Electrical Installations

1 Methodology

1.1 Listing of power demands

The study of a proposed electrical installation requires an adequate understanding of all governing rules and regulations.

The total power demand can be calculated from the data relative to the location and power of each load, together with the knowledge of the operating modes (steady state demand, starting conditions, non simultaneous operation, etc.)

From these data, the power required from the supply source and (where appropriate) the number of sources necessary for an adequate supply to the installation are readily obtained.

Local information regarding tariff structures is also required to allow the best choice of connection arrangement to the power-supply network, e.g. at medium voltage or low voltage level.

1.2 Service connection

This connection can be made at:

1. Medium Voltage level

A consumer-type substation will then have to be studied, built and equipped. This substation may be an outdoor or indoor installation conforming to relevant standards and regulations (the low-voltage section may be studied separately if necessary).

Metering at medium-voltage or low-voltage is possible in this case.

2. Low Voltage level

The installation will be connected to the local power network and will (necessarily) be metered according to LV tariffs.

1.3 Electrical Distribution architecture

The whole installation distribution network is studied as a complete system.

A selection guide is proposed for determination of the most suitable architecture.

MV/LV main distribution and LV power distribution levels are covered.

Neutral earthing arrangements are chosen according to local regulations, constraints related to the power-supply, and to the type of loads.

The distribution equipment (panel boards, switchgears, circuit connections, ...) are determined from building plans and from the location and grouping of loads.

The type of premises and allocation can influence their immunity to external disturbances.

1.4 Protection against electric shocks

The earthing system (TT, IT or TN) having been previously determined, then the appropriate protective devices must be implemented in order to achieve protection against hazards of direct or indirect contact.

1.5 Circuits and switchgear

Each circuit is then studied in detail. From the rated currents of the loads, the level of short-circuit current, and the type of protective device, the cross-sectional area of circuit conductors can be determined, taking into account the nature of the cableways and their influence on the current rating of conductors.

Before adopting the conductor size indicated above, the following requirements must be satisfied:

- The voltage drop complies with the relevant standard
- Motor starting is satisfactory
- Protection against electric shock is assured

The short-circuit current Isc is then determined, and the thermal and electrodynamic withstand capability of the circuit is checked.

These calculations may indicate that it is necessary to use a conductor size larger than the size originally chosen.

The performance required by the switchgear will determine its type and characteristics.

The use of cascading techniques and the discriminative operation of fuses and tripping of circuit breakers are examined.

1.6 Protection against over-voltages

Direct or indirect lightning strokes can damage electrical equipment at a distance of several kilometers. Operating voltage surges, transient and industrial frequency over-voltage can also produce the same consequences. The effects are examined and solutions are proposed.

1.7 Energy efficiency in electrical distribution

Implementation of measuring devices with an adequate communication system within the electrical installation can produce high benefits for the user or owner: reduced power consumption, reduced cost of energy, better use of electrical equipment.

1.8 Reactive energy

The power factor correction within electrical installations is carried out locally, globally or as a combination of both methods.

1.9 Harmonics

Harmonics in the network affect the quality of energy and are at the origin of many disturbances as overloads, vibrations, ageing of equipment, trouble of sensitive equipment, of local area networks, telephone networks. This chapter deals with the origins and the effects of harmonics and explain how to measure them and present the solutions.

1.10 Particular supply sources and loads

Particular items or equipment are studied:

- Specific sources such as alternators or inverters
- Specific loads with special characteristics, such as induction motors, lighting circuits or LV/LV transformers
- Specific systems, such as direct-current networks

1.11 Generic applications

Certain premises and locations are subject to particularly strict regulations: the most common example being residential dwellings.

1.12 EMC Guidelines

Some basic rules must be followed in order to ensure Electromagnetic Compatibility. Non observance of these rules may have serious consequences in the operation of the electrical installation: disturbance of communication systems, nuisance tripping of protection devices, and even destruction of sensitive devices.

