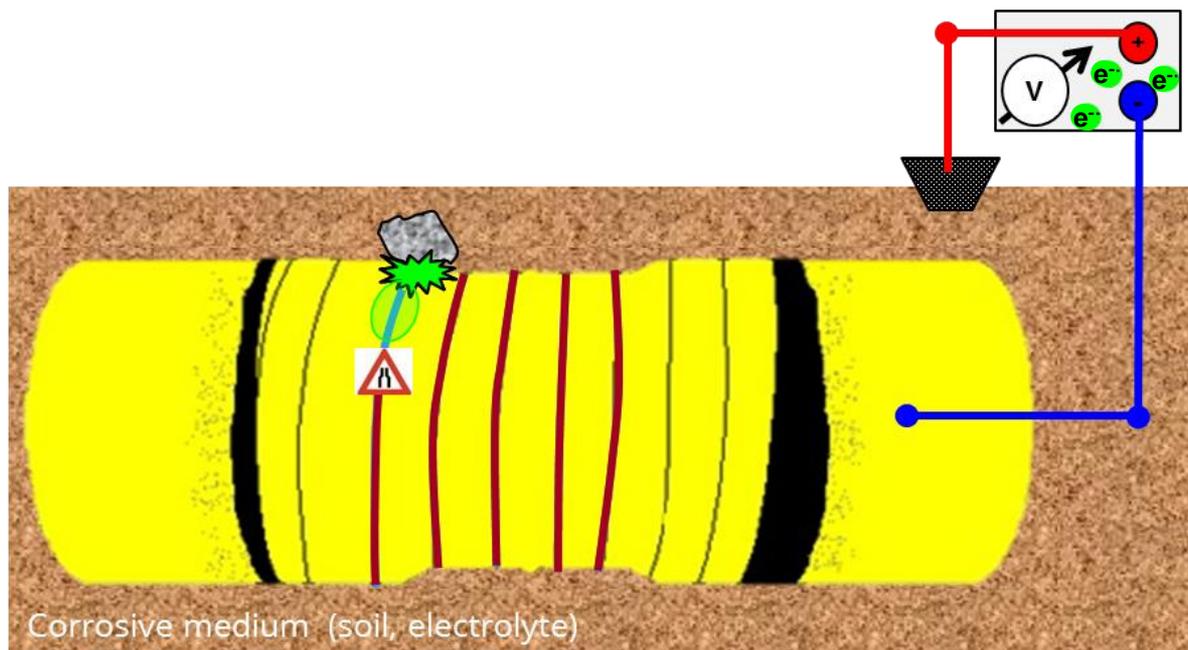


✗ Corrosion !!

How it all started

Why does the **CP** - in this case - not protect against corrosion?

The CP current cannot follow the spiral and therefore...



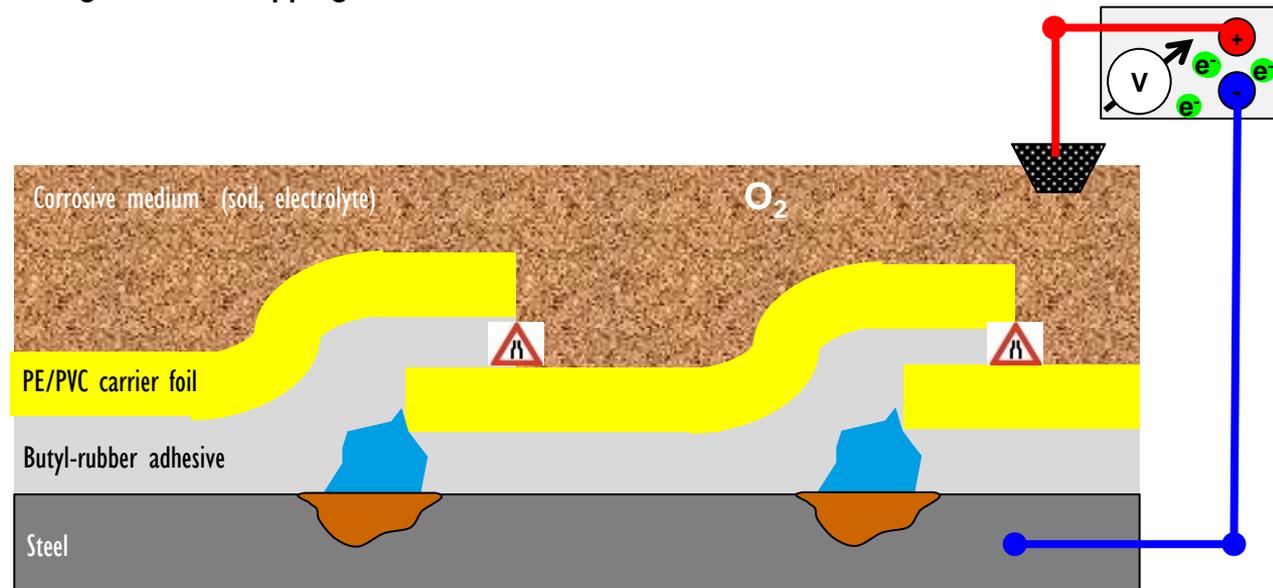
— ..there is no **activation polarization** along the spiral



How it all started

There is also no current flow through the overlapping area.
But molecules are able to diffuse through the overlapping

- Two **just bonded** tapes allow
1. diffusion of molecules,
but at the same time
 2. providing an **electrical shielding.**



That is commonly called the **“Shielding effect”**



Searching for a Solution

Knowing the effect of **Spiral Corrosion (and Shielding effect)**, two different approaches have been developed

Option A:

- 1) Continue with **2-ply tape** technology.
- 2) Allow **water/oxygen** to get in contact with **steel surface** to transport electrons from the CP.
- 3) **Current (CP)** is strictly **mandatory** to flow “any time and place”.



Option B:

- 1) Provide a **hose-like coating**. No micro-tunnels!
- 2) Do not allow **water/oxygen** to get in contact with **steel surface**.
- 3) **Current (CP)** as **additional** protection (second line of defense).

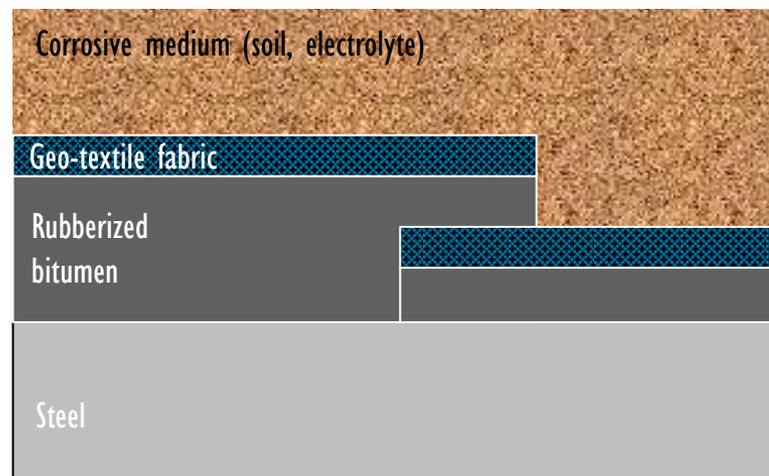


Option A

Polymeric Mesh-Backed Coating

The woven Geo-textile fabric backing is always **as wet as the soil** (...or as dry as the soil).

Only one ply/layer (in this case rubberized bitumen) keeps the corrosive medium away from the steel.



