Technical Seminar for Cathodic Protection to GOGC Design Unit Specialists

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Cathodic Protection Criteria

The pipe-to-electrolyte potential at which the corrosion rate is less than 0,01 mm per year for carbon steel and cast iron is the protection potential, E_p. This corrosion rate is sufficiently low so that corrosion will be acceptable for the design life. The criterion for CP is therefore, given by the condition in Equation (1):

$$E_{IRfree} \leq E_p \qquad (1)$$

where

E_p is the protection potential criterion;

E_{IRfree} is the potential at the metal/electrolyte interface, i.e. the potential that is free from the IR drop in the corrosive environment (IR-free potential, also commonly known as “polarized potential”).

Cathodic Protection Criteria

Some metals can be subject to hydrogen embrittlement at too-negative potentials, and coating disbondment and/or blistering can also occur at too-negative potentials. These phenomena are known as being the so-called “cathodic over-protection”. The IR-free potential E_{IRfree} shall not be more negative than a limiting critical potential E_l.

In such cases, the criterion for CP is given by the condition in Equation (2):

$$E_l \leq E_{IRfree} \leq E_p$$

Metals or alloys	**Environmental conditions**	**Free corrosion potential range** (indicative values) $Ecor$ V	**Protection potential** (IR-free) E_p V	**Limiting critical potential** (IR-free) E_l V
Carbon steels, low alloyed steels and cast iron	Soils and waters in all conditions except those hereunder described	-0,65 to -0,40	-0,85	a
	Soils and waters at 40 °C < T < 60 °C	—	b	a
	Soils and waters at T > 60 °C c	-0,80 to -0,50	-0,95	a
	Soils and waters in aerobic conditions at T < 40 °C with 100<ρ<1 000 Ω.m	-0,50 to -0,30	-0,75	a
	Soils and waters in aerobic conditions at T < 40 °C with ρ >1 000 Ω.m	-0,40 to -0,20	-0,65	a
	Soils and waters in anaerobic conditions and with corrosion risks caused by Sulphate Reducing Bacteria activity	-0,80 to -0,65	-0,95	a
Austenitic stainless steels with PREN < 40	Neutral and alkaline soils and waters at ambient temperatures	- 0,10 to + 0,20	-0,50	d
Austenitic stainless steels with PREN > 40		- 0,10 to + 0,20	- 0,30	-
Martensitic or austeno-ferritic (duplex) stainless steels		- 0,10 to + 0,20	- 0,50	e
All stainless steels	Acidic soils and waters at ambient temperatures	- 0,10 to + 0,20	e	e
Copper	Soils and waters at ambient temperatures	-0,20 to 0,00	-0,20	-
Galvanized steel		- 1,10 to - 0,90	- 1,20	

NOTE 1 All potentials are IR free and refer to a copper/saturated copper sulphate reference electrode, $E_{Cu} = E_H$ - 0.32 V.

NOTE 2 During the lifetime of the structure any possible changes of resistivity of the medium around the structure are to be taken into account

[a] To prevent hydrogen embrittlement on high strength non alloyed and low alloyed steels with designed yield strength exceeding 550 N.mm-², the critical limit potential shall be documented or determined experimentally.

[b] For temperatures 40 ° C ≤ T ≤ 60 ° C, the protection potential may be interpolated linearly between the potential value determined for 40 ° C (-0,65 V, -0,75 V, -0,85 V or –0,95 V) and the potential value for 60 ° C (-0,95 V).

[c] The risk of high pH stress corrosion cracking increases with increase of temperature.

[d] In case of presence of any martensitic or ferritic phase (e.g. due to hardening), the risk of hydrogen embrittlement should be determined by documentation or experimentally.

[e] Determination by documentation or experimentally.

Cathodic Protection Criteria

To prevent disbondment and/or blistering of the coating, the limiting critical potential El should not be more negative than □1200 mV (CSE) for the currently used pipeline coatings.

Cathodic Protection Criteria - Alternative methods

- **100 mV cathodic potential shift**

NACE Publication n°35108, *Report on the 100 mV Cathodic Polarization Criterion*

- **Other methods**

Alternative methods may be used if it can be demonstrated that the control of corrosion is achieved