1.13 Use Of Electrical Design Software

It provides a complete design package for LV installations, in accordance with IEC standards and recommendations.

The following features are included:

- Construction of one-line diagrams
- Calculation of short-circuit currents
- Calculation of voltage drops
- Optimization of cable sizes
- Required ratings of switchgear and fuse-units
- Discrimination of protective devices
- Recommendations for cascading schemes
- Verification of the protection of people
- Comprehensive print-out of the foregoing calculated design data

2 Rules and statutory regulations

Low-voltage installations are governed by a number of regulatory and advisory texts, which may be classified as follows:

- Statutory regulations (decrees, factory acts, etc.)
- Codes of practice, regulations issued by professional institutions, job specifications
- National and international standards for installations
- National and international standards for products

2.1 Regulations

In most countries, electrical installations shall comply with more than one set of regulations, issued by National Authorities or by recognized private bodies. It is essential to take into account these local constraints before starting the design.

2.2 Standards

This Guide is based on relevant IEC standards, in particular IEC 60364. IEC 60364 has been established by medical and engineering experts of all countries in the world comparing their experience at an international level. Currently, the safety principles of IEC 60364 and 60479-1 are the fundamentals of most electrical standards in the world (see table below)

IEC 60038 Standard voltages
IEC 60076-2 Power transformers - Temperature rise
IEC 60076-3 Power transformers - Insulation levels, dielectric tests and external clearances in air
IEC 60076-5 Power transformers - Ability to withstand short-circuit
IEC 60076-10 Power transformers - Determination of sound levels
IEC 60146 Semiconductor convertors - General requirements and line commutated convertors
IEC 60255 Electrical relays
IEC 60265-1 High-voltage switches - High-voltage switches for rated voltages above 1 kV and less than 52 kV
IEC 60269-1 Low-voltage fuses - General requirements
IEC 60269-2 Low-voltage fuses - Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications)
IEC 60282-1 High-voltage fuses - Current-limiting fuses
IEC 60287-1-1 Electric cables - Calculation of the current rating - Current rating equations (100% load factor) and calculation of losses - General
IEC 60364 Electrical installations of buildings
IEC 60364-1 Electrical installations of buildings - Fundamental principles
IEC 60364-4-41 Electrical installations of buildings - Protection for safety - Protection against electric shock
IEC 60364-4-42 Electrical installations of buildings - Protection for safety - Protection against thermal effects
IEC 60364-4-43 Electrical installations of buildings - Protection for safety - Protection against over-current

IEC 60364-4-44 Electrical installations of buildings - Protection for safety - Protection against electromagnetic and voltage disturbance
IEC 60364-5-51 Electrical installations of buildings - Selection and erection of electrical equipment - Common rules
IEC 60364-5-52 Electrical installations of buildings - Selection and erection of electrical equipment - Wiring systems
IEC 60364-5-53 Electrical installations of buildings - Selection and erection of electrical equipment - Isolation, switching and control
IEC 60364-5-54 Electrical installations of buildings - Selection and erection of electrical equipment - Earthing arrangements