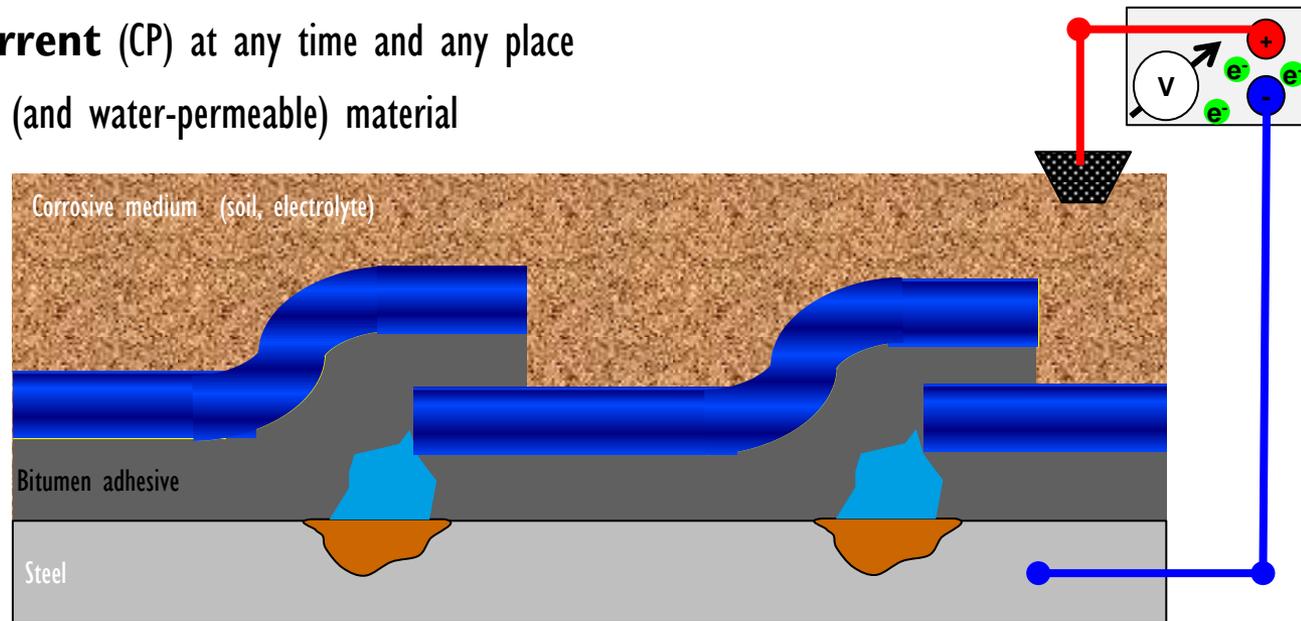
one layer to the steel only.

Option A



Option “A” continues with **2-ply tape technology** to solve the problem:

The Idea: Eliminating the “**Shielding Effect**” of **2-ply tapes** by providing **access** of the **current** (CP) at any time and any place by using an electro-conductive (and water-permeable) material as carrier foil.

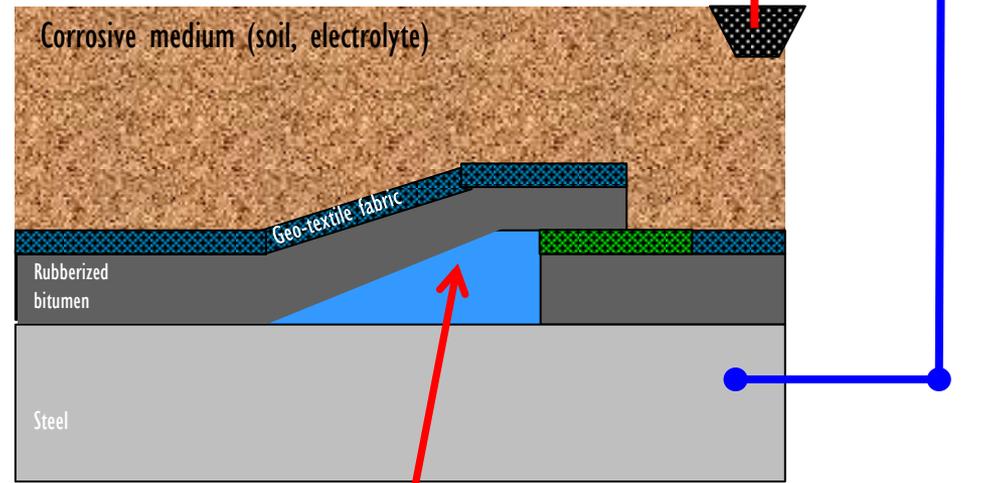
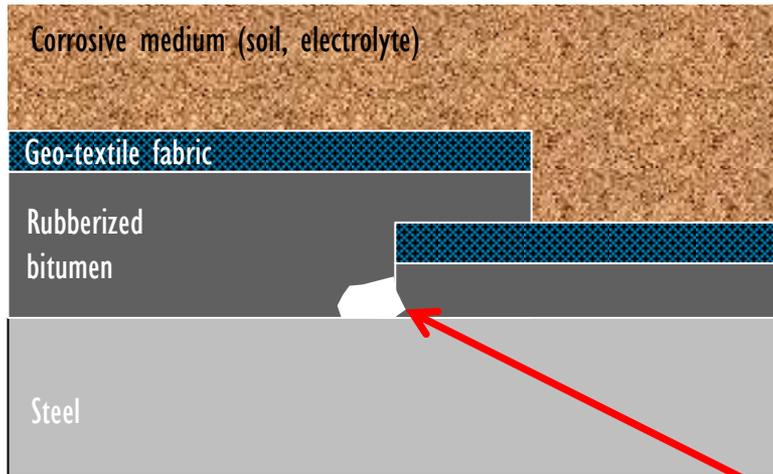


No Corrosion (theoretically)

Option A



Polymeric Mesh-Backed Coating



The woven Geo-textile fabric backing is always **as wet as the soil** (...or as dry as the soil).

Water is brought to the steel through the weak point of the coating → **disbondment**

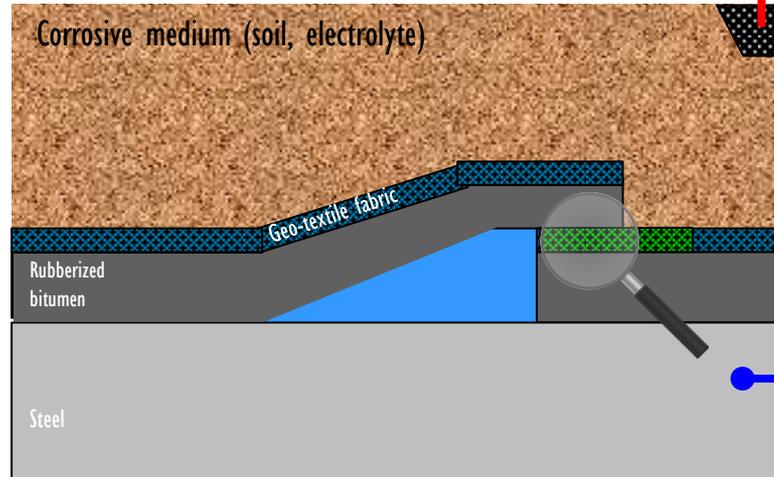
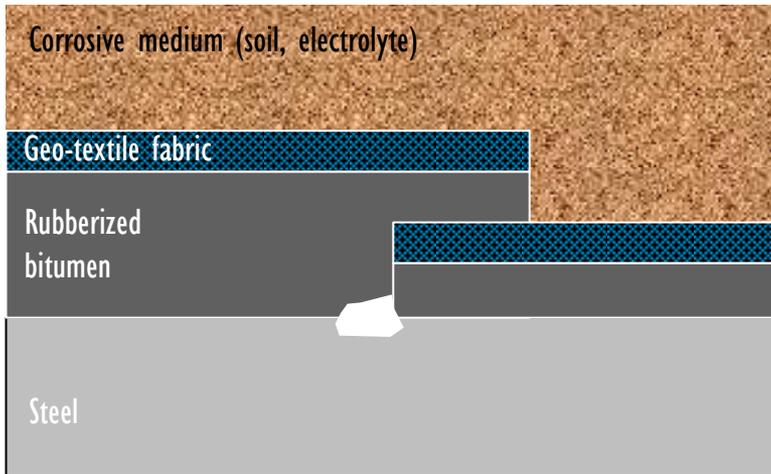


Cathodic Protection (CP) works.

Option A



Remember: an insufficient adhesion of 2-ply tapes...



... resulted in the penetration of water and caused **Spiral Corrosion**.

