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## Systèmes électroacoustiques pour services de secours

## Sound systems for emergency purposes



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# INTERNATIONAL ELECTROTECHNICAL COMMISSION

# SOUND SYSTEMS FOR EMERGENCY PURPOSES

## FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard 60849 has been prepared by subcommittee 100C: Audio, video and multimedia subsystems and equipment, of IEC technical committee 100: Audio video and multimedia systems and equipment.

This second edition cancels and replaces the first edition published in 1989 and constitutes a technical revision.

The text of this standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 100C/188/FDIS | 100C/217/RVD |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

Annexes A, C and D are for information only.

Annex B forms an integral part of this standard.

# SOUND SYSTEMS FOR EMERGENCY PURPOSES

## 1 Scope and object

### 1.1 Scope

This International Standard applies to sound reinforcement and distribution systems to be used to effect a rapid and orderly mobilization of occupants in an indoor or outdoor area in an emergency situation.

This standard applies to systems using tone signals and to systems with voice announcements for emergency purposes.

NOTE 1 – The use of the system for normal sound reinforcement and distribution systems purposes under non-hazardous circumstances is not excluded.

NOTE 2 – It is recommended that the system, when used for emergency purposes, should form part of a complete facility (equipment, operating procedures and training programmes) for the control of emergencies.

NOTE 3 – Sound systems for emergency purposes may be the subject of approval by relevant authorities.

### 1.2 Object

The purpose of this standard is to specify the performance requirements for sound systems which are primarily intended to broadcast information for the protection of lives within one or more specified areas in an emergency.

The standard gives the characteristics and the methods of test necessary for the specification of the system.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60027: *Letter symbols to be used in electrical technology*

IEC 60065:1985, *Safety requirements for mains operated electronic and related apparatus for household and similar use*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60079: *Electrical apparatus for explosive gas atmospheres*

IEC 60268-11:1987, *Sound system equipment – Part 11: Application of connectors for the interconnection of sound system equipment*

IEC 60268-12:1987, *Sound system equipment – Part 12: Application of connectors for broadcast and similar use*

IEC 60268-16:–, *Sound system equipment – Part 16: Objective rating of speech intelligibility by speech transmission index*[1])

IEC 60364: *Electrical installations of buildings*

IEC 60417:1973, *Graphical symbols for use on equipment*

IEC 61938:1996, *Audio, video and audiovisual systems – Interconnections and matching values – Preferred matching values of analogue signals*

## 3 Definitions

For the purpose of this standard, the following definitions apply.

**3.1**
**area of coverage**
the area, inside and/or outside a building, where the system meets the requirements laid down in this standard

NOTE – Certain parts of an area may be excluded, see 5.1

**3.2**
**loudspeaker zone**
any part of the area of coverage to which information can be given separately

**3.3**
**information**
any speech or intended audio signal

**3.4**
**audibility**
that property of sound which allows it to be heard among other sounds

NOTE – At present for objective analysis, for example when using the STI equation (see IEC 60268-16), the concept of audibility takes account of the relative loudness and frequency content of the sound in comparison with other sounds present at the same time.

**3.5**
**intelligibility**
a measure of the proportion of the content of a speech message that can be correctly understood

NOTE – Satisfactory intelligibility requires adequate audibility and adequate clarity.

**3.6**
**clarity**
the property of a sound which allows its information-bearing components to be distinguished by a listener. It is related to the freedom of the sound from distortion of all kinds.

NOTE – There are three kinds of distortion involved in the reduction of clarity of a speech signal in an electroacoustic system:

a) amplitude distortion, due to non-linearity in electronic equipment and transducers;

b) frequency distortion, due to non-uniform frequency response of transducers and selective absorption of high frequencies in acoustic transmission;

c) time domain distortion, due to reflection and reverberation in the acoustic domain.

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[1]) To be published.

**3.7**
**alarm**
a signal, or condition, warning of an emergency

**3.8**
**warning**
important notice concerning any change of status which demands attention or activity

**3.9**
**danger**
risk of harm or damage

**3.10**
**emergency**
imminent risk or serious threat to persons or property

**3.11**
**emergency zone**
a subdivision of the premises such that the occurrence of an emergency within it will be indicated separately from any other subdivision

**3.12**
**critical signal path**
all components and interconnections between every emergency broadcast initiation point and the input terminals on, or within, each loudspeaker enclosure

## 4 General system requirements

### 4.1 Principal features

A sound system for emergency purposes shall permit the broadcasting of intelligible information of measures to be taken for the protection of lives within one or more specified areas.