IEC 60364-5-55 Electrical installations of buildings - Selection and erection of electrical equipment - Other equipments
IEC 60364-6-61 Electrical installations of buildings - Verification and testing - Initial verification
IEC 60364-7-701 Electrical installations of buildings - Requirements for special installations or locations - Locations containing a bath tub or shower basin
IEC 60364-7-702 Electrical installations of buildings - Requirements for special installations or locations - Swimming pools and other basins
IEC 60364-7-703 Electrical installations of buildings - Requirements for special installations or locations - Locations containing sauna heaters
IEC 60364-7-704 Electrical installations of buildings - Requirements for special installations or locations - Construction and demolition site installations
IEC 60364-7-705 Electrical installations of buildings - Requirements for special installations or locations - Electrical installations of agricultural and horticultural premises
IEC 60364-7-706 Electrical installations of buildings - Requirements for special installations or locations - Restrictive conducting locations
IEC 60364-7-707 Electrical installations of buildings - Requirements for special installations or locations - Earthing requirements for the installation of data processing equipment
IEC 60364-7-708 Electrical installations of buildings - Requirements for special installations or locations - Electrical installations in caravan parks and caravans
IEC 60364-7-709 Electrical installations of buildings - Requirements for special installations or locations - Marinas and pleasure craft
IEC 60364-7-710 Electrical installations of buildings - Requirements for special installations or locations - Medical locations
IEC 60364-7-711 Electrical installations of buildings - Requirements for special installations or locations - Exhibitions, shows and stands
IEC 60364-7-712 Electrical installations of buildings - Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
IEC 60364-7-713 Electrical installations of buildings - Requirements for special installations or locations - Furniture

IEC 60364-7-714 Electrical installations of buildings - Requirements for special installations or locations - External lighting installations
IEC 60364-7-715 Electrical installations of buildings - Requirements for special installations or locations - Extra-low-voltage lighting installations
IEC 60364-7-717 Electrical installations of buildings - Requirements for special installations or locations - Mobile or transportable units
IEC 60364-7-740 Electrical installations of buildings - Requirements for special installations or locations - Temporary electrical installations for structures, amusement devices and booths at fairgrounds, amusement parks and circuses
IEC 60427 High-voltage alternating current circuit-breakers
IEC 60439-1 Low-voltage switchgear and controlgear assemblies - Type-tested and partially type-tested assemblies
IEC 60439-2 Low-voltage switchgear and controlgear assemblies - Particular requirements for busbar trunking systems (busways)
IEC 60439-3 Low-voltage switchgear and controlgear assemblies - Particular requirements for low-voltage switchgear and controlgear assemblies intended to be installed in places where unskilled persons have access for their use - Distribution boards
IEC 60439-4 Low-voltage switchgear and controlgear assemblies - Particular requirements for assemblies for construction sites (ACS)
IEC 60446 Basic and safety principles for man-machine interface, marking and identification - Identification of conductors by colours or numerals
IEC 60439-5 Low-voltage switchgear and controlgear assemblies - Particular requirements for assemblies intended to be installed outdoors in public places - Cable distribution cabinets (CDCs)
IEC 60479-1 Effects of current on human beings and livestock - General aspects
IEC 60479-2 Effects of current on human beings and livestock - Special aspects

IEC 60479-3 Effects of current on human beings and livestock - Effects of currents passing through the body of livestock
IEC 60529 Degrees of protection provided by enclosures (IP code)
IEC 60644 Specification for high-voltage fuse-links for motor circuit applications
IEC 60664 Insulation coordination for equipment within low-voltage systems
IEC 60715 Dimensions of low-voltage switchgear and controlgear. Standardized mounting on rails for mechanical support of electrical devices in switchgear and controlgear installations.
IEC 60724 Short-circuit temperature limits of electric cables with rated voltages of 1 kV (Um = 1.2 kV) and 3 kV (Um = 3.6 kV)
IEC 60755 General requirements for residual current operated protective devices
IEC 60787 Application guide for the selection of fuse-links of high-voltage fuses for transformer circuit application
IEC 60831 Shunt power capacitors of the self-healing type for AC systems having a rated

voltage up to and including 1000 V - General - Performance, testing and rating - Safety requirements - Guide for installation and operation

IEC 60947-1 Low-voltage switchgear and controlgear - General rules

IEC 60947-2 Low-voltage switchgear and controlgear - Circuit-breakers

IEC 60947-3 Low-voltage switchgear and controlgear - Switches, disconnectors, switchdisconnectors and fuse-combination units

IEC 60947-4-1 Low-voltage switchgear and controlgear - Contactors and motor-starters - Electromechanical contactors and motor-starters

