IEC 61000-3-2

Edition 3.2 2009-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electromagnetic compatibility (EMC) –
Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)

Compatibilité électromagnétique (CEM) –
Partie 3-2: Limites – Limites pour les émissions de courant harmonique (courant appelé par les appareils ≤16 A par phase)

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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Tél.: +41 22 919 02 11
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)

FOREWORD

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International Standard IEC 61000-3-2 has been prepared by sub-committee 77A: Low-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This consolidated version of IEC 61000-3-2 consists of the third edition (2005) [documents 77A/503/FDIS and 77A/516/RVD], its amendment 1 (2008) [documents 77A/625/FDIS and 77A/641/RVD] and its amendment 2 (2009) [documents 77A/674/FDIS and 77A/677/RVD].

The technical content is therefore identical to the base edition and its amendments and has been prepared for user convenience.

It bears the edition number 3.2.

A vertical line in the margin shows where the base publication has been modified by amendments 1 and 2.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

IEC 61000 is published in separate parts, according to the following structure:

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description levels

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits (in so far as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 6: Generic standards

Part 9: Miscellaneous

Each part is further subdivided into sections which are to be published either as international standards, technical specifications, or as technical reports.

These standards and reports will be published in chronological order and numbered accordingly (for example, 61000-6-1).

This part is an international standard which gives emission limits for harmonic currents from equipment having an input current up to and including 16 A per phase.

This part is a Product Family Standard.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)

1 Scope

This part of IEC 61000 deals with the limitation of harmonic currents injected into the public supply system.

It specifies limits of harmonic components of the input current which may be produced by equipment tested under specified conditions.

Harmonic components are measured according to Annexes A and B.

This part of IEC 61000 is applicable to electrical and electronic equipment having an input current up to and including 16 A per phase, and intended to be connected to public low-voltage distribution systems.

Arc welding equipment which is not professional equipment, with input current up to and including 16 A per phase, is included in this standard.

Arc welding equipment intended for professional use, as specified in IEC 60974-1, is excluded from this standard and may be subject to installation restrictions as indicated in IEC 61000-3-4 or IEC 61000-3-12.

The tests according to this standard are type tests. Test conditions for particular equipment are given in Annex C.

For systems with nominal voltages less than 220 V (line-to-neutral), the limits have not yet been considered.

NOTE The words apparatus, appliance, device and equipment are used throughout this standard. They have the same meaning for the purpose of this standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050(131), *International Electrotechnical Vocabulary (IEV) – Chapter 131: Electric and magnetic circuits*

IEC 60050(161), *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electro-magnetic compatibility*

IEC 60107-1, *Methods of measurement on receivers for television broadcast transmissions – Part 1: General considerations – Measurements at radio and video frequencies*

IEC 60155, *Glow-starters for fluorescent lamps*

IEC 60268-1:1985, *Sound system equipment – Part 1: General*

IEC 60268-3, *Sound system equipment – Part 3: Amplifiers*

IEC 60335-2-2, *Household and similar electrical appliances - Safety - Part 2-2: Particular requirements for vacuum cleaners and water-suction cleaning appliances*

IEC 60335-2-14, *Household and similar electrical appliances - Safety - Part 2-14: Particular requirements for kitchen machines*

IEC 60974-1, *Arc welding equipment – Part 1: Welding power sources*

IEC 61000-2-2, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 2: Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

IEC/TS 61000-3-4, *Electromagnetic compatibility (EMC) – Part 3-4: Limits – Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A*

IEC 61000-3-12, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤75 A per phase*

IEC 61000-4-7, *Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto*

Recommendation ITU-R BT.471-1, *Nomenclature and description of colour bar signals*

3 Definitions

For the purpose of this part of IEC 61000, the following definitions apply, as well as the definitions of IEC 60050(161).

3.1
portable tool
an electrical tool which is hand-held during normal operation and used for a short time (a few minutes) only

3.2
lamp
a source for producing light

3.3
self-ballasted lamp
a unit which cannot be dismantled without being permanently damaged, provided with a lamp cap and incorporating a light source and any additional element necessary for starting and stable operation of the light source

3.4
luminaire
an apparatus (other than a lamp) which distributes, filters or transforms the light transmitted from one or more lamps and which includes all the parts necessary for supporting, fixing and protecting the lamps, and, where necessary, circuit auxiliaries, together with the means for connecting them to the supply

3.5

3.6
ballast
a device connected between the supply and one or more discharge lamps which serves mainly to limit the current of the lamp(s) to the required value. It may include means for transforming the supply voltage and/or frequency, correcting the power factor and, either alone or in combination with a starting device, provide the necessary conditions for starting the lamp(s)

3.7
step-down converter for lighting equipment
a unit inserted between the supply and one or more tungsten halogen or other filament lamps which serves to supply the lamp(s) with its (their) rated voltage, generally at high frequency. The unit may consist of one or more separate components. It may include means for dimming, correcting the power factor and suppressing radio interference

3.8

3.9
reference lamp
a lamp selected for testing ballasts which, when associated with a reference ballast, has electrical characteristics that are close to the objective values given in the relevant lamp specification

3.10
reference ballast
a special inductive-type ballast designed for the purpose of providing comparison standards for use in testing ballasts and for the selection of reference lamps. It is essentially characterized by a stable voltage-to-current ratio, which is relatively uninfluenced by variations in current, temperature, and the magnetic surroundings

3.11
input current
current directly supplied to an equipment or a part of equipment by the a.c. distribution system

3.12
circuit power factor
the circuit power factor is the ratio of the measured active input power to the product of the supply voltage (r.m.s.) and the supply current (r.m.s.)

3.13
active power
the mean value, taken over one period, of the instantaneous power

[IEV 131-03-18]

NOTE The active input power is the active power measured at the input supply terminals of the equipment under test.

3.14
balanced three-phase equipment
equipment having rated line current modules which differ by no more than 20 %

3.15
professional equipment
equipment for use in trades, professions, or industries and which is not intended for sale to the general public. The designation shall be specified by the manufacturer

3.16
total harmonic

3.16.1
total harmonic current
total r.m.s. value of the harmonic current components of orders 2 to 40

total harmonic current = $\sqrt{\sum_{n=2}^{40} I_n^2}$

3.16.2
total harmonic distortion
THD
ratio of the r.m.s. value of the sum of the harmonic components (in this context harmonic current components I_h of orders 2 to 40) to the r.m.s. value of the fundamental component

$$THD = \sqrt{\sum_{h=2}^{40} \left(\frac{I_h}{I_1} \right)^2}$$

3.17
built-in dimmer
dimmer, including the user control, which is entirely contained within the enclosure of a luminaire

3.18
partial odd harmonic current
total r.m.s. value of the odd harmonic current components of orders 21 to 39

partial odd harmonic current = $\sqrt{\sum_{n=21,23}^{39} I_n^2}$

3.19
lighting equipment
equipment with a primary function of generating and/or regulating and/or distributing optical radiation by means of incandescent lamps, discharge lamps or LED's

Included are:

– lamps and luminaires;
– the lighting part of multi-function equipment where one of the primary functions of this is illumination;
– independent ballasts for discharge lamps and independent incandescent lamp transformers;
– ultraviolet (UV) and infrared (IR) radiation equipment;
– illuminated advertising signs;
– dimmers for lamps other than incandescent.

