Cement-based fill materials for the annulus of pipeline casings

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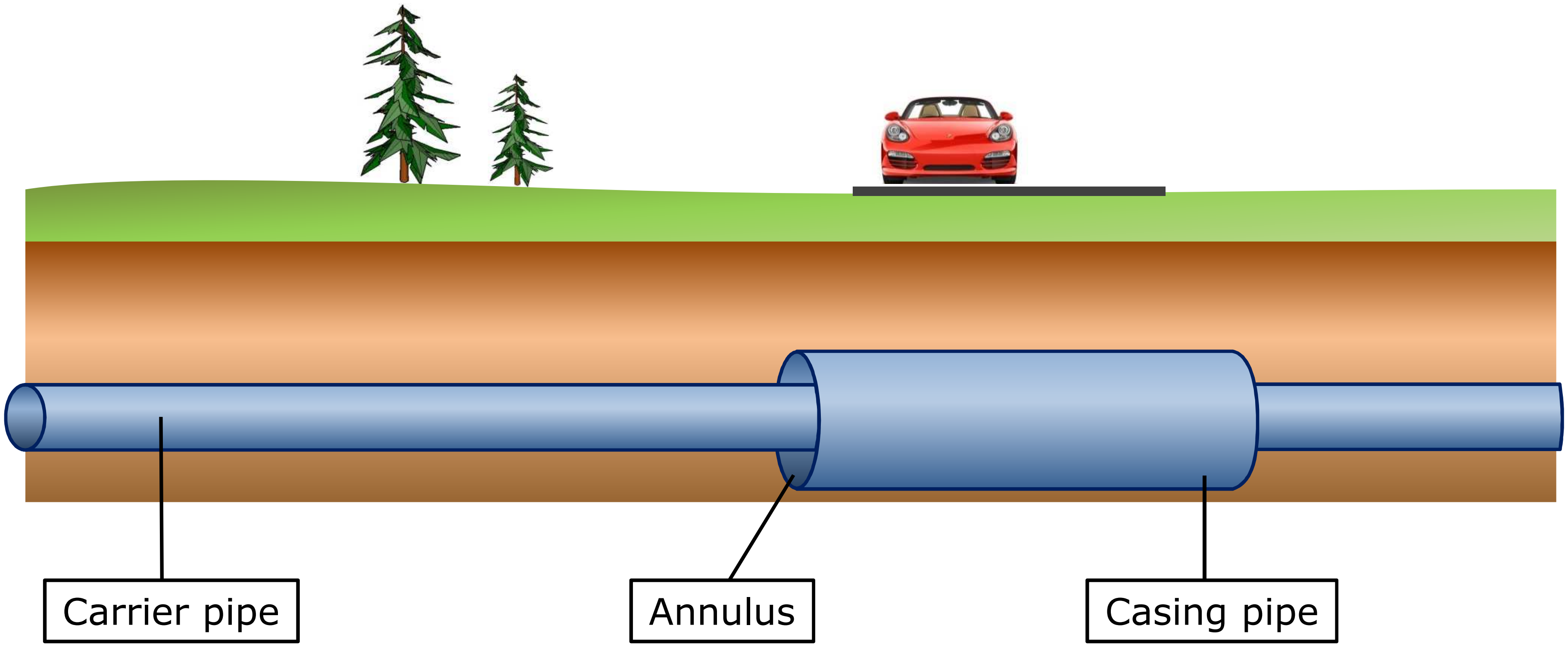
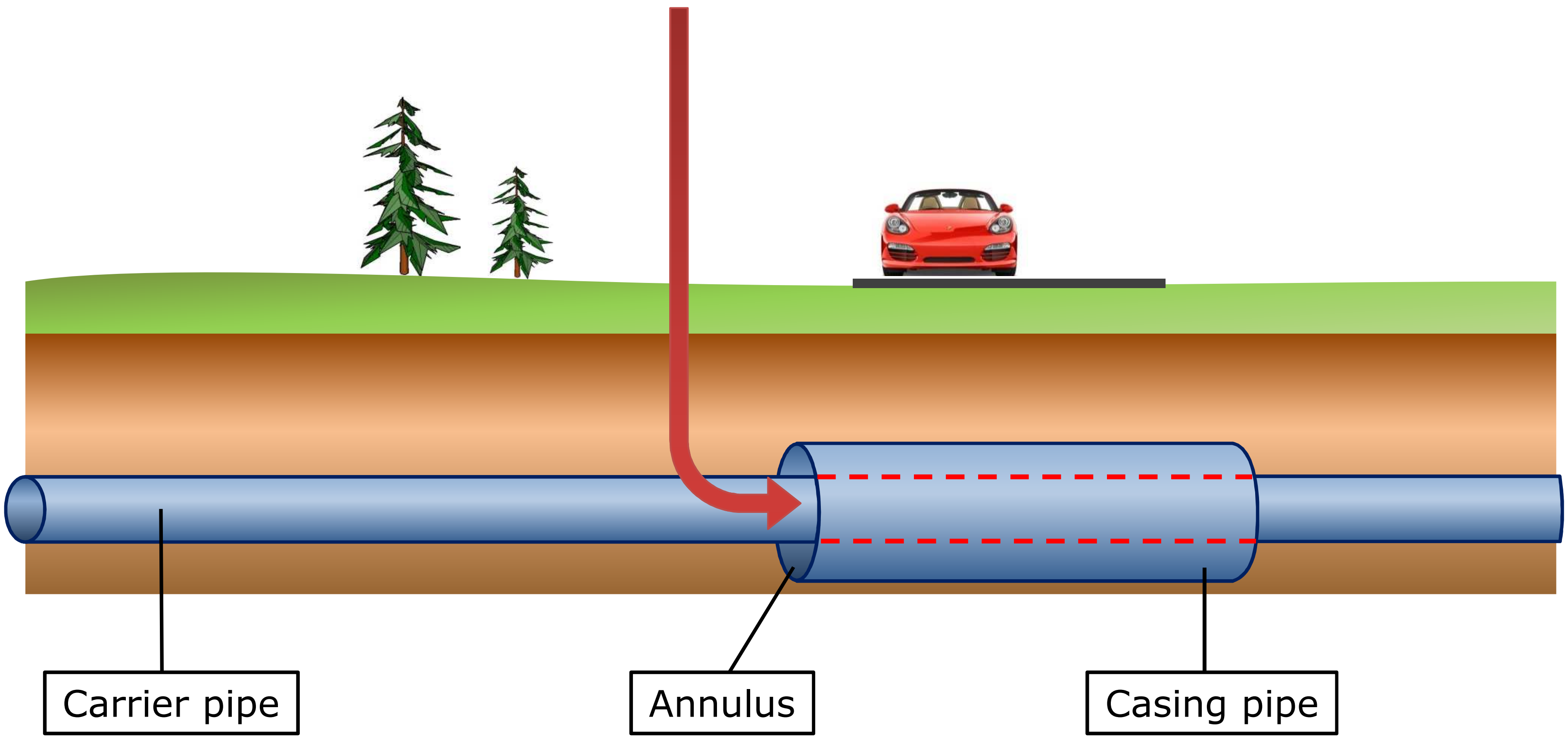
Pipeline casings



Pipeline casings

corrosion protection inside casing?



Corrosion protection inside pipeline casings

… a relevant issue?

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 15280

August 2013

ICS 23.040.99; 77.060

Supersedes CEN/TS 15280:2006

English Version

Evaluation of a.c. corrosion likelihood of buried pipelines applicable to cathodically protected pipelines

Évaluation du risque de corrosion occasionnée par les courants alternatifs des canalisations enterrées protégées cathodiquement

Beurteilung der Korrosionswahrscheinlichkeit durch Wechselstrom an erdverlegten Rohrleitungen anwendbar für kathodisch geschützte Rohrleitungen

This European Standard was approved by CEN on 5 July 2013.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

relatively narrow potential range

Foreword

This document (EN 15280:201[illegible]) has been prepared by Technical Committee CEN/TC 219 "Cathodic protection", the secretariat of which is held by BSI.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes CEN/TS 15280:2006.

With this document, CEN/TS 15280:2006 is converted into a European Standard.

The main modification concerns the criteria assumed in the presence of a.c. interference on a pipeline. While CEN/TS 15280:2006 represented a collection of various experiences in the field of a.c. corrosion, this European Standard has incorporated these criteria and thresholds together with experience gained from the most recent data. Various European countries have a different approach to the prevention of a.c. corrosion depending primarily on the d.c. interference situation. These different approaches are taken into account in two different ways:

— either in the presence of "low" ON-potentials (less negative than -1,2 V CSE), which allows a certain level of a.c. voltage (up to 15 V),

— or in the presence of "high" ON-potentials (more negative than -1,2 V CSE ; with d.c. stray current interference on the pipeline for instance) which requires the reduction of the a.c. voltage towards the lowest possible levels.