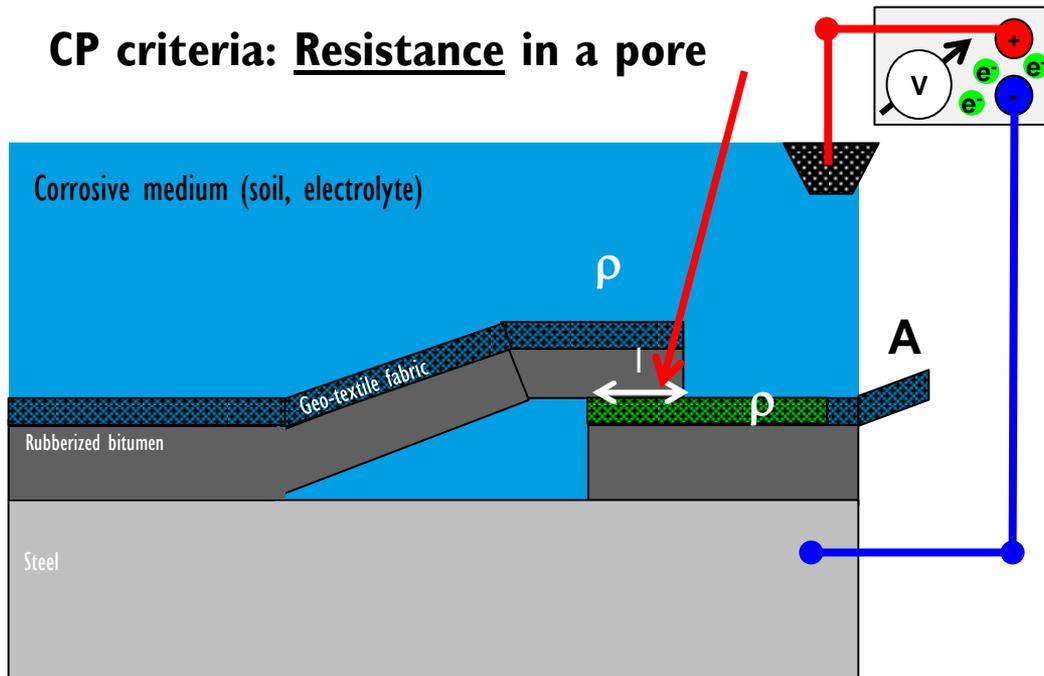
By providing only one protective layer that keeps the corrosive medium away from the steel, the situation with Polymeric Mesh-Backed Coatings is getting even worse. The argument against the fear using a geo-textile fabric is the gained conductivity. Is this really an advantage?



Let's take a look at the Cathodic Protection criteria

Option A

CP criteria: Resistance in a pore



$$\text{CP-Current } I \sim \frac{A}{\rho \cdot l}$$

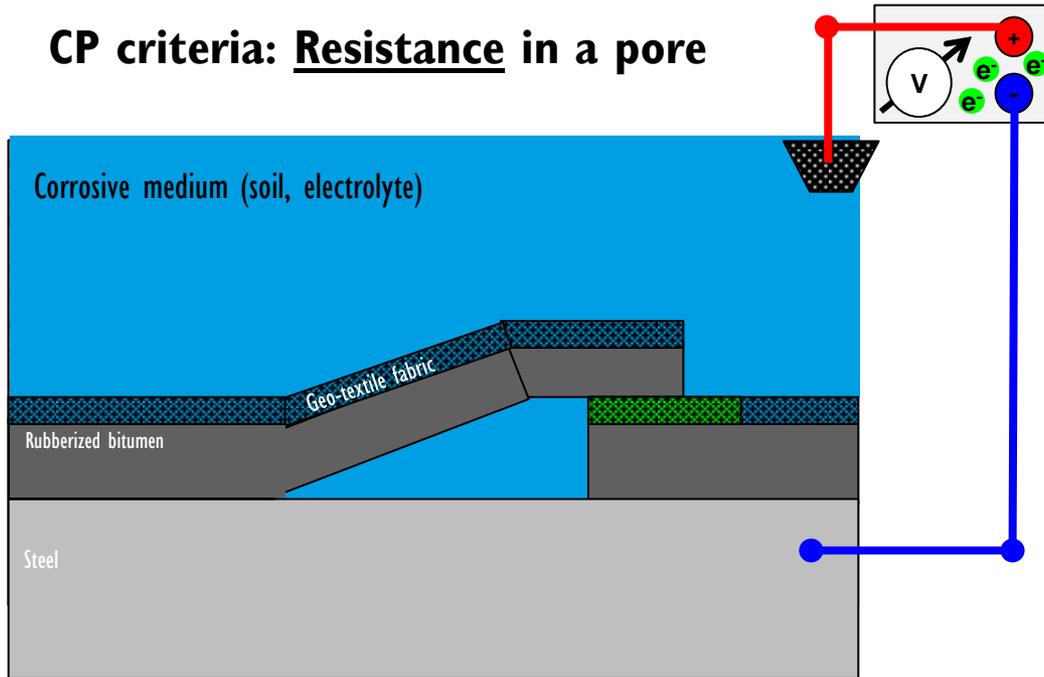
A = cross section area

ρ = specific resistance of the material

l = length of the pore

Option A

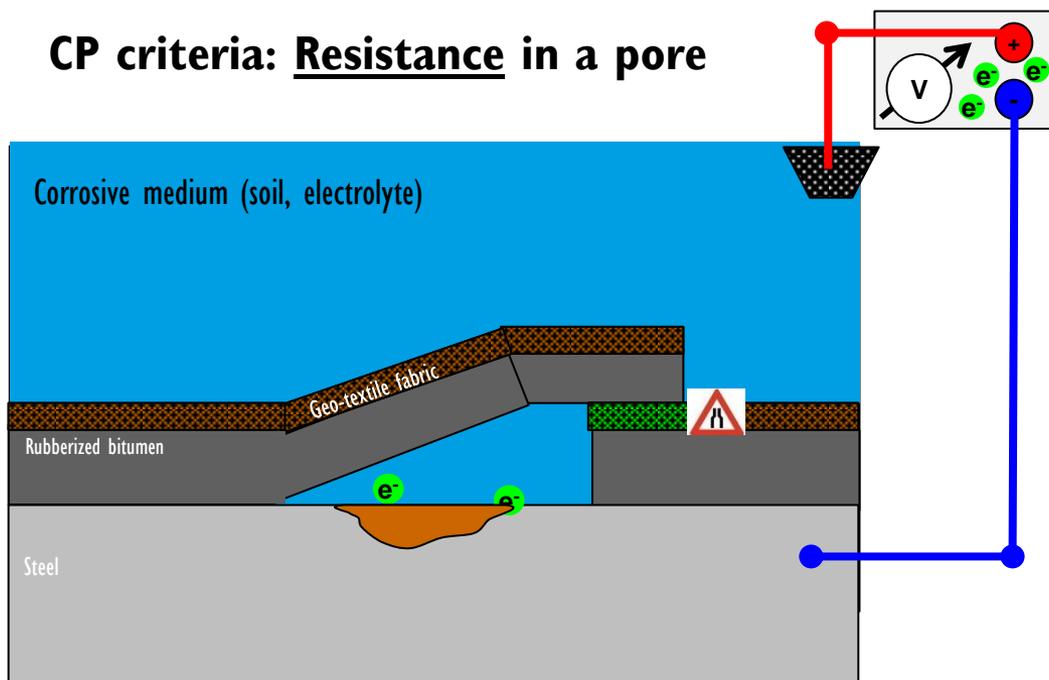
CP criteria: Resistance in a pore



$$\text{CP-Current } I \sim \frac{A}{\rho \cdot l}$$

Option A

CP criteria: Resistance in a pore



$$\text{CP-Current } I \sim \frac{A}{\rho \cdot l}$$

1) At **high soil resistivity**
(e.g. dry/sandy soil)