Excluded are:

– lighting devices built in equipment with another primary purpose such as photocopiers, overhead projectors and slide projectors or employed for scale illuminating or indication purposes;

– dimmers for incandescent lamps.

3.20
stand-by mode
sleep-mode
non-operational, low power consumption mode (usually indicated in some way on the equipment) that can persist for an indefinite time

3.21
repeatability of results of measurements
closeness of the agreement between the results of measurements of harmonic currents on the same equipment under test, carried out with the same test system, at the same location, under identical test conditions

[IEV 394-40-38, modified [1)]]

3.22
reproducibility of results of measurements
closeness of the agreement between the results of measurements of harmonic currents on the same equipment under test, carried out with different test systems under conditions of measurement intended to be the same in each case

[IEV 394-40-39, modified]

NOTE The test system and test conditions are assumed to fulfil all normative requirements in the standards.

3.23
variability of results of measurements
closeness of the agreement between the results of measurements of harmonic currents on different samples of the same type of equipment under test, having no intentional differences, carried out with different test systems under conditions of measurement intended to be the same in each case

NOTE 1 The test system and test conditions are assumed to fulfil all normative requirements in the standards.

NOTE 2 In the context of this standard, the meaning of the terms can be summarized as follows:

Term	Meaning
Repeatability	Same EUT, same test system, same test conditions, repeated tests
Reproducibility	Same EUT, different but normative test systems, different but normative test conditions
Variability	Different EUTs of the same type, having no intentional differences, different but normative test systems, different but normative test conditions

1) IEC 60050-394:2007, *International Electrotechnical Vocabulary – Part 394: Nuclear instrumentation – Instruments, systems, equipment and detectors*

4 General

The objective of this standard is to set limits for harmonic emissions of equipment within its scope, so that, with due allowance for the emissions from other equipment, compliance with the limits ensures that harmonic disturbance levels do not exceed the compatibility levels defined in IEC 61000-2-2.

Professional equipment that does not comply with the requirements of this standard may be permitted to be connected to certain types of low voltage supplies, if the instruction manual contains a requirement to ask the supply utility for permission to connect. Recommendations concerning this aspect are contained in IEC/TS 61000-3-4 or IEC 61000-3-12.

5 Classification of equipment

For the purpose of harmonic current limitation, equipment is classified as follows:

Class A:

– balanced three-phase equipment;
– household appliances, excluding equipment identified as class D;
– tools, excluding portable tools;
– dimmers for incandescent lamps;
– audio equipment.

Equipment not specified in one of the three other classes shall be considered as class A equipment.

NOTE 1 Equipment that can be shown to have a significant effect on the supply system may be reclassified in a future edition of the standard. Factors to be taken into account include:

– number of pieces of equipment in use;
– duration of use;
– simultaneity of use;
– power consumption;
– harmonic spectrum, including phase.

Class B:

– portable tools;
– arc welding equipment which is not professional equipment.

Class C:

– lighting equipment.

Class D:

Equipment having a specified power according to 6.2.2 less than or equal to 600 W, of the following types:

– personal computers and personal computer monitors;
– television receivers.

NOTE 2 Class D limits are reserved for equipment that, by virtue of the factors listed in note 1, can be shown to have a pronounced effect on the public electricity supply system.

6 General requirements

The following restrictions apply even to equipment to which no harmonic current limits apply as defined in Clause 7.

The requirements and limits specified in this clause are applicable to the power input terminals of equipment intended to be connected to 220/380 V, 230/400 V and 240/415 V systems operating at 50 Hz or 60 Hz. Requirements and limits for other cases are not yet considered.

A simplified test method is permitted for equipment that undergoes minor changes or updates, provided that, in previous full compliance tests, it has been shown to have current emissions below 60 % of the applicable limits and the THD of the supply current is less than 15 %. The simplified test method consists of verifying that the updated equipment has an active input power within ±20 % of that of the originally tested product, and that the THD of the supply current is less than 15 %. Products that fulfill these requirements are deemed to comply with the applicable limits, but in case of doubt the result of a full compliance test according to Clauses 6 and 7 takes precedence over this simplified method.

6.1 Control methods

Asymmetrical controls according to IEV 161-07-12 and half wave rectification directly on the mains supply may only be used in the following circumstances:

a) where they are the only practical solution permitting the detection of unsafe conditions, or

b) where the controlled active input power is less or equal to 100 W, or

c) where the controlled appliance is a portable equipment fitted with a two-core flexible cord and is intended for use for a short period of time, i.e. for a few minutes only.

If one of these three conditions is fulfilled, half wave rectification may be used for any purpose, whereas asymmetrical controls may only be used for the control of motors.

NOTE Such equipment includes, but is not limited to, hair dryers, electrical kitchen appliances and portable tools.

Symmetrical control methods which are prone to produce harmonics of low order ($n \leq 40$) in the input current may be used for the control of the power supplied to heating elements provided that the full sine-wave input power is less than or equal to 200 W, or that the limits of Table 3 are not exceeded.

Such symmetrical control methods are also allowed for professional equipment provided that either

a) one of the above conditions are fulfilled, or

b) the relevant limits are not exceeded when tested at the supply input terminals and in addition both the following conditions are fulfilled:

   1) it is necessary to control precisely the temperature of a heater whose thermal time constant is less than 2 s, and

   2) there is no other technique economically available.

Professional equipment whose primary purpose, considered as a whole, is not for heating, shall be tested against the relevant limits.

NOTE 1 An example of a product whose primary purpose is not heating is a photocopier, whereas a cooker is considered to have heating as its primary purpose.

Domestic equipment with symmetrical control used for a short time (for example hair dryers) shall be tested under Class A.

Even though asymmetrical controls and half-wave rectification are permitted under the conditions given above, the equipment shall still comply with the harmonic requirements of this standard.

NOTE 2 The use of asymmetrical controls and half-wave rectification is allowed in the above circumstances; however, in case of fault, the d.c. component of the supplied current may disturb certain types of protection devices. In the same way, this may also happen with the use of symmetrical controls.

6.2 Harmonic current measurement

6.2.1 Test configuration

Specific test conditions for the measurement of harmonic currents associated with some types of equipment are given in Annex C.

