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MAINTENANCE OF POWER SUPPLY AND AIRFIELD LIGHTING FACILITIES AT AERODROMES

TECHNICAL GUIDE

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This document has no prescriptive purpose and cannot replace the regulations in force. It is a decision-making tool for stakeholders in the aeronautics community who remain fully responsible for the choices made within the framework of their projects. This document lists a set of good practices and/or possible recommendations in a French context. In all cases, it is always appropriate to refer to all applicable regulatory texts.

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TECHNICAL GUIDE

Civil Aviation Technical Centre

Equipment & Security Department

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EXECUTIVE SUMMARY - KEYWORDS

EXECUTIVE SUMMARY

This manual aims at describing the good practices and the procedures of preventive maintenance that should be implemented on all power supply and airfield lighting facilities at aerodromes.

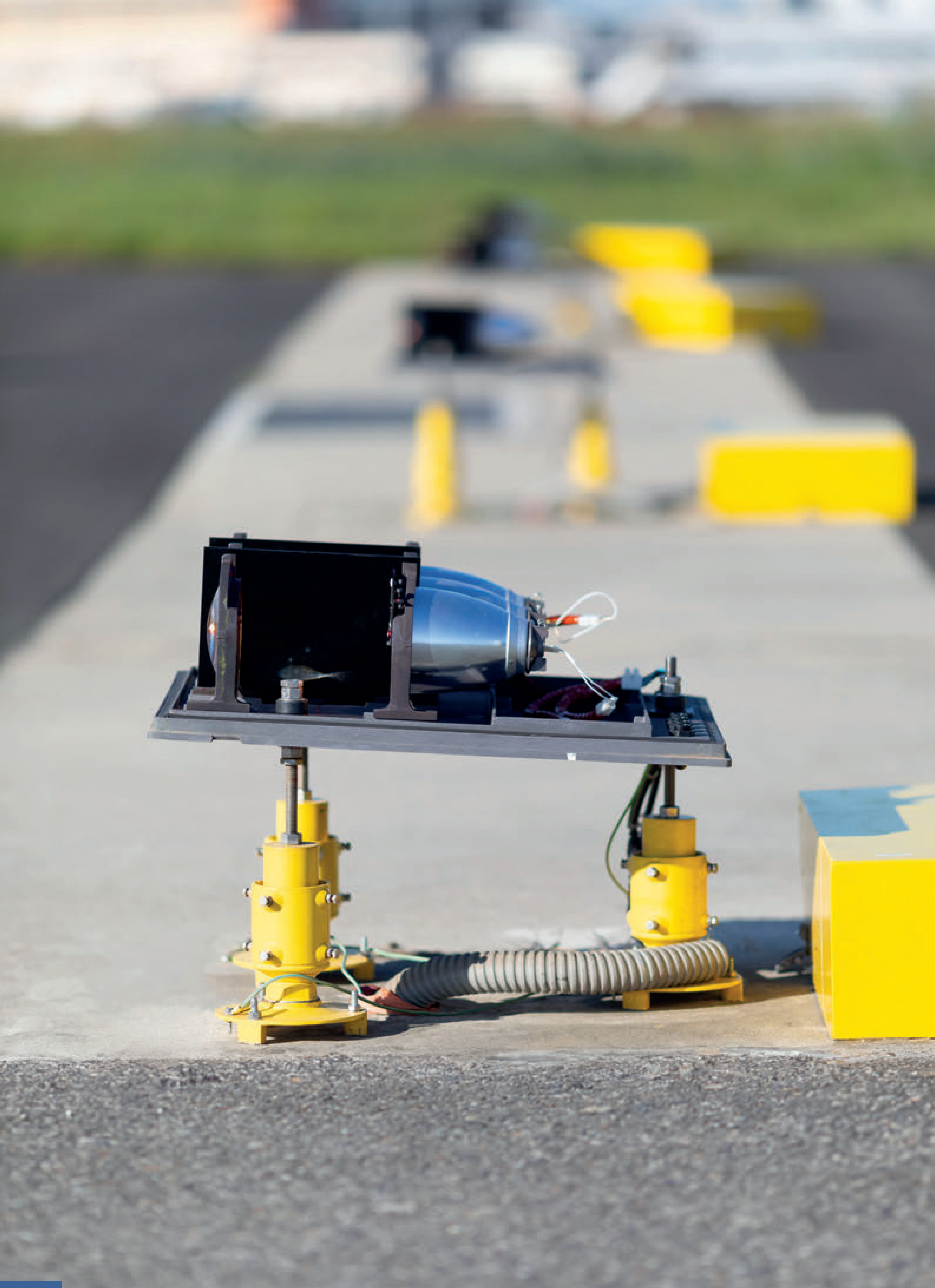
By guaranteeing the adequate availability and reliability of systems, complying with the guidance material contained in this document should ensure a sufficient safety level for aircraft operations on the manoeuvring area and protect maintenance operators against electrical risks.

Intended for employees of civil aviation supervisory authorities as well as maintenance staff working for aerodrome operators, this manual describes, among other things, as follows:

- *the training program of maintenance operators working on power supply and airfield lighting facilities at aerodromes,*
- *the procedures and periodicities of maintenance operations,*
- *the regulatory required checks to be performed on electrical systems,*
- *the maintenance performance objectives to be reached in terms of qualitative objectives (maintaining the initial functions of the systems) and quantitative objectives (maintaining the minimum percentages of serviceable airfield lights).*

KEYWORDS

Maintenance, electricity, airfield lighting, power supply



1. INTRODUCTION

1.1. BACKGROUND

Maintenance operations on power supply and airfield lighting facilities at aerodromes arise from the objective of maintaining movement area infrastructures in operational conditions. They include all the necessary measures to maintain or restore their normal operating conditions, assess their compliance with the applicable regulatory framework and, overall, reduce the risks of an operational failure.

Maintenance operations on power supply and airfield lighting facilities at aerodromes include, as follows:

- inspections ;
- routine operations and overhauls, and
- repairs.

In any case, the maintenance programme for power supply and airfield lighting facilities at aerodromes shall define, as follows:

- an organizational chart showing how the maintenance programme is included in the aerodrome management plan, defining the roles and the responsibilities of the various stakeholders and describing the human and material resources,
- the procedures and the instructions defining in-field interventions, modus operandi, experience feedbacks and event reporting,
- regularly updated and structured technical documents including overall drawings and mimic diagrams, sub-systems drawings and mimic diagrams, instruction leaflets and tracking forms of installed equipment,
- the training and skills assessment plans and the required qualifications for the tasks to be carried out.

1.2. PURPOSE

This document is only intended for guidance and shall not be regarded as a standard. It replaces the previous guide issued by the STAC in 2013 on the maintenance of airfield lighting systems and updates the version issued in January 2022.

The specifications of this guide aim at, as follows:

- describing recommended routine maintenance operations, inspections and overhauls and thus defining performance objectives for the maintenance of power supply and airfield lighting facilities at aerodromes:
    - qualitative objectives: maintaining the functional characteristics of the systems,
    - quantitative objectives: maintaining the minimum percentages of serviceable airfield lights, each minimum percentage depending on the airfield lighting system and on the category of the precision approach runway,
- describing the procedures to be implemented and the protective equipment to be worn to ensure a maximum safety level for maintenance operators.

1.3. SCOPE

Power supply and airfield lighting facilities at aerodromes include not only end-of-pipe systems such as airfield lights and signs but also power supply systems as well as remote control and monitoring systems.

The content of this guide applies to permanent (as opposed to temporary) power supply and airfield lighting facilities at aerodromes, excluding obstacle lights. Only routine maintenance operations, inspections and overhauls (i.e. preventive maintenance operations) are described.

This guide is intended for:

- aerodrome operators (units in charge of the maintenance of power supply and airfield lighting facilities),
- companies providing aerodrome operators with preventive and curative maintenance services for power supply and airfield lighting facilities at aerodromes, and
- departments of the Civil Aviation Authority and the Ministry of Defence involved in the monitoring and/or the maintenance of power supply and airfield lighting facilities at aerodromes.

This guide contains guidance material to organize and plan preventive maintenance operations and some corrective maintenance operations. Different provisions may be applied, provided they ensure an equivalent performance level.

1.4. LIMITATION

Any fault adversely affecting the fulfilment of the functional requirements for power supply and airfield lighting facilities at an aerodrome shall be corrected to ensure the continuity of aircraft operations. In case some systems cannot be immediately restored, the downgraded operating conditions of the runway shall comply with Air Ops Regulation (Commission Regulation (EU) n°965/2012):

- *Annex IV (Part-CAT), Subpart B (Operating procedures), Section 1 (Motor-powered aircraft), CAT.OP.MPA.110 (Aerodrome operating minima),*
- *Annex V (Part-SPA), Subpart E (Low visibility operations), SPA.LVO.130. (Minimum equipment).*

1.5. WARNING

The regulatory texts and standards mentioned by this guide are provided only on an informal basis. Their list is not comprehensive and they may evolve. Their validity shall be checked before applying them.

2. REFERENCES AND DEFINITIONS

2.1. BIBLIOGRAPHY/WEBOGRAPHY

- Technical guide State of the art of airfield lighting systems (STAC, 2020).
- Technical guide PAPI installation, implementation and maintenance (STAC, 2017).
- Technical note Checking for airfield lights tightening (STAC, 2015).
- Technical note LED lights specificities to be taken into account when installing them on an aerodrome (STAC, 2014).
- Technical guide Maintenance of airfield lighting systems (STAC, 2011, authors: Michel ABADIE, Christian DRÉANO, Jacques MANACH, Pierre Yvon MOAL, Patrick VERGER).
- Technical guide GUIDELEC (Central Directorate of Air Infrastructure of the Ministry of Defense, 2003).
- Installations of air navigation service centres, General specifications (DTI, 2020).
- Help guide on the lightning protection of air navigation facilities (DTI, 2020).
- STAC website https://www.stac.aviation-civile.gouv.fr
- French Civile Aviation Authority website http://www.libelaero.fr

2.2. FRENCH REGULATION

- French order of August 28, 2003, on aerodrome approval conditions and operating procedures (CHEA).
- French order of December 22, 2011, on the qualification requirements for operators in charge of the periodic checks of electrical systems and in charge of implementing the checking process for temporary electrical systems.
- French order of December 26, 2011, on the checks of or the checking process for electrical systems and on the content of the related reports.
- French order of April 19, 2012, on installation standards applicable to the electrical systems of buildings intended for workers.
- French order of June 9, 2021, on aerodrome movement area inspections and runway surface conditions assessment and reporting.
- French Labour Code – Articles R.4215-2, R.4226-1 to R.4226-21, R.4722-26 and the related implementing texts.
- Amended French instruction n°20580/DNA/2A of June 8, 1993, on PAPI and APAPI installation and implementation on aerodromes (*3rd edition of June 7, 2004*).
- NF C13-100 standard (April 2015): Consumer substations supplied by a HVA public distribution system (up to 33 kV).
- NF C13-200 standard (June 2018): High voltage electrical systems for electrical power generation sites, industrial, tertiary and agricultural sites.
- NF C15-100 standard (June 2005): Low voltage electrical systems.
- UTE C15-443 standard: Protection of low voltage electrical systems against over-voltages of atmospheric discharges or switching - Selection and erection of surge protective devices.
- NF C17-102 standard: Lightning protection systems with early streamer emission air terminal.
- NF C18-505-X standard : Live works on low voltage electrical facilities – Implemented preventive measures.
- NF C18-510:2012 standard and its amendments A1:2020 and A2:2023: Operations on electrical network and installations and in an electrical environment – Electrical risk prevention.
- NF C33-225 standard: Insulated cables and their accessories for power systems – Cables for primary circuits of airfield lighting systems - Rated voltage U0/U (Um) = 6/10 (12) kV.
- NF C33-224 standard: Insulated cables and their accessories for power systems – Cables for primary circuits of airfield lighting systems - Rated voltage U0/U (Um) = 3,6/6 (7,2) kV.
- NF C33-212 standard: Insulated cables and their accessories for power systems – Cables for primary circuits of airfield lighting systems - Rated voltage U0/U (Um) = 1/1 (1,2) kV.
- NF X60-000 standard (April 2016): Industrial maintenance – Maintenance function.
- NF EN 13306 standard : Maintenance – Maintenance terminology.
- NF EN 50164 standard: Lightning Protection Components (LPC).
- NF EN 61643 standard: Low voltage surge protective devices.
  - Part 11 : Surge protective devices connected to low voltage systems – Requirements and test methods
  - Part 12 : Surge protective devices connected to low voltage power distribution systems – Selection and application principles.
- NF EN 62305 standard: Protection against lightning – Part 3: Physical damage to structures and life hazard

2.3. EUROPEAN REGULATION

- Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) 2111/2005, (EC) 1008/2008, (EU) 996/2010, (EU) 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) 552/2004 and (EC) 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) 3922/91.
- Commission Regulation (EU) 139/2014 of 12 February 2014 laying down requirements and administrative procedures related to aerodromes pursuant to Regulation (EC) 216/2008 of the European Parliament and of the Council Text with EEA relevance.
- Decision 2014/013/R (modified) of the Executive Director of the Agency of 27 February 2014 adopting Certification Specifications and Guidance Material for Aerodromes Design (CS-ADR-DSN).
- Decision 2014/012/R (modified) of the Executive Director of the Agency of 27 February 2014 adopting Acceptable Means of Compliance and Guidance Material to Regulation (EU) 139/2014.
- Easy Access Rules for Aerodromes (Regulation (EU) 139/2014) published June 2021.
  - Annex IV (Part-ADR.OPS) – Subpart C (Aerodrome maintenance ADR.OPS.C) – ADR.OPS.C.015 (Maintenance of visual aids and electrical systems).
  - CS-ADR-DSN (Certification Specifications and Guidance Material for Aerodromes Design), Issue 5 - Chapters M (Visual aids for navigation - Lights), N (Visual aids for navigation - Signs) and S (Electrical systems).
- Commission Regulation (EU) 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operations, pursuant to Regulation (EC) 216/2008 of the European Parliament and of the Council.
- Easy Access Rules for Air Operations "EAR for Air OPS" (Regulation (EU) 965/2012) published December 2021.

2.4. INTERNATIONAL REGULATION

ICAO (International Civil Aviation Organization)

- Annex 14 to the Convention on International Civil Aviation – Volume I (Aerodrome Design and Operations), 8th edition, July 2018.
- Doc 9157: Aerodrome Design Manual.
  - Part 4 (Visual aids), 5th edition, 2021.
  - Part 5 (Electrical systems), 2nd edition, 2017.
- Doc 9137 – AN/898: Airport Services Manual - Part 9 (Maintenance), 1st edition, 1984.
- Doc 9981 : Procedures for Air Navigation Services – Aerodromes, 3rd edition, 2020.
- Doc 9476: Manual of Surface Movement Guidance and Control Systems (SMGCS), 1st edition reprinted June 2007 incorporating amendments n° 1 and 2.
- Doc 9365: Manual of All-Weather Operations, 4th edition, 2017.

IEC (International Electrotechnical Commission)

- IEC 61821:2011: Electrical installations for lighting and beaconing of aerodromes - Maintenance of constant current series circuits for aeronautical ground lighting.
- IEC 61822:2009: Electrical installations for lighting and beaconing of aerodromes - Constant current regulators.
- IEC 61823:2002: Electrical installations for lighting and beaconing of aerodromes – AGL series transformers.
- IEC 62870:2015: Electrical installations for lighting and beaconing of aerodromes - Safety secondary circuits in series circuits - General safety requirements.
- IEC TS 61827:2004: Electrical installations for lighting and beaconing of aerodromes - Characteristics of inset and elevated luminaires used on aerodromes and heliports.
- IEC TS 62143:2002: Electrical installations for lighting and beaconing of aerodromes - Aeronautical ground lighting systems - Guidelines for the development of a safety lifecycle methodology.

2.5. DEFINITIONS

A glossary of abbreviations is presented in section 7.12

Aerodrome traffic density

a) Light: where the number of movements in the mean busy hour is not greater than 15 per runway or typically less than 20 total aerodrome movements

b) Medium: where the number of movements in the mean busy hour is of the order of 16 to 25 per runway or typically between 20 to 35 total aerodrome movements

c) Heavy: where the number of movements in the mean busy hour is of the order of 26 or more per runway or typically more than 35 total aerodrome movements

Note:

- The number of movements in the mean busy hour is the arithmetic mean over the year of the number of movements in the daily busiest hour. Either a take-off or a landing constitutes a movement.

Airfield lighting facilities

Aerodrome facilities intended to provide the pilot with the necessary airfield lighting aids to ensure the safe movement (taxiing, landing and take-off) of an aircraft at an aerodrome. Three types of airfield lighting facilities may be distinguished:

- facilities allowing for the remote control and monitoring of airfield lighting systems including Human Machine Interface (HMI) systems and automation systems,
- facilities in power substations: constant current regulators, low voltage distribution switchboards, medium voltage HVA or high voltage HVB installations (cells, insulating transformers, ...), uninterruptible power supplies, parallel-connected installations, automatic transfer switches, etc, and
- facilities on manoeuvring areas including cables, manholes, insulating transformers, airfield lights and signs.

Each type of facilities has specific features requiring specific maintenance procedures.

Apron

A defined area, on a land aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking or maintenance.

Barrette

Three or more aeronautical ground lights closely spaced in a transverse line so that from a distance they appear as a short bar of light.

HVB / HVA transformer substation

Substation containing power transformers interconnecting HVB and HVA networks. (Substation to which HVB power is supplied for voltage reduction and distribution within the aerodrome).

Figure 1: HVB / HVA transformer substation of Châlons Vatry aerodrome.

Manoeuvring area

That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons.

Movement area

That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron(s).

Personal Protective Equipment (PPE)

Equipment designed and made to be worn or held by a worker to protect him against one or more hazards likely to endanger for his safety or health at work.

Note:

- For electrical operations, the term « held » was removed in order to avoid any confusion with hand tools.

Power supply systems

All the systems intended to supply adequate electrical power for the safe operation of air navigation facilities. Two power supply sources may be distinguished:

- a primary power supply source that shall be adequate for the safe functioning of air navigation facilities,
- a secondary power supply source that may be required for some air navigation facilities, depending on the operating conditions of the runway. If provided, it shall be so arranged that air navigation facilities are automatically connected to it on failure of the primary power source.

Runway code number

Number determined from Table 1 and corresponding to the highest value of the aeroplane reference field lengths of the aeroplanes for which the runway is intended.

Chiffre de code	Distance de référence de l'avion
1	< 800 m
2	≥ 800 m and < 1200 m
3	≥ 1200 m and < 1800 m
4	≥ 1800 m

Table 1: Runway code number.

Runway guard lights

Lights intended to caution pilots or vehicle drivers that they are about to enter an active runway.

Note:

- Runway guard lights are yellow flashing lights. Two configurations may be distinguished: configuration A consisting of elevated lights and configuration B consisting of inset lights.

Figure 2: Runway guard lights.

Runway-holding position

A designated position intended to protect a runway, an obstacle limitation surface, or an Instrument Landing System (ILS) / Microwave Landing System (MLS) critical / sensitive area at which taxiing aircraft and vehicles shall stop and hold, unless otherwise authorized by the aerodrome control tower.

Stop bar

Bar consisting of unidirectional in-pavement lights uniformly spaced across the taxiway, located at the point where it is desired that traffic stops and showing red in the direction that is intended for an aircraft to proceed.

Figure 3: Stop bar at Beauvais aerodrome.

Notes:

- A stop bar may be supplemented by two pairs of elevated lights (one at each end of the stop bar).
- A controlled stop bar shall be interlocked with the taxiway centre line lights installed beyond the stop bar for a distance of 90 m so that when the stop bar is activated, these inter-linked taxiway centre line lights are simultaneously extinguished and vice versa, when the stop bar is disactivated, these inter-linked taxiway centre line lights are simultaneously illuminated.
- A disactivated stop bar shall be automatically reactivated after a taxiing aircraft cleared to proceed has passed it.

Substation (of a power system)

The part of a power system, concentrated in a given place, including mainly the terminations of transmission or distribution lines, switchgear, housing and possibly transformers. It generally includes facilities necessary for power system security and control.

Figure 4: Substation of the power supply system for airfield lighting systems at Paris CDG aerodrome.

2. REFERENCES AND DEFINITIONS

Surface Movement Guidance and Control System (SMGCS)

System of aids, facilities, procedures and regulations designed to meet the requirements for guidance to, and control or regulation of an aircraft from the landing runway to the parking position on the apron and back again to the take-off runway, as well as other routes on the aerodrome surface such as from a maintenance area to an apron, or from apron to apron, consistently with the operational needs at an aerodrome.

It comprises an appropriate combination of visual aids, non-visual aids, procedures, control, regulation, management and information facilities.

Switch-over time (light)

The time required for the actual light intensity of a light measured in a given direction to fall from 50 per cent and recover to 50 per cent during a power supply changeover, when the light is being operated at light intensities of 25 per cent or above

Unserviceable light

A light, the main beam average intensity of which is less than 50 per cent of the value specified in the appropriate figure in Appendix 2 of ICAO Annex 14, Volume I. This definition is provided for maintenance purposes only, and not for operating purposes.

Example:

A runway centre line light, the main beam average intensity of which shall be greater than 5 000 cd, shall be deemed unserviceable when its main beam average intensity is lower than 2 500 cd.

Voltage ranges

In this document, rated voltages are ranked by voltage range. (See Table 2 below)

In low voltage and normal operating conditions, the real voltage of the power supply system or any part of it may exceed its rated value by 10% maximum without inducing any change of the voltage range.

Note:

This ranking also applies to supplied electrical systems.

Voltage ranges		Rated voltage value U_n (Volts)	
		Alternative current	Smoothed direct current (1)
Extra-Low Voltage (ELV) range		$U_n \le 50$	$U_n \le 120$
Low Voltage (LV) range		$50 < U_n \le 1000$	$120 < U_n \le 1500$
High Voltage (HV) range	HVA	$1000 < U_n \le 50000$	$1500 < U_n \le 75000$
	HVB	$U_n > 50000$	$U_n > 75000$

(1) Direct current with a ripple ratio not exceeding 10% (root mean square value) and a peak value not exceeding the mean value by 15%. For any other direct current, the rated voltage values defined for alternative current shall apply.

Table 2: Voltage ranges (Extract from NF C18-510:2012 standard).

3. PROTECTION OF OPERATORS WORKING ON POWER SUPPLY AND AIRFIELD LIGHTING FACILITIES AT AERODROMES

All the provisions for the prevention of electrical hazards during operations on electrical systems or in an electrical environment are gathered in NF C18-510: 2012 standard and its amendments A1: 2020 and A2:2023 (article R4544-3 of the French Labour Code).

3.1. INITIAL TRAINING AND SKILL MAINTENANCE

Operators carrying out tasks related to the design, the installation, the testing or the maintenance of power supply and airfield lighting facilities at aerodromes shall be adequately trained, skilled and experienced for these tasks.

Their theoretical and practical training, experience, skills and qualifications in power supply and airfield lighting facilities at aerodromes shall be documented by his or her employer.

The follow-up of their training, experience, skills and qualifications in power supply and airfield lighting facilities at aerodromes shall ensure the acquisition and the maintenance of the following main skills:

- adequate technical skills,
- knowledge of the specific hazards related to constant current series circuits for airfield lighting systems,
- knowledge of the adequate safety procedures for any operation on such circuits, and
- knowledge of the safety regulatory framework.

In addition to the various training courses related to power supply facilities at aerodromes that they shall attend, operators working on constant current series circuits for airfield lighting systems shall be aware of the related technical principles, risks and safety procedures.

The follow-up of their skills maintenance shall be implemented by the employer and shall be recorded in an appropriate document by the site manager or his/her delegate.

An example of the training plan of an operator in charge of the maintenance of constant current series circuits for airfield lighting systems is available in section 7.1.

3.2. ELECTRICAL ACCREDITATION

In case of electrical hazards (electrical shock or short-circuit), the employer shall deliver and renew his employee’s electrical accreditation certificates. Electrical accreditation is the recognition, by the employer, of the ability of anyone working under his authority, to carry out safely the assigned tasks with regard to electrical hazards.

Operators working on constant current series circuits for airfield lighting systems shall hold a valid and appropriate electrical accreditation certificate.

At the end of the appropriate training course, the employer shall issue an electrical accreditation certificate to any employee working under his authority and in charge of electrical or non-electrical operations requiring such an accreditation.

3. PROTECTION OF OPERATORS WORKING ON POWER SUPPLY AND AIRFIELD LIGHTING FACILITIES AT AERODROMES

The electrical accreditation certificate shall include the following items:

- information related to both the employer and the holder, the signature by the employer issuing the accreditation certificate, the holder's signature as acknowledgement of receipt and the issuing date,
- the accreditation symbol(s) (see Table 3),
- for each symbol, the scope limitation, unless provided in an appendix document quoted in the accre ditation certificate, as well as the related voltage(s) and facilities, and
- any additional information supplementing the accreditation symbol(s), the authorized operations or the possible restrictions.

The absence of an accreditation symbol shall be regarded as a proscription.

<table>
<tr><th>1st character
Voltage range</th><th>2nd character
Type of operation</th><th>3rd character
Additional letter
(supplements, if necessary, the type of works)</th><th>Additional mention
(supplements, if necessary, the previous characters)</th></tr>
<tr><td>B

Low Voltage (LV)
and
Extra-Low Voltage (ELV)</td><td>0
Non-electrical works (Performer or work supervisor)

1
Electrical works (Performer)

2
Electrical works (Work supervisor)</td><td>V
Works in the HV close vicinity zone (zone 2)

or de-energized electrical works in the LV close vicinity zone (zone 4)

T
Live works

N
Live cleaning works

X
Special operations</td><td rowspan="2">Text description of the type of operation, test, measu-rement, check or manoeuvre</td></tr>
<tr><td>H

High Voltage (HV)</td><td>R
General LV interventions

S
Basic LV interventions

C
Lockout

E
Specific operations: test, measurement, check or manoeuvre

P
Basic photovoltaic operations</td><td>–</td></tr>
</table>

Table 3: Meaning of the characters of an accreditation symbol (Extract from NF C18-510:2012 standard).

Operators working on series circuit for airfield lighting systems shall hold a valid adequate accreditation certificate.

Accreditation symbols related to low voltage or extra-low voltage electrical operations:

- Live works: B1 for a performer, B2 for a work supervisor.
- Works in the vicinity zone: B1V for a performer, B2V for a work supervisor.
- Live works for replacing an airfield lamp or light: B1X "FBA" for a performer, B2X « FBA » for a work supervisor

Note :

The letter X refers to operations different from the usual operations defined by NF C18-510 standard. The term "FBA" refers to operations on series-connected airfield lights.

- General low voltage interventions : BR, symbol to be supplemented by:
  - restrictions in terms of current or voltage range and conductors cross-section for connections and disconnections, and
  - the mention "photovoltaic application", if needed.

Accreditation symbols related to high voltage A electrical operations:

- De-energized works: H1 or H1V for a performer, H2 or H2V for a work supervisor.
- Works on primary and secondary series circuits for airfield lighting systems: H1 (CSB) for a performer and H2 (CSB) for a work supervisor .

Note :

The mention "CSB" refers to operations on primary and secondary series circuits for airfield lighting systems.

3.3. SPECIFIC PROCEDURES FOR OPERATIONS ON SERIES CIRCUITS FOR AIRFIELD LIGHTING SYSTEMS

Given the technical design specificities and the operational objectives of series circuits for airfield lighting systems, some of the requirements of the French Labour Code may not be fulfilled while carrying out operations on the latter.

Specific so-called "compensatory" procedures for carrying out operations on series circuits for airfield lighting systems shall be therefore defined and implemented in order to guarantee a maximal level of protection of the workers in charge of their maintenance.

Provisions described in this section are based on the safety principles defined by NF C18-510:2012 standard and its amendments A1:2021 and A2:2023. Some provisions are extracted or inspired from IEC 61821:2011 standard.

3.3.1. SAFETY PROCEDURES

3.3.1.1. PRELIMINARY ASSESSMENT OF ELECTRICAL RISKS

Prior to any works or intervention on series circuit for airfield lighting systems, the site manager or his/her delegate shall conduct an electrical risks assessment to identify and assess the electrical hazards arising from these works or intervention. The electrical risks assessment shall include a visual inspection of electrical facilities and shall determine the Personal Protective Equipment (PPE) and the electrical accreditation required to perform safely the works or the intervention.

Regarding live works, the electrical risks assessment shall be continued during the entire duration of the works.

Once conducted, the electrical risks assessment shall be included in the single document of assessment of professional risks (Document Unique d'Evaluation des Risques Professionnels - DUERP), document required by the French Labour Code and listing all the professional risks workers are exposed to. It shall be reviewed and updated periodically and after any event having damaged the physical integrity of an individual.

The results of the electrical risks assessment shall be taken into consideration by the aerodrome operator for the implementation of adequate safety procedures for the performed works or intervention.

3.3.1.2. DETERMINATION OF THE TYPE OF ELECTRICAL WORKS

3.3.1.2.1. DE-ENERGIZED WORKS

As a rule, works on series circuits for airfield lighting systems shall be carried out after they are de-energized, unless technically impossible.

De-energized works shall be performed after the electrical systems are locked out or de-energized. An electrical system shall always be assumed to be live and connected to the power supply system until its lockout is confirmed.

3.3.1.2.2. WORKS IN THE VICINITY ZONE

In presence of one or several uninsulated live parts in the working zone, the procedure for works in the vicinity zone shall apply. It shall consist of keeping out of reach the uninsulated live parts by means of an obstacle (a screen or an envelope with adequate mechanical characteristics restricting access to them), by distancing them (with a sufficient air distance to avoid any contact with them) or by insulating them with an insulating device.

Vicinity zones are defined by NF C18-510 standard and depend on the supply voltage of electrical systems. For low voltage operations, the simple vicinity zone is located at a distance ranging from 0,30 m to 3 m from the insulated live part and the close vicinity zone is located within 0,30 m around the uninsulated live part. For high voltage operations up to 20 000 V, the simple and the close vicinity zones are located at distances ranging respectively from 2 m to 3 m and from 0,60 m to 2 m from the uninsulated live part.

3.3.1.2.3. LIVE WORKS

Live works shall be permitted solely on the secondary loop circuits of insulating transformers of series circuits for airfield lighting systems (see section 3.3.2.3.4). The operating protocol defined in standards series NF C18-505-X shall be applied.

3.3.1.3. IDENTIFICATION OF CIRCUITS

Prior to carrying out any works or intervention on a series circuit for airfield lighting systems, any electrical equipment located within the works or intervention area shall be identified.

During any works or intervention in a cable chamber or a manhole, cables on which the works or the intervention are carried out as well as other cables shall be identified by both following manners:

- by checking visually their identification marking affixed when being installed, and
- electrically, by checking the absence or the presence of current by means of a current clamp when successively de-energizing and re-energizing the circuit.

3.3.1.4. SIGNAGE OF THE WORKS OR INTERVENTION AREA

The works or intervention area shall be delineated by adequate barriers and adequate safety notices shall be displayed. Safety notices shall also be displayed on any switching device controlling a system which was mechanically locked out and on which the works or the intervention are being carried out.

3.3.1.5. PUTTING OF THE ACTIVE PARTS OF CIRCUITS OUT OF REACH

Active parts of series circuits for airfield lighting systems, either of the constant current regulators or of the power cables, shall be put out of reach of operators. However, replacement of an airfield lamp or light may be carried out without the prior de-energizing of the constant current regulator (see section 3.3.2.3.2).

3.3.1.6. EARTHING

Prior to any works or intervention on a primary series circuit for an airfield lighting system, the latter shall be earthed at the output of the constant current regulator.

For electrical systems being installed at the issuance of this guide, the earthing shall be carried out by means of an integrated device (earthing switch).

For electrical systems already installed at the issuance of this guide and not including any integrated device, the earthing shall be carried out by one or several portable earthing and short-circuiting devices suited for the short-circuiting voltages and currents and for the time necessary to eliminate a fault. Any deliberate disconnection of such a device shall be made impossible without any intervention by the operator who installed it. The earth clamp shall be first connected, prior to carrying out the works or the intervention and shall be then disconnected last of all, once the works or the intervention are terminated.

3.3.1.7. CHECKING OF THE ABSENCE OF VOLTAGE OR CURRENT

Prior to carrying out any works or intervention on a primary series circuit for an airfield lighting system:

- the absence of voltage shall be checked at the output of the constant current regulator, using a specific device designed for this purpose, suitable for the voltage range and complying with the applicable standards for voltage detectors; the absence of voltage shall not by checked by means of a voltmeter; and
- the absence of current shall be checked on the power cable, where the intervention takes place, either by means of a single current clamp when performing the check for identification purpose or by means of two current clamps in any other case.

3.3.1.8. USE OF SUITED TESTING TOOLS AND EQUIPMENT

Testing tools and equipment shall be suited for the works or the intervention to be carried out and for the various possible weather conditions experienced at the aerodrome. Any testing equipment shall have a valid verification certificate and shall be in good working condition. Any device used to check the absence of voltage or current shall be tested before and after use.

3.3.1.9. USE OF PERSONAL AND COLLECTIVE PROTECTIVE EQUIPMENT

Personal Protective Equipment (PPE) and Collective Protective Equipment (CPE) shall comply with applicable standards in force and shall be available at any moment and suitable for the voltage range within which the works or the intervention are carried out.

For any live replacement of an airfield lamp or light (low voltage operation), at least the following equipment shall be used:

- a pair of class 00 and special-length (410 mm) insulating composite gloves,
- a class 00 or 0 low insulating stool,
- a pair of class 0 insulating shoes or overshoes,
- a pair of UV-protective glasses,
- work clothing, and
- 1000 V insulating or insulated tools.

Insulating protective equipment shall be approved for use in wet conditions. Protective equipment shall comply with applicable standards in force or, in the absence of any applicable standard, with the manufacturer's technical specifications. In any case, the procedures for the use, the maintenance, the storage, the testing and the limits of use of protective equipment shall take into consideration the manufacturer's instructions contained in their instruction leaflets. The electrical classification of insulating protective equipment is detailed by Table 4.

Electrical class	Maximum permitted voltage (Volts)	
	Alternative current (Root mean square value)	Direct current
00	500	750
0	1 000	1 500
1	7 500	11 250
2	17 000	25 500
3	26 500	39750
4	36 000	54 000

Table 4: Maximum use voltages and related electrical classes of insulating protective gloves.

3.3.1.10. CONSIDERATION OF LOCAL WEATHER CONDITIONS

Procedures for interventions in areas exposed to local weather conditions, such as manholes or cable chambers, shall take into consideration adverse weather conditions. Any intervention on series circuits for airfield lighting systems shall be prohibited in case of stormy weather conditions. Prior to carrying any operation in a manhole or a cable chamber, any water covering the electrical systems shall be removed. The pump shall be class III and its protection rating shall guarantee protection against water penetration.

For any live replacement of an airfield lamp or light in damp or wet conditions, the insulating protective equipment mentioned in section 3.3.1.9 shall be used.

3.3.1.11. RECORDING OF WORKS OR INTERVENTION

Any works or intervention carried out on series circuits for airfield lighting systems shall be recorded in a logbook or any other kind of appropriate document. Each record shall be identified by a single reference, shall be available (with the whole related technical documentation) and shall mention as follows:

- the nature of the works or the intervention,
- the results of any performed measurement or test,
- the details of any repair or corrective action,
- the date and the start time (hour, minutes) of the works or the intervention,
- the name of the operators who carried out the operation,
- the end time of the works or the intervention.

The information transmitting process shall guarantee that both the emitter and the receiver of the message understand each other well and agree on the operation to be carried out.

3.3.1.12. ISSUANCE OF A WORK AUTHORIZATION

A work authorization shall be issued by the site manager or his/her delegate to any operator in charge of electrical operations on airfield lighting facilities, prior to starting any works or intervention. It shall remain valid for the entire duration of the works or the intervention. It may be specific for a task or common to various tasks.