The following criteria shall be fulfilled:

a) When any alarm is detected, the system shall immediately disable any functions not connected with its emergency role (such as paging, music or general prerecorded announcements being broadcast to the loudspeaker zones requiring emergency broadcasts).

b) Unless damaged as a result of the emergency, the system shall be available for operation at all times (or as required by the system specification).

c) The system shall be capable of broadcasting within 10 s after primary or secondary power is applied.

d) Except during the condition described in 4.1c), the system shall be capable of broadcasting a first attention-drawing signal within 3 s of being placed in an emergency mode by the operator, or automatically on receipt of a signal from a fire or other detection system. In the latter case, the period of 3 s includes the reaction time of the detection system from the time the emergency is first detected, to commanding the alarm broadcast.

e) The system shall be able to broadcast attention-drawing signals and speech messages to one or more areas simultaneously. There shall be at least one appropriate attention-drawing signal alternating with one or more speech messages for this purpose.

f) At any time the system operator shall be able to receive, by means of a monitoring system, indications of the correct functioning or otherwise of the relevant parts of the emergency system (see also 5.2 and 5.3).

g) Failure of a single amplifier or loudspeaker circuit shall not result in total loss of coverage in the loudspeaker zone served.

NOTE 1 – The monitoring system specified in 4.1f) should indicate the failure of an amplifier or of a loudspeaker circuit.

NOTE 2 – Particularly in small buildings, it may not be necessary to install two separate loudspeaker circuits in one loudspeaker zone. A decision on this matter may be subject to local regulations.

h) An attention-drawing signal shall precede the first message for 4 s to 10 s. Successive signals and messages shall then continue until either changed in accordance with the evacuation procedure, or manually silenced. The interval between successive messages shall not exceed 30 s and attention-drawing signals shall be broadcast whenever periods of silence might otherwise exceed 10 s. Where more than one attention-drawing signal is used, such as those used for different types of emergency, each signal shall be clearly distinguishable in character.

i) All messages shall be clear, short, unambiguous and as far as practicable, preplanned. Where prerecorded messages are used they shall be held in a non-volatile form, preferably in a solid-state store, and be continuously monitored for availability. The system design shall make it inherently impossible for an external source to corrupt or derange the store or its contents.

NOTE – On grounds of reliability, it is preferable not to use storage media depending on mechanical devices.

j) The language(s) used shall be specified by the purchaser.

k) The system shall be capable of being divided into emergency loudspeaker zones if required by the evacuation procedure. Such zones need not be the same as other zones, for example emergency detection zones or non-emergency loudspeaker zones.

l) In determining loudspeaker zones, the following criteria shall apply:

1) the intelligibility of messages broadcast in one zone shall not be reduced below the requirement of 5.1 by the broadcasting of messages in other zones or from more than one source;

2) no emergency detection zone shall contain more than one emergency loudspeaker zone. For non-emergency use, a loudspeaker zone may be subdivided.

m) A secondary power source shall be available (see 5.6).

### 4.2 Responsible person

The person or body, having control of the premises shall nominate a "responsible person", identified by name or job title, who shall be responsible for ensuring that the system is properly maintained and repaired so as to continue to operate as specified.

NOTE – The responsible person should be appropriately trained.

### 4.3 Priorities

#### 4.3.1 Classification of priorities

It is necessary to decide upon an order of priority for the message distribution based upon:

a) any automatic programmed response;

b) the perceived risk to occupants, which may require manual override of the programmed response.

Events shall be given a level of priority according to their urgency. The following primary levels are recommended but there may be advantages in adding further subgroups, depending on the operational strategies of the site:

a) evacuate – potentially life-threatening situation needing immediate evacuation;

b) alert – dangerous situation nearby requiring warning of pending evacuation;

c) non-emergency – operational messages, e.g. system test, etc.

The use of these levels in descending order of priority will ensure that appropriate alarm signals and messages are provided first to the zones immediately at risk.

### 4.3.2 Operational priorities

If the voice alarm system is capable of operation in fully automatic mode, a facility shall always be available to control:

a) the type of prerecorded message being broadcast;

b) the distribution of messages to different zones;

c) real-time instructions or information to occupants via the emergency microphone (if any).

Means shall be provided for manual intervention to override any automatically programmed functions. This shall apply both to the nature of the message being broadcast and to the distribution paths of the message. Thus, manual controls shall be provided at the central control point (and also at specified remote control points) to allow:

a) starting or stopping of prerecorded alarm messages;

b) selection of appropriate prerecorded alarm messages;

c) switching on or off, of selected loudspeaker zones;

d) broadcasting of live messages via the emergency microphone (if any).

NOTE – The above controls may form part of an emergency detection control panel.

The emergency control microphone shall have the highest level of priority for access to the voice alarm system, with provision to allow it to override all other broadcasts.

### 4.4 Safety requirements

The safety requirements applying to emergency sound systems are given in IEC 60065 or other appropriate IEC safety standards.

The mechanical construction of the system shall be such that under the influence of internally generated heat, explosion or implosion, however caused, no part shall cause injury to any person.

Where any part of the system is installed in areas with hazardous or explosive atmospheres, the relevant safety requirements of IEC 60079 shall be met.

## 5 System technical requirements

### 5.1 Speech intelligibility

Unless otherwise specified, the following requirement shall be satisfied:

The speech intelligibility over all of an area of coverage (see 3.1) shall be greater than or equal to 0,7 on the common intelligibility scale (CIS). See annexes A and B for the conversion between CIS and other scales of intelligibility. The noise level (see B.5) at the time of measurement (but in the absence of the test signal) and the test signal level shall be stated with the test result.