For equipment not mentioned in Annex C, emission tests shall be conducted with the user's operation controls or automatic programs set to the mode expected to produce the maximum total harmonic current (THC) under normal operating conditions. This defines the equipment set-up during emission tests and not a requirement to measure THC or to conduct searches for worst-case emissions.

The harmonic current limits specified in Clause 7 apply to line currents and not to currents in the neutral conductor. Nevertheless, for single-phase equipment, it is permissible to measure the currents in the neutral conductor instead of the currents in the line.

The equipment is tested as presented by, and in accordance with information provided by, the manufacturer. Preliminary operation of motor drives by the manufacturer may be needed before the test are undertaken to ensure that results correspond with normal use.

6.2.2 Measurement procedure

The test shall be conducted according to the general requirements given in 6.2.3. The test duration shall be as defined in 6.2.4.

The measurement of harmonic currents shall be performed as follows:

– for each harmonic order, measure the 1,5 s smoothed r.m.s. harmonic current in each DFT time window as defined in Annex B;
– calculate the arithmetic average of the measured values from the DFT time windows, over the entire observation period as defined in 6.2.4.

The value of the input power to be used for the calculation of limits shall be determined as follows:

– measure the 1,5 s smoothed active input power in each DFT time window;
– determine the maximum of the measured values of power from the DFT time windows over the entire duration of the test.

NOTE The active input power supplied to the smoothing section of the measuring instrument as defined in Annex B is the active input power in each DFT time window.

The harmonic currents and the active input power shall be measured under the same test conditions but need not be measured simultaneously.

In order not to use a value of power at which limits change abruptly, thus giving rise to doubt as to which limits apply, the manufacturer may specify any value which is within ±10 % of the actual measured value and use it for determining the limits for the original manufacturer's conformity assessment test. The measured and specified values of power, as defined in this clause, shall be documented in the test report.

If the value of the power found by measurement during emission tests other than the original manufacturer's conformity assessment test, measured according to the terms of this clause, is not less than 90 % nor greater than 110 % of the value for power specified by the manufacturer in the test report (see 6.2.3.5), the specified value shall be used to establish the limits. If the measured value is outside of this tolerance band around the specified value, the measured power shall be used to establish the limits.

For class C equipment, the fundamental current and power factor, specified by the manufacturer, shall be used for the calculation of limits (see 3.12). The fundamental component of the current and the power factor are measured and specified by the manufacturer in the same way as the power is measured and specified for the calculation of class D limits. The value used for the power factor shall be obtained from the same DFT measurement window as the value for the fundamental component of current.

6.2.3 General requirements

6.2.3.1 Repeatability

The repeatability (see 3.21) of the average value for the individual harmonic currents over the entire test observation period shall be better than ±5 % of the applicable limit, when the following conditions are met:

– the same equipment under test (EUT) (not another of the same type, however similar);

– identical test conditions;

– the same test system;

– identical climatic conditions, if relevant.

NOTE This repeatability requirement serves the purpose of defining the necessary observation period, see 6.2.4. It is not intended to serve as a pass/fail criterion for the assessment of compliance with the requirements of this standard.

6.2.3.2 Reproducibility

The reproducibility (see 3.22) of measurements on the same EUT with different test systems cannot be definitively calculated so as to apply to all possible combinations of EUT, harmonics meter and test supply, but can be estimated to be better than ± (1 % + 10 mA), where the 1 % is 1 % of the average value of the total input current taken over the entire test observation period. Therefore, differences in results which are less than that value of current are deemed negligible, but in some cases a higher value may occur.

For the avoidance of doubt in such cases, test results, obtained at different locations or on different occasions, that show that all the relevant limits are met shall be accepted as demonstrating compliance, even though the results may differ more than the values for repeatability and reproducibility, given above.

NOTE The variability (see 3.23) of measurements on different EUTs of the same type, having no intentional differences, can be increased by practical component tolerances and other effects, such as possible interactions between the characteristics of the EUT and the measuring instrument or the power supply. The results of these effects cannot be quantified in this standard, for the same reasons as for reproducibility. The second paragraph of 6.2.3.2 also applies in the case of variability.

A regulatory concession in respect of limit values to allow for possible variability is recommended but outside the scope of this standard.

6.2.3.3 Starting and stopping

When a piece of equipment is brought into operation or is taken out of operation, manually or automatically, harmonic currents and power are not taken into account for the first 10 s following the switching event.

The equipment under test shall not be in stand-by mode (see 3.20) for more than 10 % of any observation period.

6.2.3.4 Application of limits

The average values for the individual harmonic currents, taken over the entire test observation period shall be less than or equal to the applicable limits.

For each harmonic order, all 1,5 s smoothed r.m.s. harmonic current values, as defined in 6.2.2, shall be either:

a) less than or equal to 150 % of the applicable limits, or

b) less than or equal to 200 % of the applicable limits under the following conditions, which apply all together:

   1) the EUT belongs to Class A for harmonics;

   2) the excursion beyond 150 % of the applicable limits lasts less than 10 % of the test observation period or in total 10 min (within the test observation period), whichever is smaller, and

   3) the average value of the harmonic current, taken over the entire test observation period, is less than 90 % of the applicable limits.

Harmonic currents less than 0,6 % of the input current measured under the test conditions, or less than 5 mA, whichever is greater, are disregarded.

For the 21st and higher odd order harmonics, the average value obtained for each individual odd harmonic over the full observation period, calculated from the 1,5 s smoothed r.m.s. values according to 6.2.2, may exceed the applicable limits by 50 % provided that the following conditions are met:

- the measured partial odd harmonic current does not exceed the partial odd harmonic current which can be calculated from the applicable limits;

- all 1,5 s smoothed r.m.s. individual harmonic current values shall be less than or equal to 150 % of the applicable limits.

NOTE These exemptions (the use of the partial odd harmonic current for the average values and the 200 % short term limit for single 1,5 s smoothed values) are mutually exclusive and cannot be used together.

6.2.3.5 Test report

The test report may be based on information supplied by the manufacturer to a testing facility, or be a document recording details of the manufacturer's own tests. It shall include all relevant information for the test conditions, the test observation period, and, when applicable for establishing the limits, the active power or fundamental current and power factor.

6.2.4 Test observation period

Observation periods (T_{obs}) for four different types of equipment behaviour are considered and described in Table 4.

6.3 Equipment in a rack or case

Where individual self-contained items of equipment are installed in a rack or case, they are regarded as being individually connected to the mains supply. The rack or case need not be tested as a whole.

7 Harmonic current limits

The procedure for applying the limits and assessing the results is shown in Figure 1.

For the following categories of equipment, limits are not specified in this standard:

NOTE 1 Limits may be defined in a future amendment or revision of the standard.

– equipment with a rated power of 75 W or less, other than lighting equipment;

NOTE 2 This value may be reduced from 75 W to 50 W in the future, subject to approval by National Committees at that time.

