onsite
HV SOLUTIONS

Oil & GAS INDUSTRY

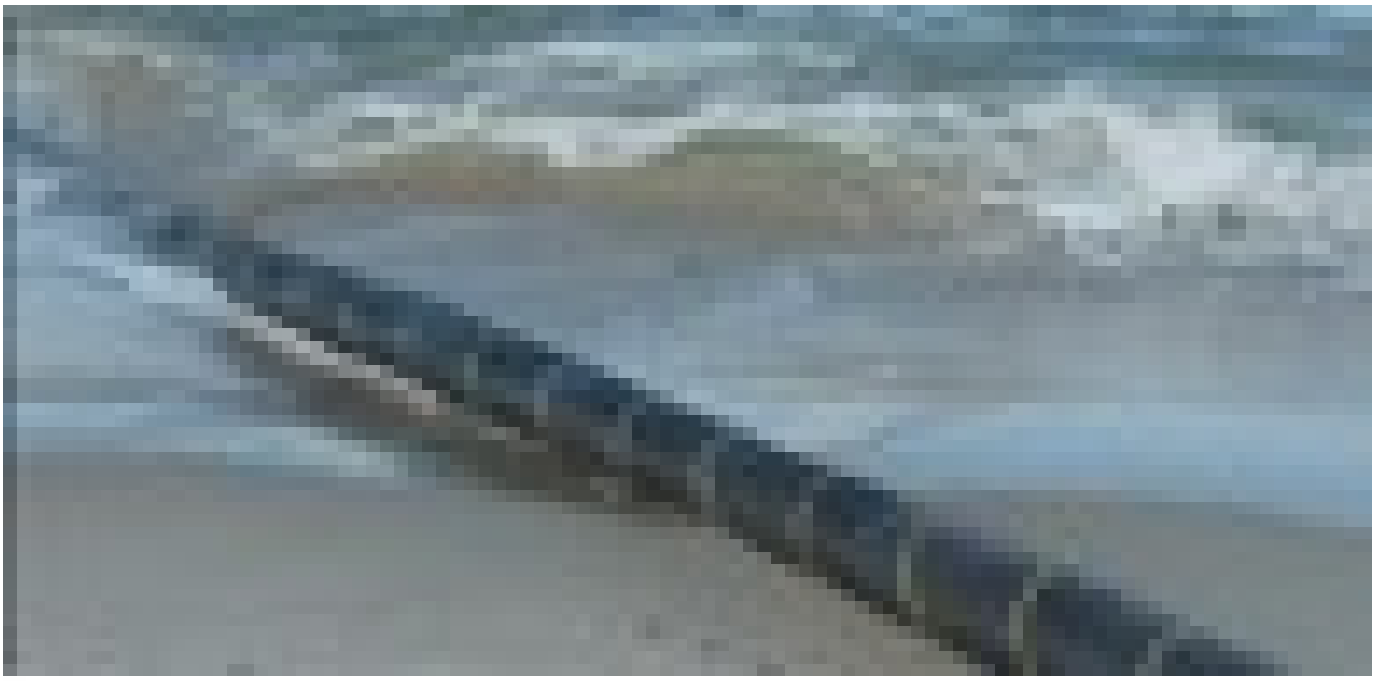
After-laying Testing and Condition Assessment of Offshore Cables

About us

onsite hv solutions, headquartered in Switzerland, is an international organization with a team of highly qualified specialists, assisting our customers with asset management decisions, and the optimal use and maintenance of medium and (extra) high-voltage components.

onsite hv solutions possesses extensive scientific knowledge combined with years of field experience, long and close cooperation with world renowned universities and leading manufacturers around the world.

In addition, onsite hv solutions is actively working in organizations like CIGRE, IEEE and IEC, which allows us to understand the needs of electric power utilities, and to develop and offer effective asset management and asset optimization solutions accordingly.



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Oil & Gas Offshore Power Cables

Submarine or subsea cables play a vital role in bringing the generated power to the offshore substation and eventually to shore. But repairing any damages to such critical infrastructure can be challenging and costly adventure.

Subsea cable damage most often arises from two areas:

- Poor planning and building at the start of the project, coupled with inadequate risk identification, sub-standard design, and deficiencies in how procedures are applied
- Faults caused in the open sea by anchor strikes, dragging fishing nets, erosion and operational service aging

The offshore sector (e.g. wind generation only) on average declares at least 10 large subsea cable failures to insurers each year. The incidents may not be very frequent, but their financial severity continues to grow to the effect of accounting for 77% of the total global cost of offshore wind farm losses. It has found that two-thirds of cable faults recorded in its claims database can be attributed to contractor errors during installation, even if they do not become evident until the offshore installation starts operations.