NOTE – If the persons who are required to understand the messages are, or will be, reasonably familiar with them through regular system tests, the effective intelligibility tends to increase by approximately 0,05 on the CIS if the intelligibility is in the range 0,6 to 0,7. This may apply, for example, in an office building. However, in a sports ground, for example, most of the messages are likely to be relatively unfamiliar to the majority of persons present, and no relaxation of the above requirement should be considered.

The system specification may exclude from the area of coverage, defined areas rarely or never occupied by people.

### 5.2 Automatic status indication

A clear indication shall automatically be given at the designated control locations of:

a) system availability;

b) power supply availability;

c) any fault condition;

d) (for systems having numerous loudspeaker zones), which loudspeaker zones are selected and the mode of operation of each zone, i.e. "evacuate" or "alert" and preselection of emergency microphone. Where different alarm messages are provided, which are dependent on the evacuation requirements, indication of which message is being broadcast and into which zone, shall be displayed by a suitable method. This information shall be continuously displayed and kept up to date.

### 5.3 Automatic fault monitoring

A clear indication shall automatically be given, at specified locations, e.g. at main equipment locations, of:

a) short-circuit or disconnection or failure of the primary power source;

b) short-circuit or disconnection or failure of the standby power source;

c) short-circuit or disconnection or failure of any battery charging equipment associated with the primary or standby power sources;

d) rupture of any fuse or operation of circuit breaker, isolator or protective device that may prevent an emergency broadcast;

e) failure of microphone, including capsule voice coil, pre-amplifier and essential wiring to the rest of the system;

f) failure of critical signal paths through the amplification chain, with individual amplifiers separately identified;

g) amplifiers or critical modules missing;

h) failure of any standby amplifier;

i) failure of emergency signal generators, including emergency prerecorded message stores,

j) failure of any loudspeaker circuit, (open- and short-circuit faults);

k) short-circuit or disconnection of visual alarm devices;

l) failure of a processor to correctly execute its software program;

m) detection of any error during memory checking;

n) cessation of any scanning or interrogation process;

o) failure of the interconnecting data or voice communication links between parts of a distributed system.

In addition to individual fault identification at these locations, a common sounder shall sound for a minimum of 0,5 s every 5 s. A fault shall cause the sounder to operate in a latched mode and a visual indicator to light, either steadily, or in a flashing mode. Manual acceptance and reset switching shall be included. When accepted, the sounder shall be silenced and the indicator shall change to (or remain in) steady illumination. The occurrence of a further fault condition shall reactivate the sounder and the visual indicator. When all the faults have been cleared, the indicator shall be switched off, either automatically or by operating a reset switch.

The fault indication should be given within 100 s of the occurrence of the fault, regardless of whether the voice alarm system is being used for non-emergency purposes, such as the transmission of background music.

### 5.4 Monitoring of software controlled equipment

The correct execution of the system software by any microprocessor shall be monitored by internal self-checking procedures and by an appropriate monitoring circuit (e.g. "watch dog" circuit) complying with the following:

a) the monitoring circuit and its associated indication and signalling circuits shall not be prevented from determining and signalling a fault condition by the failure of any microprocessor or associated clock circuits;

b) the monitoring circuit shall monitor the execution of routines associated with the main program elements (i.e. it shall not be solely associated with "waiting" or other "housekeeping" routines);

c) in the event of a failure by a microprocessor to execute its software correctly, the monitoring circuit shall (in addition to initiating an audible and visual fault warning) perform as follows:

1) re-initialize the processor and attempt to restart the program at a suitable point within 10 s of the occurrence of the failure. The reinitialization procedure shall verify that the contents of memory, both program and data, are not corrupted, and

2) either:

i) record that a failure has occurred (using a system capable of recording a minimum of 99 failures and resettable only by an operation restricted to authorized servicing personnel); or

ii) automatically reset the equipment and give an audible and visual warning that an automatic reset has occurred.

### 5.5 Interface with emergency detection system

The communication link between the emergency detection system and the sound system shall be continuously monitored for faults. This is normally performed by the control equipment for the emergency detection system which gives an audible and visual indication of a fault in the link between the two systems.

The emergency detection system shall also be capable of receiving information regarding faults in the sound system and shall include a provision, usually at its control and indicating equipment, for appropriate audible and visual indication of such faults. As a minimum, the sound system shall be capable of transmitting to the emergency detection system one general "Sound system fault" for any of the fault conditions listed in 5.3 which may occur within the sound system.

The link between a fire detection and alarm system and the voice alarm system is of crucial importance in maintaining the integrity of overall operation. It may be desirable on larger systems, where distributed control equipment is used, to provide a link at each control equipment location rather than to rely on a central location. Each link shall be monitored. The voice alarm system shall be capable of continuing to broadcast alarm messages, which have been initiated by the fire detection and alarm system, even in the event of a subsequent fault in the interconnecting link between the two systems (i.e. the voice alarm system shall "latch" on receipt of a signal from the fire detection and alarm system). Interruption by higher priority broadcasts shall still be possible.

