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TECHNICAL REPORT

UHV AC transmission systems –
Part 100: General information

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FOREWORD

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The technical report IEC 63042-100 was prepared by IEC Technical Committee 122: UHV AC transmission systems.

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

Enquiry draft	Report on voting
122/29/DTR	122/31A/RVC

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

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

A list of all parts in the IEC 63042 series, published under the general title *UHV AC transmission systems*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://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- withdrawn,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.

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

INTRODUCTION

UHV AC transmission systems are capable of transmitting large amounts of electric power. However, if a failure occurs in a UHV AC system, the system influence can be severe from the viewpoints of reliability and overall security of the supply of the power system. Most UHV AC substations are located far from city areas, with large equipment in size and mass installed. Equipment is transported over long distances from where it is manufactured and tested to where it is installed and commissioned. Also, the installation time of equipment is generally longer compared with lower voltage classes. For UHV AC transmission lines, the design of insulation is an important aspect due to non-linearity effect.

Therefore, securing the reliability, availability, and environmental aspects are crucial issues. Standards and/or applications guidance, as relevant, in the following aspects of UHV AC transmission systems exceeding 800 kV are necessary:

a) planning (guidance);
b) design;
c) technical requirements (exclusively systems-related);
d) construction;
e) commissioning;
f) reliability;
g) availability (continuity of power supply, % availability);
h) operation;
i) maintenance.

This document describes both specific issues to UHV AC transmission systems and common issues of UHV AC and lower voltage transmission systems because it is very easy to understand UHV AC transmission systems as a whole.

In this Technical Report, minimum items or requirements for the standards and guidelines for each step of UHV AC transmission systems are described.

UHV AC TRANSMISSION SYSTEMS –

Part 100: General information

1 Scope

This part of IEC 63042, which is a Technical Report, specifies the reference for the standards and guidelines for UHV AC transmission systems. This document provides an overview of these standards as well as guidelines.

This document is developed to clarify standardization items and/or guideline items for UHV AC transmission systems. It describes the items to be considered for each stage of planning, design, construction, commissioning, operation, and maintenance during the development of IEC publications for UHV AC transmission systems.

NOTE Based on this IEC/TR 63042-100, TC 122 will prepare the standards and guidelines for UHV AC transmission systems, but it is not limited by the framework of the TR. A systematic approach is necessary for the preparation of systems-oriented specifications such as those for planning, design, technical requirements, construction, commissioning, reliability, availability, operation, and maintenance.

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 60038, *IEC standard voltages*

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

3 Terms and definitions

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

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
UHV AC
the highest voltage of the AC transmission system exceeding 800 kV

Note 1 to entry: UHV stands for Ultra High Voltage.

4 Planning

4.1 General

Large scale power sources have been developed. It is important to transmit the electric power efficiently from these power sources to consumption areas. Moreover, the network enhancement might decrease the system stability and worsen fault current problems. To prevent such problems in existing high voltage transmission systems, multiple transmission lines and switchyards might be necessary due to the shortage of transmission capacity/improvement of the system stability. As a result, large facility investment will be required and inference of transmission losses will be considerable.

To solve the above-mentioned problems, the UHV AC transmission system was developed, which can transmit a large amount of electric power by minimum transmission lines effectively and in a stable way.

For example, a UHV AC transmission line can transmit three or four times a larger quantity of electric power than a 550 kV transmission line.

The UHV AC transmission system has many advantages such as:

– decrease of right of way (ROW);
– improvement of fault current condition and system stability;
– formulation of network with high reliability;
– increase of redundancy for the system enhancement;
– reduction of environmental impact.

Some countries have introduced a UHV AC system to their grid as follows:

a) Use Case 1

Case 1 had developed UHV AC transmission systems in the 1980s and started its operation in 2009. UHV AC transmission systems were selected to achieve energy bulk transmission to distant areas to serve a large capacity economically and efficiently.

To improve the transmission capacity, series capacitors are used. By using them, the transmission capacity is increased from 3 000 MW to 5 000 MW.

b) Use Case 2

Case 2 has developed UHV AC transmission systems since 1973. The power transmission capability in the power system is often constrained by power system stability because the bulk power transmission is larger than the surge impedance loading (SIL).

Additionally, special schemes for system control are applied. Problematic contingencies such as a permanent fault on both circuits of a double-circuit transmission line, or delays in fault clearance for any reason, have a very small probability of occurrence, but have a severe impact on the synchronous stability of a bulk power transmission system. Such severe contingencies may result in a loss of synchronism and the subsequent cascading outages. As a means of preventing such system-wide loss of synchronism, the following emergency relaying schemes are employed in the bulk power transmission system:

– generator tripping relays for preventing loss of synchronism;
– load shedding relays for preventing overloading;
– generation tripping and/or load shedding relays for maintaining system frequency.

4.2 Security and stability

As a UHV AC transmission line has to transmit a large amount of power over a long distance, a disturbance, such as a faulty event, may give significant influence to the whole system. Therefore, the redundancy and stability for the network system should be considered from the operational viewpoint.

4.3 Transmission systems

It should be determined whether the transmission system is UHV AC or UHV DC, considering the benefit of the transmission system. In general, UHV AC is used in power grids.

4.4 System voltage

In the case of an installation of the higher voltage class, “twice or three times as high as existing voltage class” is generally selected due to efficiency and expandability. In addition, it is important to consider future demands, power development plans, situation of the site of power plants, and technological, economical, and environmental aspects.

It is especially desirable to choose an existing voltage level in IEC standard voltages, considering the technological and economical aspects. Table 1 shows the highest voltage defined in IEC 60038 standard.

Table 1 – AC three-phase systems having a highest voltage for equipment exceeding 800 kV

Highest voltage for equipment kV
1 100
1 200

In the process of transmission voltage determination, short circuit current, power flow, stability, and voltage control with reactive power compensation are technically investigated confirming the main specifications of the power transmission system. The cost is compared between UHV and other voltage classes, where future system expansion is also considered.

4.5 Reliability and availability

To form the network system, reliability is one of the most important key factors. Particularly, for UHV, high reliability is required because it is used to transmit electric power from an important power source, and it is used as a main transmission system.

Until now, many field tests have been carried out and the reliability of each facility has been sufficiently verified in the countries where UHV AC transmission systems are installed.

As for the operating facilities, various operation records are reported. One circuit fault of a UHV AC transmission line is smaller than two circuit faults of a 550 kV transmission line. In this regard, the UHV AC transmission system also shows high availability. The UHV AC system has a developed technology to keep high reliability.

Table 2 shows the comparison of lightning fault between UHV and 550 kV systems.

Table 2 – Comparison of lightning fault between UHV and 550 kV systems

Unit: Number of fault/year/ 100 km

System	**550 kV double circuits**	**UHV double circuits**
One circuit failure [a]	0,013	Less than 0,001
Two circuit failure [b]	0,005	Less than 0,001
Estimated by the single-phase re-closing: [a] 3 lines to earth fault [b] 4 lines to earth fault		
Reference: this table is calculated by TEPCO Power Grid, Inc.		