Cigre Paris 2022

Key take aways Study Committee B1 “Insulated Cables”

Presented by Pieter Leemans (BE) and Peter van der Wielen (NL)

For power system expertise

Agenda

1. Introduction
2. Ongoing working groups and publications
3. Key take aways Paris 2022
   - Manufacturers exposition
   - Tutorial SC B1 “New Era of submarine cable”
   - Preferential Subjects
4. New working groups & task forces
5. Cigre Paris 2024

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Introduction - SCB1: in a nutshell

- The SC B1 Committee of CIGRE ("Insulated Cables") covers **Underground and submarine, AC and DC, Insulated Cable Systems**.
- SC B1 (formerly SC 21) was established in 1927 and celebrated its 90th anniversary in 2017.
- A Chairman Marco Marelli (IT) 2016-2022 replaced by **Geir Clasen** from Norway (Nexans) 2022 - ..
- A **Secretary** Matthieu Cabau from France (RTE) 2020-2026
- A **webmaster** André Cuppen from New Zealand (PowerCo) 2022 - ..
- **SAG** B1 - Strategic Advisory Group. Convenor: Geir Clasen from Norway (Nexans)
- **CAG** B1 - Customer Advisory Group. Convenor: Carla Peixoto Damasceno from Brazil (Brazilian Electricity Production and Transmission)
- **TAG** B1 - Tutorial and Publication Advisory Group. Convenor: Luigi COLLA (IT) 2022-2026
- **RAG** B1 *(new)* - Reliability Advisory Group: Russel Wheatland from Australia (AusNet Services) 2022 - ..
- Maximum of 24 **Regular Members**, each from a different National Committee. Regular Members as Belgium and the Netherlands have full voting rights in the SC.
- **13 Observer Members**, possibly one per National Committee not already represented on the Study Committee. Their number should not exceed 50 % of the regular membership (i.e. in any case maximum of 12). Observer Members have no voting rights in the SC and **6 Additional members**.

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Overview of WG's of SC B1

WG	Description	Convenor
WG B1.67	Loading pattern on cables connected to windfarms	Volker Werle (DE)
WG B1.68	Condition evaluation and lifetime strategy	Jacco Smit (NL)
JWG B1/C4.69	Recommendations for the insulation coordination on AC cable systems	Thinus Du Plessis (NL)
WG B1.70	Recommendations for the use and the testing of optical fibers in submarine cable systems	Roman Svoma (GB)
WG B1.72	Cable ratings verification (2nd part)	Frank de Wild (NL)
WG B1.73	Recommendations for the use and the testing of optical fibers in land cable systems	Alexandra Burgos (SP)
JWG B1/B3.74	Recommendations for a performance standard of insulated busbars	Pierre Mirebeau (FR)
JWG B1/D1.75	Interaction between cable and accessory materials in HVAC and HVDC applications	Anders Gustafsson (SE)
JWG B1/B3/D1.79	Recommendations for dielectric testing of HVDC gas insulated system cable sealing ends	Cees Plet (CA)
JWG A3/A2/A1/B1.44	Limitations in Operation of High Voltage Equipment Resulting of Frequent Temporary Overvoltage's	Christian Remy (FR)
JWG B1/C3.85	Environmental impact of decommissioning of underground and submarine cables	Kieron Leebrun (ZA)
WG B1.76	Increasing the role of quality assurance and quality control to reduce the cable failure possibility	Christian Freitag (GE)
WG B1.80	Guidelines for Site Acceptance Test of DTS and DAS systems	Sudhakar Cherukupalli (CA)
TF B1.81	How to have statistics every 2 years	Soren Mikkelsen (DK)
WG B1.82	MV DC cable system requirements	Paul Knapp (US)
WG B1.83	Grounding aspects for long HVDC land cable connections	Christian Remy (FR)
WG B1.86	Assessment, Prevention and Mitigation of Safety Risk in Cable Systems	Julio Lopes (BR)
WG B1.87	Finite Element Analysis for Cable Rating Calculations	James Pilgrim (GB)

Publications of SC B1 – technical brochures

WG	Description of the TB	Year of publication
WG B1.41	Long term performance of soil and backfill of cable systems	2017
WG B1.51	Fire issues for insulated cable installed in air	2018
WG B1.55	Recommendations for additional testing for submarine cables from 6 kV (Um = 7.2 kV) up to 60 kV (Um = 72.5 kV)	2018
WG B1.28	On-site Partial Discharge Assessment of HV and EHV cable systems	2018
WG B1.45	Thermal monitoring of cable circuits and grid operators' use of dynamic rating systems	2018
JWG C3/B1/B2.13	Environmental issues of high voltage transmission lines in urban and rural areas	2018
WG B1.48	Trenchless technologies	2019
WG B1.46	Conductor Connectors: Mechanical and Electrical Test	2018
WG B1.52	Fault location on land and submarine links (AC and DC)	2019
JWG B1-B3.49	Standard design of a common, dry type plug-in interface for GIS and power cables up to 145 kV	2019
WG B1.50	Sheath bonding systems of AC transmission cables Design, testing, and maintenance	2020
WG B1.44	Guidelines for safe work under induced voltages and induced currents	2020
WG B1.57	Update of service experience of HV underground and submarine cable systems	2020
WG B1.60	Maintenance of HV Cable Systems	2021
WG B1.38	After laying tests on AC and DC cable systems with new technologies	2021
WG B1.62	Recommendations for testing DC extruded cable systems for power transmission at a rated voltage up to and including 800 kV	2021
WG B1.66	Recommendations for testing DC lapped cable systems for power transmission at a rated voltage up to and including 800 kV	2021
WG B1.63	Recommendations for mechanical testing of submarine cables for dynamic applications	2022
new WG B1.56	Power cable rating examples for calculation tool verification	2022
new WG B1.65	Installation of submarine power cables	2022

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1. Introduction
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3. **Key take aways Paris 2022**
   - **Manufacturers exposition – general trends**
   - **Tutorial SC B1 “New Era of submarine cable”**
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Manufacturers exposition – general trends

Offshore/HVDC expands

- Important to focus on load calculation methodology: armour losses, use cases,… (high impact on cable design and costs)
- Array cables / dynamic cable design: push from the marked for cables > 72 kV
- PQ tests are performed on submarine cables: 275 kV HVAC and 525 kV HVDC

Monitoring on cables

- DTS/RTTR, DAS, PD (new techniques), Sheath Current Monitoring, terminal monitoring, burial depth monitoring, dynamic cable reconstruction
- Focus on consolidated GUI for end-users

Sustainability

- Oil free (dry) design of AIS terminations ≥ 150 kV
- SF6 free developments ongoing for cable terminations (g^3,…)