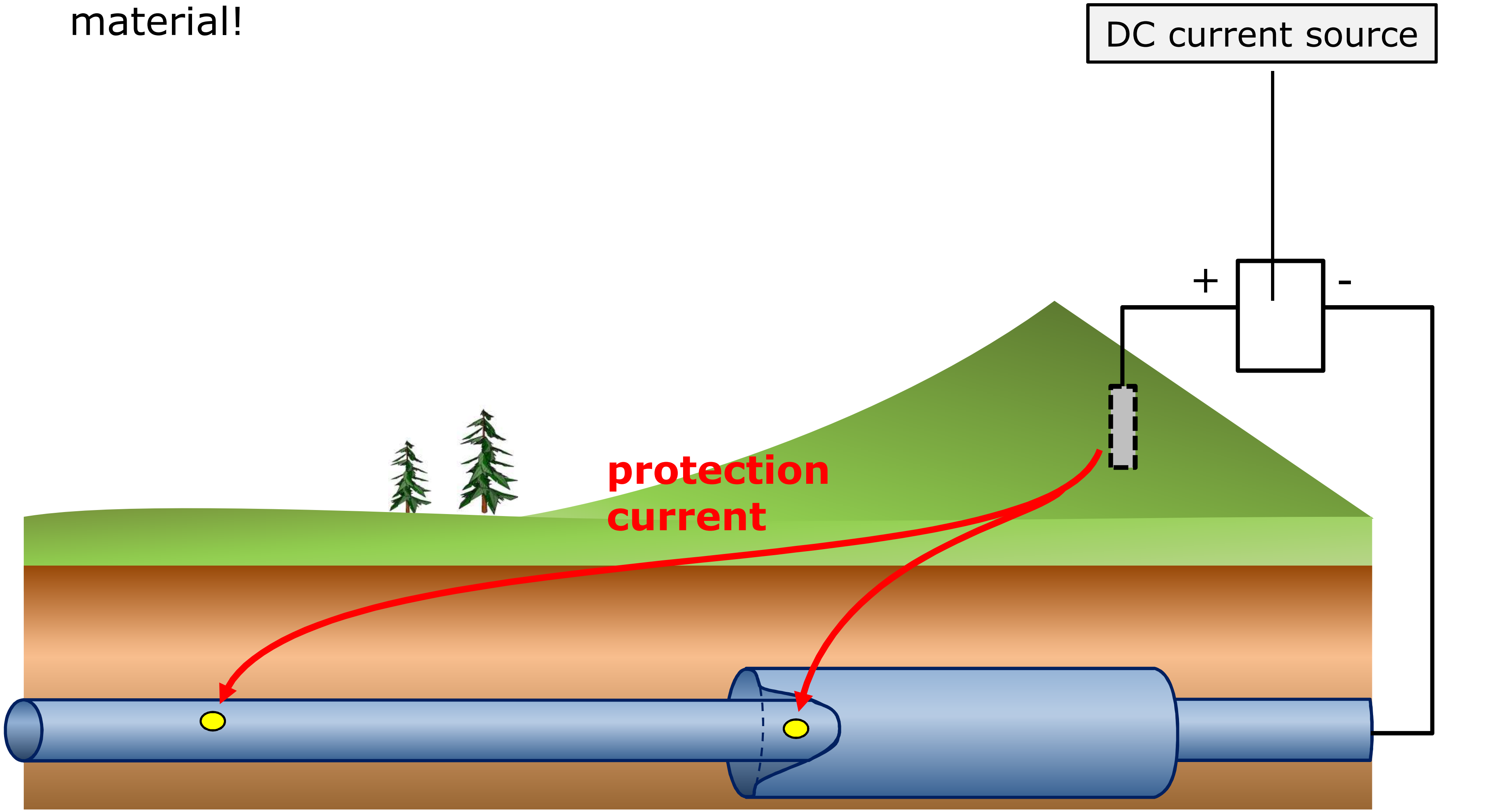
This European Standard gives also some parameters to consider when evaluating the a.c. corrosion likelihood, as well as detailed measurement techniques, mitigation measures and measurements to carry out for commissioning of any a.c corrosion mitigation system. Note that Annex E proposes other parameters and thresholds that require further validation based on practical experiences.