– professional equipment with a total rated power greater than 1 kW;

– symmetrically controlled heating elements with a rated power less than or equal to 200 W;

– independent dimmers for incandescent lamps with a rated power less than or equal to 1 kW.

NOTE 3 See also C.5.3.

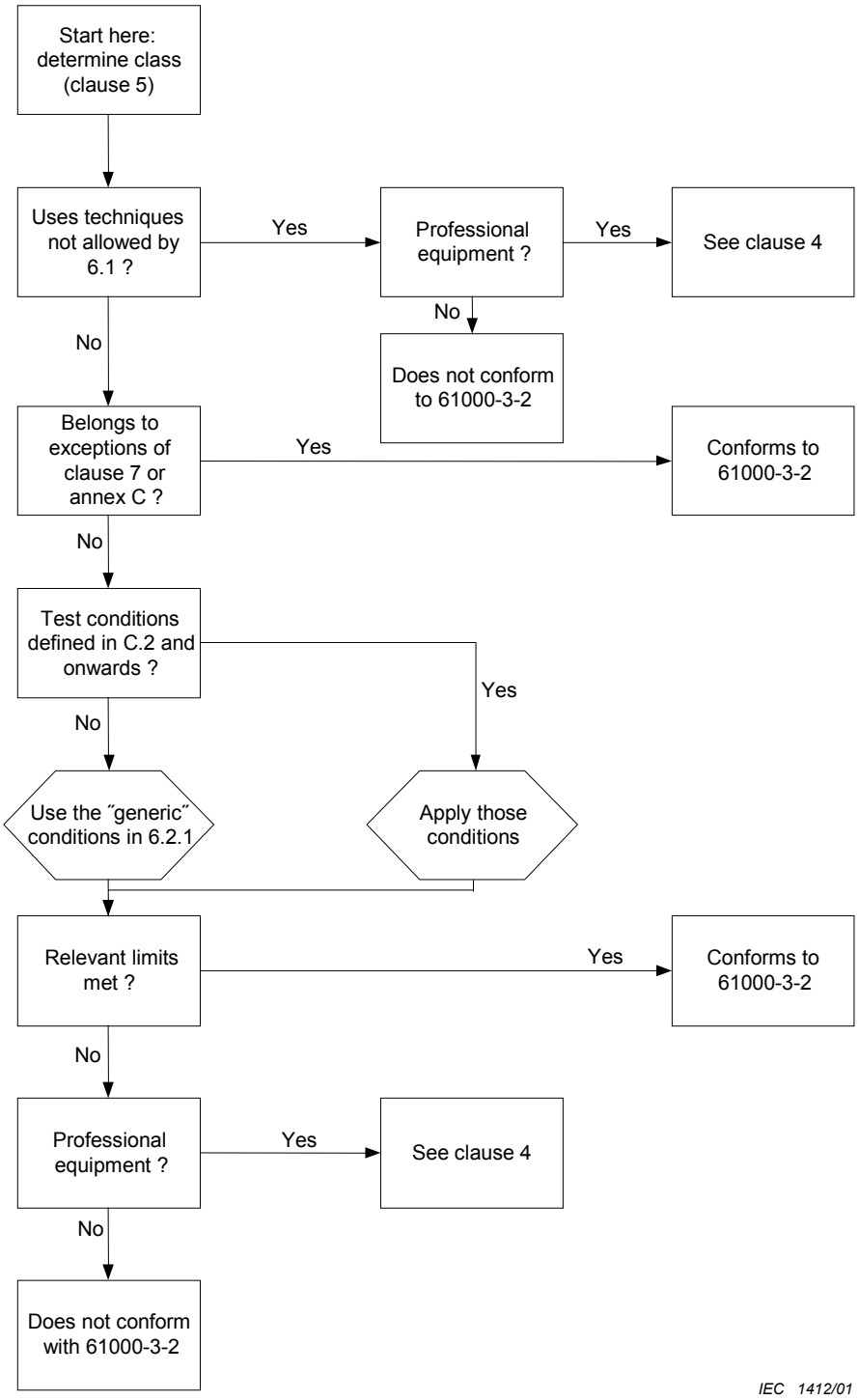
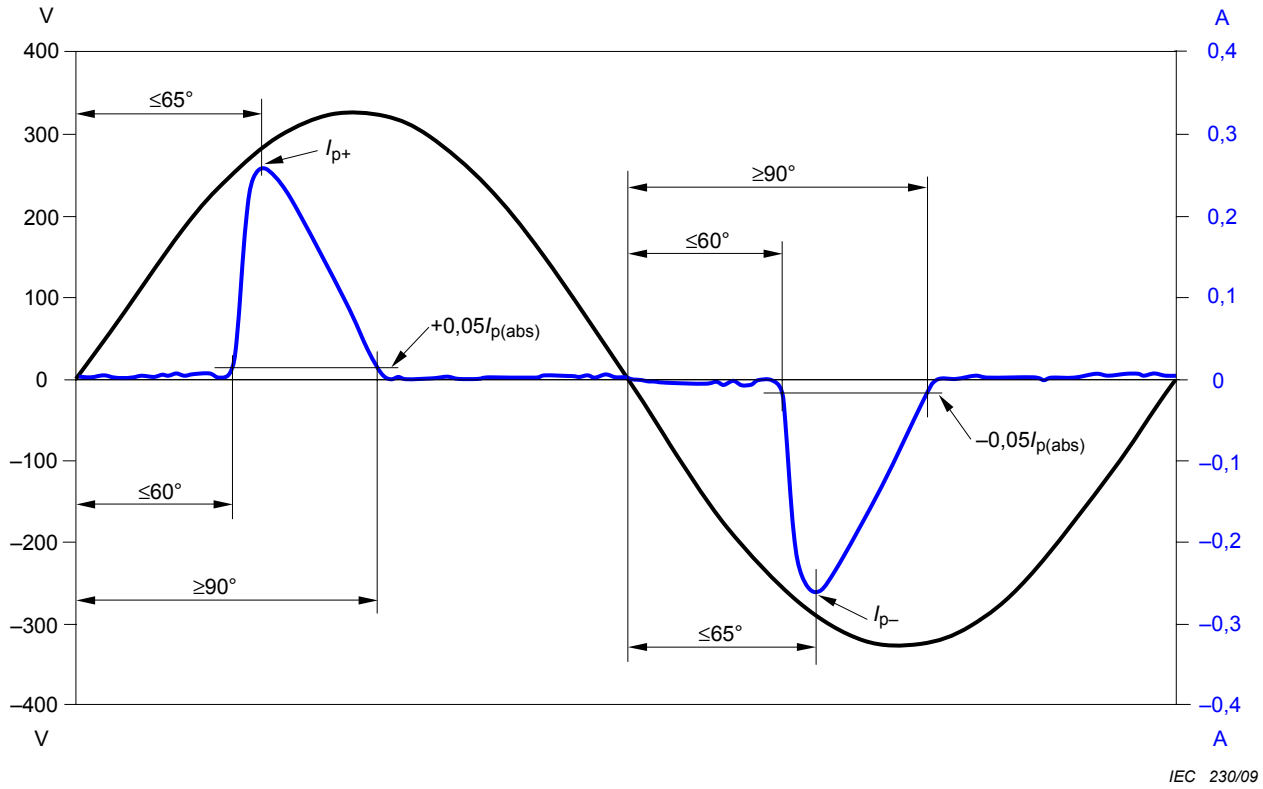