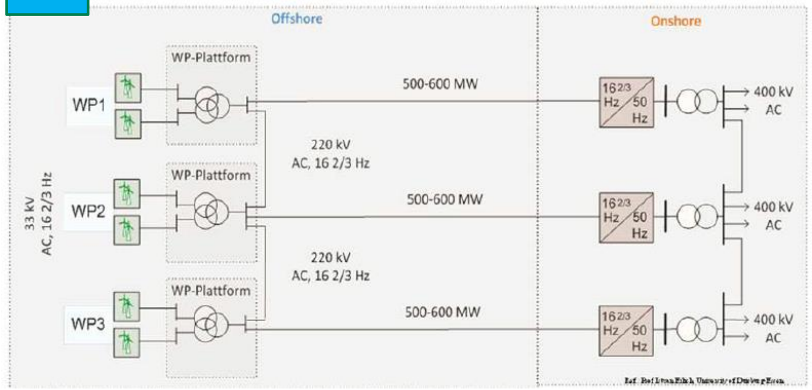
Tutorial SC B1 - New Era of submarine cable (1/3)

The expansive growth in renewable energy requires submarine cables in new areas:

- [**Cable design**] - The distance from shore to windfarms are increasing.
- [**Loading Pattern of cables**] - Traditional loading with 8 hours high load, 16 hours low load are not representative for windfarms.
- [**Losses in armoured three core cables**] - Ground cable loss calculations are not relevant and newer approaches are needed.
- [**Dynamical testing**] - Cables are being installed in platforms in deeper waters, thus need dynamic installations.
- [**Installation of submarine power cables**] - Installation techniques have evolved in line with new cable systems.

Tutorial SC B1 - New Era of submarine cable (2/3)

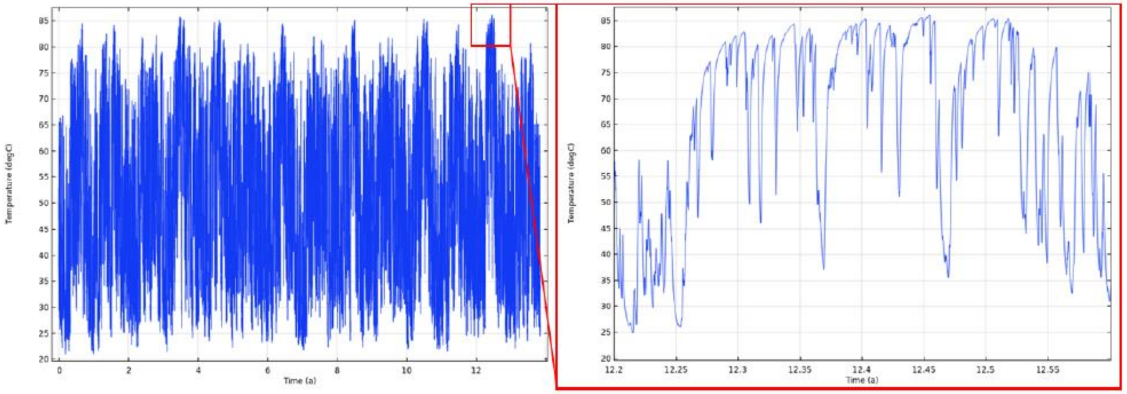
1



Special design - Long ordinary AC cables

- Turbines -16.7 Hz
- Larger transformers
- Back-to-Back converter needed on shore
- No experience so far

2



- Graph and detail showing the **conductor temperature** and detail at peak temperature **with actual load conditions**.
- The **design process** and it is divided in 3 parts; these are as follows:
  - Part 1: Inputs and constraints
  - Part 2: Dynamic Cable Rating
  - Part 3: Evaluation and Analysis

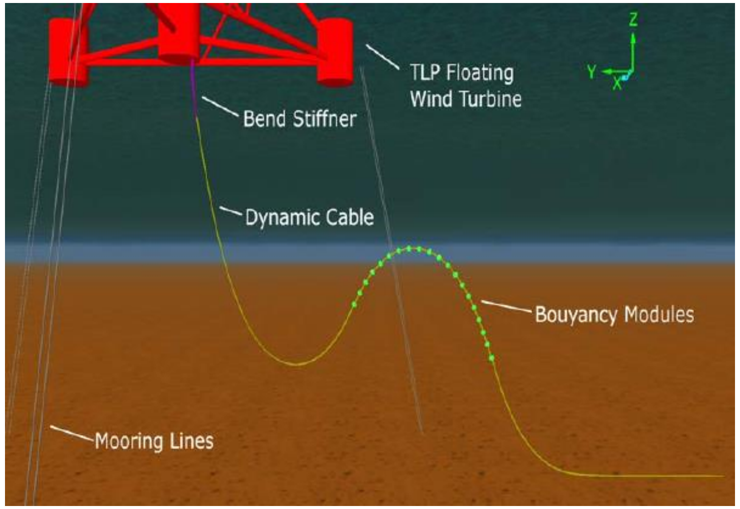
3

Calculation method	Grade 34 Contra lay (950 A)	Grade 65 Contra lay (990 A)	Grade 34 Uni lay (1025 A)
Method 1	1200 mm^2	1200 mm^2	1200 mm^2
IEC 60287	1600 mm^2	1800 mm^2	2000 mm^2

- Required conductor cross section calculated using Method 1 and IEC
- 1200 mm^2 Al cable as reference

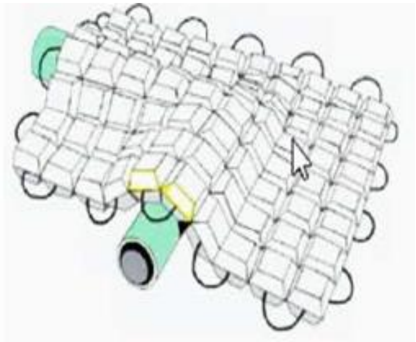
Tutorial SC B1 - New Era of submarine cable (2/2)

4



- Fast growth of floating wind expected
- Requires dynamic cables with a specific design approach:
  - **Iterative design process** including global & local analysis
  - **Full-scale fatigue test**
- New TB 862 gives recommendations on each step of this design and testing

5



- The TB "installation of Submarine Power Cables" covers the entire lifetime of the submarine cable system / project (*from concept idea to decommissioning with the installation being the focus of the brochure*)
- 30 kV to 550 kV AC and DC with various insulation types
- The following topics:
  - ➢ Consenting / Permitting aspects
  - ➢ Submarine cable installation engineering
  - ➢ Seabed survey and site investigations
  - ➢ Installation tools and considerations
  - ➢ Execution of installation including remedial work
  - ➢ Operation, maintenance, and decommissioning

Key take aways Paris 2022

Preferential subjects

1. **PS1 - Learning from experiences**
2. PS2 - Future functionalities and applications
3. PS3 - Towards sustainability

53 papers have been accepted and published for Paris 2022.

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Paper No. 11073 - Advanced Analysis of Partial Discharges and Breakdowns on HVDC Power Cables

- **Description problem & topic**

✓ Increase of reliability and availability of HVDC cable systems.

✓ Well-known approaches for PD assessment are not applicable for HVDC cables due to low repetition rates, the lack of phase information and costs.

