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TECHNICAL REPORT

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Life extension guidelines for HVDC converter stations

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LIFE EXTENSION GUIDELINES FOR HVDC CONVERTER STATIONS

FOREWORD

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IEC TR 63463 has been prepared by technical committee 115: High Voltage Direct Current (HVDC) transmission for DC voltages above 100 kV. It is a Technical Report.

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

Draft	Report on voting
115/339/DTR	115/353/RVDTR

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 Report 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/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

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- withdrawn,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

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INTRODUCTION

In today's complex environment, energy players face growing demands to improve energy efficiency while reducing costs. Energy shortages and increased ecological awareness have resulted in great expectations for grid stability and reliability. Utilities and industries are supposed to find eco-efficient solutions to maintain secure, safe and uninterrupted operations. A number of regulatory changes in the electricity market have led to increased efforts by utilities and grid operators for optimized utilization of their existing networks with respect to technical and economic aspects. As the electric power transmission system ages, the topics of life assessment and life extension have become predominant concerns. At the same time, cost pressures have increased the desire to minimize maintenance. The goals of minimum maintenance and extended life are often diametrically opposed.

The concept of simple replacement of power equipment in the system, considering it as weak or a potential source of trouble, is no longer valid in the present scenario of financial constraints. Today the paradigm has changed and efforts are being directed to explore new approaches and techniques of monitoring, diagnosis, life assessment and condition evaluation, and possibility of extending the life of existing assets.

A major challenge for grid operators worldwide is to ensure sufficient power with quality and reliability. In this regard high voltage direct current (HVDC) systems play a major role in bulk power transmission, system stability, integrating remote renewables and ride through of disturbances. Therefore, HVDC systems represent an indispensable part of the electricity grid in the countries where they are installed.

HVDC has been in commercial use since 1954, and most of the systems are still in operation. However, the early mercury arc valve systems have been phased out and replaced by thyristor valves. This has extended the life of many of the early systems, but the thyristor based systems are also approaching an age where the thyristor valves are likely to require replacement or refurbishment. Operation and maintenance issues of these ageing systems have become a challenge. The situation is further complicated by the fact that all of the HVDC systems are custom built by a relatively small number of original equipment manufacturers (OEM). The HVDC manufacturers have supplied several different generations of equipment and these differences are considered in any life extension assessment.

One major challenge in any refurbishment project is proprietary equipment. Most of the HVDC equipment is composed of unique devices for which replacement/refurbishment by other manufacturers is very difficult. For example, when planning to replace components of a thyristor valve, it is more likely to be only supplied by the original manufacturer which will drive the cost up for such replacement. However, this is still preferred if other component life is much longer, as the alternative would be to replace the entire thyristor valves which will be costlier. Proprietary equipment also causes difficulties in sharing details of equipment to other prospective suppliers for the refurbishment projects.

It is assumed that regular maintenance of HVDC system/component/equipment is being done by the owner as per the OEM recommendation as well as their maintenance practices. Further it is assumed that they are familiar with equipment details and records of equipment failure. They have knowledge of equipment behaviour, its characteristics and its impact on system performance based on international standards. This document deals with life extension of the HVDC converter station.

With the ageing of the equipment, measures to extend the equipment's life is considered by utilities and grid operators. Renovation, modernization and life extension of HVDC stations is usually one of the most cost-effective options for maintaining continuity and reliability of the power supply to the consumers. Implementation of these life extension measures is implemented with minimum impact on the HVDC system and the associated networks whilst maintaining an acceptable level of reliability and availability. If life extension is not economical, the systems are disposed of in an environmentally acceptable way. Also, consideration of environmental issues is made prior to a life extension project to avoid any inadvertent environmental damage.

The cost of outages to carry out a refurbishment is considered as part of the overall cost. This then dictates a greenfield option where a new converter station can be built and only short switch overtime is required. An example of this is the Oklaunion Converter Station (CS) in the USA, where the outage costs tipped the scale towards a greenfield versus a brownfield option for refurbishment. The definition of the interfaces in the case of a brownfield project is critical and more complicated than in a greenfield project.

Most utilities are interested in better understanding and projecting service life of HVDC equipment to help manage risk; however, generic reliability data is inadequate for current decision support needs. It is important to establish industry-wide equipment performance databases to establish a broad-based repository of equipment performance data. With proper care and analysis, this data can provide information about the past performance of equipment groups and subgroups, and the factors that influence that performance. With enough data, projections can be made about future performance. Both past and future performance information can be useful for operations, maintenance, and asset management decisions.

However, for some components it is more difficult than most to determine the useful life and the actual end of life failure modes. The thyristors themselves are an example, as they have been around for some 35 or more years and yet are showing little sign of reaching end of life, except where some design or quality issues have been uncovered.

Life-extension involves any of the following actions:

– Refurbishing the systems or subsystems,
– Selectively replacing ageing components,
– Combination of the above.

In some cases where life extension is not economically feasible, a greenfield replacement can be considered.

