
**Light and lighting – Commissioning
of lighting systems in buildings –
Explanation and justification of ISO/
TS 21274**

*Lumière et éclairage — Mise en service des systèmes d'éclairage dans
les bâtiments – Explication et justification de l'ISO/TS 21274*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 274, *Light and lighting*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The increasing use of solid-state lighting technology e.g. LED lighting, the growing scientific insight on the impact of light on humans and the diverse individual demands for lighting function bring a significant incentive for the application of lighting control. However, the resulting complexity of installed systems needs more professional skills to design, install, and maintain.

Commissioning is a very important measure that can be taken to guarantee the quality of lighting systems as close as possible to its design intent. ISO/TS 21274 specifies requirements for the commissioning of lighting systems in buildings to meet design specifications, including roles and responsibilities, commissioning activities, documentation requirements and system handover.

This document presents explanation and justification to support the correct understanding, use and national implementations of ISO/TS 21274.

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Light and lighting – Commissioning of lighting systems in buildings – Explanation and justification of ISO/TS 21274

1 Scope

This document provides information to support the correct understanding, use and national implementations of ISO/TS 21274. It gives explanations on the procedures and background information. It also provides justifications of the choices that have been made. It gives detailed examples to illustrate the overall workings of ISO/TS 21274.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TS 21274, *Light and lighting — Commissioning of lighting systems in buildings*

ISO 52000-1, *Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures*

CIE S 017, *ILV: International Lighting Vocabulary*¹⁾

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 52000-1, ISO/TS 21274 and CIE S 017 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

lighting system

system designed to provide lighting

Note 1 to entry: A lighting system can be dedicated to:

- a) the support of one or more specified visual tasks under specified conditions considering other requirements such as human comfort, safety, the appearance of the surrounding environment and energy consumption;
- b) the support of other than human tasks.

Note 2 to entry: A lighting system can include a set of light sources, other physical components, communication protocols, user interfaces, software and networks to provide control and monitoring functions.

Note 3 to entry: The light source(s) and the related equipment can be integrated in a single item, e.g. an LED module, a lamp or a luminaire.

Note 4 to entry: A lighting system can be networked to provide central or remote control and monitoring functions.

1) Online version: CIE e-ILV: <https://cie.co.at/e-ilv>

Note 5 to entry: A lighting system can be connected to or integrated with other systems or devices.

[SOURCE: CIE S 017:2020, 17-27-010]

4 General aspects

4.1 Benefits of commissioning for lighting systems

For traditional lighting solutions of interior spaces using discharge, halogen and incandescent lighting technology, the systems are relatively simple, so commissioning can be implemented after appropriate preparation. LEDs' capabilities of instantaneous response, dimming, colour tuning, and stable performance under frequent switching conditions, offer good opportunity to create a lighting environment of high quality with more energy efficient solutions.

The integration of new technology including IoT, digital control and IT into lighting systems, and better knowledge on the influence of light on human wellbeing, means that lighting technology continues its advance into IoT and advanced digital applications, adaptive lighting and integrative lighting. The transformation of lighting from simple to complex systems, providing tailored lighting conditions for diverse individual needs and demanding tasks, the trend for more hardware functions to be realized with software, and interactions with other building automation systems make the lighting system complex to design, install and put into service.

In a perfect situation, the owners/tenants clearly communicate their needs and desires, the design team is united around a concept and clearly express design intent, and installation and startup occur without error. The owners/tenants benefit from a high-quality control system. But in reality, a deficiency in one or more components can prevent the correct operation of the lighting system. If something goes wrong during the construction process, measures can be taken to assure that the final lighting system will satisfy the owners/tenants needs.

According to ISO/TS 21274, commissioning is necessary to manage the growing complexity of lighting systems. Commissioning for a lighting system is more than just an energy saving strategy, but also a quality control process ensuring that the operation of a lighting system meets the design specification, by integrating the functions of design, construction, and operation, with the involvement of the project team during each phase of the project.