- **Solution**

✓ Advanced PD evaluation for predictive maintenance of the whole cable system in combination with capability of pinpointing after a breakdown.

- **How?**

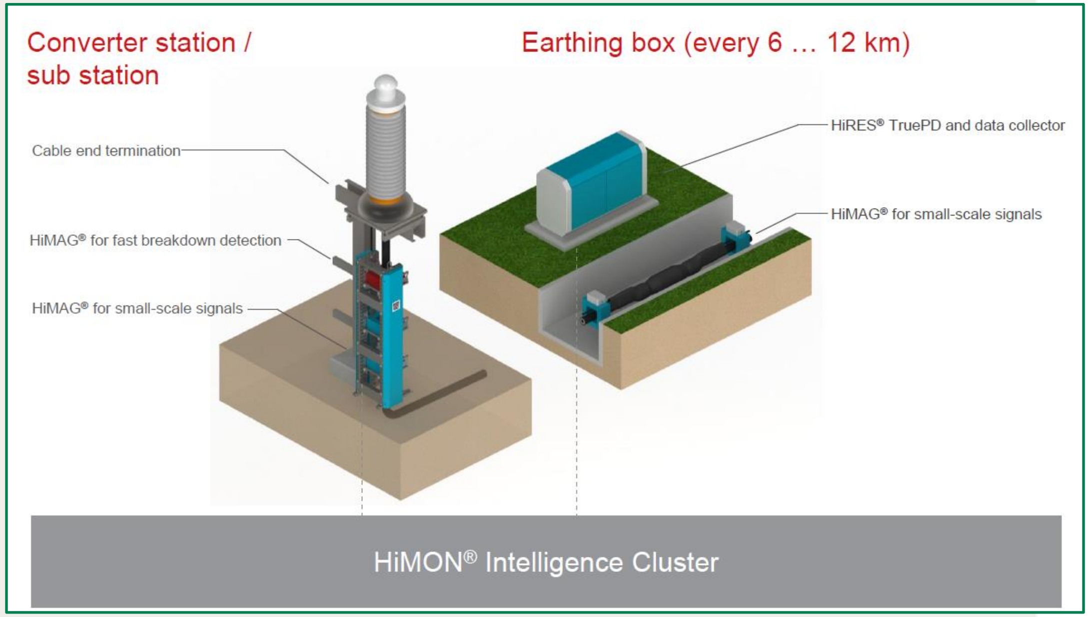
✓ New approach to evaluate PD under DC: "TruePD", plus

✓ A fault locator coupled with a High Frequency Current Transformer (HFCT) or with a conventional divider.

- **Conclusion**

✓ Real-time signal processing and machine learning algorithms can be used to classify different PD sources and monitor their behavior.

✓ Possible solution for predictive and curative maintenance on HVDC cables.



Paper No. 10774 - PD, DTS and DAS measurement of Eleclink HVDC interconnector – anticipate failures to minimize service disruption and impact on train circulation

- **Description problem & topic**

✓ The Eleclink is a 68 km long, combined HVAC (14 km) HVDC (54 km) interconnector between UK and FR, laid in air, in a railway tunnel and in close proximity to the running trains

✓ A monitoring system is installed to anticipate an incoming issue and lowering the risk of a fault and consequences of it.

- **Solution**

✓ For HVAC cables: PD, shield current, earth current, SVL, DTS and DAS,

✓ For HVDC cables: PD, DTS and DAS.

- **How?**

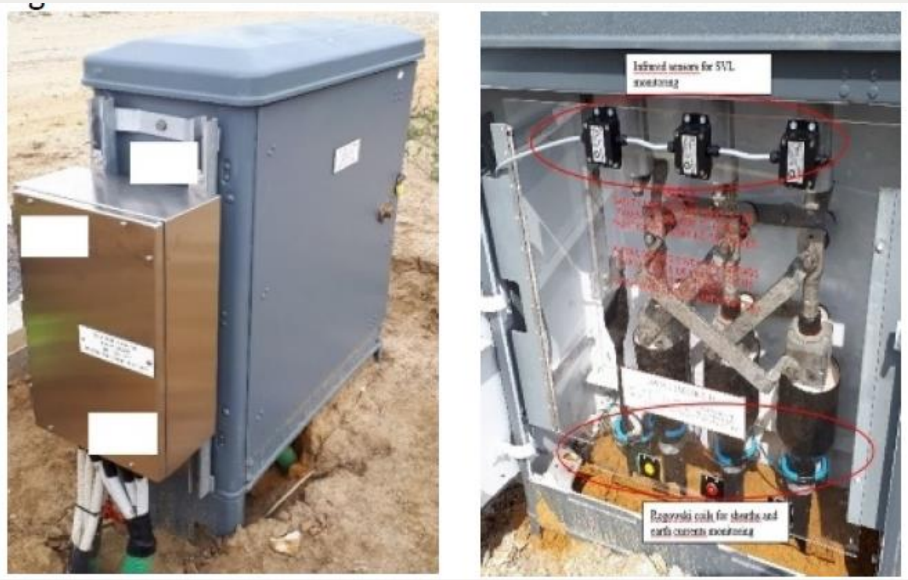
✓ Special design & concept of LV network and Communication via dedicated optical fibre

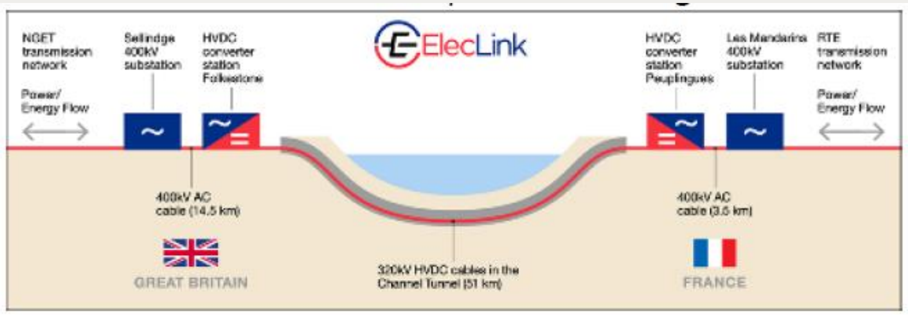
✓ PD sensors installed on cables on proximity of the cable accessories. Rogowski coils measure earth currents and IR sensors the SVL status.

✓ The DAS is capable to detect acoustic activity in proximity of the cable and distinguish possible threats from normal signals.

- **Conclusion**

✓ Monitoring solutions highlights the importance of the cable system. Important to follow up the return of the different monitoring applications.