IEC 60947-6-1 Low-voltage switchgear and controlgear - Multiple function equipment - Automatic transfer switching equipment

IEC 61000 Electromagnetic compatibility (EMC)

IEC 61140 Protection against electric shocks - common aspects for installation and equipment

IEC 61557-1 Electrical safety in low-voltage distribution systems up to 1000 V AC and 1500 V DC - Equipment for testing, measuring or monitoring of protective measures - General requirements

IEC 61557-8 Electrical safety in low-voltage distribution systems up to 1000 V AC and 1500 V DC - Equipment for testing, measuring or monitoring of protective measures

IEC 61557-9 Electrical safety in low-voltage distribution systems up to 1000 V AC and 1500 V DC - Equipment for insulation fault location in IT systems

IEC 61558-2-6 Safety of power transformers, power supply units and similar - Particular requirements for safety isolating transformers for general use

IEC 62271-1 Common specifications for high-voltage switchgear and controlgear standards

IEC 62271-100 High-voltage switchgear and controlgear - High-voltage alternating-current circuit-breakers

IEC 62271-102 High-voltage switchgear and controlgear - Alternating current disconnectors and earthing switches

IEC 62271-105 High-voltage switchgear and controlgear - Alternating current switch-fuse combinations

IEC 62271-200 High-voltage switchgear and controlgear - Alternating current metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

IEC 62271-202 High-voltage/low voltage prefabricated substations

2.3 Quality and safety of an electrical installation

In so far as control procedures are respected, quality and safety will be assured only if:

• The initial checking of conformity of the electrical installation with the standard and regulation has been achieved

• The electrical equipment comply with standards

• The periodic checking of the installation recommended by the equipment manufacturer is respected.

2.4 Initial testing of an installation

Before a utility will connect an installation to its supply network, strict pre-commissioning electrical tests and visual inspections by the authority, or by its appointed agent, must be satisfied. These tests are made according to local (governmental and/or institutional) regulations, which may differ slightly from one country to another. The principles of all such regulations however, are common, and are based on the observance of rigorous safety rules in the design and realization of the installation. IEC 60364-6-61 and related standards included in this guide are based on an international consensus for such tests, intended to cover all the safety measures and approved installation practices normally required for residential, commercial and (the majority of) industrial buildings. Many industries however have additional regulations
related to a particular product (petroleum, coal, natural gas, etc.). Such additional requirements are beyond the scope of this guide.

• The pre-commissioning electrical tests and visual-inspection checks for installations in buildings include, typically, all of the following:

• Insulation tests of all cable and wiring conductors of the fixed installation, between phases and between phases and earth

• Continuity and conductivity tests of protective, equipotential and earth-bonding conductors

• Resistance tests of earthing electrodes with respect to remote earth

• Verification of the proper operation of the interlocks, if any

• Check of allowable number of socket-outlets per circuit

• Cross-sectional-area check of all conductors for adequacy at the short-circuit levels prevailing, taking account of the associated protective devices, materials and installation conditions (in air, conduit, etc.)

• Verification that all exposed- and extraneous metallic parts are properly earthed (where appropriate)

• Check of clearance distances in bathrooms, etc.

These tests and checks are basic (but not exhaustive) to the majority of installations, while numerous other tests and rules are included in the regulations to cover particular cases, for example: TN-, TT- or IT-earthed installations, installations based
on class 2 insulation, SELV circuits, and special locations, etc. The aim of this guide is to draw attention to the particular features of different types of installation, and to indicate the essential rules to be observed in order to achieve a satisfactory level of quality, which will ensure safe and trouble-free performance. The methods recommended in this guide, modified if necessary to comply with any possible variation imposed by a utility, are intended to satisfy all pre-commissioning test and inspection requirements.

2.5 Conformity (with standards and specifications) of equipment used in the installation

Attestation of conformity

The conformity of equipment with the relevant standards can be attested:

• By an official mark of conformity granted by the certification body concerned, or
• By a certificate of conformity issued by a certification body, or
• By a declaration of conformity from the manufacturer

The first two solutions are generally not available for high voltage equipment.