→ **Decrease of the CP-Current**

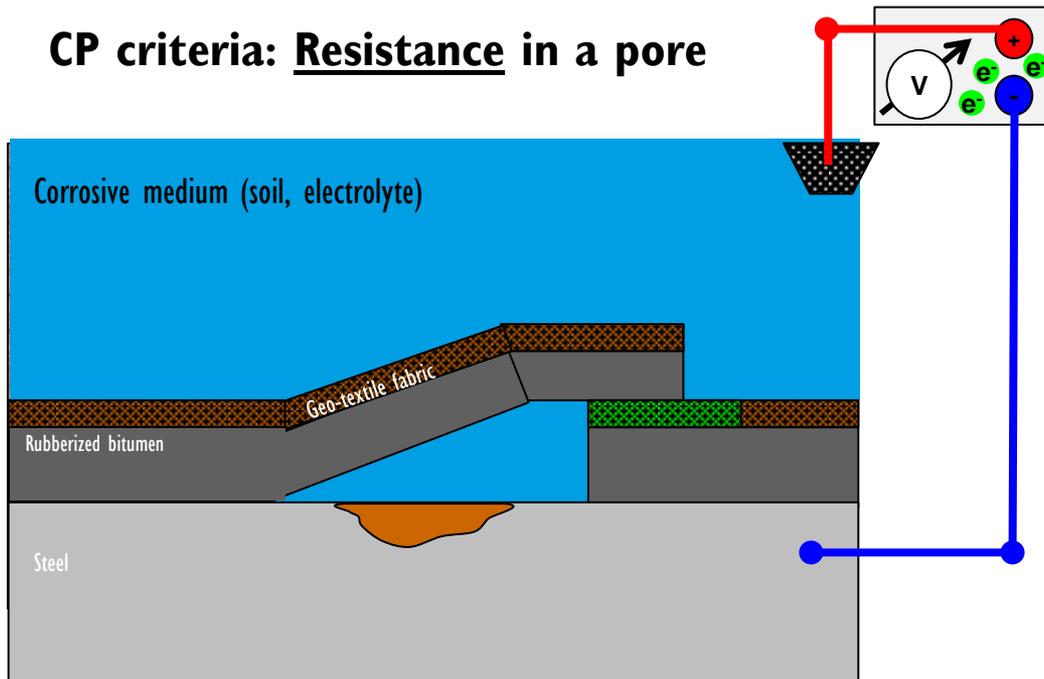


Current (CP) is not sufficient!

Corrosion starts...

Option A

CP criteria: Resistance in a pore



$$\text{CP-Current } I \sim \frac{A}{\rho \cdot l}$$

1) At **high soil resistivity**
(e.g. dry/sandy soil)

→ **Decrease of the CP-Current**

2) Changing conditions **wet** **dry**

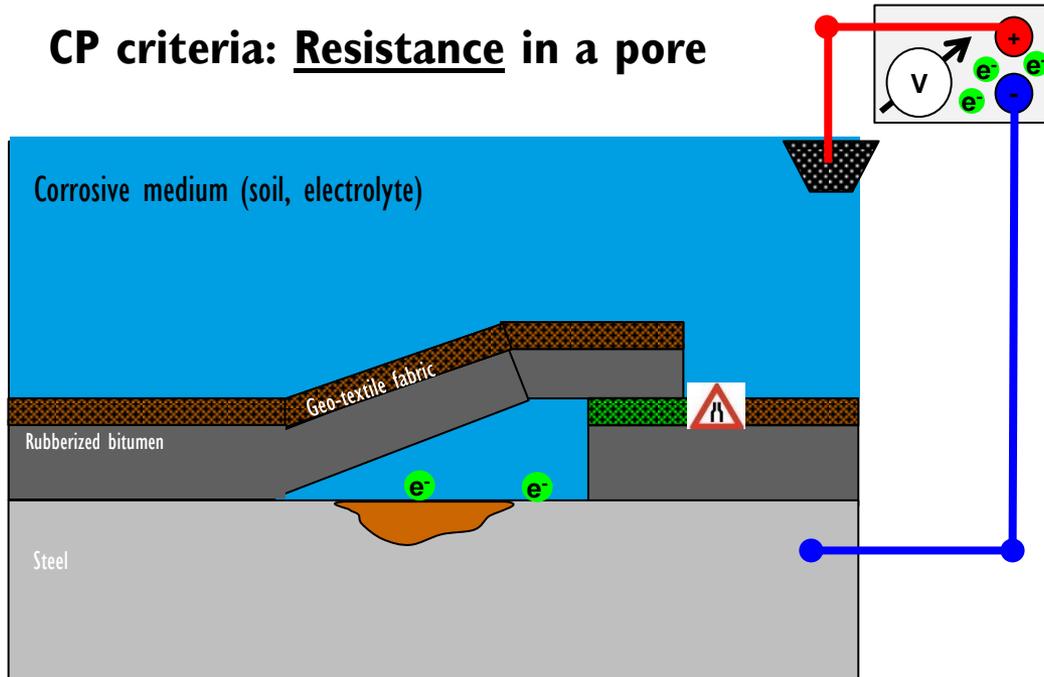
→ **Increase of the CP-Current**

Current (CP) is sufficient.

Corrosion stops...

Option A

CP criteria: Resistance in a pore



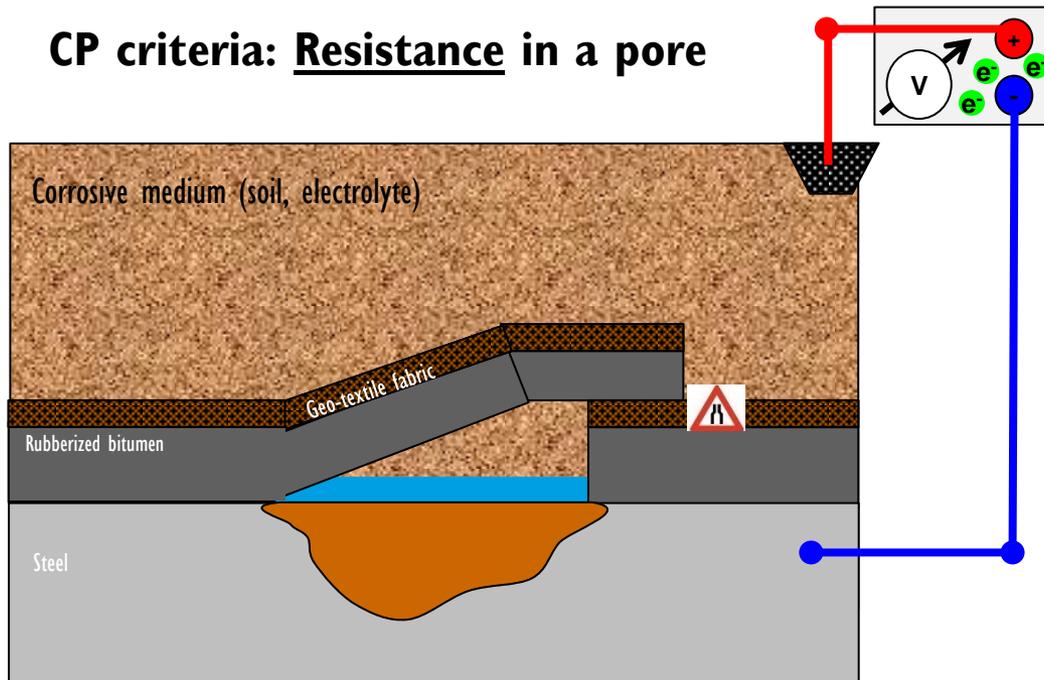
$$\text{CP-Current } I \sim \frac{A}{\rho \cdot l}$$

1) Again **high soil resistivity**
(e.g. dry/sandy soil)

→ **Decrease of the CP-Current I .**

Option A

CP criteria: Resistance in a pore



$$\text{CP-Current } I \sim \frac{A}{\rho \cdot l}$$

The disbonded area is frequently filled with fresh water and oxygen

The soil, and later the pores, dry out, but not the whole disbonded area!

