

Electromagnetic compatibility (EMC) —

**Part 3-7: Limits — Assessment of
emission limits for the connection of
fluctuating installations to MV, HV and
EHV power systems**

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National foreword

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**Electromagnetic compatibility (EMC) –
Part 3-7: Limits – Assessment of emission limits for the connection of
fluctuating installations to MV, HV and EHV power systems**

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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 of the environment

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 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 several parts published either as International Standards or as technical specifications or technical reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61000-6-1).

ACKNOWLEDGMENT

In 2002, the IEC subcommittee 77A made a request to CIGRE Study Committee C4 and CIRED Study Committee S2, to organize an appropriate technical forum (joint working group) whose scope was to prepare, among other tasks, the revision of the Technical Report IEC 61000-3-7 concerning emission limits for the connection of fluctuating installations to public supply systems at MV, HV and EHV.

To this effect, Joint Working Group CIGRE C4.103/ CIRED entitled "*Emission Limits for Disturbing Installations*" was appointed in 2003. Some previous work produced by CIGRE JWG C4.07-CIRED has been used as an input to the revision, in particular the planning levels and associated indices, along with the experience since the technical report IEC 61000-3-7 was initially published in 1996.

Subsequent endorsement of the document by IEC was the responsibility of SC 77A.

It may also be worthwhile mentioning that another CIGRE Working Group is currently preparing a Technical Report for reviewing the flicker measurement results available internationally along with the flicker propagation characteristics in systems and the related objectives (flicker levels).

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 3-7: Limits –

Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems

1 Scope

This part of IEC 61000 provides guidance on principles which can be used as the basis for determining the requirements for the connection of fluctuating installations to MV, HV and EHV public power systems (LV installations are covered in other IEC documents). For the purposes of this report, a fluctuating installation means an installation (which may be a load or a generator) that produces voltage flicker and / or rapid voltage changes. The primary objective is to provide guidance to system operators or owners on engineering practices which will facilitate the provision of adequate service quality for all connected customers. In addressing installations, this document is not intended to replace equipment standards for emission limits.

This report addresses the allocation of the capacity of the system to absorb disturbances. It does not address how to mitigate disturbances, nor does it address how the capacity of the system can be increased.

Since the guidelines outlined in this report are necessarily based on certain simplifying assumptions, there is no guarantee that this approach will always provide the optimum solution for all flicker situations. The recommended approach should be used with flexibility and engineering judgment as far as engineering is concerned, when applying the given assessment procedures in full or in part.

The system operator or owner is responsible for specifying requirements for the connection of fluctuating installations to the system. The fluctuating installation is to be understood as the customer's complete installation (i.e. including fluctuating and non fluctuating parts).

Problems related to voltage fluctuations fall into two basic categories:

- Flicker effect from light sources as a result of voltage fluctuations;
- Rapid voltage changes even within the normal operational voltage tolerances are considered as a disturbing phenomenon.

The report gives guidance for the coordination of the flicker emissions between different voltage levels in order to meet the compatibility levels at the point of utilisation. This report primarily focuses on controlling or limiting flicker, but a clause is included to address the limitation of rapid voltage changes.

NOTE The boundaries between the various voltage levels may be different for different countries (see IEC 601-01-28) [16]. This report uses the following terms for system voltage:

- low voltage (LV) refers to $U_n \leq 1 \text{ kV}$;
- medium voltage (MV) refers to $1 \text{ kV} < U_n \leq 35 \text{ kV}$;
- high voltage (HV) refers to $35 \text{ kV} < U_n \leq 230 \text{ kV}$;
- extra high voltage (EHV) refers to $230 \text{ kV} < U_n$.

In the context of this report, the function of the system is more important than its nominal voltage. For example, a HV system used for distribution may be given a "planning level" which is situated between those of MV and HV systems.

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(161), *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility*

3 Terms and definitions

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

3.1

agreed power

value of the apparent power of the disturbing installation on which the customer and the system operator or owner agree. In the case of several points of connection, a different value may be defined for each connection point

3.2

customer

a person, company or organization that operates an installation connected to, or entitled to be connected to, a supply system by a system operator or owner

3.3

(electromagnetic) disturbance

any electromagnetic phenomenon which, by being present in the electromagnetic environment, can cause electrical equipment to depart from its intended performance

3.4

disturbance level

the amount or magnitude of an electromagnetic disturbance measured and evaluated in a specified way

3.5

electromagnetic compatibility (EMC)

ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

NOTE 1 Electromagnetic compatibility is a condition of the electromagnetic environment such that, for every phenomenon, the disturbance emission level is sufficiently low and immunity levels are sufficiently high so that all devices, equipment and systems operate as intended.