Declaration of conformity

Where the equipment is to be used by skilled or instructed persons, the manufacturer's declaration of conformity (included in the technical documentation), is generally recognized as a valid attestation. Where the competence of the manufacturer is in doubt, a certificate of conformity can reinforce the manufacturer's declaration.

Note: CE marking

In Europe, the European directives require the manufacturer or his authorized representative to affix the CE marking on his own responsibility. It means that:

• The product meets the legal requirements
• It is presumed to be marketable in Europe

The CE marking is neither a mark of origin nor a mark of conformity.

Mark of conformity

Marks of conformity are affixed on appliances and equipment generally used by ordinary non instructed people (e.g in the field of domestic appliances). A mark of conformity is delivered by certification body if the equipment meet the requirements from an applicable standard and after verification of the manufacturer's quality management system.

Certification of Quality

The standards define several methods of quality assurance which correspond to different situations rather than to different levels of quality.

Assurance

A laboratory for testing samples cannot certify the conformity of an entire production run: these tests are called type tests. In some tests for conformity to standards, the samples are destroyed (tests on fuses, for example). Only the manufacturer can certify that the fabricated products have, in fact,
the characteristics stated. Quality assurance certification is intended to complete the initial declaration or
certification of conformity. As proof that all the necessary measures have been taken for assuring the quality of production, the manufacturer obtains certification of the quality control system which monitors the fabrication of the product concerned. These certificates are issued by organizations specializing in quality control, and are based on the international standard ISO 9001: 2000. These standards define three model systems of quality assurance control corresponding to different situations rather than to different levels of quality:

• Model 3 defines assurance of quality by inspection and checking of final products.
• Model 2 includes, in addition to checking of the final product, verification of the manufacturing process. For example, this method is applied, to the manufacturer of fuses where performance characteristics cannot be checked without destroying the

fuse.

• Model 1 corresponds to model 2, but with the additional requirement that the quality of the design process must be rigorously scrutinized; for example, where it is not intended to fabricate and test a prototype (case of a custom-built product made to specification).

2.6 Environment

Environmental management systems can be certified by an independent body if they meet requirements given in ISO 14001. This type of certification mainly concerns industrial settings but can also be granted to places where products are designed. A product environmental design sometimes called "eco-design" is an approach of sustainable development with the objective of designing products/services best meeting the customers' requirements while reducing their environmental impact over their whole life cycle. The methodologies used for this purpose lead to choose equipment's architecture together with components and materials taking into account the influence of a product on the environment along its life cycle (from extraction of raw materials to scrap) i.e. production, transport, distribution, end of life etc. In Europe two Directives have been published, they are called:

• RoHS Directive (Restriction of Hazardous Substances) coming into force on July 2006 (the coming into force was on February 13th, 2003, and the application date is July 1st, 2006) aims to eliminate from products six hazardous substances: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE).

• WEEE Directive (Waste of Electrical and Electronic Equipment) coming into force in August 2005 (the coming into force was on February 13th, 2003, and the application date is August 13th, 2005) in order to master the end of life and treatments for household and non household equipment. In other parts of the world some new legislation will follow the same objectives. In addition to manufacturers action in favour of products eco-design, the contribution of the whole electrical installation to sustainable development can be significantly improved through the design of the installation. Actually, it has been shown that an optimised design of the installation, taking into account operation conditions, MV/LV substations location and distribution structure (switchboards, busways, cables), can reduce substantially environmental impacts (raw material depletion, energy depletion, end of life)

3 Installed power loads – Characteristics

3.1 Induction motors

Current demand

The full-load current Ia supplied to the motor is given by the following formulae:

- 3-phase motor: $Ia = Pn \times 1{,}000 / (\sqrt{3} \times U \times \eta \times \cos \varphi)$
- 1-phase motor: $Ia = Pn \times 1{,}000 / (U \times \eta \times \cos \varphi)$

where

Ia: current demand (in amps)
Pn: nominal power (in kW)
U: voltage between phases for 3-phase motors and voltage between the terminals for single-phase motors (in volts). A single-phase motor may be connected phasetoneutral or phase-to-phase.
η: per-unit efficiency, i.e. output kW / input kW
cos φ: power factor, i.e. kW input / kVA input

Subtransient current and protection setting

- Subtransient current peak value can be very high ; typical value is about 12 to 15 times the rms rated value Inm. Sometimes this value can reach 25 times Inm.
- Merlin Gerin circuit-breakers, Telemecanique contactors and thermal relays are designed to withstand motor starts with very high subtransient current (subtransient peak value can be up to 19 times the rms rated value Inm).
- If unexpected tripping of the overcurrent protection occurs during starting, this means the starting current exceeds the normal limits. As a result, some maximum switchgear withstands can be reached, life time can be reduced and even some devices can be destroyed. In order to avoid such a situation, oversizing of the switchgear must be considered.

Motor starting current

Although high efficiency motors can be found on the market, in practice their starting currents are roughly the same as some of standard motors. The use of start-delta starter, static soft start unit or variable speed drive allows to reduce the value of the starting current (Example : 4 Ia instead of 7.5 Ia).

Compensation of reactive-power (kvar) supplied to induction motors

It is generally advantageous for technical and financial reasons to reduce the current supplied to induction motors. This can be achieved by using capacitors without affecting the power output of the motors. The application of this principle to the operation of induction motors is generally referred to as “power-factor improvement” or “power-factor correction”.

As discussed in chapter L, the apparent power (kVA) supplied to an induction motor can be significantly reduced by the use of shunt-connected capacitors. Reduction of input kVA means a corresponding reduction of input current (since the voltage remains constant).

Compensation of reactive-power is particularly advised for motors that operate for long periods at reduced power.

As noted above cos φ = kW input/kVA input

so that a kVA input reduction in kVA input will increase (i.e. improve) the value of cos
The current supplied to the motor, after power-factor correction, is given by:
I = Ia cos / cos ’
where cos is the power factor before compensation and cos ’ is the power factor after compensation, Ia being the original current.

Standard motor current values for several voltage supplies.

kW	hp	230 V	380 -415 V	400 V	440 -480 V	500 V	690 V
		A	A	A	A	A	A
0.18	-	1.0	-	0.6	-	0.48	0.35
0.25	-	1.5	-	0.85	-	0.68	0.49
0.37	-	1.9	-	1.1	-	0.88	0.64
- 0.55	1/2 -	-2.6	1.3 -	-1.5	1.1 -	-1.2	- 0.87
-	3/4	-	1.8	-	1.6	-	-
-	1	-	2.3	-	2.1	-	-
0.75	-	3.3	-	1.9	-	1.5	1.1
1.1	-	4.7	-	2.7	-	2.2	1.6
--	1- 1/2 2	--	3.3 4.3	--	3.0 3.4	--	--
1.5	-	6.3	-	3.6	-	2.9	2.1
2.2	-	8.5	-	4.9	-	3.9	2.8
-	3	-	6.1	-	4.8	-	-
3.0	-	11.3	-	6.5	-	5.2	3.8
3.7	-	-	-	-	-	-	-
4	-	15	9.7	8.5	7.6	6.8	4.9
5.5	-	20	-	11.5	-	9.2	6.7
--	7- 1/2 10	--	14.0 18.0	--	11.0 14.0	--	--
7.5	-	27	-	15.5	-	12.4	8.9
11	-	38.0	-	22.0	-	17.6	12.8
-	15	-	27.0	-	21.0	-	-
-	20	-	34.0	-	27.0	-	-
15	-	51	-	29	-	23	17
18.5	-	61	-	35	-	28	21
-	25	-	44	-	34	-	
22	-	72	-	41	-	33	24
-	30	-	51	-	40	-	-
-	40	-	66	-	52	-	-
30	-	96	-	55	-	44	32
37	-	115	-	66	-	53	39
-	50	-	83	-	65	-	-
-	60	-	103	-	77	-	-
45	-	140	-	80	-	64	47
55	-	169	-	97	-	78	57
-	75	-	128	-	96	-	-
-	100	-	165	-	124	-	-
75	-	230	-	132	-	106	77
90	-	278	-	160	-	128	93
-	125	-	208	-	156	-	-
110	-	340	-	195		156	113