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech

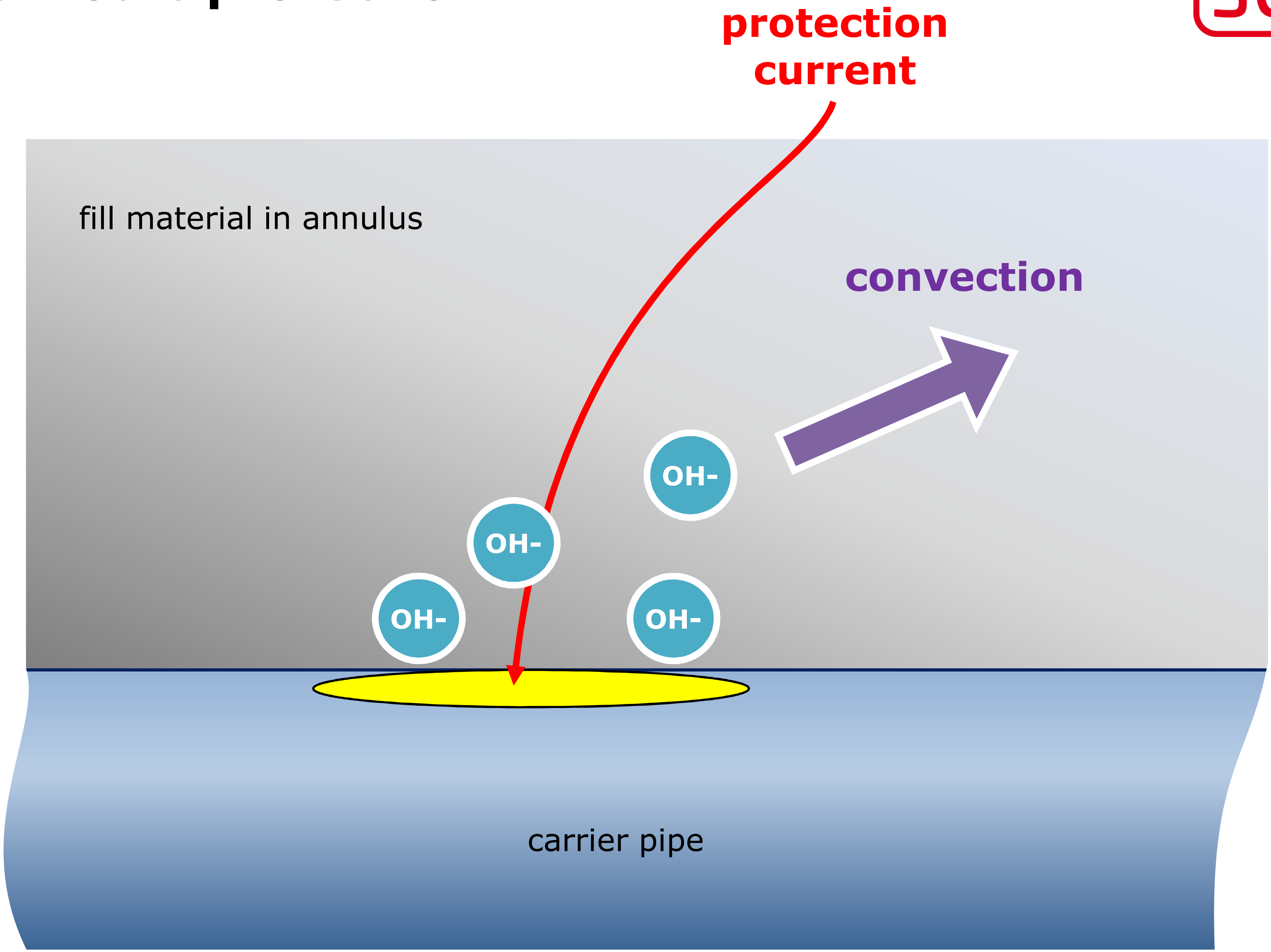
Corrosion protection

Cathodic protection

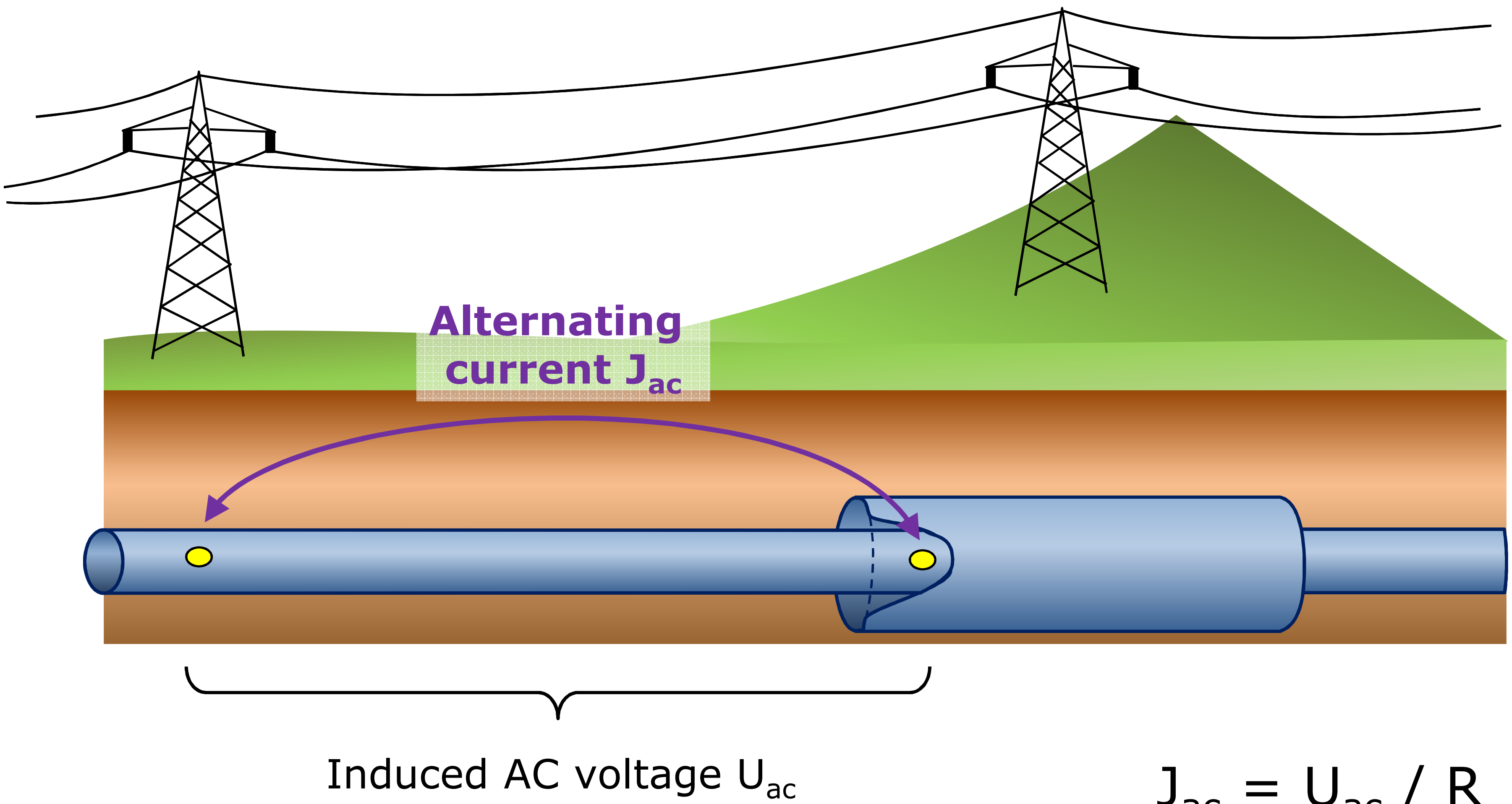
- The CP current must flow through the fill material!