Typical 33 kV XLPE cable

Fluid-filled power cables used for the Oil and Gas industries deals with a complex issue, consisting of a combination of technical, strategic and economic factors.

The process of natural ageing strongly depends on the operating mode of the cable system (nominal load or partial load, continuous or short time operation, overloads, number of starts, standstill periods) and on the local environment; the so-called TEAM-factors (Temperature, Electrical stress, Ambient conditions, Mechanical stress).

Typical 132 kV XLPE cable

33 kV, 66 kV and 132 kV Power Cables

- Those cable classes fall into different norms. According to the IEC standards, 33 kV cables are considered medium voltage and 66 kV and 132 kV high voltage cables
- As compared to 33 kV cable systems the electrical field strength in 66 kV and 132 kV cables and accessories can be much more higher
- As a result the quality of installation is becoming more important with higher demand on workmanship (at offshore conditions)
- Common installation issues at 33 kV are much more problematic at 66 kV and 132 kV
- By offshore conditions time and weather constraints can have a high impact on installation quality.

Typical 138 kV HPPT cable

Testing Considerations

- Advanced quality control for newly installed and service aged offshore cables is becoming very important. The main challenge will be the need of specialized teams for installation and testing activities, where they will need to be certified to work at offshore conditions
- Systematic testing and diagnosis during manufacturing, transportation, installation and operation can exclude or at least reduce possible risks of a failure during operation
- Advanced quality control will provide protection:
  - of the investment costs
  - against the warranty risks for contractors and subcontractors
  - of the interests of insurers
  - against reliability decrease due to service life aging
- The current state of the international standards do not provide solutions to cover the actual problems experienced on offshore cables

On-site Testing of Offshore Cable Systems

Considering the risks, the offshore industry needs to setup own reliable specifications for submarine cable testing and diagnosis.

In general an effective after-laying testing technology has to be suitable:

- For off-shore testing
- To provide the adequate information: voltage withstand testing and finger printing (e.g.. PD, tan δ) during whole installation and operation process
- To ensure a reliable operation of the offshore cables
- To provide contractors the basis for lowering the risks during the warranty period
- To enable service providers during operation a good basis for condition based maintenance

Relevant International Standards, Guidelines and Papers

General

IEC 60060-3: High Voltage Test Techniques Part 3: Definitions and Requirements for On-site Testing

On-site Testing

IEEE 400: Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5 kV and Above

IEEE 400.4: Guide for Field-Testing of Shielded Power Cable Systems Rated 5 kV and Above with Damped Alternating Current Voltage (DAC)

IEC 60502: Power Cables with Extruded Insulation and Their Accessories for Rated Voltages from 1 kV up to 30 kV - Part 2: Cables for Rated Voltages from 6 kV up to 30 kV

HD 620 S2 (CENELEC): Distribution Cables with Extruded Insulation for Rated Voltages from 6 kV up to 36 kV

IEC 60840: Power Cables with Extruded Insulation and Their Accessories for Rated Voltages Above 30kV up to 150kV – Test Methods and Requirements

IEC 62067: Power Cables with Extruded Insulation and Their Accessories for Rated Voltages Above 150 kV up to 500 kV – Test Methods and Requirements

HD 632 S2 (CENELEC): Power Cables with Extruded Insulation and Their Accessories for Rated Voltages Above 36kV up to 150kV

Cigré TB 496: Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to 500 kV

IEEE Transactions on Power Delivery: Condition Based Maintenance of Transmission Power Cables, vol. 37, no. 3, pp. 1588-1597, June 2022

Cigre Science and Engineering: Testing and Diagnosis of Power Cables using Damped AC Voltages, Cigre Science and Engineering, CSE no. 29, June 2023.

Standardized PD Detection

IEEE 400.3: Guide for PD Testing of Shielded Power Cable Systems in a Field Environment

IEC 60270: Partial discharges measurements

IEC 60885-3: Test Methods for Partial Discharges Measurements on Lengths of Extruded Power Cable

Cigré TB 502: High-Voltage On-Site Testing with Partial Discharge Measurement

IEC 62478: High voltage Test Techniques - Measurement of Partial Discharges by Electromagnetic and Acoustic Methods

Cigré TB 444: Guidelines for Unconventional Partial Discharge Measurements

Cigré TB 662: Guidelines for Partial Discharge Detection Using Conventional (IEC 60270) and Unconventional Methods

Dissipation Factor Measurement

IEC 60141: Tests on Oil-Filled and Gas-Pressure Cables and Their Accessories

IEEE 1425: Guide for the Evaluating of the Remaining Life of Impregnated Paper-insulated Transmission Cables Systems

