IEC TS 62344

Edition 2.0 2022-05
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Design of earth electrode stations for high-voltage direct current (HVDC) links – General guidelines

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.240.99

ISBN 978-2-8322-1164-9

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

DESIGN OF EARTH ELECTRODE STATIONS FOR HIGH-VOLTAGE DIRECT CURRENT (HVDC) LINKS – GENERAL GUIDELINES

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC TS 62344:2013. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC TS 62344 has been prepared by IEC technical committee 115: High Voltage Direct Current (HVDC) transmission for DC voltages above 100 kV. It is a Technical Specification.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– Changed the requirement of earthing resistance limit for short-time unipolar earth system in 5.1.3.
– Corrected the coefficient before ρ_s from 0,015 9 to 0,008 in touch voltage limit calculation formula (3) in 5.1.5.
– Deleted the analytical calculation formulas of earthing resistance for sea and shore electrodes in 6.1.3.
– Changed the current density limit from 100 A/m^2 to 40 A/m^2 ~ 50 A/m^2 for the sea electrodes that are not accessible to human beings or to marine fauna in 6.1.7.
– Extended some detailed technical requirements for the measurement of ground/water soil parameters in 6.2.5.
– Reformulated the types and characteristics of electrode element material for sea and shore electrodes in 6.3.2.
– Added an informative Annex B: Earth electrode design process.
– Added an informative Annex C: Test results of human body resistance.
– Deleted the formula for calculating the average soil resistivity using harmonic mean when processing the measurement data in D.2.6 of Annex D.
– Extended some detailed technical requirements of electrode online monitoring system in Annex H.
– CIGRE 675:2017 is added to the bibliography.
– Terminology and way of expressions are modified using more commonly used terms in the HVDC electrode design industries and English speaking countries, so as to make the readers understand the content more easily.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
115/276/DTS	115/293/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The high-voltage DC earth electrode is an important part of the DC power transmission system. It takes on the task of guiding the current into the earth under the monopolar ~~metallic~~ earth return operation mode, and the unbalanced current under the bipolar operation mode. Further, it secures and provides the reference potential of ~~valve~~ converter neutral point under the bipolar/ monopolar operation mode, to protect the safe operation of the valves.

DC earth electrodes include land electrodes, sea electrodes, and shore electrodes. Today, there are around tens of DC electrodes in the world. Their influence on the nearby and far away environment is produced when there is DC current continuously leaking into the earth through DC earth electrodes.

Their influence on the surrounding environment includes:

a) influence on humans, mainly due to step voltage, touch voltage and transferred voltage;

b) influence on the electrode itself, mainly reflected by ~~earth~~ ground temperature rise and corrosion on the electrode;

c) influence on nearby ponds and organisms in the sea;

d) influence on the AC power system, mainly reflected by the DC voltage excursion of transformer neutral point;

e) influence on buried metallic objects, mainly revealed by the corrosion of buried metallic pipelines, AC grounding grids, tower foundations for power transmission lines and armoured cables, etc.

A great deal of experience has been accumulated in the research and design work in many countries, and relevant national standards or enterprise standards have been developed. The aim of this document is to develop the design guide for DC earth electrodes, on the site selection, material selection, shape, buried depth, adoption of equipment and connection styles, etc. It ~~could~~ can be referred to by the ~~specialized employees~~ electrode design engineers in different countries, to ensure the safe operation of earth electrode under different modes, control the influence on the environment nearby and the environment far away to the acceptable level, and to reasonably decrease engineering costs.

To ensure this document is more scientific, precise and practical, ~~IEC/PAS 62344:2007 is referred to, and~~ some research results obtained in recent years are adopted.

DESIGN OF EARTH ELECTRODE STATIONS FOR HIGH-VOLTAGE DIRECT CURRENT (HVDC) LINKS – GENERAL GUIDELINES

1 Scope

This document applies to the design of earth electrode stations for high-voltage direct current (HVDC) links. It is intended to provide necessary guidelines, limits, and precautions to be followed during the design of earth electrodes to ensure safety of personnel and earth electrodes, and ~~prevent~~ reduce any significant impacts ~~they may exert~~ on DC power transmission systems and the surrounding environment.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC ~~/TS~~ 60479-1, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC TS 61201, *Use of conventional touch voltage limits – Application guide*

IEC 61936-1, *Power installations exceeding 1 kV AC and 1,5 kV DC – Part 1: ~~Common rules~~* AC