4.2 The need for commissioning

With the discovery of ipRGCs and the non-image-forming pathway, the aim of lighting in buildings has been expanding from visual performance and visual comfort to integrative lighting for creating physiological and/or psychological benefits for humans, which means that the design specification can differ from project to project for the reason of different occupant profiles, activity profiles, daylight conditions, and design philosophy etc. Therefore, the scope of commissioning can be decided according to the owner or tenants requirements, and the complexity and scale of the lighting system, design specification, and budget.

This document gives some general principles for commissioning regarding roles and responsibilities, activities, documentation, but not technical specification of lighting systems, which are supplemented by design specification as [Annex A](#) shows.

4.3 Content of commissioning for lighting systems

Commissioning is a very important measure to ensure the lighting system can work as closely as possible to the design specification. The strategy of commissioning can be different from system to system. The content of commissioning can include but is not limited to the following items:

- Installation check: The commissioning team can develop equipment installation checklists on the basis of design documents, with which they can conduct the inspection to ensure that all equipment are of the correct type and quantity, and located and connected correctly as the design documents

specify. For sensors and adjustable luminaires, ISO/TS 21274 also recommends to check the aiming of these devices, with no blocking in the specified direction.

- Operation check: The operating function of a sampled proportion of devices (including luminaires, solar shading systems, daylight redirecting systems and other systems in the building connected with the lighting systems) is checked to ensure all the control functions of local and remote-control devices operate correctly. For lighting systems with sensors, the simulated sensing signal can be used to verify the activation of different design control modes. The communication and control logics are verified during this stage.
- Performance test: Performance testing involves ensuring the installed system meets the design specification under the designed operating conditions and control modes. A step-by-step test procedure is used from components, systems to points of interaction between technical building systems, and all the problems discovered during this stage are recorded in the issue log. The possible reasons for these problems is analysed and confirmed as the basis of further calibration and configuration.
- Calibration and configuration: Calibration and configuration is a very important measure for problem solving during the commissioning process. A systematic analysis of any problems found during check and test is made with all related stakeholders, and design assumptions, device performance, and control parameters are verified. On the basis of these analyses and verification, calibration and configuration can be made accordingly.

4.4 The acceptance of commissioning deliverables

The process for each activity and deliverable includes an acceptance step as defined in the commissioning plan (Cx plan). This step formalizes the acceptance of the commissioning deliverable by the owner or tenant.

5 Commissioning methods and selection

5.1 Classification of commissioning methods

The term commissioning comes from the shipbuilding industry. A commissioned ship is a ship with all the equipment installed and tested, problems identified and corrected, and the prospective crew extensively trained.

Since its adoption by the building industry, commissioning has been widely recognized as a valuable mechanism for quality assurance, ensuring building systems are fully integrated, tested, and function properly.

Initial commissioning can be conducted during the installation stage and operation stage. It helps ensure that the performance of the lighting system meets the design specification. This type of commissioning is specified in ISO/TS 21274:2020, as Method 1, the basic method.

The growing demand on the building environment has resulted in moving from simple to complex lighting systems, which enables one to develop more efficient and flexible solutions, but also leads to a higher level of complexity.

With the increasing complexity of building systems, a lack of familiarity by the designers, installers, or end-users can lead to the misapplication of technologies and result in poor performance. How to ensure the commissionability of the lighting system and reduce the potential cost of further modification and commissioning due to minor defects in the lighting system design has become more challenging. According to ISO/TS 21274, the commissionability of lighting systems is designed so that when installed, all designed control logic can be accessed and checked easily, which requires that the cause and effect relation of control logic of lighting systems should be provided to the commissioning team, and they should have all the necessary access authorization to make configuration and calibration on the lighting systems.