Paper No. 10714 - Belgian experience with horizontal directional drilling (HDD) filling materials and thermal modelling of HDD

- **Description problem & topic**

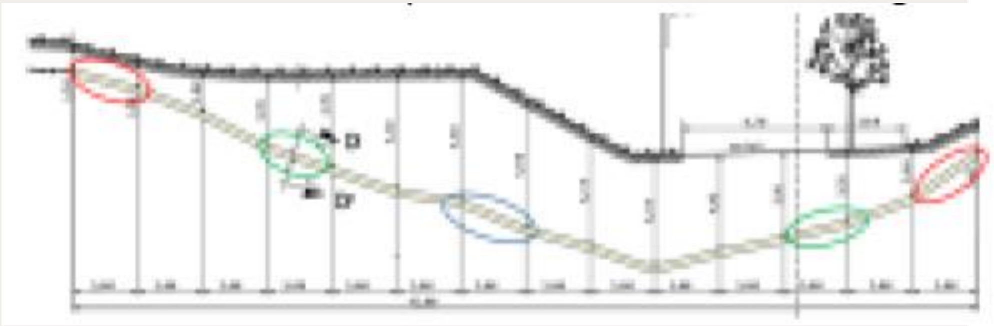
✓ Question on the behavior of the filling material of HDD and its stability over time.

✓ Compare obtained results of DTS/RTTR systems to challenge current theoretical thermal modelling of HDDs with the measured as-built transport capacity.

- **Method/approach**

✓ Compare 3 thermal filling materials. Investigate the behavior, thermal properties and practical installation.

✓ Compare the theoretical modelling of 3 different projects with HDD's with the as built thermal behavior using the measurements of a DTS-system.



- **Conclusion?**

✓ Materials: water-sand-bentonite is difficult to inject (very viscous) + important sedimentation was observed. Other 2 products were thermally stable and easy to install.

✓ Preferably HDDs with entrance points at the same heights. In any case, extra care during the filling of HDDs to assure a complete filling of the HDD.

Paper No. 10544 - Practical experience and modelling of the corrosion behavior of the Aluminium metallic cable sheath

✓ Description problem & topic

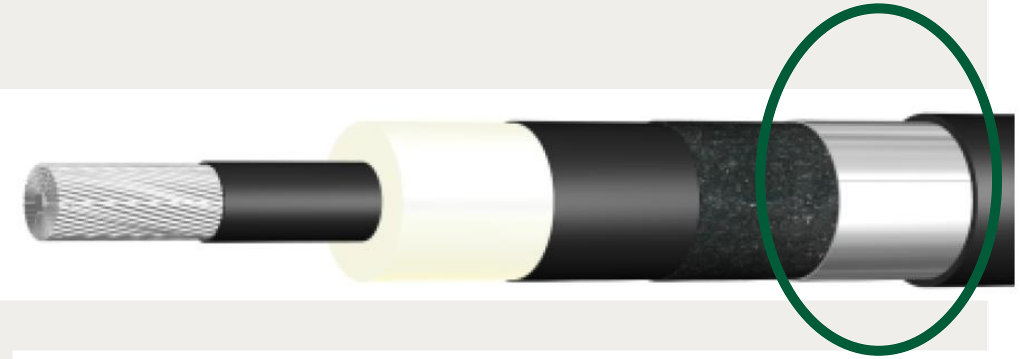
- Increasing number Aluminium sheathed cables in the TenneT grid with good service record after > 10 year of service.
- Lack of experience on long term Aluminium sheath degradation in soils

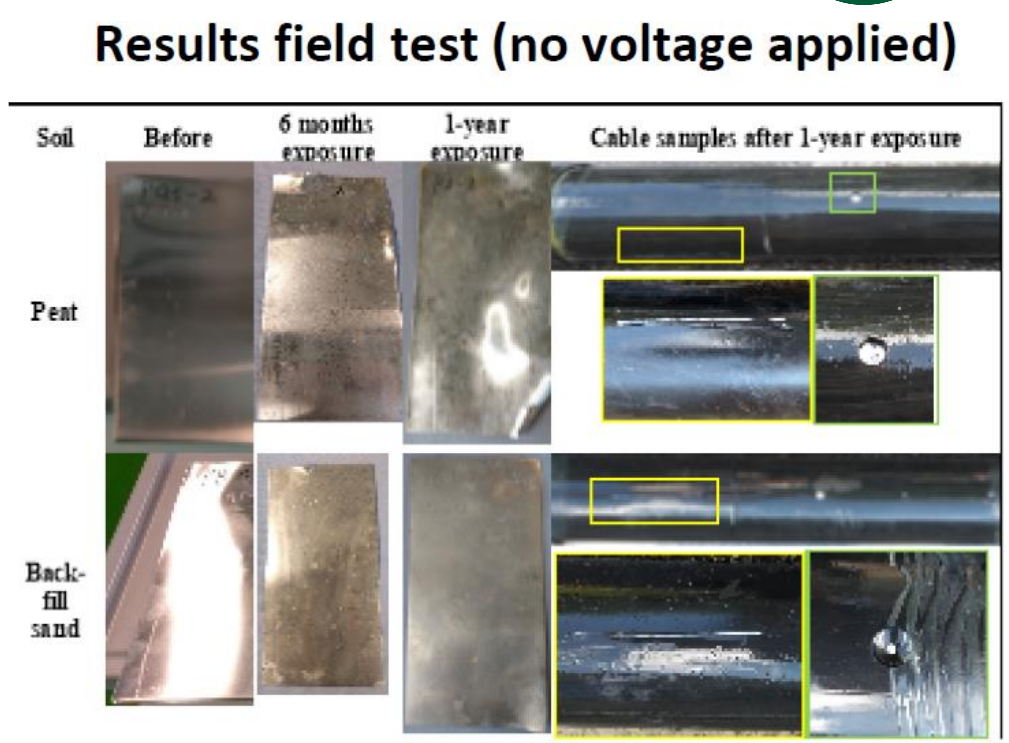
✓ Goals of the investigation

- Identify failure mechanisms and important variables (soil composition, water content, etc.) for sheath degradation
- Develop a risk assessment model to estimate the maximum repair time and asset managent practices.

✓ Conclusion?

- No aluminium sheath degradation occurs if outer jacket is not damaged.
- Under the same applied voltage, sheath degradation is more pronounced in peat than sand.
- The main driver for degradation kinetics is the AC stray current density: Threshold to avoid AC induced corrosion <10 A/m^2
- To establish more clear maintenance guidelines, the analysis of practical sheath failures cases occurred on field is needed.