Figure 1 – Flowchart for determining conformity



NOTE $I_{p(abs)}$ is the higher absolute value of I_{p+} and I_{p-}

Figure 2 – Illustration of the relative phase angle and current parameters described in 7.3 b)

7.1 Limits for Class A equipment

For Class A equipment, the harmonics of the input current shall not exceed the values given in Table 1.

Audio amplifiers shall be tested according to Clause C.3. Dimmers for incandescent lamps shall be tested according to Clause C.6.

7.2 Limits for Class B equipment

For Class B equipment, the harmonics of the input current shall not exceed the values given in Table 1 multiplied by a factor of 1,5.

7.3 Limits for Class C equipment

a) Active input power >25 W

For lighting equipment having an active input power greater than 25 W, the harmonic currents shall not exceed the relative limits given in Table 2.

However, the limits given in Table 1 apply to incandescent lighting equipment that has built-in dimmers or consists of dimmers built in an enclosure.

For discharge lighting equipment that has built-in dimmers or consists of independent dimmers or dimmers built in an enclosure, the following conditions apply:

– the harmonic current values for the maximum load condition derived from the percentage limits given in Table 2 shall not be exceeded;

– in any dimming position, the harmonic current shall not exceed the value of current allowed in the maximum load condition;

– the equipment shall be tested according to the conditions given in C.5 (see the last paragraph of C.5.3).

b) Active input power ≤25 W

Discharge lighting equipment having an active input power smaller than or equal to 25 W shall comply with one of the following two sets of requirements:

– the harmonic currents shall not exceed the power-related limits of Table 3, column 2, or:

– the third harmonic current, expressed as a percentage of the fundamental current, shall not exceed 86 % and the fifth harmonic current shall not exceed 61 %. Also, the waveform of the input current shall be such that it reaches the 5 % current threshold before or at 60º, has its peak value before or at 65º and does not fall below the 5 % current threshold before 90º, referenced to any zero crossing of the fundamental supply voltage. The current threshold is 5 % of the highest absolute peak value that occurs in the measurement window, and the phase angle measurements are made on the cycle that includes this absolute peak value. See Figure 2.

7.4 Limits for Class D equipment

For Class D equipment, the harmonic currents and the power shall be measured as defined in 6.2.2. The input currents at harmonic frequencies shall not exceed the values that can be derived from Table 3 according to the requirements specified in 6.2.3 and 6.2.4.

Table 1 – Limits for Class A equipment

Harmonic order n	**Maximum permissible harmonic current** A
Odd harmonics	
3	2,30
5	1,14
7	0,77
9	0,40
11	0,33
13	0,21
$15 \le n \le 39$	$0{,}15 \frac{15}{n}$
Even harmonics	
2	1,08
4	0,43
6	0,30
$8 \le n \le 40$	$0{,}23 \frac{8}{n}$

Table 2 – Limits for Class C equipment

Harmonic order n	Maximum permissible harmonic currrent expressed as a percentage of the input current at the fundamental frequency %
2	2
3	$30 \cdot \lambda$ *
5	10
7	7
9	5
$11 \leq n \leq 39$ (odd harmonics only)	3
* λ is the circuit power factor	

Table 3 – Limits for Class D equipment

Harmonic order n	Maximum permissible harmonic current per watt mA/W	Maximum permissible harmonic current A
3	3,4	2,30
5	1,9	1,14
7	1,0	0,77
9	0,5	0,40
11	0,35	0,33
$13 \leq n \leq 39$ (odd harmonics only)	$\frac{3,85}{n}$	See Table 1

Table 4 – Test observation period

Type of equipment behaviour	Observation period
Quasi-stationary	T_{obs} of sufficient duration to meet the requirements for repeatability in 6.2.3.1
Short cyclic ($T_{cycle} \leq 2,5$ min)	$T_{obs} \geq 10$ cycles (reference method) or T_{obs} of sufficient duration or synchronisation to meet the requirements for repeatability in 6.2.3.1 [a]
Random	T_{obs} of sufficient duration to meet the requirements for repeatability in 6.2.3.1
Long cyclic ($T_{cycle} > 2,5$ min)	Full equipment program cycle (reference method) or a representative 2,5 min period considered by the manufacturer as the operating period with the highest THC
[a] By 'synchronization' is meant that the total observation period is sufficiently close to including an exact integral number of equipment cycles such that the requirements for repeatability in 6.2.3.1 are met.	

Annex A
(normative)

Measurement circuit and supply source

A.1 Test circuit

The measured harmonic values shall be compared with the limits given in Clause 7. The harmonic currents of the equipment under test (EUT) shall be measured in accordance with the circuits given in the following figures:

– Figure A.1 for single-phase equipment;

– Figure A.2 for three-phase equipment.

Measurement equipment complying with Annex B shall be used. Test conditions for the EUT are given in Annex C.

A.2 Supply source

While the measurements are being made, the test voltage (U) at the terminals of the equipment under test, when operated according to Annex C, shall meet the following requirements.

a) The test voltage (U) shall be the rated voltage of the equipment. In the case of a voltage range, the test voltage shall be 230 V or 400 V for single-phase or three-phase supplies respectively. The test voltage shall be maintained within ±2,0 % and the frequency within ±0,5 % of the nominal value.

b) In the case of a three-phase supply, the angle between the fundamental voltage on each pair of phases of a three-phase source shall be 120° ± 1,5°.

c) The harmonic ratios of the test voltage (U) shall not exceed the following values with the EUT connected as in normal operation:

   0,9 % for harmonic of order 3;

   0,4 % for harmonic of order 5;