Cathodic Protection Criteria - Alternative methods

100 mV criterion limitations

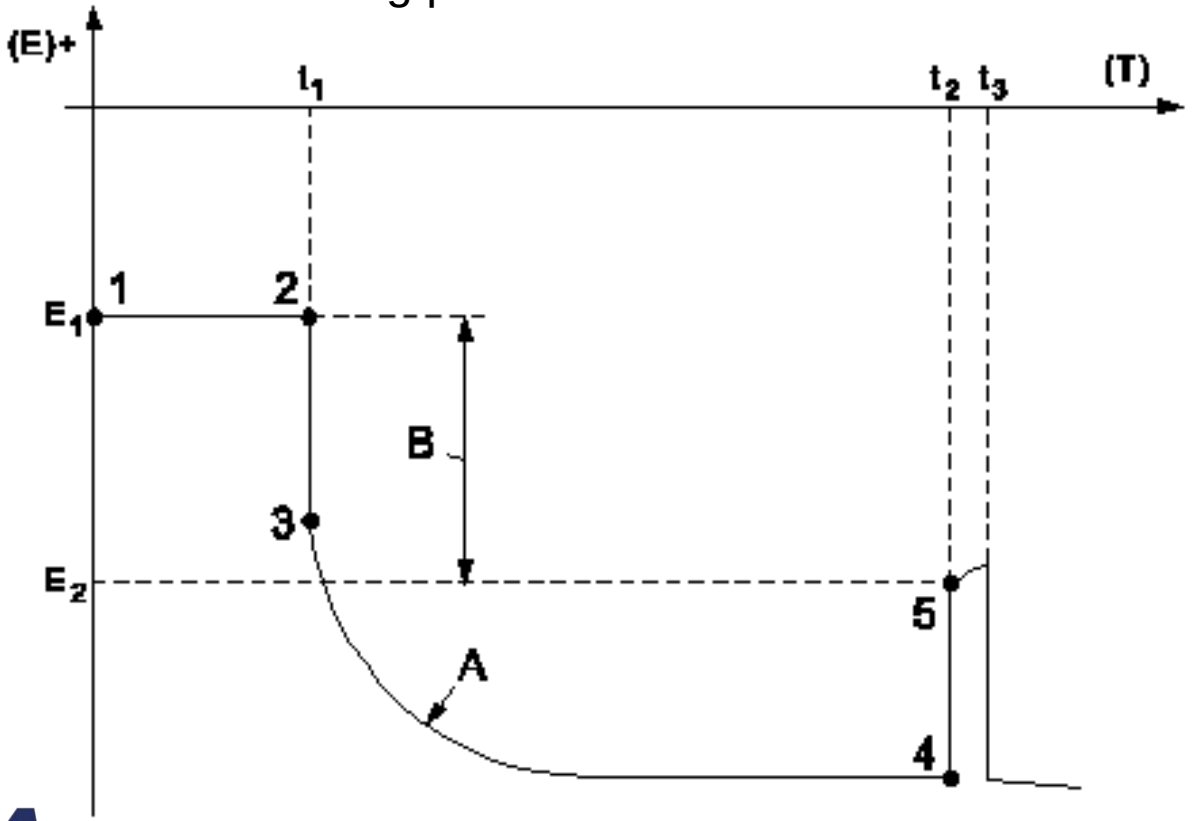
Not applicable under the following circumstances

- at operating temperatures above 40 °C
- in SRB-containing soils
- when interference currents, equalizing currents or telluric currents might be present
- when there is a risk of external stress corrosion cracking
- in the case of pipelines connected to or consisting of mixed metal components