Regarding the replacement of an airfield lamp or light, the work authorization shall be issued when hiring the operators assigned to this task.

3.3.1.13. ISSUANCE OF A WORK ORDER

A specific work order shall be issued to any operator in charge of live works or an intervention on a primary series circuit for an airfield lighting system prior to starting any works or intervention.

3.3.2. INTERVENTION PROCEDURES

3.3.2.1. DEFINITION

According to the French regulation and applicable standards, the term "intervention" in this document refers to "general low voltage works and operations" as defined by NF C18-510 standard.

3.3.2.2. INTERVENTION PROCEDURES MANUAL

Intervention forms detailing the intervention procedures shall be created on the initiative of the site manager or his/her delegate and shall be made available to any operator carrying out interventions on series circuits for airfield lighting systems. These intervention forms shall be gathered in a manual. Intervention procedures shall comply with the applicable regulations.

3.3.2.3. EXAMPLES OF PROCEDURES OF INTERVENTION

3.3.2.3.1. INTERVENTION ON A PRIMARY SERIES CIRCUIT

Any intervention on a primary series circuit for an airfield lighting system shall be carried out after the electrical and mechanical lockout of the circuit on which the intervention is carried out. The following requirements shall be met prior to carrying out the intervention:

- The operator(s) in charge of the intervention shall hold adequate electrical accreditation certificate(s).
- The operator(s) in charge of the intervention shall be issued a working order.
- The operator(s) in charge of the intervention shall locate, consult and analyse the applicable technical documents (overall drawings, mimic diagrams, technical leaflets, intervention forms).
- The operator(s) in charge of the intervention shall locate and identify the electrical facilities affected by the intervention and, if the intervention is to be carried out in a manhole or a cable chamber, the operator shall identify, in the manhole, all the circuits passing through the manhole or the cable chamber, following the instructions indicated by section 3.3.1.2.1.
- For interventions to be carried out in a manhole or a cable chamber, any series circuit passing through it should rather be de-energized. In addition, any series circuit fitted with connectors shall be imperatively locked out. However, series circuits not fitted with connectors and of good integrity may remain energized. In such a case, the operating procedure shall mention it and shall detail the safety measures to be implemented.
- The operator(s) in charge of the intervention shall locate the testing tools and equipment.
- The operator(s) in charge of the intervention shall test the testing equipment.
- The operator(s) in charge of the intervention shall identify and eliminate any potential hazard, including the presence of water in a manhole or a cable chamber, the occurrence of stormy weather conditions (see section 3.3.1.10) and the presence of live cables of other circuits that may have accessible active parts (see section 3.3.1.5).

- The monitoring and control system of the electrical facilities on which the intervention is carried out shall be put out of service.
- The low voltage power supply of the constant current regulator shall be locked out.
- The primary series circuit on which the intervention is to be carried shall be locked out and earthed at the output of the constant current regulator, using the PPE suited for the voltage range. (See sections 3.3.1.6 and 3.3.1.9.)
- The absence of voltage shall be checked on the primary series circuit on which the intervention is carried out, at the output of the constant current regulator, using a device suited for this purpose and for the voltage range.
- The absence of current shall be checked on the primary series circuit on which the intervention is carried out, where the intervention is carried out, by means of two current clamps. The intervention shall be carried out by two operators: one performing the intervention and another supervising the intervention. However, should all the series circuits for airfield lighting systems be locked out, the intervention may be carried out by a single operator if the latter is authorized to work alone. In such a case, a specific intervention procedure shall be established by the site manager or his/her delegate.

3.3.2.3.2. REPLACEMENT OF AN AIRFIELD LAMP OR LIGHT

Operators in charge of the replacement of an airfield lamp or light shall hold a work authorization (issued when hired) and a specific accreditation certificate as defined by section 3.2.

One or several procedure forms for the replacement of an airfield lamp or light shall be created by the site manager or his/her delegate. Any replacement of an airfield lamp or light should be carried out after de-energizing the constant current regulator(s) supplying it and after checking that the circuit cannot be re-energized during the intervention.

For electrical facilities already installed at the issuance of this guide, any live replacement of an airfield lamp or light shall not be permitted without the prior earthing of the metal parts (inset base and optical parts) of the light.

In case the replacement of an airfield lamp or light is carried out without the prior de-energizing of the constant current regulator, a risk assessment shall be conducted by the site manager or his/her delegate and a specific intervention procedure form shall be implemented. In such a case, PPE (composite insulating gloves, insulating shoes or overshoes, UV-protective glasses) and/or CPE (insulating stool) and insulating or insulated hand tools shall be made available to operators. PPE or CPE shall be visually checked before use.

3.3.2.3.3. INTERVENTION ON AN EARTHING CIRCUIT

Earthing circuits of electrical systems are intended to protect persons and assets, by flowing earth fault currents and by limiting voltage rises, particularly in the event of insulation fault, lightning, induction, stray currents and manoeuvres.

Protective Earthing (PE) conductors, except Protective Earthing and Neutral (PEN) conductors (combining the functions of both a protective earthing conductor and a neutral conductor) shall not be regarded as active conductors. However, currents of various intensities, possibly including high-intensity currents, permanently flow through them, for instance in case of a storm. Therefore, they carry a risk of electric shock, during electrical connection, measurement or maintenance operations. For these reasons, operations carried out on an earthing circuit shall be regarded as electrical interventions.

Electrical dismantling, connection and measurement operations on an earthing circuit are authorized, provided that the maintenance operators are adequately trained and accredited.

Provisions shall be specified to ensure permanently, as follows:

- the flowing of currents, either by means of a shunt or by connection to an earth electrode of sufficient cross-section that shall be pre-identified, and
- the equipotentiality of workstations to prevent, among other things, any operator from being simultaneously in contact with two earthing circuits or terminals of hazardous and different electrical potentials.

Prior to carrying out any opening operation on an earthing circuit, a shunt allowing current flowing shall be installed. In case the shunt cannot be installed, the operator shall wear adequate personal protective equipment and make all the necessary arrangements not to touch simultaneously two distinct earth circuits.

3.3.2.3.4. LIVE WORK

Live work shall be permitted solely on the secondary circuits of insulating transformers of series circuits for airfield lighting systems and solely after an electrical risks assessment is conducted and adequate safety procedures are implemented by the site manager or his/her delegate. The electrical risks assessment shall be continued during the entire duration of the live work.

Any operator in charge of live work shall be specifically trained by an approved training body and shall hold a “live work authorization” and a work authorization issued by the site manager or his/her delegate.

Specific and different requirements shall apply for the live replacement of an airfield lamp or light. (See section 3.3.2.3.2.).

3.4. MONITORING PROCEDURES

3.4.1. GENERAL CASE

Stringent monitoring of power supply and airfield lighting facilities at aerodromes shall be implemented as defined by sections 5 and 6, to guarantee an optimal level of protection of the operators in charge of their maintenance.

3.4.2. SPECIFIC CASE OF SERIES CIRCUITS FOR AIRFIELD LIGHTING SYSTEMS

The monitoring of series circuits for airfield lighting systems shall be carried out by operators in charge of the maintenance of airfield lighting systems. The records of these monitoring operations shall be made available to any operator carrying out operations on these circuits. The periodicity of these monitoring operations shall be defined by the site manager or his/her delegate. The monitoring of series circuits for airfield lighting systems shall ensure, as soon as practicable, the removal of the faults and the malfunctions affecting series circuits for airfield lighting systems.

The monitoring procedures are related to the following items:

- active parts of circuits for protection against direct contacts (see section 3.4.2.1),
- the equipotential bonding system for protection against indirect contacts (see section 3.4.2.2),
- the insulation resistance of primary series circuits (see section 7.5.1),
- the electrical continuity resistance of primary series circuits (see section 7.5.2),
- the update of overall drawings and mimic diagrams,
- the identification of infrastructures, and
- the HVA connections in constant current regulators (see section 6.3.1).

3.4.2.1. PROTECTION AGAINST DIRECT CONTACTS

Active parts of constant current regulators, power cables and lights that shall be put out of reach in order to ensure the protection of operators against direct contacts.

3.4.2.2. PROTECTION AGAINST INDIRECT CONTACTS

For facilities being installed at the issuance of this guide, any metal part, including those of optical parts of in-pavement lights shall be connected to a protective equipotential bonding system. The uninsulated copper cable of the equipotential bonding system shall be connected to an equipotential bonding terminal which itself shall be connected to the local earth.

For electrical facilities already installed at the issuance of this guide, any live replacement of an airfield lamp or light shall not be permitted without the prior earthing of the metal parts (inset base and optical parts) of the light.

Earthing connections and the equipotential bonding system shall be yearly checked by sampling.

3.4.2.3. INSULATION RESISTANCE OF PRIMARY SERIES CIRCUITS

As part of the periodic checks of electrical systems, the insulation resistance of any primary series circuit for an airfield lighting system shall be measured every six months, in accordance with section 6.3.1.4.

The lowest measured value shall not be lower than the theoretical value computed as described in section 7.5.1.2. In case the lowest measured value is lower than the computed value, a maintenance action shall be undertaken. In case the value of the insulation resistance cannot be raised without delay, an electrical risk assessment shall be conducted and a specific safety intervention procedure shall be subsequently implemented by the site manager or his/her delegate.

3.5. REGULATORY REQUIRED CHECKS

3.5.1. GENERAL CASE

French Committee for Accreditation (COFRAC) or by any skilled employee meeting the skill requirements laid down by the French Order of December 22, 2011, on the skill requirements for operators in charge of the periodic checks to be carried out on electrical systems and in charge of implementing the checking process on temporary electrical systems.

The main items to be checked and the applicable checking methods are laid down by the French order of December 26, 2011, on the checks to be carried out or the checking process to be implemented on electrical systems and on the content of the related reports.

3.5.2. SPECIFIC CASE OF SERIES CIRCUITS FOR AIRFIELD LIGHTING SYSTEMS

Given the specificity of primary and secondary series circuits for airfield lighting systems, the items listed below (extracts from the table of methods of the French order of December 26, 2011, on the checks to be carried out or the checking process to be implemented on electrical systems and on the content of the related reports) need not be checked:

- regarding the general installation conditions:
  - emergency switching-off,
- regarding the protection against electric shock:
  - earth electrodes,
  - protective conductors and the equipotential bonding system,
- regarding the protection against burn injuries, fire and explosion:
  - protections against overloads and short-circuits,
  - breaking capacity.

4. CONCEPT OF MAINTENANCE

4.1. DEFINITION

According to NF X60-000 standard of April 2016, maintenance refers to all technical, administrative and managerial actions during the life cycle of an asset, intended to keep it in, or restore it to, a state in which it can perform the required function.

4.2. APPLICABLE STANDARDS

- NF X60-000 standard (April 2016) : Industrial maintenance – Maintenance function
- NF EN 13306 standard : Maintenance – Maintenance terminology

4.3. MAINTENANCE TYPES

Two types of maintenance operations shall be carried out in parallel.

- **Preventive maintenance** operations are intended to assess and/or mitigate degradation and reduce the failure probability of an asset. Preventive maintenance operations shall include, as follows:
  - systematic/scheduled maintenance operations, carried out at defined time-intervals or at a frequency based on the number of uses of the asset without conducting a prior inspection,
  - condition-based maintenance operations, arising from the prior control and analysis of the actual condition of the asset, andt
  - predictive maintenance operations, arising from the continuous monitoring and the analysis of the condition of the asset (various relevant parameters and characteristics).

- **Corrective maintenance** operations are carried out after detecting a failure and intended to restore the asset to a state in which it can perform the required function. Corrective maintenance operations shall include, as follows:
  - deferred corrective maintenance operations carried out not immediately after detecting a failure, but delayed in accordance with the maintenance rules, and
  - emergency corrective maintenance operations, carried out without delay after detecting a failure, to avoid unacceptable consequences.

The following paragraphs refer to notions contained in ICAO Doc 9137 – AN/898 (Airport Services Manual), Part 9 (Maintenance), sections 1.4.3 and 1.4.4.

- Inspection comprises all measures to check and evaluate the operating condition of any item of the system including spontaneous and scheduled checks. Scheduled checks shall be carried out in accor dance with the “preventive maintenance plan” specifying the preparation of the check, the sort of check, the report on the result and the evaluation of the results. From the results, the aerodrome operator shall decide whether or not extra servicing or even repair has to be undertaken.
- Servicing and overhaul comprise all measures to maintain or return a facility or device to its required operating condition. These measures should be carried out in accordance with the “preventive maintenance plan” specifying the schedule for the service, the nature of the service and the report of compliance.

4.4. MAINTENANCE LEVELS

According to NF X60-000 standard, maintenance operations may be classified as presented below in Table 5.

Opérations de maintenance	Niveau de maintenance	Classification AFNOR
Action simple	**I**	**Utilisateur**
Opération courante	**II**	**Agent qualifié**
Opération « Spécialisée »	**III**	**Technicien qualifié**
Intervention spécifique	**IV**	**Technicien ou équipe spécialisée**
Rénovation/Reconstruction	**V**	**Constructeur, service ou société spécialisée**

Table 5: Classification of maintenance operations according to NF X60-000 standard.

- **Maintenance operations of level I:** simple actions that can be carried out by the user or an operator, following simple instructions and without using any other tool than the one integrated in the asset
- **Maintenance operations of level II:** routine operations carried out by a skilled operator or a technician, following detailed procedures and using light tools
- **Maintenance operations of level III:** general technical operations carried out by a qualified technician following complex procedures and using complex portable tools
- **Maintenance operations of level IV:** specific technical operations carried out by a specific technician or team mastering a specific technique or technology, following general or specific maintenance instructions and using specific portable tools
- **Maintenance operations of level V:** operations of renovation, rebuilding and replacement of an installation, equipment, a structural or non-operative part, according to a process similar to its initial fabrication or assembly process.

4.5. PREVENTIVE MAINTENANCE PLAN

Given the impact of the condition of power supply and airfield lighting facilities on the safety of air operations, aerodrome operators shall implement a structured and documented preventive maintenance plan specifying the nature, the schedule, the instructions, the required resources and the required duration of the maintenance operations.

The preventive maintenance plan shall be structured and strictly applied. It shall meet the following objectives:

- protect persons and assets, ensure maintenance staff safety,
- prevent any loss of operating capacity, ensure the continuity of aircraft operations, maintain the (contractually or regulatory) required service quality and meet users' satisfaction,
- improve the reliability and the performance of facilities, anticipate and prevent potential failures on them, guarantee their long-term use by monitoring their condition,
- reduce maintenance expenses,
- optimize spare parts stock and purchase management, and
- summarize maintenance instructions.

The main objective of the preventive maintenance plan for power supply and airfield lighting facilities at aerodromes is to keep them in a condition that will not adversely affect the safety of aircraft operations.

In addition, the preventive maintenance plan shall be established after analysing (auditing) the facilities, the maintenance policy and the safety objectives of the aerodrome. It shall be suited for the complexity and the quantity of facilities as well as the human and material resources required for their monitoring. It shall be regularly updated. In case of outsourcing of maintenance operations, the preventive maintenance plan shall be integrated in the maintenance outsourcing contract.

Various tools and methods may be used for its definition: Program Evaluation and Review Technique (PERT), Gantt diagram, method of assessment of industrial risks of malfunctions of equipment (Méthode d'Evaluation des Risques Industriels et des Dysfonctionnements des Equipements - MERIDE), Failure Modes, Effects and Criticality Analysis (FMECA), etc. In addition, Computerized Maintenance Management Systems (CMMS) are specifically designed to assist the maintenance staff in performing his duties.

5. MAINTENANCE OF POWER SUPPLY FACILITIES AT AERODROMES

5.1. DESIGN OF THE POWER DISTRIBUTION SYSTEM

In general, whatever the power supplier, electrical power is supplied to customers at two voltage ranges:

- HVA (20 kV),
- LV (240 / 410 V).

Depending on the power consumption and the aimed level of operating safety, the power distribution system of an aerodrome may range from the simplest to the most complex.

5.1.1. LV POWER DISTRIBUTION

Airfield facilities with reduced power consumption are usually supplied at low voltage, which allows for a significant reduction of maintenance expenses and the need for skilled workforce for maintenance operations.

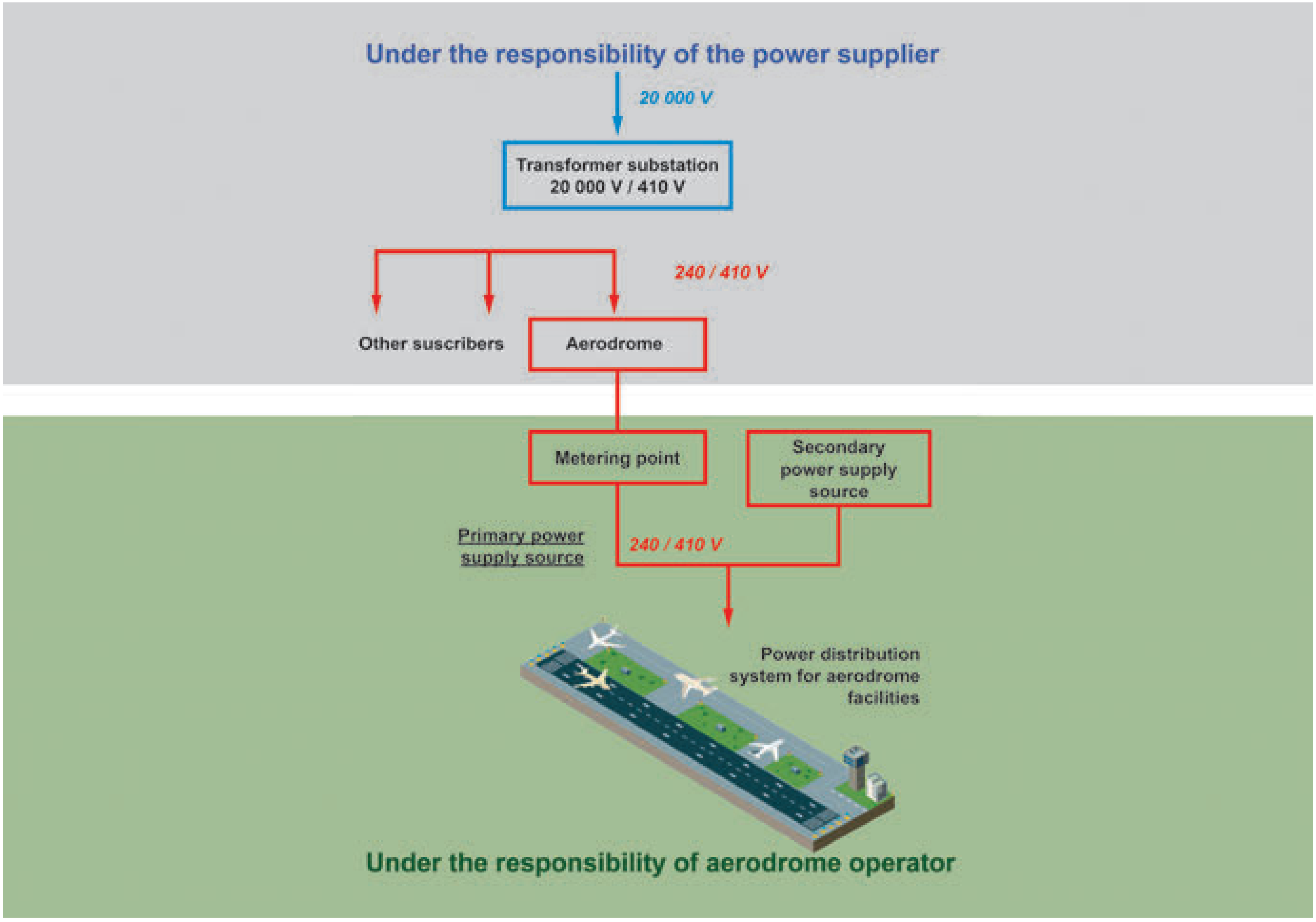


Figure 5: Example of power distribution system at aerodromes where power is supplied at low voltage.

5. MAINTENANCE OF POWER SUPPLY FACILITIES AT AERODROMES

5.1.2. HVA POWER DISTRIBUTION

Airfield facilities with high power consumption, like some of industrial or service companies, are usually supplied by one or several HVA (20 kV) power sources.

Thus, when necessary, aerodromes are not power limited and benefit from lower power rates. Moreover, they may choose their neutral point treatment.

Major aerodromes usually have their own internal HVA (5,5 kV to 20 kV) power distribution system. The voltage is reduced at HVA/LV transformer substations located as close as possible to the supplied systems and containing the power transformers interconnecting the networks of different voltages.

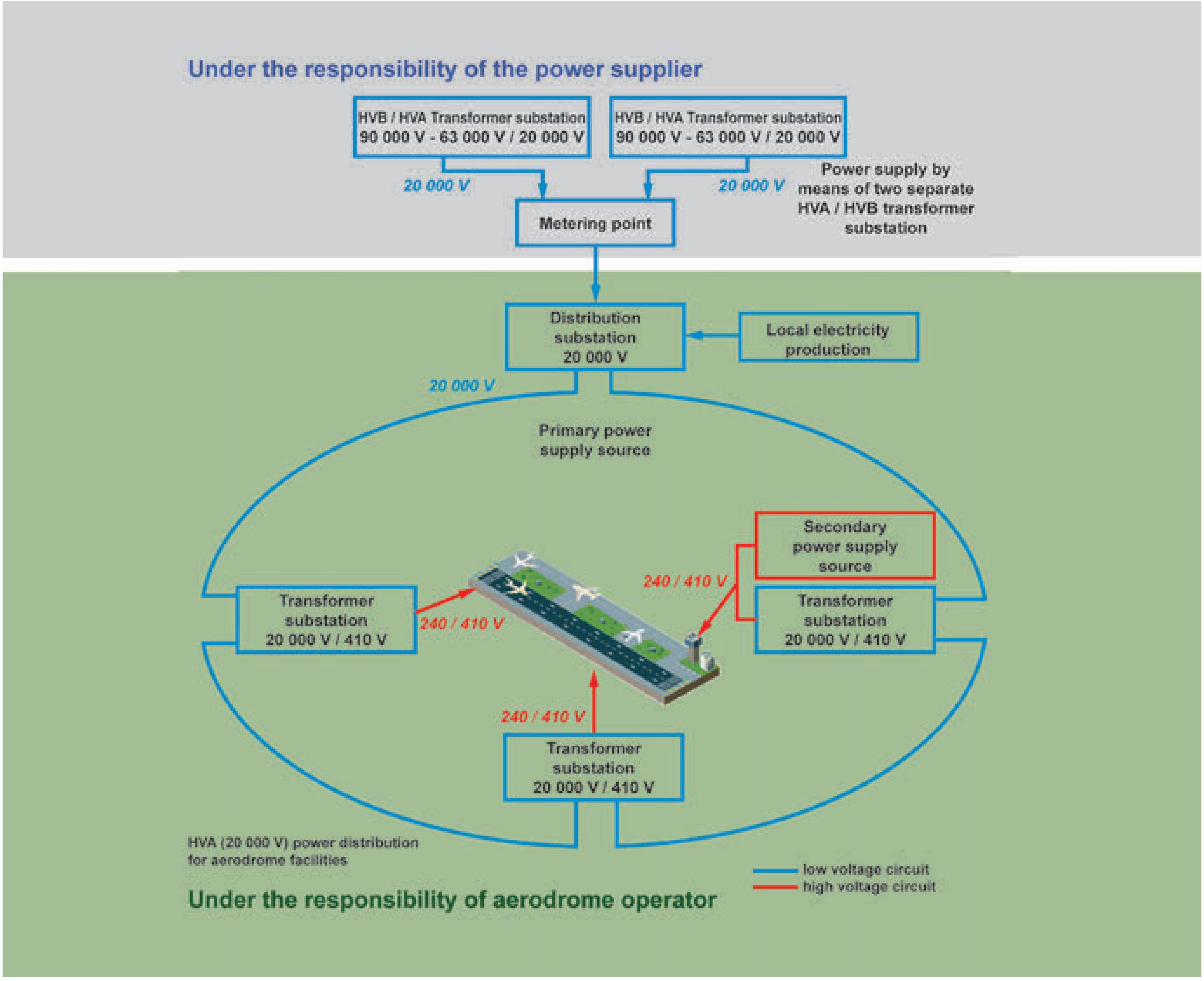


Figure 6: Example of power distribution system at aerodromes where power is supplied at high voltage.

5. MAINTENANCE OF POWER SUPPLY FACILITIES AT AERODROMES

The connection of the HVA/LV transformer substation to the HVA power distribution system may be of different types. The most usual ones are listed below:

- **a single radial connection:** the HVA/LV transformer substation is connected to the HVA power distribution system by means of a single line,
- **a ring connection:** the HVA/LV transformer substation is series connected to the HVA power distribution system, or
- **a single radial connection:** the HVA/LV transformer substation is connected to the HVA power distribution system by means of two lines (a primary one and a secondary one), ensuring a high level of service continuity.

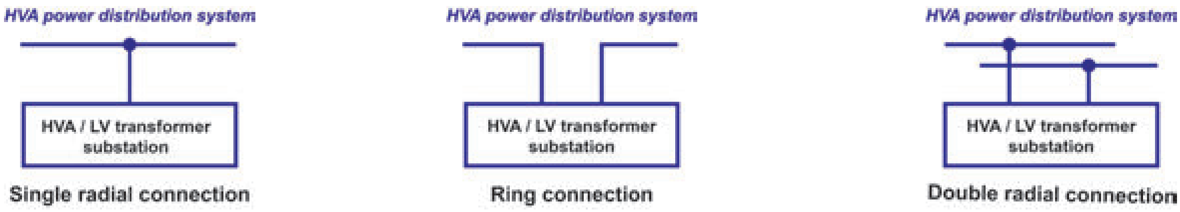


Figure 7: Possible types of connection of a HVA/LV transformer substation to a HVA power distribution system.

Figure 8: Internal HVA power distribution system at Nice aerodrome.

5.2. FUNCTIONAL REQUIREMENTS

5.2.1. DESIGN OF POWER SUPPLY SYSTEMS

Power supply systems for airfield lighting aids and radio navigation aids shall be so designed that an equipment failure will not leave the pilot with inadequate visual or non-visual guidance or misleading information.

The safety of operations at aerodromes depends on the quality of the supplied power. The total electrical power supply system may include connections to one or more external sources of electric power supply and one or more local generating facilities.

Adequate primary power supply (= normal power source) shall be available at aerodromes for the safe functioning of air navigation facilities. A secondary power source (=auxiliary power source) may be provided to ensure power supply continuity in case of failure of the primary power supply source or in case of voltage or frequency disturbances.

5.2.2. SWITCH-OVER TIME

5.2.2.1. DEFINITION

Switch-over time is strictly related to the power supply systems of airfield lights.

Switch-over time is the time required for the actual intensity of a light measured in a given direction to fall from 50 per cent and recover to 50 per cent of its initial value, during a power supply changeover.

Switch-over time therefore depends on the following times:

- the time of failure detection and resolution on the primary power source,
- the time for availability of the secondary power source,
- the time of switching from the primary power source to the secondary power source,
- the restarting time of power supply units (constant current regulators, voltage generators), and
- the time of lighting-up of airfield lights.

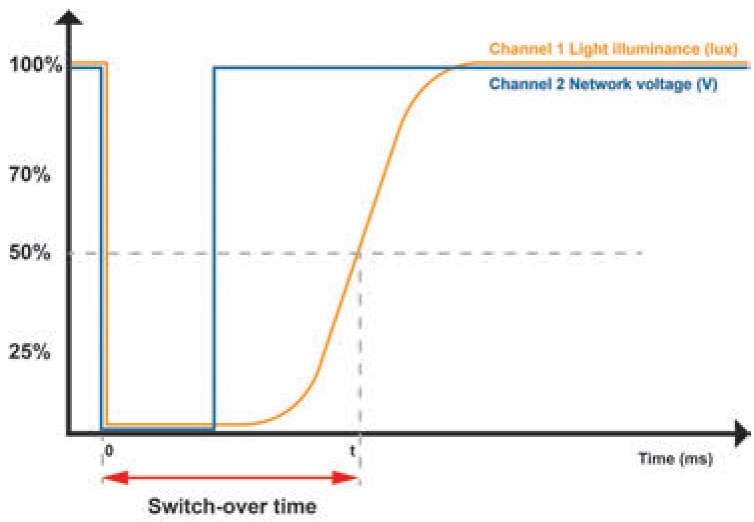


Figure 9: Switch-over time.

5.2.2.2. REGULATORY REQUIREMENTS ACCORDING TO RUNWAY OPERATING CONDITIONS

5.2.2.2.1. FRENCH REGULATORY REQUIREMENTS

Lighting aids \ Runway operating conditions		Non-precision approach	Precision approach category I		Precision approach category II or III	Runway meant for take-off	
			RVR ≥ 800 m	550 m ≤ RVR < 800 m		RVR < 800 m by night or RVR < 400 m by day	RVR ≥ 800 m by night or RVR ≥ 400 m by day
Approach lights	Inner 420 m	15 s if provided	15 s if provided	15 s	1 s	No requirement	
	Other parts				15 s		
Runway edge lights Runway threshold lights Runway end lights		15 s	15 s	1 s	1 s	1 s	15 s
Runway centre line lights		15 s if provided	15 s if provided		1 s	1 s	15 s if provided
Touchdown zone lights		15 s if provided	15 s if provided		1 s	No requirement	
Rapid exit taxiway lights		15 s if provided	15 s	1 s	1 s	No requirement	
Mandatory instruction signs		15 s	15 s	1 s	1 s	1 s	15 S
Stop bar lights		No requirement	No requirement	No requirement	1 s	1 s	15 s

Table 6: Maximum switch-over time required by the French regulation for airfield lighting aids according to runway operating conditions.

Note:

The switch-over time for all other lighting aids (runway threshold identification lights, PAPI, information signs, runway guard lights, taxiway lights other than rapid exit taxiway lights, obstacle lights) shall be less than or equal to 15 seconds whatever the operating conditions of the runway.

5.2.2.2.2. EASA REGULATORY REQUIREMENTS

Lighting aids \ Approach or runway type		Non-precision approach	Precision approach category I	Precision approach category II or III	Runway meant for take-off	
					RVR < 800 m	RVR ≥ 800 m
Approach lighting system	Inner 300 m	15 s	15 s	1 s	No requirement	
	Other parts			15 s		
PAPI		15 s (1)(2)	15 s (1)(2)	No requirement	No requirement	
Runway edge lights		15 s (2)	15 s (2)	15 s	1 s where no runway centre line lights are provided 15 s otherwise	As short as possible
Runway threshold or runway end lights		15 s (2)	15 s (2)	1 s	1 s	As short as possible
Runway centre line lights		No requirement	No requirement	1 s	1 s	As short as possible
Touchdown zone lights		No requirement	No requirement	1 s	No requirement	
Essential taxiway lights and signs		No requirement	15 s (1)	15 s	15 s (1)	As short as possible
Stop bar lights		No requirement	No requirement	1 s	1 s	As short as possible

Table 7: Maximum switch-over time required by EASA regulation for airfield lighting aids.

(1) Supplied with a secondary power source when their operation is essential to flight operation safety.
(2) One second where approaches are over hazardous or precipitous terrain.

5.3. MEANS OF COMPLIANCE

5.3.1. DESIGN OF POWER SUPPLY SYSTEMS

Requirements for the primary power supply shall be met either by an independent public power source through one or several transmission lines or by an autonomous power generating station or by a combination of both.

Requirements for the secondary power supply may be met by either of the following:

- one or more engine generators,
- energy storage systems provided with an auxiliary power source if the supplied systems shall be continuously powered,
- an additional public power source, the independence of which from the primary power supply source shall be guaranteed by the supplier, or
- a combination of these various power sources.

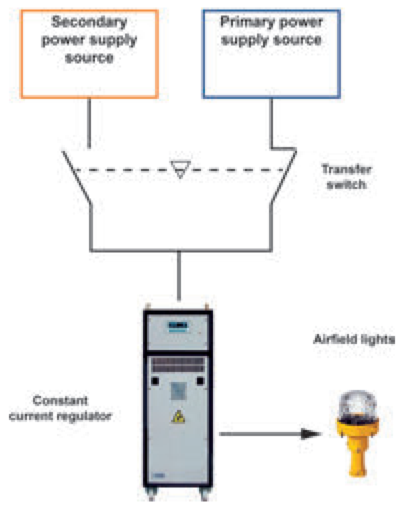
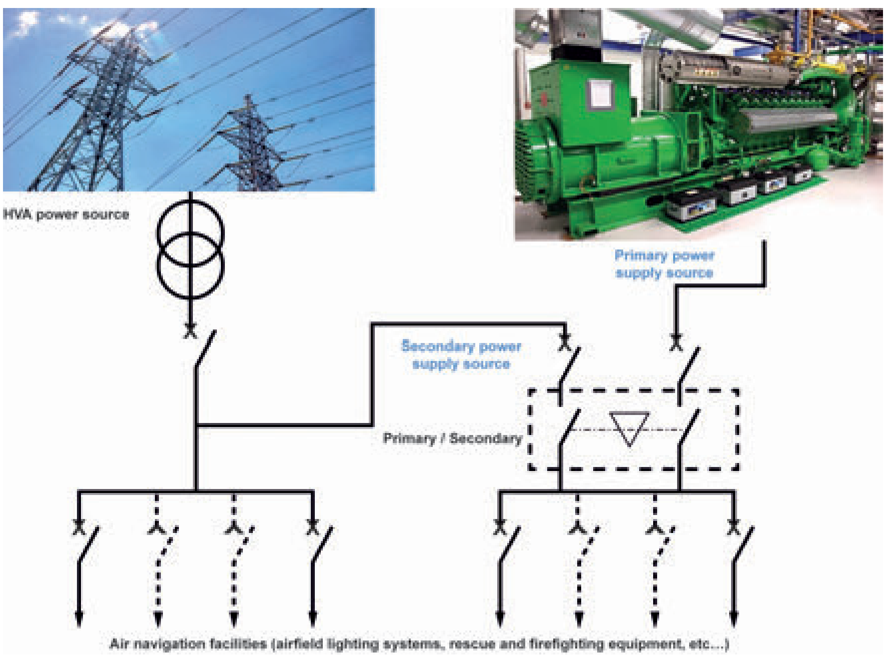


Figure 10: Functional diagram of a power supply system for airfield lighting aids including a secondary power source.

Primary and secondary power sources may be either of the following combination of power sources:



- an independent public power source and a local power source such as an engine generator,
- two public power sources, provided they are supplied from different HVB/HVA transformer substations and through different trans mission lines, or
- two local power sources such as engine generators.

Figure 11: Example of electrical power supply systems for air navigation facilities at an aerodrome.

5.3.2. SWITCH-OVER TIME

Whatever option is chosen, the maximum switch-over time shall comply with the applicable requirements depending on the operating conditions of the runway.

If too long, the switch-over time may be shortened by various manners to ensure the continuity of aircraft operations at the aerodrome, in case of adverse weather conditions.

5.3.2.1. USE OF REVERSE MODE

When requirements for the secondary power source are met by local auxiliary power units such as engine generators, the one-second requirement for the maximum switch-over time cannot be met due to the starting time of engine generators. Consequently, in case of adverse weather conditions or in case of any doubt on the reliability of the primary power source, air traffic controllers may possibly operate the secondary power source in reverse mode to meet the one-second requirement for the maximum switch-over time.

In such conditions, requirements for the primary power source are met by the engine generators while requirements for the secondary power source are met by the public power source. The switch-over time is then significantly shortened as it does not include the starting time of engine generators and thanks to the use of automatic transfer switches.

5.3.2.2. USE OF STATIC AUTOMATIC TRANSFER SWITCHES

As opposed to dynamic automatic transfer switches fitted with mobile contactors controlled by spring and bar systems and coils, static automatic transfer switches include electronic components (power semiconductors) and thus allow to achieve a reduced power disconnection time of 20 milliseconds, equalling the period of a sinusoidal wave with a frequency of 50 Hz.

