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Soil quality — Determination of redox potential — Field method

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part-1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part-2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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This document was prepared by Technical Committee ISO/TC-190, *Soil quality*, Subcommittee SC-3, *Chemical and physical characterization*.

This second edition cancels and replaces the first edition (ISO 11271:2001;2002), of which ~~has been technically revised~~.

~~it constitutes a minor revision~~. The ~~main~~ changes are as follows:

- update of normative references;
- update of bibliography;
- editorially revised.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

The redox potential is a physico-chemical parameter used to characterize soil aeration status in a global way. Under field conditions, it gives information on the condition of oxidation or reduction of those compounds which, according to cases, play an important part in plant nutrition, can induce toxicity phenomena or intervene in gas transfers to the atmosphere (greenhouse effect). It can also be used to a certain extent to follow soil performances in case of sludge disposal or composting, and to adjust applications accordingly. Under laboratory conditions it can be used in order to study oxygen diffusion phenomena to aggregate level.

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## Soil quality — Determination of redox potential — Field method

### 1 Scope

This ~~International Standard document~~ specifies a field method for the determination of soil redox potential ( $E_h$ ).

NOTE The electrochemical measurement of redox potential described ~~herein this document~~ is possible only if the relevant soil horizon has a moisture status defined as fresh or wetter according to the classes presented in ~~annex~~ Annex D.

### 2 Normative references

There are no normative references in this document.

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

#### 3.1

##### redox potential ( $E_h$ )

electrochemical potential reflecting the oxidation-reduction status of a liquid chemical system (in this case of the soil solution)

### 4 Principle

Redox potential is an electrochemical equivalent of the free energy of redox reactions, and for an ~~equilibrated~~ equilibrated single redox system of the general form:



is given by the Nernst equation:

$$E_h = E^0 + \frac{RT}{nF} \ln \frac{A_{\text{ox}}}{A_{\text{red}}} - \frac{2,303 mRT}{nF} pH \quad (2)$$

$$E_h = E^0 + \frac{RT}{nF} \ln \frac{A_{\text{ox}}}{A_{\text{Red}}} - \frac{2,303 mRT}{nF} pH \quad (2)$$

where

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- $A_{\text{ox}}$  and  $A_{\text{Red}}$  are the activities of the oxidized and reduced forms of the element, respectively;
- $e^-$  refers to the electron(s) involved in the reaction;
- $H^+$  refers to the proton(s) involved in the reaction;
- $n$  and  $m$  are the numbers of electrons and protons involved in the reaction, respectively;
- $E^0$  is the standard value of the potential in volt (V) i.e. when  $A_{\text{ox}} = A_{\text{Red}}$  and  $\text{pH} = 0$ ;
- $R$  is the universal gas constant ( $8,314 \text{ J mol}^{-1} \cdot \text{K}^{-1}$ );
- $T$  is the absolute temperature in kelvin (K);
- $F$  is the Faraday constant ( $96\,500 \text{ C} \cdot \text{mol}^{-1}$ );
- $2,303$  is the natural log of 10.

Redox potential is related to electron activity ( $e^-$ ) in the system as follows:

$$E_{\text{h}} = \frac{RT}{F} \ln(e^-) \quad E_{\text{h}} = \frac{RT}{F} \ln(e^-) \quad (3)$$

Field Code Changed

**NOTE**—Users of this [International Standard document](#) unfamiliar with these electrochemical concepts should consult appropriate texts; or seek professional advice.

The electrometric determination of redox potential is analogous to the determination of pH. The determination of  $E_{\text{h}}$  follows the principle of measuring potential differences between an inert measuring electrode (usually a platinum electrode) i.e. an electrode not reacting with the solution per se, with respect to the standard hydrogen electrode used as the reference electrode. Many redox systems are involved in the soil solution, and the resulting potential is a mixed potential depending on the existing electroactive redox couples. For practical reasons, a silver-silver chloride electrode is usually used as the reference electrode, the potential of which is added to the measured potential difference (see Annex-C) in order to obtain the values expressed on the basis of the standard hydrogen electrode.

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## 5 Apparatus

The following apparatus shall be used.

**5.1 Millivoltmeter**, with an input resistance not less than  $10 \text{ G}\Omega$  and sensitivity of 1 mV.

**5.2 A set of redox-electrodes**, constructed as [described](#) in A.1.

All electrodes should be sufficiently robust for field use. [\(see Annex A\)](#).

**5.3 Reference electrode**: silver/silver chloride reference electrode in 1 mol/l or 3 mol/l potassium chloride solution.

Other reference electrodes such as the calomel electrode can also be used, but are not recommended because of the health hazard connected with the use of mercury. The potential of such reference electrodes with respect to the standard hydrogen electrode is given in Annex B. Reference electrodes should be stored in a potassium chloride solution ([see 6.4](#)) of the same concentration as that present in the electrode, or directly in the salt bridge ([see 5.5](#)) containing the same concentration of potassium chloride. It should be noted that lower concentrations of potassium chloride will reduce contamination of the soil with this salt.

**5.4 Rigid rod**, (stainless steel has been found suitable), 20-cm to 100-cm in length with the diameter 2 mm greater than that of the redox electrodes (see 5.2).

The rod shall have a length which allows the redox electrodes to be inserted to the desired depth in the soil.

**5.5 Salt bridge**, to connect the reference electrode with the soil (see A.2).

**5.6 Hand auger**, with a diameter 3-mm to 5-mm greater than that of the salt bridge.

**5.7 Electrode cleaning materials**: finest grade of steel wool, scouring powder and some cotton cloth have been found suitable.

**5.8 Thermometer**, to measure the temperature at the location of the reference electrode (see clause 8) with an accuracy of 1 °C.

## 6 Reagents

### 6.1 Redox buffer solution, to calibrate the redox electrodes.

Use either buffered quinhydrone solution (prepared by adding quinhydrone to a pH buffer to obtain a suspension), or an equimolar solution of potassium hexacyanoferrate(III) and potassium hexacyanoferrate(II) (see Annex B).

**6.2 Water**, with an electrical conductivity less than 0,1 mS m<sup>-1</sup> (equivalent to resistivity greater than 0,01 MΩ m at 25 °C).

**6.3 Agar**, ρ = 0,5 %, in a potassium chloride solution of the same concentration as that in the reference electrode.

**6.4 Potassium chloride solution**, of the same concentration as that chosen in 5.3.

NOTE This solution is used to store the reference electrode and to add to the salt bridge, as needed.

## 7 Site selection and sampling

The selection and description of the place of measurement, and of samples for laboratory measurement, should follow the guidelines given in the ISO 18400 series and ISO 11464.

## 8 Procedure

### 8.1 Care, cleaning and testing of the redox electrode system

The platinum electrodes shall be stored in air and kept clean. They shall be inspected for damage and/or contamination at intervals of not more than one year, and every time they are used. Oils, fats and waxes, and other chemicals likely to adhere are particularly damaging to electrode performance. If contaminated with soil material, they shall be cleaned gently with a cotton cloth, and rinsed with distilled water. In cases of severe contamination, e.g. with oils etc. (above), an appropriate solvent, followed by scouring material (see 5.7,) shall be used (see Note, below).