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TECHNICAL REPORT

colour inside

HVDC installations – Guidelines on asset management

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FOREWORD

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IEC TR 62978, which is a technical report, has been prepared by IEC technical committee 115: High Voltage Direct Current (HVDC) transmission for DC voltages above 100 kV.

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

Enquiry draft	Report on voting
115/148/DTR	115/159/RVDTR

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.

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- withdrawn,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.

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INTRODUCTION

Asset management is defined as the act of structured and coordinated efforts by an organization to optimally manage its assets and their associated performance, risks and expenditures over their life cycle.

The management of physical assets (their selection, maintenance, inspection and renewal) plays a key role in determining the operational performance and profitability of industries that operate their assets as part of their core business.

In general, High Voltage Direct Current (HVDC) systems have specific requirements that need to be addressed separately as compared to conventional High Voltage Alternating Current (HVAC) power transmission due to underlying differences in technology.

HVDC systems are a well proven technology employed for bulk power transmission all over the world, mainly because of its superior controllability of transmitted power. It can be utilized for various applications such as stabilization of the connected Alternating Current (AC) network, dynamic control of frequency and modulation of active and reactive powers. In addition, HVDC is more economical for long distance transmission of bulk power and applicable for interconnecting asynchronous AC networks.

An international standard defining key elements of asset management framework for HVDC installations is therefore crucial to provide ample foundation for best practices to be implemented to achieve high efficiency, availability and reliable long-term operation.

At present the activities with respect to asset management are standardized as International Standard in the ISO 55000 series. The general principles are given in ISO 55000 with further details in ISO 55001:2014, Asset management – Management systems – Requirements and ISO 55002:2014, Asset management – Management systems – Guidelines for the application of ISO 55001. These standards are developed from the British Standard Institute (PAS-55:2008), which recommends a general asset management framework for physical assets. The PAS 55-1:2008 document was referred to in the initial development of this technical report.

In the absence of a credible standard reference on asset management of HVDC, utilities all over the world presently practice HVDC asset management based on their own interpretation and experience gathered through the years, which may not be in line with the best and prudent practices. This IEC Technical Report on the guidelines of asset management for HVDC installations is the first step, moving forward, in providing a standard framework and reference point for operators and owners of an HVDC installation based on best industry practices.

HVDC INSTALLATIONS – GUIDELINES ON ASSET MANAGEMENT

1 Scope

This document gives guidelines on the current asset management perspectives for HVDC installations based on best practices of asset owners, operators, users, original equipment manufacturers and regulators within the power industry.

Asset management is a set of systematic and coordinated activities and practices through which an organization optimally and sustainably manages its asset and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational strategic plan.

An asset management system is the embodiment of the asset life cycle starting from asset planning, creation, utilization, operation, maintenance, and to the extent of, the retirement and disposal of the asset. It consists of the organization's asset management policy, asset management strategy, asset management objectives, asset management plans and the activities, processes and organizational structures necessary for their development, implementation and continual improvement.

The scope is limited to the DC plant/equipment side of the HVDC system including related AC components of the HVDC converter station. This document covers all equipment of HVDC converter station and electrode station but does not include DC lines and cables.

This document covers HVDC systems with Line-Commutated Converters (LCC) and can be generally applied to Voltage Sourced Converters (VSC), not including specific equipment or sub-equipment required under VSC.

This document on asset management covers:

a) policy and strategy;
b) training;
c) information management;
d) change management;
e) life-cycle costing;
f) tools;
g) performance monitoring and measurement;
h) documentation, operation and maintenance; and
i) risk management.

This document provides base guidelines on fundamental aspects and prudent practices to be considered by stake holders in managing HVDC assets. Compliance to additional requirements and recommendations stipulated in this document by the supplier or OEM are non-obligatory, unless explicitly specified by the customer.

The guideline was prepared based on the following references to establish best practices:

– published documents from other related organizations e.g. CIGRE;
– an international survey on current practices of HVDC installations conducted by IEC TC 115 (see Annex B);
– regional and international forum on management of HVDC assets;

– HVDC user working group; and
– asset management practitioners.

The international survey document and results on the asset management practices are available with the Secretariat of IEC TC 115.

The main objective of this document is to highlight an asset management standard framework for HVDC installations based on best known industry practices. This guideline can be beneficial as reference document in the management of HVDC assets.

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 60633:1998, *Terminology for high-voltage direct current (HVDC) transmission*
IEC 60633:1998/AMD1:2009
IEC 60633:1998/AMD2:2015

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply; other terminology is as per IEC 60633.

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
asset inventory
list of assets in service or kept as spares

3.2
asset manager
person who manages the plant/asset and is responsible for the overall planning, operation, maintenance and performance of the asset in accordance with set criteria as assigned by the asset owner

3.3
asset owner
person who owns the plant/asset or is given the role as the operator, caretaker or manager who is responsible for and manages the plant/asset on behalf of the owner, sometimes functions as the asset manager

3.4
asset worker
staff/worker/employee who carries out the work as set out by the asset manager

3.5
asset useful life
time interval of the asset, from its first use to the end of life, where user requirements are no longer met due to economics of operation and maintenance, or obsolescence

3.6
asset tagging
identification method to recognize an asset and its associated information

3.7
barcode tagging
identification method using barcode labelling to embed asset details

3.8
computerised maintenance management system
CMMS
coordination of maintenance activities through specialised computer applications

3.9
condition based maintenance
CBM
preventive maintenance based on the assessment of physical conditions

3.10
condition monitoring system
CMS
system used in obtaining information about physical state or operational parameters

3.11
corrective maintenance
CM
maintenance carried out after fault detection to effect restoration

3.12
delivery point performance
DPP
performance measured at the point whereby the asset ownership and its functions are transferred to another entity

3.13
emergency response plan
ERP
set of pre-defined processes used to protect critical assets of an organisation from hazard risks, e.g. from unplanned outages, system disturbances and disasters, and to ensure the continuance of plant/equipment operation within their planned lifetime

3.14
energy availability
EA
measure of the energy which could have been transmitted except for limitations of capacity due to outages

3.15
energy unavailability
EU
measure of the energy which could not have been transmitted due to outages

3.16
exposure hours
EH
maximum number of hours that it is considered the HVDC system could have been in service if there had been no failures of equipment within the scope of supply. It is the number of hours in the reporting period adjusted for reductions in operating time due to unavailability of

external equipment (for example, AC transmission lines and outages caused by other equipment not in the contractor's scope of supply).