Cathodic protection



AC corrosion



$$J_{ac} = U_{ac} / R$$

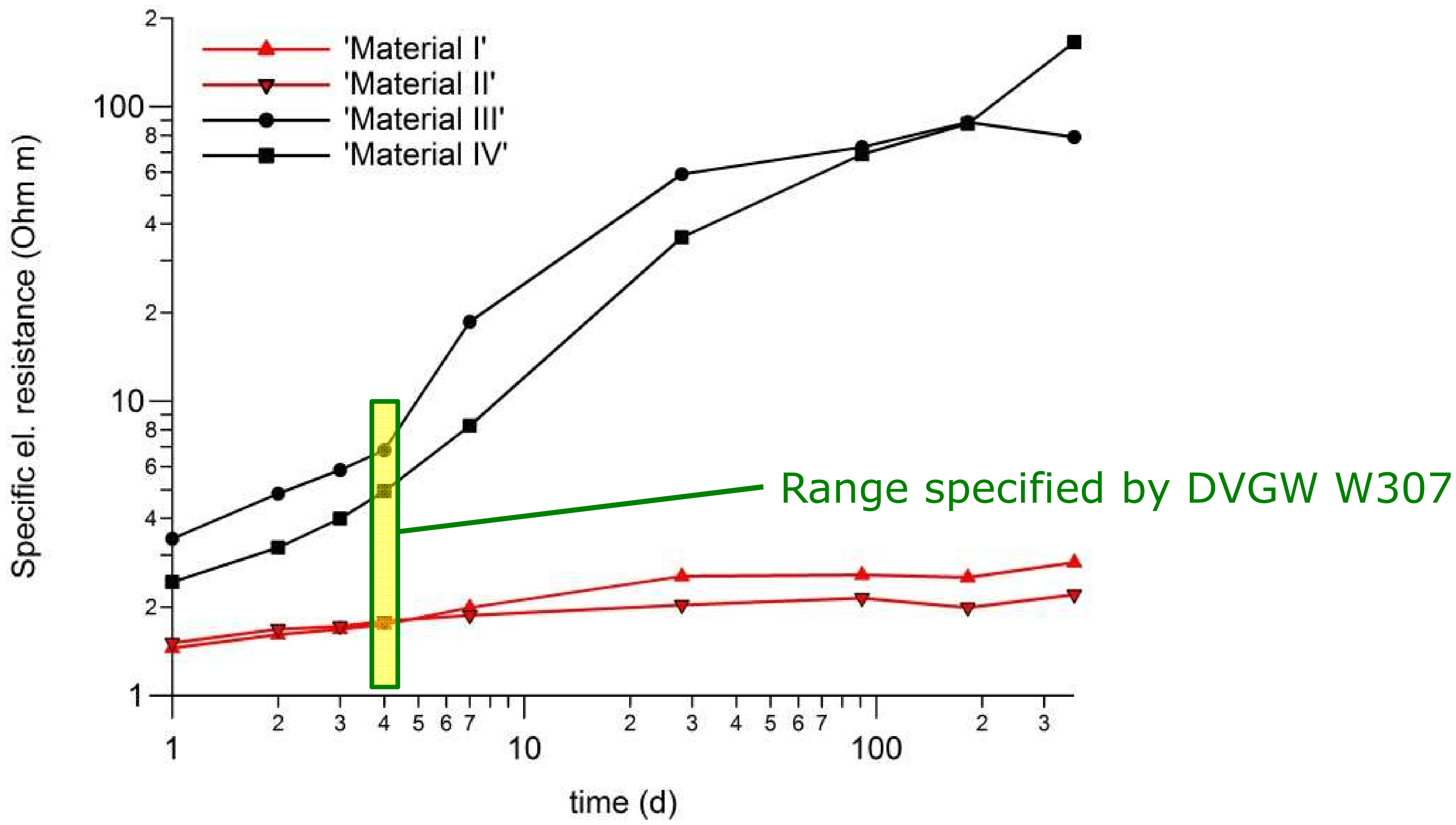
Experimental & Results

4 cement-based fill materials tested

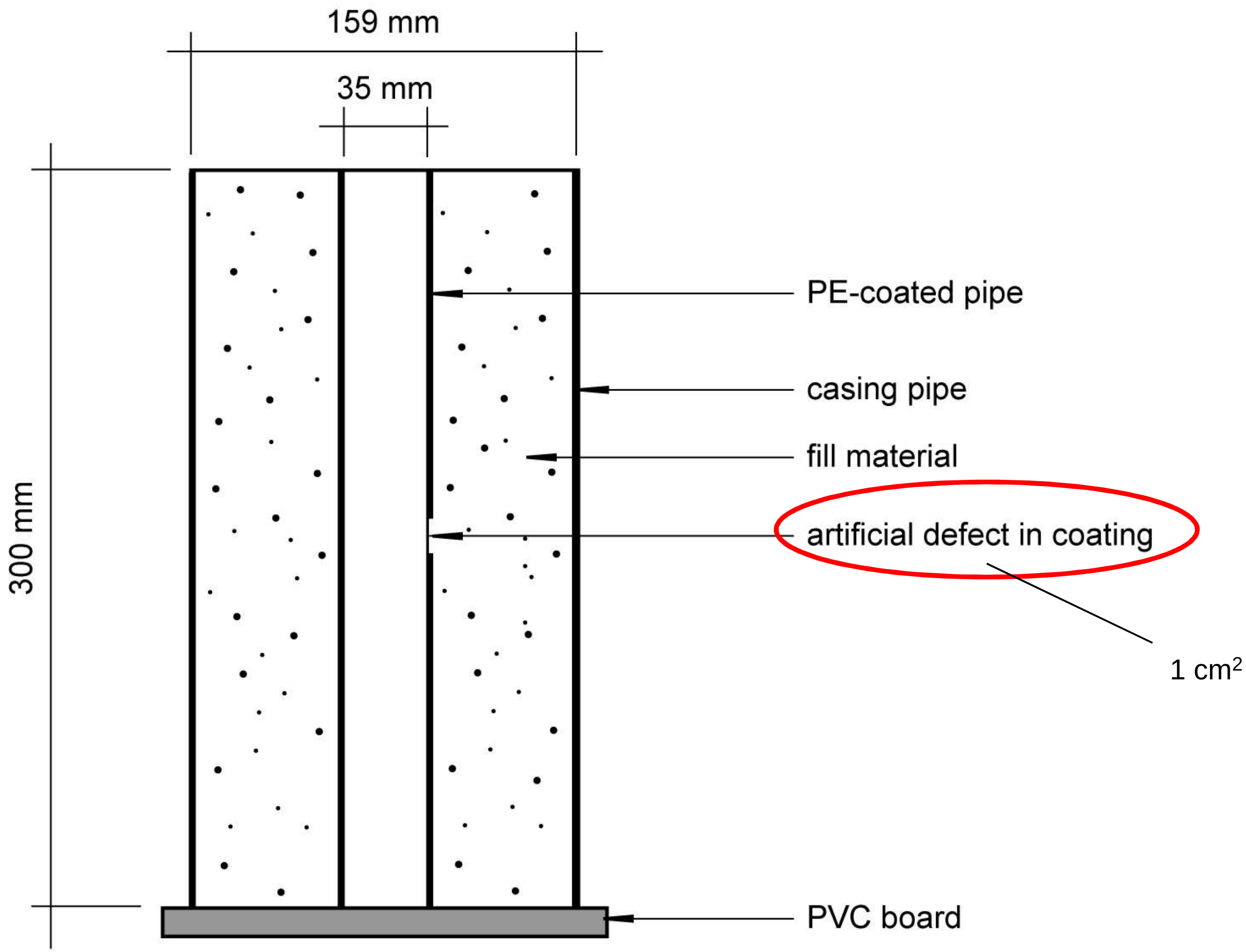
- w:s = 0.75…0.83

Fill material	pH in fresh state	pH after 202 d	pH after 369 d
Material I	12.8	12.7	
Material II	12.7	12.6	
Material III	12.8	12.2	12.3
Material IV	12.6	12.0	12.0

