Study Committee OVERHEAD LINES - B2

SPECIAL REPORT FOR SC B2
update June 29th 2021

Klemens REICH (Austria)
Tim CONDON (Ireland)
Jean-Philippe PARADIS (Canada)

Special Reporters

Information about the procedure

The Centennial Session 2021 will be a virtual session. This makes some alterations necessary for the Group discussion Meeting (GDM), compared to "traditional" physical sessions in the past.

1. The session style of the GDM at the Centennial virtual session 2021 is on-live, emulating the regular GDM as much as possible. Contributors are asked to make a live presentation from remote.
2. B2 Contributors are asked to upload their proposed contributions - derived from the Special Report - on the CIGRE platform **till Monday 26th July 2021** the latest, based on the traditional mode, i. e. a word document and PowerPoint (without voice-over), aiming to be presented in 3 minutes. This platform is accessible for contributors from the registration platform.
3. The SC Chair and the Special Reporters will review the proposed contributions and give possible contributors the acceptance to present their presentations at the GDM - as usual. Any comments from the Special Reporters will be provided to the contributors on the CIGRE platform **by August 5th**. Contributors are encouraged to visit their account on this platform to consider the result of the review - and to adapt their contributions if requested.
4. After acceptance of the contribution, CO will contact all accepted contributors and ask to access the "LENI system" to record their final versions as voice-over files as a backup, just in case the remote lively participation shows any issue. The files for our B2 GDM shall be uploaded till **13th August.** The LENI platform will be available only to contributors whose contribution has been validated by the Study Committees. CO will provide guidelines and suitable information related to this LENI system on the web.
5. For addition information please look at chapter **B2 Information for Contributors, Authors of papers and Presenters** at the end of this Special Report.
6. CIGRE Central Office CO will soon post a table with all relevant dates, for all SCs at the CIGRE website. See also Virtual Centennial Session | Cigre and FAQ | Cigre

Klemens.Reich@apg.at tim.condon@esb.ie jpparadis@preformed.ca

Introduction

Study Committee B2 covers the design, construction and operation of overhead lines. This includes the mechanical and electrical design and experimental validation of new line components (e.g. conductors, ground wires, insulators, accessories, structures and their foundations), the study of in-service line performance and assessment of aged line components, line maintenance, the refurbishment and life extension as well as upgrading and uprating of existing overhead lines.

The technical direction of SC B2 is to increase the ampacity of existing lines, ensure reliable lines, establish/improve the reliability of existing lines, ensure environmentally compatible lines, assessment of lines, methods, new tools and materials. Overhead lines play an important role for the Power System of the Future and its challenges. The activities of SC B2 are full in line with this important aspect of CIGRE´s mission.

B2 has Regular Members from 24 countries, 5 Regular Additional Members, Observers from 16 countries, and 7 Advisory Groups which coordinate.

SC B2 has selected three preferential subjects for the CIGRE Session 2021.

PS 1: Condition Based Maintenance for increased sustainability

- Monitoring and modelling
- Health index, remaining life, degradation mechanisms
- Risk assessment

PS 2: Enhancing Overhead Line Performance

- Innovative designs and materials, compaction, AC to DC conversion, voltage upgrade, ampacity uprating, losses optimization, etc.
- current carrying capacity and losses
- Earthing, lightning performance

PS 3: Resources and design considerations

- Design with respect to construction, maintenance, lifetime and restoration, live line, ergonomics, skills for erection and maintenance, robotics
- Design and refurbishment for a changing environment

PREFERENTIAL SUBJECT 1

CONDITION BASED MAINTENANCE FOR INCREASED SUSTAINABILITY

Sustainability has become increasingly important in recent years. On the one hand, sustainability is important to increase public acceptance of new projects, on the other hand, environmental and sustainability goals are more and more often part of the mandate or framework for TSOs and other asset owners. These aspects have also been covered in the papers of PS1, although the range of topics is very wide: tower design, real time monitoring, use of satellite images or neural networks, just to mention a few of them. The 17 selected papers for PS1 have been arranged into four groups.

PS1/ group 1 Monitoring of mechanical aspects, maintenance

Paper **B2-103** discusses the development of sensors for real-time monitoring of ice loads on overhead lines. The prototype load sensor was tested in a laboratory and installed on an overhead line (OHL).

