DEVELOPMENT OF A HARMONISED FRAMEWORK FOR ELECTRICAL SAFETY COMPLIANCE AT CERN

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Abstract

Electrical safety has been identified as one of the main risks in large research infrastructures. At CERN, new regulations for electrical safety are being reviewed to align with current best practices and harmonise the approach. Among other aspects, it covers the compliance of electrical equipment and installations before they are put into operation, to further reduce the risk of accidents, to save time and cost by simplifying design processes, and to standardise the application of the legal requirements.

While the new regulations were developed for CERN, they offer a model that can be applied to other research infrastructures. This paper describes the harmonised framework that was implemented to provide a practical guide for applying electrical compliance in the context of a research infrastructure. It was developed based on an analysis of best practices, validated through application to current CERN installations, and verified by industry experts. The framework optimises organisational efficiency by promoting 'right-first-time' compliance through a guided quality process.

This work is part of the CERN Electrical Safety Project, an initiative established within CERN's Accelerator and Technologies sector to take proactive steps to further mitigate electrical risks, prevent recurrence, and build an even stronger safety culture.

INTRODUCTION

Large research infrastructures, such as CERN, rely on extensive and complex electrical systems, and as such electrical safety is regarded as one of the main risks [1]. Since the late 19th century, the inherent risks associated with electrical power have necessitated the development of rigorous safety frameworks, evolving into a sophisticated legal landscape. In Europe, this is characterised by EU Directives for Electrical Equipment [2], and national laws for Electrical Installations [3, 4].

This paper describes the translation of this complex legal landscape into a practical framework termed 'Compliance' within the specific context of research infrastructures. While the framework was conceived and implemented within CERN's Accelerator and Technologies sector, it offers a scalable model that can be applied to other organisations.

In the context of designing and implementing electrical equipment and installations, compliance represents a systematic, guided approach that empowers engineers to produce inherently safe systems. This methodology was developed for three key objectives: to reduce the risk of accidents, to save time and cost by simplifying design processes, and to standardise the application of the legal requirements.

The framework distinguishes between two primary subcategories: Electrical Equipment Compliance and Electrical Installation Compliance, addressed through two distinct processes.

This paper is organised as follows: first, definitions and classifications for electrical systems are established; second, the equipment compliance methodology is described; third, the installation compliance methodology is described; fourth, the resources developed to facilitate the application of the framework are outlined.

DEFINITION AND CLASSIFICATION FOR COMPLIANCE

From a regulatory perspective, the framework is classified into two domains: Electrical Equipment and Electrical Installations.

1. **Electrical Equipment** is defined as an *item used for the generation, conversion, transmission, distribution, or utilization of electrical energy*, [5]. Equipment compliance is modelled through European Directives and Standards.
2. **Electrical Installations** are defined as an *assembly of electrical equipment to fulfil specific purposes*, [5]. Installation compliance is modelled through IEC standards and national laws for electrical installations.

The distinction between these two domains is fundamental: while the legal framework for equipment focuses on the internal design, installation compliance addresses the permanent external wiring and connections between multiple pieces of equipment installed in a specific location.

Classification Model of a Research Infrastructure

To define the roles of installations and equipment within a complex research environment, a simple top-down model was developed. This model is based on how systems are electrically connected, starting with the concept of a 'Facility', a widespread area housing multiple electrical installations.

As shown in Fig. 1, each facility is composed of several installations. These installations are further broken down into equipment, which includes off-the-shelf equipment alongside equipment that could be designed in-house or by an in-kind contributor.

ELECTRICAL EQUIPMENT COMPLIANCE

Since the legal responsibility for compliance rests with the manufacturer (as defined in [6]), commercial off-the-shelf equipment is presumed compliant for its intended use upon purchase. Consequently, the following

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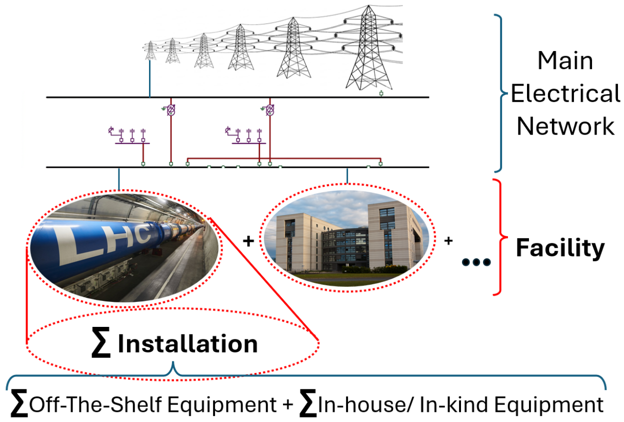

Figure 1: A model for a typical research infrastructure, broken down into facilities that are made up of installations, comprising of multiple pieces of equipment.

process applies to in-house or in-kind equipment.