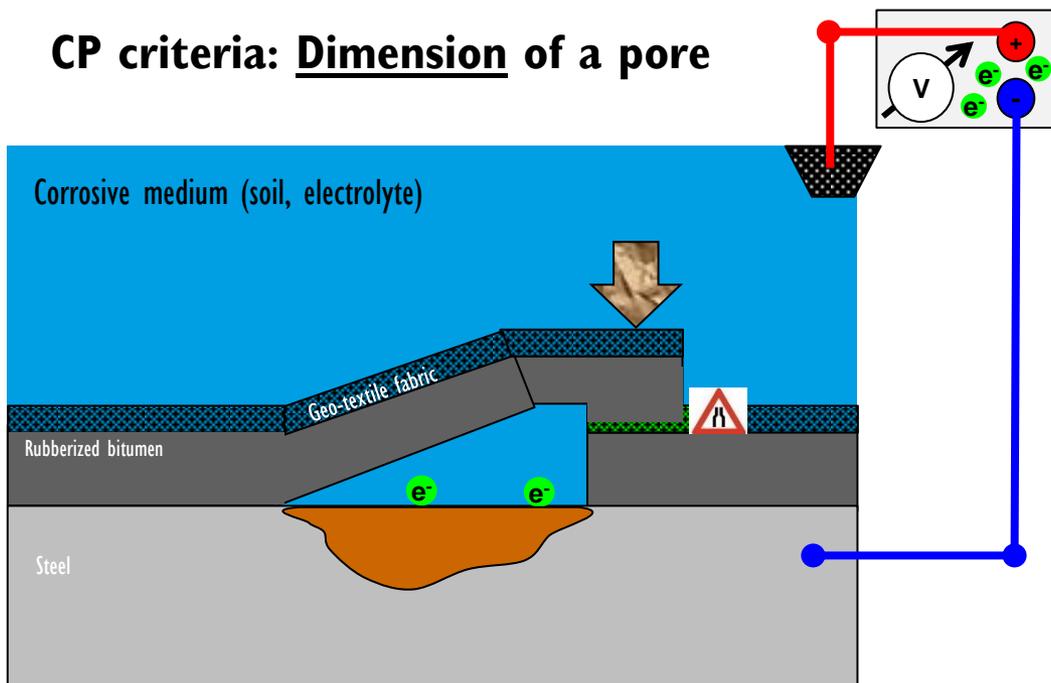


Current (CP) is not sufficient!

Corrosion proceeds...!

Option A

CP criteria: Dimension of a pore



$$\text{CP-Current } I \sim \frac{A}{\rho \cdot l}$$

Soil pressure reduces pore dimensions.

Decrease of the CP-Current.

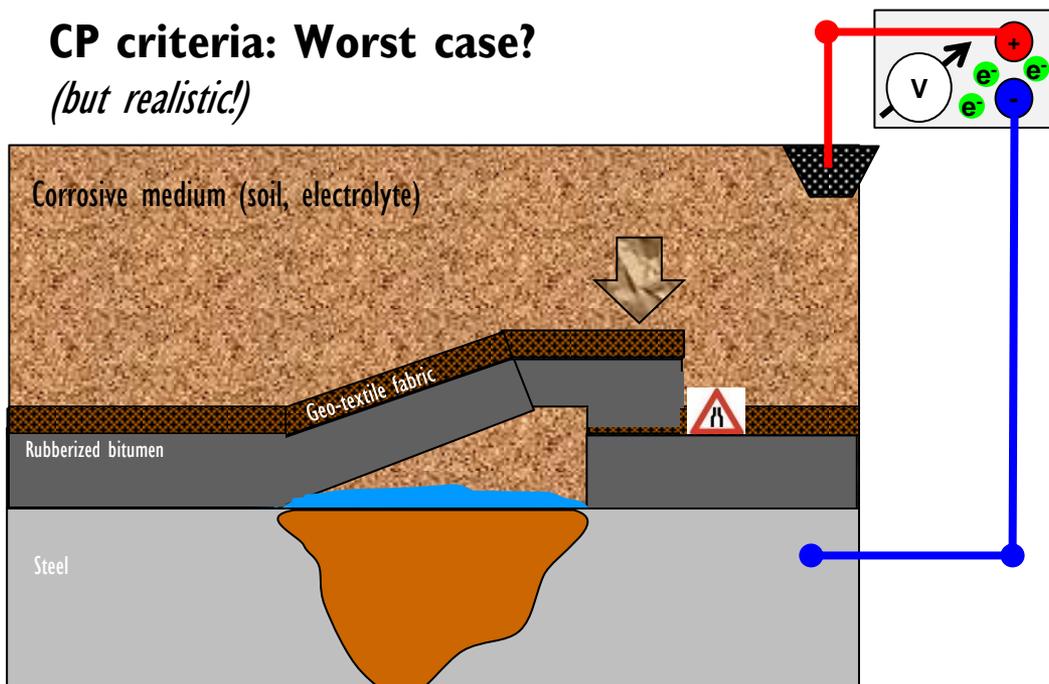


Current (CP) is not sufficient!

Corrosion again...

Option A

CP criteria: Worst case?
(but realistic!)



$$\text{CP-Current } I \sim \frac{A}{\rho \cdot l}$$

high soil resistivity (e.g. dry/sandy soil)

& soil pressure

& changing conditions wet **dry**



Current (CP) is at minimum!

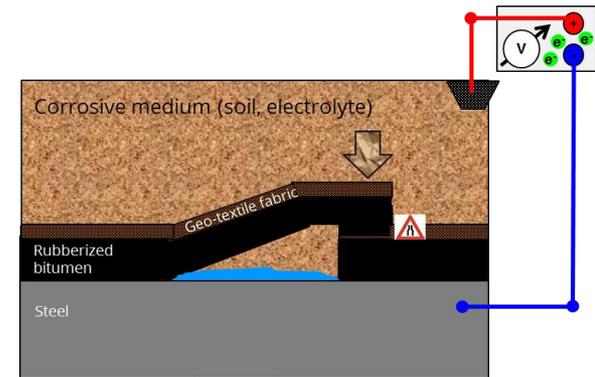
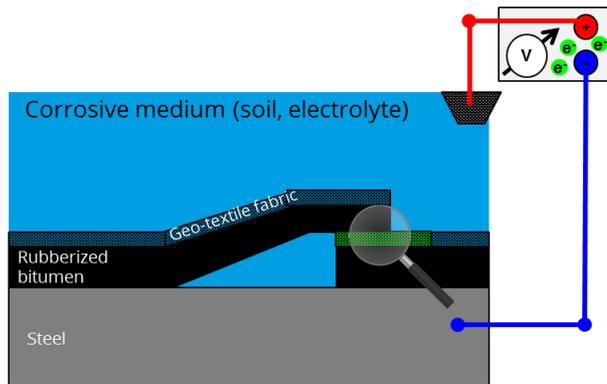
Corrosion is at maximum...



Option A



Which is the most likely/realistic condition in the field?



- 1) **No changing conditions** (only dry or wet soil)?
- 2) **No** (changing) **mechanical pressure** on coating?
- 3) **Perfect working Cathodic Protection (CP)** at “any time and place”?



- 1) **Changing conditions** (dry/wet soil)?
- 2) **Changing mechanical pressure** on coating?
- 3) **Cathodic Protection (CP)** in place and **working stable**?

Searching for a Solution



Option “A” does not seem to be a good solution...

Option A:

- 1) Continue with **2-ply tape** technology.
- 2) Allow **water/oxygen** to get in contact with **steel surface** to transport electrons from the CP.
- 3) **Current (CP)** is strictly **mandatory** to flow “any time and place”.



Option B:

- 1) Provide a **hose-like coating**. No micro-tunnels!
- 2) Do not allow **water/oxygen** to get in contact with **steel surface**.
- 3) **Current (CP)** as **additional** protection (second line of defense).

... what about Option “B” ?