The following steps can be taken to arrive at a decision:

– Review the past performance of the major HVDC equipment and systems.
– Identify the future performance issues associated with the ageing of special components of the HVDC systems. The equipment that has not shown performance issues in the past but is still required during life extension, is also considered.
– Determine economic life of various components in the converter station and for making replacement versus life extension decisions. The consideration of economic life will include capital cost, reliability and availability, cost of maintenance and the cost of outages and power losses.
– The usable life of a refurbishment is likely in the average of 15 to 20 year range whereas a greenfield option is likely 30 to 40 years and this can be factored into the evaluation but it is recognized that some components can have a different year range.

One way of going about this activity could be to develop criteria, weightings and methodology for determining near-term action and forecasting the technical and financial effect due to system ageing. This follows an approach based on condition replacement cost and importance of the equipment and components. Assessment of condition parameters could be in terms of equipment age, technology, service experience (e.g. after sales service quality, maintenance costs) and future performance, individual failure rates, and so on. A viable duration for the life extension is determined and usually 15 to 20 years is achievable. Longer durations are more difficult to assess with any degree of accuracy.

Evaluation of the possibility of extending the service life of electrical equipment is a techno-economic compromise which can lead to "run-refurbish-replace" decisions. Once the expected service life period has expired, refurbishment of such equipment falls within the life extension program.

The investment at initial stage is very capital intensive to the utility concerned, as the devices to be installed in the system for residual life assessment (RLA) and condition evaluation purpose, are very costly. However, the decision to refurbish or to replace are generally done based on the study of comparable costs and benefits over the same potential life time of the asset.

Therefore, it can be concluded that the need for life extension and replacement of equipment in HVDC system arises due to:

- Arresting the deterioration in performance,
- Improving the availability, reliability, maintainability, efficiency and safety of the equipment,
- Regaining lost capacity,
- Extending the useful life beyond originally designed life of 30 to 40 years,
- Saving investment on new equipment,
- Not having availability of new spares due to obsolescence.

These objectives help utilities as follows:

- design refurbishment strategies for their existing HVDC systems to extend equipment life,
- evaluate O&M and reliability performance improvement strategies for their existing HVDC systems,
- provide a guideline for determining economic life of various components in the converter station and for making replacement versus life extension decisions. The consideration of economic life are generally capital cost, reliability and availability, cost of maintenance and the cost of power losses.

In order to achieve above objectives this document covers primarily following aspects:

- Key factors/reasons driving need for replacement work e.g.: system concerns such as relevance of link. Technical and commercial feasibility efficiency of the refurbishment planned.

- Failure or life degradation of equipment in the HVDC station.
- Critical equipment or critical interface points in the HVDC station.
- Planning of replacement work: Procurement – utility approach for procurement (OEM/multiple vendor) and reasons for adoption based on type of equipment.
- Plan of execution – scope definition, preparation of technical specification, existing system data requirement, etc.
- Outage planning.
- Performance guarantees
- World-wide experience of system operators.
- This document provides guidelines for the general procedure for performing life assessment (Clause 4). Following this, a more detailed description of performance issues of the thyristor based HVDC systems (Clause 5) is given and the life assessment measures of equipment (Clause 6) and guidelines for accessing the techno-economic life of equipment (Clause 7). Clause 8 deals with the recommendation for specification of refurbishing HVDC system and Clause 9 follows with the testing of the refurbished and replaced equipment. Further, this document will outline environmental issues (Clause 10) and regulatory issues (Clause 8) involved in the life assessment and finalize with a financial analysis of the refurbishment options (Clause 9).

This document is about life extension of HVDC converter stations only. Upgrading the converter stations or operating them beyond their design specifications is out of the scope of this document. However, for both of these OEM can be consulted as these are complex and a custom-built installation and the normal design rules will likely not apply.

LIFE EXTENSION GUIDELINES FOR HVDC CONVERTER STATIONS

1 Scope

This document provides guidelines for the general procedure for performing life assessment for an HVDC converter station. Following this, a more detailed description of performance issues of the thyristor based HVDC systems is given and the life assessment measures of equipment and guidelines for accessing the techno-economic life of equipment are given. This document also deals with information for specification of refurbishing HVDC system and the testing of the refurbished and replaced equipment. Lastly, this document outlines environmental issues and regulatory issues involved in the life assessment and concludes with a financial analysis of the refurbishment options.

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 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
life extension
life assessment of the HVDC and the final result being beyond its original designed life time

Note 1 to entry: As a result of the life assessment, the output could be not to extend the life and this would be outside the scope of this document.

3.2
design lifetime
time for which the component has been designed to be commercially available or is commercially viable in its original supplied form

3.3
independent expert
person having an expert knowledge of a part or many parts of a HVDC link and is permitted to be a consultant or not

3.4
maintenance spare
spare component to replace a component within the system that is expected to wear out or have a limited lifetime, either in terms of operational (or storage) time or usage

Note 1 to entry: These components, known as maintenance spares, can be replaced at predictable and specified intervals.