Paper **B2-108** presents an experimental study and mechanism analysis of abnormal fever composite insulators in AC 550 kV overhead lines and inspection by infrared patrol for a 500 kV AC composite insulator. In a laboratory, insulators were scanned by electron microscope and x-ray.

Paper **B2-110** discusses the experience of refurbishment of tower foundation located in water bodies. Existing corroded steel plates were treated and additional concrete cover were applied to the foundation among other actions.

Paper **B2-117** deals with artificial intelligence augmented overhead line inspection. The trained Artificial Intelligence (AI) system can carry out the tasks with high confidence, fast speed, consistent results and cost-effective manner for insulators of a specific type.

Paper **B2-115** presents remote monitoring overhead lines using satellite images. A detailed classification of land use and the detection of possible critical changes were applied. Furthermore, the system controlled the fuel management performed by external service providers and were also used for vegetation management processes.

Paper **B2-106**, discusses the utilization of environmental factor maps and corrosion rate maps for advanced maintenance of overhead line towers to optimize cost-effective maintenance of aged infrastructure. Two methods to estimate wide-area distributions of corrosion rate and corrosive environmental factors in Japan are presented.

Question 1.1: What experiences with Artificial Intelligence (AI) exists, in which application fields are the biggest benefits achievable (e.g., inspection of specific components (which ones?), vegetation, planning processes/ routing of new lines, …) and which application fields face difficulties. Can the efforts (work force, costs) for training an AI be specified and how can be secured, that the efforts won't be lost by upgrades of the AI or new AI (e.g., when a new AI service provider is contracted)?

Question 1.2: In relation to Paper B2-305, is the data from sensors also used to improve the prediction of ice? Some sensors measure a bunch of different values – are there plans or experiences with other use cases?

PS1/ group 2 Line design, condition assessment

Paper **B2-101** presents the monitoring results of a new transmission line design. The monitoring data covers three years and includes conductor movements, towers and insulators. The results gives magnitude and rate per year for conductor galloping, leakage currents for insulators and more. The new tower design has passed and will be used for more lines in the future.

Paper **B2-104** discusses the results of a newly developed THOR hammer tester – a step change in the management of wooden utility poles by introducing a non-invasive, non-destructive seismic condition assessment device. The device provides embedment firmness, burial depth and an equivalent diameter as an indication of loss of strength. All data is GPS tagged. The device will be further developed.

Paper **B2-105** shows an approach to determine temperature exceedance in overhead line compression fittings for a 110 kV OHL. The results shows that heat cycle tests are not reliable for long time behavior estimation of tested joints and that inherent wind generation behavior may cause premature temperature increase in compression fittings.

Paper **B2-109** presents the development of compact corrosion detector to diagnosis of aged overhead conductor and shows the results. With a new diagnosis method faults of overhead conductors (inside and outside) are dedected with a portable corrosion detector.

Paper **B2-116** presents condition assessment study of OHL steel towers. The paper presents a practical assessment technique for gathering large sets of data relating to the thickness of galvanized layers on steel members.

Question 1.3: In relation with paper B2-109 and B2-105, is there an impact of external parameters (from OHL point of view), which changed in recent years (e.g. volatility of load due to extended wind

generation, changed climate conditions, …) and causes the need of revaluation of existing methods or development of new methods? If yes, are other components also effected?

Question 1.4: Regarding paper B2-101, are there methods for an over-all evaluation (e.g. including live time circle, construction and maintenance costs, acceptance …) for new OHL-designs?

PS1/ group 3 Health index, remaining life, degradation mechanisms

Paper **B2-118** discusses the limits of vibration amplitude measurement-based conductor fatigue design. The results show that design procedures based on current analytical models can be non-conservative, depending on the wire and conductor diameter, the sag angle, and the geometry of the fitting

Paper **B2-119** shows the results of a hydrophobicity classification of composite insulators using convolutional neural networks. The recognition accuracy achieved by the best of the three networks was 84.29%. The advantages of this method are easy and fast photographing process, short training time of the networks, satisfying recognition accuracy rate and ability of these networks to be deployed on embedded platforms and used in aerial applications for on-site inspecting composite insulators.

Paper **B2-102** presents a structural reliability approach to overhead line engineering with the goal of a consistent way to make use of monitoring and inspection data. The goal was a better understanding of the structural integrity to ensure a more rational investment decisions. The new structural reliability analysis (SRA) tool employs Monte Carlo simulations to provide the longterm environment, usually based on hindcast data series.