A broader concept of commissioning has been introduced, which starts from the pre-design phase, goes through the installation phase, and continues during the post-occupancy phase, and is a quality assurance process to ensure the performance of the building meets the design documents. This type of commissioning is specified in ISO/TS 21274:2020, as Method 2, the full life-cycle commissioning method.

5.2 Selection of commissioning methods

According to CIE 222:2017, lighting controls are electrical devices added to the installed lighting circuit to adjust the light output of the luminaires according to a pre-planned program or automatic detection regime or to operator managed actions. They play an essential role in all lighting systems, providing the functions of switching and/or dimming. In past decades, fast advancement of technology, higher requirement on energy saving and deeper understanding on the influence of light for human wellbeing, all push the lighting control strategy from simple to complicated. According to the control strategy, the lighting controls can be classified into the following types:

a) Manual control

These respond to human commands and are typically operated by hand. The forms of manual control can vary from simple switches used to turn the lights on, to dimmer switches and remote-control devices. It is the most popular control strategy in lighting application at the moment, and relatively simple for installation. So, the basic method for commissioning can be sufficient, and one point for consideration during the commissioning process is to ensure that users of the system can readily understand the function of any such control devices.

b) Automatic control

Here, the lighting system can switch or dim designated loads automatically in response to events such as a time schedule, illuminance, or occupancy, etc. The automatic control lighting system can have some manual control interface.

At the very beginning, the control function is realized by hardware such as a relay, which is pre-set during the manufacturing stage. The function of controls is more product-dependent, and relatively simple. The control parameters are generally difficult to modify in the field. The complexity for design, installation and commissioning of the system is relatively low, so there is no high demand for a full life-cycle commissioning method.

With the fast development of IT technology, software is playing a more and more important role in realizing the function of automatic control. Advanced performance can be achieved with the improved processing capacity of programmable control devices in lighting systems. It also gives much more flexibility, and the control function can be updated by reconfiguring the program or updating the control software without change in any of the hardware of the lighting systems. This is a very big step for lighting application, it is also the basis for connected lighting and integrative lighting.

However, the above-mentioned items also increase the complexity of lighting systems, and multidisciplinary knowledge to realize the system. A lack of familiarity by the designers, installers, or end-users can lead to the misapplication of technologies and result in poor performance. So, ISO/TS 21274 recommends a full life-cycle commissioning method, which starts from the pre-design phase, goes through the installation phase, and continues during the post-occupancy phase.

6 Roles and responsibilities

6.1 General

Lighting systems are becoming more sophisticated. The design, installation and operation complexities increase along with capabilities and benefits. There is a need for cooperation between the owner, design team, contractors (including subcontractors and suppliers) and commissioning team in a highly collaborative way. ISO/TS 21274 specifies the roles and responsibilities of all the responsible

parties related to commissioning, including the owner or tenant, the design team, the contractors and subcontractors, suppliers and Cx team.

6.2 Owner or tenant

The owner or tenant acts as a coordinator and final decision maker in the commissioning process. They make the final decision on the scope and targets of the commissioning task, the selection of the commissioning team regarding the balance of budget, and level of performance assurance and lighting system complexity, typically with input from the design team.

They review and approve the documents such as the commissioning plan and training plan.

They make the decision on the follow-up procedures for any reported items that cannot achieve the design specification in a timely and economic way during the commissioning process.

They also coordinate actions among the relevant participants during the Cx process.

6.3 Design team

The lighting system design process is an iterative process to design lighting system solutions for sustainable lighting quality and energy efficiency based on specifications in the relevant lighting application standards, for the wellbeing of users and for a pleasant built environment.

NOTE See CEN/TS 17165 for more information.

As the design is the basis for the entire project and defines how effectively it can be commissioned, it is important that the design team is aware of the commissioning requirements of the lighting systems.

