



**Civil Aviation Requirement
For
Aeronautical Telecommunications**

CAR – 10

(Volume I: Radio Navigation Aids)

First Edition – January, 2009

Civil Aviation Authority of Nepal

AMENDMENTS

Amendments and Corrigenda to these "CIVIL AVIATION REQUIREMENTS FOR AERONAUTICAL TELECOMMUNICATIONS –RADIO NAVIGATION AIDS" Nepal are regularly issued by Director General of CAA, Nepal. The space provided below shall be used to keep a record of such amendments.

Record of Amendments and Corrigenda

AMENDMENT			
No.	DATE APPLICABLE	DATE ENTERED	ENTERED BY

CORRIGENDA			
No.	DATE APPLICABLE	DATE ENTERED	ENTERED BY

TERMS OF REFERENCE

1. The following words, when used in the CAR, denote

- 1.1 "shall" means a procedure is mandatory.
- 1.2 "should" means a procedure is recommended
- 1.3 "may" means a procedure is optional
- 1.4 "approved" means obtain formal approval from the Director General, CAAN
- 1.5 "will" means futurity, not a requirement for the application of a procedure.
- 1.6 "Nepal" means Federal Democratic Republic of Nepal

2. Amendment Procedure

- 2.1 The change number and effective date are printed on each revised (replacement) or additional page.

FOREWORD

Article 28 (Air navigation facilities and standard systems) of the Convention on International Civil Aviation requires each contracting State to provide, in its territory, airports, radio services, meteorological services and other air navigation services to facilitate international air navigation, in accordance with the standards and recommended practices established from time to time, pursuant to this Convention. Under Article 37 (Adoption of international Standards and Procedures) of the Convention, each contracting State undertakes to collaborate in securing the highest practicable degree of uniformity in regulations, standards, procedures, and organization in relation to aircraft, personnel, airways and auxiliary services in all matters in which such uniformity will facilitate and improve air navigation.

In above respect, ICAO Annex 10 provides the Standards pertaining to the Aeronautical Telecommunications which are required to be adopted by the Contracting State.

This Volume of Civil Aviation Requirement for Aeronautical Telecommunications, "CAR 10-Volume I" has been enacted by Civil Aviation Authority of Nepal **Pursuant to Clause -5 Sub-Clause "Pha" and Clause- 35 of Civil Aviation Authority of Nepal Act, 2053 (1996) and Rule-82, Schedule-3 of Civil Aviation Regulation, 2058 (2002)**, in accordance with the Standard and Recommended Practices of Annex -10 "Aeronautical Telecommunications-Vol. I (Radio Navigational Aids)" to the Convention of International Civil Aviation in order to ensure uniformity and safety while installing and maintaining Radio Navigational Aids in Nepal.

All earlier national legislations still stand valid as a part of Civil Aviation requirements for practical purposes.

.....
(Director General)
Civil Aviation authority of Nepal

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CHAPTER 1. DEFINITIONS

When the following terms are used in this requirement, they have the following meanings:

Altitude. The vertical distance of a level, a point or an object considered as a point, measured from mean sea level (MSL).

Effective acceptance bandwidth. The range of frequencies with respect to the assigned frequency for which reception is assured when all receiver tolerances have been taken into account.

Effective adjacent channel rejection. The rejection that is obtained at the appropriate adjacent channel frequency when all relevant receiver tolerances have been taken into account.

Elevation. The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.

Fan marker beacon. A type of radio beacon, the emissions of which radiate in a vertical fan-shaped pattern.

Height. The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.

Human Factors principles. Principles which apply to aeronautical design, certification, training, operations and maintenance and which seek safe interface between the human and other system components by proper consideration to human performance.

Mean power (of a radio transmitter). The average power supplied to the antenna transmission line by a transmitter during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation taken under normal operating conditions.

Note.— A time of 1/10 second during which the mean power is greatest will be selected normally.

Pressure-altitude. An atmospheric pressure expressed in terms of altitude which corresponds to that pressure in the Standard Atmosphere.

Protected service volume. A part of the facility coverage where the facility provides a particular service in accordance with relevant SARPs and within which the facility is afforded frequency protection.

Touchdown. The point where the nominal glide path intercepts the runway.

Note.— “Touchdown” as defined above is only a datum and is not necessarily the actual point at which the aircraft will touch the runway.

Z marker beacon. A type of radio beacon, the emissions of which radiate in a vertical cone-shaped pattern.

CHAPTER 2: General Provisions for radio navigational aids

2.1 Aids to approach, landing and departure

2.1.1 The standard non-visual aids to non-precision approach and landing in Nepal shall be is the VHF Omni Directional Radio Range (VOR).

Note 1: The term non-visual aid is to be applied when referring to the foregoing systems specified in Chapter-3.

Note 2: The locations at which non-visual aids are required are normally established on the basis of the regional air navigation agreements.

Note 3: Since visual reference is essential for the final stages of approach and landing, the installation of non-visual aids does not obviate the need for visual aids to approach and landing in conditions of low visibility.

2.1.1.1 A non-visual aid can be replaced with an alternative non-visual aid on the basis of regional air navigation agreement.

2.1.1.2 The agreements indicated in Para 2.1.1.1 shall provide at least a five-year notice.

2.1.1.3 When a non-visual aid is provided, its performance shall correspond at least to the category of non-precision approach runway to be served.

2.1.2 Differences in non-visual aids in any respect of provisions in Para 3 of this CAR shall be published in an Aeronautical Information Publication (AIP).

2.1.3 Reserved for Future Use

2.1.4 Reserved for Future Use

2.1.4.1 Reserved for Future Use

2.1.4.2 Based upon operational requirement, a SRE conforming to the Standards contained in Para 3.2.4 and equipment for two-way communication with aircraft should be installed and operated for:

- a) the assistance of air traffic control in handling aircraft intending to use a non-visual aid;
- b) surveillance radar approaches and departures.

2.1.5 A non-visual aid should be supplemented by a source of guidance information which, when used in conjunction with appropriate procedures, will provide effective guidance to the desired reference path.

Note: The following sources of guidance have been established for purposes mentioned above.

- a) a suitably located VHF omni directional radio range (VOR) conforming to the specifications in Para 3.2 or equivalent;
- b) a locator or locators conforming with the specifications in Para 3.4 or a suitably located non-directional radio beacon (NDB);
- c) a suitably located UHF distance measuring equipment (DME) conforming to the specifications in Para 3.5 and providing continuous distance information during the approach and missed approach phase of flight.

2.2 Short-distance aids

2.2.1 In localities and along routes where conditions are traffic density and low visibility necessitates a ground based short-distance radio aid to navigation for the efficient exercise of air traffic control, or where such short-distance aid is required for the safe and efficient conduct of aircraft operation, the standard aid shall be the VHF Omni direction radio range (VOR) of the Continuous Wave (CW) phase comparison type conforming to the standard contained in Para 3.3.

2.2.1.1 VOR aerodrome check points shall be provided for the pre-flight checking of VOR airborne equipment at aerodromes regularly used by air traffic.

2.2.2 At localities where for operational reasons, or because of air traffic control reason such an air traffic density or proximity of routes, there is a need for a more precise navigation service than that provided by VOR, distance measuring equipment (DME) (Conforming to the provisions in Para 3.5) shall be installed and maintained in operation as a compliment to VOR.

2.2.2.1 DME/N equipment first installed after 1st Jan, 1989 shall also conform to the provisions of Para 3.5.

2.2.3 The installation sites for these short-distance aids shall be in accordance with the characteristics as specified in [Appendix –I](#).

2.3 Radio beacons

2.3.1 Non-directional radio beacons (NDB) An NDB conforming to the provisions in Para 3.4 shall be installed and maintained in operation at a locality where an NDB, in conjunction with direction-finding equipment in the aircraft, fulfils the operational requirement for a radio aid to navigation.

2.3.2 Reserved for Future Use

2.4 [**Reserved for Future Use**]

2.5 [**Reserved for Future Use**]

2.6 Distance measuring aids

2.6.1 If a distance measuring facility is installed and maintained in operation for any radio navigational purpose additional to that specified in Para 2.2.2 it shall conform to the specification in Para 3.5.

2.7 Ground and flight testing

2.7.1 Radio navigation aids of the types covered by the specifications in Chapter 3 and available for use by aircraft engaged in international air navigation shall be subject of periodic ground and flight tests as specified in [Appendix- II](#).

2.7.2. The next due date for such ground and flight testing shall be displayed prominently at the radio navigation aid facility.

2.7.3 The radio navigation aid facility shall be withdrawn from service if the testing requirements mentioned in Para 2.7.1 above have not been met, unless specifically authorized by the Director General.

Note: NDB need not be subjected to periodic flight inspection as specified in Appendix–I except where operationally required

2.8 Provision of information on the operational status of radio navigation aids

2.8.1 Aerodrome control towers and units providing approach control service shall be provided without delay with information on the operational status of radio navigation aids essential for approach, landing and take-off at the aerodrome(s) with which they are concerned.

2.9 Secondary power supply for radio navigation aids and communication systems

2.9.1 Radio navigation aids and ground elements of communication systems of the types specified in [Appendix-III](#) of this CAR shall be provided with suitable power supplies and means to ensure continuity of service appropriate to the needs of the service provided.

2.10 Human Factors considerations

2.10.1 Human Factors principles should be observed in the design and certification of radio navigation aids.

2.11 Maintenance of radio navigation aids

2.11.1 A radio navigation aid facility shall not be put to service unless-

- a. it conforms to configuration to which it was initially certified; Any deviation requires approval of the Director General prior to return to service.
- b. it has been maintained as per approved maintenance schedules in accordance with Requirement 2.11.2;
- c. it has been certified as serviceable by qualified personnel in accordance with Requirement 2.11.3;

2.11.2 Maintenance Schedule

2.11.2.1 The radio navigation aids referred to in this CAR shall be subject to periodic maintenance that includes testing, functional checks for ensuring serviceability as per approved maintenance schedules

2.11.2.2 Approved maintenance schedules in Requirement 2.11.2.1 above shall be prepared in accordance with the instructions or guidelines provided by the manufacturer of the equipment in its Maintenance Manual and submitted for approval by the Director General.

2.11.2.3 The radio navigation aid facility shall clearly display the approved maintenance schedule in practice.

2.11.3 Maintenance Personnel

2.11.3.1 Only licensed personnel who have undergone an approved maintenance training on the specific equipment from the manufacturer shall carry out maintenance of the radio navigation facility.

2.11.3.2 Trainee maintenance personnel undergoing on-the-job training at the radio navigation aid facility may perform maintenance only under the supervision of other licensed personnel.

2.11.3.3 The maintenance personnel shall undergo refresher training on maintenance of the equipment at intervals specified by the Director General.

2.11.4 Maintenance Records

2.11.4.1 Whenever the radio navigation facility is subject to maintenance, a certification including the following shall be made in the maintenance records of the facility by appropriately licensed personnel:

- a) basic details of the maintenance carried out including reference of the section of the Maintenance Manual used;
- b) date such maintenance was completed;
- c) the identity of the person or persons certifying the maintenance including his(her) license number;

2.11.4.2 All records of daily and periodical maintenance (whether preventive or corrective) shall be preserved at the radio navigation facility for a period of not less than two years, or longer if required by the Director General.