NOTE 2 Electromagnetic compatibility is achieved only if emission and immunity levels are controlled such that the immunity levels of the devices, equipment and systems at any location are not exceeded by the disturbance level at that location resulting from the cumulative emissions of all sources and other factors such as circuit impedances. Conventionally, compatibility is said to exist if the probability of the departure from intended performance is sufficiently low. See Clause 4 of IEC 61000-2-1 [20].

NOTE 3 Where the context requires it, compatibility may be understood to refer to a single disturbance or class of disturbances.

NOTE 4 Electromagnetic compatibility is a term used also to describe the field of study of the adverse electromagnetic effects which devices, equipment and systems undergo from each other or from electromagnetic phenomena.

3.6

(electromagnetic) compatibility level

specified electromagnetic disturbance level used as a reference level in a specified environment for coordination in the setting of emission and immunity limits

NOTE By convention, the compatibility level is chosen so that there is only a small probability (for example 5%) that it will be exceeded by the actual disturbance level.

3.7

emission

phenomenon by which electromagnetic energy emanates from a source of electromagnetic disturbance

[IEV 161-01-08 modified]

NOTE For the purpose of this report, emission refers to phenomena or conducted electromagnetic disturbances that can cause flicker or fluctuations of the supply voltage.

3.8

emission level

level of a given electromagnetic disturbance emitted from a particular device, equipment, system or disturbing installation as a whole, assessed and measured in a specified manner

3.9

emission limit

maximum emission level specified for a particular device, equipment, system or disturbing installation as a whole

3.10

flicker

impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time

NOTE Flicker is the effect on the incandescent lamps while the electromagnetic phenomenon causing it is referred as voltage fluctuations.

3.11

fluctuating installation

an electrical installation as a whole (i.e. including fluctuating and non-fluctuating parts) which is characterized by repeated or sudden power fluctuations, or start-up or inrush currents which can produce flicker or rapid voltage changes on the supply system to which it is connected

NOTE For the purpose of this report, all references to fluctuating installations not only include loads, but also generating plants.

3.12

fundamental frequency

frequency in the spectrum obtained from a Fourier transform of a time function, to which all the frequencies of the spectrum are referred. For the purpose of this technical report, the fundamental frequency is the same as the power supply frequency

NOTE In the case of a periodic function, the fundamental frequency is generally equal to the frequency of the function itself.

3.13

generating plant

any equipment that produces electricity together with any directly connected or associated equipment such as a unit transformer or converter

3.14**immunity (to a disturbance)**

ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

3.15**immunity level**

maximum level of a given electromagnetic disturbance on a particular device, equipment or system for which it remains capable of operating with a declared degree of performance

3.16**interharmonic frequency**

any frequency which is not an integer multiple of the fundamental frequency

NOTE 1 By extension from harmonic order, the interharmonic order is the ratio of the interharmonic frequency to the fundamental frequency. This ratio is not an integer (recommended notation “m”).

NOTE 2 In the case where $m < 1$ the term subharmonic frequency may be used.

3.17**interharmonic component**

component having an interharmonic frequency. For brevity, such a component may be referred to simply as an “interharmonic”

3.18**normal operating conditions**

operating conditions of the system or of the disturbing installation typically including all generation variations, load variations and reactive compensation or filter states (e.g. shunt capacitor states), planned outages and arrangements during maintenance and construction work, non-ideal operating conditions and normal contingencies under which the considered system or disturbing installation has been designed to operate

NOTE Normal system operating conditions typically exclude: conditions arising as a result of a fault or a combination of faults beyond that planned for under the system security standard, exceptional situations and unavoidable circumstances (for example: force majeure, exceptional weather conditions and other natural disasters, acts by public authorities, industrial actions), cases where system users significantly exceed their emission limits or do not comply with the connection requirements, and temporary generation or supply arrangements adopted to maintain supply to customers during maintenance or construction work, where otherwise supply would be interrupted

3.19**planning level**

level of a particular disturbance in a particular environment, adopted as a reference value for the limits to be set for the emissions from the installations in a particular system, in order to coordinate those limits with all the limits adopted for equipment and installations intended to be connected to the power supply system

NOTE Planning levels are considered internal quality objectives to be specified at a local level by those responsible for planning and operating the power supply system in the relevant area.