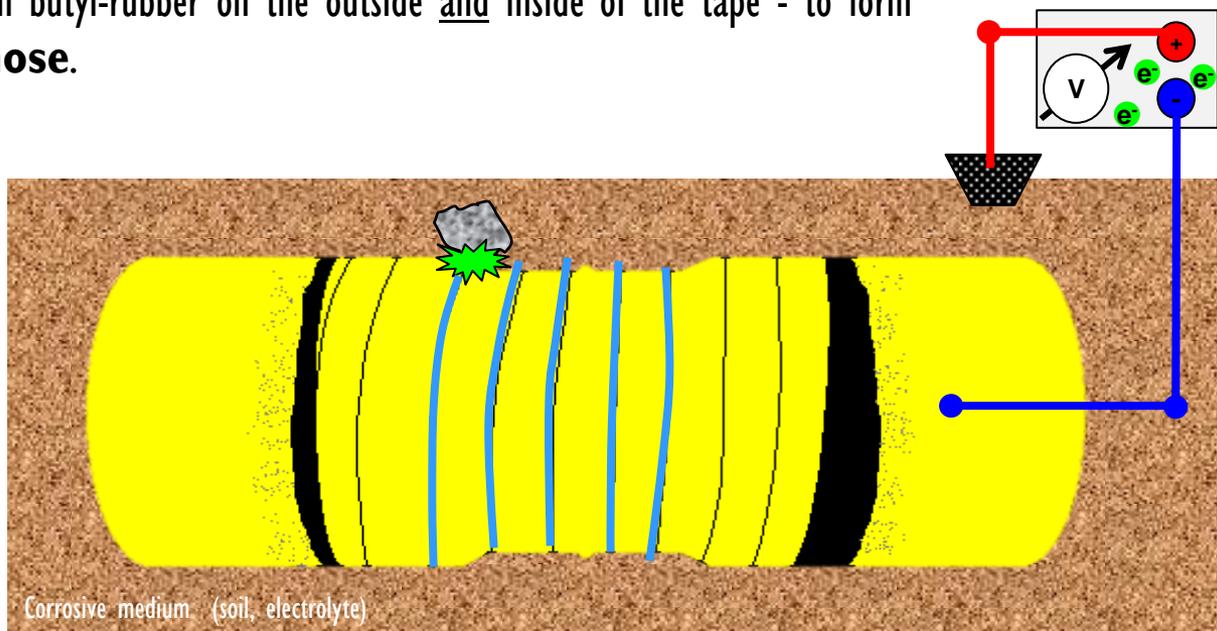
Option B

Option “B”: Providing a **hose-like Coating**, for example **3-ply tape technology**:

The idea: An adhesive tape with butyl-rubber on the outside and inside of the tape - to form a **water / oxygen-proof hose**.

No disbondment
of the layers and
therefore:

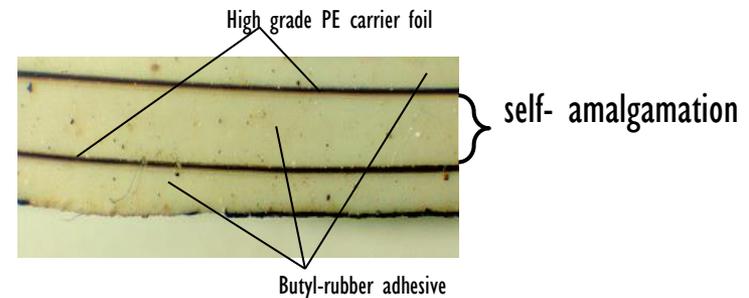
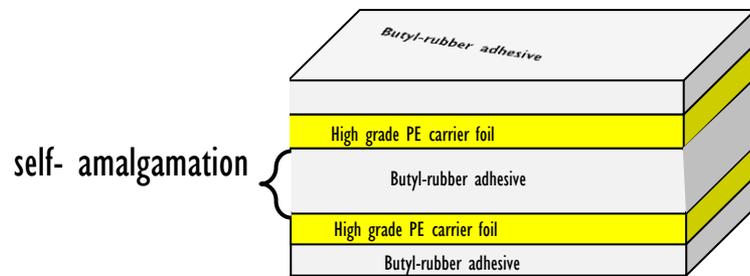
no spiral channels.



No Corrosion, not even in distance to a defect!

Option B

Technology of self-amalgamating 3-ply PE/Butyl-rubber tapes:



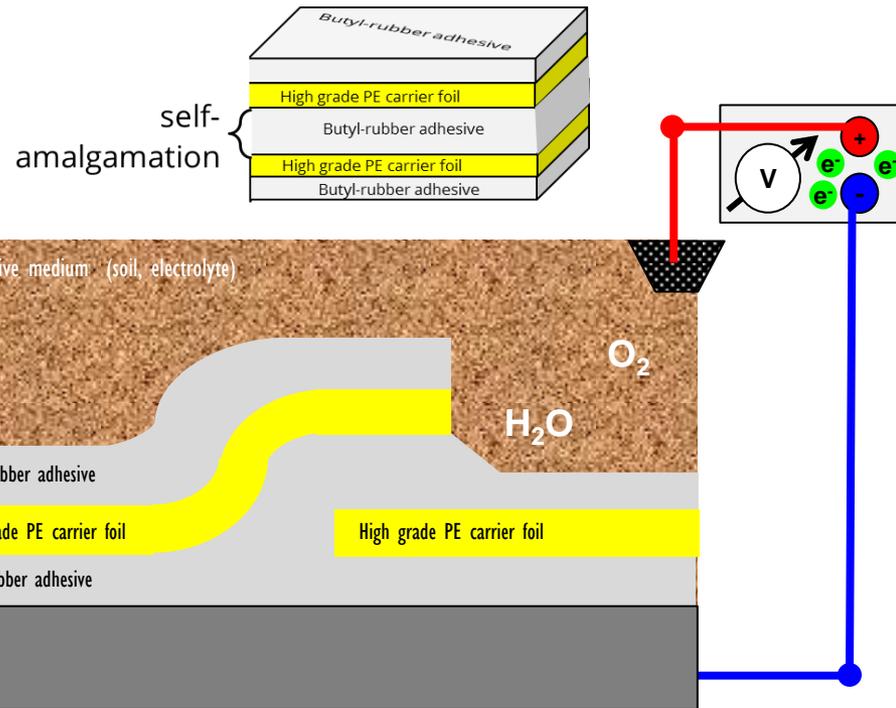
The fused layers (outer and inner Butyl-rubber adhesive) form a **water- and oxygen-proof protective hose!**

Option B



Properties of self-amalgamating 3-ply PE/Butyl-rubber tapes:

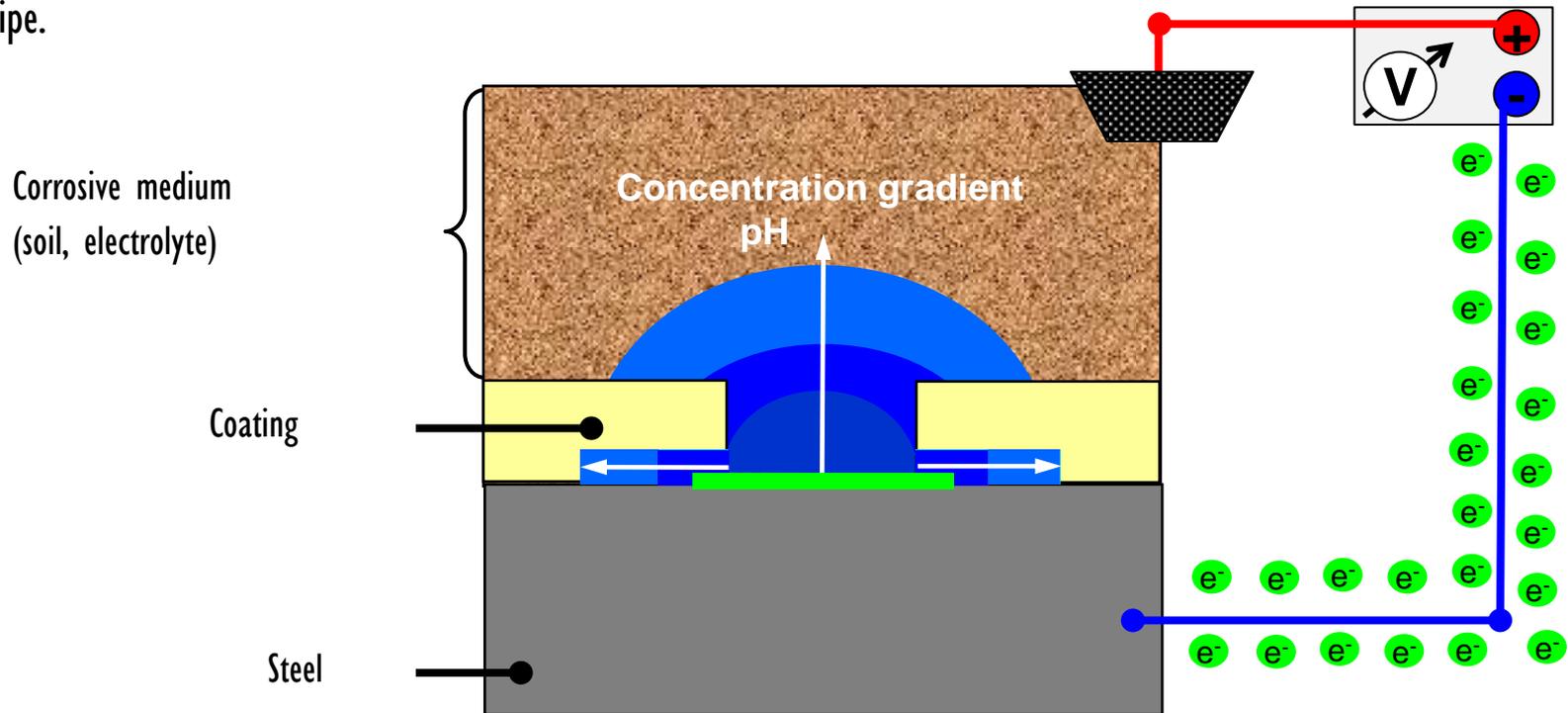
- ✓ No spiral channels.
- ✓ No contact of water/oxygen to steel surface.
- ✓ No disbondment.
- ✓ Independent on changing conditions (wet/dry soil)
- ✓ Independent on (changing) mechanical pressure.
- ✓ Cathodic Protection (CP) not mandatory.



No Corrosion

Option B

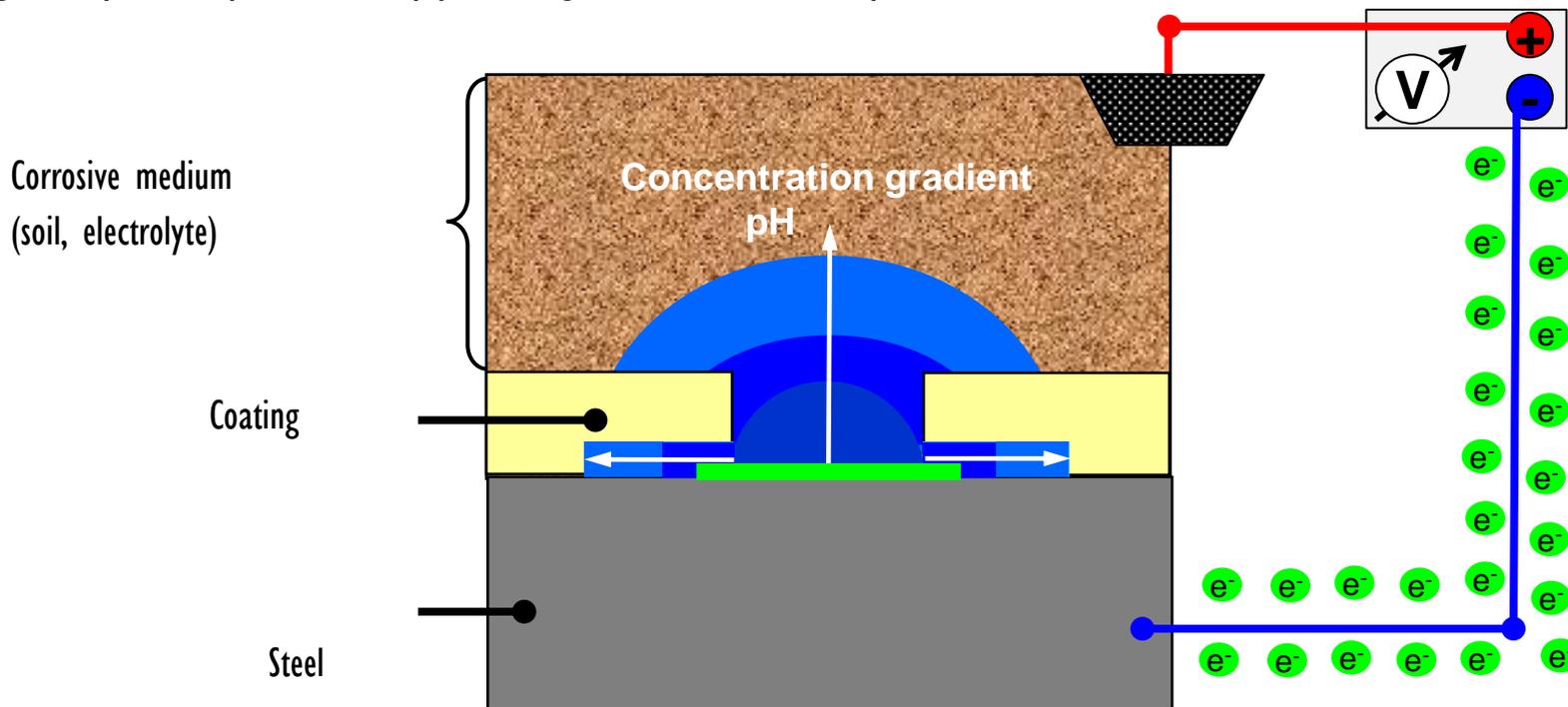
In the unlikely event of disbondment of a hose-like Coating, the mechanism of inhibition through the pH-level protects the pipe.



- █ **No Corrosion – due to activation polarization**
- █ **No Corrosion – due to concentration polarization (increase of pH) even under disbonded coating**

Option B

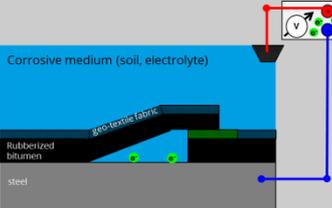
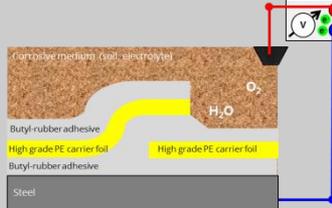
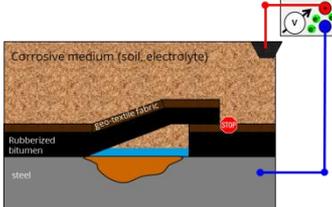
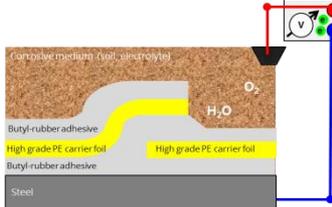
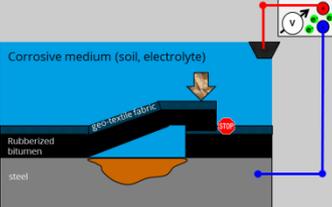
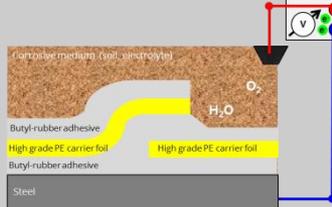
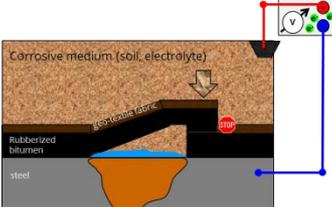
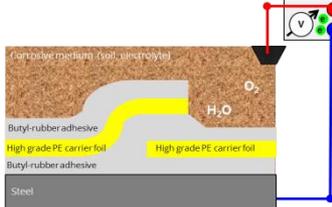
Even if the CP is interrupted in the unlikely event of disbondment of a hose-like Coating, the mechanism of inhibition through the pH-level protects the pipe through the concentration polarisation.