In complex buildings in which actions, such as initiation of evacuation signals, silencing of alarm signals, etc., can be implemented at remote voice alarm equipment, consideration shall be given to whether there is a need for such actions to be indicated at any central fire detection and alarm control and indicating equipment.

### 5.6 Secondary power supply

If the building is to be evacuated following primary power failure, a secondary power supply shall be provided. This shall be capable of operating the system in the emergency mode for a period equal to twice the evacuation time determined by the appropriate authority for the building. In any event, the secondary power supply shall be capable of powering the system for a minimum of 30 min.

If the building is not to be evacuated following failure of the principal power supply, the secondary power supply shall be capable of operating the system for at least 24 h, or 6 h if an emergency generator is available, and then powering the system in emergency mode for a minimum of 30 min. If a building remains unoccupied for several days, provision should be made to ensure that the voice alarm system is capable of operation in emergency mode for 30 min when the building is re-occupied.

Non-emergency functions within the system, such as background music, shall not operate from the secondary power supply if this will reduce the capacity for emergency operation.

If batteries are used as a secondary power supply they shall be of the secondary type, complete with automatic charging facilities. Where lead-acid batteries are used they shall be of the valve-regulated type unless otherwise specified, and the charging system shall incorporate charging current compensation for changes in the ambient temperature, where this is necessary to achieve the specified battery life.

Batteries shall be used in accordance with the manufacturer's recommendations in order to achieve their specified life, which shall be not less than four years. The end of life shall be taken as the time when deterioration to less than 80 % of the rated ampere-hour capacity (at the one-hour rate) has occurred.

Automatic charging shall ensure that the batteries are fully recharged to 80 % of their maximum rated capacity from the fully discharged state in a period of not more than 24 h.

Adequate ventilation and protection against corrosion and dangers resulting from gases emitted by the batteries shall be provided.

### 5.7 Climatic and environmental conditions

As all or part of the system may be installed inside or outside buildings, under various climatic and environmental conditions, and exposed to possible mechanical damage, full information on the conditions under which the system is required to operate shall be included in the system specification. For tests, refer to IEC 60068-1.

When not otherwise specified, equipment shall operate in accordance with the system specification under the following conditions:

a) Control and amplification equipment and associated battery power supplies:

- ambient temperature –5 °C to +40 °C;
- relative humidity 25 % to 90 %;
- air pressure 86 kPa to 106 kPa.

b) All other equipment:

- ambient temperature –20 °C to +55 °C;
- relative humidity 25 % to 99 %;
- air pressure 86 kPa to 106 kPa.

### 5.8 Marking and symbols for marking

Equipment shall be permanently marked with information regarding its function.

Terminals and controls shall be permanently marked with information regarding their function, characteristics and polarity.

The marking shall be such that it shall be possible to adjust the user controls and to confirm their positions accurately in conformity with the information given in the user instructions.

Marking shall preferably include letter symbols, signs, numbers and colours which are internationally comprehensible. Reference is required to IEC 60027 and IEC 60417. Marking not included in these standards shall be clearly explained in the user instructions.

### 5.9 Electrical matching values

For the electrical matching values, reference is required to IEC 61938 unless otherwise specified.

### 5.10 Connectors

Connectors shall comply with IEC 60268-11 or IEC 60268-12. Requirements for fire resistance of connectors may also be stipulated by the relevant authorities.

## 6 Installation requirements

The system shall be installed in accordance with IEC 60364 or with mandatory national or local standards.

If the emergency sound system forms part of an emergency detection and/or alarm system, the cabling shall meet the requirements of mandatory national or local, emergency and/or alarm system standards. Where the application specifically excludes detection and/or alarm, the cabling shall be of a standard suitable for the application.

Precautions shall be taken to prevent the spread of hazardous effects via the wiring routes.

When a sound system for emergency purposes is installed in combination with an emergency detection system, the installation standards for the sound system shall comply as far as is applicable with the standards required for that detection system.

When additions and/or modifications are made to a non-compliant system the existing system may require to be upgraded to meet this standard. In all cases the additions and/or modifications shall meet this standard.

## 7 System operation

### 7.1 Instructions for operation

Instructions for the operation of the system, including actions to be taken in accordance with established and well-rehearsed procedures, shall be available for rapid reference, preferably prominently and permanently displayed, at each control station.

As far as possible, graphic illustrations should be used: where text is necessary this should be clearly legible and in the preferred language(s).

Updating of the instructions for operation shall be carried out after additions to or modifications of the system, or on the basis of practical experience, or revised procedures.

Instructions shall include:

– the functional operation of the system;

– action to be taken in the event of a system failure.

A bound copy of the operational instructions shall be provided.

### 7.2 Records to be kept

Installation, log book and maintenance records shall be kept by the end user and/or maintenance company contracted by the end user in accordance with relevant international and national standards. These shall comprise as a minimum:

a) Installation

1) Details of the locations of all items of equipment.