So, two-way communication and coordination between design team and commissioning team is very important and necessary in the following aspects:

- a) The design team shares the design documents with the commissioning team as the basis for the development of the commissioning plan and commissioning specification, and also for their comments to maximize the functionality, operability, maintainability and ease of commissioning of the lighting system.
- b) The design team makes a review of the commissioning plan and commissioning specification to ensure that these documents comply with the design documents. ISO/TS 21274 recommends that they should participate in all of the relevant activities during the commissioning process.
- c) The design team also transfers all the information on the functionality, operability, maintainability, and ease of commissioning of the designed lighting system into design documents, so that all related contractors, subcontractors and suppliers for implementing the Cx plan during the installation stage can provide the necessary support including the access to hardware, software or onsite technical support to assist the Cx effort.

6.4 Contractors, subcontractors and suppliers

The role of the (sub)contractors is to execute the installation process, and they are responsible for proper installation, and functional testing of all of the components and equipment of the lighting systems according to the design documents. The (sub)contractors should manage their functions in the commissioning process and work closely with the Cx team to document the performance of the commissioned lighting systems.

The equipment documentation includes the instructions for installation, testing, operations, and maintenance. Suppliers are also responsible for providing the necessary operating interface for hardware, software or onsite technical support. For some complex lighting systems, the supplier can participate in the start-up and testing of the system and training.

6.5 Commissioning team

The commissioning team manages the commissioning process. ISO/TS 21274 recommends that the commissioning team should be selected at an early stage of the project. The commissioning team is expected to participate during the entire project for programmable control lighting systems and can provide continuity and technical guidance. Due to these factors, the commissioning team ideally reports directly to the owner of the project. ISO/TS 21274 recommends that the commissioning team should have good communication and organization skills, along with experience and up-to-date technical knowledge on design, installation and operation of the lighting system to be commissioned.

For a lighting system with a higher complexity, ISO/TS 21274 recommends the commissioning team reviews the design documents and makes comments for the functionality, operability, maintainability and commissionability of the lighting system.

In the pre-commissioning phase, the selected commissioning team is responsible for the development of the commissioning budget, commissioning plan and commissioning specification on the basis of the defined commissioning scope from the owner or tenant, design documents and other necessary information. ISO/TS 21274 recommends that the commissioning plan should be circulated to all the related parties of the commissioning process for comments, and finally approved by the owner or tenant.

After the approval of the commissioning plan and commissioning specification, the commissioning team will be responsible for the implementation of the approved documents with the support of other related participants in the project. The task of the commissioning team can be divided into three categories:

- a) Schedules and organizes periodic coordination meetings with all related stakeholders of the project, and additional meetings on specific topics as required, circulates and maintains the deliverables and documentation like the commissioning plan and commissioning specification.
- b) Reviews contractor submittal packages pertinent to commissioned lighting systems, audits (or reviews all depending on scope) information in the installation checklists through document reviews and field assessments, conducts on-site observations and witnesses contractor equipment verification and testing, produces and updates the issues and resolutions logs, and produces the commissioning reports.
- c) Provides training to the operations personal and occupants, dependant upon the commissioning contract, on operating and maintaining the lighting system in the occupational stage.

7 Commissioning activities

7.1 General

Dependant upon the complexity of the lighting project, the commissioning process can have different starting points from project to project.

For less complex lighting systems, the commissioning can be performed after the installation phase to check operational performance before it is handed over to the building owner. ISO/TS 21274 requires the activities listed in ISO/TS 21274:2020, 7.4 be completed during the commissioning process.

For lighting systems with higher complexity, such as lighting systems with programmable control, central control, etc., involvement of the commissioning team from the early stage of lighting design to the post occupation stage is a good solution, ISO/TS 21274 requires the commissioning activities listed in ISO/TS 21274:2020, Clause 7 to be completed.

It is important to note that according to ISO/TS 21274, the commissioning team is not authorized to make any modifications or changes directly on the design and construction; rather, their purpose is to facilitate communication, resolve issues, and document performance.

7.2 Pre-commissioning phase

The pre-commissioning phase is crucial for the preparation of commissioning, all the output of this phase will form the foundation for future commissioning activities. According to ISO/TS 21274, in the pre-commissioning phase, the following milestones shall be achieved.

- The owner or tenant determines the scope of commissioning according to their requirements and expectation on the lighting system, and its scale and the complexity of implementation.
- The owner or tenant selects a qualified, competent commissioning team according to the planning budget for commissioning of the system. The commissioning team is capable of good communication and organization skills, along with experience and up-to-date technical knowledge on design, construction and operation of the lighting system to be commissioned.
- The commissioning plan is developed on the basis of the gathered information about the project, including owners' expectation and requirements for the project, codes and regulations, site and climate, the project design completion documents, cost, schedule, etc. The draft commissioning plan is to be circulated to all the related stakeholders for comment. The commissioning plan will be updated accordingly and approved for implementation by the owner or tenant. The commissioning plan can be modified as the project evolves.
- The commissioning specification is developed on the basis of the design documents by the commissioning team, and confirmed by the design team.

As described in 6.3, the design team needs to provide all the necessary information for efficient commissioning. The commissioning team can provide technical feedback to the design team. The coordination among the building owners or tenants, design teams, suppliers and installation teams, and commissioning team is very important to clarify the design targets of the lighting system, and can help keep the project on schedule and on budget. It is crucial that the design team realizes the importance of inherent commissionability of the lighting system, and provides all the necessary information for the set-up of a commissionable lighting system in the design specification. So, for lighting systems with higher complexity or higher requirements, the early involvement of the commissioning team as the full life-cycle commissioning method requires and the circulation of design documents to the commissioning team for a technical review is a better way to guarantee the performance of lighting system.

7.3 Installation phase

The lighting system and its components are installed, connected and configured according to the final design documents, including lighting design drawing(s) and lighting specifications. According to ISO/TS 21274, all specified components are to be procured as specified, with substitutions only allowed with the written approval of the lighting designer. In the case of component substitutions, all design and commissioning documents are to be updated accordingly.

In this phase, more details are added along with comprehensive schedules. A summary report for the installation can be developed as the delivery method of design documents on the basis of the verification of the pre-installation condition, installation, and the start-up of the system by the subcontractor or commissioning team to confirm the readiness of the lighting system for field commissioning. Any negative issues discovered during this inspection are to be recorded with any corresponding further actions for tracking.

The precondition of field commissioning is confirmed at the end of installation phase, including but not limited to the following issues:

- all the components of the lighting system have been properly installed, oriented and connected according to the design documents.
- all the designed control functions have been set in the specified location with specified form, and the lighting system can be operated as the design documents specify;

- if the lighting system is connected to a network, a confirmation that the data conforms to the communication protocol and functionality testing of the lighting system will be provided;
- when the lighting is controlled by software, a version of software for commissioning is provided, with all control parameters editable by the Cx team.

When the lighting system is handed over to the commissioning team, the subcontractor or other responsible entity will submit a systems manual to the Cx team for formal acceptance and provide the necessary information on the operating interface for hardware, software or onsite technical support required by the Cx team according to the design documents.

The commissioning team has the responsibility to organize periodic meetings for communication and coordination with the contractors and subcontractors at intervals appropriate for the complexity of the lighting system, and to update the commissioning plan and specification according to the final specifications issued at the end of the construction phase.

7.4 Field commissioning phase

All the commissioning activities in this phase (including time, location, participants, output, etc.) are recorded in the commissioning observation inspection and calibration report.

The critical tasks of commissioning will be conducted according to the commissioning plan and commissioning specification, including:

a) Verification

The verification is conducted on the basis of the checklist in the commissioning plan, which is developed according to the design documents. According to ISO/TS 21274, all the items that are not consistent with the design documents observed during the verification shall be recorded in the issue log along with any remedial actions. The issues to be verified during this stage can include one or more of the following points as applicable:

- All the technical documents for the lighting system operation, configuration and maintenance to be developed by (sub)contractor or supplier have been submitted correctly.
- The commissioning team will ensure that all equipment is of the correct type and quantity and located and connected correctly as the design document specifies.
- For sensors and adjustable luminaires, the orientation and view field of these devices are checked.
- The technologies that can be used for occupancy sensing include infrared, ultrasonic, microwave and acoustic. The type of sensing technology, the sensitivity, position, aiming and coverage of the sensor, including delay time for control action are items to be checked.
- For digital controlled lighting systems, the correspondence of the components and their assigned unique identity in the control system data base is checked.
- The zoning and grouping of components will be checked against the design documents specification
- Confirmation that the location of control devices and their user interface are easily understandable.
- For lighting systems with sensors, a simulated sensing signal can be used to verify the activation of different design control modes. The communication and control logics are verified during this stage.
- The operating functions are verified for their timely and proper response, including local and remote control, and control software, including the interaction with other building systems.
- Some fault scenarios [possibly including power failure, out of test range] can be simulated to check the alarm management of the lighting systems.

b) Functional performance test

Functional performance testing is conducted according to the functional performance test protocols included in the commissioning plan. The test can include laboratory test, mock-up test or field test. The test can be carried out by the commissioning team, or any other specialized individual or organization employed for the purpose. The test of components, and mock-up test can be carried out preceding the field commissioning phase, and their test report can be the reference for commissioning activities on site.

The tests in the field commissioning phase cannot begin until the verification checklists have been completed and accepted by the commissioning team. During this stage, the main tasks of the functional performance test can be the following points, as applicable:

- The test on lighting design criteria specified in the design documents under all control modes.
- The test on the relationship between the sensing value from a photosensor and the corresponding value on the specific sensor target surface.
- The data communication connectivity and conformance test.

The participants, test condition and reported results for each test is recorded in the commissioning observation inspection and calibration report.

Any deviations from the approved commissioning plan, if permitted, will be documented or recorded digitally.

c) Calibration and Configuration, fine tuning

The commissioning team will list all items not working as intended, that are found during the verification and functional performance test, in the issue log.

According to ISO/TS 21274, the commissioning team, along with other stakeholders including design team, (sub)contractor or suppliers, etc, make an analysis of the cause of any inconsistencies and take measures for adjusting the system to work correctly, and any improper set point setting identified is to be reconfigured.

If components or systems are found to be malfunctioning, these problems are to be documented and listed in the issues log for resolution.

d) Training

For the purposes of knowledge transfer, adequate training for related operations personnel of the lighting system is very important to ensure they have the knowledge and skills required to operate and maintain the lighting system correctly, before contractual completion. The training requirements are identified corresponding to the lighting systems to be operated and maintained during the development of the commissioning plan according to the design documents.

All the training activities are performed according to the approved training plan. This phase ends with an evaluation of the trainees to verify their understanding of the pertinent information delivered during the training.

After the training, the lighting system can be formally handed over from the commissioning team to the operations team.

7.5 Post occupancy phase

With the end of commissioning, the utilization phase begins. During this stage, the performance of the lighting system can decrease gradually over time, for reasons such as dirt accumulation on luminaires, the decrease in the luminous flux of lamps and lighting components failure, so the maintenance work of the trained operations personnel is very important to keep the lighting system operating through life according to design specification.

With the increasing complexity and scale of lighting systems, and evolving demand on lighting systems, a continuous assessment for updating, system configuration and optimization can be considered as a measure to guarantee the quality of a lighting system. All these activities have higher professional demands than the operations personnel don't have. So, to extend the commissioning service into the utilization phase can be useful. For these situations, the contractual completion is the ending point for commissioning, but also the starting point for ongoing commissioning. This requires ongoing training, periodic system testing, checking and validation of control system settings in the post occupancy phase to keep the lighting system consolidated, maintained, optimized and upgraded if needed.

If, during the use of the system, it becomes apparent that a reconfiguration of fairly significant magnitude, or even a redesign of the system, is necessary, there will be a need for a new commissioning process, and the entire procedure begins anew at this point. This can be the case when further use is no longer allowed, justified, or (economically) sensible.

8 Documentation requirements of ISO/TS 21274

8.1 General

The results and interim results of the individual steps are to be documented in a comprehensible manner. This increases credibility and makes subsequent detailing and modifications easier to perform.

The deliverables and documentation developed during the commissioning process will include the commissioning plan, commissioning specifications, commissioning observation and test, training plan and commissioning report.

8.2 Commissioning plan

The commissioning plan is the document for the implementation and organization of commissioning for lighting systems. It outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

The initial commissioning plan is developed according to the input from related stakeholders of the project, including:

- The scope and budget for commissioning from the owner or tenant.
- Design documents circulated from the design team.

According to ISO/TS 21274:2020, in the commissioning plan, the following important information is to be included in the document:

- A general description of the systems to be commissioned, including the commissioning scope set by the owner or tenant, and the objective of commissioning developed according to the design documents.
- The roles and responsibilities of all stakeholders throughout the project. All the participants involved during the commissioning will be assigned their responsibility and specific tasks to be completed. The service supplier of commissioning will detail the necessary skill, knowledge and experience requirements in the document.
- The organization structure for related participants of commissioning, formal coordination between these participants with the agreed communication routes and a framework for the communication network during the commissioning process defined in the document.
- An analysis on potential failure to meet the design specification of the lighting system is made, as one of the key points for the commissioning process. The commissioning team has the responsibility to identify the test, verification and calibration tasks necessary for the project, and develop its corresponding step-by-step procedures. This includes a detailed description of the project-specific

tasks to be accomplished during commissioning with time schedule and associated roles and responsibilities.

- A list of instruments, tools and suppliers for each commissioning test, and their corresponding specification.
- The Cx evaluation checklists (an example evaluation checklist is included in [Annex A](#)) defining the verifications to be performed to ensure that critical actions were effectively completed;
- The listing and format for testing forms, issues log and the Cx progress reports that is used during the project to communicate and track critical Cx information;
- The procedures to follow whenever the Cx evaluation does not meet the design documents. Once the procedure is approved, ISO/TS 21274 requires that any deviation must be documented.

The Cx plan is circulated to the involved parties for review, including owner or tenant, design team, etc., and to be approved by the owner or tenant. Once the Cx plan has been developed and provided to the related stakeholders, the Cx team has responsibility to regularly review and update the document to reflect any change in design specification and commissioning requirements. The process for approval of the subsequent revisions will also be recorded in the Cx plan.

8.3 Commissioning specification

The commissioning specification is the most important accompanying technical document of the commissioning plan that describes in detail the implementation of commissioning relative to a specific lighting system.

The commissioning specification is developed on the basis of the design documents, including design drawings, design specification, calculation report of the lighting systems for different control modes, control system drawings, control strategy and specifications for each component of the lighting systems.

Information from the design documents will be transferred into the commissioning specification. The commissioning specification includes at least the following information:

- detailed performance for each lighting scene of the lighting system defined by the design documents. A clear description of how the lighting system is intended to be operated, and its corresponding design parameters are described systematically. All the control logic under different control scenario will be recorded as a “cause and effect” table.
- detailed performance criteria and tolerance for components of the lighting system, including sensors and control gear;
- sampling method for inspection of large lighting systems. Criteria on how to conduct the random sampling for verification and test is defined in the document, according to the complexity, scale, and importance of the lighting system, and the commissioning budget and schedule.
- verification and functional performance test procedures are identified from components and assemblies up to the whole lighting system and its interaction with other building systems. The step-by-step procedure for each task, including instruments, and tools, is developed and included in the commissioning specification, with the necessary description of a qualified supplier for the task.

ISO/TS 21274 requires that the Cx specification be confirmed by the design team.