Electrical resistivity

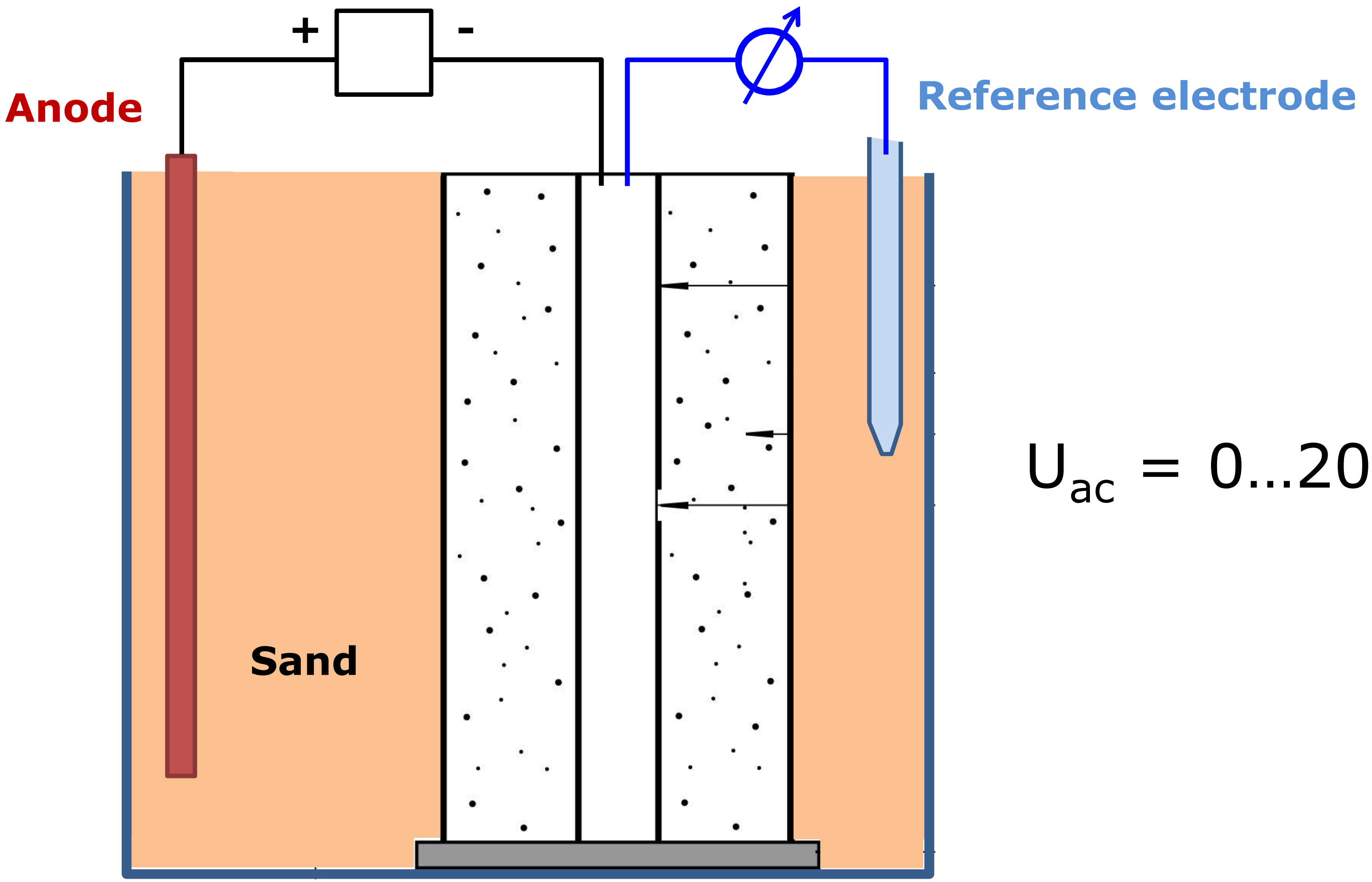


Cathodic protection experiments: Specimens



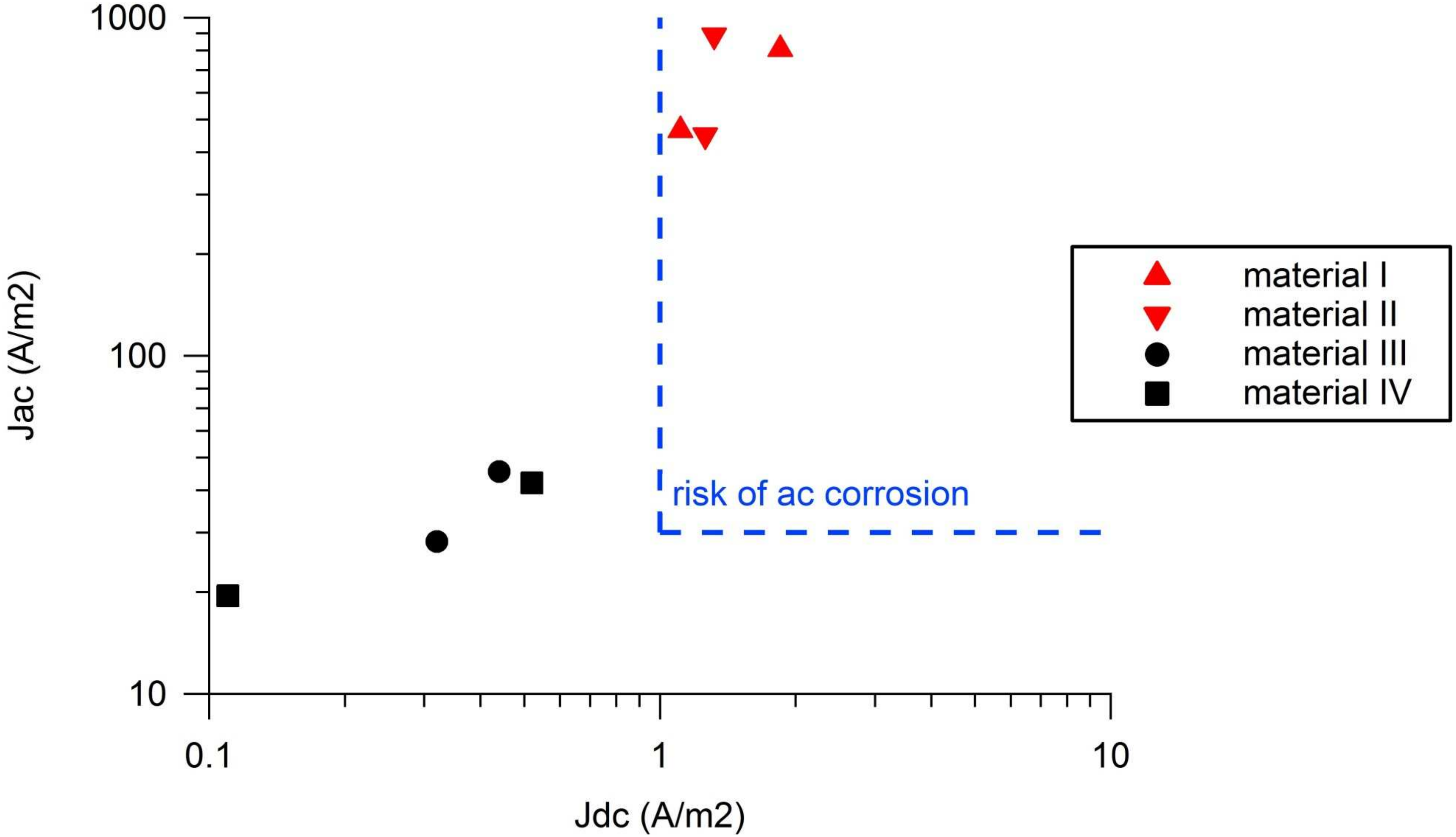
CP

$E_{on} = -1.2\ V_{CSE}$

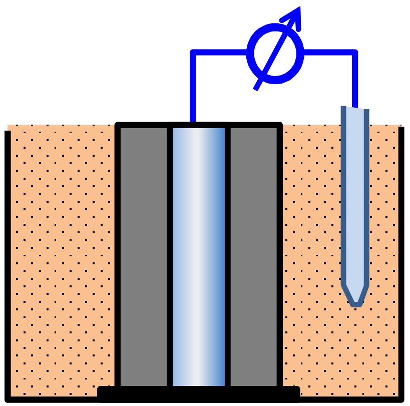


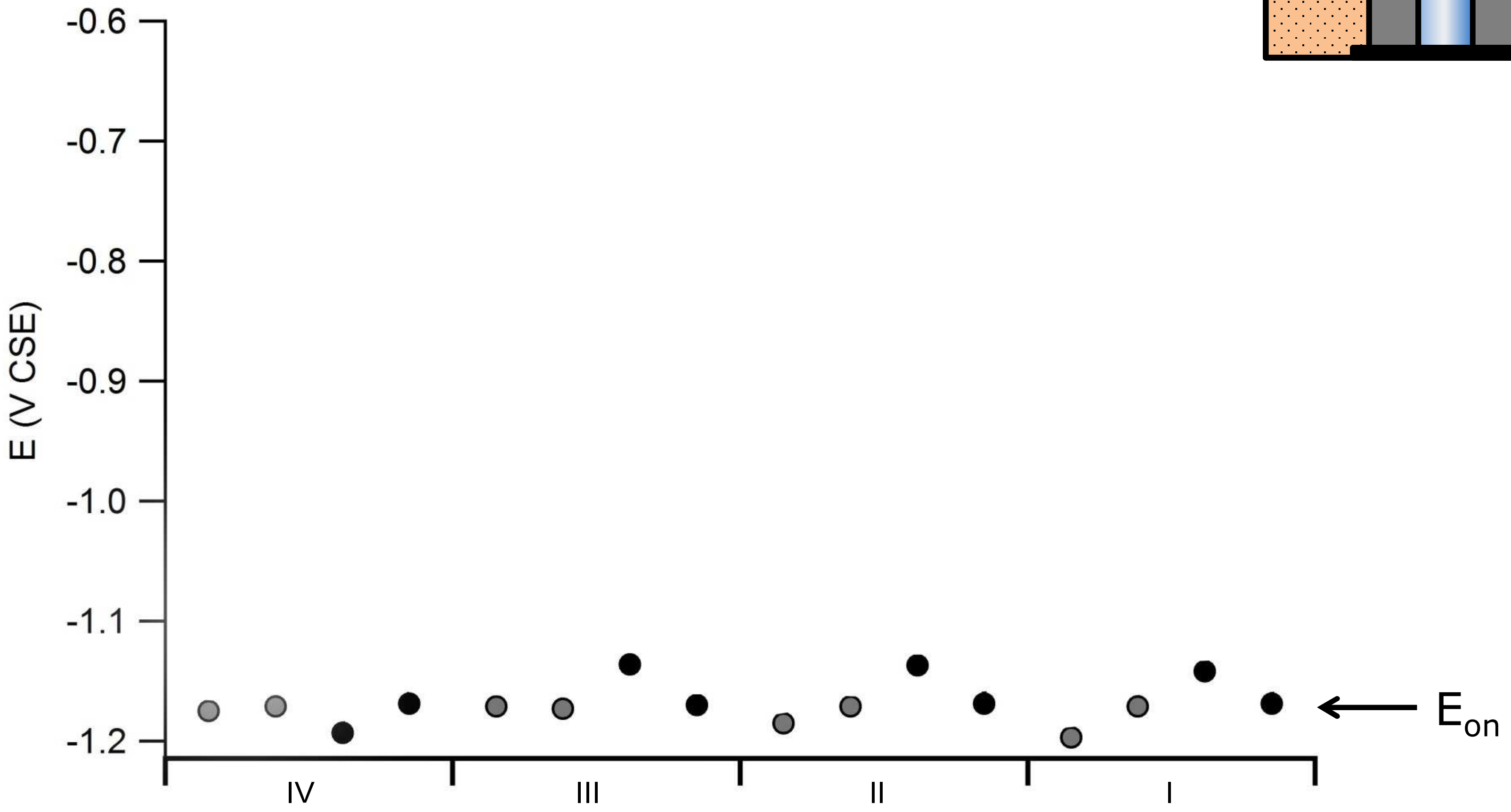
$U_{ac} = 0...20\ V$

Results J_{ac} and J_{dc}

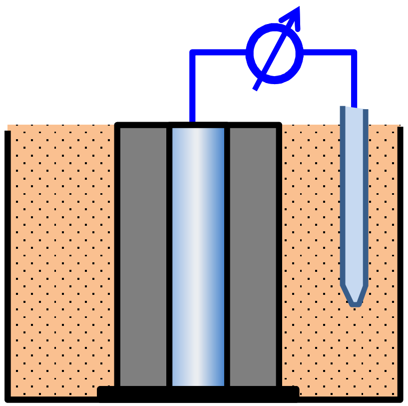


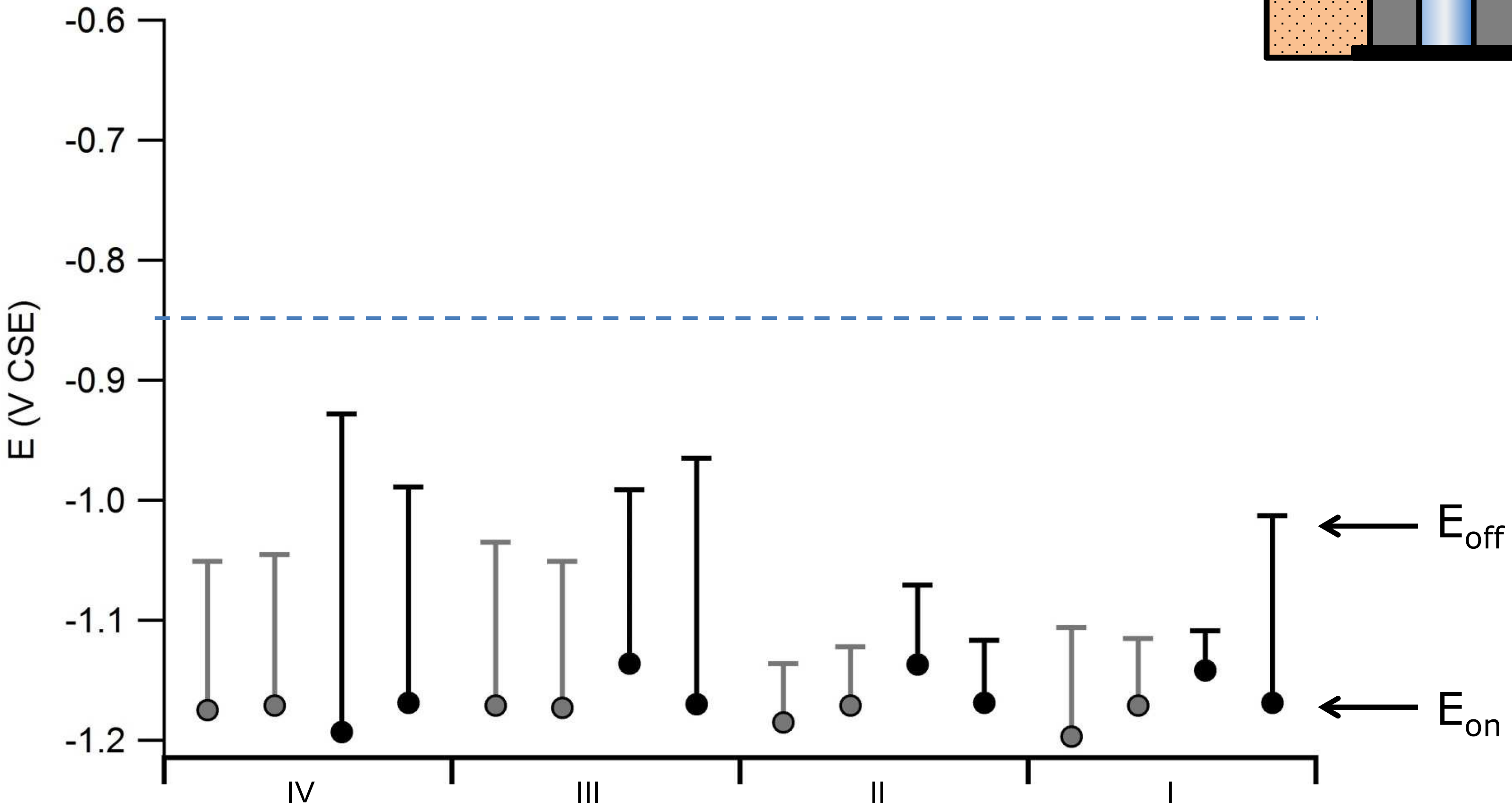
CP – apparent E_{on}



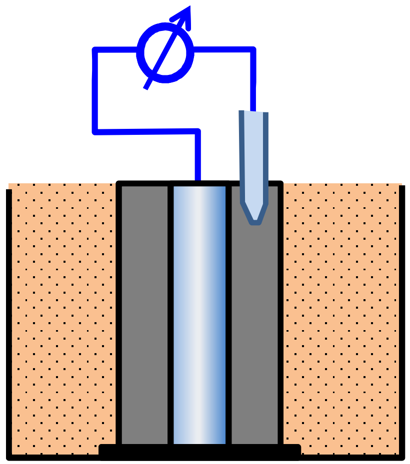


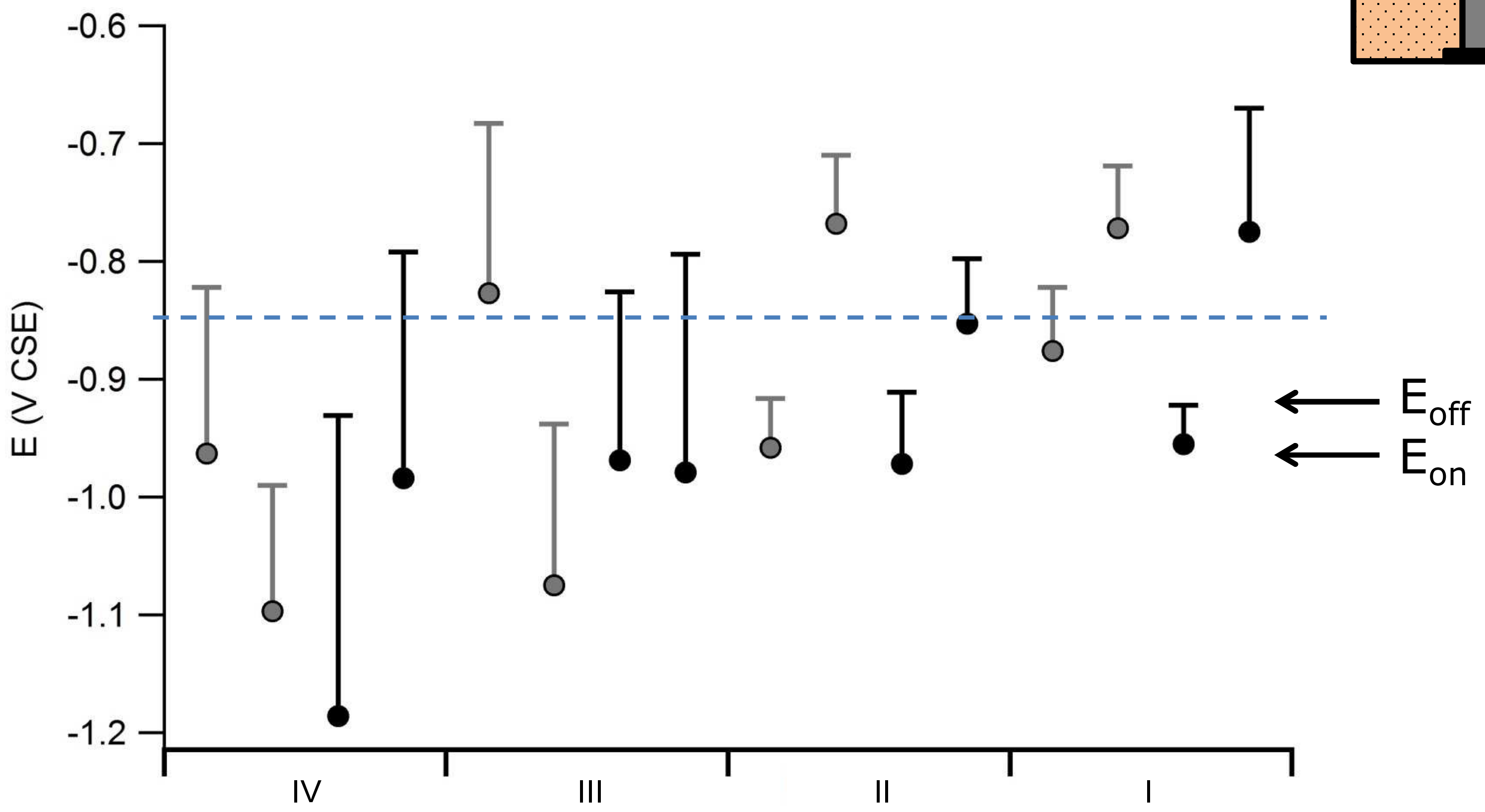
CP – apparent E_{on} and E_{off}



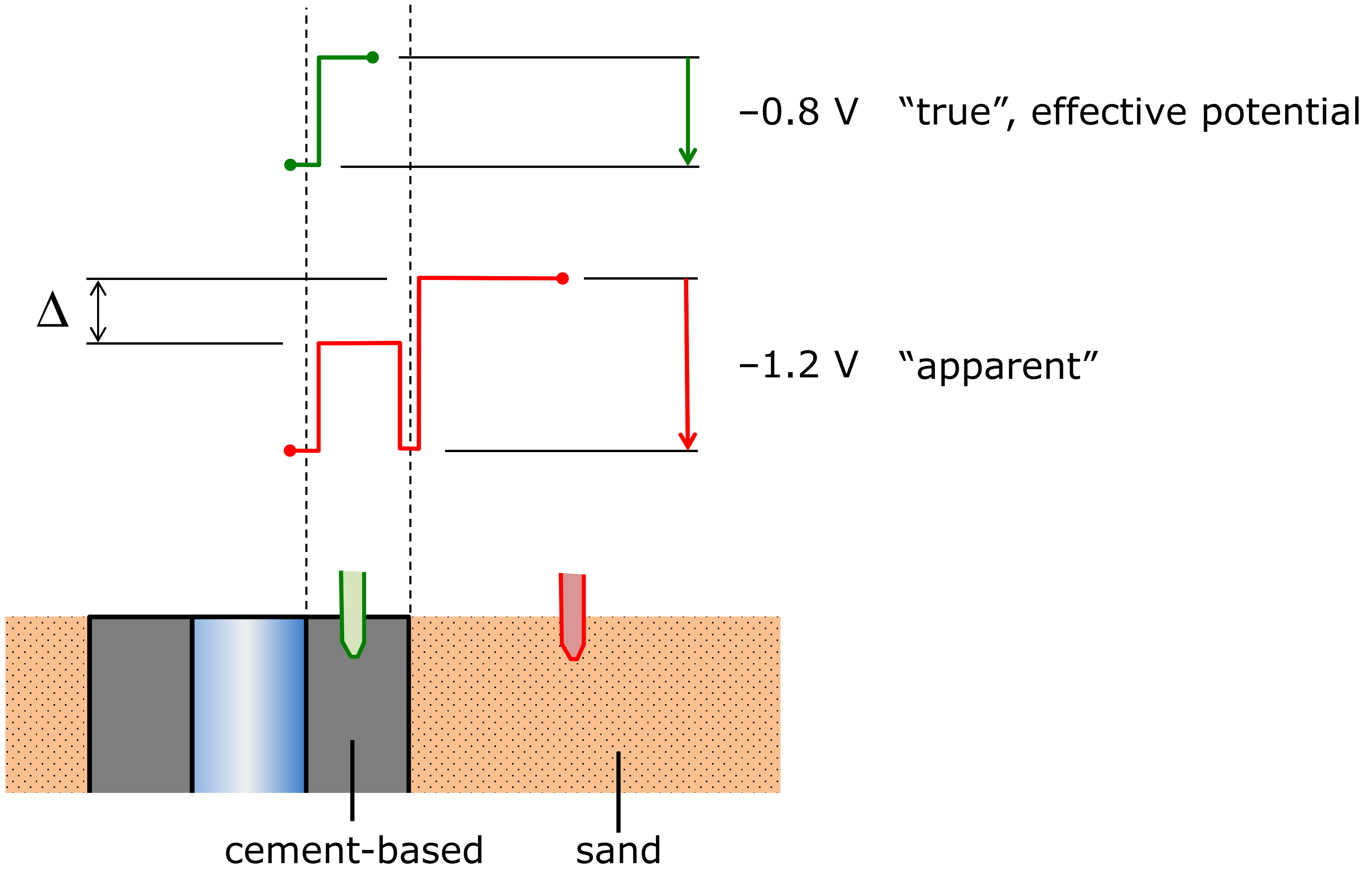


CP – effective E_{on} and E_{off}

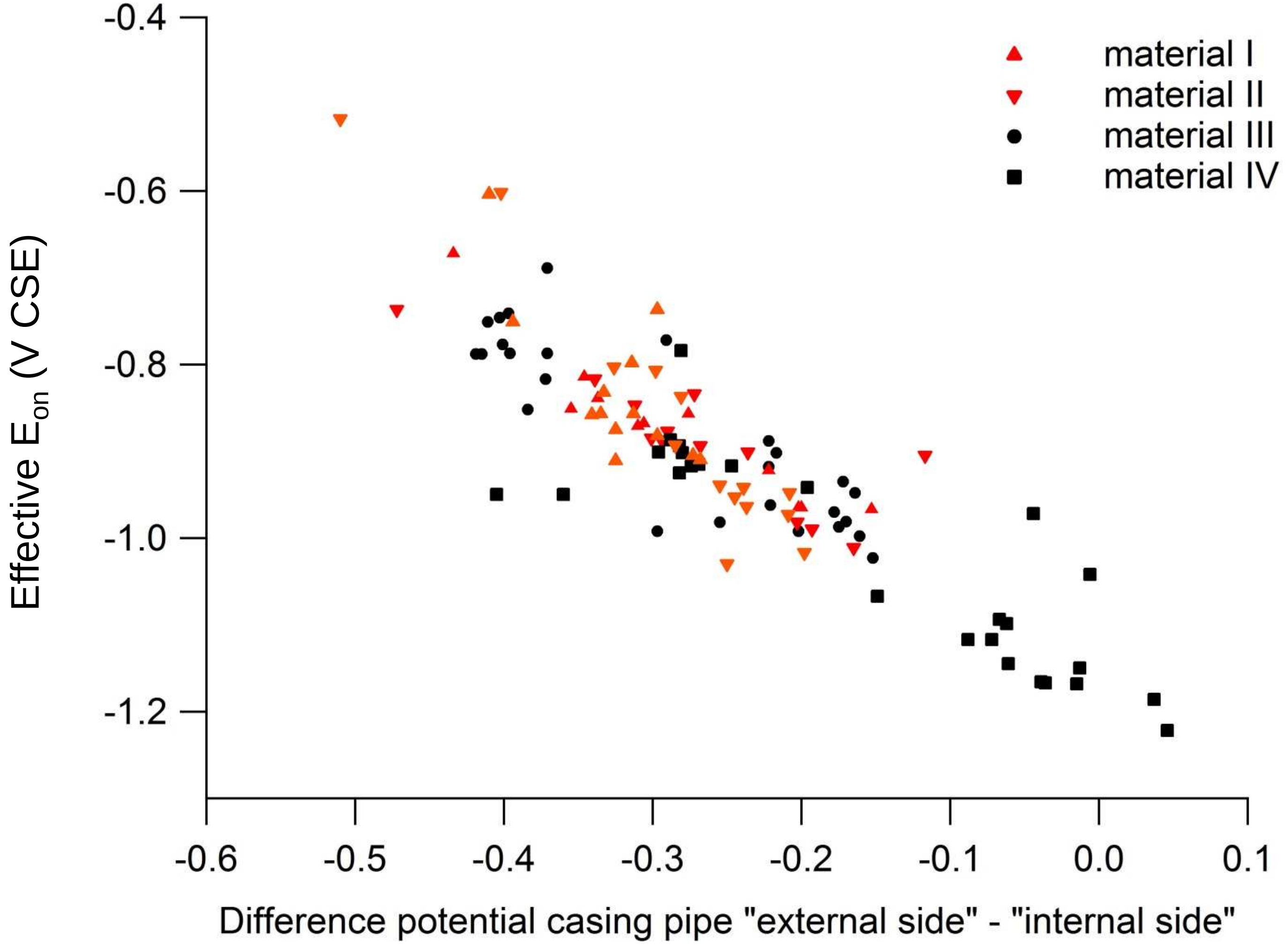




Different interfaces at casing pipe

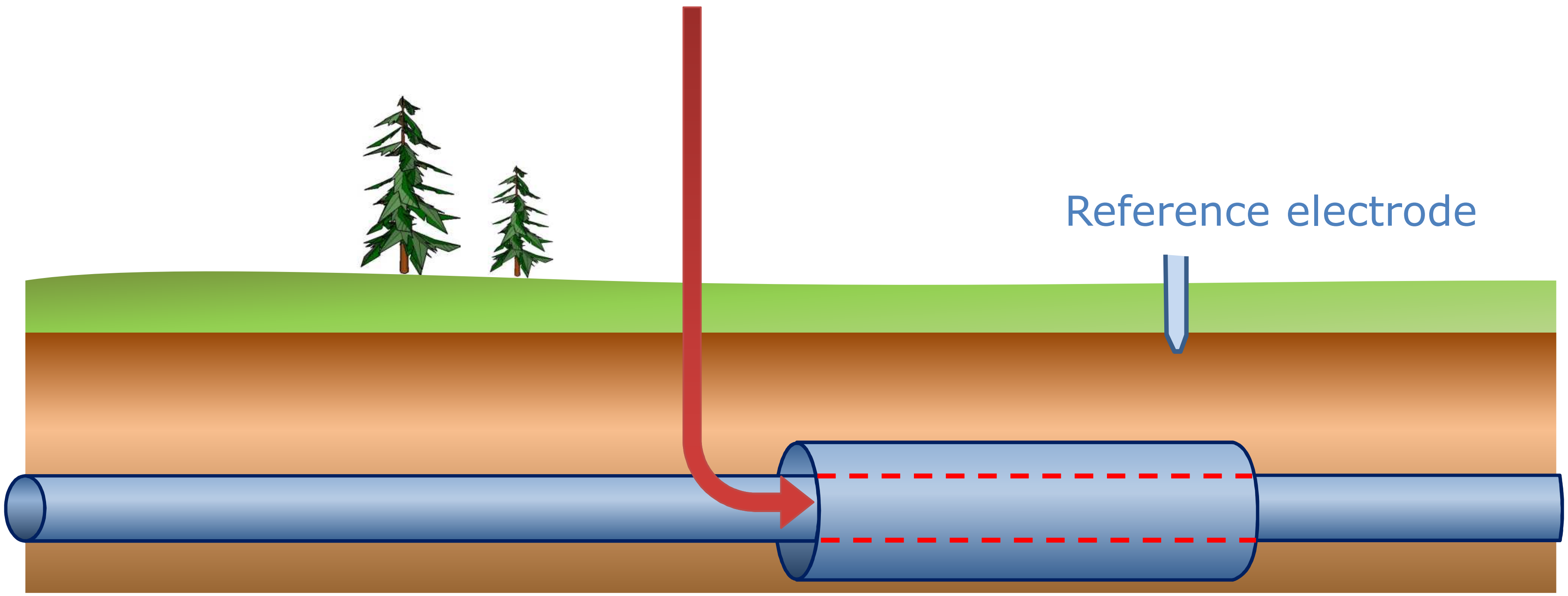


Effective $E_{IR\ free}$ as f(interfacial potentials)



Implications

E_{on} difficult to measure / control



Up to 0.5 V difference between effective and apparent E_{on}

Concluding remarks

Risk of ac corrosion

- Monitoring & controlling CP inside a casing pipe is hardly possible from the outside

  → handicaps employing the "less negative E_{on}"-strategy

