

Safety: a crucial issue to sustainability on insulated cable systems

Today a greater focus than earlier is put on safety and safe work conditions and therefore a more goal-oriented approach to safety is needed, consisting of guidelines, specifications and recommendations.

The importance and the complexity of the topic deserved to revise past documents dealing with safety in cable systems, identify gaps and plan for future activities.

Considering this, the Study Committee B1 "Insulated Cables" had a Working Group aimed to:

- > inventory existing work in documents published by SC B1;
- > check in other SCs literature if recent work has been published to address these issues, and what relevance they have for SC B1;
- > detect and understand risk for safety in cable systems, including the consequences and potential impact of any potential risk on human safety;
- > identify potential gaps; and publish a report to recommend further steps.

The methodology used to meet the objectives of this Working Group was established at the beginning of the activities.

The first step was to define the context of the work, determining which documents published by Study Committee B1 would be inventoried and establishing that only the most recent articles would be analyzed due to the large number of existing documents. It was also decided that the publications of all other Study Committees that were relevant to the SC B1 Insulated Cables would be checked.

The risks to be investigated would only be those related to human safety, and were classified into three main groups: electrical, mechanical, and chemical.

The following action was to analyze in detail all the pre-selected documents and check if all aspects inherent to risk were covered: the identification and characterization of the risk, the probability of occurrence, the consequences and potential impact on human safety, and if prevention and mitigation measures were proposed.

Finally, all possible risks were described, including the consequences and impacts for human safety, it was identified for which phases of the lifetime of an insulated cable system such risks were relevant, the list of references of the researched literature was prepared, and the existing gaps were listed, and recommendations were made on how to address them.

Bridging past and future works will anyhow start with a reflection on cultural gaps: the majority of the CIGRE community have an electrotechnical background and are therefore aware of the electrical safety risks, whereas mechanical and chemical risks are less apparent to them, due to prevailing education. This is also reflected in the literature published by CIGRE, mainly technical brochures, where the group observed that a lot of electrical safety risks are mentioned and highlighted, however in many cases sufficient guidance regarding mitigation and a conclusive treatment is missing. Furthermore, the expectation that most documents only contain risks related to land cable systems was confirmed.

Future works on safety will therefore start from solid bases on electrical aspects.

The group identified that safety risks of electrical origin are related to electric shock, electrocution, magnetic field induction, electric field coupling, step potential (voltage) and touch potential (voltage).

The main mechanism regarding electrical risk to physical integrity is electrocution, i.e. the minimum safety distance to an object under voltage is compromised and an arc is generated between the body and the object under voltage. Other physical integrity risks are related to electrical shock and to touch and step voltages which can be created by fault currents flowing to the ground or grounded metallic objects, creating voltage differences that can be bridged by human extremities and thereby cause current through the body.

Magnetic fields are created by current-carrying conductors and are subject to interaction with human bodies. Although there is no common understanding on the effects of magnetic fields on human bodies, limits are defined in terms of safety at work, but also regarding operation of power transmission lines and substations.

Currents induced in metallic objects can again create unsafe situations if a potential rise is created e. g. by insufficient grounding of metallic objects. This potential rise can result in high touch voltages and therefore need to be avoided.

Many aspects of safety risks of electrical origin are well covered by SC B1 Technical Brochures, like the TB 801 - Guidelines for Safe Work on Cable Systems under Induced Voltages or Currents.



Figure 1 - Examples of insulating working tools (source TB 801)

Safety risk gaps recommended for further investigation by future working groups are then identified to revolve around submarine cable systems (also to include mechanical risks), protection philosophies for new grid design including shorter or larger cable sections, as well as ways to mitigate safety risks for the public by preventing third party damages.

The other two pillars for future works will be about mechanical and chemical originated risks.

The majority of hazards related to safety risks are of mechanical origin and appear in all phases of the life cycle of underground and submarine insulated cable systems. Tools, equipment, machinery, civil construction, and working under difficult conditions are present from cable manufacturing to cable disposal.

The mechanical safety risks are extensive and related to use of tools, equipment, machines, civil constructions – trench and trenchless technologies, tunnels and galleries, marine operations and submarine cable installations.

Despite this, there is little SC B1 literature that covers mechanical hazards, and many gaps related to safety risks should be filled with future works.

The most prominent chemical threat is oxygen depleted atmosphere or the replacement of breathable air by gases with a higher density than air like SF₆ or methane. Contamination of air with toxic gases like carbon monoxide can also be a threat.

Regarding chemical safety risks in the context of cables non-breathable atmosphere in trenches, pits or tunnels are the common threat to safety. Also, here the issues are mentioned but a conclusive guideline to mitigate the risks is not available within CIGRE literature. Therefore, future works are being planned for chemical-related risks on cable systems.

This is different for issues generated by fire: this topic is conclusively handled in [Technical Brochure 720](#) - Fire issues for insulated cables in air.



Figure 2 – Fire test according to IEC 60332-3 (source TB 720)

The target of sustainability, specifically for safety aspects, cannot be left only to specific future Working Groups. They will be important to cover current gaps, but in the long run, where relevant, all future SC B1 Working Groups will address safety risk aspects in their work. This will help to create a different culture thus to make future cable systems designed for safety.

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