1. Objective

1.1. This directive is part of the CNS inspector handbook.

1.2. This directive provides guidance for evaluating and approving Conventional and Doppler VHF Omni-Directional (CVOR/DVOR) Navigation Radio Stations.

2. General

2.1. Under article 35(a) to the Israeli Air Navigation Law 2011 any navigation aid is required to have CAAI approval before being established or used.

2.2. Navigation Radio Station is specifically included in the definition of navigation aids in Article 1 to the ANL, 2011.

2.3. This document sets out the requirements for approval of CVOR/DVOR Navigation Radio Stations established or used within Israel to provide air traffic services.

2.4. Abbreviations

ANL	-	Air Navigation Law
ANR	-	Air Navigation Regulations
ATC	-	Air Traffic Control
ANS	-	Air Navigation Service
ATS	-	Air Traffic Service
DOC	-	Designated Operational Coverage
VHF	-	Very High Frequency

3. Reference Material ,Form& Job-Aids

3.1. Law & Regulation

3.1.1. ANL 2011 articles 35(a) & 27(a) & 29

3.1.2. ANR (Operation of Aircraft and Rules of Flight), 1981 – Reg 66(c).

3.1.3. ANR (Safety at Aerodromes of the Airport Authority), 1992 – Reg 3.

3.2. CAAI AP

3.2.1. AP 1.7.005 / 2.7.005 - ATS equipment installation, maintenance, operation & approval

3.3. ICAO Annexes & documents

3.3.1. ICAO Annex 10 Aeronautical Telecommunications Volume I- Radio Navigation Aids.

3.3.2. ICAO Annex 10 Aeronautical Telecommunications Volume V (Aeronautical Radio Frequency Spectrum Utilization).

3.3.3. ICAO Annex 11 Air Traffic Services.

3.3.4. ICAO Doc 8071 Volume I – Testing of Ground-Based Radio Navigation System

3.3.5. ICAO Doc 7192 - Training Manual Part E-2 Air Traffic Safety Electronics Personnel (ATSEP)

Note: This document incorporates the relevant SARPs from ICAO Annex 10 and Annex 11 together.

3.4. Forms & Job-Aids

3.4.1. CAAI Form ANSF 1.7.005-1 -Navigational Aid (NAVAID) Data Form

4. Process

4.1. Technical Requirements

This document sets out the Engineering Requirements for all Conventional and Doppler VHF Omni-Directional Range Beacons (CVOR/DVOR) intended for use in the provision of an ATS.

4.1.1. Safety objective

The Beacon system does not radiate a signal which falls outside standard operating tolerances or provide false guidance over its Designated Operational Coverage area (DOC).

4.1.2. General Requirements

4.1.2.1 SARPs Compliance

In addition to the requirements below, VOR beacon systems shall comply with the SARPs in ICAO Annex 10 Volume 1 Chapter 2 General Provisions for Radio Navigation Aids and Chapter 3 Section 3.3 Specification for VHF Omnidirectional Radio Range (VOR).

4.1.2.2 Radio Spectrum Management

4.1.2.2.1. The equipment and systems shall be installed, operated and maintained in compliance with the terms of specific location dependent or general frequency assignment(s) and the terms and conditions of the Approval granted in respect of the ATS being provided.

4.1.2.2.2. The DOCs associated with the frequency assignments for ATS Communications Facilities and Radio Navigation and Landing Aids at aerodromes, shall be published in the Remarks column of sections AD of the AIP respectively

4.1.2.2.3. Frequencies for En-route Navigation Facilities shall have their DOCs published in the AIP section ENR under the associated Remarks column.

4.1.2.2.4. All Aeronautical Radio Stations shall be suitably licensed by the ministry of communication.

4.1.2.2.5. Failure to renew the ministry of communication radio license will invalidate the associated CAAI Approval and the associated frequency assignment will be withdrawn. Renewal after the withdrawal of the ministry of communication radio license will be treated as a new application.

4.1.2.2.6. For new installations that operate on aeronautical frequency assignments, initial applications to establish an Aeronautical Radio Station shall be made to the CAAI, which will trigger the process with the ministry of communication.

4.1.2.2.7. All frequency assignments shall be coordinated and registered in ICAO data base.

4.1.2.2.8. In areas where new VOR installations are implemented and are assigned frequencies spaced at 50 kHz from existing VORs in the same area

4.1.2.2.9. The variable and reference phase modulation frequencies shall be 30 Hz within plus or minus 1 per cent.

4.1.2.2.10. The subcarrier modulation mid-frequency shall be 9 960 Hz within plus or minus 1 per cent.

4.1.2.2.11. For the conventional VOR, the percentage of amplitude modulation of the 9960 Hz subcarrier shall not exceed 5 per cent.