2) "As installed" performance measurements of the system including:

– measured loudspeaker loading per circuit in emergency mode;

– settings of any adjustable items within the system, including the output level of power amplifiers;

– sound pressure levels;

– intelligibility measurements.

b) Log book

A stiff-covered log book shall be kept, in which all usage of the system and all fault occurrences should be recorded, together with all available automatically produced records, to include:

1) dates and times of usage of the system;

2) details of tests and routine checks carried out;

3) time and date of each fault occurrence;

4) details of the fault found and the circumstances of it being found (for example during routine maintenance);

5) action taken to rectify or remedy;

6) date, time and name of person in charge of the system;

7) countersignature of the responsible person, if any faults occurred or have been rectified.

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## 7.3 Maintenance

### 7.3.1 General

+ | + | + There shall be an established and documented procedure for the scheduled maintenance and retesting of the sound system and equipment as recommended by the system designer in conjunction with the equipment manufacturer and in accordance with relevant international and national standards. It is recommended that a minimum of two scheduled maintenance inspections, by a competent person, be made each year. A responsible person (see 4.2) shall be nominated to ensure that the procedure continues to be carried out correctly.

### 7.3.2 Maintenance instructions

+ | + | + A stiff-covered maintenance manual should be available giving details of all work required to maintain the installation and equipment in proper working order, consistent with specified performance criteria and any other requirements of this standard and other relevant international or national standards. This should state clearly:

a) The method of maintenance.

b) Any sequence related to maintenance.

c) Identification of parts requiring maintenance, giving reference to the location of items on drawings, together with manufacturers' reference numbers, and the addresses, telephone and facsimile numbers, of suppliers of materials and parts.

d) Original versions of equipment and materials catalogues.

e) List and location of spare parts.

f) List and location of special tools.

The maintenance instructions should also include:

g) Test certificates as required to be examined by the relevant authority.

h) A set of "as fitted" drawings.

# Annex A
(informative)

# Measurement of speech intelligibility

## A.1 Introduction

A number of methods of measuring speech intelligibility have been proposed, and several are mentioned in International and National Standards. Work on this subject is continuing, notably in ISO technical committee 43. Pending a completion of this work sufficient for the needs of this standard, this annex briefly describes several methods which are available. It gives information on the correlations between them, and their limitations, either directly or by references to relevant standards. Annex B specifies the procedures to be used for the purposes of this standard.

It is recommended to choose, if possible, the method of measurement which gives the greatest discrimination in the range of intelligibility being investigated, taking into account the standard deviation to be achieved and the gradients of the relevant curves. For example, STI has the greatest discrimination at high values of intelligibility, while 256 word phonetically-balanced word scores has the greatest discrimination at low values.

## A.2 Methods of measurement

### A.2.1 Speech transmission index

The speech transmission index (STI) is derived by calculation from measurements of the modulation transfer function (MTF), and a number of computer-based measuring systems offer this facility. However, the details of the carriers and modulation frequencies to be used, and the weights given to them in the calculations, have not been standardized up to now.

NOTE – IEC 60268-16 gives weighting values which are intended to be used, unless there is a reason to the contrary.

### A.2.2 RASTI – Rapid (or room) acoustics speech transmission index

The RASTI results from a simplified method of determining the STI, using two octave-band noise carriers and four or five modulation frequencies. The method is described in IEC 60268-16.

### A.2.3 Phonetically-balanced word scores

The phonetically-balanced (PB) word score method depends on the transmission of specially-chosen words, selected from a known population, to a panel of listeners. General information is given in ISO/TR 4870 [1].[1)]

NOTE – For all types of subjective test involving room acoustics, the test words should be embedded in carrier phrases as this produces representative reflections and reverberation during the presentation of the test word.

### A.2.4 Modified rhyme test

The modified rhyme test (MRT) method also uses a panel of listeners.

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1) The numbers in square brackets refer to the bibliography given in annex D.

### A.2.5 Articulation index

The articulation index (AI) is determined by measuring the sound pressure levels of the wanted speech signals and the ambient noise. It is calculated after making corrections for masking, frequency and amplitude distortion of the speech signal, reverberation and the presence of visual clues (see [2]).

### A.2.6 Articulation loss of consonants

The articulation loss of consonants, usually expressed as a percentage with the symbol $\%AL_{cons}$, can be determined from the results of transmission tests, using specially-chosen simple words. It is described in [3].

NOTE – $AL_{cons}$ does not use test words in carrier phrases and omits vowels. This leads to erroneous results in the presence of reverberation or peak clipping.

## A.3 Limitations of the methods

### A.3.1 General

All of the above methods can give misleading results unless the measurement procedure is carried out very carefully and in strict accordance with the relevant standard. Furthermore, it is essential that the ambient noise level at the time of measurement is very similar to that which occurs under normal operating conditions, or an appropriate correction is made to the raw data of the test results.

NOTE – General information on intelligibility testing is given in ISO/TR 4870. See also B.4.

### A.3.2 Speech transmission index (STI)

Generally, STI methods are not suitable for testing systems introducing frequency shifts or frequency multiplication or using vocoders.