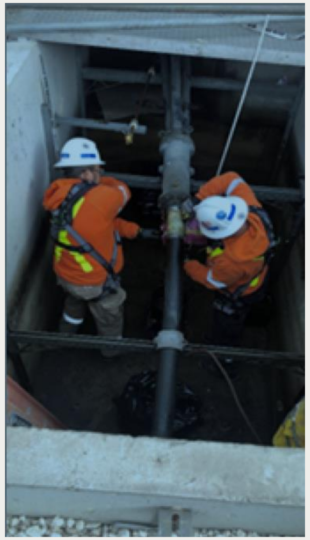
Paper No. 11164 - Experiences and Insights Rehabilitating a 69 kV SCFF Cable System after Pressure Loss

- **Description problem & topic**
- A facility operator in the United States completely lost pressure on a 69kV SCFF feeder
- The circuit consisted of 700m of three core 400mm2 cable and a reinforced 1/2C lead sheath installed in 1988

✓ **Initial inspection**
- One of the trifurcating joints was leaking in two places which caused the system to lose all hydraulic pressure + The inner valves and fittings of the oil reservoirs were severely corroded

✓ **Leakage Repair**
- Replacement of old, damaged reservoirs and piping.
- Vacuum Treating and Fluid Filling/Flushing with subsequent DGA and Moisture Content testing was performed until results reached acceptable levels
- The Impregnation Coefficient test was performed to verify the hydraulic integrity of the cable system and ensure no free gas was trapped within the insulation

✓ **Conclusion:**
- It is possible to rehabilitate a circuit that has completely lost pressure assuming there are not significant gaps that have formed and partial discharges have not occurred within the cable's insulation.
- It is far better and less expensive to perform routine maintenance and testing on the cable system to quickly identify and correct issues before they become a serious concern



Key take aways Paris 2022

Preferential subjects

1. PS1 - Learning from experiences
2. **PS2 - Future functionalities and applications**
3. PS3 - Towards sustainability

PS2 had authors from 12 different countries and 15 papers.

The special report had 5 questions, leading to 11 prepared contributions

- Innovative cables and systems, exploring the limits,
- Role and requirements of power cables in tomorrow’s grids,
- Prospective impacts from the Internet of Things, Big Data and Industry 4.0 on power cable systems.

Paper No. 10939 - Identification of Partial Discharges in Cable Terminations using Methods based on Acoustic, Electromagnetic and Electrical Measurements – (Finland)

- Paper 10142 : Strategies for maintenance and replacement of HPFF cables (same technology, LPP, partial, full conversion to solid-dielectric cable systems) - USA
- Paper 10359: 50MW, 20kV HTS cable system in Moscow. Design of cooling systems and test results - Russia
- Paper 10513: The need for special environment conditions for the prequalification of a 525kV extruded DC cable system – Sweden
- Paper 10514: Test setup for testing HVDC with Transient Over Voltages (TOV) with longer tail time – Sweden
- Paper 10642: Development of PD monitoring system with IEC 61850 communication and AI (under development) – Korea
- Paper 10691: Quality management system in Japan by means of Plan-Do-Check-Act for underground cables – Japan
- Paper 10879: Cathodic protection sensing (CPS) and DTS & DAS for monitoring HPFF cable systems – France
- Paper 10880: Superimposed chopped impulses with 270 polarity reversals were tested on two 320kV DC XLPE cables successfully – Spain
- Paper 10961: Ampacity calculations on application of single point bonding on short submarine cable sections at landfalls – Norway
- Paper 11028: Very slow front TOV and zero-crossing damped TOV tests on HPTE cables successfully – Italy
- Paper 11070: Type test on 525kV HVDC cable system including GIS components successfully – Germany
- Paper 11072: Simulations on assumed network for different levels of cable integration and the impact on harmonics. Result: frequency shifts to lower frequencies and all is very network specific - Germany

Paper No. 10297 - Simulation and Experiments on ±100 kV/1 kA DC Superconducting Energy Pipeline for Energy Interconnection – (China)

For power system expertise

- ✓ **Description problem & topic**
- Need for transmission of both large amounts of electrical and fuel energy over long distances
- Recent developments:
  - HTS tapes above 100 K
  - Natural gas (with some additives/mixtures) refrigeration below critical temperature and keep liquified in 85 K – 100 K zone
- ✓ **Method / solution**
- DC Superconducting Energy Pipeline (DC SEP) technology:
  - Integration of DC superconducting cables and LNG pipelines
  - hybrid transmission of electricity and chemic fuel via sharing a thermal insulating pipeline and refrigeration equipment (utilize CNG facilities)
  - LNG is cooled to 85 K,
  - pressurized LN_2 as insulating medium in remaining space of SEP and is non-flowing
- **Paper contents**
- +/-100kV, 1kA DC (200MW) SEP
- themal insulating pipeline, two DC superconducting cables en several LNG pipelines
- electro-magnetic-fluid-temperature multiphysics coupling FEM modelling
- Test setup:
  - Test prototype with 30m full power test system, incl cooling circulation
- Experiments with hybrid transmission
  - Temperature test
  - LNG transporting test
  - HV insulation test
  - Full power test
- ✓ **Conclusion:**
- Prototype shows feasibility

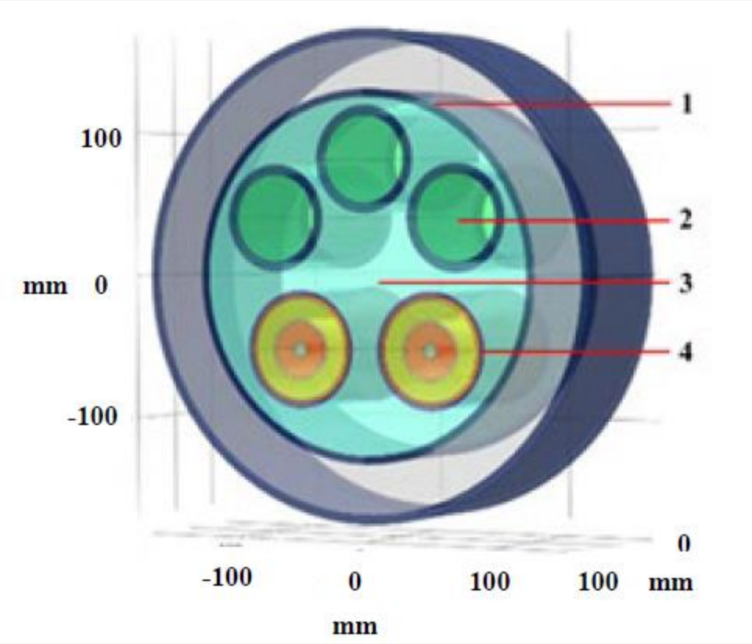
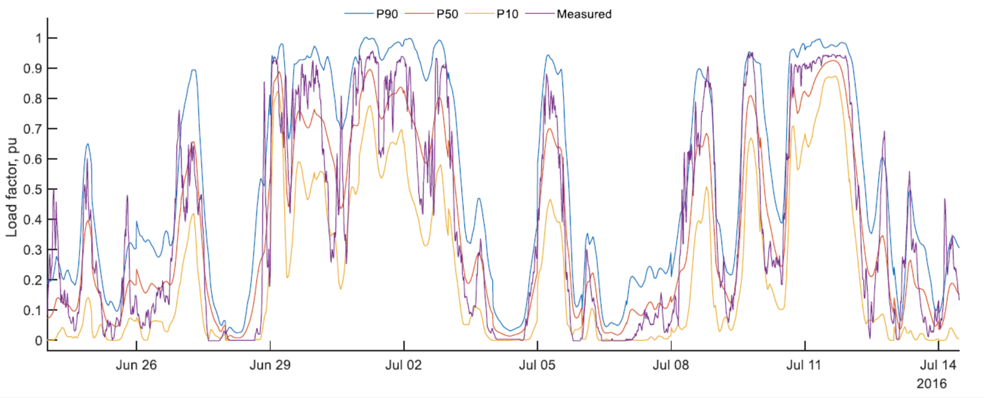