3.20**point of common coupling (PCC)**

point in the public system which is electrically closest to the installation concerned and to which other installations are or may be connected. The PCC is a point located upstream of the considered installation

NOTE A supply system is considered as being public in relation to its use, and not its ownership.

3.21**point of connection (POC)**

point on a public power supply system where the installation under consideration is, or can be connected

NOTE A supply system is considered as being public in relation to its use, and not its ownership.

3.22

point of evaluation (POE)

point on a public power supply system where the emission levels of a given installation are to be assessed against the emission limits. This point can be the point of common coupling (PCC) or the point of connection (POC) or any other point specified by the system operator or owner or agreed upon

NOTE A supply system is considered as being public in relation to its use, and not its ownership.

3.23

rapid voltage changes

changes in fundamental frequency r.m.s. voltages over several cycles; rapid voltage changes could also be in the form of cyclic changes

NOTE Rapid voltage changes are often caused by start-ups, inrush currents or switching operation of equipment.

3.24

short circuit power

theoretical value expressed in MVA of the initial symmetrical three-phase short-circuit power at a point on the supply system. It is defined as the product of the initial symmetrical short-circuit current, the nominal system voltage and the factor $\sqrt{3}$ with the aperiodic component (DC) being neglected

3.25

spur

a feeder branch off a main feeder (typically applied on MV and LV feeders)

3.26

supply system

all the lines, switchgear and transformers operating at various voltages which make up the transmission systems and distribution systems to which customers' installations are connected

3.27

system operator or owner

entity responsible for making technical connection agreements with customers who are seeking connection of load or generation to a distribution or transmission system

3.28

transfer coefficient (influence coefficient)

the relative level of disturbance that can be transferred between two busbars or two parts of a power system for various operating conditions

3.29

voltage fluctuations

a series of voltage changes or a cyclic variation of the voltage envelope

4 Basic EMC concepts related to voltage fluctuations

The international flickermeter (see IEC 61000-4-15 [1])² provides two quantities to characterize the flicker severity: P_{st} ("st" referring to "short term": one value is obtained for each 10 min period) and P_{lt} ("lt" referring to "long term": one value is obtained for each 2 h period). The flicker related voltage quality criteria are generally expressed in terms of P_{st} and/or P_{lt} , with P_{lt} typically being derived from groups of 12 consecutive P_{st} values.

² Figures in square brackets refer to the bibliography.

$$P_{lt} = \sqrt[3]{\frac{1}{12} \cdot \sum_{j=1}^{12} P_{stj}^3} \quad (1)$$

Flicker emission levels are assessed at the point of evaluation (POE) of a fluctuating installation (see Clause 6), at the MV, HV or EHV level in the context of this report. However, it should be remembered that the background for limits is the possible annoyance to LV customers, therefore flicker attenuation between LV, MV, HV and EHV should be considered in assessing the impact of emissions.

It is also assumed in this report that the flickermeter and the associated severity factors are adapted to the type of incandescent lamps in use (e.g.: 120 V or 230 V) so that the flicker limits remain the same irrespective of the voltage of the lamps. This is important because 120 V lamps are less sensitive to voltage fluctuations than 230 V lamps (see Annex A) and 100 V lamps are even less sensitive.

The development of emission limits for individual equipment or a customer's total installation should be based on the effect that these emissions will have on the quality of the voltage. Some basic concepts are used to evaluate voltage quality. In order for these concepts to be used for evaluation at specific locations, they are defined in terms of where they apply (locations), how they are measured (measurement duration, sample times, averaging durations, statistics), and how they are calculated. These concepts are described hereafter and illustrated in Figures 1 and 2. Definitions may be found in IEC 60050(161).

4.1 Compatibility levels

These are reference values (see Table 1) for coordinating the emission and immunity of equipment which is part of, or supplied by, a supply system in order to ensure the EMC in the whole system (including system and connected equipment). Compatibility levels are generally based on the 95 % probability levels of entire systems, using statistical distributions which represent both time and space variations of disturbances. There is allowance for the fact that the system operator or owner cannot control all points of a system at all times. Therefore, evaluation with respect to compatibility levels should be made on a system-wide basis and no assessment method is provided for evaluation at a specific location.