IEC 60141: Tests on Oil-Filled and Gas-Pressure Cables and Their Accessories;

Cigré TB 627: Condition Assessment for Fluid-Filled Insulation in AC Cables

Aspects of Off-shore Cables

Manufacturing

- Factory joints are installed to produce long lengths of offshore cables
- Cables with very long length up to few tens of kilometers have to be wound on a turntable to store it prior to transport
- During the production of long lengths of submarine power cables, there is a need for quality control of the cable by means of electrical tests

Transportation

- Rewinding on another turntable for high transport weights
- Receipt and storage of submarine power cables and accessories at quayside in a port
- Transportation of submarine power cable and accessories to the site of installation

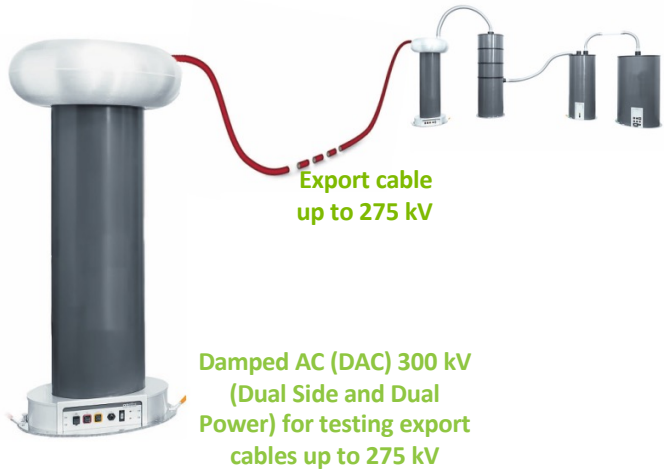
Installation

- Submarine offshore cable laying and burial methodology depending on seabed
- Temporary pulling facilities on offshore structures for cable pull-in (J-tubes)
- Construction of crossings, including rock placement or other material placement for protection
- Adjustment of cable lengths, cutting of cables, sealing of cable ends and securing of cable ends by permanent hang-offs at offshore platforms
- Installation of the cable terminations and installation in the switchgear
- Testing of the installed cables to verify cable integrity

Operation

- The process of natural ageing strongly depends on the operating mode of the cable system and on the local environment.

On-site Testing of Long-length Offshore Power Cables



Damped AC (DAC) 300 kV (Dual Side and Dual Power) for testing export cables up to 275 kV

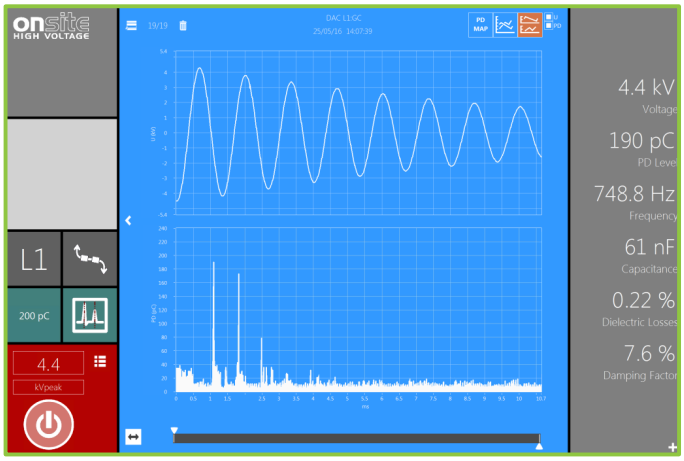
Damped AC (DAC) 110 kV* off-shore version for cables up to 66 kV

Damped AC (DAC) 60 kV * off-shore version for cables up to 33 kV

* Dual Side and Dual Power configuration available

In accordance with IEC 60060-3, IEEE 400, IEEE 400.3 and IEEE 400.4

Damped AC (DAC) Testing

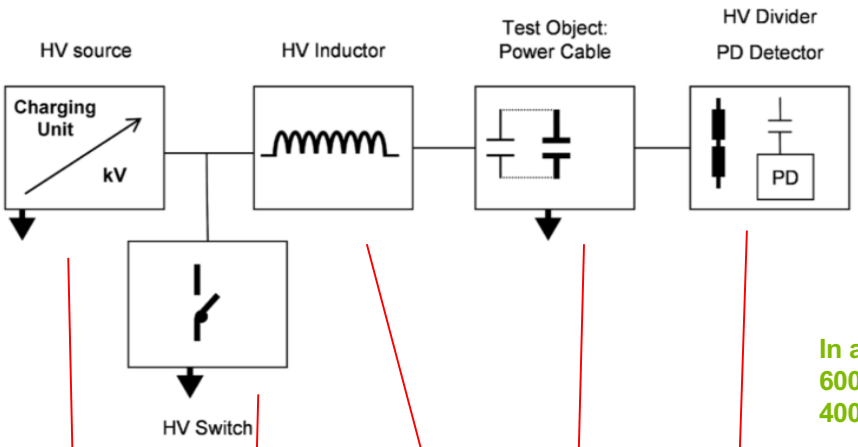


For 20 years in use and in accordance with relevant parameters from international standards and recommendations (IEEE, IEC, CIGRE).