With some measuring versions (see IEC 60268-16), the results are meaningful only if:

a) the system does not use any amplitude compression, expansion or non-stationary temporal processing;

b) the total harmonic distortion of a sinusoidal signal giving the same sound pressure level at the measuring position as the STI test signal does not exceed 17 % (corresponding to approximately 1 dB of compression of a pink-noise signal due to peak clipping).

### A.3.3 RASTI

The results are meaningful only if the requirements given in IEC 60268-16 are satisfied. In general, RASTI is suitable for room acoustics with direct sound transmission between speaker and listener. Only in specific conditions (i.e. substantially linear systems), can the method be applied to sound systems.

### A.3.4 Phonetically balanced word scores (256 and 1 000 population)

The limitations are given in ISO/TR 4870. It should be noted that, because the method is based on the reception of words by listeners, there are no limitations in respect of the characteristics of the sound system or those of the environment.

### A.3.5 Modified rhyme test

The limitations are similar to those given in ISO/TR 4870. It should be noted that, because the method is based on the reception of words by listeners, there are no limitations in respect of the characteristics of the sound system or those of the environment.

### A.3.6 Articulation index

The limitations are given in [2].

### A.3.7 Articulation loss of consonants

The limitations are similar to those given in ISO/TR 4870. It should be noted that, if the measurement procedure is based on the reception of words by listeners, there are no limitations in respect of the characteristics of the sound system or those of the environment. If, however, another method of measurement is used, there may be limitations in these respects.

## A.4 Correlation of the results of the various methods

In order to specify a single figure for the intelligibility requirements of a system, and to compare results of different measurements, much work has been done to determine relationships between the results of the various methods of measurement. In most cases, these relationships are now firmly established and accepted, despite being subject to a degree of uncertainty or statistical variation. For the purposes of the present standard, it has been found necessary to correlate the results of each of the above methods to a new scale, termed the "common intelligibility scale" (CIS). An essential requirement, due to the above-mentioned uncertainty, is that the gradient of each correlation curve is neither too small nor too great, as each of these conditions exaggerates the uncertainty in the correlation, see [4].

The correlations which have been determined are shown in figure B.1.

# Annex B
(normative)

# Measurement method

## B.1 Choice of method of measurement

The intelligibility shall be measured by one or more of the methods listed in annex A, for which the requirements for reliable results are satisfied. The results shall then be converted to the CIS according to the relevant curve(s) given in figure B.1.

## B.2 Status of the sound system

Usually, the whole sound system should be in operation for all measurements. If measurements are carried out with the sound system in a special status, this shall be stated with the results.

## B.3 Number of measurements and calculation of the result

The measurements shall be made at a sufficient number (n) of representative points, which shall be detailed in the system specification, in each area of coverage. The arithmetical average $I_{av}$ of the intelligibility values on the CIS, and the standard deviation $\sigma$ of the results, shall be calculated. The quantity $I_{av} - \sigma$ shall exceed the limit value specified in 5.1.

If the result is within $\pm \sigma$ of the limit, the measurements should be repeated, preferably at a larger number of points.

The mean value of intelligibility, and its 95 % confidence interval, over the whole area of coverage shall be calculated, taking into account the shape of the statistical distribution of the results of the measurements.