2.11.4.3 The radio navigation facility and maintenance records thereof shall be promptly made available for inspection to the CNS Inspector following his request.

2.11.5 *Test Equipment used in Maintenance*

2.11.5.1 Test equipment deployed for maintenance at the radio navigation aid facility shall be duly calibrated at intervals specified by the test equipment manufacturer.

2.11.5.2 Valid certificates of calibration of the test equipment as mentioned in Requirement **2.11.5.1** above shall be made available at the radio navigation aid facility.

CHAPTER 3: Specifications for radio navigation aids

3.1 Reserved for Future Use

3.2 Reserved for Future Use

3.3 Specification for VHF omni directional radio range (VOR)

3.3.1 General

3.3.1.1 The VOR shall be constructed and adjusted so that similar instrumental indications in aircraft represent equal clockwise angular deviations (bearing), degree for degree from magnetic North as measured from the location of the VOR.

3.3.1.2 The VOR shall radiate a radio frequency carrier with which are associated two separate 30 Hz modulations. One of these modulations shall be such that its phase is independent of the azimuth of the point of observation (reference phase). The other modulation (Variable phase) shall be such that its phase at the point of observation differs from that of the reference phase by an angle equal to the bearing of the point of observation with respect to the VOR.

3.3.1.3 The reference and variable phase modulations shall be in phase along the reference meridian through the station.

Note: The reference and variable phase modulations are in phase when the maximum value of the sum of the radio frequency carrier and the sideband energy due to the variable phase modulation occurs at the same time as the highest instantaneous frequency of the reference phase modulation

3.3.2 Radio Frequency

3.3.2.1 The VOR shall operate in the band 111.975 MHz to 117.975 MHz. The channel separation shall be in increments of 50 KHz. The frequency tolerance of the radio frequency carrier where 50 KHz channel spacing is in use shall be plus or minus 0.002 per cent. The highest assignable frequency shall be 117.950 MHz. The channel separation shall be in increments of 50 KHz referred to the highest assignable frequency.

3.3.2.2 The frequency tolerance of the radio frequency carrier of all installations in India where 50 KHz channel spacing is in use shall be plus or minus 0.002 percent.

3.3.2.3 In areas where new VOR installations are implemented and are assigned frequencies spaced at 50 KHz from existing VORs in the same area, priority shall be given to ensuring that the frequency tolerance of the radio frequency carrier of the existing VORs is reduced to plus or minus 0.002 percent.

3.3.3 Polarization and pattern accuracy

3.3.3.1 The emission from the VOR shall be horizontally polarized. The vertically polarized component of the radiation shall be as small as possible.

3.3.3.2 The accuracy of the bearing information conveyed by the horizontally polarized radiation from the VOR at a distance of approximately four wavelength for all elevations angles between 0 to 40 degrees, measured from the center of the VOR antenna system, shall be within plus or minus 2 degrees.

3.3.4 Coverage

3.3.4.1 The VOR shall provide signals such as to permit satisfactory operation of a typical aircraft installation at the levels and distances required for operational reasons, and up to an elevation angle of 40 degrees.

3.3.4.2 The field strength or power density in space of VOR signals required to permit satisfactorily operation of a typical aircraft installation at the minimum service level at the maximum specified service radius should be 90 micro volt per meter or minus 107 dbW/m square.

3.3.5 Modulation of navigational signals

3.3.5.1 The radio frequency carrier as observed at any point in space shall be amplitude modulated by two signals as follows:

- a) a sub carrier of 9960 Hz of constant amplitude, frequency modulated at 30 Hz and having a deviation ratio of 16 plus or minus 1 (i.e. 15 or 17)
 - i. For the conventional VOR, the 30 Hz component of this FM sub carrier is fixed without respect to azimuth and is termed the “reference phase”
 - ii. For the Doppler VOR, the phase of the 30 Hz component varies with azimuth and is termed the “variable phase”
- b) A 30 Hz amplitude modulation component:
 - i. For the conventional VOR, this component results from a rotating field pattern, the phase of which varies with azimuth, and is termed the “variable phase”.
 - ii. For the Doppler VOR, this component, of constant phase with relation to azimuth and constant amplitude, is radiated omni directionally and is termed the “reference phase”.

3.3.5.2 The depth of modulation of the radio frequency carrier due to the sub carrier of 9960 Hz shall be within the limits of 28 percent and 32 percent.

3.3.5.3 The depth of modulation of the radio frequency carrier due to the 30 Hz or 9960 Hz signals, as observed at any angle of elevation up to 5 degrees, shall be within 28 to 32 percent.

3.3.5.4 The variable and reference phase modulation frequencies shall be 30 Hz within plus or minus 1 percent.

3.3.5.5 The sub carrier modulation mid-frequency shall be 9960 Hz within plus or minus 1 percent.

3.3.5.6

- a) For the conventional VOR, the percentage of amplitude modulation of the 9960 Hz sub carrier shall not exceed 5 percent.
- b) For the Doppler VOR, the percentage of amplitude modulation of the 9960 Hz sub-carrier shall not exceed 40 percent when measured at a point at least 300 m (1000ft) from the VOR.

3.3.5.7 Where 50 KHz VOR channel spacing is implemented, the sideband level of the harmonics of the 9960 Hz component in the radiated signal shall not exceed the following levels referred to the level of the 9960 Hz sideband:

Sub-carrier Level

9960Hz 0 dB reference

2nd Harmonics - 30 dB

3rd Harmonics -50 dB

4th Harmonics & above -60 dB

3.3.6 Voice and Identification

3.3.6.1 If the VOR provides a simultaneous communication channel ground to air, it shall be on the same radio frequency carrier as used for the navigational function. The radiation on this channel shall be horizontally polarized.

3.3.6.2 The peak modulation depth of the carrier on the communication channel shall not be greater than 30 percent.

3.3.6.3 The audio frequency characteristics of the speech channel shall be within 3dB relative to the level 1000Hz over the range 300Hz to 3000Hz.

3.3.6.4 The VOR shall provides for the simultaneous transmission of a signal of identification on the same radio frequency carrier as that used for the navigational function .The identification signal radiation shall be horizontally polarized.

3.3.6.5 The identification signal shall employ the International Morse code and consist of two or three letters. It shall be sent at a speed corresponding to approximately 7 words per minutes. The signal shall be repeated at least once every 30 seconds and the Modulation tone shall be 1020Hz within plus or minus 50Hz.

3.3.6.5.1 The identification signal should be transmitted at least three times each 30 seconds, spaced equally within that time period. One of these identification signals may take the form of voice identification.

3.3.6.6 The depth to which the radio frequency carrier is modulated by the code identification signal shall be close to, but not in excess of 10 percent except that where a communication

channel is not provided, it shall be permissible to increase the modulation by the code identification signal to a value not exceeding to 20 percent.

3.3.6.6.1 If the VOR provide the simultaneous communication channel ground to air, the modulation depth of the code identification signal should be 5 plus or minus 1 percent in order to provide a satisfactory voice quality.

3.3.6.7 The transmission of speech shall not interfere in any way with the basic navigational function. When speech is being radiated the code identification shall not be suppressed.

3.3.6.8 The VOR receiving function shall permit positive identification of the wanted signal under signal conditions encountered within the specified coverage limits, and with the modulation parameters specified at 3.3.6.5, 3.3.6.6 and 3.3.6.7 above

3.3.7 Monitoring

3.3.7.1 Suitable equipment located in the radiation field shall provide signals for the operation of an automatic monitor. The monitor shall transmit to a control point and either removes the identification and navigational components from the carrier or cause radiation to cease if any one or a combination of the following deviations from established arises:

- a) A change in excess of 1 degree at the monitor of the bearing information transmitted by the VOR.
- b) A reduction of 15 percent in the modulation components of the radio frequency signals voltage level at the monitor of either the sub carrier, or 30 Hz amplitude modulation signals or both.

3.3.7.2 Failure of Monitor itself shall transmit a warning to a control point and either:

- a) By removing the identification and navigations components from the carrier; or
- b) Cause radiation to cease.

3.3.8 Interference Immunity Performance for VOR receiving systems

3.3.8.1 The VOR receiving system shall provide adequate immunity to interference from two signals, third order inter-modulation products caused by VHF FM broadcast signals having levels in accordance with the following:

$$2N_1 + N_2 + 72 = 0$$

for VHF FM sound broadcasting signals in the range 107.7 – 108.0 MHz and

$$2N_1 + N_2 + 3 (24 - 20 \log \Delta f / 0.4) = 0$$

for VHF FM sound broadcasting signals below 107.7 MHz, where the frequencies of the two VHF FM sound broadcasting signals produced, within the receiver, at two signal, third order

inter-modulation product on the desired VOR frequency. N_1 and N_2 are the levels (dBm) of the two VHF FM sound broadcasting signals at the VOR receiver input. Neither level shall exceed the desensitization criteria set forth in 3.3.8.2 below. $\Delta f = 108.1 - f_1$, where f_1 is the frequency of N_1 , the VHF FM sound broadcasting signal closure to 108.1 MHz.

3.3.8.2 The VOR receiving system shall not be de-sensitized in the presence of VHF FM broadcast signals having levels in accordance with the following table.

Frequency (MHz)	Maximum level of unwanted signal at receiver input
88 – 102	+ 15 dBm
104	+ 10 dBm
106	+ 5 dBm
107.9	- 10 dBm

Note: The relationship is linear between adjacent points designated by the above frequencies.

3.3.8.3 All installations of airborne VOR receiving system shall meet the provision of 3.3.8.1 and 3.3.8.2 above.

3.4 Specification for non-directional Radio beacon (NDB)

3.4.1 Definitions

Average Radius of rated coverage: The radius of a circle having the same area as the rated coverage.

Effective Coverage: The area surrounding an NDB within which bearings can be obtained with accuracy sufficient for the nature of the operation concerned.

Locator: An LF/MF NDB used as an aid to final approach.

Note: A locator usually has an average radius of rated coverage of between 18.5 and 46.3 km (10 and 25 NM).

Rated coverage: The area surrounding an NDB within which the strength of the vertical field of the ground wave exceeds the minimum value specified for the geographical area in which the radio beacon is situated.

Note: The above definition is intended to establish a method of rating radio beacons on the normal coverage to be expected in the absence of sky wave transmission and/or anomalous propagation from the radio beacon concerned or interference from other LF/MF facilities, but taking into account the atmospheric noise in the geographical area concerned,

3.4.2 Coverage

3.4.2.1 The minimum value of field strength in the rated coverage of an NDB should be 70 micro volts per meter.

Note: The selection of locations and times at which the field strength is measured is important in order to avoid abnormal results for the locality concerned; locations on air routes in the area around the beacon are operationally most significant.

3.4.2.2 All notifications or promulgations of NDBs shall be based upon the average radius of the rated coverage.

Note 1: In classifying radio beacons in areas where substantial variations in rated coverage may occur diurnally and seasonally, such variations should be taken into account.

Note 2: Beacons having an average radius of rated coverage of between 46.3 and 278 km (25 and 150NM) may be designated by the nearest multiple of 46.3 km (25NM) to the average radius of rated coverage, and beacons of rated coverage over 278 km (150NM) to the nearest multiple of 92.7 km (50NM).

3.4.2.3 Where the rated coverage of an NDB is materially different in various operationally significant factors, its classifications should be expressed in terms of the average radius of rated coverage and the angular limits of each sector as follows. Radius of coverage of sector/angular limits of sector expressed as magnetic bearing clockwise from the beacon. Where it is desirable to classify an NDB in such a manner, the number of sectors should be kept to a minimum and preferably should not exceed two.

3.4.3 Limitations in radiated power

The power radiated from an NDB shall not exceed by more than 2dB that necessary to achieve its agreed rated coverage, except that this power may be increased if coordinated regionally or if no harmful interference to other facilities will result.

3.4.4 Radio Frequencies

3.4.4.1 The radio frequencies assigned to NDBs shall be selected from those available in that portion of the spectrum between 190 KHz and 1750 KHz.

3.4.4.2 The frequency tolerance applicable to NDBs shall be 0.01 per cent except that, for NDBs of antenna power above 200 W using frequencies of 1606.5 KHz and above, the tolerance shall be 0.005 per cent.

3.4.4.3 Reserved for Future Use

3.4.4.4 Reserved for Future Use

3.4.5 Identification

3.4.5.1 Each NDB shall be individually identified by a two-or three-letter International Morse Code group transmitted at a rate corresponding to approximately 7 words per minute.

3.4.5.2 The complete identification shall be transmitted at least once every 30 seconds, except where the beacon identification is effected by the on/off keying of the carrier. In this latter

case, the identification shall be at approximately 1-minute intervals, except that a shorter interval may be used at particular NDB stations where this is found to be operationally desirable.

3.4.5.2.1 Except for those cases where the beacon identification is effected by on/off keying of the carrier, the identification signal should be transmitted at least three times each 30 seconds, spaced equally within that time period.

3.4.5.3 For NDBs with an average radius of rate coverage of 92.7 km (50 NM) or less that are primarily approach and holding aids in the vicinity of an aerodrome, the identification shall be transmitted at least three times each 30 seconds, spaced equally within that time period.

3.4.5.4 The frequency of the modulating tone used from identification shall be 1020 Hz plus or minus 50 Hz or 400 Hz plus or minus 25 Hz.

3.4.6 Characteristics of emissions:

Note: The following specifications are not intended to preclude employment of modulations or types of modulations that may be utilized in NDBs in addition to those specified for identification, including simultaneous identification and voice modulation, provided that these additional modulations do not materially affect the operational performance of the NDBs in conjunctions with currently used airborne direction finders, and provided their use does not cause harmful interference to other NDB services.

3.4.6.1 Except as provided in 3.4.6.1.1, all NDBs shall radiate an uninterrupted carrier and be identified by on/off keying of an amplitude modulating tone (NON/A2A).

3.4.6.1.1 NDBs other than those wholly or partly serving as holding approach and landing aids or those having an average radius of rated coverage of less than 92.7 km (50NM), may be identified by on/off keying of the un modulated carrier (NON/AIA) if they are in areas of high beacon density and/or where the required rated coverage is not practicable of achievement because of:

- a) Radio interference from radio stations;
- b) High atmospheric noise;
- c) Local conditions.

Note: In selecting the types of emission, the possibility of confusion, arising from an aircraft tuning from a NON/A2A facility to a NON/AIA facility without changing the radio compass from “MCW” to “CW” operation, will need to be kept in mind.

3.4.6.2 For each NDB identified by on/off keying of an audio modulating tone, the depth of modulation shall be maintained as near to 95 per cent as practicable.

3.4.6.3 For each NDB identified by on/off keying of an audio modulating tone, the characteristics of emission during identification shall be such as to ensure satisfactory identification at the limit of its rated coverage.

Note: The foregoing requirement necessitates as high a percentage modulation as practicable, together with maintenance of an adequate radiated carrier power during identification.

3.4.6.4 The carrier power of an NDB with NON/A2A emissions should not fall when the identify signal is being radiated except that, in the case of an NDB having an average radius of rated coverage exceeding 92.7 km (50 NM), a fall of not more than 1.5 dB may be accepted.

3.4.6.5 Unwanted audio frequency modulations shall total less than 5 per cent of the amplitude of the carrier.

Note: Reliable performance of airborne automatic direction finding equipment (ADF) may be seriously prejudiced if the beacon emission contains modulation by an audio frequency equal or close to the loop switching frequency or its second harmonic. The loop switching frequencies in currently used equipment lie between 30 Hz and 120 Hz.

3.4.6.6 The bandwidth of emissions and the level of spurious emissions shall be kept at the lowest value that the state of technique and the nature of the service permit.

3.4.7 Siting of Locators

3.4.7.1 Where locators are used as a supplement to the ILS, they should be located at the sites of the outer and middle marker beacons. Where only one locator is used as a supplement to the ILS, preference should be given to location at the site of the outer marker beacon. Where locators are employed as an aid to final approach in the absence of an ILS, equivalent location to those applying when an ILS is installed should be selected, taking into account the relevant obstacle clearance provisions of the ICAO Doc 8168 – Procedures for Air Navigation Services (Aircraft Operations)

3.4.7.2 Where locators are installed at both the middle and outer marker positions, they should be located, where practicable, on the same side of the extended centre line of the runway in order to provide a track between the locators which will be more nearly parallel to the centre line of the runway.

3.4.8 Monitoring:

3.4.8.1 For each NDB, suitable means shall be provided to enable detection of any of the following conditions at an appropriate location:

- a) a decrease in radiated carrier power of more than 50 per cent below that required for the rated coverage.
- b) Failure to transmit the identification signal;
- c) Malfunctioning or failure of the means of monitoring itself.

3.4.8.2 When an NDB is operated from a power source having a frequency which is close to airborne ADF equipment switching frequencies, and where the design of the NDB is such

that the power supply frequency is likely to appear as a modulation product on the emission, the means of monitoring should be capable of detecting such power supply modulation on the carrier in excess of 5 per cent.

3.4.8.3 During the hours of service of a locator, the means of monitoring shall provide for a locator, the means of monitoring shall provide for a continuous check on the functioning of the locator as prescribed in 3.4.8.1 (a) (b) and (c) above.

3.4.8.4 During the hours of service of an NDB other than a locator, the means of monitoring should provide for a continuous check on the functioning of the NDB as prescribed in 3.4.8.1 (a), (b), and (c).

3.5 Specification for UHF distance measuring equipment (DME)

Note 1: In the following section, provision is made for two type of DME facility: DME/N for application as outlined in Chapter 2.2.2.2 and DME/P as outlined in 3.11.3 below.

Note 2: In the following paragraph, those denoted by = are applicable to equivalent first installed after 1 January 1989 (Chapter 2.2.2.2.1)

3.5.1 Definition

Control motion noise (CMN): That portion of the guidance signal error which causes control surface, wheel and column motion and could affect aircraft attitude angle during coupled flight, but does not cause aircraft displacement from the desired course and/or glide path (See 3.11 below)

DME dead time: A period immediately following the decoding of a valid interrogation during which a received interrogation will not cause a reply to be generated. (dead time is intended to prevent the transponder from replying to echoes resulting from multipath effects.)

DME / N: Distance measuring equipment, primarily serving operational needs of enroute of TMA navigation, where the “N” stands for narrow spectrum characteristics (to be distinguished from “W”).

DME/P. The distance measuring element of the MLS, where the “P” stands for precise distance measurement. The spectrum characteristics are those of DME/N.

Equivalent isotropically radiated power (e.i.r.p.): The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain).

Key down time: The time during which a dot or dash or a Morse character is being transmitted.

Mode W, X, Y, Z, A Method of coding DME transmission by time spacing pulses of a pulse pair, so that each frequency can be used more than once.

Partial rise time: The time as measured between the 5 and 30 per cent amplitude points on the leading edge of the pulse envelope, i.e. between points h and i on Figure 3-1 and 3-2.

Path following error (PFE): That portion of the guidance signal error which could cause aircraft displacement from the desired course and/or glide path.

Pulse amplitude: The maximum voltage of the pulse envelope, i.e. A in Figure 3-1.

Pulse decay time: The time as measured between the 90 and 10 per cent amplitude points on the trailing edge of the pulse envelope, i.e. between point e and g on Figure 3-1.

Pulse code: The method differentiating between W, X, Y and Z modes and between FA and IA modes.

Pulse duration: The time interval between the 50 per cent amplitude point on leading and trailing edges of the pulse envelope, i.e. between points b and f on Figure 3-1.

Pulse rise time: The time as measured between the 10 and 90 per cent amplitude points on the leading edge of the pulse envelope, i.e. between points a and c on Figure 3-1.

Reply efficiency: The ratio of replies transmitted by the transponder to the total of received valid interrogations.

Search: The condition which exists when the DME interrogator is attempting to acquire and lock on to the response to its own interrogations from the selected transponder./

System efficiency: The ratio of valid replies processed by the interrogator to the total of its own interrogations.

Track: The condition which exists when the DME interrogator has locked onto replies in response to its own interrogations, and is continuously providing a distance measurement.

Transmission rate: The average number of pulse pairs transmitted from the transponder per second.

Virtual Origin: The point at which the straight line through the 30 per cent and 5 per cent amplitude points on the pulse leading edge intersects the 0 per cent amplitude axis (see Figure 3-2)

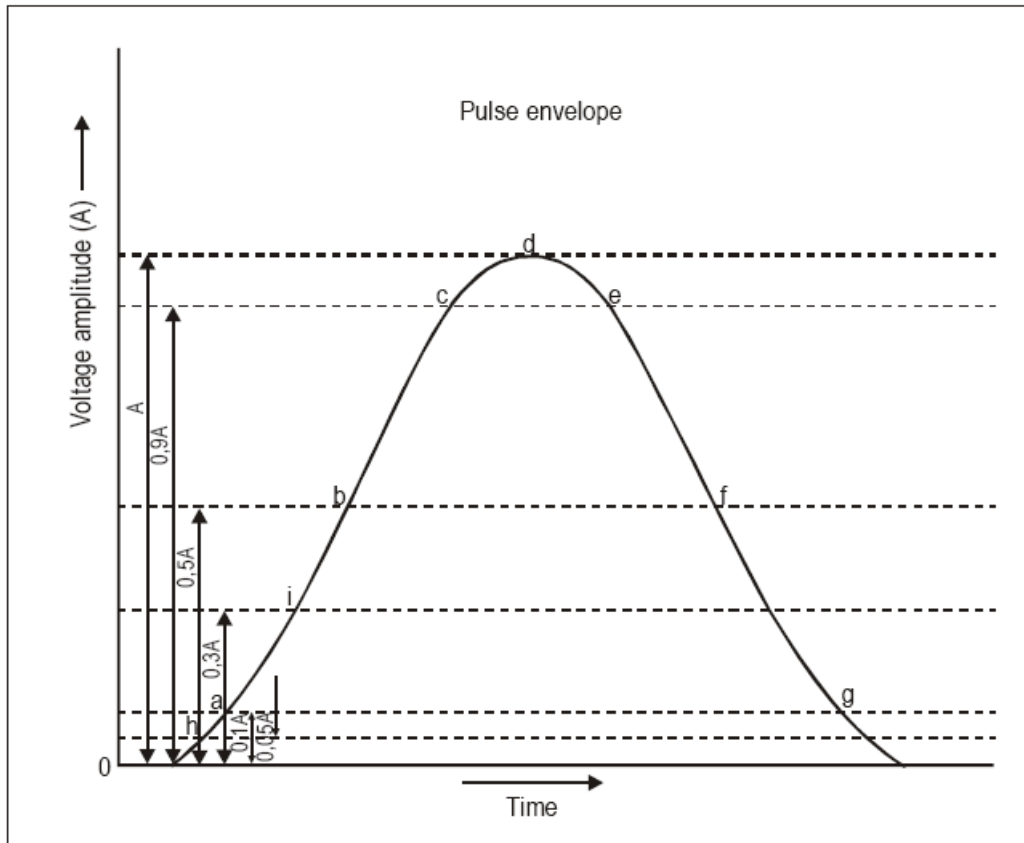


Figure 3 - 1

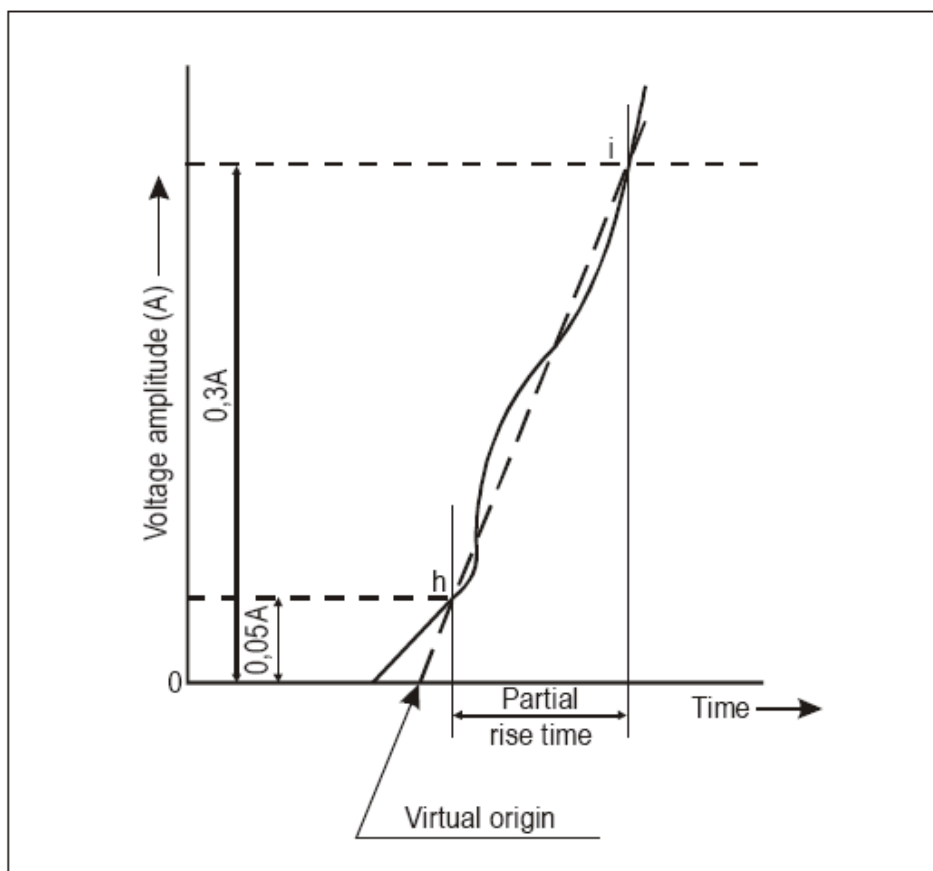


Figure 3 - 2

3.5.2 General

3.5.2.1 The DME system shall provide for continuous and accurate indication in the cockpit of the slant range distance of an equipped aircraft from an equipped ground reference point.

3.5.2.2 The system shall comprise two basic components, one fitted in the aircraft, the other installed on the ground. The aircraft component shall be referred to as the interrogator and the ground component as the transponder.

3.5.2.3 In operation, interrogators shall interrogate transponders which shall, in turn, transmit to the interrogator replies synchronized with the interrogations, thus providing means for accurate measurement of distance.

3.5.2.4 Reserved for Future Use

3.5.2.5 When a DME function is combined with either an ILS or VOR for the purpose of constituting a single facility, they shall be considered to be associated in a manner complying with Chapter 2, Para 2.2.2 only when :

- a) operated on a standard frequency pairing in accordance with 3.5.3.3.5 below;
- b) collocated within the limits prescribed for associated facilities in 3.5.2.6 below;
- c) complying with the identification provisions of 3.5.3.6.4 below.

3.5.2.6 Collocation limits for a DME facility associated with an ILS, MLS or VOR Facility

3.5.2.6.1 Associated VOR and DME facilities shall be collocated in accordance with following:

a) **coaxial collocation:** the VOR and DME antennas are located on the same vertical axis; or

b) **offset collocation :**

- 1) for those facilities used in terminal areas for approach purpose or other procedures where the highest position fixing accuracy of system capability is required, the separation of the VOR and DME antennas does not exceed 30m (100ft) except that, at Doppler VOR facilities, where DME service is provided by a separate facility, the antennas may be separated by more than 30m (100ft) but not in excess of 80m (260ft)
- 2) for purposes other than those indicated in 1), the separation of the VOR and DME antennas does not exceed 600m (2000ft).

3.5.2.6.2 Reserved for Future Use

3.5.3 System characteristics

3.5.3.1 Performance

3.5.3.1.1 Range: The system shall provide a means of measurement of slant range distance from an aircraft to a selected transponder to the limit of coverage prescribed by the operational requirements for the selected transponder.

3.5.3.1.2 Coverage:

3.5.3.1.2.1 When associated with VOR and DME/N coverage shall be at least that of the VOR to the extent practicable.

3.5.3.1.2.2 Reserved for Future Use

3.5.3.1.3 Accuracy

3.5.3.1.3.1 **System accuracy:** The accuracy standards specified herein shall be met on at 95 percent probability basis.

Note: The total system limits include errors from all causes such as those from airborne equipment, ground equipment, propagate ion and random pulse interference effects.

3.5.3.1.3.2 **DME/N accuracy:** At distances of from zero to 370km (200NM) from the transponder, dependent upon the particular service application, the total system error, excluding reading error, should be not greater than plus or minus 460m (0.25NM) plus 1.25 percent of distance measured.

3.5.3.1.3.3 The total system error shall not exceed plus or minus 370m (0.2NM) Note: This system accuracy is predicated upon the achievement of an airborne interrogator error contribution of not more than plus of minus 315m (0.17NM)

3.5.3.2 Radio frequencies and polarization: The system shall operate with vertical polarization in the frequency band 960 MHz to 1215 MHz. The interrogation and reply frequencies shall be assigned with 1 MHz spacing between channels.

3.5.3.3 Channeling

3.5.3.3.1 DME operating channels shall be formed by pairing interrogation and reply frequencies and by pulse coding on the paired frequencies.

3.5.3.3.2 Reserved for Future Use

3.5.3.3.3 DME operating channels shall be chosen from Table A of 352 channels in which the channel numbers, frequencies, and pulse codes are assigned.

3.5.3.3.4 Area channel assignment

3.5.3.3.4.1 In a particular area, the number of DME operating channels to be used shall be decided regionally.

3.5.3.3.4.2 The specific DME operating channels to be assigned in such a particular area shall also be decided regionally, taking into consideration the requirements for co channel and adjacent channel protection.

3.5.3.3.4.3 Coordination of regional DME channel assignments should be effected through ICAO.

3.5.3.3.5 **Channel pairing:** When a DME transponder is intended to operate in association with a single VHF navigation facility in the 108 MHz to 117.95 MHz frequency band and the DME operating channel shall be paired with the VHF channel as given in Table A.

3.5.3.4 Interrogation pulse repetition frequency

3.5.3.4.1 **DME/N** The interrogator average pulse repetition frequency (PRF) shall not exceed 30 pairs of pulses per second, based on the assumption that at least 95 percent of the time is occupied for tracing.

3.5.3.4.2 **DME/N:** If it is desired to decrease the time of search, the PRF may be increased during search but shall not exceed 150 pairs of pulses per second.

3.5.3.4.3 **DME/N:** After 15000 pairs of pulses have been transmitted without acquiring indication of distance, the PRF should not exceed 60 pairs of pulses per second thereafter, until a change in operating channel is made or successful search is completed.

3.5.3.4.4 **DME/N:** When, after a time period of 30 seconds, tracking has not been established the pulse pair repetition frequency shall not exceed 30 pulse pairs per second thereafter.

3.5.3.5 Aircraft handling capacity of the system

3.5.3.5.1 The aircraft handling capacity of transponders in an area shall be adequate for the peak traffic of the area of 100 aircraft, whichever is the lesser.

3.5.3.5.2 Where the peak traffic in an area exceeds 100 aircraft, the transponder should be capable of handling that peak traffic.

3.5.3.6 Transponder identification

3.5.3.6.1 All transponders shall transmit an identification signal in one of the following forms as required by 3.5.3.6.5 below:

- a) An “independent” identification consisting of coded (international Morse Code) identity pulses which can be used with all transponders.
- b) An “associated” signal which can be used for transponders specifically associated with a VHF navigation facility which itself transmits an identification signal.

3.5.3.6.2 Both systems of identification shall use signals, which shall consist of the transmission for an appropriate period of a series of paired pulses transmitted at a repetition rate of 1350 pulse pairs per second, and shall temporarily replace all reply pulses that would normally occur at that time except as in 3.5.3.6.2.2 below. These pulses shall have similar characteristics to the other pulses of the reply signals.

3.5.3.6.2.1 **DME/N** Reply pulses shall be transmitted between key down times.

3.5.3.6.2.2 **DME/N:** If it is desired to preserve a constant duty cycle, an equalizing pair of pulses having the same characteristics as the identification pulse pairs, should be transmitted 100 microseconds plus or minus 10 microseconds after each identity pair.

3.5.3.6.3 The characteristics of the “independent” identification signal shall be as follows:

- a) the identity signal shall consist of the transmission of the beacon code in the form of dots and dashes (International Morse code) of identity pulses at least once every 40 seconds at a rate of at least 6 words per minute: and
- b) the identification code characteristic and letter rate for the DME transponder shall conform to the following to ensure that the maximum total key down time does not exceed 5 seconds per identification code group. The dots shall be a time duration of 0.1 second to 0.160 second, the dashes shall be typically 3 times the duration of the dots. The duration between dots and/or dashes shall be equal to that of one dot plus or minus 10 per cent. The time duration between letters or numerals shall not be less than three dots. The total period for transmission of an identification code group shall not exceed 10 seconds.

Note: The tone identification signal is transmitted at a repetition rate of 1350 pps. This frequency may be used directly in the airborne equipment as an aural output for the pilot, or other frequencies may be generated at the option of the interrogator designer (see 3.5.3.6.2 above)

3.5.3.6.4 The characteristics of the “associated” signal shall be as follows:

- a) when associated with a VHF facility, the identification shall be transmitted in the form of dots and dashes (international Morse code) as in 3.5.3.6.3 above and shall be synchronized with the VHF facility identification code:
- b) each 40 second interval shall be divided into four or more equal periods, with the transponder identification transmitted during one period only and the associated VHF facility identification, where these are provided, transmitted during the remaining periods:

3.5.3.6.5 Identification implementation

3.5.3.6.5.1 The “independent” identification code shall be employed wherever a transponder is not specifically associated with a VHF navigational facility.

3.5.3.6.5.2 Wherever a transponder is specifically associated with a VHF navigational facility identification shall be provided by the “associated” code.

3.5.3.6.5.3 When voice communications are being radiated on an associated VHF navigational facility, an “associated” signal from the transponder shall not be suppressed.

3.5.4 Detailed technical characteristics of transponder and associated monitor

3.5.4.1 Transmitter

3.5.4.1.1 Frequency of operation: The transponder shall transmit on the reply frequency appropriate to the assigned DME channel (see 3.5.3.3.3 above).

3.5.4.1.2 Frequency stability: The radio frequency of operation shall not vary more than plus or minus 0.002 per cent from the assigned frequency.

3.5.4.1.3 Pulse shape and spectrum: The following shall apply to all radiated pulses:

- a) Pulse rise time: DME/N shall not exceed 3 microseconds.
- b) Pulse duration shall be 3.5 microseconds plus or minus 0.5 microseconds.
- c) Pulse decay time shall nominally be 2.5 microseconds but shall not exceed 3.5 microseconds.
- d) The instantaneous amplitude of the pulse shall not, at any instant between the point of the leading edge which is 95 per cent of maximum amplitude and the point of the trailing edge which is 95 per cent of the maximum amplitude, fall below a value which is 95 per cent of the maximum voltage amplitude of the pulse.
- e) For DME/N the spectrum of the pulse modulated signal shall be such that during the pulse the effective radiated power contained in a 05 MHz band centered on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel frequency in each case shall not exceed 200 mW, and the effective radiated power contained in a 05 MHz band centered on frequencies 2 MHz above and 2 MHz below the nominal channel frequency in each case shall not exceed 2mW. The effective radiated power contained within any 0.5 MHz band shall decrease monotonically as the band center frequency moves away from the nominal channel frequency.
- f) To ensure proper operation of the thresh holding techniques, the instantaneous magnitude of any pulse turn on transients which occur in time prior to the virtual origin shall be less than one per cent of the pulse peak amplitude. Initiation of the turn-on process shall not commence sooner than 1 microseconds prior to the virtual origin.

Note 1: The time “during the pulse” encompasses the total interval from the beginning of pulse transmission to its end. For practical reasons this interval may be measured between the 5 per cent points on the leading and trailing edges of the pulse envelope.

Note 2: The power contained in the frequency bands specified in 3.5.4.1.3 e) and f) above is the average power during the pulse. Average power in a given frequency band is the energy contained in this frequency band divided by the time of pulse transmission as above.

3.5.4.1.4 Pulse spacing

3.5.4.1.4.1 The spacing of the constituent pulses of transmitted pulse pairs shall be as given in the table in 3.5.4.4.1.

3.5.4.1.4.2 DME/N The tolerance on the pulse spacing shall be plus or minus 0.25 microsecond.

3.5.4.1.4.3 DME/N The tolerance on the DME/N pulse spacing should be plus or minus 0.10 microsecond.

3.5.4.1.4.4 Reserved for Future Use

3.5.4.1.4.5 The pulse spacing shall be measured between the half voltage points on the leading edges of the pulses.

3.5.4.1.5 Peak power output

3.5.4.1.5.1 DME/N The peak effective radiated power should not be less than that required to ensure a peak pulse power density of minus 89 dBW/m² under all 1 operational weather conditions at any point within coverage specified in 3.5.3.1.2 above.

3.5.4.1.5.2 DME / N. The peak equivalent isotropically radiated power shall not be less than that required to ensure peak pulse power density of minus 89 dBW/m² under all operational weather condition at any point with in coverage specified in 3.5.3.1.2 above.

Note: Although the Standard 3.5.4.1.5.2 above implies an improved interrogator receiver sensitivity, it is intended that the power density specified in 3.5.4.1.5.1 above be available at the maximum specified service range and level.

3.5.4.1.5.4 The peak power of the constituent pulses of any pair of pulses shall not differ by more than 1 dB.

3.5.4.1.5.5 The reply capability of the transmitter should be such that the transponder should be capable of continuous operation at a transmission rate of 2700 plus or minus 90 pulse pairs per second (if 100 aircraft are to be served).

3.5.4.1.5.6 The transmitter shall operate at a transmission rate, including randomly distributed pulse pairs and distance reply pulse pairs, of not less than 700 pulse pairs per seconds except during identity. The minimum transmission rate shall be as close as practicable to 700 pulse pairs per seconds.

3.5.4.1.6 **Spurious radiation:** During intervals between transmission of individual pulses, the spurious power received and measured in a receiver having the same characteristics as a transponder receiver, but tuned to any DME interrogation or reply frequency, shall be more than 50 dB below the peak pulse power received and measured in the same receiver tuned to the reply frequency in use during the transmission of the required pulses. This provision refers to all spurious transmissions, including modulator and electrical interference.

3.5.4.1.6.1 DME/N The spurious power level specified in 3.5.4.1.6 above shall be more than 80 dB below the peak pulse power level.

3.5.4.1.6.2 Reserved for Future Use

3.5.4.1.6.3 **Out of band spurious radiation:** At all frequencies from 10 to 1800 MHz but excluding the band of frequencies from 960 to 1215 MHz, the spurious output of the DME transponder transmitter shall not exceed minus 40 dBm in any one KHz of receiver bandwidth.

3.5.4.1.6.4 The equivalent isotropically radiated power of any CW harmonic of the carrier frequency on any DME operating channel shall not exceed minus 10 dBm.

3.5.4.2 Receiver

3.5.4.2.1 **Frequency of operation:** The receiver center frequency shall be the interrogation frequency appropriate to the assigned DME operating channel (see 3.5.3.3.3 above)

3.5.4.2.2 **Frequency stability:** The centre frequency of the receiver shall not vary more than plus or minus 0.002 percent from the assigned frequency.

3.5.4.2.3 Transponder sensitivity

3.5.4.2.3.1 In the absence of all interrogation pulse pairs, with the exception of those necessary to perform the sensitivity measurement interrogation pulse pairs with the correct spacing and nominal frequency shall trigger the transponder if the peak power density at the transponder antenna is at least minus 103 dBW/m² for DME/N.

3.5.4.2.3.2 The minimum power densities specified in 3.5.4.2.3.1 above shall cause the transponder to reply with an efficiency of at least 70 percent for DME/N.

3.5.4.2.3.3 **DME/N dynamic range:** The performance of the transponder shall be maintained when the power density of the interrogation signal at the transponder antenna has any value between the minimum specified in 3.5.4.2.3.1 above up to a maximum of minus 22 dBW/m² when installed with ILS and minus 35 Ddb/m² when installed for other applications.

3.5.4.2.3.4 Reserved for Future Use

3.5.4.2.3.5 The transponder sensitivity level shall not vary by more than 1 dB for transponder loadings between 0 and 90 percent of its maximum transmission rate.

3.5.4.2.3.6 DME/N .When the spacing of an interrogator pulse pair varies from the nominal value by up to plus or minus 1 microsecond, the receiver sensitivity shall not be reduced by more than 1 dB.

3.5.4.2.4 Load limiting:

3.5.4.2.4.1 DME/N: When transponder loading exceeds 90 percent of the maximum transmission rate, the receiver sensitivity should be automatically reduced in order to limit the transponder replies, so as to ensure that the maximum permissible transmission rate is not exceeded. (The available range of sensitivity reduction should be at least 50 dB.

3.5.4.2.5 **Noise:** When the receiver is interrogated at the power densities specified in 3.5.4.2.3.1 above to produce a transmission rate equal to 90 percent of the maximum, the noise generated pulse pairs shall not exceed 5 per cent of the maximum transmission rate.

3.5.4.2.6 Band width

3.5.4.2.6.1 The minimum permissible bandwidth of the receiver shall be such that the transponder sensitivity level shall not deteriorate by more than 3dB when the total receiver drift is added to an incoming interrogation frequency drift of plus or minus 100 KHz.

3.5.4.2.6.2 DME/N. The receiver bandwidth shall be sufficient to allow compliance with 3.5.3.1.3 above when the input signals are those specified in 3.5.5.1.3 below.

3.5.4.2.6.3 Reserved for Future Use

3.5.4.2.6.4 Reserved for Future Use

3.5.4.2.6.5 Signals greater than 900 KHz removed from the desired channel nominal frequency and having power densities up to the values specified in 3.5.4.2.3.3 for DME/N

shall not trigger the transponder. Signals arriving at the intermediate frequency shall be suppressed at least 80dB. All other spurious response or signals within the 960MHz to 1215 MHz band and image frequencies shall be suppressed at least 75 dB.

3.5.4.2.7 Recovery time. Within 8 micro second of the reception of a signal between 0dB and 60dB above minimum sensitivity level, the minimum sensitivity level of the transponder to a desired signal shall be within 3dB of the value obtained in the absence of signals. This requirement shall be met with echo suppression circuits, if any rendered in operative. The 8 microseconds are to be measured between the half voltage points on the leading edges of the two signals, both of which conform in shape, with the specifications in 3.5.1.3 below.

3.5.4.2.8 Spurious Radiations: Radiation from any part of the receiver or allied circuits shall meet the requirements stated in 3.5.4.1.6 above

3.5.4.2.9 CW and echo suppression: CW and echo suppression should be adequate for the sites at which the transponder will be used.

Note: In this connection, echoes mean undesired signals caused by multi path transmission (reflection, etc).

3.5.4.2.10 Protection against interference: Protection against interference outside the DME frequency band should be adequate for the sites at which the transponders will be used.

3.5.4.3 Decoding

3.5.4.3.1 The transponder shall include a decoding circuit such that the transponder can be triggered only by pairs of received pulses having pulse duration and pulse spacing appropriate to interrogator signals as described in 3.5.5.1.3 and 3.5.5.1.4 below.

3.5.4.3.2 The decoding circuit performance shall not be affected by signals arriving before, between, or after the constituent pulses of a pair of the correct spacing.

3.5.4.3.3 DME/N- Decoder rejection: An interrogation pulse pair with a spacing of plus or minus 2 microseconds, or more from the nominal value specified in 3.5.4.2.3.3 shall be rejected such that the transmission rate does not exceed the value obtained when interrogations are absent.

3.5.4.4 Time delay

3.5.4.4.1 When a DME is associated only with a VHF facility, the time delay shall be the interval from the half voltage point on the leading edge of the second constituent pulse of the interrogation pair and half voltage point on the reply transmission. This delay shall be consistent with the following table, when it is desired that aircraft interrogations are to indicate distance from transponder site.

Channel Suffix	Operating mode	Pulse pair spacing (μs)		Time delay (μs)	
		Interrogation	Reply	1st pulse timing	2nd Pulse timing
X	DME/N	12	12	50	50
Y	DME/N	36	30	56	60

3.5.4.4.2 Reserved for future use

3.5.4.4.3 For the DME/N the transponder time delay should be capable of being set to an appropriate value between the nominal value of the time delay minus 15 micro-seconds and the nominal value of the time delay, to permit aircraft interrogations to indicate zero distance at a specific point remote from the transponder site.

Note: Modes not allowing for the full 15 microseconds range of adjustment in transponder time delay may only be adjustable to the limits given by the transponder circuit delay and recovery Time

3.5.4.4.3.1 DME/N. the time delay shall be the interval from the half voltage point on the leading edge of the first constituent pulse of the interrogation pair and the half voltage point on the leading edge of the first constituent pulse of the reply transmission.

3.5.4.4.4 DME/N. Transponders should be sited as near to the point at which zero indication is required as is practicable. Note: It is desirable that the radius of the sphere at the surface of which zero indication is given be kept as small as possible in order to keep the zone of ambiguity to a minimum.

3.5.4.5 Accuracy

3.5.4.5.1 DME/N. The transponder shall not contribute more than plus or minus 1 microsecond (150 m (500ft)) to the over-all system error.

3.5.4.5.2 DME/N. A transponder associated with a landing aid shall not contribute more than plus or minus 0.5 micro-second (75m (250ft)) to the over-all system error.

3.5.4.6 Efficiency

3.5.4.6.1 The transponder reply efficiency shall be at least 70 per cent for DME/N at all values of transponder loading up to the loading corresponding to 3.5.3.5 above and at the minimum sensitivity level specified in 3.5.4.2.3.1 and 3.5.4.2.3.5 above.

Note: When considering the transponder reply efficiency value, account is to be taken of the DME dead time and of the loading introduced by the monitoring function.

3.5.4.6.2 **Transponder dead time:** The transponder shall be rendered inoperative for a period normally not to exceed 60 microseconds after a valid interrogation decode has occurred. In extreme cases when the geographical site of the transponder is such as to produce undesirable reflection problems, the dead time may be increased but only by the minimum amount necessary to allow the suppression of echoes for DME/N.

3.5.4.7 Monitoring and control

3.5.4.7.1 Means shall be provided at each transponder site for the automatic monitoring and control of the transponder in use.

3.5.4.7.2 DME/N monitoring action

3.5.4.7.2.1 In the event that any of the conditions specified in 3.5.4.7.2.2 below occur, the monitor shall cause the following action to take place:

- a) a suitable indication shall be given at a control point;
- b) the operating transponder shall be automatically switched off; and
- c) the standby transponder, if provided, shall be automatically placed in operation.

3.5.4.7.2.2 The monitor shall cause the actions specified in 3.5.4.7.2.1 above if:

- a) the transponder delay differs from the assigned value by 1 microsecond(75m(500ft)) or more;
- b) in the case of a DME/N associated with a landing aid, the transponder delay differs from the assigned value by 0.5 microsecond(75m(250ft)) or more;

3.5.4.7.2.3 The monitor should cause the action specified in 3.5.4.7.2.1 above if the spacing between the first and second pulse of the transponder pulse pair differs from the nominal value specified in the table following 3.5.4.4.1 above by 1 microsecond or more.

3.5.4.7.2.4 The monitor should also cause suitable indication to be given at a control point if any of the following conditions arise:

- a) a fall of 3dB or more in transponder transmitted power output;
- b) a fall of 6dB or more in the minimum transponder receiver sensitivity (provided that this is not due to the action of the receiver automatic gain reduction circuits);
- c) the spacing between the first and second pulse of the transponder reply pulse pair differs from the normal value specified in 3.5.4.1.4 above by 1 microsecond or more;
- d) variation of the transponder receiver and transmitter frequencies beyond the control range of the reference circuits (if the operating frequencies are not directly crystal controlled).

3.5.4.7.2.5 Means shall be provided so that any of the conditions and malfunctioning enumerated in 3.5.4.7.2.2, 3.5.4.7.2.3., and 3.5.4.7.2.4 above which are monitored can persist for a certain period before the monitor takes the action. This period shall be as low as practicable, but shall not exceed 10 seconds, consistent with the need for avoiding interruption, due to transient effects, of the service provided by the transponder.

3.5.4.7.2.6 The transponder shall not be triggered more than 120 times per second for either monitoring or automatic frequency control purposes, or both.

3.5.4.7.3 Reserved for future use except the following

3.5.4.7.3.5 **DME/N monitor failure:** Failure of any part of the monitor itself shall automatically produce the same results as the malfunctioning of the element being monitored.

3.5.5 Technical characteristics of interrogator

Note: The following sub paragraph specifies only those interrogator parameters which must be defined to ensure that the interrogator:

- a) does not jeopardize the effective operation of the DME system, e.g. by increasing transponder loading abnormally; and
- b) is capable of giving accurate distance readings.

3.5.5.1 Transmitter

3.5.5.1.1 Frequency of operation: The interrogator shall transmit on the interrogation frequency appropriate to the assigned DME channel (see 3.5.3.3.3 above)

3.5.5.1.2 Frequency stability. The radio frequency of operation shall not vary more than plus or minus 100 KHz from the assigned value.

3.5.5.1.3 Pulse shape and spectrum. The following shall apply to all radiated pulses:

- a) Pulse rise time for DME/N shall not exceed 3 micro seconds.
- b) Pulse duration shall be 3.5 microseconds plus or minus 0.5 microseconds.
- c) Pulse decay time shall normally be 2.5 microseconds, but shall not exceed 3.5 microseconds.
- d) The instantaneous amplitude of the pulse shall not, at any instant between the point of the leading edge which is 95 percent of maximum amplitude and the point of trailing edge which is 95 percent of the maximum amplitude, fall below a value which is 95 percent of the maximum voltage amplitude of the pulse.
- e) The spectrum of the pulse modulated signal shall be such that at least 90 percent of the energy in each pulse shall be within 0.5 MHz in a band centered on the nominal channel frequency.
- f) To ensure proper operation of the thresh holding techniques, the instantaneous magnitude of any pulse turn-on transients which occur in time prior to the virtual origin shall be less than one percent of the pulse peak amplitude. Initiation of the turn on process shall not commence sooner than 1 microsecond prior to the virtual origin.

3.5.5.1.4 Pulse spacing

3.5.5.1.4.1 The spacing of the constituent pulses of transmitted pulse pairs shall be as given in the table in 3.5.4.4.1 above.

3.5.5.1.4.2 DME/N. The tolerance on the pulse spacing shall be plus or minus 0.5 microseconds.

3.5.5.1.4.3 DME/N The tolerance on the pulse spacing should be plus or minus 0.25 microseconds.

3.5.5.1.4.4 Reserved for future use

3.5.5.1.4.5 The pulse spacing shall be measured between the half voltage points on the leading edges of the pulses.

3.5.5.1.5 Pulse repetition frequency

3.5.5.1.5.1 The pulse repetition frequency shall be as specified in 3.5.3.4 above.

3.5.5.1.5.2 The variation in time between successive pairs of interrogation pulses shall be sufficient to prevent false lock-on.

3.5.5.1.6 **Spurious radiation.** During intervals between transmission of individual pulses, the spurious pulse power received and measured in a receiver having the same characteristics of a DME transponder receiver, but tuned to any DME interrogation or reply frequency, shall be more than 50 dB below the peak pulse power received and measured in the same receiver tuned to the interrogation frequency in use during the transmission of the required pulses. This provision shall apply to all spurious pulse transmissions. The spurious CW power radiated from the interrogator on any DME interrogation or reply frequency shall not exceed 20 microwatts (minus 47 dBW).

Note: Although spurious CW radiation between pulses is limited to levels not exceeding minus 47 dBW, states are cautioned that where DME interrogators and secondary surveillance radar transponders are applied in the same aircraft, it may be necessary to provide protection to airborne SSR in the band 1015 MHz to 1045 MHz. This protection may be provided by limiting conducted and radiated CW to a level of the order of minus 77 dBW. Where this level can not be achieved, the required degree of protection may be provided in planning the relative location of the SSR and DME aircraft antennas. It is to be noted that only a few of these frequencies are utilized in the VHF/DME pairing plan.

3.5.5.1.7 The spurious pulse power received and measured under the condition stated in 3.5.5.1.6 above should be 80 dB below the required peak pulse power received.

Note: Reference 3.5.5.1.6 and 3.5.5.1.7 above—although limitation of spurious CW radiation between pulses to levels not exceeding 80 dB below the peak pulse power received is recommended, States are cautioned that where users employ airborne secondary surveillance radar transponder in the same aircraft, it may be necessary to limit direct and radiated CW to not more than 0.02 microwatt in the frequency band 1 015 MHz to 1 045 MHz. It is to be noted that only a few of these frequencies are utilized in the VHF/DME pairing plan.

3.5.5.2 Time delay

3.5.5.2.1 The time delay shall be consistent with the table in 3.5.4.4.1 above.

3.5.5.2.2 DME/N. The time delay shall be the interval between the time of the half voltage point on the leading edge of the second constituent interrogation pulse and the time at which the distance circuits reach the condition corresponding to zero distance indication.

3.5.5.2.3 DME/N. The time delay shall be the interval between the time of the half voltage point on the leading edge of the first constituent interrogation pulse and the time at which the distance circuits reach the condition corresponding to zero distance indication.

3.5.5.3 Receiver

3.5.5.3.1 **Frequency of operation.** The receiver centre frequency shall be the transponder frequency appropriate to the assigned DME operating channel (see 3.5.3.3.3 above).

3.5.5.3.2 Receiver sensitivity

3.5.5.3.2.1 DME/N. The airborne equipment sensitivity shall be sufficient to acquire and provide distance information to the accuracy specified in 3.5.5.4 below for the signal power density specified in 3.5.4.1.5.2 above.

3.5.5.3.2.2 Reserved for future use

3.5.5.3.2.3 DME/N. The performance of the interrogator shall be maintained when the power density of the transponder signal at the interrogator antenna is between the minimum values given in 3.5.4.1.5 above and a maximum of minus 18 dBW/m².

3.5.5.3.3 Bandwidth

3.5.5.3.3.1 DME/N. The receiver bandwidth shall be sufficient to allow compliance with 3.5.3.1.3, when the input signals are those specified in 3.5.4.1.3.

3.5.5.3.4 Interference rejection

3.5.5.3.4.1 When there is a ratio of desired to undesired co-channel DME signals of at least 8 dB at the input terminals of the airborne receiver, the interrogator shall display distance information and provide unambiguous identification from the stronger signal.

Note: Co-channel refers to those reply signals that utilize the same frequency and the same pulse pair spacing.

3.5.5.3.4.2 DME/N. DME signals greater than 900 KHz removed from the desired channel nominal frequency and having amplitudes up to 42 dB above the threshold sensitivity shall be rejected.

3.5.5.3.5 Decoding

3.5.5.3.5.1 The interrogator shall include a decoding circuit such that the receiver can be triggered only by pairs of received pulses having pulse duration and pulse spacing appropriate to transponder signals as described in 3.5.4.1.4.

3.5.5.3.5.2 DME/N Decoder rejection: A reply pulse pair with a spacing of plus or minus 2 micro seconds, or more, from the nominal value and with any signal level up to 42 dB above the receiver sensitivity shall be rejected.

3.5.5.4 Accuracy

3.5.5.4.1 DME/N The interrogator shall not contribute more than plus or minus 315m (plus or minus 0.17NM) to overall system error.

3.6 Reserved for future use

3.7 Reserved for future use

3.8 System characteristics of airborne ADF receiving systems

3.8.1 Accuracy of bearing indication

3.8.1.1 The bearing given by the ADF system shall not be in error by more than plus or minus 5 degrees with a radio signal from any direction having a field strength of

70 microvolts per metre or more radiated from an LF/MF NDB and in the presence also of an unwanted signal from a direction 90 degrees from the wanted signal and:

- a) on the same frequency and 15 dB weaker; or
- b) plus or minus 2 KHz away and 4 dB weaker; or
- c) plus or minus 6 KHz or more away and 55 dB stronger.

Note.— The above bearing error is exclusive of aircraft magnetic compass error.

Appendix I

Siting Requirements for short-distance RADIO NAVIGATIONAL AIDS

(As per Requirement 2.2.3)

Guidance in respect of siting of VOR

A1) The site should be on the highest ground in the vicinity to obtain the greatest line-of-sight coverage and should be level or should slope away from the station (at a downgrade not exceeding 4 per cent) to a distance of at least 300 m (1 000 ft) and preferably to 600 m (2 000 ft) from the station. The site contours should be circular with respect to the antenna array to a radius of at least 300 m (1 000 ft). The site should be as far removed from wire lines and fences as possible. The height of wire lines and fences should not subtend a vertical angle of more than 1.5 degrees or extend more than 0.5 degree above the horizontal as measured from the antenna array. These limits may be increased by 50 per cent for fences or lines which are essentially radial to the antenna array or which subtend a horizontal angle of no more than 10 degrees. Single trees of moderate size, up to 9 m (30 ft) in height, may be tolerated beyond 150 m (500 ft). No groups of trees should subtend a vertical angle greater than 2 degrees or be situated within 300 m (1 000 ft) of the station. Provisions should be made for clearing trees to 600 m (2 000 ft) if it should prove necessary. No structures should subtend a vertical angle greater than 1.2 degrees or be situated within 150 m (500 ft) of the station. Wooden structures with negligible metallic content and with little prospect of future metallic additions may subtend vertical angles up to 2.5 degrees.

A2) In mountainous terrain, a mountain-top site will often be preferable. The site should be on the highest accessible hilltop or mountain, the top of which should be graded flat to a radius of at least 45 m (150 ft). On such sites, the antenna system should be installed approximately a half wavelength above ground level in the centre of the graded area and the transmitter building should be beyond the graded area, far enough down the slope to be below optical line of sight from the antenna array. No ground, trees, power lines, buildings, etc. between 45 m (150 ft) and 360 m (1 200 ft) should be within optical line of sight of the antenna array.

Guidance in respect of siting of DME/N

B1) The DME should, where possible, provide to the pilot an indicated zero range at touchdown in order to satisfy current operational requirements.

B2) In the case of DME/N, the provision of zero range indication may be achieved by siting the transponder as close as possible to the point at which zero range indication is required. Alternatively, the transponder time delay can be adjusted to permit aircraft interrogators to indicate zero range at a specified distance from the DME antenna. When the indicated DME zero range has a reference other than the DME antenna, consideration should be given to publishing this information.

B3) In considering DME sites, it is also necessary to take into account technical factors such as runway length, profile, local terrain and transponder antenna height to assure adequate signal levels in the vicinity of threshold and along the runway. Care is also to be taken that where distance information is required in the runway region, the selected site is not likely to cause the interrogator to lose track due to excessive rate of change of velocity.

Appendix II

Testing Requirements for RADIO NAVIGATIONAL AIDS

(As per Requirement 2.7.1)

Summary of testing requirement – VOR

Parameter	Annex 10, Volume I, reference	Testing
Rotation	3.3.1.1	FVG
Sensing	3.3.1.3	FVG
Frequency	3.3.2	G
Polarization	3.3.3.1	FVG
Pattern accuracy	3.3.3.2	FVG
Coverage	3.3.4	FVG
9 960 Hz deviation	3.3.5.1	FVG
9 960 Hz modulation depth	3.3.5.2	FVG
30 Hz modulation depth	3.3.5.3	FVG
30 Hz modulation frequency	3.3.5.4	FVG
9 960 Hz subcarrier frequency	3.3.5.5	FVG
CVOR AM modulation of 9 960 Hz subcarrier	3.3.5.6	FVG
DVOR AM modulation of 9 960 Hz subcarrier	3.3.5.6	FVG
Sideband level of the harmonics of the 9 960 Hz	3.3.5.7	G
Peak modulation of voice channel	3.3.6.2	G
Audio frequency characteristics	3.3.6.3	G
Identification speed	3.3.6.5	G
Identification repetition	3.3.6.5	G
Identification tone	3.3.6.5	G
Identification modulation depth	3.3.6.6	FVG
Speech effect on normal navigation function	3.3.6.7	FVG
Bearing monitor	3.3.7.1	FVG
Modulation monitor	3.3.7.1	G

Legend: F = Flight test/inspection
G = Ground test

Summary of ground testing requirement – VOR

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measurement	Tolerance	Uncertainty	Periodicity
Rotation	3.3.1.1	2.2.4	Clockwise	Correct		12 months
Sensing	3.3.1.3	2.2.5	Correctness	Correct		12 months
Carrier frequency	3.3.2	2.2.6	Frequency	±0.002%	0.0004%	12 months
Polarization	3.3.3.1	2.2.34	Deviation	±2.0°	0.3°	
Pattern accuracy	3.3.3.2	2.2.7 2.2.8	Alignment	±2.0°	0.4°	12 months
Coverage	3.3.4	2.2.9	Field strength	90 µV/m	3 dB	12 months
9 960 Hz deviation	3.3.5.1	2.2.11	Ratio	16 ±1		12 months
9 960 Hz modulation depth	3.3.5.2	2.2.12	Modulation depth	28 to 32%	1%	12 months
30 Hz modulation depth	3.3.5.3	2.2.15 to 2.2.18	Modulation depth	28 to 32%	1%	12 months
30 Hz modulation frequency	3.3.5.4	2.2.19	Frequency	30 Hz ±1%	0.06 Hz	12 months
9 960 Hz subcarrier frequency	3.3.5.5	2.2.20	Frequency	9 960 Hz ±1%	20 Hz	12 months
CVOR AM modulation of 9 960 Hz subcarrier	3.3.5.6	2.2.21	Modulation depth	≤5%	1%	12 months
DVOR AM modulation of 9 960 Hz subcarrier	3.3.5.6	2.2.22	Modulation depth	≤40%	1%	12 months
Sideband level of harmonics of 9 960 Hz	3.3.5.7	2.2.23	Modulation depth 2nd harmonic 3rd harmonic 4th and above	9 960 Hz = 0 dB ref. ≤ -30 dB ≤ -50 dB ≤ -60 dB	1 dB	12 months
Peak modulation of voice channel	3.3.6.2	2.2.24	Modulation depth	≤30%	1%	12 months
Audio frequency characteristics	3.3.6.3	2.2.25	Power	±3 dB	1 dB	12 months
Identification speed	3.3.6.5	2.2.27	Time	7 words/minute		12 months
Identification repetition	3.3.6.5	2.2.28	Time	≥2 times/min		12 months
Identification tone frequency	3.3.6.5	2.2.29	Frequency	1 020 ±50 Hz	10 Hz	12 months
Identification modulation depth With communications channel No communications channel	3.3.6.6	2.2.30	Modulation depth	≤10% ≤20%	1%	12 months
Speech effect on navigation function Deviation Modulation	3.3.6.7	2.2.26	Deviation Modulation		0.3% 1%	12 months
Bearing monitor	3.3.7.1	2.2.32	Deviation	±1.0°	0.3°	12 months
Modulation monitor	3.3.7.1	2.2.33	Volts	15%	1%	12 months
Spurious modulation	None	2.2.35	Modulation depth	≤0.5%	0.1%	12 months
Site infringement	None	2.2.36				12 months

Summary of flight inspection requirement – VOR

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measurand	Tolerance	Uncertainty	Inspection type
Rotation	3.3.1.1	2.3.4	Clockwise	Correct		C, P, S
Sensing	3.3.1.3	2.3.3	Correctness	Correct		C, P, S
Polarization	3.3.3.1	2.3.5	Deviation	$\pm 2.0^\circ$	0.3°	C, P, S
Pattern accuracy	3.3.3	2.3.9 to 2.3.11	Deviation	$\pm 2.0^\circ$	0.6°	C, P, S
Alignment		2.3.12		$\pm 3.5^\circ$	0.6°	
Bends		2.3.13		$\pm 3.0^\circ$	0.3°	
Roughness and scalloping		2.3.14		Flyable	Subjective	
Coverage	3.3.4	2.3.15 2.3.16	Field strength	90 μ V/m	3 dB	C
Modulation	3.3.5	2.3.17	Modulation depth	28 to 32%	1%	C, P, S
9 960 Hz modulation						
30 Hz modulation						
Voice channel	3.3.6.2	2.3.18	Clarity	Clear		C, P
Identification	3.3.6.5	2.3.20 2.3.21	Clarity	Clear		C, P
Speech effect on navigation	3.3.6.7	2.3.19	Deviation	No effect	0.3°	C, P
Bearing			Modulation		1%	
Bearing monitor	3.3.7.1	2.3.22 to 2.3.25	Deviation	$\pm 1.0^\circ$	0.3°	C
Reference checkpoint		2.3.26 to 2.3.27	As required			C, P
Standby power		2.3.28 to 2.3.29	Normal operation			C, P
Standby equipment		2.3.30	As required			C, P
Complementary facilities		2.3.31	As required			C, P

Legend: C = Commissioning
P = Periodic. Nominal periodicity is 12 months. Some States have extended this interval, particularly for DVORs, based on the improved immunity of the Doppler equipment to multipath interference. Intervals of up to 5 years are applied by some States.
S = Site proving

Summary of testing requirement – DME

Parameter	Annex 10, Volume I reference	Testing
Coverage	3.5.3.1.2	F
Accuracy	3.5.3.1.3	F
Transmitter		
Frequency stability	3.5.4.1.2	G
Pulse spectrum	3.5.4.1.3	G
Pulse shape	3.5.4.1.3	F/G
Pulse spacing	3.5.4.1.4	F/G
Peak power output	3.5.4.1.5	G
Variation of peak power in any pair of pulses	3.5.4.1.5.4	G
Pulse repetition frequency (PRF)	3.5.4.1.5	G
Receiver		
Frequency stability	3.5.4.2.2	G
Sensitivity (reply efficiency)	3.5.4.2.3	G
Bandwidth	3.5.4.2.6	G
Decoder		
Decoder rejection	3.5.4.3.3	G
Time delay	3.5.4.4, 3.5.4.5	G
Identification	3.5.3.6	F/G
Monitor	3.5.4.7.2	G