Fig. 1. The 3D structure of DC SEP. (1. the thermal insulating pipeline; 2. LNG pipeline; 3. LN2; 4. superconducting cable)

Paper No. 10882 - Optimal energy management of offshore wind farms considering the combination of overplanting and dynamic rating – (France)

✓ Description problem & topic

- More offshore wind energy demand than installed transmission infrastructure allows
- Possibility: “overplanting”: installed generation capacity > infrastructure capacity
- Curtailment needed

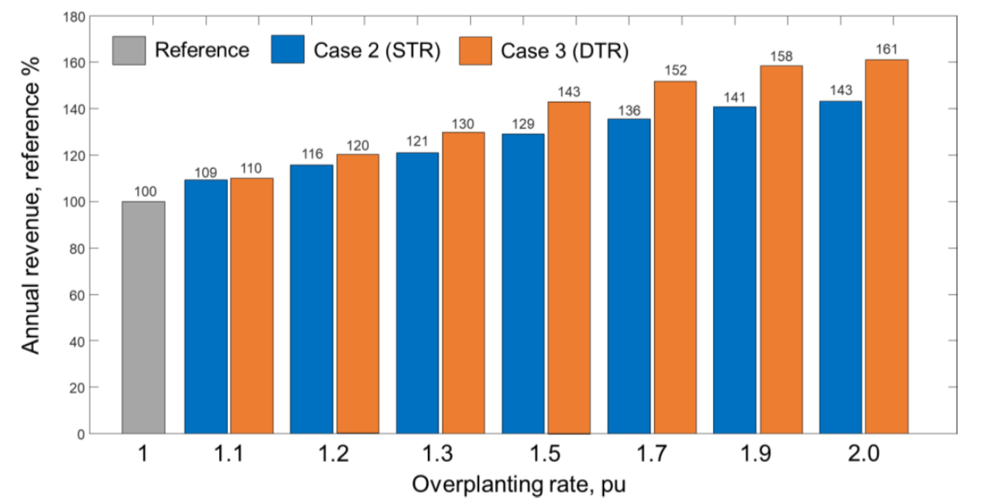


✓ Method / solution

- Use dynamic rating on top of curtailment

✓ Paper contents

- Benefits of DR with enhanced forecasting against business-as-usual
- Theoretic case to define upper bound on annual revenu
- Export cable only (225kV, 339MVA), data of French TSO and Belgium OWF



✓ Conclusion

- With DR extension of additional revenu from 10% up to 61 % (overplanting rate 2.0)
- Up to 130% overplanting rate, the revenu increases in same proportion
- Not CAPEX and OPEX implications, only revenu
- Energy prices are considered as known in advance
- Source code and related documentation in open-access repositories

Paper No. 10939 - Identification of Partial Discharges in Cable Terminations using Methods based on Acoustic, Electromagnetic and Electrical Measurements – (Finland)

✓ **Description problem & topic**

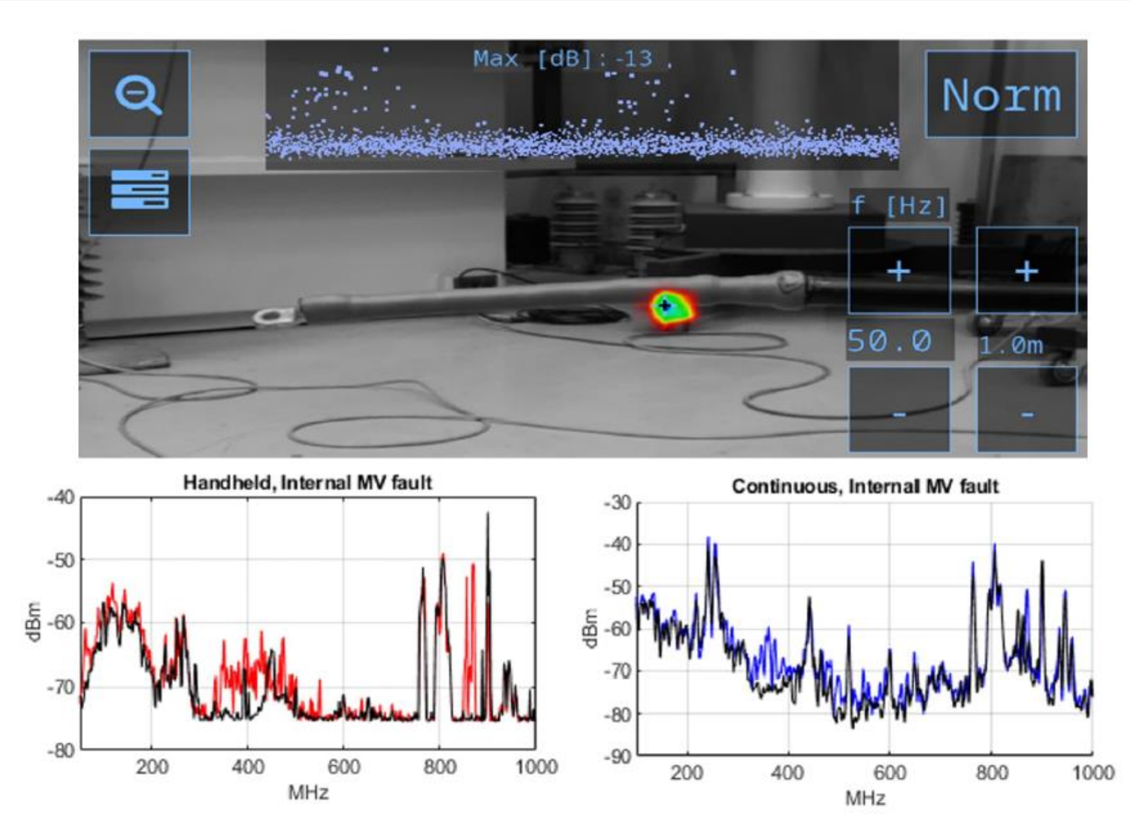
- PD detection devices, what are the capabilities/differences?