The compatibility levels for flicker in LV systems are reproduced in Table 1 from IEC 61000-2-2 [2]. In some cases, higher values have been reported without a correlation with complaints. In these cases, measurements were possibly made at EHV/HV levels, during daylight hours, or for other reasons. Additional information is available in reference [3].

Compatibility levels are not defined by IEC for MV, HV and EHV systems.

**Table 1 – Compatibility levels for flicker in low voltage systems
reproduced from IEC 61000-2-2**

	Compatibility levels
P_{st}	1,0
P_{lt}	0,8

4.2 Planning levels

4.2.1 Indicative values of planning levels

These are voltage flicker levels that can be used for the purpose of determining emission limits, taking into consideration all fluctuating installations. Planning levels are specified by the system operator or owner for all system voltage levels and can be considered as internal

quality objectives of the system operator or owner and may be made available to individual customers on request. Planning levels should allow coordination of voltage fluctuations between different voltage levels. It is worth noting that at HV and EHV, coordination of flicker levels can still be achieved while considering the attenuation of flicker due to motor loads and generators connected downstream which have a steadying influence on voltages and can reduce flicker perception.

Only indicative values may be given because planning levels will differ from case to case, depending on system structure and circumstances. Indicative values of planning levels for flicker are shown in Table 2.

Table 2 – Indicative values of planning levels for flicker in MV, HV and EHV power systems

	Planning levels (see NOTE 2)	
	MV	HV-EHV
P_{st}	0,9	0,8
P_{lt}	0,7	0,6

NOTE 1 These values were chosen on the assumption that the transfer coefficient between MV or HV systems and LV systems is unity.

NOTE 2 In practice, the transfer coefficients between different voltage levels are less than 1,0. This can be taken into account when establishing new planning levels. For example, a typical value for the transfer coefficient between HV and LV is $T_{PstHL} = 0,8$. In such a case, the indicative planning level for HV becomes $L_{PstHV} = 0,8/0,8 = 1,0$.

NOTE 3 In some countries, planning levels are defined in national standards or guidelines.

NOTE 4 Voltage characteristics that are quasi-guaranteed levels exist in some countries for MV and HV systems. These should be coordinated with the planning levels [3].

As stated in NOTE 2, for the purpose of setting emission limits, it is recommended to weight the given planning levels at MV and HV-EHV by taking into account the flicker transfer coefficient from the source of emissions to the POE at EHV, HV, MV and LV. In addition, planning levels must allow coordination between different voltage levels. To enable this, the system operator or owner has to evaluate the flicker transfer coefficients for various operating conditions of the system. Further discussion of the assessment of flicker transfer coefficients is given in Annex B of this report. Reallocation of planning levels is exemplified in Annex C.

Where national circumstances make it appropriate depending on system characteristics, intermediate values of planning levels may be needed between the MV and HV EHV values due to the possibly wide range of voltage levels included in HV-EHV (>35 kV). Additionally, an apportioning of planning levels between HV and EHV may also be necessary to take account of the impact on HV systems of disturbing installations connected at EHV.

The remainder of this report outlines procedures for using these planning levels to establish the emission limits for individual fluctuating installations.

4.2.2 Assessment procedure for evaluation against planning levels

The measurement methods to be used for flicker is the class A method specified in IEC 61000-4-30 [4] and the related IEC 61000-4-15 [1]. The data flagged in accordance with IEC 61000-4-30 should be removed from the assessment. For clarity, where data is flagged, the percentile used in calculating the indices defined below is calculated using only the valid (unflagged) data.

The minimum measurement period is one week with normal business activity. The monitoring period should include some part of the period of expected maximum flicker levels.

One or more of the following indices may be used to compare the actual flicker levels with the planning levels. More than one index may be needed for planning levels in order to assess the impact of higher emission levels allowed for shorter periods of time such as during bursts or start-up conditions.

- The 95 % probability weekly value of P_{st} .
- The 99 % probability weekly value of P_{st} .
- The 95 % probability weekly value of P_{lt} .