Still no Corrosion – due to concentration polarization (pH-level)



„Option A“ vs. „Option B“

Situation	Non-Shielding Tape 2-ply Polymeric Mesh-Backed Coating	Hose-like Coating (i.e. 3-ply Tape) High grade, Co-extruded, self-amalgamating
	 <ul style="list-style-type: none"> • Spiral channels • CP works • No corrosion 	 <ul style="list-style-type: none"> • NO channels • CP armed • NO corrosion
	 <ul style="list-style-type: none"> • Spiral channels • Unsuccessful CP • Corrosion 	 <ul style="list-style-type: none"> • NO channels • CP armed • NO corrosion
	 <ul style="list-style-type: none"> • Spiral channels • Unsuccessful CP • Corrosion 	 <ul style="list-style-type: none"> • NO channels • CP armed • NO corrosion
	 <ul style="list-style-type: none"> • Spiral channels • Minimum CP • Maximum Corrosion 	 <ul style="list-style-type: none"> • NO channels • CP armed • NO corrosion



Conclusion

**Applying Polymeric Mesh-Backed Coatings,
so called “Non-Shielding Tapes”,
to avoid **Spiral Corrosion** by supporting the current of the
Cathodic Protection (CP) to reach any area of the pipe
is a very questionable approach:**

Do you really think it is a good solution...

- ? ... to **provide only one protective layer?**
- ? ... to enable **water and oxygen** to reach the **steel surface?**
- ? ... to assume **no changing conditions** (wet/dry soil)?
- ? ... to assume **no pressure on the mesh-backed coating?**
- ? ... to rely always on a **perfectly working Cathodic Protection (CP)?**

Conclusion



Furthermore: using a Bitumen-based adhesive on the coating is an old-fashioned solution, which fails because of the weakness of the material Bitumen. When aging, Bitumen gets brittle and does not provide any reliable protection anymore.

➔ Why should you weaken **The First Line of Defense?**



Conclusion

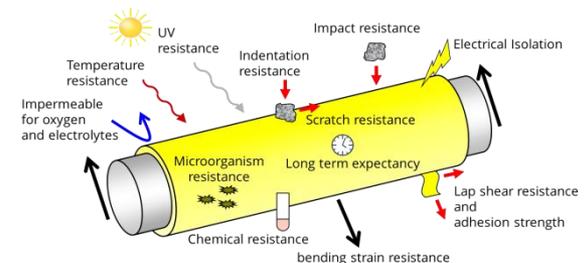
Any coating (factory-coating or field-coating) should always be designed to **perfectly protect the pipeline.**

In the case of field applied coatings

Hose-like coatings, such as liquid coatings, shrinkable sleeves and self-amalgamating 3-ply tapes, provide the best solution

- ✓ ... by **preventing water and oxygen** to reach the **steel surface!**
- ✓ ... to work under **changing conditions** (wet/dry soil)!
- ✓ ... to endure **pressure** on the coating!
- ✓ ... by having **Cathodic Protection (CP)** only as second line of defense!

✓ **Choosing a corrosion prevention system that works under any condition will be the first choice!**



Answer to the initial question:

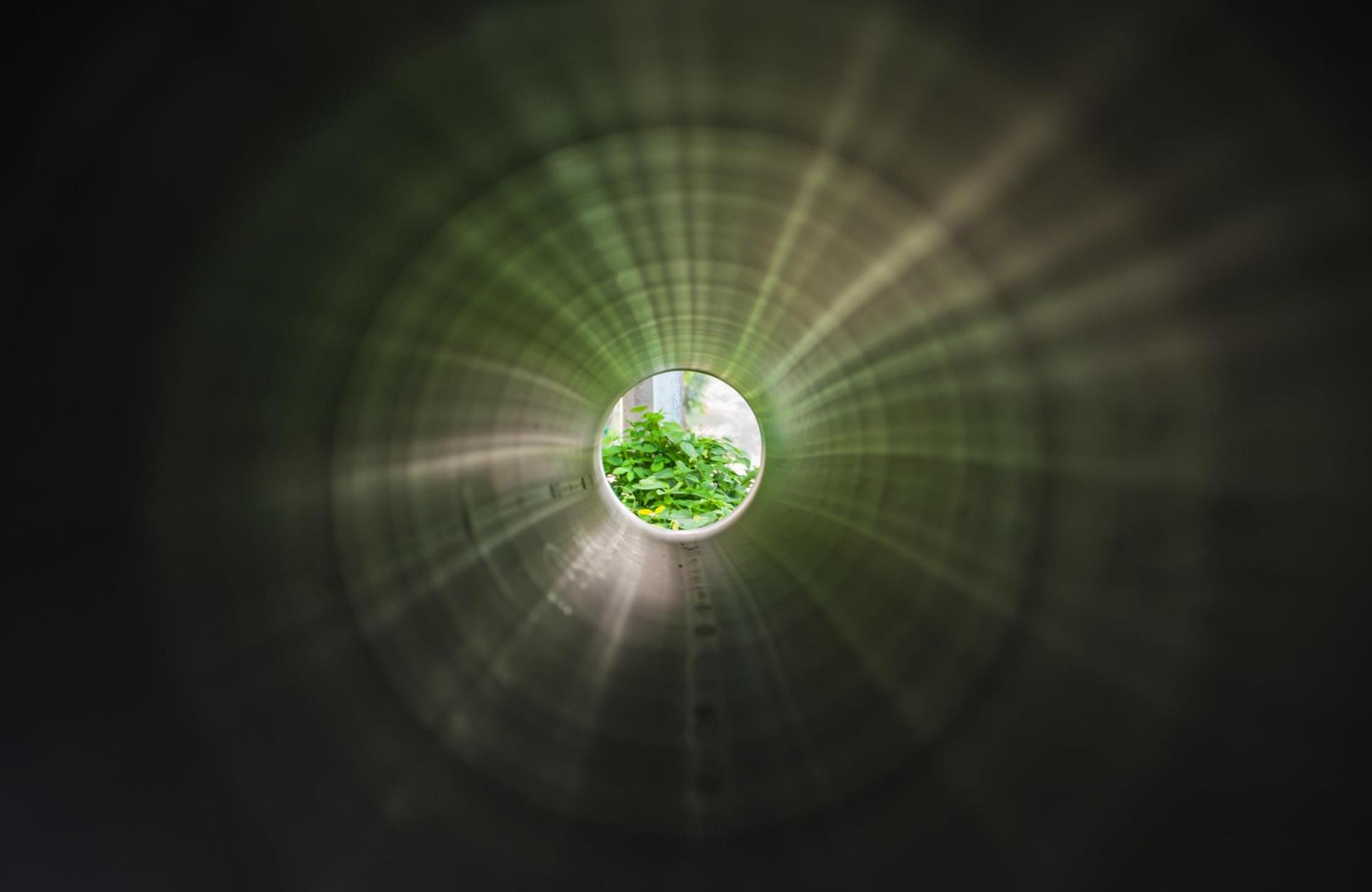


“Shielding”
or
“Non-Shielding”?

This is not the correct question:

Non-Shielding products, such as polymeric mesh-backed tapes, are based on an old-fashioned technology, which proved to fail in field (2-ply tapes for corrosion prevention). By promoting a “non-shielding” effect, the huge disadvantages of those polymeric mesh-backed 2-ply tapes are somewhat compensated. This takes place at the expense of other important properties, which are then significantly weakened.

The best solutions are modern, high-quality hose-like coatings - and they usually have shielding properties.



Thank you !!





Film-Abspann mit Referenzen

References of self-amalgamating 3-ply PE/Butyl-rubber tapes:

- ✓ Worldwide first co-extruded 3-ply PE/Butyl-rubber tape invented in 1973.
- ✓ 45 years of proven success worldwide. No cases of Spiral Corrosion.
- ✓ Track record of millions of square meter of co-extruded 3-ply PE/Butyl-rubber tapes applied successfully.



SASOL
reaching new frontiers



BR PETROBRAS



- ✓ The world's only corrosion prevention system with a proven real-life **operation period of 40 years** without defects on a pipeline!