## B.4 Sound pressure level

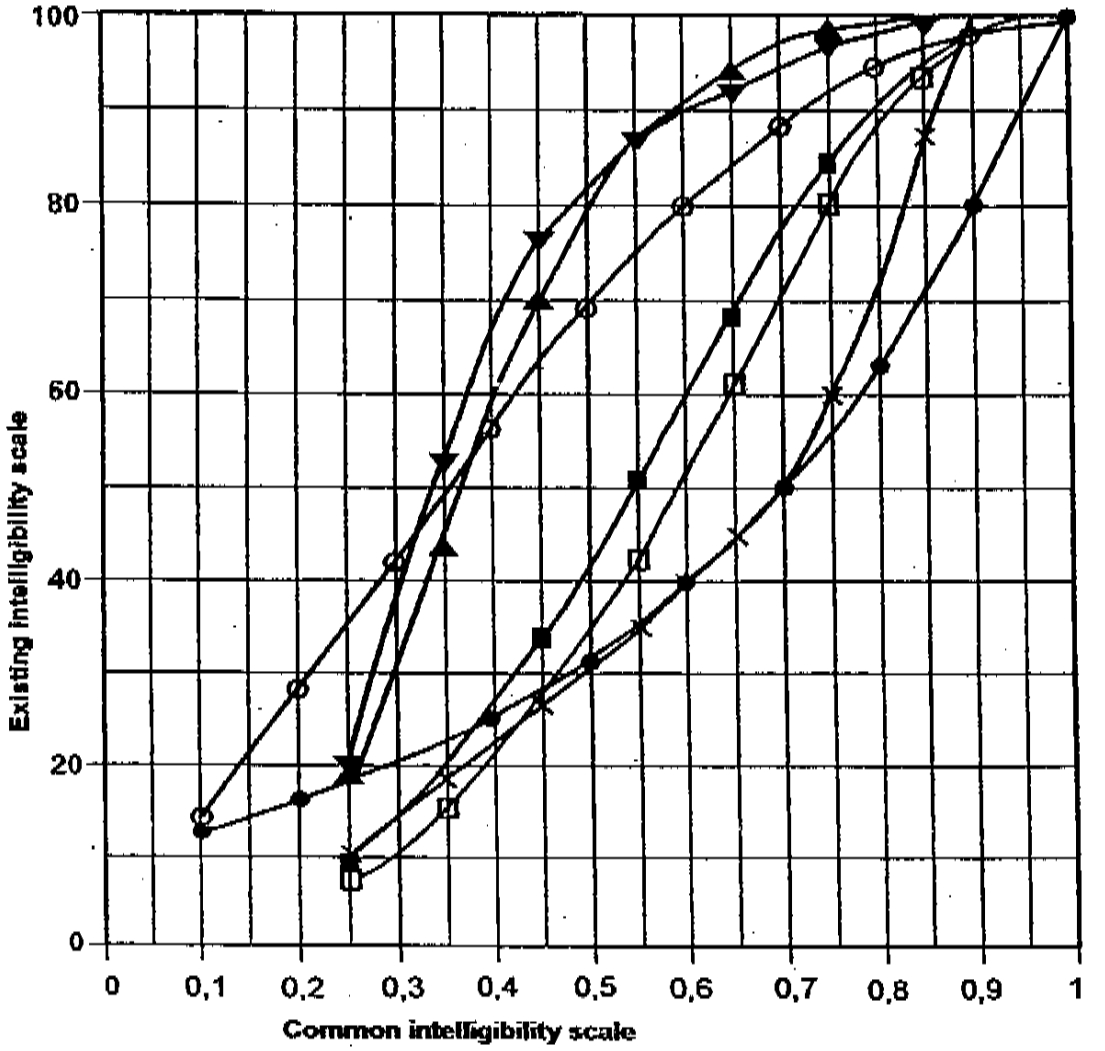
The C-weighted sound pressure level for the measurement shall be equal to the $L_{Ceq,}$ measured for not less than 16 s at the measuring point when the system is in normal operation as an emergency sound system.

NOTE 1 – If the RASTI method is used, A-weighting may be used for both measurements instead of C-weighting.

NOTE 2 – Linear response may be used instead of C-weighting, only if the results are reliable.

## B.5 Ambient noise level

The A-weighted ambient noise level (the residual noise level) in the absence of the test signal (the residual noise) shall be measured, in decibels re 20 µPa, over a period sufficient to reasonably represent the residual noise at the time of the intelligibility test. Measurements of the equivalent A-weighted sound pressure level shall be made at representative points over the area of coverage. The positions, duration and time of measurements shall be reported, together with a note of any unusual circumstances which might affect the validity of the measurements.




NOTE – The marked points on the curves indicate the correlation values which were derived from published sources. See annex D, reference [5].

**Figure B.1 – Conversion of existing intelligibility scales to the common intelligibility scale**

# Annex C
(informative)

# Attention drawing audible signals

## C.1 Introduction

Sound signals may be used to warn of an imminent announcement. To be effective they shall be sufficiently audible. This annex recommends appropriate sound levels and measurement procedures.

## C.2 Audibility of attention drawing signals

Attention drawing signals over the whole an area of coverage (see 3.1) should meet the following criteria:

a) absolute minimum sound level: 65 dBA;

b) absolute minimum sound level in sleeping mode: 75 dBA;

c) alarm sound audibility over background noise (signal-to-noise): 6 dBA to 20 dBA (or 9 dB to 23 dB in relevant alarm frequency bands);

d) maximum alarm sound level (to limit exposure): 120 dBA.

## C.3 Measurements of attention drawing audible signals

These measurements are designed to verify the perceptibility of audible alarm signals and should be used to assess the audibility of such signals over background noise.

### C.3.1 Alarm sound levels

Where more than one type of alarm signal is used, measurements shall be repeated for each type. Measurements shall be made, with the alarm signal sounding, at representative points throughout the area to be covered.

For continuous single-frequency alarms, the $L_{Aeq}$ and $L_{max}$ octave-band sound pressure levels shall be recorded. For two-frequency, variable-frequency or intermittent alarms, the $L_{AMax}$ and $L_{max}$ octave band sound pressure levels shall be recorded.

For a two-frequency, variable-frequency or intermittent alarm system, the measurements shall be made over a period of at least five repetitions of the sequence. For a single continuous tone, the measurements shall be made over a minimum period of 10 s.

NOTE – Either $L_{Aeq}/L_{eq}$ octave band or $L_{AMax}/L_{max}$ may be used. The octave bands concerned are those corresponding to the range of frequencies of the alarm signal.

### C.3.2 Background noise levels

Representative background noise levels shall be measured at identical test points to those in C.3.1. These measurements shall be taken during periods of normal personnel activity and mechanical equipment operation.

Measurements shall verify the overall $L_{Aeq}$ and octave band $L_{eq}$ sound pressure levels. The duration of measurement shall be sufficient to obtain constant $L_{Aeq}$ levels to an accuracy of 0,5 dBA.