5.3.2.3. USE OF UNINTERRUPTED POWER SUPPLY (UPS) SYSTEMS

Being capable of providing uninterrupted alternating current power whatever happens to the power supply system, Uninterrupted Power Supply (UPS) systems make up for power disconnections or micro-disconnections.

A UPS system include the following cascaded devices:

- a rectifier which converts input AC power into DC power,
- a power storage system (secondary battery, supercapacitor, superconducting magnetic energy storage system, inertia flywheel, inertia engine, inertia machine, compressed gas),
- an inverter which converts DC power back to pure sine-wave output power.

In normal mode of operation, a UPS system stores power: the rectifier charges the power storage system while airfield lighting aids and the rectifier are supplied by the primary power source. In case of failure of the primary power source, the stored power is released: airfield lighting aids are supplied by the inverter which itself is supplied by the power storage system.

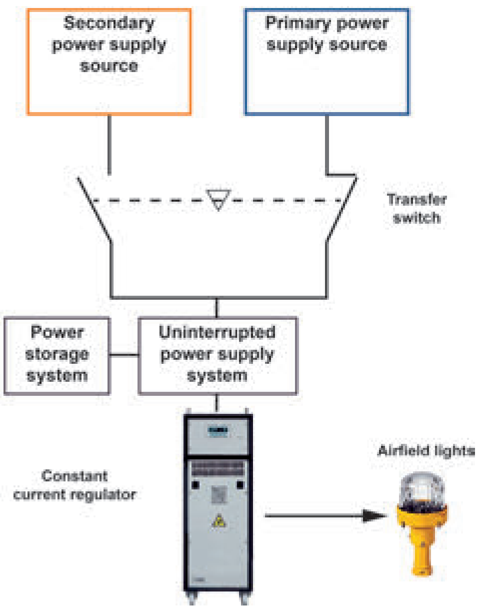


Figure 12: Functional diagram of a power supply system for airfield lighting aids including a UPS system.

There is also double conversion UPS systems which include a static by-pass switch transfering the load to another power source in the event of an internal malfunction in the UPS system.

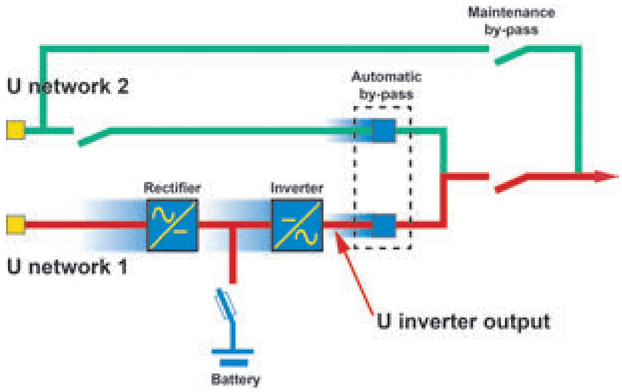


Figure 13: Functional diagram of a static double conversion UPS system.

5.3.2.4. USE OF HYBRID ROTARY UPS SYSTEMS (NO-BREAK SYSTEMS)

Being capable of providing uninterrupted alternating current power and the necessary power conditioning to loads sensitive to power disturbances, a hybrid rotary UPS system makes up for disconnections, micro-disconnections and power disturbances at the same time.

The power supplied by a hybrid rotary UPS system is high quality (voltage-regulated and free of harmonic disturbances) and therefore suitable for facilities sensitive to power disturbances.

As compared to other UPS systems, a hybrid rotary UPS system combines an inverter, an inertia flywheel, a motor-generator set and an auxiliary power source (generally a diesel engine) together.

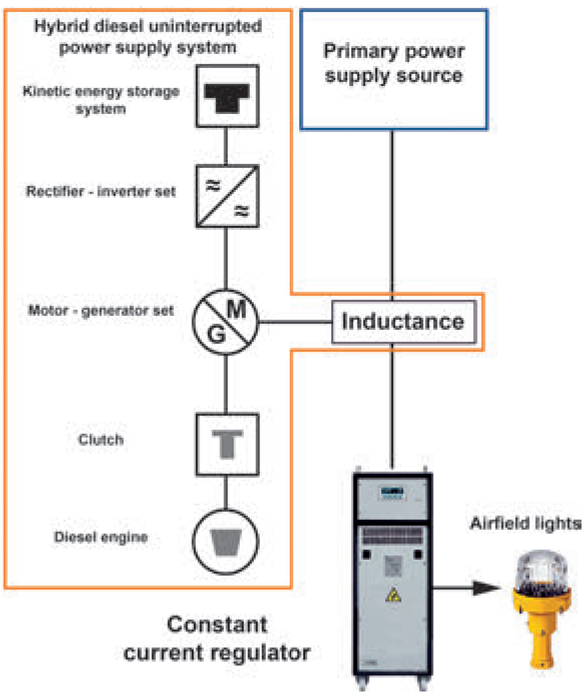


Figure 14: Functional diagram of a diesel hybrid rotary UPS system including a kinetic energy storage system (Source: Piller).

The motor-generator set is connected to the primary power source via a choke. It absorbs load harmonic disturbances and produces a pure sine-wave output power to supply the load. Some hybrid rotary UPS systems are equipped with a motor-generator set with separate windings having the same stator and the same rotor.

In normal mode of operation, the motor-generator set and airfield lighting aids are powered by the primary power source while the inertia flywheel stores kinetic energy.

When the primary power source fails, airfield lighting aids are supplied by the motor-generator set which itself is driven by either of the following:

- the kinetic energy storage system, in case of micro-disconnection, or
- the diesel engine, in case of longer disconnections (for several seconds).

In case of an internal malfunction in the hybrid rotary UPS system, the static by-pass switch turns on and airfield lighting aids are supplied directly from the primary power supply system.

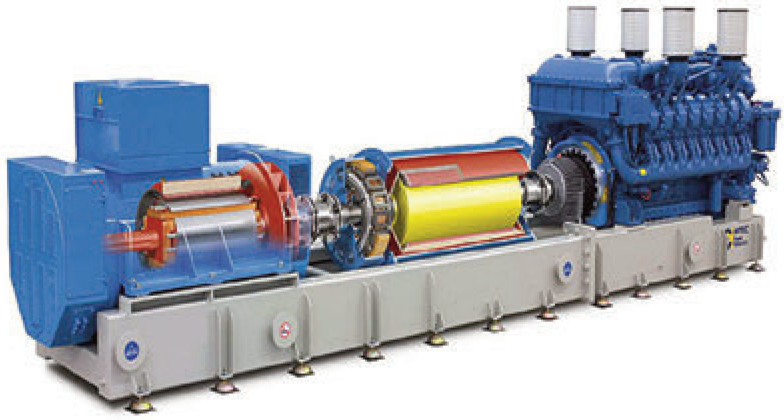


Figure 15: Diesel hybrid rotary UPS system including a kinetic energy storage system (Source: HITEC Power Protection).

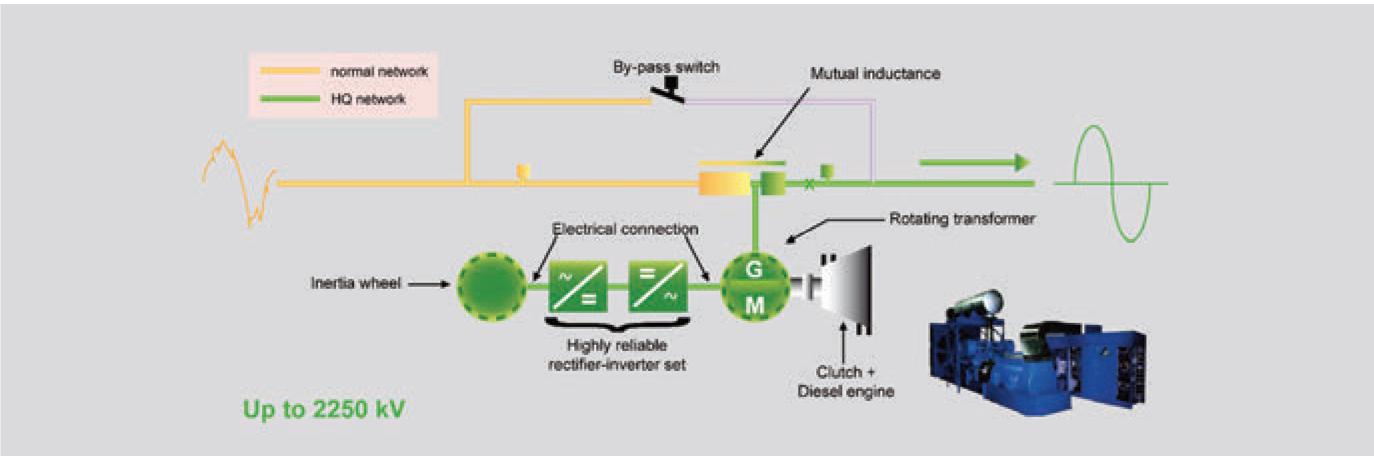


Figure 16: Functional diagram of power supply systems for airfield lighting aids including a diesel rotary UPS system.

5. MAINTENANCE OF POWER SUPPLY FACILITIES AT AERODROMES

5.4. RECOMMENDED PREVENTIVE MAINTENANCE OPERATIONS

See section 7.6 for summaries of recommended preventive maintenance operations to be carried out on power supply facilities at aerodromes (one summary per type of facilities and one summary per periodicity).

5.4.1. ELECTRICAL PREMISES

5.4.1.1. GENERAL

For extended electrical facilities, power distribution system may be spread over several remote electrical premises (distribution substations, premises for constant current regulators, ...) powered at high voltage A or low voltage.

In order to ensure the reliability of airfield lighting facilities, electrical equipment installed in electrical premises should be operated in a clean and dry environment and within the temperature and humidity ranges defined by manufacturers.

Space arrangement of electrical premises should be rational and functional and should ensure adequate and sufficient safety conditions to maintenance operators carrying out operations on this electrical equipment in case of failure.

Figure 17: Substation for the power supply of airfield lighting systems at Paris Orly aerodrome.

5.4.1.2. FOLLOW-UP NOTEBOOK

Preventive and corrective maintenance operations should be recorded in a follow-up notebook (one per electrical premises) or in the CMMS. The follow-up notebook should keep track of all the operations carried out in the electrical premises, in a synthetic manner, and should contain at least, for any operation, the following items:

- the entry date and time,
- the names of and the signatures by anyone present,
- the purpose of the inspection,
- a short description of the operation,
- the reference of the operation, if scheduled, and
- the exit time.

Figure 18: Substation for the power supply of airfield lighting systems at Toulouse Blagnac aerodrome.

5.4.1.3. CHECKLIST ITEMS

The following visual checks should be carried out on electrical premises to meet the objective described by section 5.4.1.1:

- checking the electrical premises for over-all condition:
  - cleanness (floor, walls, …),
  - waterproofness (absence of water infiltration into or water flow onto electrical devices),
  - ventilation and/or air conditioning,
  - absence of rodents or birds, and
  - absence of clutter in hallways.
- checking the technical documents for availability and update:
  - the diagrams and the mimic diagrams of the facilities,
  - the identification labels of the equipment, and
  - the maintenance follow-up notebook,
- checking the personal protective equipment for availability and compliance with the applicable standards,
- checking the spare parts for adequate storage conditions and accessibility,
- checking the gutters for over-all condition and presence of cover plates, and
- checking the self-powered emergency lighting system for serviceability.

Other safety equipment shall be checked but are outside the scope of this guide (smoke or fire detectors, leak detectors for tanks, intrusion detectors, fire extinguishers, …).

5.4.1.4. PERIODICITY OF CHECKS

Each of the visual checks as listed above for electrical premises should be carried out every six months. The periodicity should be adapted, depending on the possible changes to the facilities or depending on the presence or absence of heat engines such as engine generators. A general visual check of electrical premises should be performed by maintenance operators when carrying out operations inside them.

5.4.2. HV BAYS AND HV POWER DISTRIBUTION NETWORKS

5.4.2.1. GENERAL

HVA distribution substations and HVA/LV transformer substations are generally fitted with precast bays, each one fulfilling a specific function (supply, disconnecting, HV protection, LV protection, ...).

Each bay may be equipped with disconnectors, switch-disconnectors, circuit-breakers, contactors, fuses, etc.

Figure 19 : HVA substation at Marseille aerodrome.

5.4.2.2. APPLICABLE STANDARDS

- NF C13-100 standard (April 2015): Consumer substations supplied by a HVA public distribution system (up to 33 kV)
- NF C13-200 standard (June 2018): High voltage electrical systems for electrical power generation sites, industrial, tertiary and agricultural sites
- NF C15-100 standard (June 2005): Low voltage electrical systems

5.4.2.3. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for HV bays and HV power distribution systems should include the following operations:

- periodic preventive maintenance operations other than preventive maintenance operations of level I, II, III or IV:
  - running opening and closing cycles on the disconnectors and the circuit-breakers, and
  - inspecting visually the ambient operating conditions (temperature, humidity, ventilation, ...).

- preventive maintenance operations of level I, II, III or IV:
  - checking the power distribution networks for proper identification,
  - dusting,
  - visually checking for rust,
  - checking the connections for looseness and tightening,
  - checking the anchor clamps for cleanness, cleaning and greasing,
  - checking the interlocks,
  - checking the control and manoeuvring units for cleanness and serviceability, cleaning and greasing,
  - replacing the wearing parts,
  - measuring the switching on and switching off times,
  - checking the connections for simultaneity of contacts,
  - measuring the contact resistances,
  - checking the oil and SF_6 pressure levels,
  - checking the protection relays,
  - checking and testing the electric signalling,
  - etc.

5.4.2.4. PERIODICITIES OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations on HV bays and HV power distribution networks should be carried out in accordance with manufacturer's instructions. Preventive maintenance operations of level I, II, III or IV should be performed every three years and other periodic preventive maintenance operations should be performed yearly.

5.4.3. TRANSFORMERS

5.4.3.1. GENERAL

Transformers are part of the essential and critical devices of electrical systems. In case of failure, consequences may be significant (power supply interruption for all or part of the electrical system, fire, ...).

Being highly sensitive to lightning, over-voltage, high temperature, components aging and pollution hazards, transformers shall be maintained to ensure the continuity and the safety of aircraft operations.

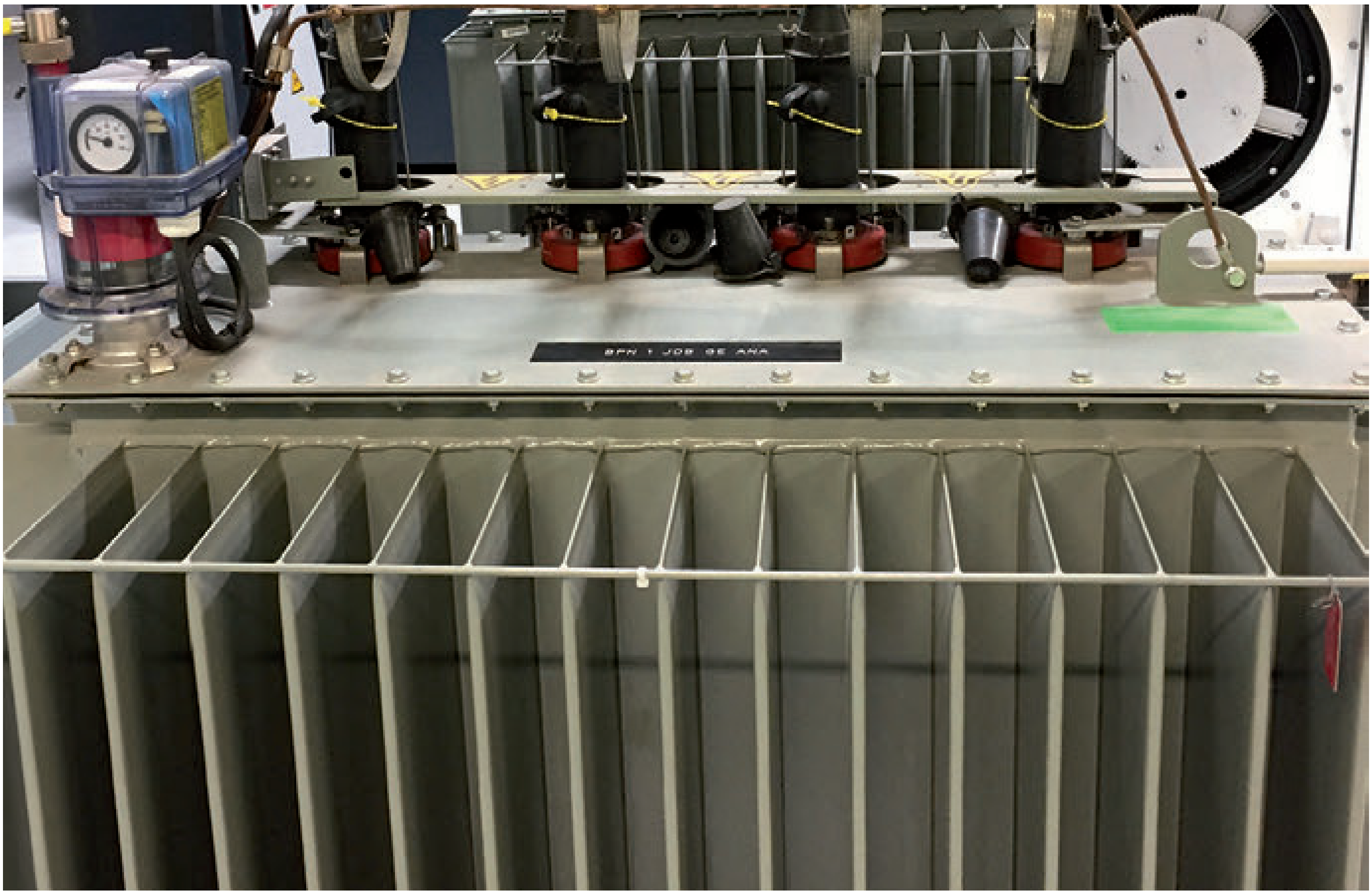


Figure 20: HVA/LV transformer at Nice aerodrome.

5.4.3.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for transformers should include the following operations (of level I, II, III or IV):

- over-all cleaning,
- visually checking for rust,
- for oil transformers only: visually checking for leaks,
- checking the connections for looseness, tightening,
- checking the equipotential bonding system,
- checking the interlocks,
- searching for hotspots due to bad connections, overloads or phase unbalances,
- checking the protective devices,
- measuring the insulation resistance,
- measuring the transformation ratios,
- measuring the power factor, checking the insulating parts for insulation faults,
- checking the oil level, replacing the seals of the tank, the busbar and the spade terminals, and
- analysing the oil.

5.4.3.3. PERIODICITIES OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations on transformers should be carried out in accordance with manufacturer's instructions. Preventive maintenance operations of level I, II, III or IV should be carried out every three years.

5.4.4. ENGINE GENERATORS

5.4.4.1. GENERAL

Given the requirement for the provision of a secondary power source to ensure the continuity of aircraft operations whatever the visibility conditions, engine generators shall be regularly maintained. Maintenance of engine generators helps extend their lifetime as well as ensure their availability and proper working.

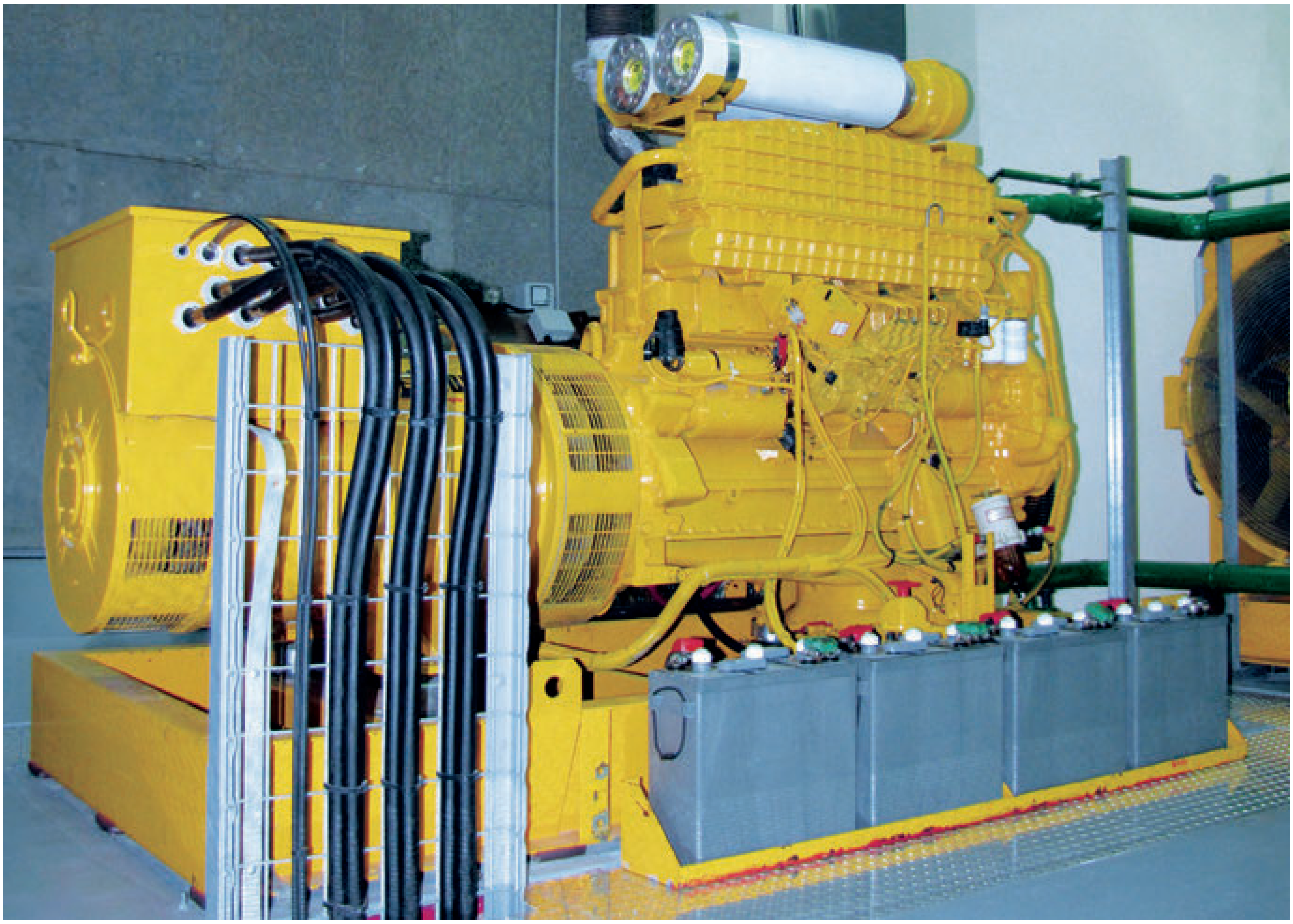


Figure 21: 400 kV.A engine generator at Saint Pierre aerodrome.

5.4.4.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for engine generators should include at least the following operations:

- checking the over-all condition,
- checking, by means of a torque wrench, the tightening torques of connections of electrical equipment for looseness,
- checking the battery charge level,
- checking the electrolyte level,
- cleaning the battery terminals,
- checking the compressed air system (the compressor, the air receiver tank, the pipes) in case of air starting,
- checking the electrical equipment for over-all condition,
- cleaning the relays and the contactors, and
- running functional tests under real operating conditions with airfield lighting facilities being operated at the maximum brilliancy step.

The following additional preventive maintenance operations are specific for diesel engines (non-exhaustive list provided only as guidance):

- checking the oil and coolant levels,
- checking the air and fuel filters,
- running functional tests at the rated speed and at 50 - 70 % of the maximum load for 30 minutes minimum,
- draining the engine oil and replacing the oil filter,
- replacing the fuel filter part(s),
- checking the ventilation system,
- checking the supports,
- checking for equipotential bonding,
- checking the belt and the automatic tensioner for tension,
- checking, draining and flushing the cooling circuit,
- checking the air inlet system,
- checking the exhausts,
- checking and setting the engine speed,
- setting the valve lash,
- replacing the injectors,
- checking the storage tank and the daily-supply tank, and
- checking the fluid circuits.

5.4.4.3. PERIODICITIES OF PREVENTIVE MAINTENANCE OPERATIONS

A preventive maintenance plan specifying the schedule for and the nature of maintenance operations on engine generators should be drawn up in accordance with the manufacturer's instructions, the number of operating hours and the ambient operating conditions.

Preventive maintenance operations of first level (checking indicators and oil levels, running functional tests) should be carried out every week (or about every 10 operating hours). Preventive maintenance operations of level II or more (draining of the engine oil, replacement of the filters, ...) should be carried out every year (or about every 500 operating hours).

5.4.5. LOW VOLTAGE MAIN DISTRIBUTION BOARDS (LVMDB), LOW VOLTAGE DISTRIBUTION BOARDS (LVDB) AND LOW VOLTAGE POWER DISTRIBUTION NETWORKS

5.4.5.1. GENERAL

The LVMDB is the key point of the power distribution of an electrical system. It may comprise one or several LVDB.

The LVMDB shall ensure, as follows:

- power distribution to the various electrical circuits,
- protection of power distribution lines and equipment,
- protection of persons.

The LVMDB may be redundant to ensure power supply continuity. It may supply circuits either directly or through one or several interconnected low voltage distribution boards forming a low voltage power distribution network.

For extended electrical systems, each electrical premises or substation may include one or several LVMDB.

Figure 22: LVMDB at Paris Orly aerodrome.

5. MAINTENANCE OF POWER SUPPLY FACILITIES AT AERODROMES

Parallel connected runway equipment mentioned in the next section are usually, as follows:

- flashing lights such as runway threshold identify cation lights and sequence-flashing centre line lights for approach lighting systems,
- obstacle lights,
- wind direction indicators, and
- 24 or 48 V DC power supply units.

At some aerodromes, the following airfield lighting aids may also be parallel connected:

- luminous signs, and
- runway guard lights (using a voltage booster or step-down transformer).

Figure 23: Distribution board for signs and runway guard lights.

5.4.5.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for LVMDB, LVDB and LV power distribution networks should comply with the applicable standards such as NF C15-100 standard and shall include the following operations:

- checking the distribution boards for overall condition and cleanness, cleaning,
- checking the ventilation systems, the electrical pipes, the switchgears and the control gears of the distribution boards for general condition,
- checking the overall drawings and mimic diagrams for availability, update by maintenance staff and consistency,
- checking the protection ratings and the interlocks,
- checking the busbars and the terminals for general condition, tightness, tightening, thermographic inspection for hot spots,
- checking the cable conductors for tightness,
- checking the cable reinforcement,
- checking the drawout devices (fixed parts and moving parts),
- checking the insulation controllers (in case of IT system as neutral point treatment),
- checking the indicator lights and the measuring stations,
- running mechanical and electrical tests on the switchgears and the control gears,
- measuring the earth terminal resistance,
- measuring the insulation resistance of the busbars (supporting structure, configuration) for insulation defects,
- measuring the insulation resistance between the neutral and the phase conductors and between the earth and the phase conductors of the outgoing feeders to remote and parallel connected systems,
- measuring the electrical continuity resistance of the equipotential bonding system of the outgoing feeders to remote and parallel connected systems, and
- measuring the electrical continuity resistance of the protective conductors of the outgoing feeders to remote and parallel connected systems.

5.4.5.3. PERIODICITIES OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations on LVMBD, LVDB and LV power distribution networks as listed above shall be carried out every year.

Additional specific preventive maintenance operations as defined by the manufacturer may be required for some devices (masterpacks, static transfer switches, static switches, ...).

The ageing of LVMDB, LVDB and their components should be assessed every ten years.

5.4.6. STATIC TRANSFER SWITCHES

5.4.6.1. GENERAL

Static transfer switches, as compared to electromechanical switches, may be used to achieve reduced detection and switching times, and in some cases, to meet the one-second requirement for the switch-over time, when the secondary power source is operated in reverse mode. (See section 5.3.2.1.)

Being able to ensure the full separation of either of the power supply sources from the distribution circuit, whatever the operating conditions, static transfer switches may also be used in combination with two independent power supply sources to meet the requirement for power supply sources redundancy.

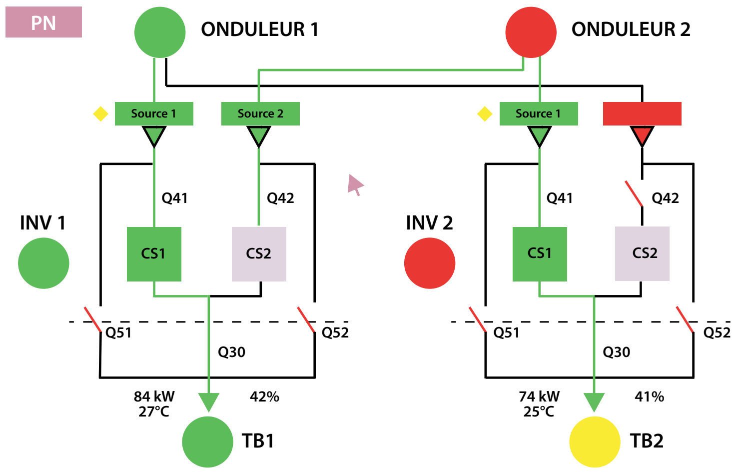


Figure 24: Monitoring of static transfer switches at Lyon aerodrome.

5.4.6.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for static transfer switches should include the following operations:

- measuring the load voltages and currents,
- checking the components,
- cleaning and dusting the outside and inside parts,
- checking the connections for tightness, tightening,
- running functional tests on the by-pass switches,
- checking the event logs and alarms,
- checking the indicator lights, and
- updating the software.

5.4.6.3. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations on static transfer switches should be carried out yearly (in accordance with manufacturer's instructions), by a qualified technician.

5.4.7. UNINTERRUPTED POWER SUPPLY (UPS) SYSTEMS

5.4.7.1. GENERAL

The operating life of static UPS systems depends on several factors such as their loading conditions (rate of usage, linearity, variability) and their ambient operating conditions (temperature, humidity, level of pollution).

The nominal operating temperature of the batteries is about 25°C, as indicated by the manufacturer. Lower or higher operating temperatures may have a significant impact on their operating life and their maintenance expenses. As a reminder, a deviation of +/- 5°C from the nominal operating temperature reduces by half the operating life.

Periodic and regular maintenance of UPS systems is essential to ensure their proper working and the power supply continuity of electrical equipment.

5.4.7.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for UPS systems should include the following operations:

- autonomy tests under real operating conditions with visual lighting facilities being operated at the maximum brilliancy step,
- periodic preventive maintenance operations other than preventive maintenance operations of level I, II, III or IV:
    - inspecting visually the ambient operating conditions (temperature, humidity, ventilation, ...),
    - running functional tests on the HMI systems,
    - and analysing the history data.
- preventive maintenance operations of level I, II, III or IV:
    - measuring the input and output currents and voltages,
    - measuring the power consumption,
    - searching for hotspots,
    - running functional tests on the internal by-pass switch,
    - checking the components,
    - cleaning and dusting the outside and inside parts,
    - checking the connections for tightness, tightening,
    - checking and, if necessary, replacing the batteries, and
    - updating the software,

Figure 25: UPS system at Saint Denis La Réunion aerodrome.

5.4.7.3. PERIODICITIES OF PREVENTIVE MAINTENANCE OPERATIONS

A preventive maintenance plan specifying the schedule for and the nature of preventive maintenance operations on UPS systems should be drawn up in accordance with the manufacturer's instructions.

The autonomy of UPS systems should be tested every six months. Preventive maintenance operations of level I, II, III or IV on UPS systems should be carried out every year. Other periodic preventive maintenance operations on UPS systems should be carried out every two weeks.

Electrical quantities measurements performed by the measuring station of the UPS may be used.

5.4.8. SPECIFIC CASE OF HYBRID ROTARY UPS SYSTEMS (NO-BREAK SYSTEMS)

5.4.8.1. OUTSOURCING OF MAINTENANCE OPERATIONS

Due to their level of complexity and criticality, preventive and corrective maintenance of no-break systems shall be sub-contracted to a specialized company.

Figure 26: Diesel rotary UPS system in a container unit at Toulouse Blagnac aerodrome.

The maintenance outsourcing contract should include the following requirements for the company in charge of the maintenance operations:

- the company should establish its own preventive maintenance program (electrical and mechanical visual inspections, replacement of the fluids, the filters and the wearing parts, mechanical overhaul operations, etc.),
- the company should plan preventive maintenance operations in agreement with the aerodrome operator,
- the company should provide repair services within a minimum period as negotiated with the aerodrome operator, and
- the company should train the aerodrome maintenance staff for monitoring operations and possible preventive maintenance operations of first level.

However, the following preventive maintenance operations on no-break systems should be carried out by the aerodrome maintenance staff:

- maintenance operations of level I (checking the indicator lights, checking the measurements from measuring stations, checking for leaks, etc) and
- functional tests with visual lighting aids being operated at the maximum brilliancy step..

5.4.8.2. PERIODICITIES OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations of level I on no-break systems should be carried out every week. Functional tests with visual lighting facilities being operated at the maximum brilliancy step should be carried out every month.

5.4.9. LIGHTNING PROTECTION SYSTEMS (LPS)

5.4.9.1. APPLICABLE STANDARDS

- NF C15-100 standard (June 2005): Low voltage electrical systems.
- NF EN 62305 standard: Protection against lightning – Part 3: Physical damage to structures and life hazard.
- NF EN 61643 standard: Low voltage surge protective devices:
  - Part 11: Surge protective devices connected to low voltage systems – Requirements and test methods.
  - Part 12: Surge protective devices connected to low voltage power distribution systems – Selection and application principles.
- NF EN 50164 standard: Lightning Protection Components (LPC).
- NF C17-102 standard: Lightning protection systems with early streamer emission air terminal.
- UTE C15-443 standard: Protection of low voltage electrical systems against over-voltages of atmospheric discharges or switching – Selection and erection of surge protective devices.

5.4.9.2. GENERAL

Lightning protection systems include External Lightning Protection Systems (ELPS) and Internal Lightning Protection Systems (ILPS).

ELPS are intended for capturing direct lightning strikes and dissipating lightning currents into the ground without damaging the facilities and without overvoltage that may be hazardous to persons. ELPS are made of the following items:

- a lightning air terminal intended for capturing lightning strikes,
- a down conductor intended for flowing lightning currents into the ground, and
- an earth termination system intended for dissipating lightning currents while limiting hazards to the systems and the persons close to the facilities.

Figure 27: External lightning protection system and lightning air terminal at Toulouse Blagnac aerodrome.

ILPS consist of protective equipotential bonding and Surge Protective Devices (SPD) commonly referred to as surge arresters or lightning arresters.

ILPS are intended for partly reducing the following indirect effects of lightning:

- transient overvoltage,
- electromagnetic induction, and
- spark-over causing fire, explosion, chemical pollution or electromagnetic pollution hazards.

Any installed LPS shall be classified according to its Lightning Protection Level (LPL) ranging from I to IV, defined by NF EN 62305 standard and based on the likelihood of physical damages to or internal default in the power supply systems in case of lightning strike on the facilities.

Due to corrosion, weather-related damages, mechanical damages and lightning-related damages, LPS components may lose effectiveness over time. Regular maintenance is therefore recommended to ensure they are not damaged and they still meet the requirements for which they were designed.

5.4.9.3. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The aerodrome maintenance plan shall specify the preventive maintenance programme for LPS.

The preventive maintenance programme for LPS should include the following operations:

- checking all the conductors and components,
- measuring the electrical continuity resistance,
- measuring the resistance of the earth termination system,
- checking the components and the connections of conductors for tightness, tightening,
- checking the mechanical protection of the components and the conductors,
- running functional tests after any modification of the facilities,
- checking the status indicators for conformance to manufacturer's instructions, and
- checking the circuit-breakers combined with surge protective devices.