NOTE It is recommended that each new P_{st} value be incorporated in a revised P_{lt} calculation using a sliding window where the oldest P_{st} measurement is replaced by the newest P_{st} value at each 10 minute interval. This recommended P_{lt} calculation procedure results in 144 P_{lt} values each day. In some cases, this may require post-processing of P_{st} outputs from a flickermeter.

The 95 % probability value should not exceed the planning level. The 99 % probability value may exceed the planning level by a factor (for example: 1 to 1,5) to be specified by the system operator or owner, depending on the system and load characteristics.

NOTE Comparing 99 % to 95 % percentiles may be useful. If the ratio between them is greater than 1,3 (1,3 is typical of a single arc furnace installation) one should investigate the reason for the discrepancy. Possible abnormal results (e.g. due to voltage dips or other transients) should then be eliminated.

4.3 Illustration of EMC concepts

The basic concepts of planning and compatibility levels are illustrated in Figure 1 and Figure 2. They are intended to emphasize the most important relationships between the basic variables.

Within an entire power system it is inevitable that some level of interference will occur on some occasions, hence there is a risk of overlapping between the distributions of disturbance levels and immunity levels (see Figure 1). Planning levels are generally equal to or lower than the compatibility level (for flicker, the transfer characteristics between different voltage levels may allow planning levels at HV and EHV to be higher while still achieving coordination with the compatibility levels that apply at LV); they are specified by the system operator or owner. Immunity test levels are specified by relevant standards or agreed upon between manufacturers and customers.

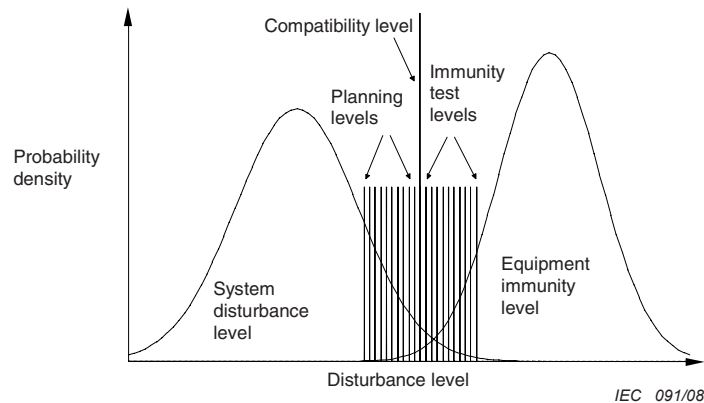


Figure 1 – Illustration of basic voltage quality concepts with time/location statistics covering the whole system

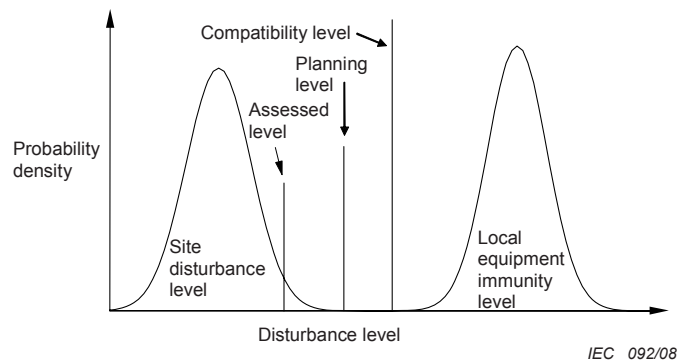


Figure 2 – Illustration of basic voltage quality concepts with time statistics relevant to one site within the whole system

As illustrated in Figure 2, the probability distributions of disturbance and immunity levels at any one site are normally narrower than those in the whole power system, so that at most locations there is little or no overlap of disturbance and immunity level distributions. Interference is therefore not generally a major concern, and equipment is anticipated to function satisfactorily. Electromagnetic compatibility is therefore more probable than Figure 1 appears to suggest.

4.4 Emission levels

The coordination approach recommended in this report relies on individual emission levels being derived from the planning levels. For this reason, the same indices are applied both when evaluating actual measurements against the emission limits and against the planning levels as described in the following text.

One or more of the following indices can be used to compare the actual emission level with the customer's emission limit. More than one index may be needed in order to assess the impact of higher emission levels allowed for short periods of time such as during bursts or start-up conditions.