- Advisable to reduce the AC voltage on the cased pipe by other means (decoupling devices, design aspects, etc.)

Corrosion protection

- To protect the carrier pipe effectively, we need a high pH
- Advantages of cement-based fill materials over other fill materials: high alkalinity, pH buffer capacity, high degree of filling, convection barrier, etc. → corrosion protection also in the absence of CP

Tusen takk for oppmerksomheten.

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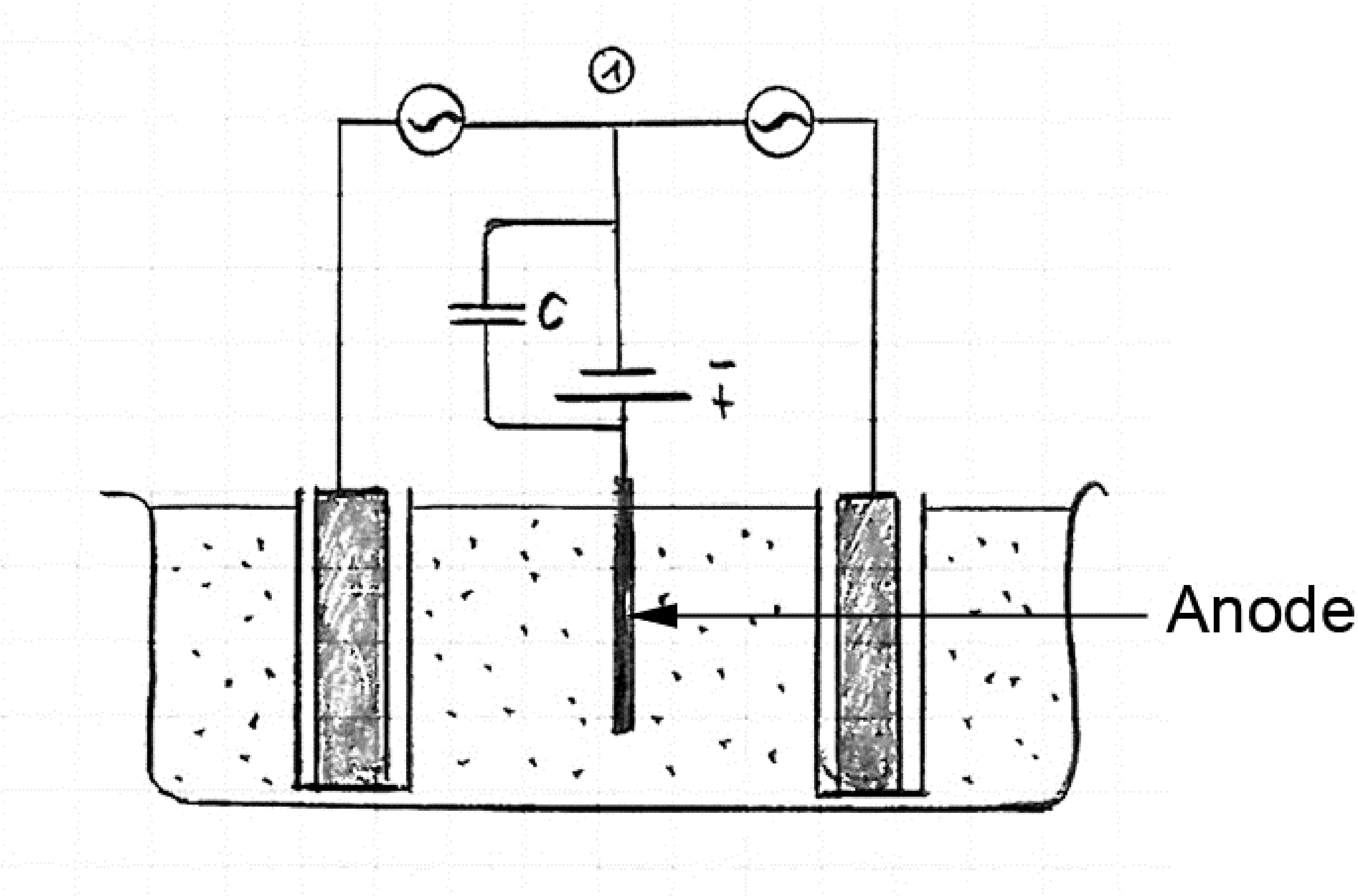
Setup for AC interference

Cathodic protection (with AC)



Fill materials

Potential corrosion issues

Unfilled annuli
or annuli filled with wax/paraffin

- water may enter the annulus and **cause corrosion**
- CP current cannot reach the carrier pipe
- In short: **undefined conditions**

Annuli filled with sand

- pH neutral (no inherent corrosion protection)
- CP difficult to control (moisture gradients, etc)

Annuli filled with cement-based materials

- Alkaline medium → **corrosion protection**
- High degree of filling (thanks to low viscosity)