Due to its extremely low input power demand very compact DAC technology makes easy energizing of very long lengths of power cables.

Applicable for on-site after-laying/commissioning, and diagnostic testing of all types of AC and HVDC on- and offshore power cables up to 230 kV.

Provides standardized PD detection and dissipation factor estimation during voltage withstand test and partial discharge test according to IEC 60270. IEEE 4003 and IEC 60885-3.



In accordance with IEC 60060-3, IEEE 400, IEEE 400.3 and IEEE 400.4

Quality Assurance versus Risk Management

Criteria for the risk management for de contractor (e.g. 5 year warranty) system operators, insurers have to be related to the quality control e.g.:

Soak test = due to lack of information about operational reliability = **No warranty**

AC Voltage test only = due to showing by an over-voltage extreme defects only = **Limited warranty**

Damped AC voltage test = due to sensitive (PD- and Tan δ) finger printing = **Full warranty**

Regarding condition assessment of service aged XLPE, HPFF and HPGF power cables with voltage ratings of 69 kV, 115 kV, 138 kV, 230 kV and 345 kV, see our other two onsite hv solutions flyers:

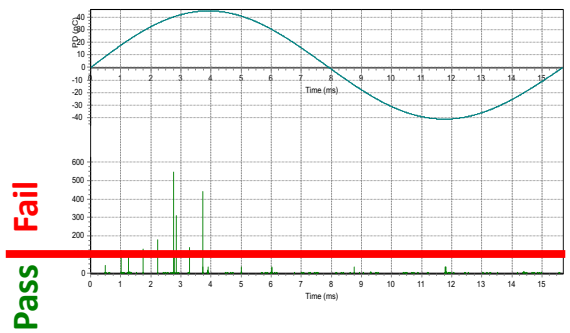
1. ***Recommendation for condition assessment of service aged XLPE insulated transmission power cables***
2. ***Recommendation for condition assessment of service aged fluid-filled transmission power cables***

Summarizing

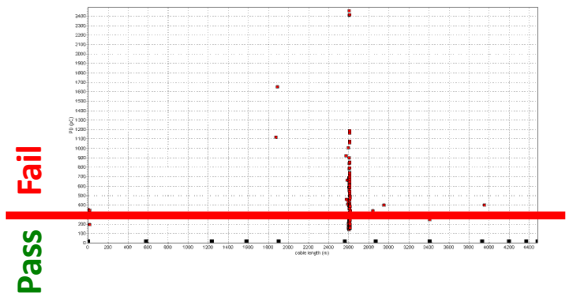
- The various stresses during manufacturing, transportation and installation of offshore cables require an effective after-installation testing technology
- The current international recommendations are deficient and are not covering the needs for after-installation testing of offshore cabling
- Case studies have shown the value of applying the damped AC testing including PD detection and dissipation factor estimation to find upcoming failure prior to service operation
- Advanced testing methods e.g. integral finger printing by damped AC testing are available to assess the cable circuit integrity for cable installation both: newly installed and under operation
- Damped AC technology makes it possible to energize very long lengths of power cables with a high capacitance, due to its low input power demand
- Applicable for factory acceptance testing and on-site after-laying/commissioning, maintenance and diagnostic testing
- Due to Dual-side based PD-monitored voltage withstand testing allows sensitive PD detection and localization in long-length power cables

On-site testing techniques for offshore cables damped AC voltage integral quality finger printing

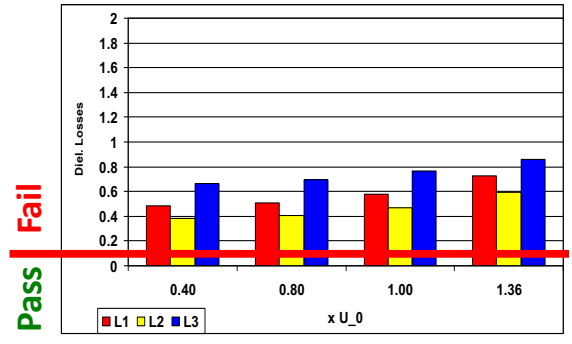
PD pattern up to 2Uo



PD mapping up to 2 Uo



Dissipation factor tan δ up to 2Uo



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