Additional checks that shall be carried out by specialized organisms, as required by NF EN 62305-3 standard.

5.4.9.4. PERIODICITIES OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance plan for a LPS and the schedule for the required operations should be drawn up by the installer or the designer, in agreement with the aerodrome operator, when designing it.

The periodicity of additional checks required by NF EN 62305-3 standard and that shall be carried out by specialized organisms, depends on the type and the geographical location of the facilities.

5.4.10. REACTIVE POWER COMPENSATION DEVICES

5.4.10.1. GENERAL

Some aerodrome operators choose to equip their electrical systems (mainly those powered at low voltage) with energy storage capacitors to reduce the reactive part of apparent consumed power.

The available active power is therefore increased, which provides the three following advantages:

- decrease in power consumption,
- reduction in the size of installations (power cables cross-section, line loss, voltage drop), and
- improvement of environmental protection.

Figure 28: Low voltage energy storage capacitors at Tahiti FAA'A aerodrome

5.4.10.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for reactive power compensation devices should include the following operations:

- inspecting visually the ambient operating conditions (temperature, humidity, ventilation, ...), the shell and the various parts,
- dusting and cleaning the outside and inside parts,
- checking the connections for tightness, tightening,
- checking the settings,
- recording and analysing the alarms from the control system,
- checking the protectors,
- checking the capacitors,
- checking the protection relays, and
- measuring the voltage at the terminals of and the current intensity flowing through the capacitor stacks.

5.4.10.3. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

The periodicity of maintenance operations on reactive power compensation devices may vary, depending on its intensity of use and its ambient operating conditions. Preventive maintenance operations on reactive power compensation devices should be carried out yearly (in accordance with the manufacturer's instructions), by qualified operators.

5.4.11. ACTIVE HARMONIC CURRENT COMPENSATION DEVICES

5.4.11.1. GENERAL

Constant current regulators constitute non-linear loads. They absorb non-sinusoidal currents which, given the circuit impedances, distort the sinusoidal voltage. This phenomenon is referred to as harmonic distortion.

Some aerodrome operators use harmonics filters to meet the following objectives:

- avoid unnecessary protection tripping,
- ensure proper working of electrical systems,
- decrease power consumption, and
- save the maintenance expenses of systems.

Figure 29: Active harmonic current compensation device SineWave 60 A at Paris CDG aerodrome.

5.4.11.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for active harmonic current compensation devices should include the following operations:

- measuring the load currents and voltages,
- measuring the load currents spectrum,
- searching for hotspots,
- checking the components,
- dusting and cleaning the inside and outside parts,
- tightening the connections,
- checking the settings,
- checking the light indicators, and
- updating the software.

5.4.11.3. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

As a rule, preventive maintenance operations on active harmonic current compensation devices should be performed yearly (in accordance with the manufacturer's instructions) by qualified staff.

5.4.12. PROGRAMMABLE LOGIC CONTROLLERS (PLC)

5.4.12.1. GENERAL

A PLC is a programmable electronic system intended for automating processes such as the control and monitoring process of airfield lighting facilities and the control process of primary and secondary power supply systems.

A preventive maintenance programme for PLC should be implemented to increase their life duration and reduce malfunction risks of automated systems.

Figure 30: Programmable logic controller at Nice aerodrome.

5.4.12.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for PLC should include the following operations:

- checking the ambient operating conditions (temperature, humidity, ...),
- checking the surrounding space for heat-dissipation clearance,
- dusting and cleaning,
- checking the LED indicators located on the front side,
- checking the battery and the indicator lights of the power supply system,
- measuring the power supply voltage,
- replacing the cell (in accordance with manufacturer's instructions),
- checking the connections,
- checking the programme for update and availability and
- checking the spare parts set for availability.

5.4.12.3. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations on PLC should be performed yearly.

5.4.13. 24 OR 48 V DC POWER SUPPLY UNITS

5.4.13.1. GENERAL

Control and monitoring systems (HMI systems, control and display units, PLC, ...) for power supply and airfield lighting facilities at aerodromes may be supplied by 24 or 48 V DC power sources. Specific power supply units fitted with batteries may therefore be installed to supply these systems.

Given the importance of these systems, their power supply units should be redundant to ensure power supply continuity in case of failure of one of the units. In addition, preventive maintenance operations should be stringently performed to reduce default risks.

5.4.13.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for 24 or 48 V DC power supply units should include the following operations (of level I, II, III or IV):

- checking the ambient operating conditions (temperature, humidity, ...),
- checking the surrounding space for the heat-dissipation clearance,
- dusting and cleaning the outside and inside parts,
- checking the HMI systems,
- measuring the input power supply voltage,
- measuring the output voltage,
- checking the indicator lights and the display unit located on the front side of the rectifier,
- checking the connections,
- running autonomy tests and, if necessary, replacing the battery

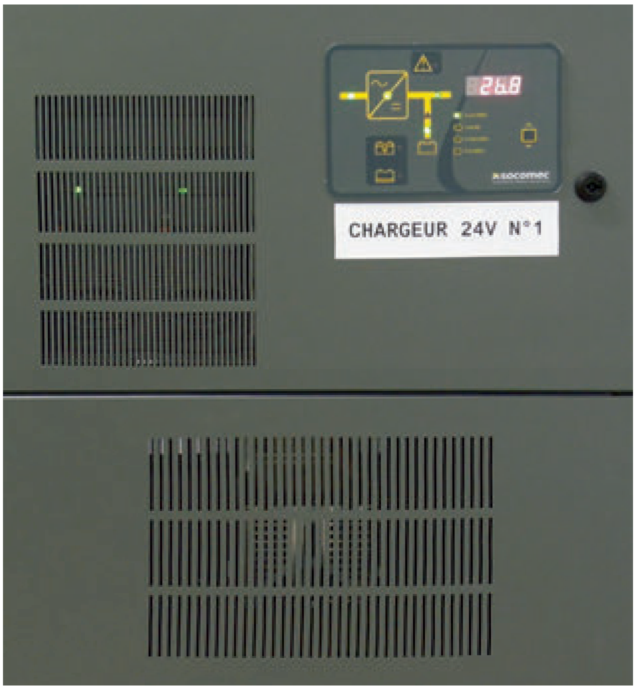


Figure 31: 24 V DC charger / rectifier at Toulouse Blagnac aerodrome.

5.4.13.3. PERIODICITIES OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations of level II, III or IV on 24 or 48 V DC power supply units should be performed every year. Preventive maintenance operations of level I on 24 or 48 V DC power supply units should be performed every two weeks, in accordance with manufacturer's instructions.

5.4.14. POWER SUPPLY SYSTEMS FOR AIRFIELD LIGHTING

As part of the preventive maintenance programme, the aerodrome operator should perform periodic routine and specialized tests on power supply systems for airfield lighting to ensure their reliability.

Routine and specialized tests performed on power supply systems for airfield lighting to check their reliability should be carried out in each of the various possible operating configurations of the power supply systems.

5.4.14.1. ROUTINE TESTS

Routine tests performed on power supply systems for airfield lighting to check their reliability are as follows:

- running start test on engine generators at full load, and
- checking the information relayed to air traffic controllers and the technical support service for conformation.

5.4.14.2. SPECIALIZED TESTS

Specialized tests performed on power supply systems for airfield lighting to check their reliability are as follows:

- running restart tests on failure of the primary power source, with airfield lighting aids being illuminated, and
- running reverse mode operation tests with airfield lighting aids being illuminated and with a simulated failure of the engine generator.

While running specialized tests on power supply systems for airfield lighting to check their reliability, the information relayed to air traffic controllers and the technical support service should be checked and the following quantities should be measured and recorded:

- the switch-over time (see section 5.4.14.3 for the measurement method), and
- some electrical quantities such as active power, reactive power, current, voltage, power factor, etc.

Depending on the number of power supply sources (engine generators, UPS systems, hybrid rotary UPS systems) and the various possible configurations of power supply systems for airfield lighting, running numerous tests may be required to ensure the availability of the secondary power supply sources whatever the operating conditions.

See section 7.3 for examples of specialized test form for checking the reliability of power supply systems for airfield lighting systems.

5.4.14.3. MEASUREMENT METHOD OF THE SWITCH-OVER TIME

Measurement of the switch-over time shall be performed from the continuous measurement of the luminous intensity of the airfield light.

Given the operational consequences, measuring the switch-over time for essential airfield lights such as runway edge lights may be performed on a temporary extra light temporarily connected to the series circuit inside the electrical premises of the constant current regulator supplying the circuit. The luminous intensity is deduced from the illuminance which itself may be measured by means of an illuminance meter. A specific device (a recorder or a numeric oscilloscope) may be connected both to the illuminance meter output and to the output of the constant current regulator for voltage measurement, to compare the switch-over time with the power disconnection time.

Such a measurement protocol may be implemented for essential airfield lights such as runway edge lights for precision approach runways category I or runway centre line lights or touchdown zone lights for precision approach runways category II or III.

This measurement protocol may be implemented several times on the same circuit or on any other circuit if the latter includes another model of constant current regulator or LED lights.

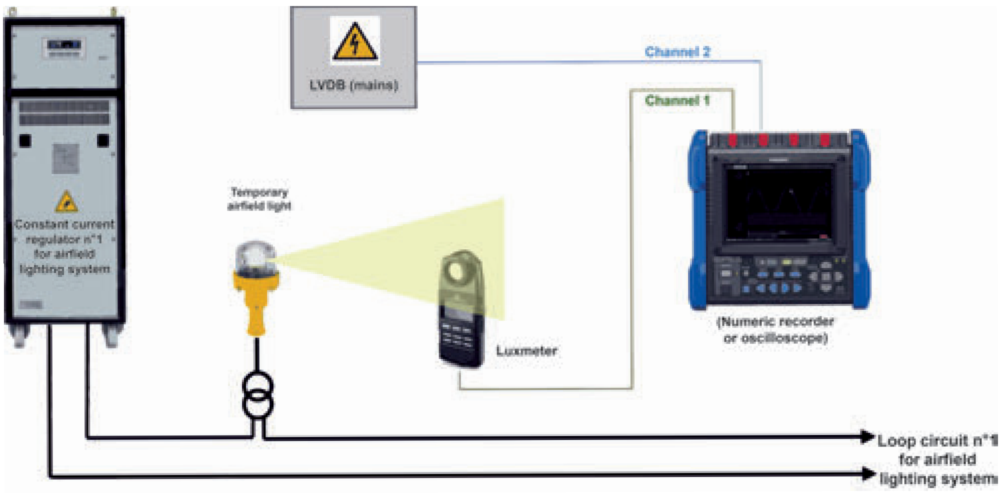


Figure 32: Switch-over time measurement principle.

5.4.14.4. PERIODICITIES OF TESTS

Preventive maintenance plan for the power supply sources for airfield lighting systems should specify the schedule for routine and specialized tests.

Routine tests on the power supply sources for airfield lighting systems should be performed monthly. Specialized tests on the power supply sources for airfield lighting systems, including the switch-over time measurement, should be performed every three year or after any major change to the power supply systems (modification of the power distribution system, replacement of an engine generator, modification of one or several components of an automation system, replacement of a constant current regulator, replacement of all the lights connected to the same series circuit, etc) that may impact the operation of automatic systems or the power consumption.

6. MAINTENANCE OF AIRFIELD LIGHTING FACILITIES

6.1. DESIGN RECOMMENDATIONS

Recommended methods and good practices for the design of airfield lighting systems are described in the technical guide "State of the art of airfield lighting systems design" co-written by the STAC and the UAF-FA, and available on internet, on the STAC website and on www.libelaero.fr.

6.2. FUNCTIONAL REQUIREMENTS

6.2.1. INITIAL FIELD INSTALLATION

Photometric and colorimetric performances of airfield lights and signs shall comply with the requirements of IACO Annex 14, Volume 1 (which are incorporated in EASA rules) for initial field installation.

At French aerodromes where EASA rules apply, the compliance of airfield lights and signs with the applicable requirements may be demonstrated by either of the following:

- a type certificate of conformity issued by the Technical Service of the French Civil Aviation Authority (STAC)[3], or
- a test report issued by a third part body which shall be accredited according to NF ISO/CEI 17025 standard for photo metric and colorimetric testing.

At French aerodromes where the French order of August 28, 2003 on aerodrome approval conditions and operating procedures (CHEA) applies, the compliance of airfield lights and signs already installed at the issuance of this guide shall be demons-trated by a type certificate of conformity issued by the STAC.

Figure 33: Airfield lights samples.

See section 7.8 for further information on the laboratory measurement method of the luminous intensity of airfield lights. See section 7.10 for further information on the requirements and the method for the vertical and the horizontal setting of airfield lights.

(3) A list of the STAC-type-certificated airfield lights and signs is available at www.stac.aviation-civile.gouv.fr.

6.2.2. MAINTENANCE OBJECTIVES

6.2.2.1. GENERAL

A system of preventive maintenance of airfield lighting aids shall be employed to ensure their reliability i.e. to maintain them in a condition which does not impair the safety, regularity or efficiency of air navigation.

The following specifications are intended to define the performance level objectives of preventive maintenance. They are not intended to define whether an airfield lighting system is operationally out of service. The allowable percentage of unserviceability lights are specified with the aim of not altering the basic pattern of the lighting system, to provide continuity of guidance.

An airfield light shall be deemed unserviceable when the main beam average intensity is less than 50 per cent of the minimum value required for field installation, as indicated in Table 8 below for a precision approach runway, in accordance with IACO Annex 14, Volume I, Appendix 2.

Airfield lights		Required minimum value of main beam average light intensity (cd)	
		Initial field installation	Maintenance objective
Approach centre line lights and crossbars (white light)		20 000	10 000
Approach side row lights (red light)		5 000	2 500
Runway threshold lights		10 000	5 000
Runway edge lights	White light	10 000	5 000
	Yellow light	4 000	2 000
	Red light	1 500	750
Runway centre line lights (white light) Touchdown zone lights		5 000	2 500
Runway centre line lights (red light)		750	375
Runway end lights		2 500	1 250

Table 8: Required minimum values of the main beam average light intensity of precision approach lights and precision approach runway lights (for field installation and as maintenance objectives).

Maximum allowable percentages of unserviceable lights are solely specified for precision approach runways and runways meant for take-off with the aim of not altering the basic pattern of the lighting system, to provide continuity of guidance.

Maximum allowable percentages of unserviceable lights specified in sections 6.2.2.2 to 6.2.2.5 (Table 9, Table 10, Table 11 and Table 12) shall be converted into maximum allowable numbers of unserviceable lights, per runway and per lighting system, by rounding down the results to the nearest integers.

In addition to the maximum allowable percentages of unserviceable lights, additional restrictions in terms of adjacency of unserviceable lights, shall apply per lighting system, in order to provide continuity of guidance, as indicated in Table 9, Table 10, Table 11 and Table 12. With respect to barrettes, crossbars and runway edge lights, lights are regarded as adjacent if located consecutively and:

- laterally: in the same barrette or crossbar, or
- longitudinally: in the same row of edge lights or barrettes.

Neither maximum allowable percentage of unserviceable lights nor other restrictions are specified for sequence-flashing approach lights, taxiway edge lights, stopway lights, unserviceability lights and obstacle lights.

6.2.2.2. PRECISION APPROACH RUNWAY, CATEGORY I

Neither maximum allowable percentage of unserviceable lights nor other restrictions are specified for taxiway centre line lights on taxiways other than rapid exit taxiways associated with a precision approach runway, category I.

Airfield lighting system	Restrictions in terms of unserviceable lights	
	Maximum allowable percentage	Additional restrictions
Approach lighting system	15%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
PAPI	Nil	More than one unserviceable light shall not be permitted.
Runway end lights	15%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway edge lights	15%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway centre line lights, if any	15%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway end lights	15%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway treshold Identification Lights (RTIL), if any	Nil	Lights shall flash simultaneously. Lights shall be so designed that they are all automatically turned off in case of failure of one single light.
Rapid exit taxiway centre line lights, if any	Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light.
(Elevated) runway guard lights, type A	Nil	Any unserviceable light shall not be permitted.
(Inset) runway guard lights, type B	Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light. More than two unserviceable lights shall not be permitted.
Intermediate holding position lights	Nil	More than one unserviceable light shall not be permitted.
Mandatory instruction signs	Nil	Signs shall remain legible. Either of the signs installed on each side of the taxiway shall not be altered.
Information signs	Nil	Signs shall remain legible.

Table 9: Maximum allowable percentages of unserviceable lights and related restrictions for precision approach runways, category I.

6.2.2.3. PRECISION APPROACH RUNWAY, CATEGORY II OR III

Airfield lighting system	Restrictions in terms of unserviceable lights	
	Maximum allowable percentage	Additional restrictions
Inner 450 m of approach lighting system	5%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Approach lighting system beyond 450 m	15%	
PAPI	Nil	Any unserviceable light shall not be permitted.
Runway threshold lights	5%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway edge lights	5%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway centre line lights	5%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Touchdown zone lights	10%	An unserviceable light shall not be permitted adjacent to another unserviceable light. More than one unserviceable light per barrette shall not be permitted.*
Runway end lights	15%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway Treshold Identification Lights (RTIL)	Nil	Lights shall flash simultaneously. Lights shall be so designed that they are all automatically turned off in case of failure of one single light.
Taxiway centre line lights – Rapid exit taxiways**	10%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Taxiway centre line lights – Taxiways intended for use in RVR < 350m	Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Taxiway centre line lights – Other taxiways	Nil	Three adjacent unserviceable lights shall not be permitted.
Stop bar lights	Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light. More than two unserviceable lights shall not be permitted.
Taxiway centre line lights beyond a stop bar	Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light. More than two unserviceable lights shall not be permitted.
(Elevated) runway guard lights, type A	Nil	Any unserviceable light shall not be permitted.
(Inset) runway guard lights, type B	Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light. More than two unserviceable lights shall not be permitted.
Intermediate holding position lights	Nil	More than one unserviceable light shall not be permitted.
Mandatory instruction signs	Nil	Signs shall remain legible. Either of the signs installed on each side of the taxiway shall not be altered.
Information signs	Nil	Signs shall remain legible.

*A touchdown zone barrette shall be composed of at least three touchdown zone lights. Touchdown zone barrettes shall be symmetrically located about the runway centre line.
** Only lights showing alternately yellow and green: from the first (green) light near the runway centre line to the nearest (yellow) light to the perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface, whichever is the farthest from the runway.

Table 10: Maximum allowable percentages of unserviceable lights and related restrictions for precision approach runways, category II or III.

6.2.2.4. RUNWAY MEANT FOR TAKE-OFF IN RVR CONDITIONS LESS THAN A VALUE OF 550 M

Airfield lighting system		Restrictions in terms of unserviceable lights	
		Maximum allowable percentage	Additional restrictions
Runway edge lights		5%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway centre line lights		5%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway end lights		25%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Taxiway centre line lights	Taxiways intended for use in RVR < 350m	Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light.
	Other taxiways	Nil	Three adjacent unserviceable lights shall not be permitted.
Stop bar lights		Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light. More than two unserviceable lights shall not be permitted.
Taxiway centre line lights beyond a stop bar		Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light. More than two unserviceable lights shall not be permitted.
(Elevated) runway guard lights, type A		Nil	Any unserviceable light shall not be permitted.
(Inset) runway guard lights, type B		Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light. More than two unserviceable lights shall not be permitted.
Intermediate holding position lights		Nil	More than one unserviceable light shall not be permitted.
Mandatory instruction signs		Nil	Signs shall remain legible. Either of the signs installed on each side of the taxiway shall not be altered.
Information signs		Nil	Signs shall remain legible.

Table 11: Maximum allowable percentages of unserviceable lights and related restrictions for runways meant for take-off in RVR conditions less than a value of 550 m

6.2.2.5. RUNWAY MEANT FOR TAKE-OFF IN RVR CONDITIONS OF A VALUE OF 550 M OR GREATER

Airfield lighting system	Restrictions in terms of unserviceable lights	
	Maximum allowable percentage	Additional restrictions
Runway edge lights	15%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Runway end lights	15%	An unserviceable light shall not be permitted adjacent to another unserviceable light.
Taxiway centre line lights	Nil	Three adjacent unserviceable lights shall not be permitted.
(Elevated) runway guard lights, type A	Nil	Any unserviceable light shall not be permitted.
(Inset) runway guard lights, type B	Nil	An unserviceable light shall not be permitted adjacent to another unserviceable light. More than two unserviceable lights shall not be permitted.
Intermediate holding position lights	Nil	More than one unserviceable light shall not be permitted.
Mandatory instruction signs	Nil	Signs shall remain legible. Either of the signs installed on each side of the taxiway shall not be altered.
Information signs	Nil	Signs shall remain legible.

Table 12: Maximum allowable percentages of unserviceable lights and related restrictions for runways meant for take-off in RVR conditions of a value of 550 m or greater.

6.3. RECOMMENDED MAINTENANCE OPERATIONS

See section 7.6 for summaries of recommended preventive maintenance operations for airfield lighting facilities (one summary per type of facilities and one summary per periodicity).

6.3.1. CONSTANT CURRENT REGULATORS (CCR)

6.3.1.1. GENERAL

As a rule, the design of the power supply systems for airfield lighting aids is based on that of series circuits. Airfield lights and some airfield signs are supplied by constant current regulators which themselves are controlled and may be set at different current steps.

Current step values depend on the number of brilliancy steps. Typical current step values used for airfield lighting aids are as follows:

- when using a 4-step CCR : 3,3 A – 4,4 A – 5,5 A – 6,6 A or,
- when using a 5-step CCR : 2,8 A – 3,4 A – 4,1 A – 5,2 A – 6,6 A.

CCR are current generators capable of supplying current for output loads up to and including 30 kV.A. HVA voltages may be obtained from them.

Figure 34: Thyristor CCR at Pointe à Pitre aerodrome.

6.3.1.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

The preventive maintenance programme for a CCR should be in accordance with manufacturer's instructions and should include the following operations:

- checking the parts for cleanness, dusting the bottom parts of cabinets to ensure their proper cooling, dusting the printed boards and the low or high voltage parts for cleanness,
- checking the power supply connections, the earthing connections, the connections to series circuit and the internal connections (the screws and the terminal blocks) for tightness, tightening the connections and inspecting the connections for hotspots (possibly by means of a thermographic camera),
- checking the surge arresters for general condition,
- measuring the insulation resistance of the supplied primary loop circuit (see section 7.5.1.2 for the measurement method),
- measuring the electrical continuity resistance of the supplied primary loop circuit (see section 7.5.2.2 for the measurement method),
- checking the control and command system for proper functioning,
    - checking the supplied current value measured by the control and command system for conformation with the setpoint value at each brilliancy step,
    - checking the ability of the control and command system to detect and report malfunctions within the expected time frame,
- checking and, if necessary, adjusting the power setting for suitability to the estimated load of the supplied primary loop circuit (see section 7.5.3.2 for detailed information on the computation method of the load of a primary loop circuit for an airfield lighting system)
- analysing and archiving the follow-up form.

6.3.1.3. FOLLOW-UP

Any servicing work, any checking of or any change to the power setting performed on a CCR should be recorded in a specific follow-up form (one follow-up form per CCR).

The maintenance follow-up form for a CCR should mention at least, as follows:

- the date of the checking,
- the name of and the signature by the operator,
- the supplied airfield lighting system,
- the overall load of the supplied primary loop circuit and the power setting of the CCR,
- the estimated length of the supplied primary loop circuit,
- the number of supplied systems: insulating transformers, lights and signs, etc,
- the measured values of the insulation resistance and the electrical continuity resistance of the supplied primary loop circuit when putting the circuit into operation, referred to as reference values,
- the measured values of the insulation resistance and the electrical continuity resistance of the supplied primary loop circuit when carrying out a maintenance operation, and
- the detected and reported malfunctions, if any, and the related corrective actions.

See section 7.5.4.2 for an example of follow-up form for a CCR.

6.3.1.4. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations on a CCR should be carried out according to the following periodicities:

- the supplied current value measured by the control and command system shall be checked every month for conformation with the setpoint value at each brilliancy step,
- the surge arresters shall be checked every six months or after any storm event for general condition,
- the insulation resistance and the electrical continuity resistance shall be measured every six months as well as before and after any operation on any part (insulating transformer, connector, power cable) of the supplied primary loop circuit,
- the ability of the control and command system to detect and report malfunctions within the expected time frame shall be checked every six months, and
- the following operations shall be carried out every year:
  - checking the parts for cleanness,
  - checking the connections for tightness and hotspots,
  - checking and, if necessary, adjusting the power setting for suitability to the estimated load of the supplied primary loop circuit, and
  - analysing and archiving the follow-up form.

6.3.2. SAFETY EXTRA LOW VOLTAGE (SELV) AND PROTECTIVE EXTRA-LOW VOLTAGE (PELV) CIRCUITS

Some designers of power supply systems for airfield lighting systems may choose to install extra low voltage secondary circuits on series circuits for airfield lighting. The safety of maintenance staff is therefore improved during possible live operations such as replacements of an airfield lamp or light.

The implementation of extra low voltage circuits may be achieved through the emergence of new lighting technologies requiring reduced wattage consumption and therefore reduced voltages.

Design and installation procedures of extra low voltage circuits shall comply with the requirements of IEC 62870:2015 standard. Extra low voltage circuits may be either of the following:

- Safety Extra Low Voltage (SELV) circuits, where, in any case, lights shall not be connected to the earth, or
- Protective Extra-Low Voltage (PELV) circuits, where lights may be connected to the earth.

In any case, the root-mean-square value of the alternative voltage at any light terminals shall be limited to 50 V in dry conditions.

Monitoring and preventive maintenance requirements for SELV circuits should be enhanced to maintain optimum values for the insulation resistance of power cables.

6.3.3. SYSTEMS OF REMOTE CONTROL AND MONITORING OF AIRFIELD LIGHTING SYSTEMS

6.3.3.1. GENERAL

Systems of remote control and monitoring of airfield lighting systems include all the systems necessary for the control, the command and the automatic monitoring of airfield lighting systems. They may be divided into several functional assemblies, as follows:

- regarding the Air Navigation Service Provider (ANSP):
  - the HMI systems intended for Air Traffic Service (ATS): the remote control and command deck in the Air Traffic Control (ATC) tower,
  - the HMI systems intended for the technical support service,
  - the systems of management of all HMI systems, including those of monitoring and recording systems, and
  - the communication interfaces between ATS and the aerodrome operator,

Figure 35: Control and command deck for the remote control of airfield lighting systems at Paris Orly aerodrome.

- regarding the aerodrome operator:
  - the communication interfaces between ATS and the aerodrome operator,
  - the integrated and non-integrated automated systems,
  - the interfaces with power supply systems (constant current regulators, power supply sources, other systems),
  - the maintenance and monitoring systems, including the recording systems.

Similarly, the components of these functional assemblies may be classified as follows:

- cables: internal or external assembly of one or more metal conductors and/or optical fibres, with a protective covering and possibly filling, insulating and protective material,
- specific or general power supply units,
- sub-systems such as touch screens, control decks with buttons, Programmable Logic Controllers (PLC), computers, monitoring screens, printers, etc. and
- electrical interfaces between sub-systems or between airfield lighting facilities and equipment such as modems, printed boards for lightning arresters, electrical connection boxes and adaptors.

Note:

Depending on the aerodrome traffic density, functional assemblies may be more or less integrated.

6.3.3.2. OPERATING TESTS

6.3.3.2.1. PURPOSE AND DESCRIPTION

The preventive maintenance programme for systems of control and monitoring of airfield lighting systems used by ATS should include operating tests for checking their proper functioning in normal operating conditions.

These operating tests should consist in, as follows:

- checking the activation by ATS, of permanent and controlled stop bars,
- checking the dynamic activation by means of a vehicle simulating an aircraft, and the de-activation by ATS, of non-permanent and controlled stop bars,
- checking the activation by ATS, of systems required for the implementation of Low Visibility Procedures (LVP),
- checking the activation and de-activation by ATS, of other airfield lighting systems, from at least one of the HMI systems of the control desk, (checking a different HMI system every day, in case of several HMI systems in the ATC tower),
- checking, on each HMI system (mimic panel), the information on the operational status of airfield lighting systems, relayed to ATS, for conformation with the visual observations,
- checking each brilliancy step setting for conformation with the visual observations, and
- checking the monitoring systems for recording the simulated events and checking the recorded simulated events for conformation with the visual observations.

6.3.3.2.2. PERIODICITIES

Operating tests on systems of control and monitoring of airfield lighting systems may be partly carried out at the same time as the daily visual inspections of airfield lighting systems which themselves shall be carried out during the daily inspection of the runway.

Operating tests on systems of control and monitoring of airfield lighting systems should be carried out in accordance with the following periodicities:

- every day for any airfield lighting aid except stop bars and those required for the implementation of LVP,
- every week for stop bars, if any, and
- at least every month for airfield lighting systems required for the implementation of LVP, if provided: to be defined, depending on the start-up and control characteristics of the secondary power supply source (for instance engine generators) and the systems other than airfield lighting systems required for the implementation of LVP.

6.3.3.3. MALFUNCTION DETECTION AND REPORTING TESTS

6.3.3.3.1. PRINCIPE

The preventive maintenance programme for systems of control and monitoring of airfield lighting systems should include tests aiming at checking their ability to detect and report malfunctions in the airfield lighting systems, within the expected time frame, to ATS and the technical support service.

Malfunctions may be simulated either at the level of airfield lighting systems (for instance, when being checked) or at the level of the electrical interfaces between the airfield lighting systems and their control and monitoring systems.

6.3.3.3.2. PERIODICITY

Malfunction detection and reporting tests on systems of control and monitoring of airfield lighting systems should be carried out every six months. Spare components of HMI systems may be tested when performing these tests.

6.3.3.4. SERVICING AND OVERHAUL OF COMPONENTS

See article 6.3.3.1 for the various categories of systems of control and monitoring of airfield lighting systems.

As a rule, components of systems of control and monitoring of airfield lighting systems are not airfield lighting-specific industrial products but standardized industrial products.

6.3.3.4.1. SUBSYSTEMS

Servicing of subsystems such as touch screens, control decks with buttons, Programmable Logic Controllers (PLC), computers, monitoring screens and printers should be carried out in accordance with the periodicities and other instructions given by manufacturers.

See section 5.4.12 for detailed information on the servicing operations to be carried out on PLC.

6.3.3.4.2. SPECIFIC OR GENERAL POWER SUPPLY UNITS

Servicing of power supply units should be carried out in accordance with the periodicities and other instructions given by manufacturers. Their characteristic parameters should be checked every month. Their autonomy should be checked every six months. See section 5.4.7 for detailed information on the servicing operations to be carried out on UPS systems.

6.3.3.4.3. ELECTRICAL INTERFACES

Servicing of electrical interfaces such as modems, printed boards for lightning arresters, various electrical connection boxes and adaptors should be carried out in accordance with the periodicities and other instructions given by manufacturers. Servicing of lightning arrester components should be carried out every six months.

6.3.3.4.4. CABLES

Cables are subject to various stresses depending on their installation conditions. As a rule, stresses may be regarded as more aggressive in an outdoor environment.

Consequently, the servicing programme for cables should take these stresses into account and should include the following operations:

- when routing exclusively inside of buildings:
  - every year, inspecting visually the cables along their various routes (especially for damages due to inadequate bend radius or due to the fixing systems to trays or racks) and the connections by means of connectors, and
  - every two years, measuring the electrical or optical characteristic parameters, or
- when routing outside of buildings: every year, inspecting visually the accessible parts and measuring the electrical or optical characteristic parameters.

6.3.4. SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEMS (SMGCS) AND SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEMS (A-SMGCS)

Maintenance of SMGCS and A-SMGCS related to airfield lighting systems should be performed in accordance with manufacturer’s instructions and with the provisions of this document related to the maintenance of airfield lights and signs and related remote-control systems.

6.3.5. AIRFIELD LIGHTING INFRASTRUCTURES

Airfield lighting infrastructures are intended for receiving or supporting airfield lighting systems and some related electrical equipment such as power cables, connectors, insulation transformers, electrical interfaces of remote control and command systems, etc. Airfield lighting infrastructures are installed on or in the close vicinity of the movement area (runways, taxiways) and shall also comply with the applicable requirements for airfield lighting aids in terms of operational safety (resistance to static loads, mechanical shocks and aircraft engine blast) and reliability.

Airfield lighting infrastructures to be considered include manholes, cable chambers, supporting structures of elevated lights, cable ducts and kerfs.

6.3.5.1. MANHOLES AND CABLE CHAMBERS

Manholes are intended to contain various electrical equipment for airfield lighting systems such as insulating transformers, primary and secondary circuit cables, connectors, relays, specific equipment for individually monitored lights.

Cable chambers are intended for cable routing, for instance under pavement.

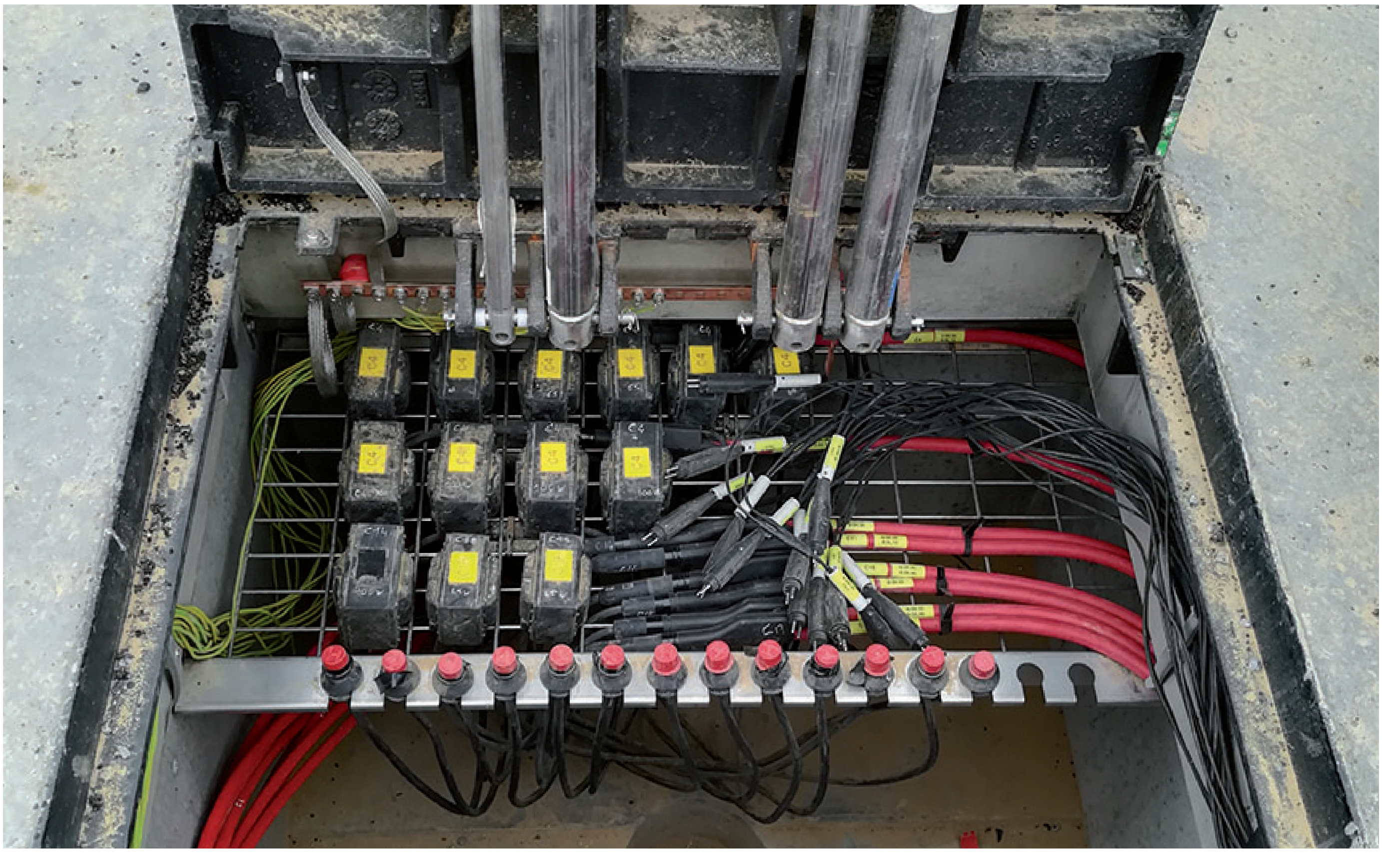


Figure 36: Manhole for airfield lighting systems at Paris Orly aerodrome.