Paper **B2-111** shows the results of the creation of a geographic information system of thunderstorm activity based on the existing complex of 6-110 kV grids using the devices for identifying faults in overhead lines.

Question 1.5: In relation with paper B2-119, can the system handle also different types and colors of insulators, different ages and/or different producers?

PS1/ group 4 Risk assessment, resilience

Paper **B2-113** discusses a holistic regulatory framework and strategies regarding resilience for electrical facilities against wildfire. A tool to quantify the performance of a power system during and after a wildfire is proposed. Also the systematic evaluation and quantification of the effects of different actions and investments on the transmission network in context of resilience to extreme wildfires are concidered.

Paper **B2-114** discusses the results of overhead powerline LiDAR inspection with unmanned aerial vehicles. The main objective is the regulatory verification of distances compliance in overhead power line corridors.

Question 1.6: In relation with paper B2-113, is the deployment of conductor or tower mounted sensors also discussed? Are there experiences with sensor data, drones or satellite data in context with wild fire resilience?

PREFERENTIAL SUBJECT 2

ENHANCING OVERHEAD LINE PERFORMANCE

In the field of overhead lines, there is continuous improvement in the development of innovative designs and materials to help keep pace with the ever-growing demands and reliance on the electrical supply networks. Secondly, there is an increasing trend towards the measurement and analysis of

overhead line components to achieve greater utilisation and optimisation. Both of these points are reflected in the work and findings of the 24 papers selected for preferential subject 2. The selected contributions have been divided into four main topics.

PS2/group 1 Overhead line conductors

Paper **B2-201** discusses HTLS conductor consisting of stranded carbon fibre core and outlines the application of such a conductor on a 138 kV OHL in Brazil.

Paper **B2-203** outlines the design and characteristics of a special mega strength steel core for HTLS conductor and the challenges that were overcome with its installation at a line crossing at the port of Antwerp in Belgium.

Paper **B2-211** reports on field testing undertaken on HTLS conductor in Ireland and looks at the criteria applied to select test spans. The results of their data and subsequent analysis is presented.

Paper **B2-220**, from Russia, discusses the development and characteristics of an aluminium compacted conductor, together with its advantages.

Question 2.1: Experts are invited to share their experiences on field measurements and performance of conductors consisting of composite core or high strength-steel core and gap-type construction.

Question 2.2: Paper B2-203 reports on specially developed conductor material. Conductor manufacturers and utilities are asked to share views and experiences on the technologies, practices and experiences on the protection of conductor systems from environmental conditions. What factors of safety are applied to the conductor in applying coordination of strength principles for the overhead line system?

PS2/group 2 Overhead line structures

Paper **B2-204** presents the design, verification and validation approach and results for composite structures intended to be used on a 420 kV line in Norway.

Paper **B2-209** describes the experience of a German TSO with the design, installation and performance monitoring of Compact overhead line structures leading to greater public acceptance.

Paper **B2-212** provides an account of the development and application of a compact steel tube double circuit tower together with the considerations required with assembly and maintenance.

Paper **B2-214** and paper **B2-215** discuss the application of composite insulator crossarms for voltage uprate projects in China. Paper B2-214 outlines design considerations while paper B2-215 also includes a financial comparison to that of traditional tower uprate methods.

Finally, for this category, in paper **B2-213**, the authors detail the research and development undertaken to construct a sophisticated Overhead line - cable interface structure that enables greater functionality and public acceptance whilst minimising occupied land foot-print area.

Question 2.3: In relation to Paper B2-204, can the authors advise on their progress with the validation of the tower design through the full-scale tests intended to be undertaken as prescribed in the paper. What is the experience of Utilities in undertaking full-scale tests to validate software calculations for the electrical and/or mechanical design of towers or tower foundations?

Question 2.4: Papers B2-212, B2-214 and B2-215 report on the application of compact line design. What innovative solutions have been applied by utilities and what is the reported outcome in terms of acceptance and performance of compact lines?

PS2/group 3 Overhead line insulators

Paper **B2-206** highlights a study undertaken on glass cap & pin insulators with RTV coating of varying thickness and reports on the testing techniques employed to compare performance characteristics.