The core principle of the equipment compliance framework is the **'3D'** process. Equipment must be:

1. **Developed** in accordance with Directives, Regulations and Standards.
2. **Documented** in an Equipment Technical File.
3. **Declared** compliant with a Declaration of Conformity (DoC) that it meets design standards.

The contents of the technical file depends on which directives apply [2].

Development in Accordance with Directives, Regulations, and Standards

The framework develops a simplified guideline for the selection of applicable directives, regulations and standards, tailored to research infrastructures such as CERN.
The project identified the following four regulations and directives as the most relevant for electrical equipment: the Low Voltage Directive (LVD), which mandates comprehensive product safety [6]; the Electromagnetic Compatibility Directive (EMC), ensuring devices operate without electromagnetic interference [7]; the Restriction of Hazardous Substances Directive (RoHS), which limits the use of specific toxic materials [8]; and the General Product Safety Regulation (GPSR), providing a universal safety baseline for risks not covered by specific legislation [9].
The selection of applicable directives depends on the equipment's voltage range and whether it is classified as a 'fixed installation', meaning that it will be installed in a permanent, predefined location [8, 10]. If the equipment is classified as a fixed installation, it is exempt from the full conformity assessment process for the EMC Directive and the RoHS Directive.
Table 1 shows a simplified explanation of the applicability criteria, although it should be noted that exceptions may apply. The framework can be easily extended to cover additional directives, such as the Radio Equipment Directive (RED), the Equipment for Potentially Explosive Atmospheres Directive (ATEX), the Pressure Equipment Directive (PED), etc. Note that the selection of Directives may vary depending on the specific characteristics of the research infrastructure.

Table 1: The Main Applicability Criteria for Full Conformity Assessment Against Directives and Regulations which Commonly Apply to Electrical Equipment

Directive	Applicability Criteria
LVD	Voltage between 50–1000 V ac or 75–1500 V dc.
GPSR	Voltage outside the LVD limits, either <50 V ac, <75 V dc, >1000 V ac, or >1500 V dc).
EMC	Not applicable for fixed installations.
RoHS	Not applicable for large-scale fixed installations.

Documentation in the Equipment Technical File

The contents of the technical file are governed by the relevant directives and are compiled systematically throughout the design and manufacturing phases. Figure 2 illustrates the documentation timeline associated with each directive.

Declaration of Conformity

Final compliance is formalised through a signed Declaration of Conformity (DoC) and the application of equipment marking. Within this simplified framework, equipment under the scope of the LVD, EMC, or RoHS directives require a CE marking DoC [2]. However, equipment exclusively under the scope of the GPSR cannot be CE marked [9], so the framework proposes a specific DoC to formally document compliance.

ELECTRICAL INSTALLATION COMPLIANCE

The core priniciple of the installation compliance framework is the **'3DI'** process. Installations must be:

1. **Developed** in accordance with standards.
2. **Documented** in an Installation Technical File.
3. **Inspected** by an independent third party.
4. **Declared** compliant with an 'Attestation of Conformity' (AoC).

Development in Accordance with Standards

Installations must be developed in accordance with standards, which impose rules ensuring that the installation is safe. In general, installation standards are based on IEC 60364 [11], with national variants written into law in different countries. At CERN, the national standards of France are used, such as NF C15-100 [12] and NF C13-200 [13].

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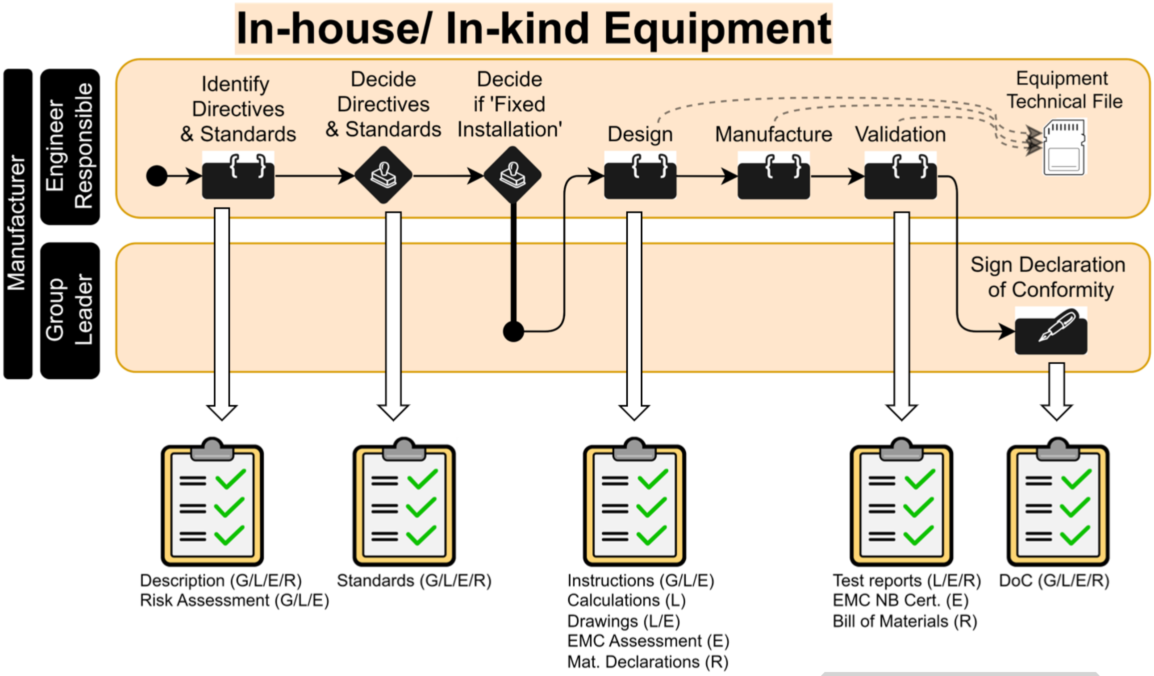

Figure 2: The process for equipment compliance, and at which stage each part of the technical file is created. The applicable directives for each document are given in brackets: 'G=GPSR', 'L=LVD', 'E=EMC', 'R=RoHS'.

Documentation in the Installation Technical File

For electrical installations, the technical file remains largely consistent across projects, as it is dictated by prescriptive legal requirements such as the Arrêté du 20 avril 2012, [14].

Initial Inspection

Within the French legal framework, the initial inspection must be carried out by an independent third party against a standardised set of criteria, based on national installation standards. Any identified non-conformities must be resolved before the installation can be declared compliant.

Declaring Compliance with the Attestation of Conformity

The Attestation of Conformity serves as a formal record that the installation is compliant. The Attestation is a document specific to the organisation, which is required for the transition from development to operation. It attests that the installation has been realised in accordance with standards, that it has the required documentation, that it has been inspected, and if applicable, that any non-conformities have been resolved.

COMPLIANCE GUIDELINES

A key outcome of this work is the development of dedicated guidelines for compliance [15]. This document translates complex requirements for compliance into actionable steps, providing engineers with the necessary tools to achieve compliance efficiently. The guidelines include the following:

- Flow charts to classify equipment and installations.
- Compliance process diagrams.
- Simplified guidance on identifying applicable directives and regulations.
- Recommended standards.
- Checklists for documentation.
- Documentation templates.
- Case studies and examples.

To ensure the accuracy of the legal interpretations presented in the guidelines, they were validated by two different third-party consulting firms, who specialise in compliance.

CONCLUSION

To address the inherent electrical risks within research infrastructures, this paper presents a harmonised framework for compliance for electrical installations and electrical equipment. The framework provides a robust approach for classifying electrical systems. Through a detailed analysis of the regulatory landscape, simplified guidelines for identifying directives, regulations, standards, and documentation to achieve compliance were developed. Finally, these guidelines were verified by industry experts, creating an accessible, actionable pathway to compliance, with concrete examples.

Future work includes tailored training sessions addressed to technical groups. It is also planned to publish a generalised framework for other research infrastructures and an extension to cover additional directives.

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