6.3.5.1.1. PREVENTIVE MAINTENANCE OPERATIONS ON OUTSIDE PARTS

In any case, manholes and cable chambers shall not create any obstruction or safety hazard on a runway, a shoulder, a runway strip, a taxiway strip in the event of a runway or taxiway excursion by an aircraft.

Manholes and cable chambers should be checked for mechanical integrity, stability, compliance with applicable standards and any major land subsidence around them that may arise from landslides.

The identification of cables and other items in manholes and cable chambers should be checked for conformation with drawings and diagrams.

6.3.5.1.2. PREVENTIVE MAINTENANCE OPERATIONS ON INSIDE PARTS

Electrical equipment such as insulating transformers, power cables, connectors, relays, electrical interfaces of systems of remote control and command of airfield lighting systems, etc should be functionally arranged to reduce the duration of maintenance operations.

Insulating transformers, connectors and other electrical equipment should be positioned on cable racks, angle irons or other supporting structures allowing them to be out of water.

Caution should be exercised when installing power cables and cords, about their bend radius. The bend radius of power cables and cords should be in accordance with manufacturers' instructions.

Electrical equipment should be so labelled as to ensure quick identification of their function. Labels shall be indelibly marked.

As a rule, regarding the earth circuit, earth conductors of lights shall be connected to the earth inside manholes by means of a bar or another system which itself is connected to the earth, either by the bar copper conductor circling the runway or by an earth rod positioned at the bottom or in the vicinity of the manhole. Connectors of 6 kV cable screens shall be also connected to the earth. These connections may be severely damaged due to the surrounding conditions. A visual inspection should be carried out to detect severe corrosion damages which may result in opening the earth circuit and cause electrical hazards for the maintenance staff.

Inside parts of manholes and cable chambers should be also checked for cleanness to avoid accumulation of mud, stones, plants or other things that may extend the duration of maintenance operations.

6.3.5.1.3. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

Inside as well as outside parts of manholes and cable chambers should be visually inspected at least once a year for over-all condition.

6.3.5.2. MASSIFS SUPPORTS

6.3.5.2.1. GÉNÉRALITÉS

Elevated approach, runway or taxiway lights, PAPI, airfield signs, wind direction indicators shall be mounted on cement concrete supporting structures.

The dimensions of the supporting structures depend on the type of the light and the nature of the land.

In any case, supporting structures for airfield visual aids shall not create any obstruction or safety hazard on a runway, a shoulder, a runway strip, a taxiway strip in the event of a runway or taxiway excursion by an aircraft.

Figure 37: Supporting structure for a wind direction indicator at Paris Orly aerodrome.

6.3.5.2.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

Supporting structures for airfield visual aids should be checked for mechanical integrity, stability and any major land subsidence that may arise around them from landslides. Caution should be exercised with respect to the supporting structures of visual approach slope indicator systems. See section 6.3.9 for details on the maintenance operations on PAPI light units.

Fixing systems of airfield lights to their supporting structures should be visually checked for mechanical integrity, stability, stiffness, height, oxidation, threading.

6.3.5.2.3. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations on supporting structures as listed above should be carried out at least once a year. Due to the possible occurrence of landslides, more frequent checks should be carried out during the months following the installation of a supporting structure.

6.3.5.3. CABLE DUCTS

6.3.5.3.1. GENERAL

Power and control cables may be drawn through cable ducts connecting them from one manhole or cable chamber to another and ensuring their mechanical protection.

6.3.5.3.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

Network diagrams of cable ducts should be updated to ensure easy identification, easy installation and easy replacement of cables, if necessary, as part of maintenance operations.

Ends of cable ducts in manholes or cable chambers should be checked for endcaps. Endcaps covering the end of cable ducts avoid their obstruction and ensure the easy routing of cables.

6.3.5.3.3. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

Cable ducts should be visually checked yearly to ensure they are not damaged. Network diagrams of cable ducts should be updated every year. Cable ducts should be checked for obstruction every five years in critical areas such as pavement crossing areas to ensure quick replacement of defective cables.

6.3.5.4. KERFS

6.3.5.4.1. GENERAL

Power cables of inset lights, some elevated lights and stop bars may be laid down in kerfs cut in the pavement.

Figure 38: Kerf cut in the concrete pavement of a runway.

6.3.5.4.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

Kerfs should be visually checked for damages due to the local climatic conditions and/or aircraft taxiing that may cause cables to break or to be torn off.

Visual checks on kerfs should be carried out in coordination with the aerodrome services in charge of the maintenance of pavement structures.

6.3.5.4.3. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

Visual checks on kerfs should be carried out at least every six months. This periodicity should be suited to the aerodrome traffic density and the local climatic conditions.

6.3.5.4.4. REPAIRS

Repairs on kerfs such as sawing, laying down cables or casting resins should be carried out in accordance with the instructions given by the manufacturers of the various materials, especially as regards their compatibility between each other and with the pavement and the equipment. Repaired kerfs should be monitored for the weeks following the repair.

6.3.6. AIRFIELD LUMINOUS SIGNS

6.3.6.1. GENERAL

Airfield luminous signs include mandatory instruction signs and information signs. Airfield signs may be internally or externally illuminated or non-illuminated (retroreflective or non-retroreflective).

Airfield luminous signs may be exposed to aircraft jet blast, stone chipping and poor weather conditions.

Figure 39: Runway holding position sign and location sign.

6.3.6.2. LIST OF PREVENTIVE MAINTENANCE OPERATIONS

Servicing of airfield luminous signs should be performed in accordance with manufacturer's instructions.

In addition, the servicing programme for airfield luminous signs should include the following visual inspections:

- checking the sign for general condition (integrity and proper functioning),
- checking the mounting feet for proper condition, tightness and attachment to the supporting structure, tightening, if necessary
- checking the face for integrity and, if any, the coloured covering film for condition,
- checking the power connections for condition,
- checking the light sources if any, for proper condition, functioning and arrangement, and
- checking the inscriptions for legibility and the absence of obstructions such as plants.

6.3.6.3. PERIODICITY OF PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance operations on airfield luminous signs as listed above should be carried out at least once a year. They should include a visual inspection by night. However, the visual inspections on airfield signs for integrity and proper functioning shall be carried out at each of the daily inspections of airfield lighting aids as mentioned in section 6.3.8.1.

6.3.7. ROAD-HOLDING POSITION LIGHTS

6.3.7.1. LOCATION AND CHARACTERISTICS

A road-holding position light shall be provided at each road-holding position serving a runway.

A road-holding position light shall comprise either of the following:

- a controllable red (stop)/green (go) traffic light, or
- a flashing-red light flashing at a frequency between 30 and 60 flashes per minute.

Figure 40: Road-holding position light at Strasbourg Entzheim aerodrome.

6.3.7.2. PREVENTIVE MAINTENANCE OPERATIONS

Preventive maintenance of road-holding position lights should be performed in accordance with manufacturer's instructions.

In addition to the preventive maintenance operations required by the manufacturer, visual inspections on road-holding position lights should be carried out at each of the daily inspections of airfield lighting aids as mentioned in section 6.3.8.1.

6.3.8. AIRFIELD LIGHTS (EXCEPT ROAD-HOLDING POSITION LIGHTS)

6.3.8.1. VISUAL INSPECTIONS

Airfield lights shall be visually checked according to the following periodicity:

- at least once a day for a runway where the code number is 1 or 2, and
- at least twice a day for a runway where the code number is 3 or 4.

Visual inspections of airfield lights may be carried out during the daily inspections of the runway.

6.3.8.2. FIELD PHOTOMETRIC MEASUREMENTS

6.3.8.2.1. GENERAL

Light intensity of airfield lights cannot be visually checked. The difference in light intensity between two airfield lights can be perceived by the human eye only if the light intensity ratio is above two. Therefore, the main beam average intensity of airfield lights shall be field measured and measurements results shall be compared to the required minimum values as maintenance objectives, indicated in Table 8 of section 6.2.2.1. For detailed information on photometric quantities, see section 7.7.

In-field measurement of the main beam average intensity of lights included in runway lighting systems shall be undertaken by measuring all lights, as far as practicable, to ensure their monitoring and assess the degradation in their performance.

In-field measurement of the main beam average intensity of lights included in approach lighting systems shall be undertaken by measuring all lights, as far as practicable, depending on their installed height.

In-field measurement of the main beam average intensity of lights included in taxiway lighting systems shall be undertaken only on stop bar lights and exit taxiway lights from the runway centre line to the perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface, whichever is the farthest from the runway.

It should be noted that other characteristics of airfield lights such as the main beam minimum intensity, the minimum intensities required in the directions located within the areas defined by the outer isocandela curves, the ratio between the main beam maximum and minimum intensities and the chromatic coordinates of the main beam shall be laboratory tested for compliance with the applicable requirements before field installation. See section 7.8 for further information on the laboratory measurement method of the luminous intensity of airfield lights.

At French aerodromes, in-field photometric measurement of airfield lights may be undertaken either manually by means of a portable luxmeter or using a mobile photometric measuring unit that shall be granted a positive technical opinion from the STAC.

6.3.8.2.2. MANUAL MEASUREMENT METHOD

When performing manually in-field photometric measurements on an airfield light by means of a portable luxmeter, the following requirements shall be met.

- **Measuring equipment:** The luxmeter shall be adequate for the airfield light, whether incandescent or LED.
- **Measuring distance:**
  - The measuring distance between the luxmeter and the airfield light shall be known accurately as a deviation of a few centimetres may significantly impact the measurement results.
  - The measuring distance between the luxmeter and the airfield light shall be adequate for the luxmeter characteristics, the airfield light characteristics (light intensity, light source size, elevated or inset type, number of light sources) and the ambient light conditions. A measuring distance ranging from 3 to 5 meters proves to be consistent. Using a measuring distance of 3,16 metres enables a rapid computation of the maximum light intensity which can be obtained by multiplying the measured illuminance by 10 (≈ $3{,}16^2$). See Table 13 for instances of recommended measuring distance values for precision approach lights and precision approach runway lights.

Airfield lights		Minimum value of main beam average light intensity required for field installation (cd)	Elevated or inset type Number of light sources	Recommended measuring distance (m)
Approach centre line lights and crossbars (White light)		20 000	Inset or elevated lights	5
Approach side row lights (Red light)		5 000	Elevated lights	3
			Inset lights with a single light source	3
			Inset lights with 2 or 3 light sources	5
Runway threshold lights		10 000	Elevated lights	3
			Inset lights with 2 or 3 light sources	5
Runway edge lights	White light Yellow light Red light	10 000 4 000 1 500	Elevated lights	3
			Inset lights with 2 or 3 light sources	5
Runway centre line lights (White light) Touchdown zone lights		5 000	Inset lights	3
Runway centre line lights (Red light)		750	Inset lights	3
Runway end lights		2 500	Elevated lights	3
			Inset lights with 2 or 3 light sources	5

Table 13: Recommended photometric measuring distances of precision approach lights and precision approach runway lights.

- **Measuring conditions:** Measurements shall be performed at night (to guarantee the measurement reproducibility) and with a dry pavement (in order to avoid light reflexions on the pavement which may lead to overestimating the light intensity).

- **Measurement protocol:** The following steps shall be followed.
  - Position the luxmeter perpendicularly with respect to the direction of the main beam of the airfield light
  - Move slowly the luxmeter top-down and from right to left while keeping the same measuring distance, in order to find the maximum value E_{max} of illuminance (in lux).
  - The maximum value I_{max} of light intensity can be then computed from the following formula: $I_{max} = E_{max} \cdot d^2$ where **d** is the measuring distance.
  - Finally, the average value I_{avg} of the main beam light intensity may be obtained by applying a weighting coefficient **K** to the maximum value I_{max} of light intensity ($I_{avg} = K \cdot I_{max}$). **The weighting coefficient K shall be adequate for the airfield light model and type and should be provided by the airfield light manufacturer.** If not provided by the manufacturer, a default value of 0,70 may be applied as the most disadvantageous value.

Table 14 gives of weighting coefficient and of in-field photometric measurement results with the related required minimum value (as maintenance objective) of the main beam average light intensity of precision approach lights and precision approach runway lights. These examples are given for guidance only.

Airfield lights		Elevated or inset type	Measuring distance (m)	Maximum measured value of illuminance E_{max} (lux)	Maximum measured value of light intensity I_{max} (cd)	Weighting coefficient	Main beam average light intensity I_{avg} (cd)		Serviceable or unserviceable
							Measured value	Required minimum value as maintenance objective	
Approach centre line lights and crossbars (White light)		Elevated	5	1257	31 425	0.70	21 998	10 000	Serviceable
				502	12 550	0.70	8 785	10 000	Unserviceable
Runway threshold lights		Inset	5	275	6 875	0.85	5 844	5 000	Serviceable
		Elevated	3	604	5 436	0.85	4 620	5 000	Unserviceable
Runway centre line lights	White light	Inset	3	332	2 988	0.82	2 450	2 500	Unserviceable
	Red light	Inset	3	68	612	0.82	502	375	Serviceable
Runway edge lights (White light)		Inset	3	1692	15 228	0.75	11 421	5 000	Serviceable
		Elevated	3	733	6 597	0.75	4 948	5 000	Unserviceable
Runway end lights		Inset	3	240	2 160	0.90	1 944	1 250	Serviceable

Table 14: Examples of in-field photometric measurement results of precision approach lights and precision approach runway lights.


Figure 41: Manual in-field photometric measurement of a runway threshold light.

6.3.8.2.3. PERIODICITIES

The periodicity of field photometric measurements of airfield lights for a precision approach runway, category II or III, shall be based on the traffic density, the local pollution level, the reliability of the installed lighting equipment and the continuous assessment of the measurement results but, in any event, shall not be less than twice a year for inset airfield lights and not less than once a year for other airfield lights.

The periodicities of field photometric measurements indicated in the following tables are only provided as guidance and shall be adjusted in accordance with the measurement results.

6.3.8.2.3.1. INSET AIRFIELD LIGHTS

Being run over by aircraft wheels, traffic density shall be considered to determine the periodicity of field photometric measurements of inset airfield lights.

Basic periodicities are defined for low traffic density levels. Multiplying factors are defined for upper traffic density levels (one per traffic density level). A multiplying factor of 2 is related to an average traffic density level and a multiplying factor of 4 to a high traffic density level.

Table 15 gives examples of periodicities of field photometric measurements of inset airfield lights, depending on the traffic density level and the operating conditions of the runway. In accordance with section 1.3, other periodicities may be defined, provided they ensure an equivalent performance level.

Runway \ Traffic density level		Low	Average	High
Precision approach runway, category II or III		Twice a year	4 times a year	8 times a year
Precision approach runway, category I		Once a year	Twice a year	4 times a year
Runway meant for take-off	**RVR < 150 m**	Twice a year	4 times a year	8 times a year
	150 m ≤ RVR < 550 m	Once a year	Twice a year	4 times a year
	RVR ≥ 550 m	Once every 2 years	Once a year	Twice a year

Table 15: Examples of periodicities of field photometric measurements of inset airfield lights, depending on the operating conditions of the runway and the traffic density of the aerodrome.

6.3.8.2.3.2. ELEVATED AIRFIELD LIGHTS

Local pollution level and local weather conditions shall be considered to determine the periodicity of field photometric measurements of airfield elevated lights. Traffic density need not be considered.

Table 16 gives examples of periodicities of field photometric measurements of elevated high intensity airfield lights, depending on the operating conditions of the runway. In accordance with section 1.3, other periodicities may be defined, provided they ensure an equivalent performance level.

Runway		Periodicity
Precision approach runway, category II or III		1 measurement every year
Precision approach runway, category I		1 measurement every year
Non precision approach runway		1 measurement every 2 years
Non instrument runway		1 measurement every 4 years
Runway meant for take-off	RVR < 150 m	1 measurement every 2 years
	150 m ≤ RVR < 550 m	1 measurement every year or 1 measurement every 2 years if runway centre line lights are provided
	RVR ≥ 550 m	1 measurement every 2 years

Table 16 : Examples of periodicities of field photometric measurements of elevated high intensity airfield lights, depending on the operating conditions of the runway.

6.3.8.2.4. ADJUSTMENTS TO THE MAINTENANCE PROGRAMME

Field photometric measurement results of airfield lights should be analysed.

Depending on these results, the following changes may be introduced to existing preventive maintenance actions to comply with the serviceability requirements for airfield lighting systems:

- adapting the periodicities of preventive maintenance actions to take into consideration the operating conditions of the runway, the local weather conditions and the traffic density of the aerodrome,
- assessing the effectiveness of the light cleaning process by performing field photometric measurements before and after cleaning the lights and, if necessary, changing the light cleaning process,
- adjusting the periodicity of field photometric measurements,
- questioning the field photometric measurement results performed by a third-party service provider.

In any case, adequate corrective maintenance actions (light glass cleaning, light source replacement, current measurement, ...) shall be undertaken as soon as practicable, should the maximum allowable percentage of unserviceable lights be exceeded for any lighting system. Additional photometric measurements shall be carried out after the corrective maintenance actions to check their effectiveness.

6.3.8.3. OTHER PREVENTIVE MAINTENANCE OPERATIONS

6.3.8.3.1. GENERAL

This section aims at defining preventive maintenance operations, excluding field photometric measurements, that should be performed on approach lights, runway lights, taxiway lights and obstacle lights, whether flashing or fixed, as a supplement to manufacturer's instructions for their servicing.

Airfield lights should be individually identified, marked, monitored and periodically checked.

Airfield lighting systems should be also monitored and regularly checked.

Elevated airfield lights and inset airfield lights being fundamentally different in terms of mechanical and optical characteristics, specific preventive maintenance operations should be performed on each of both types of lights.

6.3.8.3.2. OPERATIONS SPECIFIC FOR AIRFIELD LIGHTING SYSTEMS

The preventive maintenance programme for airfield lighting systems should include the following visual inspections:

- checking the interleaving of series circuits for adequate visual guidance in case of a power supply source failure,
- checking each brilliancy step setting (from both the remote control and command system and the power supply source) for conformation with visual observation at night, and
- checking the supplied current value measured by the CCR for conformation with the setpoint value for each brilliancy step.

6.3.8.3.3. OPERATIONS SPECIFIC FOR ELEVATED AIRFIELD LIGHTS

The preventive maintenance programme for elevated airfield lights should include the following specific operations:

- checking the mounting structure (foot and fixing system) for integrity and tightness, and, if necessary, tightening,
- checking the power cable and the connector for integrity, waterproofness, tensile strength and wearing condition,
- checking the optical part for integrity, cleanness, toe-in and vertical setting (see section 0), and
- checking the identification for conformance to facilities map.

6.3.8.3.4. OPERATIONS SPECIFIC FOR INSET AIRFIELD LIGHTS

The preventive maintenance programme for inset airfield lights should include the following specific operations:

- regarding the inset base:
  - checking visually the general condition,
  - checking visually the sealing compound,
  - checking visually the horizontal and vertical settings,
  - checking visually the inside part for cleanness and waterproofness, and
  - checking the identification for conformance to facilities map,
- regarding the top fitting:
  - checking visually the prisms for integrity and cleanness,
  - checking visually the top part for cracks,
  - checking the power cable and the power connections for integrity, waterproofness, tensile strength and wearing condition,
  - checking the bolting system for integrity and tightness, and, if necessary, tightening, and
  - checking the identification for conformance to facilities map.

6.3.8.3.5. OPERATIONS SPECIFIC FOR LED AIRFIELD LIGHTS

LED airfield lights requiring less frequent replacement of their light source(s) than incandescent airfield lights, their bolting systems are less frequently unbolted and re-bolted and may therefore untighten. Bolting systems of LED airfield lights, especially LED inset airfield lights, should be therefore periodically checked for tightness.

For further information, see the technical information note STAC/SE/E/EBA/15-514 by the STAC on the checking of bolting systems of airfield lights for tightness (available at www.stac.aviation-civile.gouv.fr).

6.3.8.3.6. PERIODICITIES

Preventive maintenance operations as described in sections 6.3.8.3.2 and 6.3.8.3.3 should be carried out at least once a year. They should include a visual inspection by night.

Preventive maintenance operations as described in section 6.3.8.3.4 should be carried out at least every six months.

Bolting systems of LED airfield lights should be checked for tightness according to an adequate periodicity.

Airfield lights shall be checked for proper operation at each of the daily inspections of airfield lighting aids as mentioned in section 6.3.8.1.

6.3.9. PRECISION APPROACH PATH INDICATOR (PAPI)

6.3.9.1. GENERAL

Requirements for the installation and the siting of a PAPI system are defined in the technical guide on the installation and the siting of a PAPI system issued by the STAC in January 2017 and available at www.stac.aviation-civile.gouv.fr.

A PAPI system being regarded as an elevated lighting system, preventive maintenance operations as described in 6.3.8.3.3 should therefore be performed on the mounting structures, the optical parts, the power cables and the connectors of the light units. However, additional specific preventive maintenance operations are required due to the specific features and functionalities of a PAPI system.

Each of the four light units of a PAPI system should be identified and marked, using the letters A, B, C and D (letter A for the furthest light unit from the runway and letter D for the closest light unit to the runway). The actual value of the elevation setting angle of each light unit should be marked on each light unit.

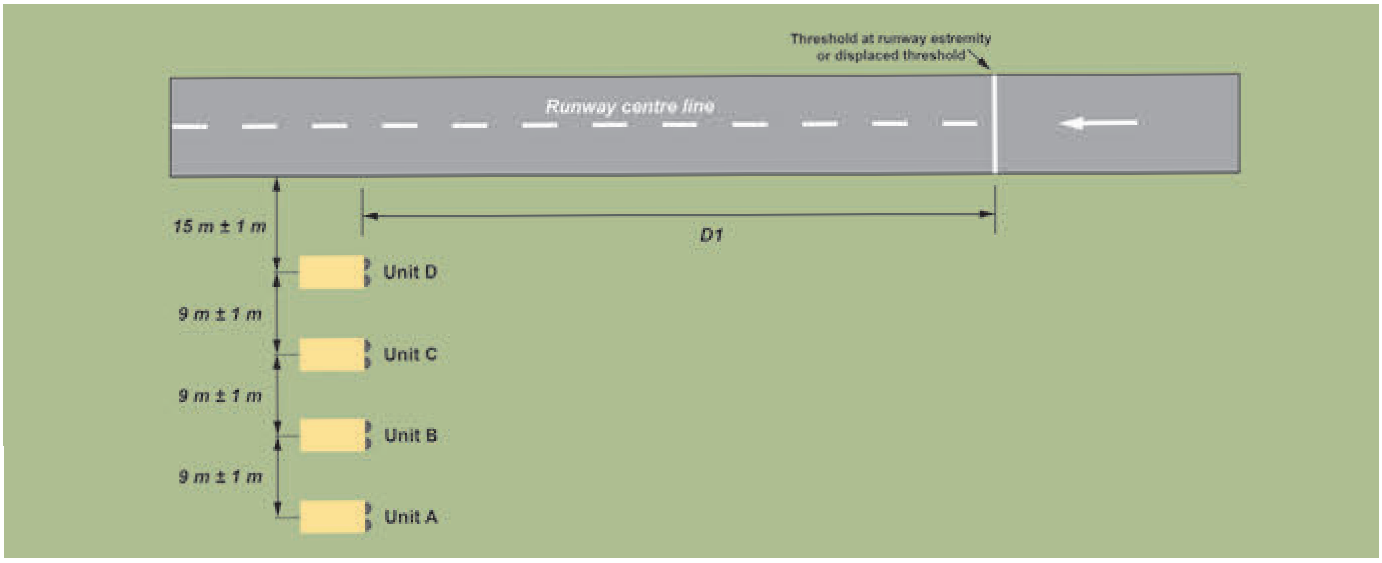


Figure 42: Siting and identification of the light units of a PAPI system.

Servicing and setting operations of light units of PAPI systems should be performed in accordance with manufacturer's instructions regarding the recommended procedure to be implemented and the recommended setting device.

Preventive maintenance and other maintenance operations performed on light units of PAPI systems as well as any replacement of a light unit should be recorded and the records should be made available to maintenance staff.

Special features (operating conditions, colour shift issue due to water condensation) that some models of PAPI system may have as well as the method of measurement of the elevation setting angle of a light unit of a PAPI system, are described in the technical information notes issued by the STAC and available at www.stac-aviation.civile.gouv.fr

6.3.9.2. GENERAL CHECKS

Supporting structures of light units of PAPI systems should be checked for integrity and stability as they directly impact the setting of the light units.

In case of any impact between a light unit of a PAPI system and, for instance, with a tractor when mowing, the elevation and the horizontal setting angles shall be checked for compliance.

In addition, the preventive maintenance programme for a light unit of a PAPI system should include the following operations:

- checking visually the light unit for proper functioning (absence of unserviceable light source),
- checking visually the light unit for integrity,
- checking visually the light unit for the absence of plants that may hide the light beam, (due to their remote position from the runway edge, from 15 to 42 m),
- checking visually the inside and outside parts (especially the front glasses) for cleanness, cleaning, if necessary,
- checking the mounting structure (feet and fixing systems) for integrity and tightness, tightening, if necessary,
- checking visually the red filters, lenses and reflectors for integrity and cleanness, cleaning if necessary, and
- checking visually the colorimetric transition areas of the beams of each light unit.

Figure 43: Light unit of a PAPI system at Châlons Vatry aerodrome.

6. MAINTENANCE OF AIRFIELD LIGHTING FACILITIES

Checking visually the colorimetric transition aeras of the beams of a light unit of a PAPI system is a simple action that should be carried out prior to checking its elevation setting angle, whether it shall be performed by means of an alidade or according to another method.

It consists of several steps :

- taking up position in front of the light beams, at a distance of about 15 meters away from the light unit,
- searching visually for the colorimetric transition areas,
- checking visually that both colorimetric transition areas are aligned (see Figure 44 and Table 17)

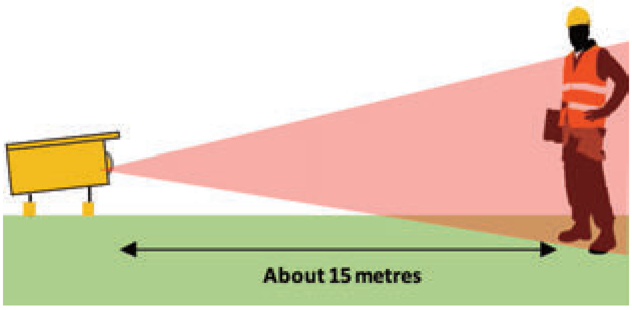


Figure 44: Checking of the colorimetric transition areas of the beams of a light unit of a PAPI system for alignment.

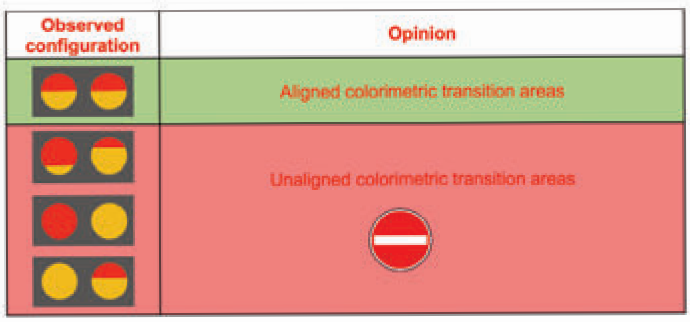


Table 17: Various configurations of the colorimetric transition areas of the beams of a light unit of a PAPI system.

An incorrect alignment of colorimetric transition areas of the beams of a light unit of a PAPI system may be caused by one of the following defects :

- an uneven front part of the light unit (see section 6.3.9.4),
- an incorrect position of the red filter(s) of the light unit,
- a distortion of the light unit,
- a misadjustment in the orientation of the lenses (which occurred after the initial adjustment by the manufacturer).

In the latter two cases, the manufacturer of the PAPI system shall be requested for repairing or replacing the light unit.

It is to be noted that a PAPI system shall be deemed unserviceable when at least one of its light units does not comply with the applicable requirements for one of the following reasons:

- unserviceable light source,
- non-compliant setting angle,
- non-compliant colorimetric transition, for instance due to a damaged filter, or
- broken foot or broken fixing system.

6.3.9.3. CHECKING OF THE FRONT PARTS OF THE LIGHT UNITS FOR ALIGNMENT WITH EACH OTHER

Checking the light units of a PAPI system for alignment with each other should ensure that the installation requirements and tolerances are met. The light units of a PAPI system shall be mounted as low as possible and aligned in a same horizontal plane, which may be checked by means of either a theodolite or a laser level. A maximum height deviation of 5 cm between the light units is allowed. A maximum horizontal deviation of 1,25 % is allowed for the slope formed by the light units, provided it is uniformly spread across them.

The front parts of the light units of a PAPI system shall be also aligned with each other in a same vertical plane perpendicular to the runway centre line direction with a maximum deviation of 5 cm.

The light beam of any light unit of a PAPI system shall be set parallel to the runway centre line with a maximum deviation of 1°, except in particular cases.

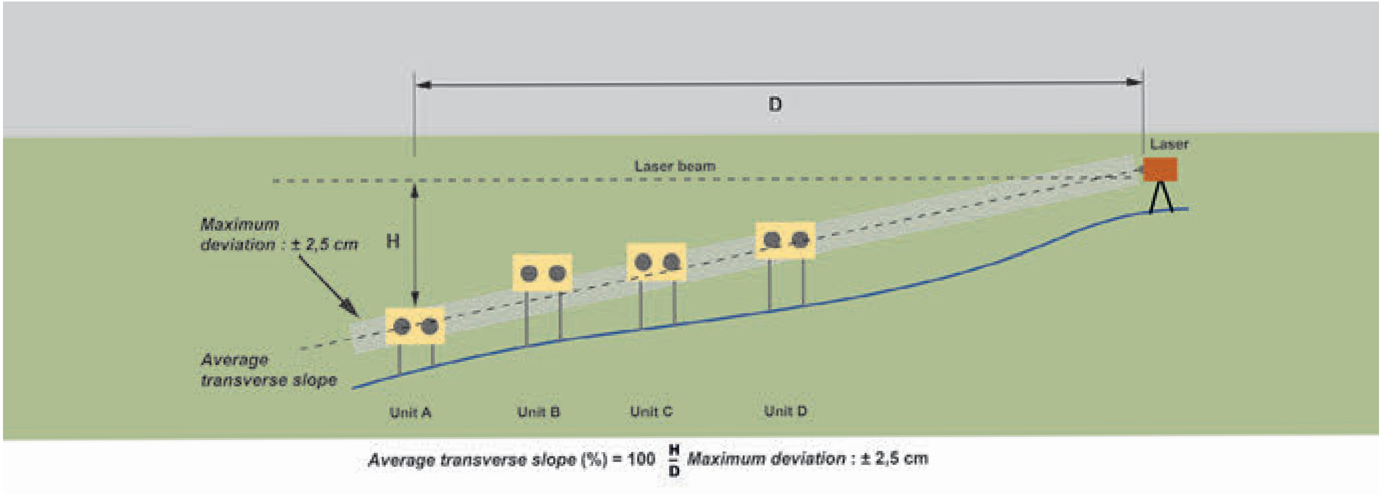


Figure 45: Measurement, by means of a laser level, of the slope formed by the light units of a PAPI system with respect to the horizontal.

6.3.9.4. CHECKING OF THE FRONT PART OF A LIGHT UNIT FOR HORIZONTAL ALIGNMENT

The front part of a light unit of a PAPI system should be checked for horizontal alignment by means of a suitable device (spirit level, for instance), designed by the PAPI system manufacturer, following the appropriate procedure provided by the latter for this purpose. If necessary, the front lenses should be levelled with an accuracy of about 4 arcminutes.

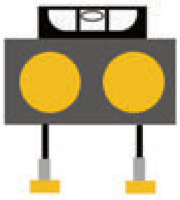


Figure 46: Checking of the front part of a light unit of a PAPI system for horizontal alignment.

6.3.9.5. CHECKING OF THE ELEVATION SETTING OF A LIGHT UNIT

Prior to checking the elevation setting angle of a light unit of a PAPI system, the following checks should be performed:

- checking the light unit for alignment with the other light units, in accordance with section 6.3.9.3, and
- checking the front part of the light unit for horizontal alignment, in accordance with section 6.3.9.4.

Figure 47: Checking of the elevation setting angle of the light units of a PAPI system at Avignon aerodrome.

The elevation setting angle of a light unit of a PAPI system shall be checked for conformance, by means of a specific measuring instrument called a clinometer or an alidade, provided or approved by the PAPI system manufacturer, implementing the appropriate procedure provided by the latter for this purpose. This measuring instrument should be regularly calibrated and particular caution should be exercised when handling or storing it. The consistency of the visual information provided by the PAPI system is ensured by its manufacturer provided the elevation setting of the light units is performed by means of the specific alidade model for the PAPI system. Maintenance staff for airfield lighting at an aerodrome should therefore be given all the alidade models appropriate for the setting of the various PAPI systems installed at the aerodrome. It is strongly recommended not to use a different model. However, in such a case, the information given by the alidade should be checked for consistency with the visual information given by the PAPI system.

Note :

Two measurement units can be used for the expression of the elevation setting angle of a light unit of a PAPI system : decimal degrees (often used in aeronautical publications) or sexagesimal degrees (often used by alidades). Particular attention should be paid to the choice of the measurement unit. Numerous websites offer online appropriate conversion tools.

Measurement results of the elevation setting angle of a light unit of a PAPI system should be recorded and analysed for monitoring purpose. The following corrective actions shall be taken:

- if the deviation (absolute value) between the measured value and the required value is less or equal to 5 arcminutes, no corrective action is required,
- if the deviation (absolute value) between the measured value and the required value is greater than 5 arcminutes but less than or equal to 10 arcminutes, the vertical setting shall be adjusted and then checked again 6 months later, or
- if the deviation (absolute value) between the measured value and the required value is greater than 10 arcminutes, either the PAPI system shall be declared out of service, or the vertical setting angle of the light unit shall be adjusted without delay and then monthly checked for at least 3 months until the deviation is stabilised and the reasons for this deviation are ascertained.

At French aerodromes, measurement results of the elevation setting angle of a light unit of a PAPI system obtained by use of an alidade should be confirmed by additional measurements according to one of the four other measurement methods approved by the supervisory authority at the issuance of this guide. See section 7.11 for further information on these methods, combining specific procedures and equipment and requiring qualified operators. **Any newly developed method or any change to any of these measurement methods shall be subject to approval by the supervisory authority.**

A maximum deviation of 5 arcminutes is allowed between the measurement results obtained by use of an alidade and those obtained by use of one of the four other measurement methods approved by the supervisory authority at the issuance of this guide. In case of significant deviation, the cause should be formally identified (defective alidade, distortion of the light unit or incorrect implementation of one of both measurement methods) and the necessary adjustments should be carried out. If these adjustments cannot be carried out, a new reference value to be measured by means of the alidade shall be determined for the elevation setting of the light unit of the PAPI system. This new reference value shall take into account the measured deviation in order to ensure a correct elevation setting of the light beam.