✓ **Paper contents**

- Laboratory experiments comparing the PD detection capabilities
    - Acoustic camera
    - RFI handheld tool
    - RFI continuous measurement tool
    - Conventional PD detection as reference

✓ **Conclusion:**

- All tools detected PDs, but different performance
- Acoustic camera
    - very accurate for external PDs (corona, surface),
    - internal PD detection unreliable
    - Also sometimes detection of covered areas (wherr UV cameras fail)
    - Easy to locate, easy to interpret
- RFI handheld
    - External and internal PDs
- RFI continuous device
    - Internal PDs (external unreliable)
- Overall:
    - No direct relation between measured intensities and PD magnitudes
    - Large variations
    - Recommendation to use combinations



Key take aways Paris 2022

Preferential subjects

1. PS1 - Learning from experiences
2. PS2 - Future functionalities and applications
3. **PS3 - Towards sustainability**

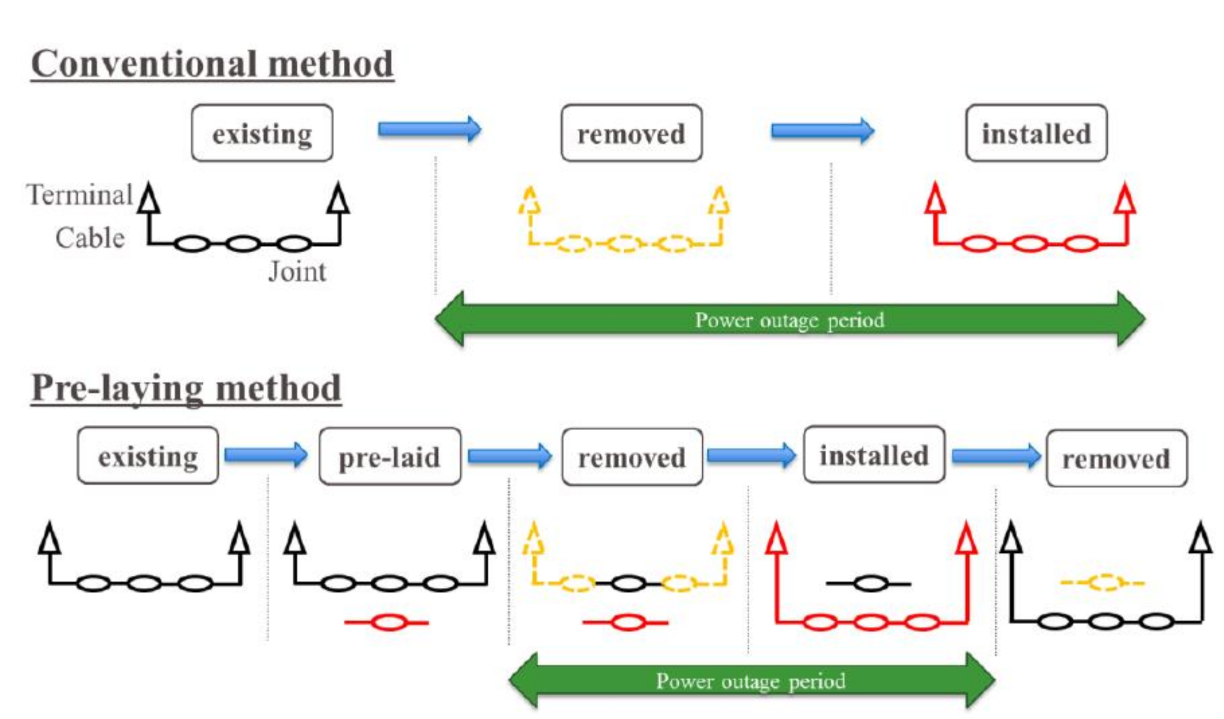
PS3 had 3 papers.
The special report had 4 questions, leading to 9 prepared contributions

- Environmental challenges impacting current, planned and future cable systems,
- Safety considerations, cyber and physical security, including case studies,
- Projects and initiatives to promote access to affordable, reliable, sustainable distribution and transmission cable lines for all

Paper No. 10692 - Replacement by utilizing existing facilities for EHV Underground Transmission Lines – (Japan, Kansai T&D)

✓ **Description problem & topic**

- Many EHV cable systems that were installed in the 1970s need replacement
- Need for reduction of:
  - Environmental impact
  - Outage duration during replacement works



✓ **Paper contents**

- Description of method of pre-laying
- Practical examples

✓ **Conclusion:**

- Time savings 21 → 3 months, 12 → 3 months
- Environmental impact low, compared to conventional method
- Important elements to take into account:
  - Design to take future replacement into account
  - Confirm beforehand that old and new should have suitable interfacing
  - Make optimal replacement plan

Paper No. 10717 - Towards Sustainability: A Power Cable Industry Supplier's Perspective – (Belgium, Borealis)

✓ **Description problem & topic**

- What sustainability impacts have the various options for polyolefins

✓ **Paper contents**

- Overview of various options and considerations
- Full lifecycle:
  - Selection of raw materials (mechanical, chemical, bio-based feedstock recycling)
  - Raw material production (cracking, use of heat, GHG, carbon capturing, clean electricity sources, packaging, logistics)
  - Design (voltage & insulation thickness vs current & conductor size, dry vs wet designs, layer reduction, installation impact)
  - Cable manufacturing (extrusion temp., degassing)
  - Use phase (TB689: CO_2 emissions fare-out highest, temp. choice, AC vs DC)
  - End-of-life (RTE: synthetic cables: 85-100 years, leaking into environment non-existing, mix with HDPE or PP)

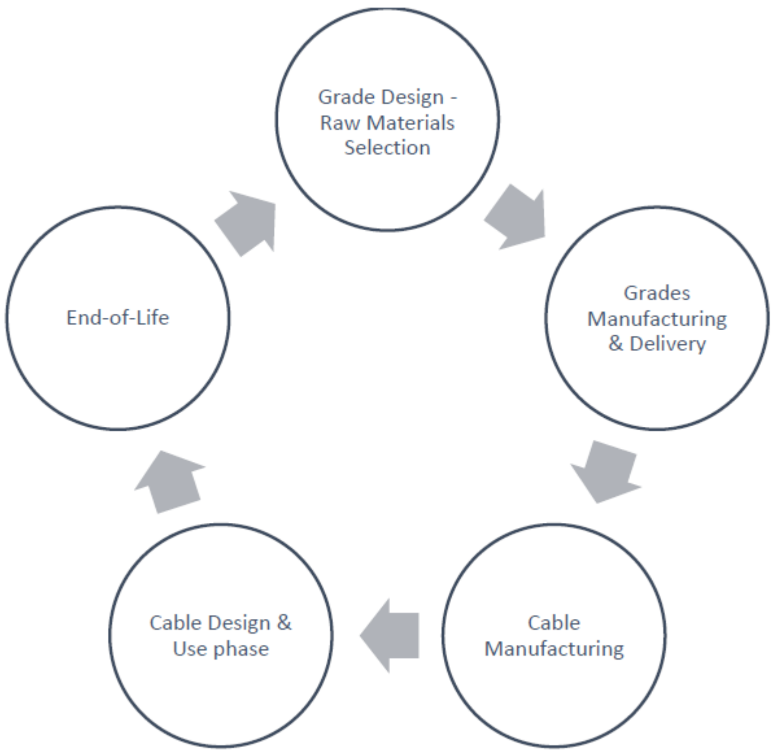


Figure 1: overview of the PO grades lifecycle for cable applications

✓ **Conclusion**

- call for dialog across value chain to identify most efficient actions

Paper No. 10962 - Availability modelling of submarine high voltage cable systems – (Norway, Nexans)