Paper **B2-208** provides a detailed account of testing undertaken and results obtained for both field-aged (removed after 7-, 8- and 9-years service) and laboratory aged RTV coated insulators.

Paper **B2-218** reports on research undertaken on Composite, Glass and RTV coated glass cap and pin insulators at two insulator test stations in France and S. Africa detailing an analysis of leakage current characteristics observed.

Paper **B2-221** reports on the evaluation undertaken of the rod-housing interface of composite insulators, the influence of electric fields on insulator integrity and the effects of nitric and sulphuric acid on the insulator housing. A revised version of paper B2-221 has been received for the Cigre Centennial 2021 session. It includes additional results from multi-stress testing (combining nitric acid exposure the tracking and erosion test) undertaken by the paper authors.

Question 2.5: Papers B2-206, B2-208 and B2-218 discuss experiences of testing and application of RTV coated insulators. At present, with limited National or International standards published on RTV coated insulators, experts are invited to share their experiences on the specification, testing, validation and experience of such insulators.

Question 2.6: Paper B2-221 has reported on the import role that e-field calculation and analysis plays in determining the appropriate design of insulator and insulator sets. However, different methods and parameters needs to be considered when undertaking such analysis. Experts are asked to make contributions on the practices and means of validation when undertaking such e-field calculations.

PS2/group 4 Overhead line operation modelling, performance and optimisation

Paper **B2-202** presents the challenges in how minor differences of some variables can play a significant role in the accuracy of line rating calculations when applied to high temperature conductors. The revised paper B2-202 includes additional information on correlated values for absorption and emissivity. It furthermore provides greater clarity on the conductor temperatures used in the sensitivity analysis of variables.

Paper **B2-219** describes an overhead line modelling system that takes into account climatic conditions, conductor parameters and line profile design characteristics to enable optimised line operation.

Paper **B2-224** discusses the application of Dynamic Line Rating in India and together with a case-study presenting the challenges and recommendations for DLR application in such tropical environments.

Paper **B2-205** outlines an analysis undertaken by the authors of different phase conductor bundle configurations with different conductor designs in order to reduce line Joule losses.

Paper **B2-210** compares grounding impedance characteristics of mountainous and flat terrain and the resulting differences in line performance under lighting discharge conditions.

Paper **B2-222** presents the research undertaken on corona performance of conductors when subjected to outdoor test conditions such as rain, fog and dew – highlighting the significance weather changes can play in the formation of corona.

Paper **B2-216** reports on the transient overvoltage performance of a 500 kV DC bi-pole Transmission line in Korea highlighting the influence of line-cable terminations along the circuit route.

Paper **B2-217** gives an example of an uprate project involving conductor replacement in India that presented particular challenges in terms for right-of-way obstacles and necessitating live-line working arrangements.

Finally, Paper **B2-223** describes and presents the results of a measuring and monitoring system on overhead line tower structures that enables tower mechanical utilisation and performance to be better understood

Question 2.7: Paper B2-202 highlights the sensitivity that many variables play in determining the line ratings for an overhead line circuit. Utilities and experts are invited to share their experiences on the considerations and criteria they apply in determining line ratings on their network. Have discrepancies arisen between assumptions made versus measured values? What were the sources of error in such discrepancies?

Question 2.8: Paper B2-217 reports on the challenges with undertaking line uprate works while maintain power supply. Experts and utilities are invited to share their experiences on innovative techniques used to facilitate line uprate or upgrade works whilst maintaining line operation.

PREFERENTIAL SUBJECT 3

RESOURCES AND DESIGN CONSIDERATIONS

Whether it's refurbishing existing lines to new standards, designing new lines for a changing environment or improving the safety of live line work, the ten papers selected by Study Committee B2 for preferential subject 3 present a wide range of innovative contributions to overhead line design.

The selected contributions have been divided into three main topics PS3/group 1 – 3.

PS3/group 1: Making Overhead Lines safer

Paper **B2-302** demonstrates the feasibility of using a portable protective arrester for personnel worksite protection during live work. This tool enables live work on structures with reduce clearances and on lines where live work was not previously possible.

Paper **B2-304** presents a detailed analysis of the risks related to the exposure of workers to electric and magnetic fields on a 100 kV double-circuit line. The author presents a methodology to demonstrate that work on the passive circuit can be performed safely with the second circuit active.