IEC TS 61936-2, *Power installations exceeding 1 kV a.c. and 1,5 kV d.c. – Part 2: d.c.*

IEC TS 62344

Edition 2.0 2022-05

TECHNICAL SPECIFICATION

colour inside

Design of earth electrode stations for high-voltage direct current (HVDC) links – General guidelines

IEC TS 62344:2022-05(en)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

DESIGN OF EARTH ELECTRODE STATIONS FOR HIGH-VOLTAGE DIRECT CURRENT (HVDC) LINKS – GENERAL GUIDELINES

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC TS 62344 has been prepared by IEC technical committee 115: High Voltage Direct Current (HVDC) transmission for DC voltages above 100 kV. It is a Technical Specification.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– Changed the requirement of earthing resistance limit for short-time unipolar earth system in 5.1.3.
– Corrected the coefficient before ρ_s from 0,015 9 to 0,008 in touch voltage limit calculation formula (3) in 5.1.5.
– Deleted the analytical calculation formulas of earthing resistance for sea and shore electrodes in 6.1.3.
– Changed the current density limit from 100 A/m^2 to 40 A/m^2 ~ 50 A/m^2 for the sea electrodes that are not accessible to human beings or to marine fauna in 6.1.7.

– Extended some detailed technical requirements for the measurement of ground/water soil parameters in 6.2.5.

– Reformulated the types and characteristics of electrode element material for sea and shore electrodes in 6.3.2.

– Added an informative Annex B: Earth electrode design process.

– Added an informative Annex C: Test results of human body resistance.

– Deleted the formula for calculating the average soil resistivity using harmonic mean when processing the measurement data in D.2.6 of Annex D.

– Extended some detailed technical requirements of electrode online monitoring system in Annex H.

– CIGRE 675:2017 is added to the bibliography.

– Terminology and way of expressions are modified using more commonly used terms in the HVDC electrode design industries and English speaking countries, so as to make the readers understand the content more easily.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
115/276/DTS	115/293/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The high-voltage DC earth electrode is an important part of the DC power transmission system. It takes on the task of guiding the current into the earth under the monopolar earth return operation mode, and the unbalanced current under the bipolar operation mode. Further, it secures and provides the reference potential of converter neutral point under the bipolar/ monopolar operation mode, to protect the safe operation of the valves.

DC earth electrodes include land electrodes, sea electrodes, and shore electrodes. Today, there are around tens of DC electrodes in the world. Their influence on the nearby and far away environment is produced when there is DC current continuously leaking into the earth through DC earth electrodes.

Their influence on the surrounding environment includes:

a) influence on humans, mainly due to step voltage, touch voltage and transferred voltage;

b) influence on the electrode itself, mainly reflected by ground temperature rise and corrosion on the electrode;

c) influence on nearby ponds and organisms in the sea;

d) influence on the AC power system, mainly reflected by the DC voltage excursion of transformer neutral point;

e) influence on buried metallic objects, mainly revealed by the corrosion of buried metallic pipelines, AC grounding grids, tower foundations for power transmission lines and armoured cables, etc.

A great deal of experience has been accumulated in the research and design work in many countries, and relevant national standards or enterprise standards have been developed. The aim of this document is to develop the design guide for DC earth electrodes, on the site selection, material selection, shape, buried depth, adoption of equipment and connection styles, etc. It can be referred to by the electrode design engineers in different countries, to ensure the safe operation of earth electrode under different modes, control the influence on the environment nearby and the environment far away to the acceptable level, and to reasonably decrease engineering costs.

To ensure this document is more scientific, precise and practical, some research results obtained in recent years are adopted.

DESIGN OF EARTH ELECTRODE STATIONS FOR HIGH-VOLTAGE DIRECT CURRENT (HVDC) LINKS – GENERAL GUIDELINES

1 Scope

This document applies to the design of earth electrode stations for high-voltage direct current (HVDC) links. It is intended to provide necessary guidelines, limits, and precautions to be followed during the design of earth electrodes to ensure safety of personnel and earth electrodes, and reduce any significant impacts on DC power transmission systems and the surrounding environment.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60479-1, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC TS 61201, *Use of conventional touch voltage limits – Application guide*

IEC 61936-1, *Power installations exceeding 1 kV AC and 1,5 kV DC – Part 1:* AC

IEC TS 61936-2, *Power installations exceeding 1 kV a.c. and 1,5 kV d.c. – Part 2: d.c.*