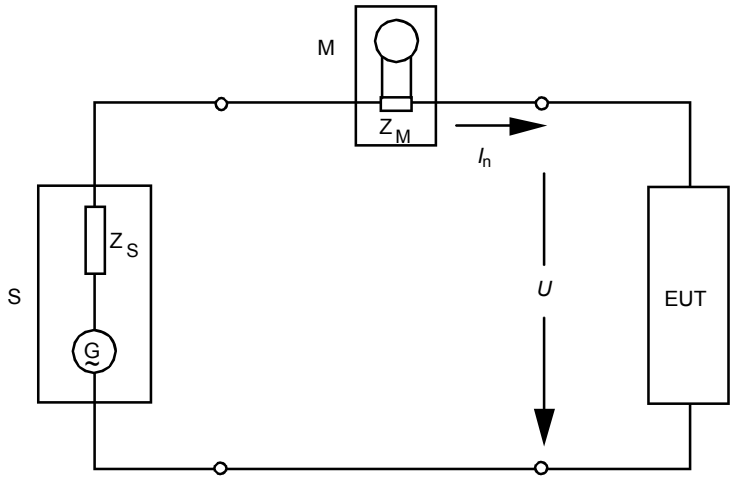
   0,3 % for harmonic of order 7;

   0,2 % for harmonic of order 9;

   0,2 % for even harmonics of order from 2 to 10;

   0,1 % for harmonics of order from 11 to 40.

d) The peak value of the test voltage shall be within 1,40 and 1,42 times its r.m.s. value and shall be reached within 87° to 93° after the zero crossing. This requirement does not apply when Class A or B equipment is tested.



IEC 1778/2000

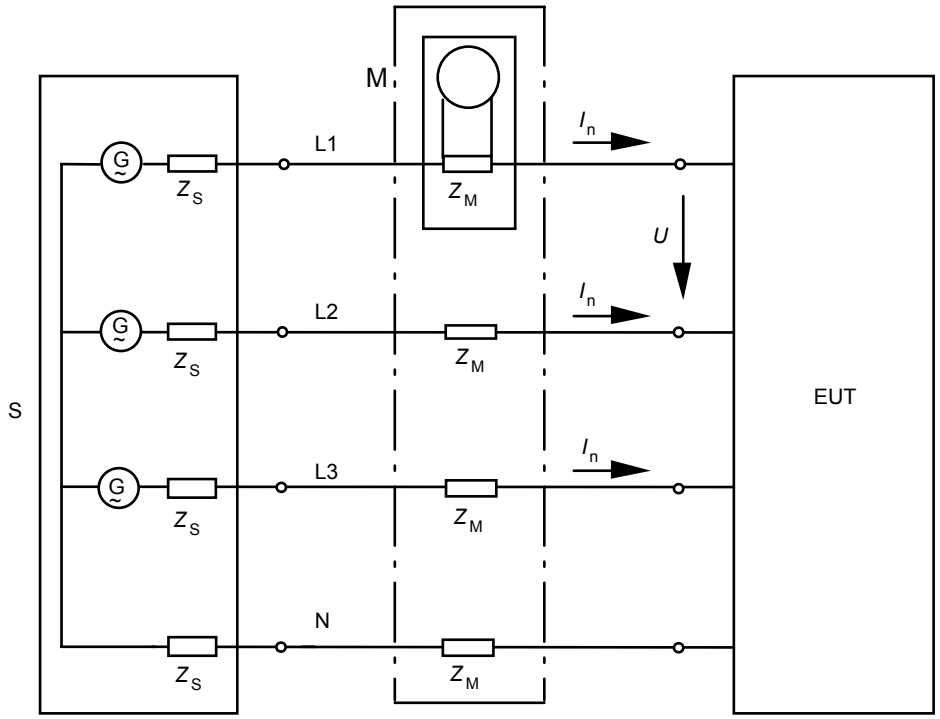
S	power supply source	Z_M	input impedance of measurement equipment
M	measurement equipment	Z_S	internal impedance of the supply source
EUT	equipment under test	I_n	harmonic component of order n of the line current
U	test voltage	G	open-loop voltage of the supply source

NOTE 1 Z_S and Z_M are not specified, but must be sufficiently low for the requirements of Clause A.2 to be met. This is checked by measuring the properties of the supply voltage at the point of connection of the EUT to the measurement equipment. More information can be found in IEC 61000-4-7.

NOTE 2 In some special cases, particular care may be necessary to avoid resonance between the internal inductance of the source and the capacitances of the equipment under test.

NOTE 3 For some types of equipment, such as single-phase uncontrolled rectifiers, the harmonic amplitudes vary greatly with the supply voltage. To minimize variability, it is recommended to maintain the voltage at the point of connection of the EUT to the measurement equipment to 230 V or 400 V within ±1,0 V, evaluated over the same 200 ms observation window, used for harmonic assessment.

Figure A.1 – Measurement circuit for single-phase equipment



IEC 1779/2000

S power supply source
M measurement equipment
EUT equipment under test
G open-loop voltage of the supply source
Z_M input impedance of the measurement equipment
Z_S internal impedance of the supply source
I_n harmonic component of order of the line current
U test voltage (shown as an example between phases L1 and L2)

NOTE 1 Z_S and Z_M are not specified, but must be sufficiently low for the requirements of Clause A.2 to be met. This is checked by measuring the properties of the supply voltage at the point of connection of the EUT to the measurement equipment. More information can be found in IEC 61000-4-7.

NOTE 2 In some special cases, particular care may be necessary to avoid resonance between the internal inductance of the source and the capacitances of the equipment under test.

NOTE 3 For some types of equipment, such as single-phase uncontrolled rectifiers, the harmonic amplitudes vary greatly with the supply voltage. To minimize variability, it is recommended to maintain the voltage at the point of connection of the EUT to the measurement equipment to 230 V or 400 V within ±1,0 V, evaluated over the same 200 ms observation window, used for harmonic assessment.

Figure A.2 – Measurement circuit for three-phase equipment

Annex B
(normative)

Requirements for measurement equipment

The requirements for measurement equipment are defined in IEC 61000-4-7.

Annex C
(normative)

Type test conditions

C.1 General

The test conditions for the measurement of harmonic currents associated with some types of equipment are given in the following clauses.

NOTE Product committees are invited to submit proposals for defined test conditions for specific products to IEC SC 77A, for inclusion in this Annex.

C.2 Test conditions for television (TV) receivers

C.2.1 General conditions

Measurements shall include the loading of any auxiliary circuits included in the receiver, but exclude the loading of any peripheral equipment powered from the receiver.

C.2.2 Conditions for measurement

A radio-frequency signal modulated in accordance with C.2.2.1 shall be supplied by a test generator, and the receiver shall be adjusted to display a picture with appropriate settings for brightness, contrast and sound level in accordance with C.2.2.2.

C.2.2.1 The TV receiver is fed by an r.f. TV input signal with a level of 65 dB(μV) across 75 Ω and with the following test modulations.

a) Color television

   Radio-frequency signal: a full TV signal with modulated picture chrominance and sound carrier:

   – the sound modulation factor is 54 % at 1 000 Hz;
   – the picture modulation content is a color bar test pattern according to Recommendation ITU-R BT.471-1:
     - 100 % reference white level bar;
     - 0 % reference black level bar;
     - 75 % amplitude (reference made to the white level); and
     - 100 % saturation.

b) Monochrome television

   Radio-frequency signal: a full TV signal with modulated picture and sound carrier:

   – sound modulation: see item a) above;
   – the picture modulation is a monochrome test pattern with a black and white level according to item a) and an average overall picture content of 50 % of the reference white level.