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-	150	-	240	-	180	-	-
132	-	400	-	230	-	184	134
-	200	-	320	-	240	-	-
150	-	-	-	-	-	-	-
160	-	487	-	280	-	224	162
185	-	-	-	-	-	-	-
-	250	-	403	-	302	-	-
200	-	609	-	350	-	280	203
220	-	-	-	-	-	-	-
-	300	-	482	-	361	-	-
250	-	748	-	430	-	344	250
280	-	-	-	-	-	-	-
-	350 -		560 -		414 --		
-	400 -		636 -		474 --		
300	--		--		---		
315 - 335	- 540 -	940 -----		540 - -	- 515 -	432 --	313 --
355 - 375	- 500 -	1061 - -	- 786 -	610 - -	- 590 -	488 --	354 --
400 -425 - 450 -		1200 -----		690 -----		552 --	400 --
475 -500 - 530 -		--1478 ---		--850 ---		-680 -	- 493 -
560 -600 - 630 -		1652 --- 1844 -		950 ---1060 -		760 - 848	551 - 615
670 -710 - 750 -		--2070 ---		--1190 ---		-952 -	- 690 -
800 -850 - 900 -		2340 --- 2640 -		1346 --- 1518 -		1076 -1214	780 - 880
950 -1000 -		--2910 -		--1673 -		-1339	- 970

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3.2 Resistive-type heating appliances and incandescent lamps (conventional or halogen)

The current demand of a heating appliance or an incandescent lamp is easily obtained from the nominal power Pn quoted by the manufacturer (i.e. cos ϕ = 1)

Nominal power	Current demand (A)			
	1-phase	1-phase	3-phase	3-phase
(kW)	127 V	230 V	230 V	400 V
0.1	0.79	0.43	0.25	0.14
0.2	1.58	0.87	0.50	0.29
0.5	3.94	2.17	1.26	0.72
1	7.9	4.35	2.51	1.44
1.5	11.8	6.52	3.77	2.17
2	15.8	8.70	5.02	2.89
2.5	19.7	10.9	6.28	3.61
3	23.6	13	7.53	4.33
3.5	27.6	15.2	8.72	5.05
4	31.5	17.4	10	5.77
4.5	35.4	19.6	11.3	6.5
5	39.4	21.7	12.6	7.22
6	47.2	26.1	15.1	8.66
7	55.1	30.4	17.6	10.1
8	63	34.8	20.1	11.5
9	71	39.1	22.6	13
10	79	43.5	25.1	14.4

The currents are given by:

- 3 -3p-hphaassee c caassee:: Ia = Pn/√3 U

(1)

- 1 -1p-phase case: Ia = Pn/U

wheherere U is the voltage between the terminals of the equipment.
For an incandescent lamp, the use of halogen gas allows a more concentrated light source.
The light output is increased and the lifetime of the lamp is doubled.
Note: At the instant of switching on, the cold filament gives rise to a very brief but intense peak of current.
Fluorescent lamps and related equipment
The power Pn (watts) indicated on the tube of a fluorescent lamp does not include the power dissipated in the ballast.
The current is given by :
Ia = {P (ballast) +Pn} / U cos ϕ

Where U =the voltage applied to the lamp complete with kits related equipment if no powerloss value is indicated for the ballast a figure 25% of Pn may be used .
Standard tubular fluorescent lamps
With (unless otherwise indicated):

- cos ϕ = 0.6 with no power factor (PF) correction(2) capacitor
- cos ϕ = 0.86 with PF correction(2) (single or twin tubes)
- cos ϕ = 0.96 for electronic ballast.