For power system expertise

✓ Description problem & topic

- most the research work and papers have mainly focused on the reliability modelling of the converters, wind turbines. For cables only very simple models without influencing factors
- Need for model on availability of submarine power cables

✓ Paper contents

- Model for availibility of submarine cables
- Markov method (states: functioning, failed and maintenance)
- Weather conditions as main influencing factor for repair operation
- Exposure of cables as main factor for vulnerability to external forces
- Other factors incorporated in failure rates
- Route survey as failure preventive action
- Model outputs: cable availibility, forced outage, planned outage, MTF, MDT
- Sensitivity analysis

✓ Conclusion

- The details introduced in the model enable the cable operators to have an estimation of different state probabilities, enabling optimization of maintenance.

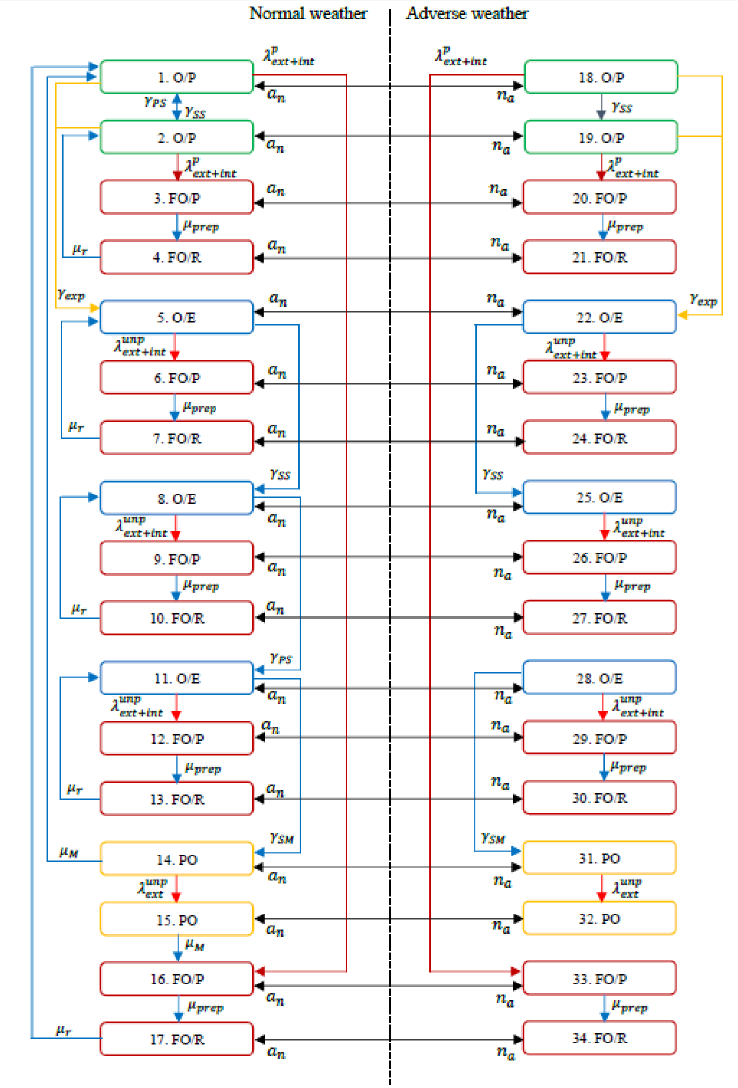


Figure 1 Detailed Markov model for availability assessment of submarine cables

Agenda

1. Introduction
2. Ongoing working groups and publications
3. Key take aways Paris 2022
   - Manufacturers exposition – general trends
   - Tutorial SC B1 “New Era of submarine cable”
   - Preferential Subjects
4. **New working groups & task forces**
5. Cigre Paris 2024

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New working groups and task forces – B1

Title	WG/TF		#	Countries	Convener
Replacement gas for SF6 in cable accessories	WG	B1.	88	CN, CH, JP, DE, CA, ES, GB, NL, IT, US, SE, FR	Pierre MIREBEAU (FR)
Cable systems failure analysis	WG	B1.	89	CN, AU, BR, NZ, IN, CH, BE, ZA, JP, DE, CA, ES, GB, DK, NO, PT, NL, KR, US, IT, IL, FR, RO, AT, TH	To be defined
Cable Systems Electrical Characteristics (Update of TB 531)	WG	B1.	90	AU, DE, ES, GB, DK, NO, IT, US, SE, FR, IN, NL	To be defined
Transient Thermal Modelling of Power Cables (update to IEC 60853)	WG	B1.	91	BR, CN, AU, CH, ZA, DE, CA, GB, DK, NO, NL, IT, US, SE, FR	Frederic LESUR (FR)
Transition facilities between overhead and underground lines	JWG	B2/B1.	-	AU, BR, IN, BE, ZA, JP, DE, CA, ES, RO, GB, PT, KR, NL, IT, US, SE, FR, CN	from SC B2
Qualification of Lead-free Submarine Cables at 72.5kV<Um<170 kV	TF	B1.	92	CN, CH, JP, DE, CA, ES, GB, DK, NO, KR, NL, IT, US, SE, FR	James PILGRIM (UK)
Robotic supervision of tunnels	TF	B1.	93	CN, AU, NZ, IN, CH, BE, DE, GB, NL, IT, US, FR, ES	Jianbin FAN (CN)
Reliability advisory group (RAG) (from TF B1.81)	RAG	B1			Russell Wheatland (AU)

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Cigré 2024

- Preferential subjects session 2024 (Paris):
  - PS1 - Learning from experiences
    - Design, manufacturing, installation techniques, maintenance, and operation,
    - Quality, monitoring, condition assessment, diagnostic testing, fault location, upgrading and uprating methodologies and relevant management,
    - **Lessons learned from permitting, consent and safety issues from design to implementation.**
  - PS2 - Future functionalities and applications
    - Innovative cables and systems, exploring the limits,
    - Role and requirements of power cables in tomorrow’s grids,
    - Prospective impacts from the Internet of Things, Big Data and Industry 4.0 on power cable systems.
  - PS3 - Towards sustainability
    - Environmental challenges impacting current, planned and future cable systems,
    - **Impact of circularity and roadmap to net zero,**
    - Projects and initiatives to promote access to affordable, reliable, sustainable distribution and transmission cable lines for all

- Other related conferences to keep an eye on (not complete):
  - Jicable 2023 18-22 June in Lyon,
  - Cired 2023 Rome
  - Cigre 2023 4-7 Sept in Cairns

Thank you for your attention

Pieter Leemans (BE) and Peter van der Wielen (NL)

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