C.2.2.2 The receiver shall be tuned according to IEC 60107-1.

The white reference level corresponds to 80 cd/m^2 and the black level to less than 2 cd/m^2.

The magenta bar corresponds to 30 cd/m^2.

The volume control is set in such a manner that one-eighth of rated output power is obtained, measured at the loudspeaker terminals, at a frequency of 1 000 Hz. In the case of stereophonic equipment, this output shall be present at both outputs.

NOTE For devices that operate on base-band signals, suitable video and audio input signals should be used, and the same settings made for brightness, contrast and volume controls.

C.3 Test conditions for audio amplifiers

C.3.1 Conditions

Audio amplifiers which draw a supply current which varies less than 15 % of the maximum current with input signal voltages between zero and rated source e.m.f. (as defined in IEC 60268-3) shall be tested with no input signal.

Other audio amplifiers shall be tested under the following conditions:

- rated supply voltage;
- normal position of user controls. In particular, any controls affecting the frequency response set to give the widest flat response achievable;
- input signals and loads as given in C.3.2.

C.3.2 Input signals and loads

The following test procedure applies.

a) Connect suitable resistors, equal to the rated load impedance(s), to each amplifier output for supplying loudspeakers. To monitor the output voltage waveform of the audio amplifier of a powered loudspeaker, the audio analyzer/oscilloscope is connected to internal wiring at a point representing the electrical output of the amplifier.

NOTE 1 In the case of powered loudspeakers with internal audio amplifiers, the load is the loudspeaker and associated crossover network.

b) Apply a sinusoidal signal at 1 kHz (see Note 2) to a suitable input. For multi-channel amplifiers in which the surround sound channel amplifiers cannot be alternatively used as a second set of left and right channel amplifiers, set the controls so that the surround sound channel amplifiers are supplied with signal at a level 3 dB lower than the signal applied to the left and right channels.

NOTE 2 For products not intended to reproduce 1 kHz signals, a frequency geometrically centred within the reproducing bandwidth of the amplifier is applied.

c) Adjust the input signal and/or amplifier gain control(s) so as to obtain an output signal for the left and right channels having 1 % total harmonic distortion, simultaneously. If 1 % total harmonic distortion cannot be obtained, adjust the signal voltage and/or gain controls to obtain the highest achievable power output at each output simultaneously. Confirm that the output signals of the surround sound channel amplifiers are 3 dB lower than the output signal at the outputs of the left and right channels.

d) Measure the output voltages of all channels and then readjust the input signal voltage and/or controls to obtain voltages of 0,354 ($1/\sqrt{8}$) times the voltages obtained at the end of step c) above.

e) In the case of products with provision for connection to external loudspeakers, proceed as specified in 6.2.

f) For products with internal loudspeakers and without provision for connection to external loudspeakers, note the r.m.s. output voltage of the sinusoidal signal at the output of each amplifier. Substitute the sinusoidal signal by a pink noise signal, bandwidth-limited as specified in 6.1 of IEC 60268-1. Confirm the r.m.s. value of the pink noise signal as it appears at the output of each amplifier output is equal to the r.m.s. value of the sinusoidal waveform for that channel set as in step d) above. Proceed as specified in 6.2.

C.4 Test conditions for video-cassette recorders

Measurements shall be made in the playback mode with the standard tape speed.

C.5 Test conditions for lighting equipment

C.5.1 General conditions

Measurements shall be made in a draught-free atmosphere and at an ambient temperature within the range from 20 °C to 27 °C. During measurement the temperature shall not vary by more than 1 K.

C.5.2 Lamps

Discharge lamps shall be aged for at least 100 h at rated voltage. Discharge lamps shall be operated for at least 15 min before a series of measurements is made. Some lamp types require a stabilization period exceeding 15 min. Information given in the relevant IEC lamp performance standard shall be observed.

During ageing, stabilization and measurement, lamps shall be installed as in normal use. Self-ballasted lamps shall be operated in cap-up position.

C.5.3 Luminaires

The luminaire is measured as manufactured. It shall be tested with reference lamps, or with lamps having electrical characteristics close to their nominal values. In case of doubt measurements are made with reference lamps. When the luminaire incorporates more than one lamp, all lamps are connected and operated during the test. When the luminaire is assigned for use with more than one type of lamp, measurements shall be made with all the types and the luminaire shall comply each time. In the case where the luminaire is equipped with a glow starter, a starter in accordance with IEC 60155, shall be used.

Incandescent lamp luminaires which do not incorporate an electronic transformer or a dimming device are deemed to fulfil the harmonic current requirements and need not be tested.

If separate tests with reference lamps have proved that ballasts for fluorescent or other discharge lamps or step-down converters for tungsten halogen or other filament lamps, comply with the requirements, the luminaire is deemed to comply with these requirements and need not be checked. Where these components have not been approved separately, or do not comply, the luminaire itself shall be tested and shall comply.

If a luminaire has a built-in dimming device, the harmonic currents shall be measured at the maximum load of the lamps as specified by the manufacturer. The setting of the dimming device is varied in five equidistant steps between the minimum and the maximum power in order to obtain comprehensive results.

C.5.4 Ballasts and step-down converters

Ballast for fluorescent or other discharge lamps or step-down converters for tungsten halogen or other filament lamps shall be tested with reference lamps, or with lamps having electrical characteristics close to their nominal values. In case of doubt, measurements are made with reference lamps.

In the case where a ballast can be used, with or without a series capacitor, or where a ballast or step-down converter is designed for several types of lamps, the manufacturer shall indicate in his catalogue for which type of circuit and lamps the ballast fulfils the harmonic requirements, and the ballast shall be tested accordingly.

C.6 Test conditions for independent and built-in incandescent lamp dimmers

The dimmer is tested with incandescent lamps having the maximum power allowed for the dimmer. The control is set to firing-angle of 90° ± 5°, or if controlled by steps, to that step closest to 90°.

C.7 Test conditions for vacuum cleaners

The air inlet of the vacuum cleaner is adjusted according to normal operation as defined in IEC 60335-2-2.

During the test observation period, which shall not be shorter than 6 min, vacuum cleaners with electronic control are tested in three modes of operation, each for an identical time interval, with the control adjusted:

– to maximum input power,

– to a firing-angle of 90° ± 5°, or, if controlled by steps, to that step closest to 90°,

– and to minimum input power.