If no power-loss value is indicated for the ballast, a figure of 25% of Pn may be used.

Arrangement	Tube power	Current (A) at 230 V			Tube length
of lamps, starters	(W) (3)	Magnetic ballast			
and ballasts				Electronic Ballast	(cm)
		Without PF correction capacitor	With PF correction capacitor		
Single tube	18	0.20	0.14	0.10	60
	36	0.33	0.23	0.18	120
	58	0.50	0.36	0.28	150
Twin tubes	2 x 18		0.28	0.18	60
	2 x 36		0.46	0.35	120
	2 x 58		0.72	0.52	150

Compact fluorescent lamps

Compact fluorescent lamps have the same characteristics of economy and long life as classical tubes. They are commonly used in public places which are permanently illuminated (for example: corridors, hallways, bars, etc.) and can be mounted in situations otherwise illuminated by incandescent lamps

Type of lamp	Lamp power	Current at 230 V
	(W)	(A)
Separated ballast lamp	10	0.080
	18	0.110
	26	0.150
Integrated ballast lamp	8	0.075
	11	0.095
	16	0.125
	21	0.170

Discharge lamps

Gives the current taken by a complete unit, including all associated ancillary equipment. These lamps depend on the luminous electrical discharge through a gas or vapour of a metallic compound, which is contained in a hermetically-sealed transparent envelope at a pre-determined pressure. These lamps have a long start-up time, during which the current Ia is greater than the nominal current In. Power and current demands are given for different types of lamp (typical average values which may differ slightly from one manufacturer to another).

Type of	Power	Current In(A)		Starting Ia/In		Luminous efficiency	Average timelife of	Utilization
lamp (W)	demand	PF not	PF					
	(W) at	corrected	corrected		Period (mins)	(lumens	lamp (h)	
	230 V 400 V	230 V 400 V	230 V 400 V			per watt)		
High-pressure sodium vapour lamps								
50	60	0.76	0.3	1.4 to 1.6	4 to 6	80 to 120	9000	b Lighting of
70	80	1	0.45					large halls
100	115	1.2	0.65					b Outdoor spaces
150	168	1.8	0.85					b Public lighting
250	274	3	1.4					
400	431	4.4	2.2					
1000	1055	10.45	4.9					
Low-pressure sodium vapour lamps								
26	34.5	0.45	0.17	1.1 to 1.3	7 to 15	100 to 200	8000	b Lighting of
36	46.5		0.22				to 12000	autoroutes
66	80.5		0.39					b Security lighting,
91	105.5		0.49					station
131	154		0.69					b Platform, storage
								areas
Mercury vapour + metal halide (also called metal-iodide)								
70	80.5	1	0.40	1.7	3 to 5	70 to 90	6000	b Lighting of very
150	172	1.80	0.88				6000	large areas by
250	276	2.10	1.35				6000	projectors (for
400	425	3.40	2.15				6000	example: sports
1000	1046	8.25	5.30				6000	stadiums, etc.)
2000	2092 205 2	16.5 0 8.6 0	10.50 6				2000	
Mercury vapour + fluorescent substance (fluorescent bulb)								
50	57	0.6	0.30	1.7 to 2	3 to 6	40 to 60	8000	b Workshops
80	90	0.8	0.45				to 12000	with very high
125	141	1.15	0.70					ceilings (halls,
250	268	2.15	1.35					hangars)
400	421	3.25	2.15					b Outdoor lighting
700	731	5.4	3.85					b Low light output(1)
1000	1046	8.25	5.30					
2000	2140 208 0	15	11 6.1					

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