Finally, paper **B2-312** explains how using insulation foil at tower bases can reduce ground potential rise. This approach was shown to reduce voltage potential in the surroundings of the tower and has the advantage of slowing vegetation growth at the tower base.

Question 3.1: What is the next frontier for live-line work? What can't we do today that technologies under development will allow maintenance team to do in the future?

Question 3.2: With aging power transmission networks, what are the main challenges related to transmission line grounding.

PS3/group 2: Designing lines for changing environmental requirements

Paper **B2-311** relates the Peruvian experience with the design of a 500 kV at altitudes in the range of 4500 m. Air clearances were calculated using the IEC and IEEE methods, although correction factors for this altitude are not standardized. Calculations were complemented with EMTP simulations.

Paper **B2-309** describes a new type of tubular tower developed to facilitate transportation to remote areas. The design is based on the use of lap joints and vertically separated modules.

The author of Paper **B2-307** presents guidelines on selecting overhead line equipment based on CO2 emission calculations.

Finally, Paper **B2-310** details various methods that can be used in the assessment of loads on containment structures, including a new probabilistic cost-risk optimization model. A case study where the cost-risk model is applied to select a cascade risk mitigation system is presented.

Question 3.3: Experts are invited to share their experience with line upgrades aimed at mitigating cascade failure risk.

Question 3.4: In relation to Paper B2-311, can authors and expert comment on the use of negative shield angle at high altitude? Is this recommendation driven by altitude or topography only?

PS3/group 3: New tools to support line maintenance and refurbishing

Paper **B2-303** is about the development of a robotic device to install markers safely and quickly, The robotic device is positioned on the line using a helicopter. Over 400 markers have been installed to date with this technology.

The subject of Paper **B2-308** is the behaviour of drones when operating in the vicinity of overhead lines.

Finally, Paper **B2-305** presents the results of an investigation on the audible noise performance of conductors considering aging and various surface treatments. Ageing of conductors was shown to reduce audible noise.

Question 3.5: In relation to Paper B2-305, can the authors provide additional information on the application of the conductor cleaning process developed?

Question 3.6: Is there any work underway, by authors of Paper B2-303 or other experts, to develop robotic tools to *remove* existing accessories from conductors? Can other experts share their experience with robot-assisted installation of fittings?

B2 Information for Contributors, Authors of papers and Presenters

B2 Group Discussion Meeting GDM

The B2 Group Discussion Meeting (former called "B2 Session") will be held on **Wednesday 18th and Thursday 19th August 2021,** on both days from 12:00 to 16:00h CEST. This will be better timeslots for attendees outside Europe.

It is planned, that the SC Chairman, SC Secretary and the Special Reporters will lead the virtual session from a video-studio in the Palais de Congrès in Paris, depending on the Covid Situation and on personal and company´s estimations of the situation at that point in time. All other participants will attend per video.

Authors of session papers and other delegates wishing to present contributions to the questions raised by the Special Reporters in this Special Report are asked to notice the information given at the beginning of this Special Report under "Information about the procedure". In addition the following applies:

- The access to the uploading is given only to duly registered delegates. As a consequence, the registration to the CIGRE Session has to be finalized before uploading contributions online. For registration *Click here .* The contributions uploading is open now.
- A guide for contributors, templates and sample pages are available on the CIGRE Centennial website - see "Group Discussion Meetings" in the top menu bar - and has to be strictly observed. Contributions | Cigre

There will be no Poster Sessions in 2021

B2 Tutorial

Please note that the **B2 tutorial** "State of the art on sustainability of OHL conductors and fittings - conductor condition assessment" will be held on **Wednesday 25th August 2021 from 12:00 to 14:00h**. Presenter is Cécile Rozé, chair of WG B2.68.

B2 Annual Meeting

The annual meeting (Technical and Administrative meetings) will be on August 23rd and 24th from 12:00 to 16:00h CEST as GoToWebinar-meeting. Updated information will be in KMS.

Contact Addresses

Special Reporter PS1: Klemens REICH Klemens.Reich@apg.at

Special Reporter PS2: Tim CONDON tim.condon@esb.ie

Special Reporter S3: Jean-Philippe PARADIS jpparadis@preformed.ca

B2 Secretary: Wolfgang TROPPAUER Wolfgang.Troppauer@mosdorfer.com

B2 Chairman: Herbert LUGSCHITZ Herbert.Lugschitz@cigre.org