6.3.9.6. PERIODICITIES OF CHECKS

Preventive maintenance operations on a light unit of a PAPI system should be carried out according to the following periodicities:

- every day:
  - checking the light source for proper functioning (absence of unserviceable light source),
  - checking visually the light unit for integrity,
  - checking visually the light unit for the absence of plants that may hide the light beam,
- every month:
  - checking visually the light unit (especially the front glass) for cleanness, cleaning, if necessary,
  - checking visually the mounting structure (feet and fixing systems) for integrity and tightness, tightening, if necessary,
  - checking the red filter, lenses and reflectors for integrity and cleanness, cleaning, if necessary,
  - checking visually the colorimetric transition areas of the light beams of each light unit for alignment,
- before being put into operation, 6 months after being put into operation and every year: measuring the elevation setting angle of each light unit after carrying out the associated preliminary checks, analysing and recording the measurement results in a follow-up form (one per light unit), and
- before being put into operation, every five years and after any land subsidence: measuring the elevation setting angle of each light unit by means of another method than the alidade method, that shall be approved by the supervisory authority (flight checking method, lift platform method, RPAS method or ground measuring method described in section 7.11), analysing and recording the measurement results in a follow-up form (one per light unit).

6.4. ISSUES SPECIFIC TO LED AIRFIELD LIGHTING FACILITIES

6.4.1. GENERAL

Incandescent lights have been progressively replaced by LED lights due to their increased service life, lower power consumption and lower maintenance expenses. (LED light sources are less frequently replaced.)

However, some issues were reported, when introducing the LED technology in runway, approach or, to a lesser extent, taxiway lighting. The issues listed below shall be taken into consideration as adjustments or additional tests may be required to ensure the compliance of the related power supply systems with the applicable requirements.

It shall be noted that malfunctions observed for a given light may differ from one manufacturer to another. There is no specific rule.

For further information, see the technical note STAC/SE/E/EBA/19-5021 by the STAC on the particularities of LED airfield lights to be taken into account when installing them (available at www.stac.aviation-civile.gouv.fr).

Note:

Some specific electrical tests may be carried out by the STAC, upon request.

6.4.2. POSSIBLE INCREASE IN THE SWITCH-OVER TIME

The switch-over time for some LED airfield lights (in case of failure of the primary power source) may be increased due to their design features.

Warning:

In certain circumstances, some electrical systems that used to meet the requirements for the switch-over time may not meet them anymore, when replacing incandescent airfield lights by LED airfield lights.

The possible increase in switch-over time due to the replacement of incandescent airfield lights by LED airfield lights should be taken into consideration when conducting the related preliminary impact assessment and the switch-over time shall be checked for compliance with the applicable requirements.

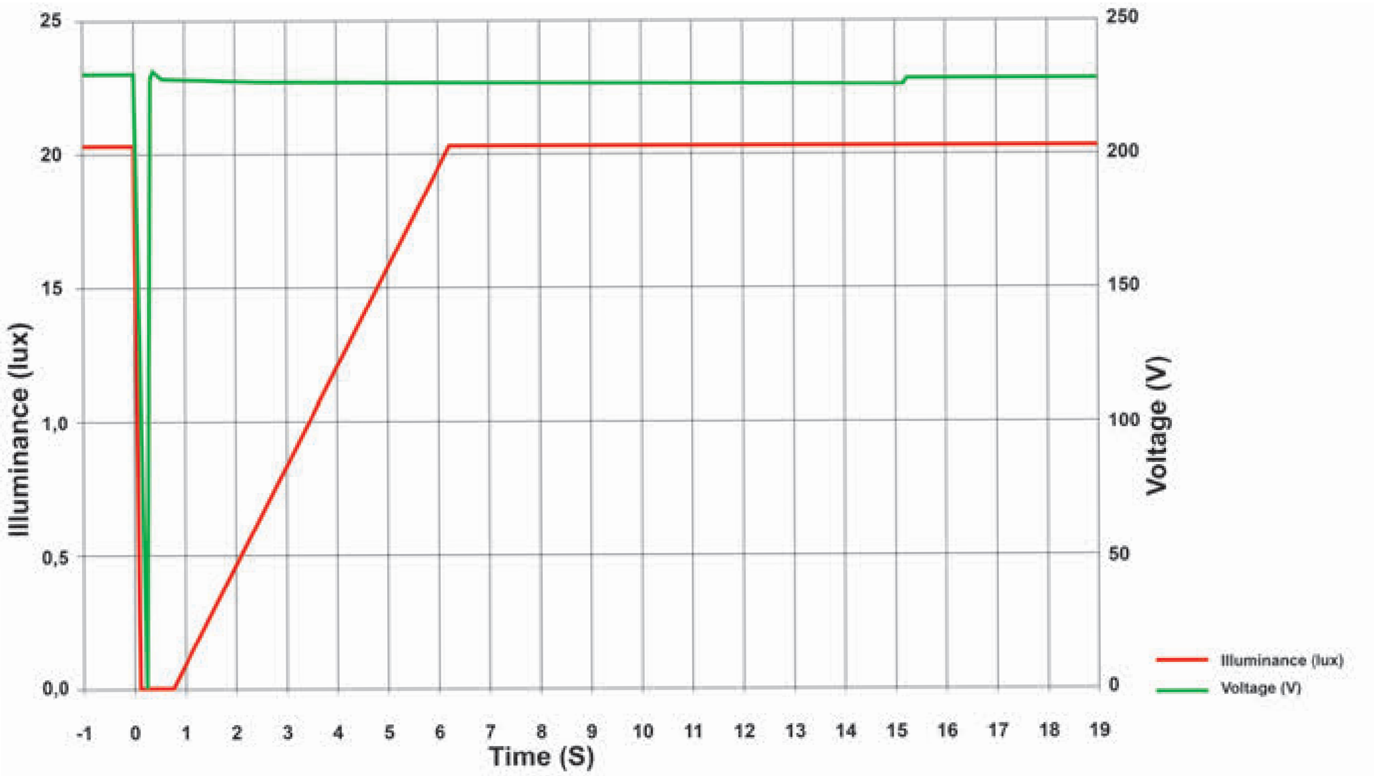


Figure 48: Example of measurement of the switch-over time for an LED airfield light during a power supply changeover (switching to the primary power source for use in reverse mode).

6.4.3. HARMONIC DISTURBANCES AND NEED FOR ADJUSTMENT OF THE CCR POWER

When replacing incandescent airfield lights by LED airfield lights, the power setting of the CCR shall be adjusted to reduce harmonic emissions which may lead to malfunctions in part of the electrical systems or even in the whole electrical systems.

The following issues were experienced by aerodrome operators (non-exhaustive list):

- Airfield lights being a 3,5 kV.A load were flashing when supplied by a 10 kV.A CCR. The 10 kV.A CCR was replaced by a 20 kV.A CCR as a corrective action.
- Airfield lights were flickering due to a faulty current regulation by the CCR. A series-connected inductance was added to the secondary loop circuit as a corrective action.
- CCR were being shut down due to 10 kHz harmonic emissions impairing the current regulation by thyristors.

6.4.4. PILOTS' DAZZLING AND NEED FOR ADJUSTMENT OF THE SUPPLIED CURRENT (BRILLIANCY)

LED lights may be perceived brighter than incandescent lights at the same luminous intensities as LED lights are of greater saturation. Pilots' complaints about dazzling by LED airfield lights, particularly at night, in good visibility conditions were reported. This may be solved by setting the CCR at the minimum brilliancy step i.e. at 2,8 A, in the case of a 5-step CCR compliant with IEC 61822:2009 standard.

At some aerodromes, it is to be noted that, for operational purpose and after conducting a risk assessment, LED airfield lights may be operated at 2,3 A which is below the minimum allowed value of current (2,8 A). However, the nominal brilliancy step related to a current value of 6,6 A shall remain unchanged to meet light intensity requirements in low visibility conditions.

In case of LED airfield lights being operated at 2,3 A, 2,8 A or less, the aerodrome operator shall consult with the CCR and the lights manufacturers to ensure their proper functioning at such a current value (electronic control systems, control systems using the power-line carrier/communication technology, ...).

7.1. EXAMPLE OF TRAINING PLAN FOR OPERATORS IN CHARGE OF THE MAINTENANCE OF SERIES CIRCUITS FOR AIRFIELD LIGHTING SYSTEMS

The training plan for an operator in charge of the maintenance of series circuits for airfield lighting systems should be suitable for the aerodrome facilities, his assigned duties and his skill.

Job : Operator in charge of the maintenance of series circuits for airfield lighting systems	
Description	Preventive and curative maintenance of airfield lighting equipment Operations on series circuits for airfield lighting systems
Required training course	Electrician training course
Initial training	• On-site job training through mentoring • Internal or external specialized training on series circuits for airfield lighting systems • Local training: - Training in operating vehicles on the movement area - Training in air transport security : airport identification card (Titres de Circulation Aéroportuaire : TCA) - Management training (for managerial position) • Other training, if needed
Required electrical accreditations	• Specific electrical accreditations for operations on airfield lights: - Performer: **B1X "FBA"** - Work supervisor: **B2X "FBA"** • Specific electrical accreditations for operations on primary series circuits for airfield lighting systems: - Performer: **H1X "CSB"** - Work supervisor: **H2X "CSB"** • General electrical accreditation: - Lockout supervisor: **BC-HC** - Specific operations supervisor: **BE-HE** - Performer: **B1-H1** - Work supervisor: **B2-H2**
Required time of mentoring for validation of skills	Variable, depending on the size of the systems
Skills assessment	Every year

Table 18: Example of training plan for an operator in charge of the maintenance of series circuits for airfield lighting systems.

Table 19: Example of training follow-up form for an operator in charge of the maintenance of series circuits for airfield lighting systems.

Operator		
Name		
First name		
Date of birth		
Date of taking up of duties		
Degree(s)		
Initial training		
Date		
Training institute or internal trainer		
Electrical accreditation		
	Issuance date	Expiry date
Initial training		
Retraining		
Mentoring		
Start date		
End date		
Assessment of skills		
	Date	Examiner
Initial		
Yearly		
Additional trainings		
Title	Date	Training institute

7.2. APPLICABLE STANDARDS FOR POWER CABLES AND INSULATION TRANSFORMERS OF SERIES CIRCUITS FOR AIRFIELD LIGHTING SYSTEMS

Power cables for airfield lighting systems shall comply with the electrical and mechanical requirements contained in the following applicable French standards:

- NF C33-225 standard: Insulated cables and their accessories for power systems – Cables for primary circuits of airfield lighting systems – Rated voltage U0/U (Um) = 6/10 (12) kV,
- NF C33-224 standard: Insulated cables and their accessories for power systems – Cables for primary circuits of airfield lighting systems – Rated voltage U0/U (Um) = 3,6/6 (7,2) kV, and
- NF C33-212 standard: Insulated cables and their accessories for power systems – Cables for primary circuits of airfield lighting systems – Rated voltage U0/U (Um) = 1/1 (1,2) kV.

Insulation transformers for airfield lighting systems shall comply with IEC 61823:2002 standard: Electrical installations for lighting and beaconing of aerodromes – AGL series transformers.

7.3. SPECIALIZED TEST FORM FOR CHECKING THE RELIABILITY OF POWER SUPPLY SYSTEMS FOR AIRFIELD LIGHTING SYSTEMS

A test form should be filled in for any specialized test for checking the reliability of power supply systems for airfield lighting systems.

<table>
<tr><th colspan="3">Specialized test on power supply sources for airfield lighting systems</th></tr>
<tr><td colspan="2">N°</td><td></td></tr>
<tr><td colspan="2">Title</td><td></td></tr>
<tr><td colspan="2">Purpose</td><td></td></tr>
<tr><td colspan="2">Runway operating conditions</td><td></td></tr>
<tr><td colspan="3">Configuration of power supply systems
(for instance a public primary power supply source and an engine generator as a secondary power supply source)</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Simulated failure(s)
(for instance simulated failure of the primary power supply source or simulated failure of the engine generator)</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Expected results
(for instance switching over of the load from the primary power supply source to the engine generator)</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Observed results</td></tr>
<tr><td colspan="2">Power disconnection time (s)</td><td></td></tr>
<tr><td colspan="2">Switch-over time (s)</td><td></td></tr>
<tr><td colspan="2">Observed malfunctions</td><td></td></tr>
<tr><td colspan="2">Conformation of the information relayed to air traffic controllers and the technical support service</td><td></td></tr>
<tr><td rowspan="2">Apparent power (kV.A)</td><td>Engine generator</td><td></td></tr>
<tr><td>Airfield lighting system</td><td></td></tr>
</table>

Table 20: Example of specialized test form for checking the reliability of power supply sources for airfield lighting systems.

7.4. TEST FORM FOR CHECKING THE INFORMATION RELAYED TO ATC ABOUT THE OPERATING STATUS OF CCR SUPPLYING AIRFIELD LIGHTING SYSTEMS

Supplied airfield lighting system	Number and type of loop circuits	CCR put out of service	Information relayed to air traffic controllers about the operating status of the CCR		Comments
			Expected results	Observed results	
Runway edge lighting system	2 interleaved	None			
		1			
		2			
		1+2			
Approach lighting system	2 interleaved	None			
		1			
		2			
		1+2			
Runway threshold lighting system	2 interleaved	None			
		1			
		2			
		1+2			
Taxiway centre line lighting system	1	None			
		1			
PAPI	1	None			
		1			

Table 21: Example of test form for checking the information relayed to ATC about the operating status of CCR supplying airfield lighting systems.

7.5. INSULATION RESISTANCE, ELECTRICAL CONTINUITY RESISTANCE AND LOAD OF PRIMARY LOOP CIRCUITS FOR AIRFIELD LIGHTING SYSTEMS

7.5.1. INSULATION RESISTANCE MEASUREMENT

7.5.1.1. PURPOSE

Measurement of the insulation resistance of a primary loop circuit for an airfield lighting system allows to monitor the ageing of cables, connectors and insulation transformers of the circuit.

The measured value of the insulation resistance of a primary loop circuit for an airfield lighting system depends on the value of the test voltage, the quality of the electrical equipment (power cables, insulation transformers, connectors), the quality of the changes to the electrical equipment and its ambient operating conditions (humidity or immersion) during the measurement.

7.5.1.2. METHOD

The insulation resistance of a primary loop circuit for an airfield lighting system should be measured by means of megohmmeter capable of providing a voltage up to 5 000 V.

Prior to the measurement, all the electrical systems of the circuit should have been locked out, in accordance with the applicable safety rules.

The measurement shall be performed over a period longer than one minute so that the power cable can get loaded. The power cable should be unloaded after the measurement, by connecting its conductor to the earth.

The measured value of the insulation resistance of a primary loop circuit for an airfield lighting system should be compared to the minimum theoretical value which may be computed according to the following formula:

$$R_{Min-L} = \frac{U_{Test}}{I_{IT} \cdot n_{IT\text{-}L} + I_{Cable} \cdot L_L}$$

Where:

- ***$R_{Min\text{-}L}$*** *is the minimum insulation resistance (in MΩ) of the primary loop circuit **L** for an airfield lighting system,*
- ***U_{Test}*** *is the test voltage (**U_{Test}**=5 000 V if the power cable of the primary loop circuit is designed for a voltage of 6 000 V, **U_{Test}** =1 000 V if the power cable of the primary loop circuit is designed for a voltage of 1 000 V),*
- ***I_{IT}*** *is the leakage current intensity (in µA) from an insulation transformer (**I_{IT}** =2 µA),*
- ***$n_{IT\text{-}L}$*** *is the number of insulation transformers connected to the primary loop circuit **L** for an airfield lighting system,*
- ***I_{Cable}*** *is the leakage current intensity (in µA) from 1 km long power cable (**I_{Cable}** =10 µA.km^{-1}), and*
- ***L_L*** *is the length (in km) of the primary loop circuit **L** for an airfield lighting system.*

7.5.2. ELECTRICAL CONTINUITY RESISTANCE MEASUREMENT

7.5.2.1. GENERAL

The electrical continuity resistance of a primary loop circuit for an airfield lighting system may differ by up to about 20% from one circuit to another, depending on the supplied lighting system (runway centre line lighting system, touch down zone lighting system, approach lighting system, etc), i.e. on the number of insulation transformers and connectors connected to the circuit.

7.5.2.2. PURPOSE

The measured value of electrical continuity resistance of a primary loop circuit for an airfield lighting system should be compared to the theoretical value obtained by computation, the previously measured value or the reference value for consistency. The reference value is the value measured when putting the circuit into operation. The reference value shall be close to the theoretical value obtained by computation.

Any significant difference (i.e. greater than 30%) allows to bring to light defects, generally power connection defects, in the circuit. Such defects generate hotspots which themselves may generate electric arcs and, in the most serious cases, fires in manholes, finally leading to the failure of several airfield lighting systems.

7.5.2.3. METHOD

Measurement of the electrical continuity resistance of a primary loop circuit for an airfield lighting system shall be performed by means of a multimeter used as an ohmmeter (or resistance meter).

Prior to the measurement, all the electrical systems of the circuit shall have been locked out in accordance with the applicable safety rules.

The electrical continuity resistance of a 6 mm^2 cross section cable being about 3 Ω·km^{-1} and that of an insulation transformer being, on average, about 0,1 Ω (depending on the power characteristic), an estimated value of the electrical continuity resistance $\boldsymbol{R_L}$ of the primary loop circuit $\boldsymbol{L}$ for an airfield lighting system may be computed according to the following formula:

$$R_L = 3 \cdot L_L + 0{,}1 \cdot n_{IT\text{-}L}$$

Where:

- $\boldsymbol{L_L}$ is the length (in km) of the primary loop circuit $\boldsymbol{L}$ for an airfield lighting system, and
- $\boldsymbol{n_{IT\text{-}L}}$ is the number of insulation transformers connected to the primary loop circuit $\boldsymbol{L}$ for an airfield lighting system.

The estimated theoretical value of the electrical continuity resistance of a primary loop circuit for an airfield lighting system shall be computed after any change to the circuit, whether it be in length or in the number of connected lights.

7.5.3. THEORETICAL COMPUTATION OF THE LOAD

7.5.3.1. PURPOSE

The power setting of the CCR supplying a primary loop circuit for an airfield lighting system should be compared and adjusted to the estimated theoretical value of the circuit load to achieve an optimized current regulation without partitioning. The nearest higher value of power setting should be selected. For instance, if the estimated theoretical value of the load of a primary loop circuit is 13,25 kV.A and if the circuit is supplied by a 20 kV.A CCR, then the CCR power should be set to 3/4 (i.e. 15 kV.A) and not 5/8 (i.e. 12,5 kV.A) for optimized operating conditions.

Note:

Some CCR may be fitted with a system capable of automatically estimating the load of the supplied primary loop circuit (absolute value or relative value with respect to the maximum power of the CCR).

7.5.3.2. FORMULA

The theoretical value of the load P_L (in V.A) of the primary loop circuit L for airfield lighting may be computed according to the following formula:

$$P_L = N_L \cdot \frac{P_{Light} + P_{Secondary}}{\eta \cdot \cos \varphi} + P_{Primary} \cdot L_L$$

Where:

- N_L is the number of light sources of the primary loop circuit L for an airfield lighting system,
- P_{Light} is the light wattage consumption (in W) increased by 10% which corresponds to the manufacturing tolerance,
- $P_{Secondary}$ is the power loss (in W) in the power cable of the secondary circuit of an insulation transformer (to be estimated, supposing a unit power loss of 200 W/km in a 4 mm^2 cross section cable carrying a 6,6 A current),
- *η is the insulation transformer efficiency (80% for a wattage consumption of 45 W, 85% for a wattage consumption of 100 W and 90% for higher values of wattage consumption),*
- φ is the phase difference between voltage and current, due to an insulation transformer (**cos φ**=0,95),
- L_L is the length (in km) of the primary loop circuit L for an airfield lighting system, and
- $P_{Primary}$ is the unit power loss (in W/km) in the power cables of a primary loop circuit for an airfield lighting system ($P_{Primary}$=135 W/km for a 6 mm^2 cross section cable carrying a 6,6 A current).

7.5.4. EXAMPLE OF FORMS

7.5.4.1. MEASUREMENT OF ELECTRICAL CONTINUITY AND INSULATION RESISTANCE

Primary loop circuit / Measured electrical quantity	Identification										
	Number of insulation transformers										
	Length (km)										
Electrical continuity resistance	Measurement date										
	Measuring equipment										
	Estimated theoretical value (Ω)										
	Measured value (Ω)										
	4 previously measured values (Ω)										
Insulation resistance	Measurement date										
	Measuring equipment										
	Test voltage										
	Estimated theoretical minimum value (Ω)										
	Measured value (Ω)										
	4 previously measured values (Ω)										

Table 22: Example of test form for the measurement of the electrical continuity resistance and the insulation resistance of primary loop circuits for airfield lighting systems.

7.5.4.2. CCR FOLLOW-UP

CCR		
Identification code		
Brand		
Type		
Power setting		
Number of brilliancy settings		
Corresponding current settings		
Operator		
Name		
Work order n°		
Supplied primary loop circuit		
Length		
Number of insulation transformers		
Insulation resistance	Estimated theoretical value	
	Measured value when putting the circuit into operation	
Electrical continuity resistance	Estimated theoretical value	
	Measured value when putting the circuit into operation	
Operations		
Date		
Start time		
End time		
Description	**Periodicity**	**Observation**
Checking of the supplied current value measured by the CCR control and command system for conformation with the setpoint value at each brilliancy step	Every month	
Checking of the surge arresters for proper condition	Every six months and after any storm event	
Measurement of the insulation resistance and the electrical continuity resistance	Every six months and after any operation on any part (insulating transformer, connector, power cable) of the supplied primary loop circuit	
Checking of the ability of the control and command system to detect and report malfunctions within the expected time frame	Every six months	
Checking of the parts for general condition and cleanness	Every year	
Checking of the connections for tightness and hotspots		
Checking and, if necessary, adjusting of the power setting for suitability to the estimated load of the supplied primary loop circuit		
Analysis and archiving of the follow-up forms (to be performed by the supervisor)		
Work description, general observations		
Date and supervisor's signature		

Table 23: Example of follow-up form for a CCR.

7.6. SUMMARIES OF RECOMMENDED PREVENTIVE MAINTENANCE OPERATIONS ON POWER SUPPLY AND AIRFIELD LIGHTING FACILITIES AT AERODROMES

7.6.1. SUMMARY PER TYPE OF FACILITIES

Preventive maintenance operation(s)	Section	Periodicity
Electrical premises		
Checking the over-all condition for cleanness, waterproofness, ventilation and/or air conditioning, rodents or birds, clutter in hallways Cleaning	5.4.1	Every six months
Checking the technical documents for availability and update		
Checking the personal protective equipment for availability and compliance		
Checking the spare parts for adequate storage conditions and accessibility		
Checking the gutters for over-all condition and presence of cover plates		
Checking the self-powered emergency lighting system for serviceability		
HV bays		
Preventive maintenance operations of level I, II, III or IV	5.4.2	Every three years or in accordance with manufacturer's instructions
Other periodic preventive maintenance operations		Every year or in accordance with manufacturer's instructions
Transformers		
Preventive maintenance operations of level I, II, III or IV	5.4.3	Every three years or in accordance with manufacturer's instructions
Other periodic preventive maintenance operations		Every year or in accordance with manufacturer's instructions
Engine generators		
Preventive maintenance operations of level I	5.4.4	Every week or about every ten operating hours
Preventive maintenance operations of level II, III or IV		Every year or about every 500 operating hours or in accordance with manufacturer's instructions
LVMDB, LVDB, LV power distribution networks		
Measurement of the earth terminal resistance	5.4.5	Every year
Measurement of the insulation resistance of the conductors (of the outgoing feeders to remote and parallel connected devices)		
Measurement of the electrical continuity resistance of the protective conductors (of the outgoing feeders to remote and parallel connected devices)		
Measurement of the electrical continuity resistance of the equipotential bonding system (of the outgoing feeders to remote and parallel connected devices)		
Other preventive maintenance operations		
Ageing assessment		Every ten years
Static transfer switches		
Preventive maintenance operations	5.4.6	Every year or in accordance with manufacturer's instructions
Uninterrupted power supply systems		
Preventive maintenance operations of level I, II, III or IV	5.4.7	Every year or in accordance with manufacturer's instructions
Autonomy tests in real operating conditions		Every six months
Other periodic preventive maintenance operations		Every two weeks or in accordance with manufacturer's instructions
Lightning protection systems		
Preventive maintenance operations	5.4.9	In accordance with manufacturer's instructions
Reactive power compensation devices		
Preventive maintenance operations	5.4.10	Every year or in accordance with manufacturer's instructions
Active harmonic compensation devices		
Preventive maintenance operations	5.4.11	Every year or in accordance with manufacturer's instructions
Programmable logic controller		
Preventive maintenance operations	5.4.12	Every year
24 or 48 V DC power supply units		
Preventive maintenance operations of level II, III or IV	5.4.13	Every year
Preventive maintenance operations of level I		Every two weeks
Power supply systems for airfield lighting		
Routine tests for checking their reliability	5.4.14.1	Every three years or after any major change impacting the operation of automatic systems or the power consumption
Specialized tests for checking their reliability	5.4.14.2	
Switch-over time measurement		

Table 24: Recommended preventive maintenance operations for power supply facilities at aerodromes.

Preventive maintenance operation(s)	Section	Periodicity
HMI systems intended for the remote control by ATS of airfield lighting systems except stop bars and those required for the implementation of LVP		
Operating tests	6.3.3.3	Every day
Malfunction detection and reporting tests Spare components tests	6.3.3.3	Every six months
HMI systems intended for the monitoring by the technical support service of airfield lighting systems except stop bars and those required for the implementation of LVP		
Operating tests	6.3.3.3	Every day
Malfunction detection and reporting tests Spare components tests	6.3.3.3	Every six months
HMI systems intended for the remote control and monitoring of stop bars		
Operating tests	6.3.3.3	Every week
Malfunction detection and reporting tests Spare components tests	6.3.3.3	Every six months
HMI systems intended for the remote control and monitoring of airfield lighting systems required for the implementation of LVP		
Operating tests	6.3.3.3	Every month
Malfunction detection and reporting tests Spare components tests	6.3.3.3	Every six months
Subsystems (touch screens, control decks with buttons, Programmable Logic Controllers (PLC), computers, monitoring screens, printers, etc)		
Servicing operations	6.3.3.4.1	In accordance with manufacturer's instructions
Specific power supply units		
Measurement of the characteristic parameters	6.3.3.4.2	Every month
Autonomy tests		Every six months
Servicing operations		In accordance with manufacturer's instructions
Electrical interfaces		
Servicing operations	6.3.3.4.3	In accordance with manufacturer's instructions
Checking of the lightning arrester components		Every six months
Control cables routing exclusively inside of buildings		
Visual inspection	6.3.3.4.4	Every year
Measurement of the electrical and optical characteristic parameters		Every two years
Control cables routing outside of buildings		
Visual inspection Measurement of the electrical and optical characteristic parameters	6.3.3.4.4	Every year

Table 25: Recommended preventive maintenance operations for systems of remote control and monitoring of airfield lighting systems.

<table>
<tr><th>Preventive maintenance operation (except photometric measurements)</th><th>Section</th><th>Periodicity</th></tr>
<tr><td colspan="3">Constant current regulators (CCR)</td></tr>
<tr><td>Checking of the supplied current value measured by the control and command system for conformation with the setpoint value at each brilliancy step</td><td rowspan="8">6.3.1</td><td>Every month</td></tr>
<tr><td>Checking of the surge arresters for general condition</td><td>Every six months or after any storm event</td></tr>
<tr><td>Measurement of the insulation resistance of the supplied primary loop circuit
Measurement of the electrical continuity resistance of the supplied primary loop circuit</td><td>Every six months or after any operation on the supplied primary loop circuit (insulating transformer, connector, power cable)</td></tr>
<tr><td>Checking of the ability of the control and command system to detect and report malfunctions in the expected time frame</td><td>Every six months</td></tr>
<tr><td>Checking of the parts for cleanness</td><td>Every month</td></tr>
<tr><td>Checking of the connections for tightness and hotspots</td><td rowspan="3">Every year</td></tr>
<tr><td>Checking and, if necessary, adjustment of the power setting for suitability to the estimated load of the supplied primary loop circuit</td></tr>
<tr><td>Analysis and archiving of the follow-up forms</td></tr>
<tr><td colspan="3">Airfield lighting infrastructures</td></tr>
<tr><td>Visual inspection of the manholes and the cable chambers</td><td>6.3.5.1</td><td rowspan="4">Every year</td></tr>
<tr><td>Checking of the supporting structures for mechanical integrity, stability and any major land subsidence around them</td><td>6.3.5.2</td></tr>
<tr><td>Visual inspection of the cable ducts for damages</td><td rowspan="3">6.3.5.3</td></tr>
<tr><td>Update of the cable ducts network diagrams</td></tr>
<tr><td>Checking of the critical areas of cable ducts for obstruction</td><td>Every five years</td></tr>
<tr><td>Visual inspection of the kerfs for general condition and damages</td><td>6.3.5.4</td><td>Every six months</td></tr>
<tr><td colspan="3">Airfield signs</td></tr>
<tr><td>Visual inspection for integrity and proper functioning</td><td rowspan="7">6.3.6.2</td><td>Every day
(Runway code number = 1 or 2)
or twice a day
(Runway code number = 3 or 4)</td></tr>
<tr><td>Checking of the mounting feet for proper condition, tightness and attachment to the supporting structure
Tightening</td><td rowspan="6">Every year</td></tr>
<tr><td>Checking of the face (and the coloured covering film, if any) for integrity</td></tr>
<tr><td>Checking of the power connections</td></tr>
<tr><td>Checking of the lighting sources, if any, for proper condition, functioning and arrangement</td></tr>
<tr><td>Checking of the inscriptions for night-time legibility</td></tr>
<tr><td>Checking for the absence of plants hiding the inscriptions</td></tr>
<tr><td colspan="3">Elevated airfield lights</td></tr>
<tr><td>Visual inspection for integrity and proper functioning</td><td>6.3.8.1</td><td>Every day
(Runway code number = 1 or 2)
or twice a day
(Runway code number = 3 or 4)</td></tr>
<tr><td>Checking of each brilliancy step setting for conformation with visual observation</td><td rowspan="2">6.3.8.3.2</td><td rowspan="5">Every year</td></tr>
<tr><td>Checking of the interleaving of series circuits for adequate visual guidance in case of a circuit failure</td></tr>
<tr><td>Visual checking of the mounting structure (foot and fixing system) for integrity and tightness</td><td rowspan="3">6.3.8.3.3</td></tr>
<tr><td>Checking of the power cable and connections for integrity, waterproofness, tensile strength and wearing condition</td></tr>
<tr><td>Visual checking of the optical part for integrity, cleanness, toe-in and vertical setting</td></tr>
<tr><td colspan="3">Inset airfield lights</td></tr>
<tr><td>Visual inspection for integrity and proper functioning</td><td>6.3.8.1</td><td>Every day
(Runway code number = 1 or 2)
or twice a day
(Runway code number = 3 or 4)</td></tr>
<tr><td>Checking of each brilliancy step setting for conformation with visual observation</td><td rowspan="2">6.3.8.3.2</td><td rowspan="2">Every year</td></tr>
<tr><td>Checking of the interleaving of series circuits for adequate visual guidance in case of a circuit failure</td></tr>
<tr><td>Visual checking of the inset base for general condition</td><td rowspan="8">6.3.8.3.4</td><td rowspan="8">Every six months</td></tr>
<tr><td>Visual checking of the sealing compound of the inset base</td></tr>
<tr><td>Visual checking of the horizontal and vertical settings of the inset base</td></tr>
<tr><td>Visual checking of the inside part of the inset base for cleanness and waterproofness</td></tr>
<tr><td>Visual checking of the prisms for general condition and cleanness</td></tr>
<tr><td>Visual checking of the top part for cracks</td></tr>
<tr><td>Checking of the power cable and connection of the top fitting for integrity, waterproofness, tensile strength and wearing condition</td></tr>
<tr><td>Checking of the bolting system of the top fitting for integrity and tightness
Tightening, if necessary</td></tr>
</table>

Table 26: Recommended preventive maintenance operations (except photometric measurements) for airfield lighting facilities.

Preventive maintenance operation (except photometric measurements)	Section	Periodicity
PAPI light units		
Visual checking for proper functioning of the light source (absence of unserviceable light source)	6.3.9.2	Every day
Visual checking for integrity		
Visual checking for the absence of plants that may hide the light beams		
Visual checking of the inside and outside parts (especially the front glasses) for cleanness Cleaning if necessary		Every month
Visual checking of the mounting structure (feet and fixing systems) for integrity and tightness Tightening if necessary		
Visual checking of the red filters, lenses and reflectors for integrity and cleanness, cleaning if necessary		
Visual checking of the colorimetric transition areas of the light beams for alignment		
Measurement of the elevation setting angles by means of the alidade method Associated preliminary checks Analysis and recording of the measurement results	6.3.9.5	Before being put into operation 6 months after being put into operation Every year 6 months after the deviation with respect to the required value for the elevation setting angle is measured greater than 5 arcminutes but less than or equal to 10 arcminutes Every month (for at least 3 months) if the deviation between the measured value and the required value for the elevation setting angle is greater than 10 arcminutes
Measurement of the elevation setting angle by means of a method different from the alidade method and approved by the supervisory authority Associated preliminary checks Analysis and recording of the measurement results		Before being put into operation Every five years After any land subsidence

Table 27: Recommended preventive maintenance operations (except photometric measurements) for PAPI light units.

7.6.2. SUMMARY PER PERIODICITY

Equipment	Preventive maintenance operations	Section
Twice a day		
Airfield signs and lights where the runway code number is 3 or 4	Visual inspection for integrity and proper functioning	6.3.8.1
Every day		
Systems of remote control and monitoring of airfield lighting systems except stop bars and those required for the implementation of LVP	Operating tests of the HMI systems for ATS Operating tests of the HMI systems for the technical support service	6.3.3.2
Airfield signs and lights where the runway code number is 1 or 2	Visual inspection for integrity and proper functioning	6.3.8.1
PAPI light units	Visual inspection for integrity Visual inspection for proper functioning of the light source (absence of unserviceable light source) Visual inspection for the absence of plants that may hide the light beam	6.3.9.2
Every week		
Engine generators	Preventive maintenance operations of level I	5.4.4
Systems of remote control and monitoring of stop bars	Operating tests of the HMI systems	6.3.3.2
Every two weeks		
Uninterrupted power supply systems	Preventive maintenance operations of level I	5.4.7
24 or 48 V DC power supply units	Periodic preventive maintenance operations other than preventive maintenance operations of level II, III or IV	5.4.13
Every month		
Power supply systems for airfield lighting	Routine tests for checking their reliability	5.4.14.1
Constant current regulators	Checking of the supplied current value measured by the control and command system for conformation with the setpoint value at each brilliancy step	6.3.1
Systems of remote control and monitoring of airfield lighting systems required for the implementation of LVP	Operating tests of the HMI systems	6.3.3.2
	Measurement of the characteristic parameters of specific power supply units	6.3.3.4.2
PAPI light units	Visual checking of the inside and outside parts (especially the front glasses) for cleanness Cleaning if necessary Visual checking of the mounting structure (feet and fixing systems) for integrity and tightness Tightening if necessary Visual checking of the red filters, lenses and reflectors for integrity and cleanness, cleaning if necessary Visual checking of the colorimetric transition areas of the light beams for alignment	6.3.9.2
Every month for at least three months		
PAPI light units for which the deviation between the measured value and the required value for the elevation setting angle is greater than 10 arcminutes	Measurement of the elevation setting angle Associated preliminary checks Analysis and recording of the measurement results	6.3.9.5

Table 28: Recommended preventive maintenance operations for power supply and airfield lighting facilities at aerodromes (Summary per periodicity).