NOTE Alternatively, the equipment may be tested for 3 identical time intervals – each at least 2 min long – during which the vacuum cleaner is operated in the above three modes. These 3 time intervals need not be consecutive, but the application of limits is done as if the intervals were consecutive, without taking into account harmonic current values outside these 3 intervals.

If the vacuum cleaner includes a control to select a temporary high-power ('booster') mode of operation, which automatically returns to a lower power mode, this high-power mode is not considered for the calculation of the average values. This mode shall be tested only against the limits for single 1,5 s smoothed r.m.s. values (see 6.2.3.4).

C.8 Test conditions for washing machines

The washing machine shall be tested during a complete laundry program incorporating the normal wash-cycle, filled with the rated load of double hemmed, pre-washed cotton cloths, size approximately 70 cm × 70 cm, dry weight from 140 g/m^2 to 175 g/m^2.

The temperature of the fill water shall be

- 65 °C ± 5 °C for washing machines without heating elements and intended for connection to a hot water supply;

- from 10 °C to 25 °C for other washing machines.

For washing machines with a programmer, the 60 °C cotton programme without pre-wash, if available, shall be used, otherwise the regular wash programme without pre-wash shall be used. If the washing machine contains heating elements which are not controlled by the programmer, the water shall be heated to 65 °C ± 5 °C before starting the first wash period.

If the washing machine contains heating elements and does not incorporate a programmer, the water shall be heated to 90 °C ± 5 °C or lower if steady conditions are established, before starting the first wash period.

C.9 Test conditions for microwave ovens

The microwave oven is tested with 100 % nominal power. It is operated with a potable water load of initially 1 000 g ± 50 g in a cylindrical borosilicate glass vessel, having a maximum material thickness of 3 mm and an outside diameter of approximately 190 mm. The load is placed at the centre of the shelf.

C.10 Test conditions for information technology equipment (ITE)

C.10.1 General conditions

ITE (including personal computers) which is marketed without 'factory-fitted options' and without expansion slot capabilities is tested as supplied. ITE, other than personal computers, which is marketed with 'factory-fitted options' or has expansion slots, is tested with additional loads in each expansion slot that result in the maximum power consumption attainable using the “factory-fitted options” specified by the manufacturer.

For the testing of personal computers with up to 3 expansion slots, load cards configured for the maximum permitted power for each expansion slot shall be added to each respective expansion slot. For the testing of personal computers with more than 3 expansion slots, additional load cards shall be installed at the rate of at least one load card for each group of up to 3 additional slots (i.e. for 4, 5 or 6 slots a total of at least 4 load cards shall be added. For 7, 8 or 9 slots a total of at least 5 load cards shall be added, etc.).

Modular equipment, such as hard drive arrays and network servers, are tested in their maximum configuration.

In all configurations, the use of additional load cards shall not cause the total DC output power available to be exceeded.

NOTE 1 The above does not mean that multiple options of the same type, such as more than one hard drive, should be fitted, unless that is representative of the user configuration, or the product is of a type (such as Redundant Arrays of Inexpensive Disks (RAID)) for which such a configuration is not abnormal.

NOTE 2 Common load cards for expansion slots such as PCI or PCI-2 are configured for 30 W but may be adjusted as industry standards change.

Emission tests shall be conducted with the user’s operation controls or automatic programs set to the mode expected to produce the maximum total harmonic current (THC) under normal operating conditions.

Power saving modes which may cause large power level fluctuations shall be disabled, so that all, or part, of the equipment does not automatically switch off during the measurements.

For ITE systems designed for use with a manufacturer-supplied power distribution system, such as one or more transformers, UPS or a power conditioner, compliance with the limits of this standard shall be met at the input supplied from the public low-voltage distribution network.

C.10.2 Optional conditions for measuring emissions of IT equipment with external power supplies or battery chargers

For IT equipment with external power supplies or battery chargers, manufacturers may choose

- either to test the whole equipment according to C.10.1 (General conditions),
- or to test the equipment by measuring the AC input power and the harmonic emissions of the associated power supply or battery charger according to 6.2.2 with the DC output side loaded by a resistive load, provided that, with the resistive load applied, the peak-to-peak ripple voltage across the load is not greater than 5 % of the DC output voltage.

The resistance value of the load shall be such that the active power dissipated in the load is equal to the DC output power rating, or, if that is not available, to the DC output voltage rating multiplied by the DC output current rating marked on the power supply/battery charger unit.

Power supply/battery charger units whose AC input power measured according to 6.2.2 under the above load conditions is 75 W or less are deemed to conform without further testing, as specified in Clause 7.

C.11 Test conditions for induction hobs

Induction hobs are operated with an enamelled steel pan which contains approximately half its capacity of water at room temperature, and positioned at the centre of each cooking zone, in turn. Thermal controls are adjusted to their highest setting.

The diameter of the base of the pan is to be at least the diameter of the cooking zone. The smallest pan complying with this requirement is used. The maximum concavity of the base of the pan is 3D/1 000 where D is the diameter of the flat area of the base of the pan. The base of the pan is not to be convex.

The concavity is checked at room temperature using an empty pan.

C.12 Test conditions for air conditioners

If the input power of the air conditioner is controlled by an electronic device so that the revolution speed of the fan or compressor motor is changed in order to get the suitable air temperature, the harmonic currents are measured after the operation becomes steady-state under the following conditions:

– The temperature control shall be set to the lowest value in the cooling mode and to the highest value in the heating mode.
– The ambient temperature for testing shall be 30 °C ± 2 °C in the cooling mode, and 15 °C ± 2 °C in the heating mode. If in the heating mode the rated input power is reached at a higher temperature, the air conditioner shall be tested at this ambient temperature but no higher than 18 °C. The ambient temperature is defined as the temperature of the air inhaled from the indoor and from the outdoor unit of appliance.

If the heat is not exchanged to the ambient air but to another medium for example water, all settings and temperatures shall be chosen so that the appliance is operated with the rated input power.

If the air conditioner does not contain power electronic elements (e.g. diodes, dimmers, thyristors, etc.), it need not be tested against harmonic current limits.

C.13 Test conditions for kitchen machines as defined in IEC 60335-2-14

Kitchen machines as listed in the scope of IEC 60335-2-14 are deemed to conform to the harmonic current limits of this standard without further testing

C.14 Test conditions for arc welding equipment which is not professional equipment

The arc welding power source is connected to a conventional load, which is adjusted in accordance with Table C1. The equipment is tested at the load current given by the maximum size of the rated electrode as specified by the manufacturer.

Table C.1 – Conventional load for arc welding equipment tests

Rated electrode diameter mm	**Load current*** A	**Load voltage** V
1,6	40	19,6
2	55	20,2
2,5	80	21,2
3,15	115	22,6
4	160	24,4
* Interpolation is allowed.		

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch