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Specification No. 15

United Kingdom Civil Aviation Authority

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This Specification is only directly applicable to those aircraft where Issue 1 of the Specification dated 27 January 1989 was included as a part of the Certification Basis. For all other aircraft, it serves the purpose of guidance material only. It is recommended that the reader consult a CAA Surveyor for advice as to the suitability of application to a specific aircraft or piece of equipment. Contact numbers for CAA Surveyor staff are given in CAP 562, Leaflet A-10.

Public Address Systems

1 Applicability

This Specification applies to public address systems installed in aeroplanes for the purpose of broadcasting safety-related announcements to the occupants. The Specification prescribes minimum performance standards and installation requirements for such systems submitted for approval in accordance with the provisions of the Air Navigation Order.

2 Systems Independence

The public address system shall be capable of operation independent of any flight crew to flight attendants' interphone system except for handsets, headsets, microphones, selector switches and signalling devices, which may be common to both systems.

3 Equipment and Installation

3.1 Environmental Qualification

3.1.1 The equipment shall be shown to be suitable for use in the environmental conditions associated with their installed positions in the aeroplane when operated within the range of environmental conditions expected in service.

NOTE: Acceptable equipment environmental standards include EUROCAE ED14B/RTCA DO160B[1], dated July 1984 and the British Standard 3G100[1] series.

3.1.2 The system components shall be capable of normal operation after an Emergency Alighting in which the inertia forces stated below occur. All combinations of these inertia forces shall be considered excepting those exceeding 9g. The direction of forces shall be taken as relative to the aeroplane.

4.5g downwards to 2.0g upwards

9.0g forwards to 1.5g rearwards

Zero to 1.5g sideways

1. Reference documents are listed in Appendix 3.

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3.2 Equipment Performance

The performance characteristics of individual system components shall be such that, when used in combination, the overall performance of the Public Address System will meet the performance objectives of paragraph 5.

NOTE: Information for audio equipment characteristics is available in RTCA document DO-170[1], dated January 1980 and the equivalent EUROCAE Document ED18[1].

3.3 Installation Requirements

The public address installation shall comply with the relevant installation requirements of BCAR Section D, J, K and R, BCAR-23 or JAR 25, as applicable to the aeroplane concerned.

4 Accessibility for Use

4.1 Accessibility to Flight Crew

The public address system shall be accessible for immediate use from each of two flight crew member stations in the pilot compartment.

NOTE: Broadcasts initiated by the flight crew will need to have priority automatically over those initiated by flight attendants.

4.2 Accessibility to Flight Attendants

4.2.1 At least one public address system microphone intended for flight attendant use shall be positioned adjacent to a flight attendant seat that is located near each required floor level emergency exit in the passenger compartment and be readily accessible to the seated flight attendant.

NOTES:
1) Where practicable, the public address system microphone should be positioned also so as to be readily accessible to the f light attendant whilst standing without obstructing an emergency evacuation route.
2) It is not intended that more than one microphone should be installed where flight attendants' seats are co-located provided that the microphone is readily accessible at each designated flight attendant seat.

4.2.2 The system shall be capable of operation within three seconds from the time a microphone is removed from its stowage by a flight attendant at those stations in the passenger compartment from which its use is accessible.

4.3 Controls

4.3.1 Controls which are not normally adjusted in flight shall not be readily accessible to the flight crew or to the flight attendants.

4.3.2 Where the output level of the system is controlled automatically as a function of flight phase, means to select manually the output to a high level shall be provided at, at least, one flight attendant's station. This requirement need not be met where failure of the automatic level control to select a high level, when required, is shown to be REMOTE. (See definition in ACJ No.1 to JAR 25.1309).

NOTE: Where the level is raised automatically to compensate for noise from engines, it will be necessary to maintain a high level setting in the event of an engine failure in order to compensate for the noise from the remaining serviceable engines.

1. Reference documents are listed in Appendix 3.

5 System Performance

The overall performance of the equipment and its installation shall be such that messages may be broadcast so as to be audible and intelligible at all passenger seats, lavatories, and flight attendant seats and work stations.

NOTES:

1) Where necessary to prevent acoustic instability during a broadcast, it is permissible to reduce automatically, the output level of loudspeakers near a flight attendant's station from which the broadcast is being made.

2) When installed, the passenger entertainment system will need to be muted when the public address system is being used for safety related broadcasts, except where the passenger entertainment system is being used to augment the public address system. Where headphones are issued to passengers for use with the entertainment system, messages broadcast over the public address system should be broadcast also through these headphones.

3) The performance of the system will need to be re-assessed following any significant modification to the cabin furnishings or layout.

4) Appendix 1 provides an overview of an acceptable means of performance assessment based on measurement of Articulation Index. Similarly, Appendix 2 deals with the measurement of Speech Transmission Index.

6 Electrical Supply

The public address system shall be supplied from an electrical power source which is independent of engine operation, auxiliary power unit operation and the forward motion of the aeroplane.

NOTE: The electrical power supply arrangement will need to ensure that the public address system is readily available to the flight crew for use in conjunction with other emergency services e.g. those required to assist the evacuation of the aeroplane.

7 Maintenance Provisions

The certification tests shall include measurements at defined locations within the aeroplane which establish performance reference levels suitable for subsequent maintenance checks of the system.

NOTE: An acceptable means of compliance would be to specify minimum broadcast sound levels for defined locations within the aeroplane.

8 Cockpit Voice Recorder

Attention is directed to CAA Specification No 11, as amended, "Cockpit Voice Recorder Systems" which requires the broadcasts on the public address system to be recorded if a free channel is available on the Cockpit Voice Recorder.

Acknowledgment

The CAA wishes to acknowledge its indebtedness to the Institute of Sound and Vibration Research at the University of Southampton, to British Airways, and to Bruel & Kjaer (UK) Ltd for their assistance and advice given during the preparation of this specification.

Appendix 1

Demonstration of System Performance by Measurement of Articulation Index

A1.1 Articulation Index (AI)

A1.1.1 The articulation index value is derived from acoustical measurements of broadcast and noise levels at the listening position. Where rigorous analysis is required, the sound spectrum can be divided into 20 equal bands between 200 and 6100 Hz. Broadcast sound peak levels and ambient noise levels are measured separately in decibels in each band either directly, or from a recording. The broadcast sound to noise ratio in each band is calculated and then weighted according to the relative contribution those frequencies could make to intelligibility. A single Articulation Index value is obtained by summing all of the weighted contributions. The Articulation Index value determined by this method will be in the range 0 to 1.0. An Articulation Index value of 1.0 means that all the speech, loudest and softest sounds, lie above the noise level and 100% intelligibility is to be expected. As shown in Figure A1.1, the Articulation Index values can be interpreted as the percentage of material correctly understood on the basis of previous experimental results. For instance, a value of AI = 0.4 can be seen to correspond to:

93% of sentences (first presentation to the listener) understood correctly

or

62% of isolated, phonetically balanced words understood correctly.

A1.1.2 A less rigorous analysis, will normally suffice for an aeroplane PA system with measurements made using octave bandwidths with nominal centre frequencies at 500, 1000, 2000 and 4000 Hz (the bands are 354-709Hz, 707-1414Hz, 1411-2822 Hz and 2815-5630 Hz).

A1.1.3 For speech/noise (S/N) values obtained from four octave bandwidths, a close approximation of the articulation index can be derived as follows:-

Articulation Index = 0.0048 (S/N)500 +
0.0074 (S/N)1000 +
0.0109 (S/N)2000 +
0.0078 (S/N)4000

Where $(S/N)_{1000}$ is the difference in dB between the speech peaks and the noise in the octave band centred at 1000 Hz etc. Values of S/N less than 0 are assigned the value 0, and values exceeding 30 are assigned the value 30 since values outside this range cannot contribute to overall intelligibility.

A1.2 Broadcast Coverage Assessment

A1.2.1 A subjective, but effective, check of broadcast coverage may be performed under quiet conditions by injecting broad-band random noise into the public address amplifier. A listener is then able to detect areas of high and low broadcast sound levels whilst moving about the aeroplane~ cabin and crew work stations.

A1.2.2 Subsequent measurements of broadcast sound levels for derivation of articulation index may then concentrate on the expected worst locations.

A1.3 **Performance Levels**

A1.3.1 Figure A1.2 specifies the articulation index values which should be achieved under various flight conditions.

A1.3.2 Further details of the test equipment procedures and which may be used to derive articulation index are given in the reference documents listed in Appendix 3.

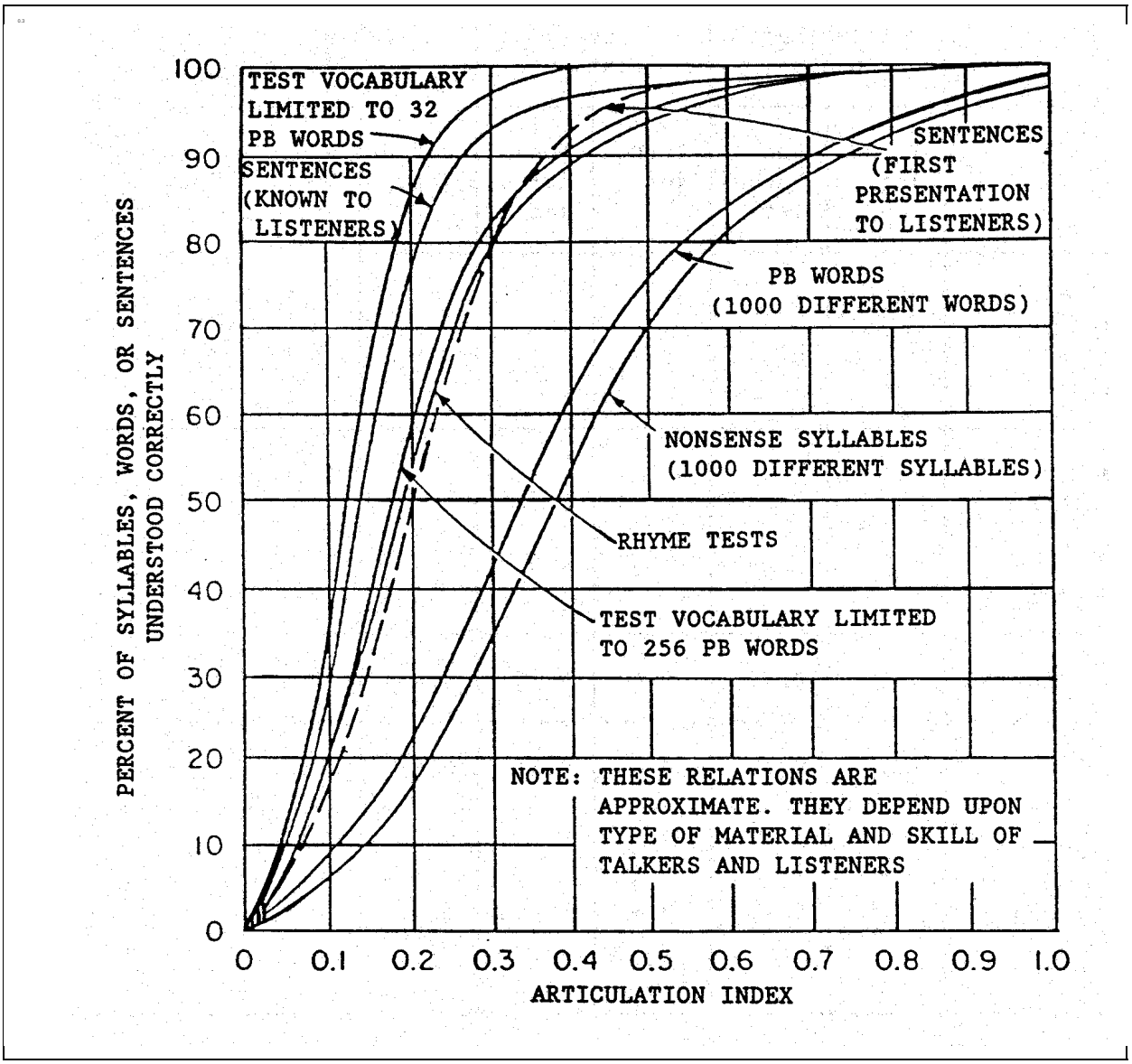

Figure A1.1 Relationship Between Articulation Index and Speech Intelligibility

Operational Phase	Location In Aeroplane							
	Flight Attendants Seats		Flight Attendants Work Stations		Passenger Cabin		Lavatories	
	Turbo-Jet	Non Turbo-Jet	Turbo-Jet	Non Turbo-Jet	Turbo-Jet	Non Turbo-Jet	Turbo-Jet	Non Turbo-Jet
Parked-Engines and APU Stopped	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Parked-Engines stopped and APU Running	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4
Taxying	0.4	0.35	0.4	0.35	0.4	0.35	0.4	0.35
Cruise	0.4	0.35	0.4	0.35	0.4	0.35	0.4	0.35
Final Approach Gear Down Flaps Extended	0.4	0.35	0.4	0.35	0.4	0.35	0.4	0.35

Figure A1.2 Minimum Acceptable Values of Articulation Index

Appendix 2

Demonstration of System Performance by Measurement of Speech Transmission Index

A2.1 Speech Transmission Index

A2.1.1 Speech transmission Index (STI) is a physical quantity which represents the transmission quality of speech with respect to intelligibility.

A2.1.2 The determination of the transmission quality of speech with respect to intelligibility is based on the reduction of the modulation index of a test signal, simulating the acoustical characteristics of a real talker, as it passes from its source to the reception point. The test signal consists of a noise carrier with a speech-shaped frequency spectrum and a sinusoidal intensity modulation. The reduction in modulation index is interpreted in terms of an apparent signal-to-noise ratio irrespective of the cause of the reduction which can be reverberation, echoes or interfering noise. The STI method uses a total of 14 modulation frequencies in 7 octave bands giving 98 data points.

A2.2 Rapid Speech Transmission Index

A2.2.1 The Rapid Speech Transmission Index (RASTI) is a condensed version of the STI method using a subset of the original 98 data points. The analysis is restricted to 4 or 5 modulation frequencies and only two octave bands, with centre frequencies of 500 Hz and 2 kHz, giving 9 data points.

A2.2.2 The mean of the nine values obtained is normalised in the range 0 to 1.0. Figure A2.1 shows the general relationship between the quality of speech transmission with respect to intelligibility and the RASTI value.

A2.2.3 The RASTI method is acceptable for the evaluation of an aeroplane PA system.

2.3 Performance Levels

A2.3.1 Figure A2.2 specifies the RASTI values which should be achieved under various flight conditions.

A2.3.2 Broadcast coverage may be assessed as detailed in paragraph A1.2 of Appendix 1.

A2.3.3 Further details of the test equipment and procedures which may be used to derive RASTI values are given in document reference A3.1 f) of Appendix 3.

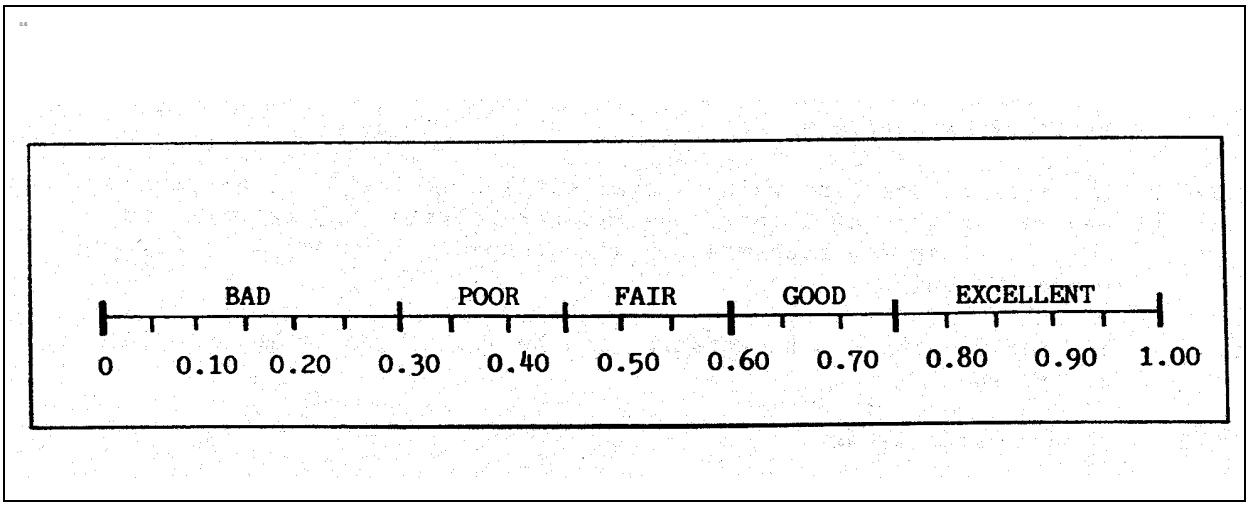

Figure A2.1 General Relationship Between Quality of Speech Transmission with Respect to Intelligibility and the RASTI Value

	Location In Aeroplane							
Operational Phase	**Flight Attendants Seats**		**Flight Attendants Work Stations**		**Passenger Cabin**		**Lavatories**	
	Turbo-Jet	**Non Turbo-Jet**	**Turbo-Jet**	**Non Turbo-Jet**	**Turbo-Jet**	**Non Turbo-Jet**	**Turbo-Jet**	**Non Turbo-Jet**
Parked-Engines and APU Stopped	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Parked-Engines Stopped and APU Running	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6
Taxying	0.6	0.55	0.6	0.55	0.6	0.55	0.6	0.5
Cruise	0.6	0.5	0.6	0.5	0.6	0.5	0.6	0.5
Final Approach Gear Down Flaps Extended	0.6	0.55	0.6	0.55	0.6	0.55	0.6	0.5

Figure A2.2 Minimum Acceptable RASTI Values

Appendix 3

Reference Documents

A3.1 International Standards and British Standards

ISO and British Standards are obtainable from the British Standards Institution, 2 Park Street, London W1Y 4AA.

a) BS G229:1982 (International Standard ISO 7137 and RTCA/EUROCAE document DO16OA/ED 14A) - 'Environmental Conditions and Test Procedures for Airborne Equipment'. See also A3.2 b).

b) BS 3G100 Series - 'General Requirements for Equipment for use in Aircraft'.

c) BS 2475:1964 (IEG Publication 225 (1966)) - 'Octave, Half Octave and Third Octave Band Filters intended for the Analysis of Sounds and Vibrations'.

d) BS 5969:1981 (IEC Publication 651) - 'Sound Level Meters'.

e) ISO 5129:1981 - 'Acoustics - Measurement of Noise inside Aircraft".

f) IEG Report 268-16 'The Objective Rating of Speech Intelligibility in auditoria by the 'RASTI' method'. (1988)

A3.2 RTCA/EUROCAE Documents

RTCA documents are obtainable from RTCA, One McPherson Square, 1425K Street, N.W., Suite 500, Washington 20005, USA.

EUROCAE documents are obtainable from EUROCAE, 11 Rue Hamelin, 75783, Paris, CEDEX 16, France.

a) RTCA D0l70 (1980) - 'Audio Systems Characteristics and Minimum Performance Standards Aircraft Microphones (except carbon) Aircraft Headsets and Speakers, Aircraft Audio Selector Panels and Amplifiers'.

EUROCAE ED18 is an equivalent document.

b) RTCA/EUROCAE DO160B/ED14B - 'Environmental Conditions and Test Procedures for Airborne Equipment'. See also A3.1 a).

3.3 Other Documents

a) ANSI S3.5 - 1969. American National Standard Methods for Calculation of Articulation Index, obtainable from the American National Standards Institute, 1430 Broadway, New York, NY 10018, USA.

b) Steeneken, H.J.M. and Houtgast T. A physical method for measuring speech transmission quality. J Acoust.Soc. Amer.67, (1980) 318.