Cathodic Protection Criteria - Alternative methods

- **100 mV cathodic potential shift**

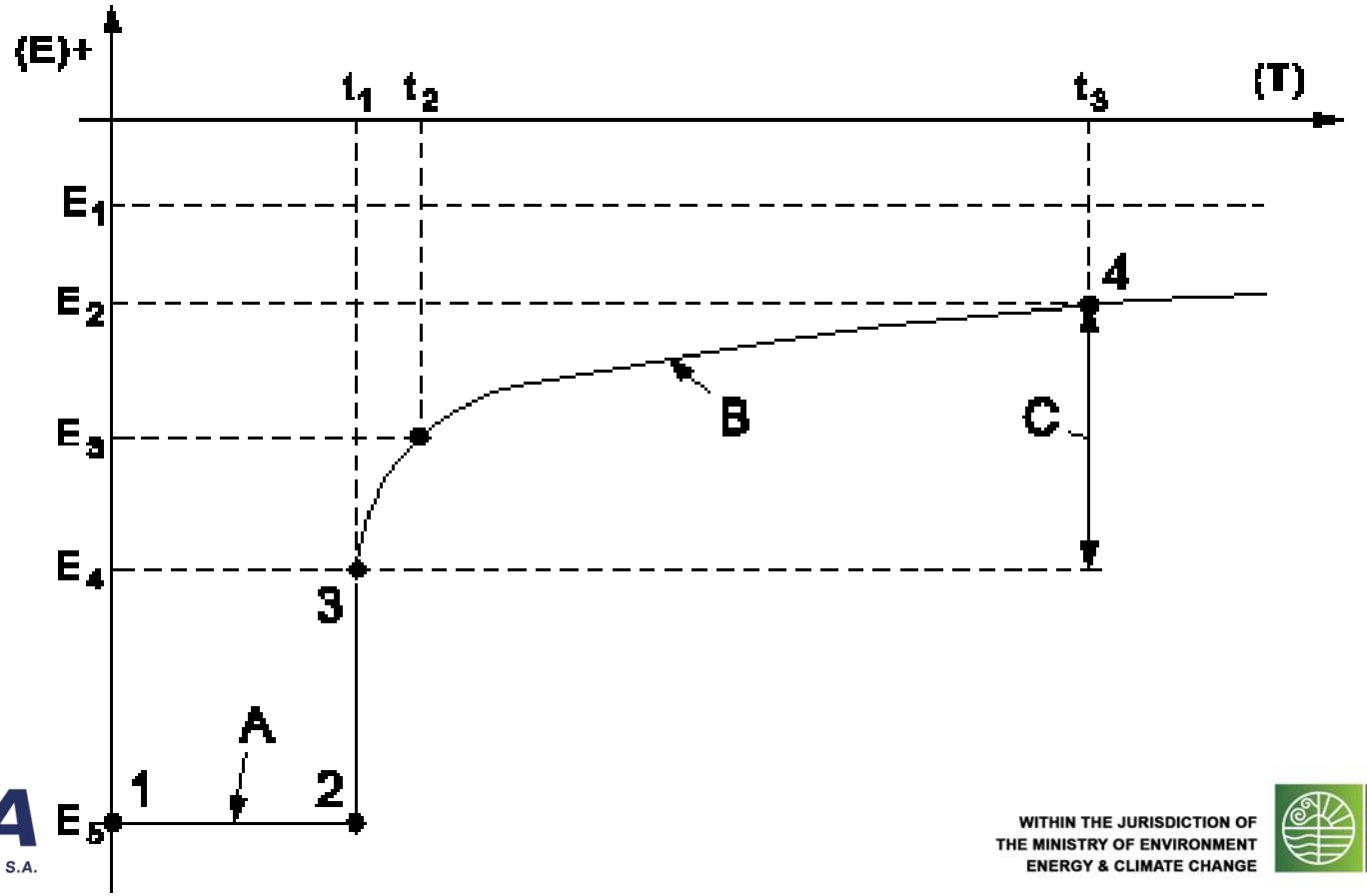
Measurement method during polarisation



Cathodic Protection Criteria - Alternative methods

- **100 mV cathodic potential shift**