- The 95 % probability weekly value of P_{sti} should not exceed the emission limit E_{Psti} .
- The 99 % probability weekly value of P_{sti} may exceed the emission limit E_{Psti} by a factor (for example: 1 to 1,5) to be specified by the system operator or owner, depending on the system and load characteristics.
- The 95 % probability weekly value of P_{lti} should not exceed the emission limit E_{Plti} .

In order to compare the level of flicker emissions from a customer's installation with the emission limits, the minimum measurement period should be one week. However, shorter measurement periods might be needed for assessing emissions under specific conditions. Such shorter periods should represent the expected operation over the longer assessment period (i.e. a week). In any case, the measurement period must be of sufficient duration to capture the highest level of flicker emissions which is expected to occur. If the flicker level is dominated by one large item of equipment, the period should be sufficient to capture at least two complete operating cycles of this equipment. If the flicker level is caused by the summation of several items of equipment, the period should be at least one operating shift.

Where significant the following factors should also be taken into account:

- effect of compensating equipment;
- capacitor banks within the installation with possible amplification of low order interharmonics that can cause flicker.

The measurement methods to be used are IEC 61000-4-15 [1] and the Class A measurement method defined in IEC 61000-4-30 [4] for flicker (for rapid voltage changes see Clause 10). The data flagged in accordance with the latter standard should be removed from the assessment. For clarity, where data is flagged the percentile used in calculating the indices defined in this report is calculated using only the valid (unflagged) data.

The emission level from a fluctuating installation is the flicker level assessed according to the subclauses of Clause 6.

5 General principles

The proposed approach for setting emission limits of fluctuating installations depends on the agreed power of the customer, the power of the flicker-generating equipment, and the system characteristics. The objective is to limit the flicker injection from the total of all fluctuating installations to levels that will not result in flicker levels that exceed the planning levels (taking into consideration the transfer coefficient, where applicable). Three stages of evaluation are defined, which may be used in sequence or independently.

5.1 Stage 1: simplified evaluation of disturbance emission

It is generally acceptable for customers to install small appliances without specific evaluation of flicker emission by the system operator or owner. Manufacturers of such appliances are generally responsible for limiting the emissions. For instance, IEC 61000-3-3 [5], IEC 61000-3-5 [6] and 61000-3-11 [7] are product family standards which define flicker emission limits for equipment connected to public LV systems. There are currently no emission standards for MV equipment for the following reasons:

- medium voltage varies between 1 kV and 35 kV;
- no reference impedance has been internationally defined for medium-voltage systems.

Even without a reference impedance, it is possible to define criteria for quasi-automatic acceptance of customers on the MV system (and even HV system). If the total fluctuating power of the installation, or the customer's agreed power, is small relative to the short-circuit power at the point of evaluation, it should not be necessary to carry out detailed evaluation of flicker emission levels.

In 8.1 and 9.1, specific criteria are developed for applying stage 1 evaluation.

5.2 Stage 2: emission limits relative to actual system characteristics

If an installation does not meet stage 1 criteria, the specific characteristics of the flicker generating equipment within the customer's installation should be evaluated together with the absorption capacity of the system. The absorption capacity of the system is derived from the

planning levels and is apportioned to individual customers according to their demand with respect to the total system supply capacity. The disturbance level transferred from upstream voltage systems should also be considered when apportioning the planning levels to individual customers.

The principle of this approach is that, if the system is fully utilised to its designed capacity and all customers are injecting up to their individual limits, the total disturbance levels will be equal to the planning levels taking into account transfer factors between different voltage levels and the summation effect of various flicker producing equipment. The procedure for apportioning the planning levels to individual customers is outlined in 8.2 and 9.2.

NOTE If the capacity of the system increases in future the emission levels of individual customers should become lower. It is important therefore, where possible, to consider future expansions of the system.

5.3 Stage 3: acceptance of higher emission levels on a conditional basis

Under some circumstances, a customer may require acceptance to emit disturbances beyond the basic limits allowed in stage 2. In such a situation, the customer and the system operator or owner may agree on special conditions that facilitate the connection of the fluctuating installation. A careful study of the actual and future system characteristics will need to be carried out in order to determine these special conditions.

NOTE Emission limits obtained from the application of the methods recommended in Clauses 8 and 9 are intended to keep flicker levels below the planning levels. The application of other methods recommended in Clause 10 is intended to limit the magnitude of rapid voltage changes.