Equipment	Preventive maintenance operations	Section
Every six months		
Electrical premises	Checking of the over-all condition for cleanness, waterproofness, ventilation and/or air conditioning, rodents or birds, clutter in hallways Cleaning	5.4.1
	Checking of the technical documents for availability and update	
	Checking of the personal protective equipment for availability and compliance	
	Checking of the spare parts for adequate storage conditions and accessibility	
	Checking of the gutters for over-all condition and presence of cover plates	
	Checking of the self-powered emergency lighting system for serviceability	
Uninterrupted power supply systems	Autonomy tests in real operating conditions	5.4.7
Constant current regulators	Checking of the ability of the control and command system to detect and report malfunctions within the expected time frame	6.3.1
	Checking of the surge arresters for condition	
	Measurement of the insulation resistance of the supplied primary loop circuit Measurement of the electrical continuity resistance of the supplied primary loop circuit	
Systems of remote control and monitoring of airfield lighting systems	Malfunction detection and reporting tests of HMI systems Tests of spare components of HMI systems	6.3.3.4
	Autonomy tests of specific power supply units	6.3.3.4.2
	Checking of lightning surge arrester components	6.3.3.4.3
Airfield lighting infrastructures	Visual inspection of kerfs for general condition and damages	6.3.5.4
Inset airfield lights	Visual checking of the inset base for general condition	6.3.8.3.4
	Visual checking of the sealing compound of the inset base	
	Visual checking of the horizontal and vertical settings of the inset base	
	Visual checking of the inside part of the inset base for cleanness and waterproofness	
	Visual checking of the prisms for general condition, cleanness	
	Visual checking of the top part for cracks	
	Checking of the power cable and connection of the top fitting for integrity, waterproofness, tensile strength and wear	
	Checking of the bolting system of the top fitting for integrity and tightness Tightening, if necessary	
PAPI light unit for which the deviation between the measured value and the required value of the elevation setting angle is greater than 5 arcminutes but less than or equal to 10 arcminutes	Measurement of the elevation setting angle Associated preliminary checks Analysis and recording of the measurement results	6.3.9.5

Table 28 (follow-up): Recommended preventive maintenance operations for power supply and airfield lighting facilities at aerodromes (Summary per periodicity).

Equipment		Preventive maintenance operations	Section
Every year			
HV bays		Other periodic preventive maintenance operations than preventive maintenance operations of level I, II, III or IV	5.4.2
Transformers		Other periodic preventive maintenance operations than preventive maintenance operations of level I, II, III or IV	5.4.3
Engine generators		Preventive maintenance operations of level I, II, III or IV	5.4.4
LVMDB, LVDB, LV power distribution network		Measurement of the earth terminal resistance	5.4.5
		Measurement of the insulation resistance of the protective conductors of the outgoing feeders for remote and parallel connected devices for insulation defects	
		Measurement of the electrical continuity resistance of the conductors of the outgoing feeders for remote and parallel connected devices	
		Measurement of the electrical continuity resistance of the equipotential bonding system of the outgoing feeders for remote and parallel connected devices	
		Other preventive maintenance operations	
Static transfer switches		Preventive maintenance operations	5.4.6
Uninterrupted power supply systems		Preventive maintenance operations of level II, III or IV	5.4.7
Reactive power compensation devices		Preventive maintenance operations	5.4.10
Active harmonic compensation devices		Preventive maintenance operations	5.4.11
Programmable logic controller		Preventive maintenance operations	5.4.12
24 or 48 V DC power supply units		Preventive maintenance operations of level II, III or IV	5.4.13
Constant current regulators		Preventive maintenance operations of level II, III or IV	6.3.1
		Checking of the parts for cleanness	
		Checking of the connections for tightness and hotspots	
		Checking and, if necessary, adjustment of the power setting for suitability to the estimated load of the supplied primary loop circuit	
		Analysis and archiving of the follow-up forms	
Systems of remote control and monitoring of airfield lighting systems		Visual checking of the control cables	6.3.3.4.4
		Measurement of the electrical and optical characteristic parameters of the control cables routing outside of buildings	
Airfield lighting infrastructures	Manholes and cable chambers	Visual checking	6.3.5.1
	Supporting structures	Checking for mechanical integrity, stability and any major land subsidence	6.3.5.2
	Cable ducts	Visual checking for damages	6.3.5.3
		Update of network diagrams	
Airfield signs		Checking of the mounting feet for proper condition, tightness and attachment to the supporting structure Tightening	6.3.6
		Checking of the face (and the coloured covering film, if any) for integrity	
		Checking of the power connections	
		Checking of the lighting sources, if any, for proper condition, functioning and arrangement	
		Checking of the inscriptions for night-time legibility	
		Checking for the absence plants hiding the inscriptions	
Elevated or inset airfield lights		Checking of each brilliancy step setting for conformation with visual observation	6.3.8.3.2
		Checking of the interleaving of series circuits for adequate visual guidance in case of a circuit failure	
Elevated airfield lights		Visual checking of the mounting structure (foot and fixing system) for integrity and tightness	6.3.8.3.3
		Checking of the power cable and power connections for integrity, waterproofness, tensile strength and wear	
		Visual checking of the optical part for integrity, cleanness, toe-in and vertical setting	
PAPI light units		Measurement of the elevation setting angles Associated preliminary checks Analysis and recording of the measurement results	6.3.9.5

Table 28 (follow-up): Recommended preventive maintenance operations for power supply and airfield lighting facilities at aerodromes (Summary per periodicity).

Equipment	Preventive maintenance operations	Section
Every two years		
Systems of remote control and monitoring of airfield lighting systems	Measurement of the electrical and optical characteristic parameters of the control cables routing exclusively inside of buildings	6.3.3.4.4
Every three years		
HV bays	Preventive maintenance operations of level I, II, III or IV	5.4.2
Transformers	Preventive maintenance operations of level I, II, III or IV	5.4.3
Power supply systems for airfield lighting	Specialized tests for checking their reliability Switch-over time measurement	5.4.14.2
Every five years		
Cable ducts	Checking of the critical areas for obstruction	6.3.5.3
PAPI light units	Measurement of the elevation setting angles by means of a method different from the alidade method and approved by the supervisory authority Associated preliminary checks Analysis and recording of the measurement results	6.3.9.5
Every ten years		
LVMDB, LVDB, LV power distribution networks	Ageing assessment	5.4.5
About every ten operating hours		
Engine generators	Preventive maintenance operations of level I	5.4.4
About every 500 operating hours		
Engine generators	Preventive maintenance operations of level II, III or IV	5.4.4
Periodicity in accordance with manufacturer's instructions		
HV bays	Preventive maintenance operations of level I, II, III or IV Other periodic preventive maintenance operations than preventive maintenance operations of level I, II, III or IV	5.4.2
Transformers	Preventive maintenance operations of level I, II, III or IV Other periodic preventive maintenance operations than preventive maintenance operations of level I, II, III or IV	5.4.3
Static transfer switches	Preventive maintenance operations	5.4.6
Uninterrupted power supply systems	Preventive maintenance operations of level I, II, III or IV Periodic preventive maintenance operations other than autonomy tests in real operating conditions and preventive maintenance operations of level I, II, III or IV	5.4.7
Lightning protection systems	Preventive maintenance operations	5.4.9
Reactive power compensation devices	Preventive maintenance operations	5.4.10
Active harmonic compensation devices	Preventive maintenance operations	5.4.11
Systems of remote control and monitoring of airfield lighting systems	Servicing operations of the subsystems (touch screens, control decks with buttons, Programmable Logic Controllers (PLC), computers, monitoring screens, printers, etc)	6.3.3.4.1
	Servicing operations of the specific power supply units	6.3.3.4.2
	Servicing operations of the electrical interfaces	6.3.3.4.3
After any storm event		
Constant current regulators	Checking of the surge arresters for general condition	6.3.1
Before and after any operation on any part (insulating transformer, connector, power cable) of a primary loop circuit		
Constant current regulators	Measurement of the insulation resistance of the supplied primary loop circuit Measurement of the electrical continuity resistance of the supplied primary loop circuit	6.3.1
Before being put into operation or after any land subsidence		
PAPI light units	Measurement of the elevation setting angles by means of the alidade method and by means of another method approved by the supervisory authority Associated preliminary checks Analysis and recording of the measurement results	6.3.9.5
Six months after being put into operation		
PAPI light units	Measurement of the elevation setting angles Associated preliminary checks Analysis and recording of the measurement results	6.3.9.5
After any major change impacting the operation of automatic systems or the power consumption		
Power supply systems for airfield lighting	Specialized tests for checking their reliability Switch-over time measurement	5.4.14.2

Table 28 (follow-up): Recommended preventive maintenance operations for power supply and airfield lighting facilities at aerodromes (Summary per periodicity).

7.7. PHOTOMETRIC QUANTITIES

7.7.1. LUMINOUS FLUX

Luminous flux (or luminous power) is the power of visible light produced by a light source. Luminous flux shall be expressed in lumens (lm).

Figure 49: Luminous flux.

7.7.2. LUMINOUS INTENSITY (OR LIGHT INTENSITY)

Luminous intensity is defined as the quotient of the elementary luminous flux by the elementary solid angle in a given direction. Luminous intensity shall be expressed in candelas (cd).

Luminous intensity is independent of the measuring distance.

Luminous intensity of airfield lights shall be measured in different directions as the light is not emitted uniformly in any direction.

Figure 50: Luminous intensity.

7.7.3. ILLUMINANCE

Illuminance is the incident luminous flux received per unit area. Illuminance shall be expressed in lux (lx).

An illuminance of one lux is equal to a luminous flux of one lumen spread uniformly over an area of one square metre.

The illuminance ***E*** (in lux) on a lighted surface, the luminous intensity ***I*** (in candelas) of a light source and the distance ***d*** (in metres) between the light source and the lighted area are related by the following formula: $I = E \cdot d^2$

Illuminance is inversely proportional to the square of the distance between the light source and the lighted area. If the distance is doubled and the luminous intensity remains unchanged, then the illuminance is divided by four.

7.8. LABORATORY MEASUREMENT METHOD OF LUMINOUS INTENSITY

When being laboratory tested for photometric and colorimetric compliance with applicable requirements for field installation, measurement of the light intensity of an airfield light shall be performed in hundreds of horizontal and vertical directions to compute the following photometric quantities:

- the main beam average light intensity,
- the main beam minimum intensity,
- the ratio between the main beam maximum and minimum light intensities, and
- the minimum light intensities within the directions defined by the outer isocandela curves.

Photometric characteristics of airfield lights may vary depending on the airfield lighting system in which they are included. Main beam average light intensity is the arithmetic mean of light intensity values measured in several tens of horizontal and vertical directions.

Figure 51 below illustrates the photometric requirements for an approach centre line and crossbar light as well as the horizontal and vertical directions of photometric and colorimetric measurements, as follows:

- the light intensity spread: the main beam isocandela curve and the related required minimum average and local light intensities (respectively 20 000 cd and 10 000 cd), the outer isocandela curves delineating the secondary beams and the related required minimum local light intensities (2 000 cd and 1 000 cd),
- the horizontal and vertical directions in which light intensity measurements shall be performed to compute the photometric quantities as listed above, and
- the horizontal and vertical directions related to the main beam in which chromatic coordinates measurements shall be performed and the horizontal and vertical directions related to the outermost beam in which chromatic coordinates measurements should be performed.

Type certification of airfield lights allows to ensure their compliance with applicable photometric and colorimetric requirements for field installation. Photometric and colorimetric performances of airfield lights decrease over time due to the wearing of components (particularly that of light sources), the contamination of optical systems and the opacification of prisms.

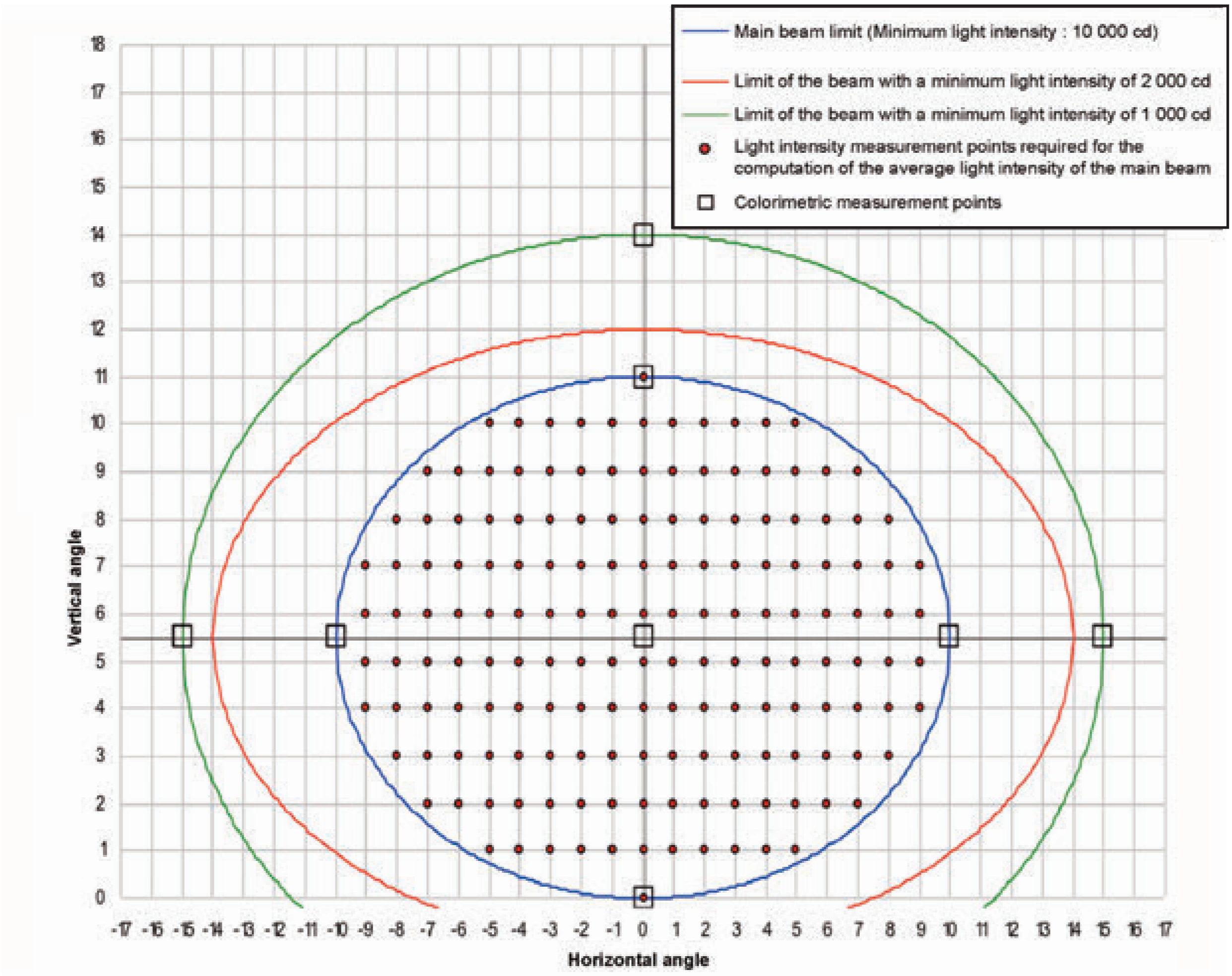
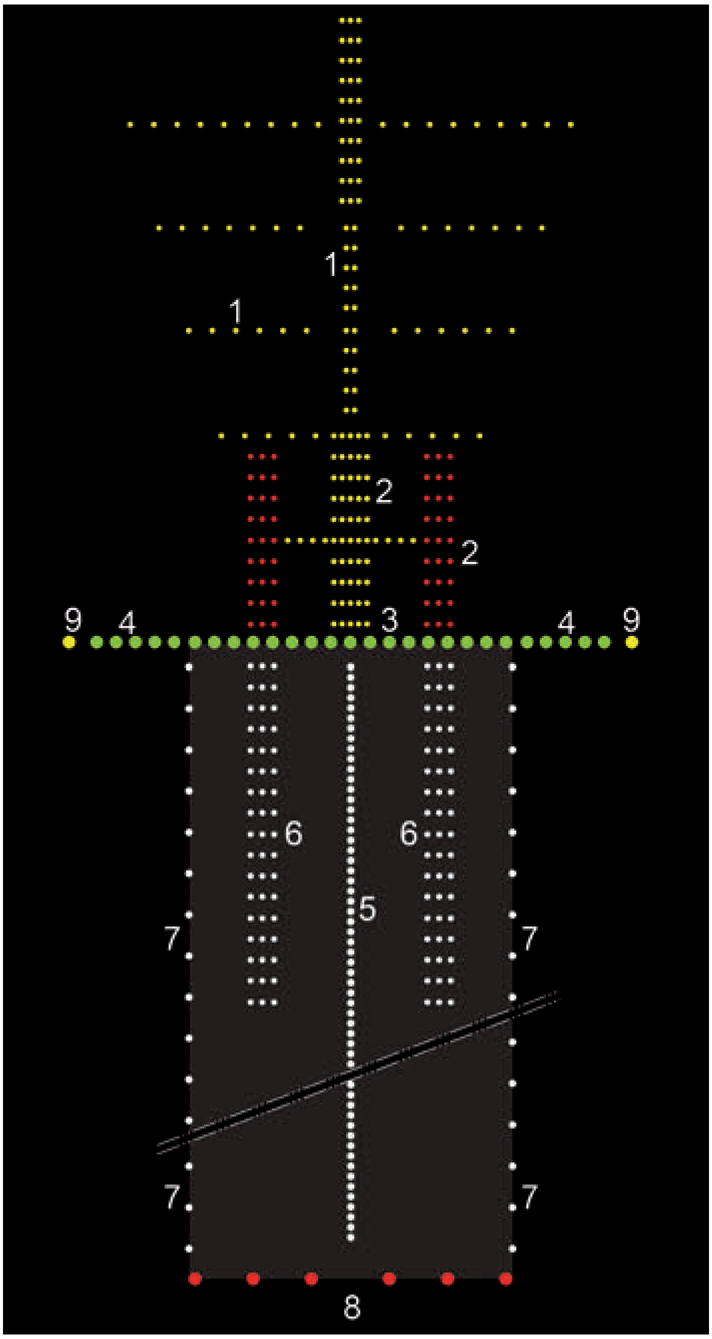


Figure 51: Isocandela diagram for approach centre line light and crossbars (white light).

7.9. LIGHTING SYSTEMS FOR A PRECISION APPROACH RUNWAY



1. Approach lighting system for precision approach runway, category I
2. Approach lighting system for precision approach runway, category II or III
3. Runway threshold lights
4. Runway threshold wing bar lights
5. Runway centre line lights
6. Touchdown zone lights
7. Runway edge lights
8. Runway end lights
9. Runway threshold identification lights (flashing lights)

Figure 52: Runway and approach lighting systems for a precision approach runway.

7.10. VERTICAL AND HORIZONTAL SETTING OF AIRFIELD LIGHTS

7.10.1. DEFINITIONS

The horizontal (or toe-in) setting angle of an airfield light is defined as the angle between the maximum light intensity axis of the light and the vertical plane passing through the runway centre line direction.

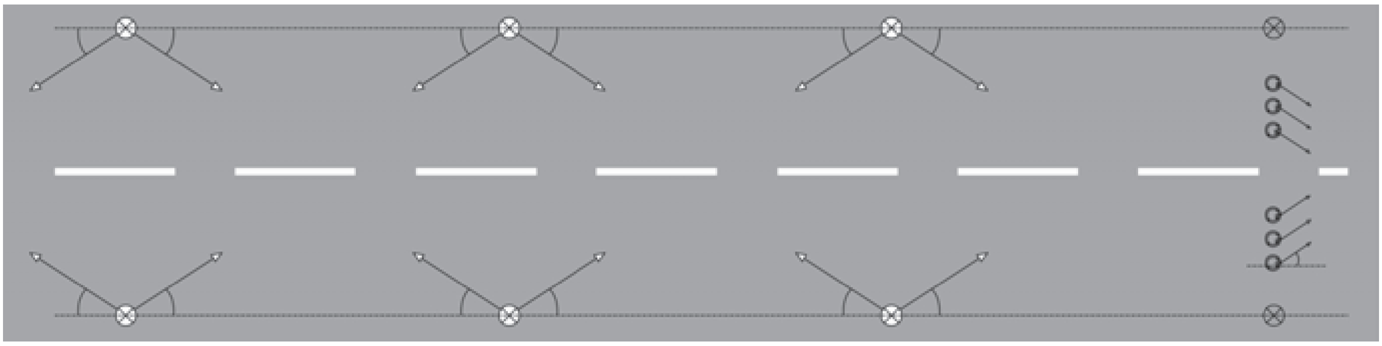


Figure 53: Horizontal (or toe-in) setting angle of runway edge lights (top view).

The vertical (or elevation) setting angle of an airfield light is defined as the angle between the horizontal plane and the maximum light intensity axis of the light.

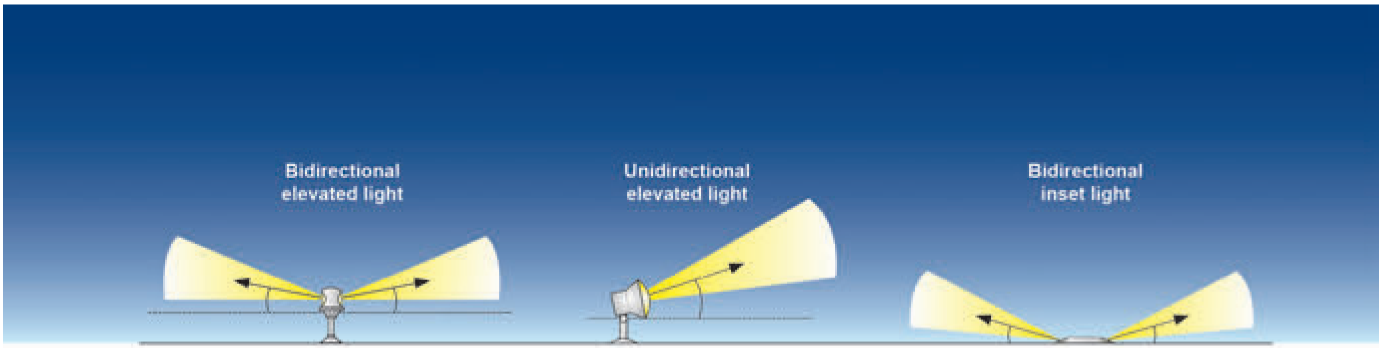


Figure 54: Vertical (or elevation) setting angle of runway edge lights (side view).

7.10.2. REQUIREMENTS

Figures 59 to 66 illustrate the horizontal and vertical setting angles required for the following airfield lights (see section 7.9 for an illustration of lighting systems for a precision approach runway) :

- lights included in approach lighting systems for precision approach runway, category I
- lights included in approach lighting system for precision approach runway, category II or III,
- runway threshold lights and runway threshold wing bar lights,
- runway centre line lights,
- touchdown zone lights,
- runway edge lights,
- runway end lights, and
- runway threshold identification lights (flashing lights).

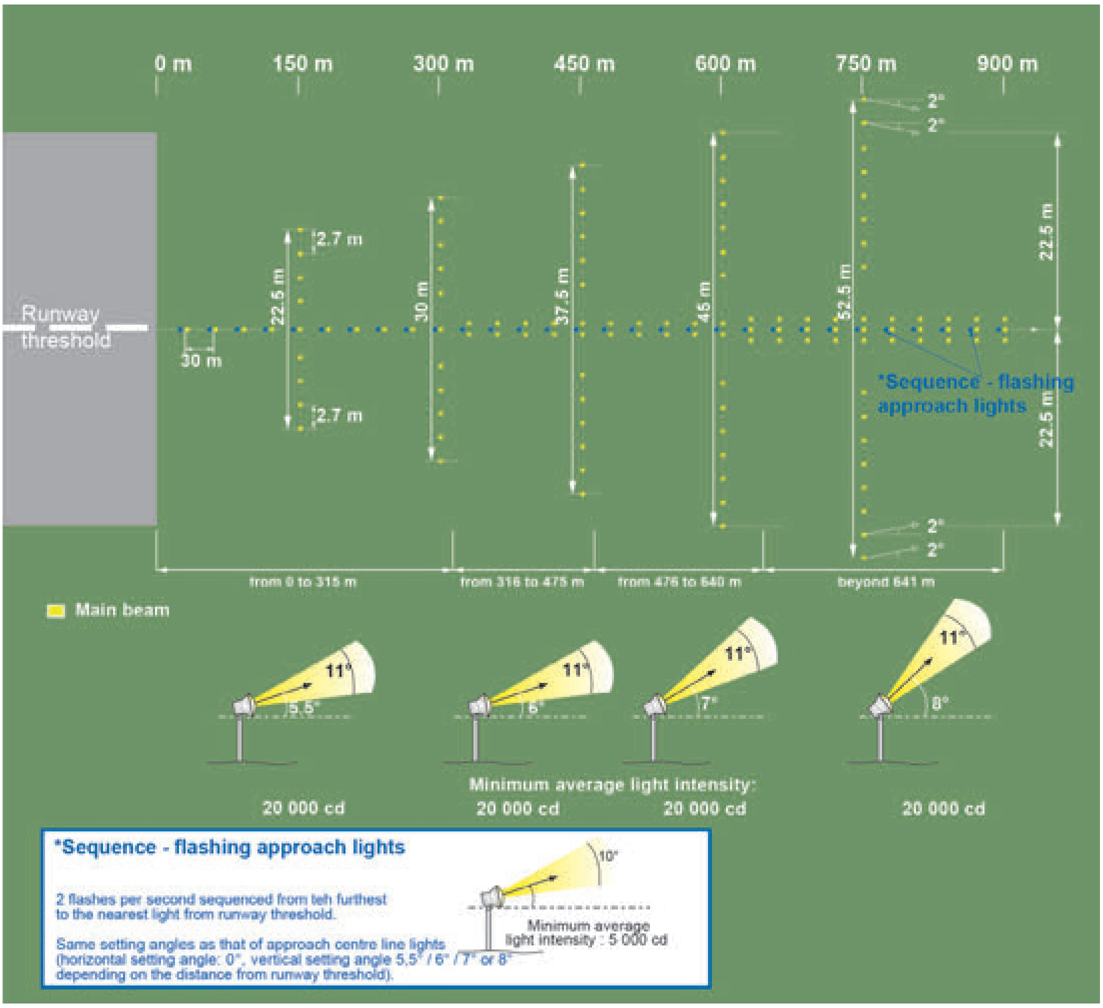


Figure 55: Vertical and horizontal setting angles required for lights included in approach lighting systems for precision approach runway, category I.

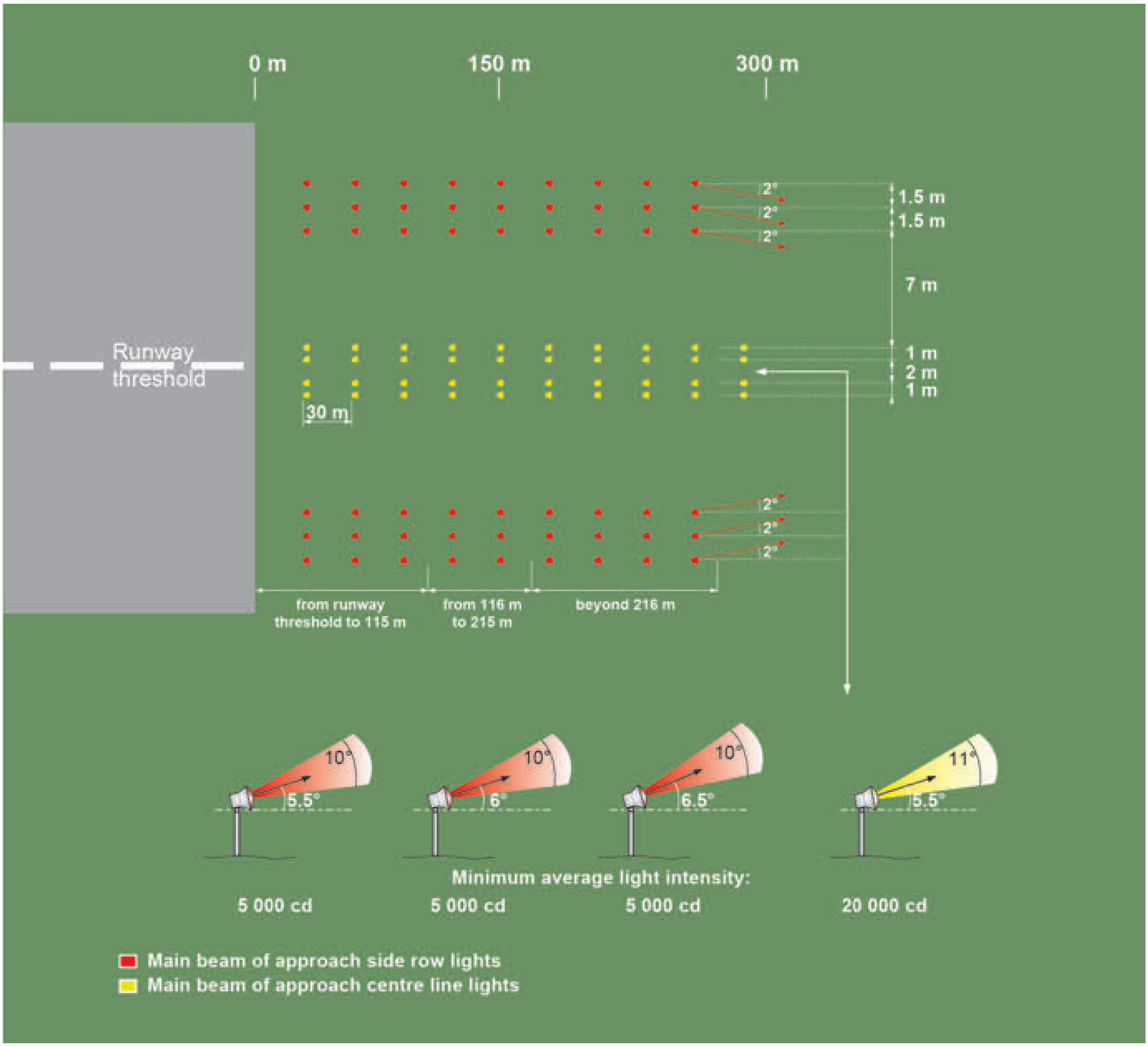


Figure 56: Vertical and horizontal setting angles required for lights included in approach lighting systems for precision approach runway, category II.

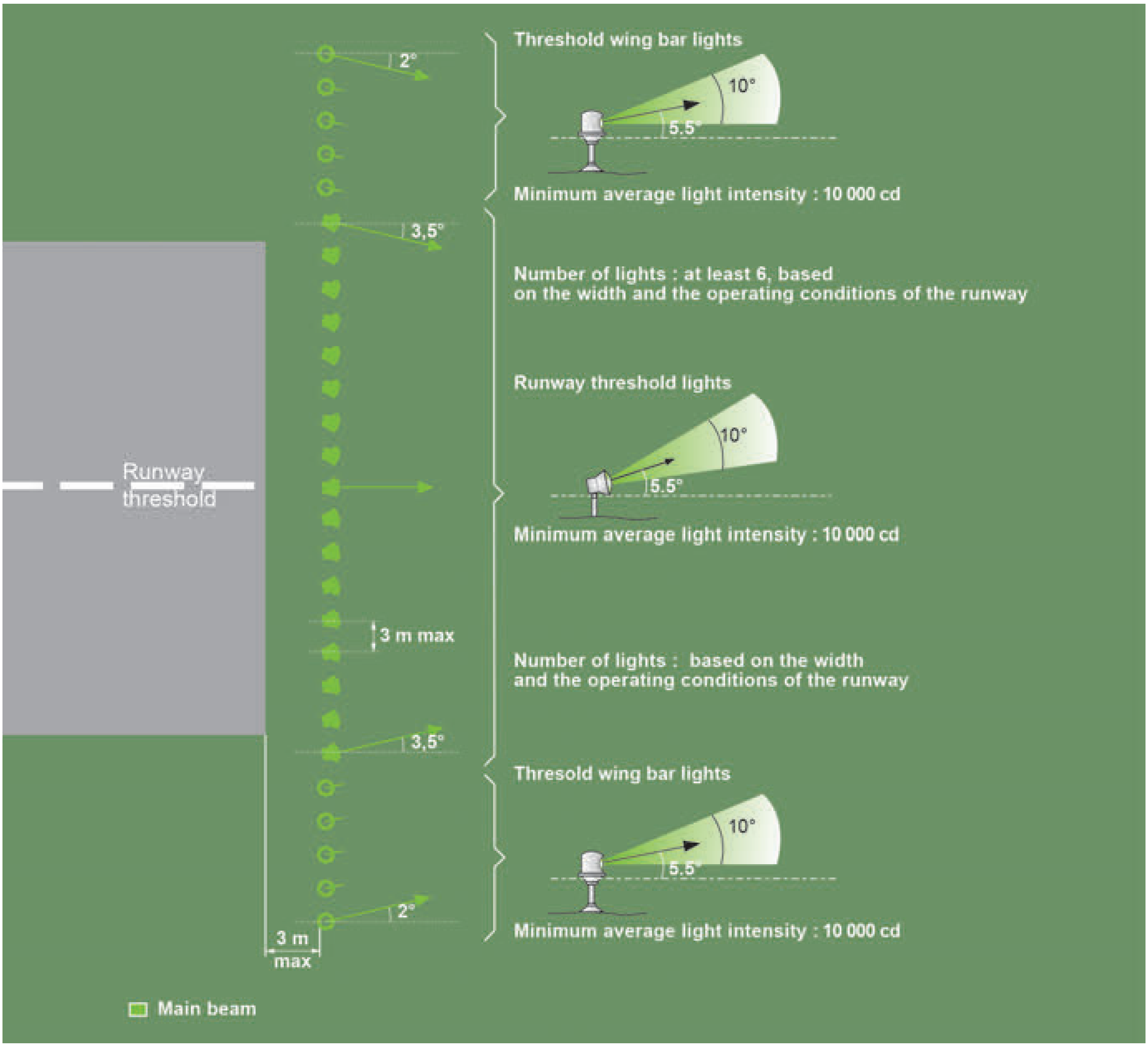


Figure 57: Vertical and horizontal setting angles required for runway threshold lights and runway threshold wing bar lights.

Note:

Runway threshold lights installed on each side of the runway centre line shall be toed-in 3,5° and their beam shall be orientated towards the runway centre line.