Measurement method during depolarisation



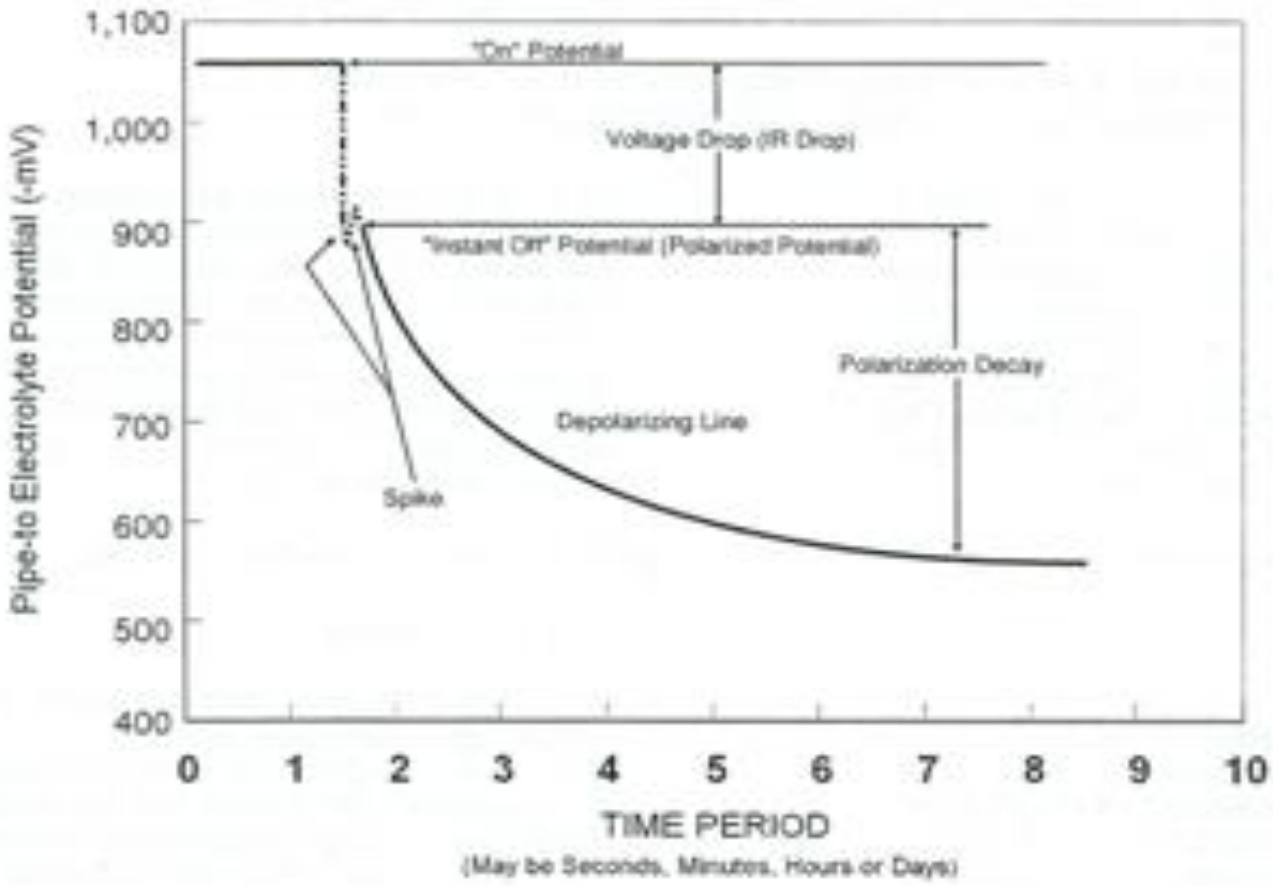


Figure 3a
Polarization Decay

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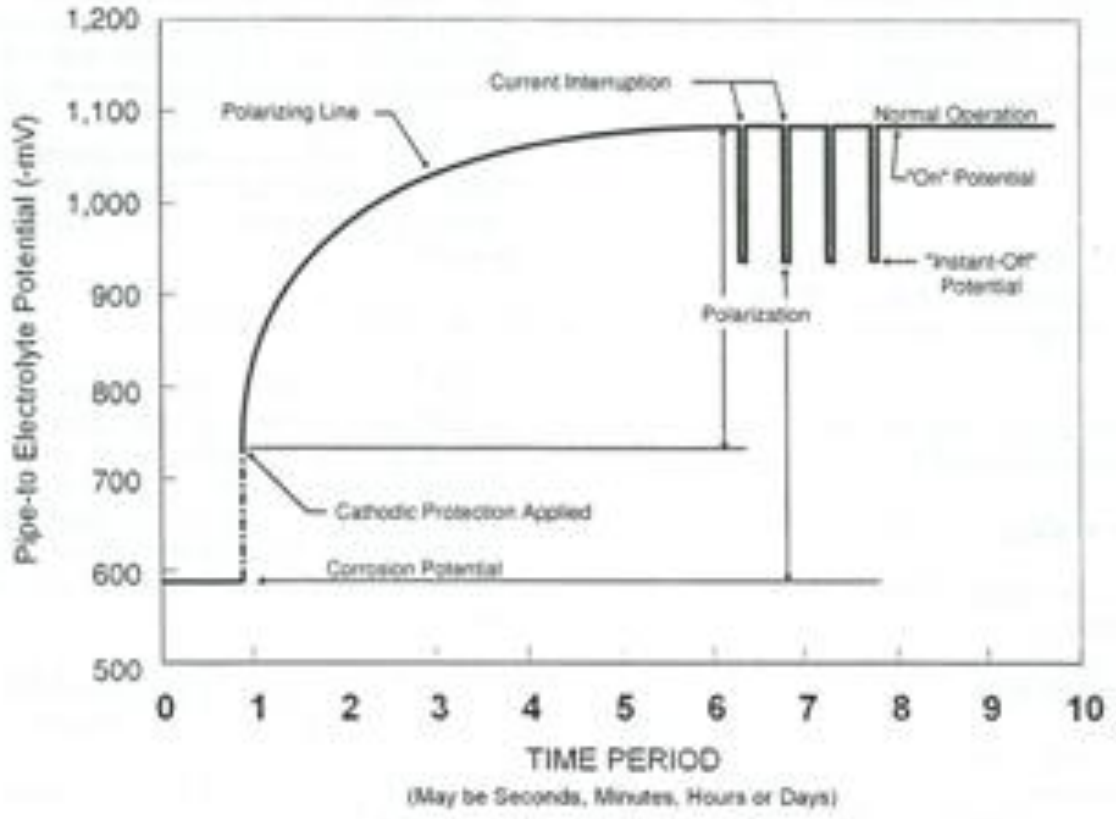
Polarization Decay



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