Legend: F = Flight test/inspection
G = Ground test

Summary of ground test requirement – DME

Parameter	Annex 10, Volume I reference	Doc 8071, Volume I reference	Measurement	Tolerance	Uncertainty	Periodicity
Transmitter						
— Frequency stability	3.5.4.1.2	3.2.4	Frequency	Assigned channel frequency, $\pm 0.002\%$	0.001%	12 months
— Pulse spectrum	3.5.4.1.3	3.2.5	Power	Output radiated within each 0.5 MHz band centred at ± 0.8 MHz from the nominal frequency is not more than 200 mW; output radiated within each 0.5 MHz band centred at ± 2 MHz from the nominal frequency is not more than 2 mW. Amplitude of successive lobes decreases in proportion to their frequency separation from the nominal frequency.	1 dB	6 months
— Pulse shape	3.5.4.1.3	3.2.6	Time, amplitude	Rise time $\leq 3 \mu\text{s}$ Duration $3.5 \mu\text{s}$, $\pm 0.5 \mu\text{s}$ Decay time $\leq 3.5 \mu\text{s}$ Amplitude, between 95% rise/fall amplitudes, $\pm 95\%$	0.1 μs 1%	6 months
— Pulse spacing	3.5.4.1.4	3.2.7	Time	X-channel: $12 \pm 0.25 \mu\text{s}$ Y-channel: $30 \pm 0.25 \mu\text{s}$	0.1 s	6 months
— Peak power output (see Note 1)	3.5.4.1.5	3.2.8	Power	Peak EIRP such that field density $\geq -89 \text{ dBW/m}^2$ at service volume limits	1 dB	6 months
— Peak variation	3.5.4.1.5.4	3.2.9	Power	Power difference between pulses of a pair $\leq 1 \text{ dB}$	0.2 dB	6 months
— Pulse repetition frequency	3.5.4.1.5.6	3.2.10	Rate	$\geq 700 \text{ pps}$	10 pulse pairs	6 months
Receiver						
— Frequency stability	3.5.4.2.2	3.2.11	Frequency	Assigned channel frequency, $\pm 0.002\%$	0.001%	6 months
— Sensitivity (see Note 2)	3.5.4.2.3.1	3.2.12	Power	Such that power density at antenna $\geq -103 \text{ dBW/m}^2$	1 dB	6 months
— Sensitivity variation with load	3.5.4.2.3.5	3.2.13	Power	$< 1 \text{ dB}$ for loadings between 0 and 90% of maximum transmission rate	0.2 dB	6 months
— Bandwidth	3.5.4.2.6	3.2.14		Such that sensitivity degrades $\leq 3 \text{ dB}$ for interrogation frequency drift of $\pm 100 \text{ kHz}$.	0.5 dB	6 months
Decoder	3.5.4.3	3.2.15	Count	No response to interrogations with pulse spacing more than $2 \mu\text{s}$ from nominal	10 pulse pairs	6 months
Time delay	3.5.4.4	3.2.16	Time	X-channel: $50 \mu\text{s}$ Y-channel: $56 \mu\text{s}$	1 μs	6 months
Identification	3.5.3.6	3.2.17	Identification	1 350 pulse pairs during key down periods proper Morse code sequence dot length = 0.1 to 0.16 s; dash = 0.3 to 0.48 s; spacing between dot and dash = dot length $\pm 10\%$; spacing between letters ≥ 3 dots total length of one code sequence ≤ 10 seconds	10 pulse pairs 10 μs 0.5 s	12 months
Monitor						
Monitor action	3.5.4.7.2.2	3.2.18	Time	Monitor alarms when: Reply delay varies by more than $1 \mu\text{s}$ ($0.5 \mu\text{s}$ for DME associated with a landing aid)	0.2 μs	12 months
Monitor action delay	3.5.4.7.2.5		Time	Delay ≤ 10 seconds	0.5 s	12 months

Notes:
1. Peak power output should be as set at commissioning.
2. Receiver sensitivity should be as set at commissioning.

Summary of flight test requirement – DME

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measured	Tolerance	Uncertainty	Inspection type (See Notes 1-3)
Coverage (see Note 4)	3.5.3.1.2	3.3.5 to 3.3.8	AGC Level	Signal strength such that field density ≥ -89 dBW/m ² at limits or operational requirements (see Note 4).	1 dB	S, C
Accuracy	3.5.4.5	3.3.9	Distance	≤ 150 m ≤ 75 m for DME associated with landing aids	20 m	S, C, P
Pulse shape	3.5.4.1.3	3.3.10	Time, Amplitude	Rise time ≤ 3 μ s Duration 3.5 μ s, ± 0.5 μ s Decay time ≤ 3.5 μ s Amplitude, between 95% rise/fall amplitudes, $\geq 95\%$ of maximum amplitude	0.1 μ s 1%	S, C, P
Pulse spacing	3.5.4.1.4	3.3.11	Time, Amplitude	X channel: 12 ± 0.25 μ s Y channel: 30 ± 0.25 μ s	0.05 μ s	S, C, P
Identification	3.5.3.6	3.3.13	Identification	Correct, clear, properly synchronised	N/A	S, C, P
Reply efficiency		3.3.14	Change in efficiency, position	Note areas where this changes significantly	N/A	S, C, P
Unlocks		3.3.15	Unlocking, position	Note where unlocking occurs	N/A	S, C, P
Standby equipment		3.3.16	Suitability	Same as primary transmitter	N/A	S, C, P
Standby power		3.3.17	Suitability	Should not affect transponder parameters	N/A	S, C, P

Notes:

1. Site proving tests (S) are usually carried out to confirm facility performance prior to final construction of the site.
2. Commissioning checks (C) are to be carried out before the DME is initially placed in service. In addition, re-commissioning may be required whenever changes that may affect its performance (e.g. variations or repairs to the antenna system) are made.
3. Periodic checks (P) are typically made annually.
4. The uncertainty of 1 dB in coverage refers to the repeatability of equipment calibration, not to absolute accuracy.

Summary of test requirement – NDB

Parameter	Annex 10, Volume I, reference	Testing
Identification	3.4.5.1, 3.4.5.2, 3.4.5.3	F/G
Voice		F
Rated coverage	3.4.2	F
Airway coverage	3.4.2	F
Holding pattern, approach procedures (where applicable)		F
Station passage		F
Standby equipment		F/G
Carrier frequency	3.4.4.2	G
Antenna current		G
Field strength	3.4.2.1	F
Modulation depth	3.4.6.2	G
Modulation frequency	3.4.5.4	G
Modulation depth of power supply frequency components	3.4.6.5	G
Carrier level change during modulation	3.4.6.4	G
Audio distortion		G
Monitor system (see Note)		G
a) Antenna current or field strength	3.4.8.1 a)	
b) Failure of identification	3.4.8.1 b)	

Note.— When the monitor is remotely located, it measures the field strength rather than the antenna current.

Legend: F = Flight test/inspection
G = Ground test

Summary of ground test requirement – NDB

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measured	Tolerance	Uncertainty	Periodicity
Carrier frequency	3.4.4.2	5.2.3	Frequency	±0.01% (±0.005% for power >200 W at frequencies above 1 606.5 kHz)	0.001%	1 year
Antenna current		5.2.4	RF amperes	+30% of value set at commissioning	4%	6 months
Modulation depth	3.4.6.2	5.2.5	Depth, per cent	85% to 95%	2%	6 months
Modulation frequency	3.4.5.4	5.2.6	Audio frequency	1 020 ±50 Hz 400 ±25 Hz	5 Hz	6 months
Modulation depth of power supply frequency components	3.4.6.5	5.2.7	Modulation depth, per cent	Less than 5% modulation depth	1%	6 months
Carrier level change during modulation	3.4.6.4	5.2.9	Signal strength	Less than 0.5 dB (1.5 dB) for beacons with less (greater) than 50-mile coverage	0.1 dB rel. modulation	6 months
Identification	3.4.5.2, 3.4.5.3		Keying	Clearly audible, proper keying, correct coding		
Audio distortion		5.2.10	Modulation depth	10% distortion maximum		As required
Monitor system		5.2.11	RF current or field strength keying	Alarm for 3 dB decrease (see Note) Alarm for loss of or continuous modulation	1 dB	6 months
a) Antenna current or field strength	3.4.8.1 a)					
b) Failure of identification	3.4.8.1 b)					

Note.— Certain States have a monitor system which also alarms for a 2 dB increase in radiated power.

Summary of flight test requirement – NDB

Parameter	Annex 10, Volume I, reference	Doc 8071, Volume I, reference	Measurement	Tolerance or purpose of flight check	Uncertainty	Dispositive type
Identification	3.4.5.1	5.3.3	Keying	Clearly audible, proper keying, correct coding to the limit of coverage.		C, P
Voice		5.3.4		Clearly audible and free from interference to the limit of coverage.		C, P
Rated coverage	3.4.2	5.3.7	Signal strength or bearing	The minimum signal strength as required for the particular geographical area ADF needle oscillations not to exceed +10 degrees throughout the specified coverage area. See Note 3.	3 dB 2 degrees	C
Airway coverage	3.4.2	5.3.9	Bearing	ADF needle oscillations not to exceed +10 degrees to the limit of coverage specified for the airway. See Note 3.	2 degrees	C, P
Holding pattern, approach procedures (where applicable)		5.3.11	Bearing	Adequate flyability, needle oscillations not to exceed ±5 degrees, with no erroneous reversals giving false impression of station passage. See Note 3.	2 degrees	C, P
Station passage		5.3.12		Absence of any tendency for false station passage or excessive ADF needle oscillation.		C, P
Standby equipment		5.3.13		Same tolerances as main equipment.		See 5.3.13

Notes:

- Commissioning checks (C) are to be carried out before the NDB is initially placed in service. In addition, special checks that include most or all of those required for commissioning may be required whenever changes that may affect its performance, such as a different antenna system, frequency change, etc., are made to the NDB.
- Periodic checks (P) are typically made annually. In some cases, e.g. locator beacons used in a low approach procedure, more frequent checking may be found desirable. Locator beacons associated with an ILS facility can be checked coincident with the ILS routine check.
- External and aircraft noise sources as well as terrain/features routinely affect NDB cross-pointer accuracy. Although tolerances are shown for airways, approaches, and holding patterns, it is not necessary to restrict or remove from service an NDB solely because it provides momentary out-of-tolerance needle oscillations that are brief, relative to the intended procedural use. As long as bearing errors greater than the listed tolerances are generally oscillatory in nature rather than one-sided, and have durations less than 4 seconds for approaches and 8 seconds for airways and holding patterns, the NDB may be considered acceptable. (These time periods apply to each occurrence of oscillatory out-of-tolerance needle activity.)

Appendix III

Requirements for power supply switch-over times for RADIO NAVIGATIONAL AIDS

(As per Requirement 2.9.1)

Power Supply switch-over times for ground-based radio aids used in the vicinity of aerodromes

Power supply switch-over times for ground-based radio aids used at aerodromes		
Type of Runway	Aids requiring	Maximum switch-over times (seconds)
Instrument approach	VOR	15
	NDB	15