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TECHNICAL SPECIFICATION

colour inside

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

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

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62344, which is a technical specification, has been prepared by IEC technical committee 115: High-voltage direct current (HVDC) transmission for d.c. voltages above 100 kV.

This technical specification cancels and replaces IEC/PAS 62344 published in 2007. This first edition constitutes a technical revision.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
115/53/DTS	115/64/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International Standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

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

D.C. earth electrodes include land electrodes, sea electrodes, and shore electrodes. Today, there are around tens of d.c. electrodes in the world. Their influence on the nearby and far away environment is produced when there is d.c. current continuously leaking into the earth through d.c. 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 temperature rise and corrosion on the electrode;
c) influence on nearby ponds and organisms in the sea;
d) influence on the a.c. power system, mainly reflected by the d.c. voltage excursion of transformer neutral point;
e) influence on buried metallic objects, mainly revealed by the corrosion on buried metallic pipelines, a.c. grounding grids, tower foundations for power transmission lines and armoured cables, etc.

For years, a great deal of experience has been accumulated in the research and design work in many countries, and relevant native standards or enterprise standards have been developed. The aim of this Technical Specification is to develop the design guide for d.c. earth electrodes, on the site selection, material selection, shape, buried depth, adoption of equipment and connection styles, etc. It could be referred to by the specialized employees 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 Technical Specification 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 Technical Specification 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 any significant impact they may exert on d.c. power transmission systems and the surrounding environment.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 a.c. – Part 1: Common rules*

3 Terms and definitions

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

3.1
earth electrode
ground electrode (US)
structure with a conductor or a group of conductors embedded in the soil or immersed in sea water, directly or surrounded with a specific conductive medium

EXAMPLE Coke, providing an electric connection to the earth, for transmission of d.c. current from a d.c. system.

[SOURCE: IEC 60050-195:1998, 195-02-01]

3.2
land electrode
earth electrode buried in the ground more than 1 km away from the coastline

3.3 shore electrode

3.3.1
beach electrode
electrode located on the beach inside the waterline (usually less than 1 km away from the waterline), and the active part of the electrode makes contact with the soil or with underground water, but not directly with seawater or pond electrodes

3.3.2
pond electrode
electrode usually placed outside but within 100 m of the waterline, having electrodes directly in contact with sea water, within a small area which is usually protected against waves and possible ice damage by a breakwater

3.4
sea electrode
electrode located away from the shoreline at a distance deeper than 100 m into the sea

3.5
electrode station
whole system which guides current from electrode line to the earth or sea water, usually including, in addition to the electrode itself, the feeding cable, towers, switchgear and necessary auxiliary equipment

3.6
common earth electrode
earth electrode system, which is composed of a single earth electrode or multiple earth electrodes in parallel, shared by multiple converter stations

Note 1 to entry: It mainly consists of earth electrodes and intertie lines between sub- earth electrodes in different electrode sites.

3.7
electrode site
site where the earth electrode is located

3.8
electrode line
overhead line or underground cable used to connect the neutral bus in a converter station to the earth electrode station

3.9
feeding rod
earthing conductor buried underground or in the sea for guiding earthing current into the surrounding medium (soil or sea water)

Note 1 to entry: They are the most important devices in an earth electrode station.

3.10
feeding cable
cable used to guide current from current-guiding wire to feeding rods

3.11
current-guiding wire
main branch used to conduct current from electrode line (or bus) to feeding cables

3.12
current guiding system
system used to guide the current from electrode line to feeding rods

Note 1 to entry: It consists of current-guiding wire(s), disconnecting switches, feeding cables and connections.

3.13
jumper cable
cable used to connect two feeding rods placed at some distance from each other

EXAMPLE At two sides of a channel.

3.14
earth return operation mode
operation mode in the HVDC power transmission system, using d.c. lines and earth (or sea water) as the current loop

3.15
earth return system
series of devices designed and built specifically for earth return operation mode

Note 1 to entry: It mainly consists of the electrode line, earth electrode, current guiding system, and other auxiliary facilities.

3.16
rated current under monopolar mode
current of a converter station at rated power in monopolar (operation) mode

3.17
maximum overload current
maximum current for which the associated d.c. system(s) is designed for monopolar operation for longer than several minutes

3.18
maximum transient overcurrent
average maximum current flowing through the earth electrode for a few seconds when a system disturbance occurs

3.19
unbalanced current
difference of current between two poles during operation of a bipolar d.c. system

Note 1 to entry: For symmetrical bipolar operation mode, the unbalance current flowing can be controlled automatically by the control system within about 1 % of the rated current.

Note 2 to entry: For asymmetrical bipolar operation mode, the current flowing through the earth electrode is the difference in currents between the two poles.

3.20
cathode
electrode capable of emitting negative charge carriers to and/or receiving positive charge carriers from the medium of lower conductivity

Note 1 to entry: The direction of electric current is from the medium of lower conductivity, through the cathode, to the external circuit.

Note 2 to entry: In some cases (e.g. electrochemical cells), the term "cathode" is applied to one or another electrode, depending on the electric operating condition of the device. In other cases (e.g. electronic tubes and semiconductor devices), the term "cathode" is assigned to a specific electrode.

[SOURCE: IEC 60050-151:2001, 151-13-03]

3.21
anode
electrode capable of emitting positive charge carriers to and/or receiving negative charge carriers from the medium of lower conductivity

Note 1 to entry: The direction of electric current is from the external circuit, through the anode, to the medium of lower conductivity.

Note 2 to entry: In some cases (e.g. electrochemical cells), the term "anode" is applied to one or another electrode, depending on the electric operating condition of the device. In other cases (e.g. electronic tubes and semiconductor devices), the term "anode" is assigned to a specific electrode.

[SOURCE: IEC 60050-151:2001, 151-13-02]

3.22 current-releasing density

3.22.1
current-releasing density per unit length
current released to earth from a unit length of feeding rod (in A/m)

3.22.2
current-releasing density per unit area
current released to earth from a unit area of coke surface (in A/m^2)

3.23
designed lifespan
designed operational lifespan of the earth electrode, typically of the same order as the operational lifespan of the converter station

3.24
corrosion lifespan
time integral of current when a earth electrode runs as an anode, such as monopolar operation and bipolar operation with unbalanced current, during its designed lifespan, in the unit of ampere hour (Ah)

3.25
thermal time constant
time required for the temperature of the soil to reach the steady state temperature at the initial rate of rise of temperature

Note 1 to entry: In practice the soil temperature rises nonlinearly when earthing current is released into earth through an electrode, see Annex F.

3.26
earthing resistance
resistance between an earth electrode and earth at an infinite distance

3.27
step voltage
voltage between two points on the Earth's surface that are 1 m distant from each other, which is considered to be the stride length of a person

[SOURCE: IEC 60050-195:1998, 195-05-12]

3.28
touch voltage
potential difference between a grounded metallic structure and any point on the earth 1 m from the structure

3.29
transferred voltage
potential difference applied to a person when this person stands on the ground near the earth electrode and touches a conductor grounded at a remote site, or when this person stands on the ground far away from the earth electrode and touches a conductor grounded near the electrode site

3.30
insulated metallic structures
metallic structures buried in the ground near an earth electrode and coated with insulating material