5.4 Responsibilities

In the context of this report from the EMC point of view, the following responsibilities are defined.

- The customer is responsible for maintaining his emissions at the specified point of evaluation below the limits specified by the system operator or owner.
- The system operator or owner is responsible for the overall coordination of emission levels under normal operating conditions in accordance with regional or national requirements. For evaluation purposes the system operator or owner should, where required, provide relevant system data such as the system short-circuit power or impedance and existing flicker levels. The evaluation procedure is designed in such a way that the flicker emissions from all fluctuating installations do not cause the overall system flicker levels to exceed the planning and compatibility levels. However, given local conditions and the assumptions that are necessary in this evaluation procedure there is no guarantee that the recommended approach will always avoid exceeding the levels.
- Finally, the system operator or owner and customers should cooperate when necessary in the identification of the optimum method to reduce emissions. The design and choice of method for such reduction are the responsibility of the customer.

6 General guidelines for the assessment of emission levels

6.1 Point of evaluation

The point of evaluation (POE) is the point where the emission levels of a given customer's installation are assessed for compliance with the emission limits. This is also a point within the considered power system at which the planning levels are defined. This point could be the point of connection (POC) or the point of common coupling (PCC) of the disturbing installation or any other point specified by the system operator or owner or agreed upon. More than one point of evaluation may also be specified for a given customer's installation depending on the system structure and characteristics of the installation; in this case, the evaluation should be made considering the system characteristics and agreed powers applicable to the different points of evaluation.

NOTE 1 It should be noted, however, that for the determination of the emission limits and for the evaluation of the emission levels it is often necessary to take account of system parameters beyond the point of evaluation.

NOTE 2 Depending on the location of the point of common coupling compared to the point of connection of the fluctuating installation, the flicker level might be higher at the latter.

NOTE 3 It should be remembered that as voltage characteristics or contracted limits generally apply at the point of connection, these should be taken into account in discussions between parties.

6.2 Definition of flicker emission level

The emission level from an installation into the power system is the magnitude of flicker which the considered installation gives rise at the point of evaluation (POE). The emission level is required to be less than the emission limit assessed according to the relevant clauses in this document.

6.3 Assessment of flicker emission levels

It is recommended that the emission levels be assessed under normal operating conditions, unless otherwise specified. The assessment of flicker emission levels from fluctuating installations should consider the worst normal operating conditions including contingencies for which the system or the customer's installation is designed to operate and that may last for a specified percentage of the time, e.g. more than 5 % of time based on a statistical average. Additionally, for large installations compared to the system size (ex.: $S_{sc}/S_i < 30$; note that the ratio of 30 can be adjusted to meet particular conditions), it may also be necessary to assess emission levels for occasional operating conditions lasting less than 5 % of the time. However, higher emission limits may be allowed under such occasional conditions or during start-up or burst conditions (for example: 1 to 1,5 times, to be specified by the system operator or owner, depending on the system and installation characteristics).

Other details on the assessment of the emission levels in the power supply of industrial plants may be found in another IEC publication [8].

Measurement of flicker emission level is also possible. For situations where the flicker background level is relatively low ($P_{st} < 0,5$), two sets of measurement should be performed in the following conditions:

- with the fluctuating installation and any compensating equipment of the customer connected;
- with the fluctuating installation and any compensating equipment of the customer disconnected.

The second measured flicker value should be subtracted from the first one by using the recommended summation law (see Clause 7).

For situations where the existing P_{st} level at the POE is higher than 0,5, a more refined method should be used. Correlation between the fluctuating current and the observed voltage fluctuations may be used to determine the emission level of a particular fluctuation equipment or installation. Other methods are possible and some applications are discussed in Annex E.

In practice, the emission levels are generally predicted by making a pre-connection study from the available data concerning the installation and the system. Simplified and advanced methods for predicting flicker severity are given in this report in Annex E. Simplified methods which may be used for easily-defined fluctuations (e.g., step changes, ramp changes, etc.) are based on the " $P_{st} = 1$ curve" in Annex A and shape factor curves given in Annex E. Advanced techniques which are more suitable for arcing and randomly-fluctuating installations are based on system and end-use equipment characteristics (including compensation and mitigation equipment) and flickermeter simulation.

For post-connection assessments, direct measurements of flicker are often sufficient but might not be in full agreement with predictions made during the pre-connection assessment. If