8.4 Commissioning observation inspection and calibration report

The installation, coordination and interaction among all components of the commissioned systems is evaluated according to the approved Cx plan and Cx specification. All the results of observation, inspection and calibration are recorded in documents, which are an important part of the handover information for the owner or tenant.

The commissioning observation inspection and calibration report includes at least the following information:

- the systems or components under test, the recorded information includes but is not limited to the name (or identification number) and type of lighting components, and its installed location;
- The test is conducted under stable condition, with all the necessary information recorded, such as ambient conditions, the power supply information, daylighting information, control mode, furniture and decoration of the test space;
- The test date and time, location of test space or room, instruments used for test and their calibration documents, measurement points location and orientation, the test reference of first test and retest(s) following correction of an issue, and if there is any deviation from the test standard are to be reported and analysed for any potential influence on the test result;
- design values and their tolerance for the tested system or assemblies under the test scenarios are listed in the test report;
- test data with indication of whether this performance is acceptable or whether there is any possibility for further optimization on the lighting system by configuring or calibration, and its priority on the basis of its impact;
- the reason for any failed test will be determined with support from the design team, suppliers, or some external experts if this is necessary, with the development of the corresponding measures. If it is impossible to achieve the design specification in a timely and economical manner, this will be recorded and reported to the owner and tenants.

The completed commissioning observation inspection and calibration report will be submitted to the project team for review. All checklists and test results during commissioning are to be compiled in the final Cx report.

NOTE As inspection is a higher form of observation, "commissioning inspection and calibration report" is more suitable. In this document, "commissioning observation inspection and calibration report" is used to keep consistency with ISO/TS 21274.

8.5 Issues log

The Cx team is primarily responsible for maintaining the issues log according to the Cx plan. It is important that all comments and issues identified are recorded and tracked in a formal issues log in sufficient detail so as to provide clarity and a point of future reference for any comments. The updated issues log will be distributed periodically to any persons relevant to commissioning so that everybody is operating with the same information. An online system for logging is a good solution for sharing the information during commissioning among all the relevant parties. All the contents requested in ISO/TS 21274 will be recorded in the issues log.

8.6 Training plan

The operation and maintenance of lighting systems plays an important role in keeping the lighting systems operating as designed and efficiently; the higher complexity of the lighting systems has much higher knowledge requirements for the operation and maintenance of lighting systems. The commissioning team is responsible for delivery of all the necessary technical knowledge and documents to the operational and maintenance staff by training.

It is suggested that training requirements are developed on the basis of the identification of training needs for operations and maintenance personnel, and occupants for lighting systems relative to commissioned lighting systems, integrated building features, and conditions, in the early stage of commissioning process.

The training plan will include the lighting system manual covering all measurable learning objectives and describe the knowledge that each participant is expected to acquire, which can include procedures

for normal operation (how to adjust the systems, maintenance and inspection, troubleshooting and repair) and procedures for keeping critical lighting systems operational during emergencies. The planned location of the training sessions (classroom, on-site or off-site), the minimum duration and instructor of each training session is provided in the training plan. A feedback method from trainees will be defined in the plan to make sure all the participants have correctly understood the required knowledge for correctly operating and maintaining the lighting system. This will also allow student to provide feedback on the training courses.

The training plan is submitted and accepted by the owner or tenant prior to the delivery of any instruction.

8.7 Commissioning report

The commissioning report provides documentary evidence of the commissioning outcomes achieved, which will be the basis for the post occupation operation and maintenance of the commissioned lighting system. It is the document prepared during the acceptance phase of the commissioning process, which includes an executive summary, project description, the completed commissioning plan and commissioning specification, and all documentation developed during the process along with completed commissioning test plans, as requested in ISO/TS 21274. The document is submitted to the owner or tenant and other nominated persons for review and acceptance.

9 Contractual completion

The milestone of the commissioning is the approval and acceptance of all the commissioning documents.