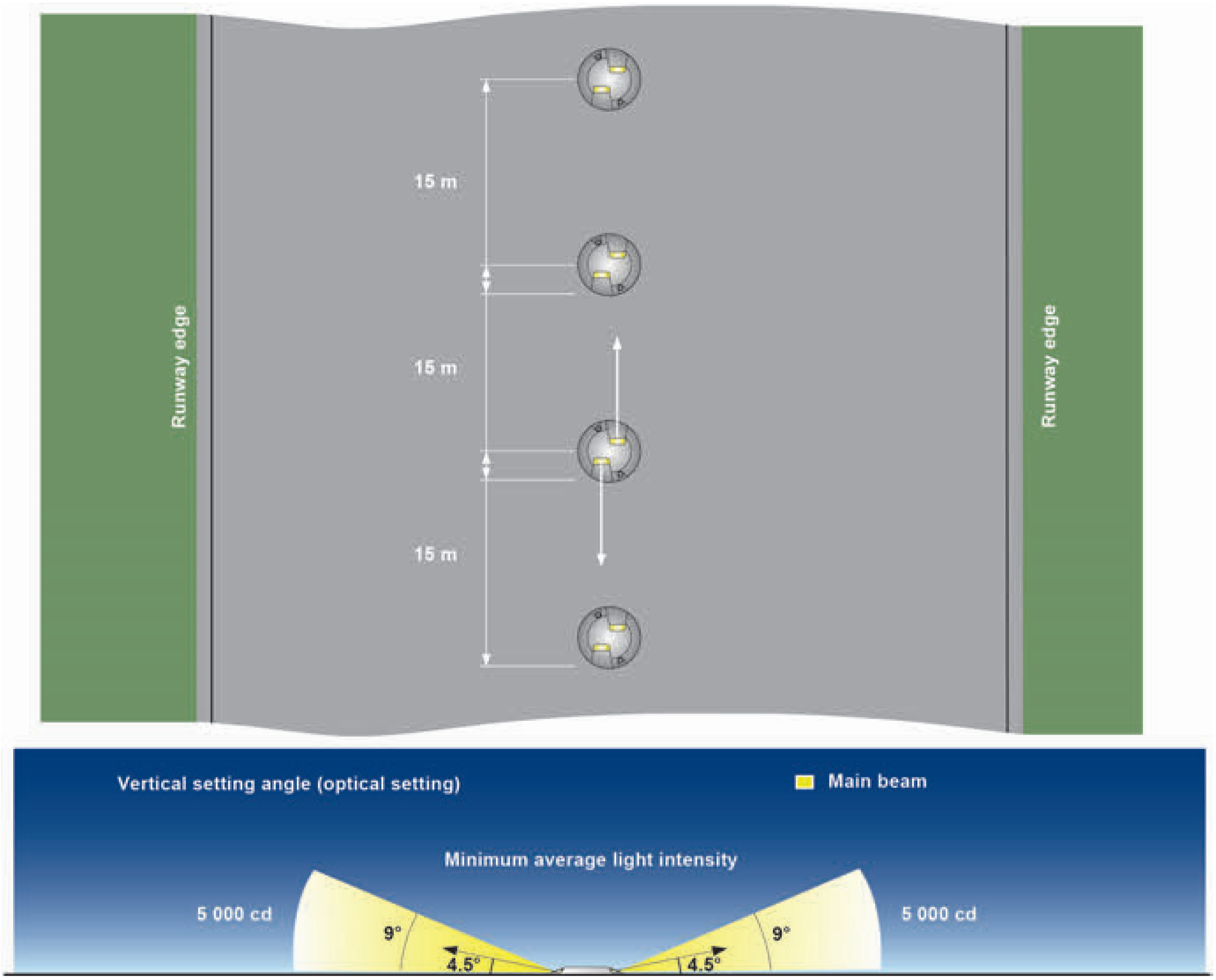


Figure 58: Vertical setting angle required for runway centre line lights.

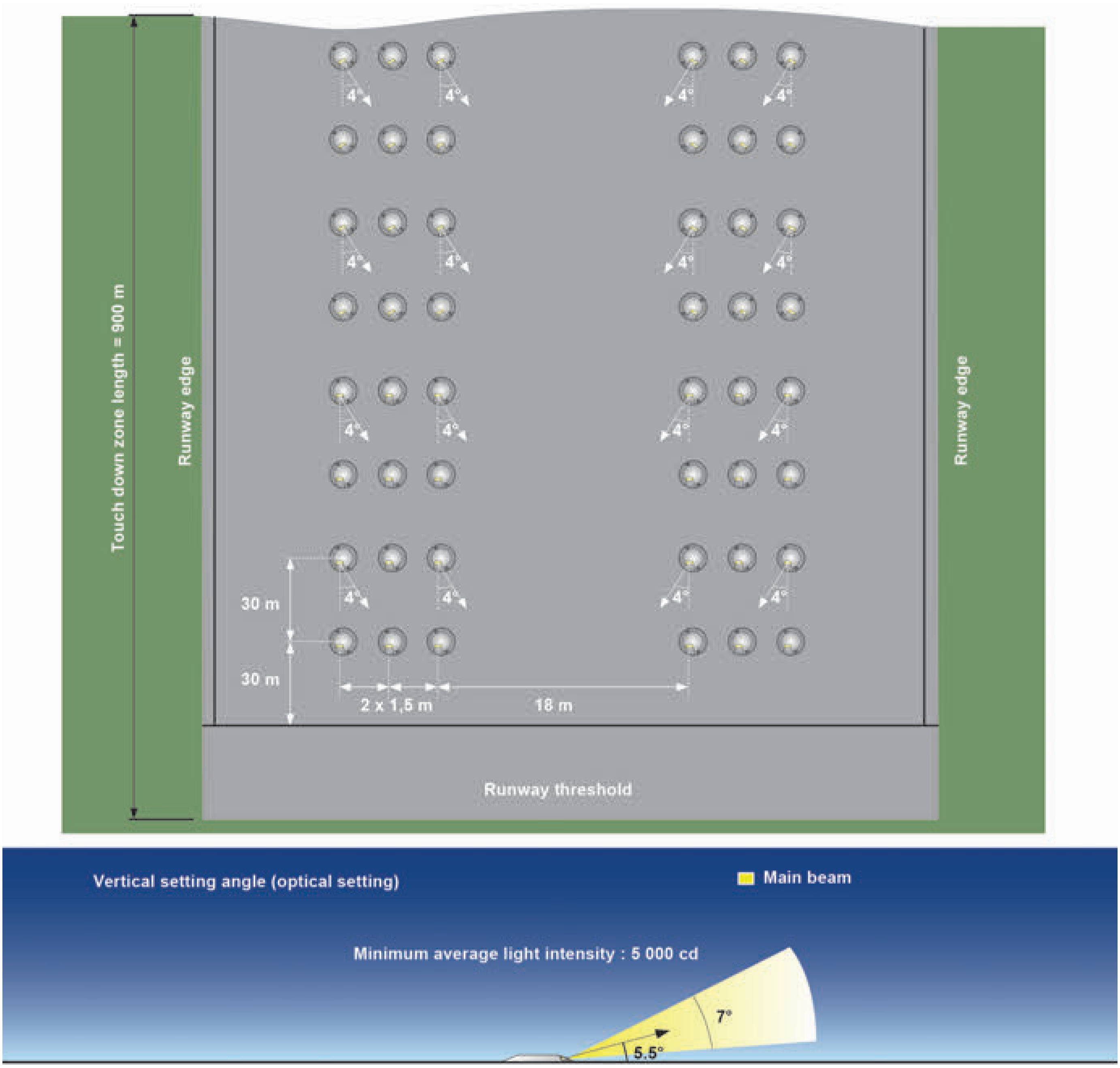


Figure 59: Vertical and horizontal setting angles required for touchdown zone lights.

Note:

Touchdown zone lights shall be toed-in 4°.

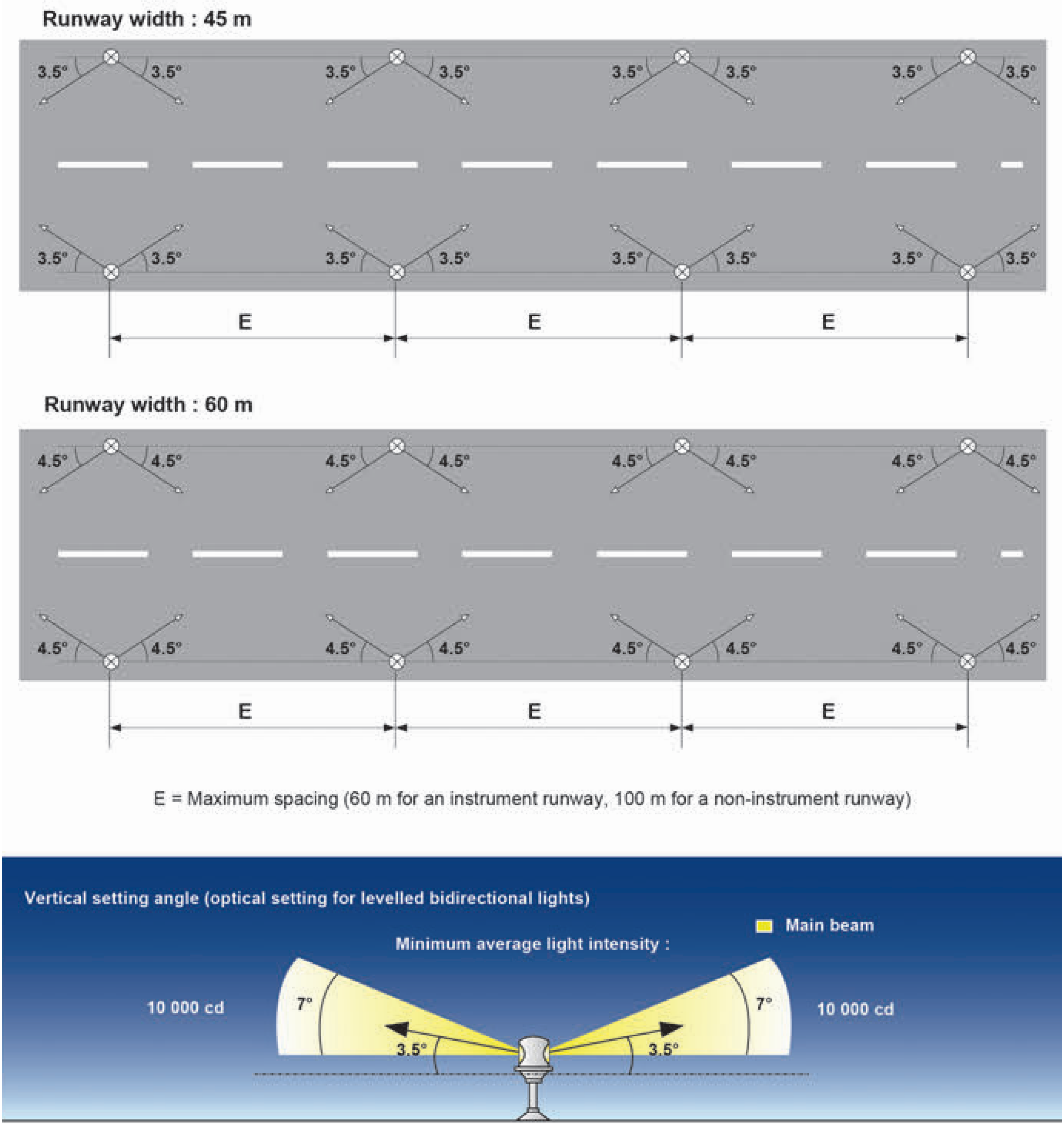


Figure 60: Vertical and horizontal setting angles required for runway edge lights.

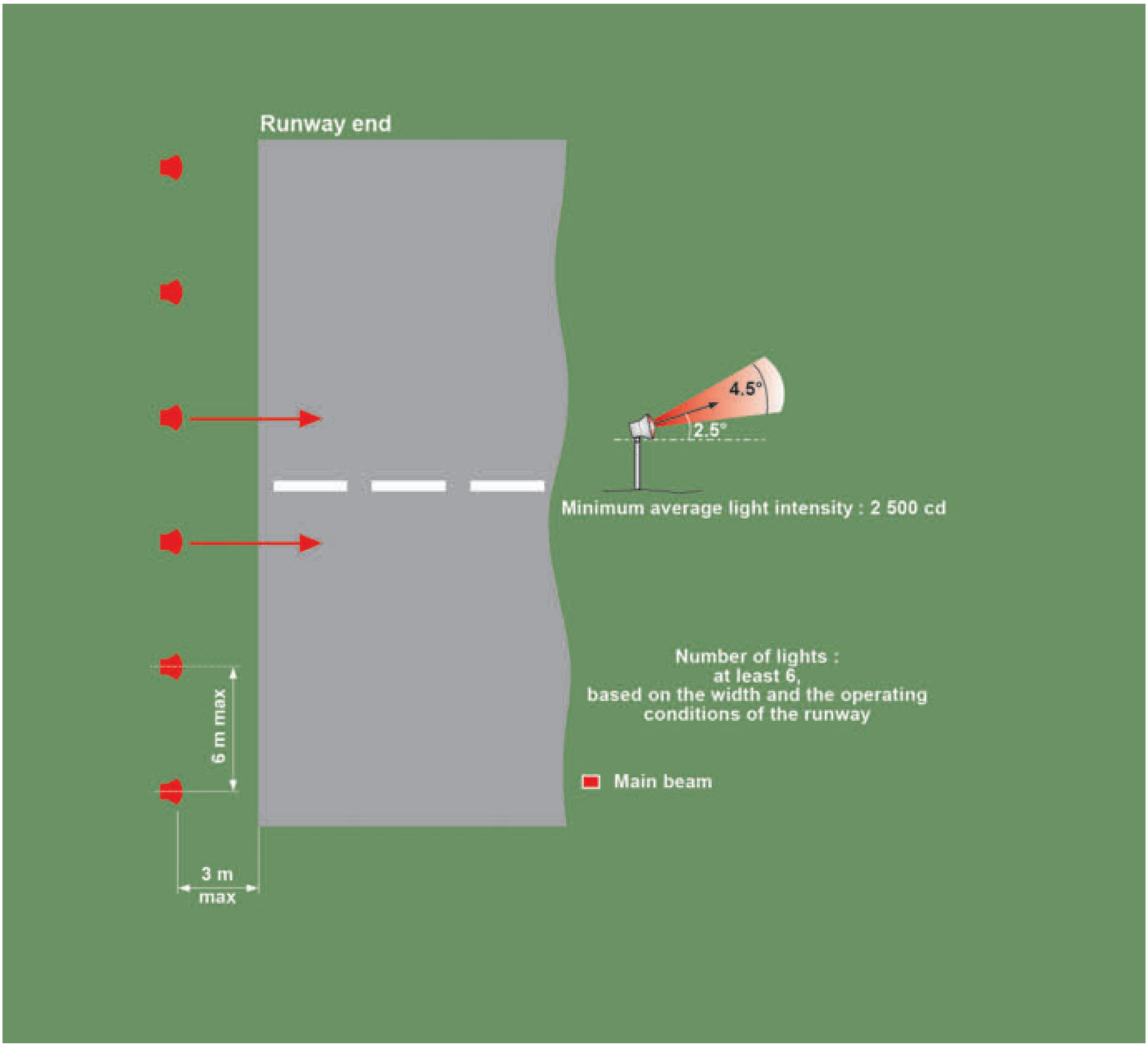


Figure 61: Vertical setting angle required for runway end lights.

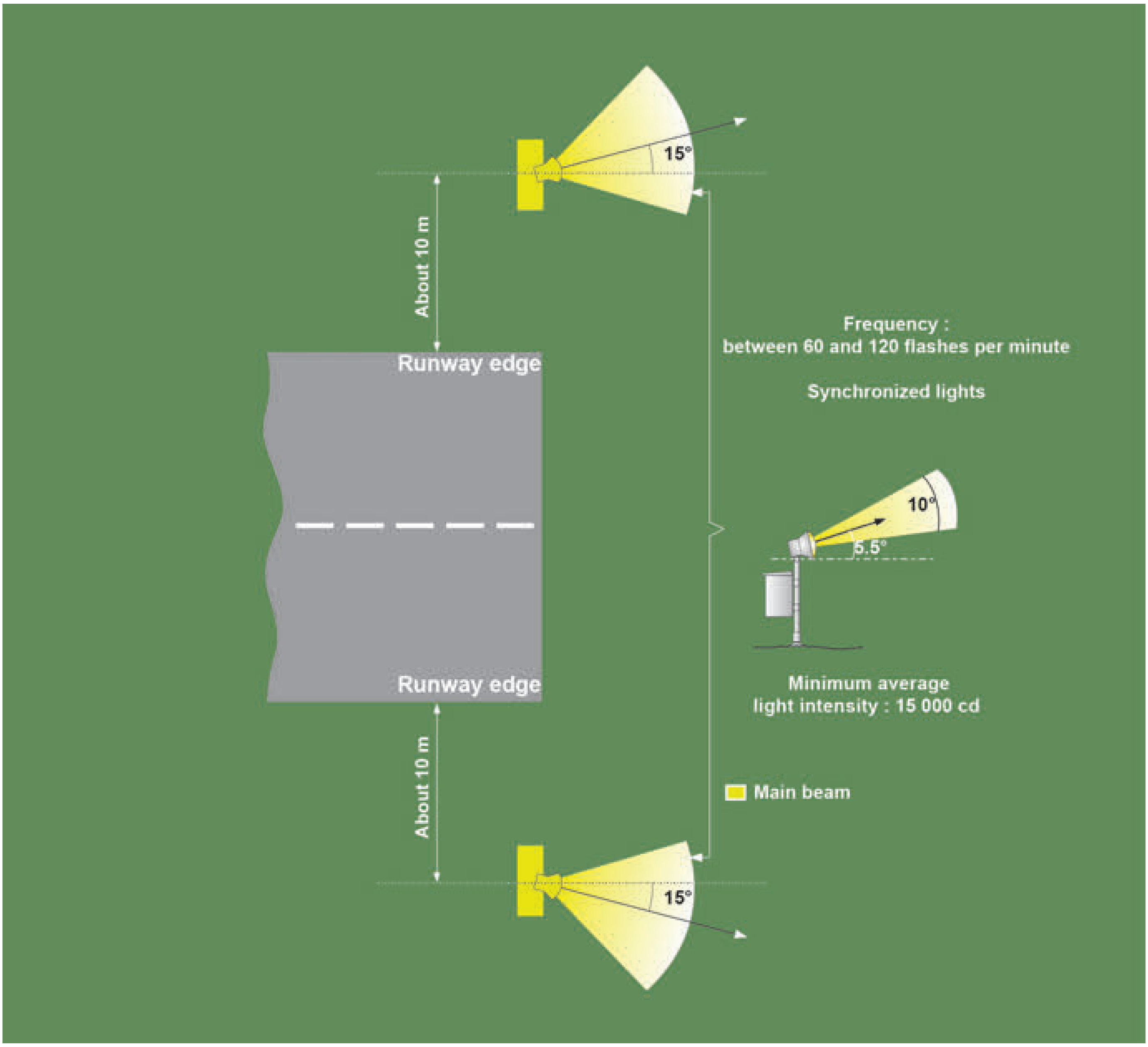


Figure 62: Vertical and horizontal setting angles required for runway threshold identification lights (flashing lights).

Note:

As a rule, runway threshold identification lights should be located symmetrically about the runway centre line, in line with the threshold. Where it is physically impracticable to install them in line with the threshold, they may be located within a distance ranging from 10 m before the threshold to 30 m beyond the threshold and within a distance ranging from 10 to 25 m from the runway edge.

7.10.3. METHODS

Procedures and related instructions for airfield light setting shall be provided by the manufacturer of the setting device.

Procedures for airfield light setting differ according to the airfield light type: a distinction shall be made between unidirectional elevated airfield lights, bidirectional elevated airfield lights and inset airfield lights.

Airfield light setting may be obtained either solely mechanically (case of elevated unidirectional airfield lights, for instance approach lights), or both optically and mechanically (case of some inset airfield lights and bidirectional elevated airfield lights, for instance elevated runway edge lights).

Vertical and horizontal setting of bidirectional elevated airfield lights such as elevated runway edge lights shall be obtained both optically and mechanically. They shall be horizontally levelled and aligned parallel to the runway centre line, which, in combination with their optical design characteristics, ensures their adequate vertical and horizontal setting.

Vertical setting of inset airfield lights shall be obtained both mechanically and optically. They shall be horizontally levelled, which, in combination with their optical design, ensures their vertical setting. Horizontal setting of inset airfield lights may be obtained either both optically and mechanically, by aligning the inset base parallel to the runway or taxiway centre line, or solely mechanically, by aligning the inset base in such a way to ensure adequate toe-in with respect to the runway or taxiway centre line.

7.11. METHODS OF MEASUREMENT OF THE ELEVATION SETTING ANGLE OF A LIGHT UNIT OF A PAPI SYSTEM (METHODS DIFFERENT FROM THE ALIDADE METHOD)

The methods presented hereinafter are also detailed in ICAO Doc. 9157, part 4 (Visual aids), 5th edition.

7.11.1. FLIGHT CHECKING METHOD

The historical method of measurement of the elevation setting angle of a PAPI light unit requires both a ground-based operator using a theodolite and an observer on-board an aircraft sinusoidally flying above and below the glide path.

The theoretical reference point from which the angles are measured by the theodolite shall be in the colorimetric transition area of the light unit beam to be measured. Non-measured light unit beam shall be masked.

The ground-based operator shall point the theodolite at the aircraft nose while the on-board observer shall give a signal to the ground-based operator each time a colorimetric transition area is observed, either from white to red or from red to white.

The ground-based operator shall record the angle measured by the theodolite each time a signal is given by the on-board observer.

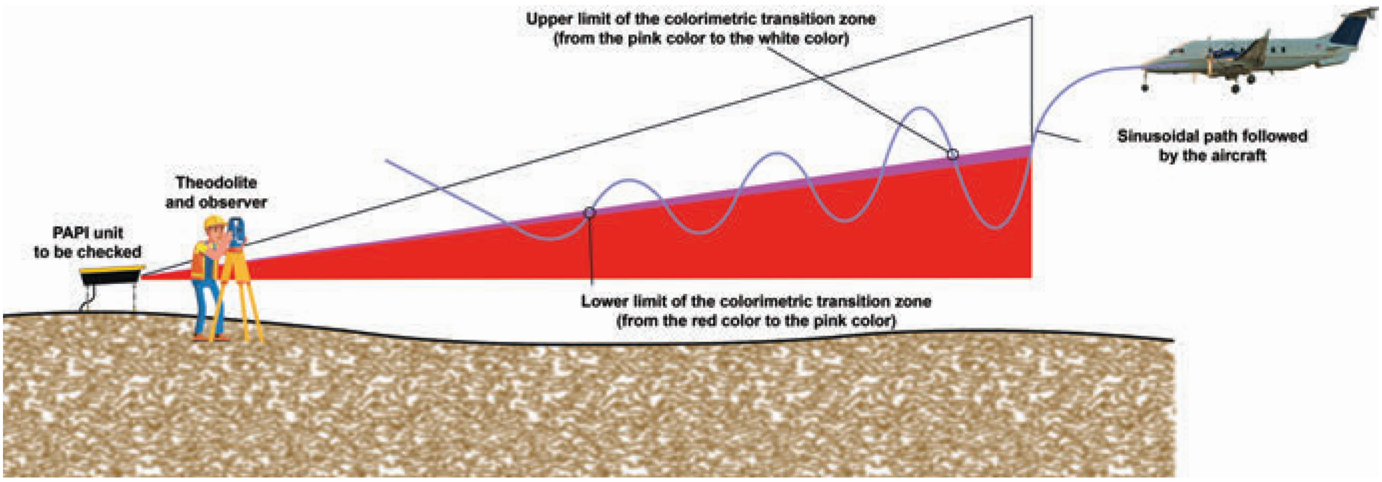


Figure 63: Measurement of the elevation setting angle of a light unit of a PAPI system by the flight-checking method.

7.11.2. LIFT PLATFORM METHOD

Figure 64: Lift platform positioned for the measurement of the elevation setting angle of a PAPI light unit at Toulouse Blagnac aerodrome.

Another method of measurement of the elevation setting angle of a PAPI light unit is based on the static observation of the colorimetric transition zone from a significant height and from a long distance to improve measurement accuracy.

This method requires the use of the following equipment:

- a theodolite to be installed close to the PAPI system, and
- a mobile lift platform to be installed in front of the PAPI system, allowing to observe the light beams from a height of up to 15 m (to consider the topography of the aerodrome) and from different distances that shall be adequate for the required elevation setting angle of any light unit.

The lift platform shall be positioned ahead of the light unit, on its centre line, at about 150 m from it. The height of the lift platform shall be adjusted by the lift platform driver until the observer on the lift platform can see a full white signal when standing and a full red signal when slightly bending his knees. Then, the observer shall be able to view the colorimetric transition zone by bending slightly his knees.

The theodolite shall be positioned by a ground-based expert-surveyor in accordance with its characteristics and with the location of the lens of the light unit. The observer on the lift platform shall hold a targeting prism at his eyes level. The ground-based expert-surveyor shall point the theodolite at the targeting prism held by the observer on the lift platform. The angle measured by the theodolite shall be recorded by the expert-surveyor when the observer on the lift platform can view the colorimetric transition by slightly bending his knees.

Figure 65: Observer on a lift platform, holding a targeting prism for the measurement of the elevation setting angle of a PAPI light unitl.

Note:

- The colorimetric transition zone between the full white signal and the full red signal is pink-coloured and the angle it forms may be up to 3 arcminutes
- The colorimetric transition zone from the full white signal to the pink signal is more easily distinguishable as the change in luminous intensity is more significant. Experience proved that searching for the full red signal at the lower limit of the colorimetric transition area resulted in measurement errors (underestimated results). Measurement results should be therefore recorded only when the observer on the lift platform views the upper limit of the colorimetric transition area (change from the full white signal to the pink signal).
- When the observer on the lift platform indicates that he views the upper limit of the colorimetric transition area, the expert surveyor should record the angle measured by the theodolite.

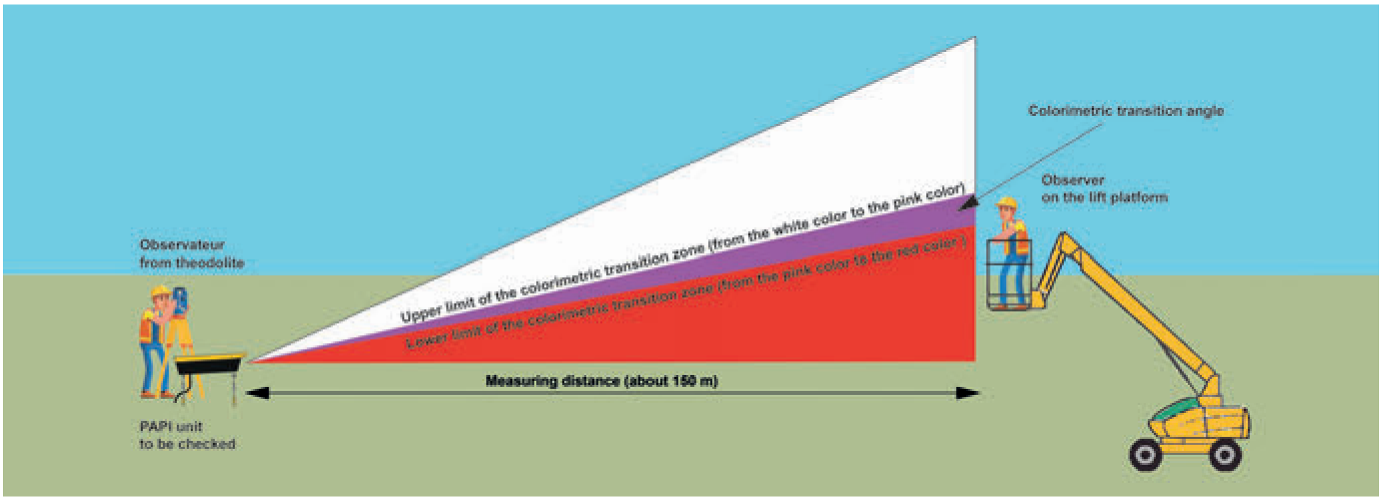


Figure 66: Measurement principle of the elevation setting angle of a PAPI light unit by the lift platform method (Side view)

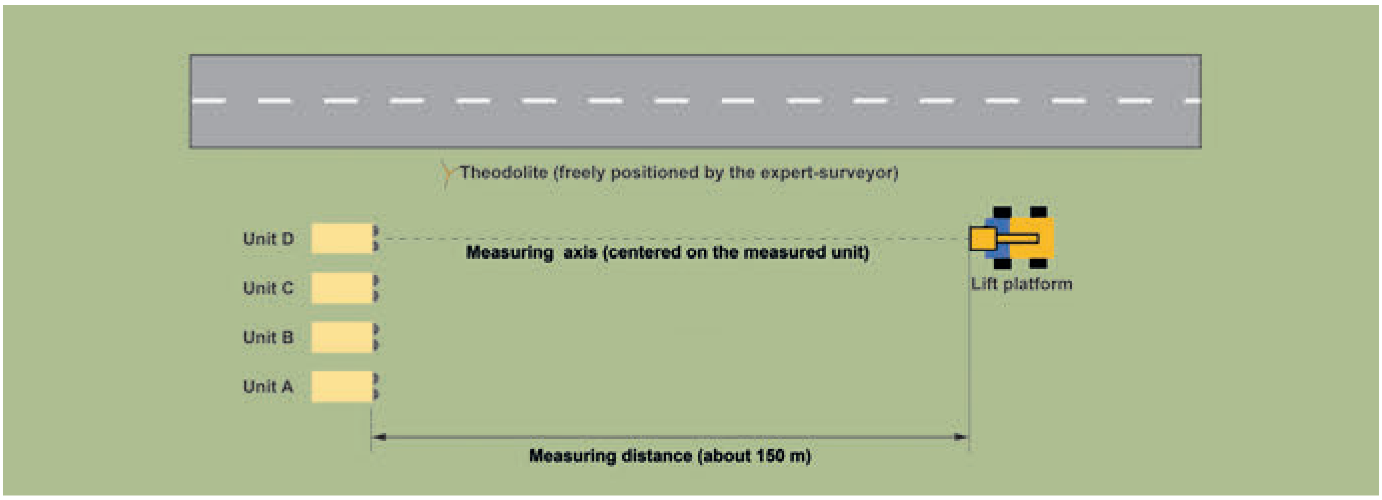


Figure 67: Measurement principle of the elevation setting angle of a PAPI light unit by the lift platform method (Top view).

7.11.3. REMOTELY PILOTED AIRCRAFT SYSTEM (RPAS) METHOD

Another method of measurement of the elevation setting angle of a PAPI light unit consists in using a specific RPAS to observe the colorimetric transition area. This RPAS includes a Remotely Piloted Aircraft (RPA) and a ground processing unit to which measurement data are downloaded. Specific procedures shall be applied, particularly for the video recording by the RPAS and the GPS positioning of the RPA. The operating procedure may vary depending on the implemented measurement method.

The images captured during the vertical scanning of the light unit by the RPA shall be recorded and may be processed by either of the following manners to determine the heights of the upper and lower limits of the colorimetric transition area:

- displayed on a monitor for real-time viewing at the site and analysis by a ground-based operator, or
- automatically analysed by means of algorithms.

The elevation setting angle of the light unit may be then computed.

Figure 68: Real-time viewing of PAPI light units using a RPAS.

In order to perform high-accuracy measurements (about 2 cm accuracy), the Real-Time Kinematik (RTK) positioning method may be used. In this case, the RTK base station transmitting RTK correction data to the RPA shall be located at the runway threshold which is identified as the reference point for the RPA position. The deviation in measurement height related to the position of the GPS antenna of the RPA shall be considered. The horizontal distance of measurement of the light unit shall be suitable for the RPA. For a typical operation, the RPA should be positioned at least 300 m downwind of the PAPI system.

Figure 69: Consideration of the position of the GPS antenna of the RPA for the measurement of the elevation setting angle of a PAPI light unit by the RPAS method at Toulouse Blagnac aerodrome.

Figure 70: RTK base station located at the runway threshold for the measurement of the elevation setting angles of PAPI light units by the RPAS method at Toulouse Blagnac aerodrome.

7.11.4. IMAGE ANALYSIS METHOD

Another method of measurement of the elevation setting angle area of a PAPI light unit consists in measuring the spatial orientation of the centre of the pink transition area by means of a ground measuring equipment including a high-definition Pan-Tilt-Zoom (PTZ) camera/sensor mounted on a high-accuracy inclinometer and linked to a portable computer equipped with specialized image analysis software.

The measurement head on the top of a dedicated tripod shall be placed ahead of the light unit, at a typical distance between 10 and 15 metres from it, at a height that intersects the colorimetric transition area. Once the operator makes the initial positioning, the system software causes the camera to automatically seek a point of inclination equal to that of the centre of the colorimetric transition area. The elevation setting angle measurement result, within an accuracy better than 1 arcminute, is available immediately on the computer screen.

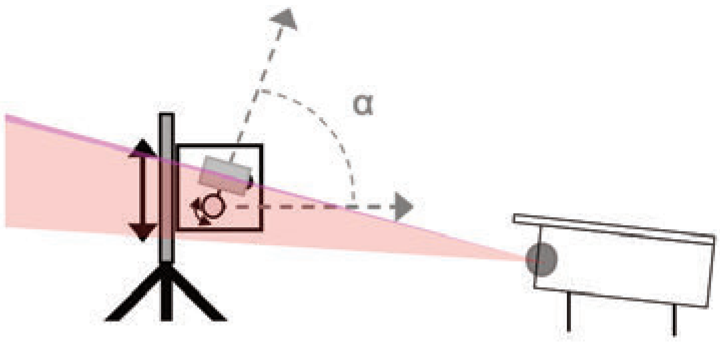


Figure 71: Principle of measurement of the elevation setting angle of a PAPI light unit by the image analysis method.

Figure 72: Measurement of the elevation setting angle of a PAPI light unit by the image analysis method at Toulouse Blagnac aerodrome.

7.11.5. NUMBER OF MEASUREMENTS

For each PAPI light unit, five measurements of the elevation setting angle shall be performed, whatever the method used. Measured values shall be recorded in a table. The selected value shall be the average of the five measured values, excluding outlier values.

7.11.6. RUNWAY OCCUPANCY TIME

The runway occupancy time required to perform the measurement of the elevation setting angle of the four light units of a PAPI system may be estimated as follows:

- two hours using the flight checking method,
- half a day using the lift platform method,
- two hours using the RPAS method,
- two hours using the ground measuring method.

7.12. GLOSSAIRE

A

AFNOR
Association Française de NORmalisation

ANSP
Air Navigation Service Provider

APAPI
Abreviated Precision Approach Path Indicator

ATS
Air Traffic Services

C

CCR
Constant Current Regulator

CD
Candélas

CHEA
Conditions d'Homologation et procédures d'Exploitation des Aérodromes

COFRAC
COmité FRançais d'ACcréditation

CPE
Collective Protective Equipment

CMMS
Computerized Maintenance Management System

CS
Commutateur Statique

CSB
Circuits Série primaires et secondaires du Balisage lumineux des aérodromes

D

DNA
Direction de la Navigation Aérienne

DUERP
Document Unique d'Evaluation des Risques Professionnels

E

EASA
European Aviation Safety Agency

EC
European Community

EEC
European Economic Community

EFVS
Enhanced Flight Vision System

ELPS
External Lightning Protection System

ELV
Extra-Low Voltage

EU
European Union

F

FBA
Feux des circuits série du Balisage lumineux des Aérodromes

FMECA
Failure Modes, Effects and Criticality Analysis

G

GPS
Global Positioning System

H

HV
High Voltage

HVA
High Voltage A

HVB
High Voltage B

HMI
Human Machine Interface

I

IEC
Internall Electrotechnical Commission

ILPS
Internal Lightning Protection System

ILS
Instrumental Landing system

IR
Infra-Red

IT
Insulation Transformer

7. ANNEXES

L

LED
Light Emitting Diode

LPC
Lightning Protection Components

LPL
Lightning Protection Level

LPS
Lightning Protection System

LV
Low Voltage

LVDB
Low Voltage Distribution Board

LVMDB
Low Voltage Main Distribution Board

LVP
Low Visibility Procedure

M

MERIDE
Méthode d'Évaluation des Risques Industriels des Dysfonctionnements des Équipements

MLS
Microwave Landing System

N

NF
Norme Française

P

PAPI
Precision Approach Path Indicator

PE
Protective Earthing

PEN
Protective Earthing and Neutral

PERT
Program Evaluation and Review Technique

PLC
Programmable Logic Controller

PPE
Personal Protective Equipment

PTZ
Pan Tilt Zoom

R

RTIL
Runway Threshold Identification Light

RTK
Real Time Kinematik

RVR
Runway Visual Range

S

SELV
Safety Extra Low Voltage

SMGCS
Surface Movement Guidance and Control System

T

TCA
Titres de Circulation Aéroportuaire

U

UAF & FA
Union des Aéroports Français et Francophones Associés

UPS
Uninterrupted Power Supply

UTE
Union Technique de l'Électricité

UV
Ultra-Violet

7.13. TABLE DES ILLUSTRATIONS

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7. ANNEXES

7.14. LIST OF TABLES

7. ANNEXES

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