Unfilled annuli

- Upon settlement of the soil, the **casing pipe may contact the carrier pipe** → disadvantageous for cathodic protection
- In case end sealings are not tight, **water may enter** the annulus and **cause corrosion**
- Cathodic protection current cannot reach the carrier pipe in air filled annuli
- In short: **undefined conditions**

Filled annuli

- Advantages:
  - In case of loss of stiffness / strength of casing pipe, the fill material **stabilizes the soil** and prevents settlement
  - Fill materials **eliminate the risk of metallic contact** between carrier and casing pipe
  - Fill materials may facilitate **corrosion protection** (depending on the material, see next slide)

Comparing different options for casings

Fill materials

- **Sand**:
  - May be **difficult to completely fill the annulus**
    some parts at the upper side may remain empty
    → undefined conditions
  - **Moisture**: water condensation/ingress → wet sand
  - Sand is **pH neutral**, no "chemical" corrosion protection
  - **Cathodic protection is efficient, but not controllable**
  - In short: **risk of corrosion**

Comparing different options for casings

Fill materials

- **Paraffin / wax**:
  - If well filled → some corrosion protection
  - If, however, not 100% filled: gaps with undefined conditions and risk of corrosion
  - Acts like an **electrical isolation**
  - Thus: cathodic protection current cannot reach the carrier pipe
  - **Undefined humidity might be trapped**
  - In short: **risk of corrosion not completely eliminated**

Comparing different options for casings

Fill materials

- **Cement-based materials**:
  - **High degree of filling** (thanks to low viscosity)
  - **High alkalinity** (=high pH, including some buffer capacity)
    → **Corrosion protection**
  - Electrolytically conductive: Allows cathodic protection current to reach the carrier pipe

Metallic contact carrier/casing pipe

Cathodic protection – metallic contact

- If the casing pipe contacts the carrier pipe…
- …it acts like a huge defect (casing pipe = uncoated)
- Thus, the casing pipe is protected
- **Any defects close to or inside the casing are shielded from the CP current!**
  = unprotected!