3.17
forced outage rate
FOR

number of forced outages that would occur during a one-year exposure period. It is calculated from the number of forced outage events caused by the equipment in the OEM's supply during the exposure hours in the reporting period

Note 1 to entry The Forced Outage Rate should be calculated in accordance with the following formula:

FOR = number of Forced Outage Events during the reporting period (Exposure Hours (EH)/8760).

3.18
life cycle activities
activities carried out throughout operational life cycle of equipment, particularly to prolong performance and/or useable life span

3.19
life cycle cost analysis
analysis to estimate prospective cost throughout the operational life of equipment/plant

3.20
life extension/refurbishment strategy
strategy to prolong useable lifespan of equipment/plant

3.21
minimum stock level
least possible quantity of a product/plant/equipment to be kept as spares

3.22
nameplate tagging
identification method using traditional nameplate to engrave relevant asset details

3.23
operational based maintenance
OBM
generic maintenance technique in which in-service equipment maintenance is performed based on operating conditions, period and other related parameters

3.24
original equipment manufacturer
OEM
company (manufacturer) that makes/produces the individual equipment/plant/system/subsystem which is purchased/used/utilised by another company (herein referred to as the asset owner)

3.25
preventive maintenance
PM
maintenance carried out to mitigate degradation and reduce the probability of failure

3.26

rehabilitation and refurbishment
activity conducted as part of asset renewal, commonly done at the end of asset life

3.27
reliability
ability to perform as required without failure for a given time interval under given conditions

Note 1 to entry: The reliability will be assessed by determining the Forced Outage Rate (FOR) of the HVDC system.

3.28
reliability centred maintenance
RCM
systematic method for determining the respective maintenance actions and associated frequencies, based on the probability and consequences of failure

3.29
schedule maintenance
maintenance carried out in accordance with a specified time schedule

Note 1 to entry: Also referred to as Time Based Maintenance (TBM).

3.30
service provider
entity that provides services in the management of the asset, mainly in the areas of maintenance, training and provision of parts and technical support

3.31
strategic spares
critical spare parts of equipment/plant/system that are purposely kept to ensure rapid or immediate maintenance operation when required

3.32
supplier
party that supplies goods or services to organizations, differently than contractor, with added specialized input such as overall engineering and system design

Note 1 to entry: Can be a manufacturer or Engineering, Procurement and Construction (EPC) contractor.

4 HVDC asset

4.1 Asset background

Electrical power is generated as an Alternating Current (AC) and transmitted as well as distributed as AC, and apart from certain traction and industrial drives and processes, it is consumed as AC.

In many circumstances, however, it is economically and technically advantageous to introduce Direct Current (DC) links into the electrical supply network and in some particular situations, it may be the only feasible method of power transmission. When two AC systems cannot be synchronized or when the distance to transmit the large power by overhead line or cable is too long for stable and economic operation, a DC transmission is often the most viable solution.

High Voltage Direct Current (HVDC) is a well proven technology employed for power transmission all over the world, given the need for large bulk power transmission which has grown along with the consumption, and the increased exchange of energy between different power pools. This power exchange results from it being more economical to utilize the installed generating capacity in different regions than to build new power stations in each region.

The development of the HVDC technology has also contributed to make HVDC more competitive in comparison to HVAC, thus making HVDC feasible in more projects than before.

A well-known technical advantage of HVDC is in its inherent ability for control of transmitted power. The controllability can be utilized for different objectives such as stabilization of the connected AC network, control of the frequency of a receiving island network and in assisting frequency control of generator radially connected to the rectifier of an HVDC transmission. Combined active and reactive power modulation feature can be applied when found advantageous.

By the early 1970s thyristor valves began replacing mercury arc valves, and until late 1990s all systems have employed the same semiconductor technology. This is now complemented with the development of Insulated Gate Bipolar Transistors (IGBT) with high voltage ratings, which in turn accelerates the development of Voltage Sourced Converters (VSC) for HVDC applications, mainly in the weak power network and lower power range. VSC uses self-commutated semiconductor devices.

4.2 Asset facilities

Most of the facilities required for the HVDC converter stations, AC switchyards associated with the converter system, cable terminal stations, electrode stations, fibre optic communication systems and other works are as specified below, including but not limited to the following:

a) all civil works, foundations, firewalls and structures and perimeter fencing for the AC / DC switchyards associated with the converter station including the transformers and AC filter areas;

b) AC switchyard equipment including power transformer and buses;

c) valve hall;

d) DC switchyard and DC filter;

e) AC switchyard control and relay equipment;

f) AC / DC converter equipment;

g) cable terminal stations including all facilities, buildings, fencing and surveillance and security systems;

h) DC ground electrodes including terminal facilities;

i) firefighting system including water storage and pump house, and

j) transformer oil and glycol containment and oil-water separation systems.

4.3 Asset components and layout arrangement

The main assets for HVDC installation at the facilities as mentioned above are given in Table 1 and a typical simplified layout arrangement in Figure 1.