### C.3.3 Recording of results

The location, type of measurement, time at which taken, duration and measured levels shall be recorded for all alarm and background noise level tests.

## C.4 Assessment

Assessment of the alarms shall be made in accordance with the flowchart in figure C.1.

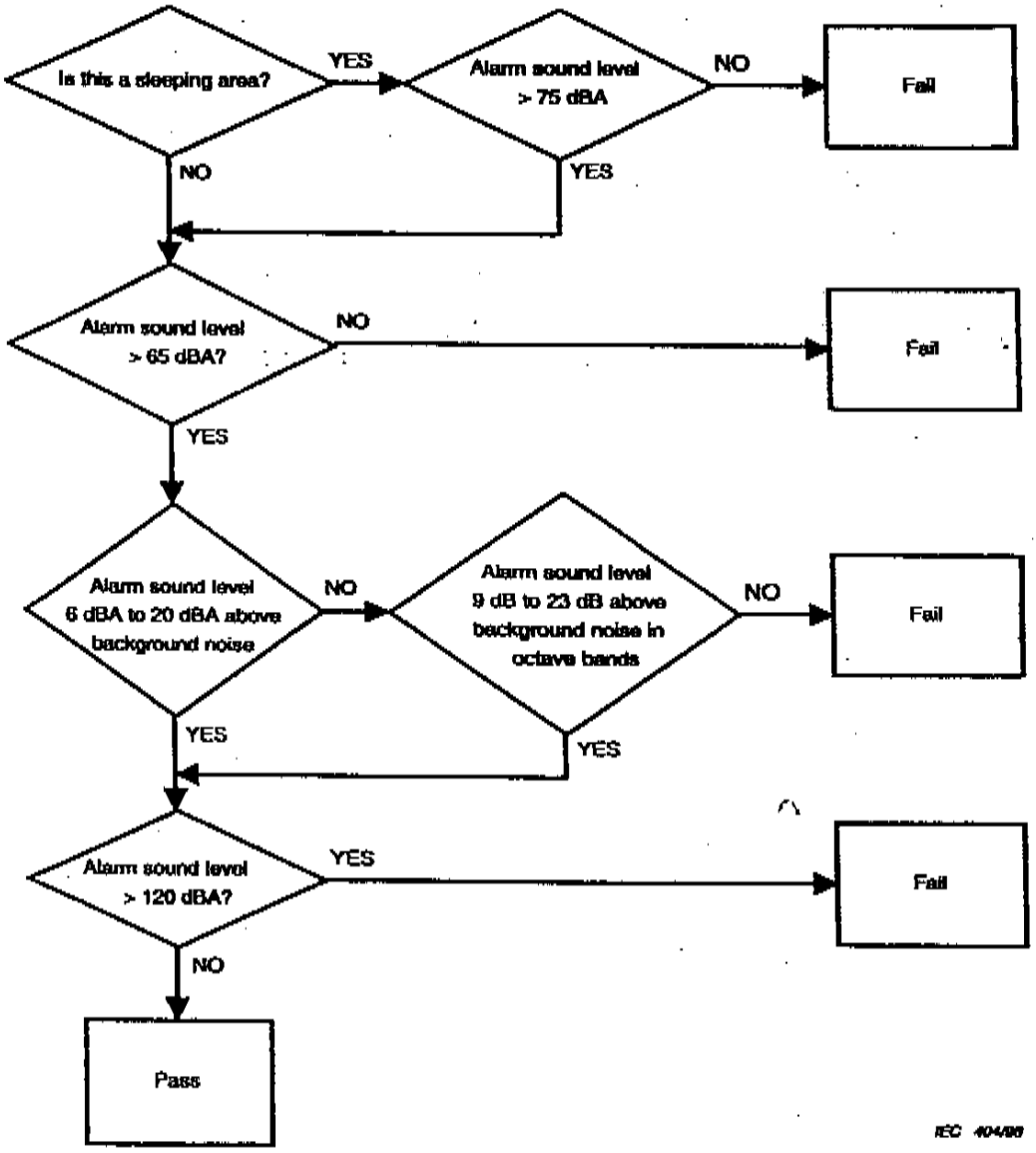



**Figure C.1 – Flowchart for the assessment of alarm signals**

# Annex D
(informative)

## Bibliography

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[2] American National Standard ANSI S 3.5 (1969), American National Standards Institute, New York, USA

[3] Peutz, V.M.A., "Articulation loss of consonants as a criterion for speech transmission in a room", *J. Aud. Eng. Soc.* **19**, 12 (Dec. 1971)

[4] Knight, R.D., "The Common Intelligibility Scale", *Proc. Inst.S.C.E.*, May 1994 pp. 60-67 (obtainable from the Library of the Institute of Sound and Communication Engineers, PO Box 258, St. Albans, Hertford AL1 1QZ, England)

[5] Barnett, P.W. and Knight, R.D., "Some practical limitations of STI method", *Proc. Inst. Acoust.* 14.5 (1992), St. Albans, England