4.1.2.2.12. For the Doppler VOR, the percentage of amplitude modulation of the 9960 Hz subcarrier shall not exceed 40 per cent when measured at a point at least 300 m (1000 ft.) from the VOR.

Recommendation - The field strength or power density in space of VOR signals required to permit satisfactory operation of a typical aircraft installation at the minimum service level at the maximum specified service radius should be 90 microvolts per meter or minus 107 dBW/m^2

4.1.2.2.13. Inspection of Aeronautical Radio Stations - The equipment and systems at aeronautical radio stations and associated records shall be inspected by CAAI Inspector.

4.1.2.2.14. Demonstration of compliance will be required. This may include measurements to verify transmitter frequency, modulation depth, transmitter output power and a determination of effective radiated power. The ATS Provider is expected to provide this information.

4.1.2.2.15. The equipment shall transmit only on the frequency assigned by the CAAI and as appears in the schedule to the radio license issued under the Wireless Telegraphy order (1972).

4.1.2.3 Coverage of the VOR.

The DOC will be determined as part of a standard flight check during the commissioning of the VOR.

4.1.2.4 Identification

4.1.2.4.1. The identification signal shall employ the International Morse Code and consist of two or three letters.

4.1.2.4.2. The Identification shall be suppressed when the VOR is not available for operational purposes, e.g. under maintenance.

Note: The normal identity code may be radiated for short periods during maintenance or flight inspection as necessary.

4.1.2.5 **Speech Modulation**

With the exception of ATIS, no other voice communication channel shall be transmitted via the VOR system

4.1.2.6 **Standby Power**

Standby power supplies shall be provided commensurate with the service being supported.

4.1.2.7 **Status Information**

4.1.2.7.1. ATC directly responsible for approach, landing and take-off at the aerodrome(s) with which they are concerned shall be provided with information on the operational status of radio navigation services, on a timely basis, consistent with the use of the service(s) involved

4.1.2.7.2. Where status information is reliant upon a visual status indicator, then an audible alarm should be provided which indicates that the visual indicator has changed state.

4.1.2.8 **Monitoring**

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

- a change in excess of 1 degree at the monitor site of the bearing information transmitted by the VOR;
- a reduction of 15 per cent in the modulation components of the radio frequency signals voltage level at the monitor of either the subcarrier, or 30 Hz amplitude modulation signals, or both.

4.1.2.8.2. Failure of the monitor itself shall transmit a warning to a control point and either:

- remove the identification and navigation components from the carrier; or
- cause radiation to cease.

4.1.2.9 **Communications Availability**

Adequate safety assurance, risk assessment and mitigation shall be performed by the Service Provider to ensure that the equipment and system design, installation, operation and maintenance ensures availability of communications appropriate for the Air Traffic Services and environment in which it is being provided.

4.1.2.10 **Ground testing**

Ground testing shall be carried out in accordance with the requirements in paragraph 4.2.

4.1.2.11 **Flight Inspection**

Flight inspection shall be carried out in accordance with the requirements in paragraph 4.3.

4.2. VOR Ground testing Types and Requirements

Ground test requirements are listed in Table I.

Table I - Summary of ground test requirements - VOR

Parameter	Annex 10 Volume I Reference	Doc 8071 Volume I Reference	Measured	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°	0.3°	12 months
Pattern accuracy	3.3.3.2	2.2.7 2.2.8	Alignment	±2°	0.4°	12 months
Coverage	3.3.4	2.2.9	Field strength	90 μV/m	3 dB	12 months
9960 Hz deviation	3.3.5.1	2.2.11	Ratio	16 ±1		
9960 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
9960 Hz subcarrier frequency	3.3.5.5	2.2.20	Frequency	9960 Hz ±1%	20 Hz	12 months
CVOR AM modulation of 9960 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 9960 Hz	3.3.5.6	2.2.23	Modulation depth 2nd harmonic 3rd harmonic 4th and above	9960 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

Table I - Summary of ground test requirements - VOR

Parameter	Annex 10 Volume I Reference	Doc 8071 Volume I Reference	Measured	Tolerance	Uncertainty	Periodicity
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	1020 ±50 Hz	10 Hz	12 months
Identification modulation depth	3.3.6.6	2.2.30	Modulation depth		1%	12 months
With communications channel				≤10%		
No communications channel				≤20%		
Speech effect on navigation function						12 months
Deviation			Deviation		0.3%	
Modulation			Modulation		1%	
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

4.2.1. Ground test procedures

The VOR should be inspected in accordance with the manufacturer's recommended procedures. The following procedures provide guidance for testing of VOR specific parameters specified in Annex 10, Volume I. The manufacturer's procedures should include at least these tests.

4.2.2. Rotation

Correct rotation should be confirmed. This can be performed during the measurement of a ground error curve to determine antenna pattern accuracy.

4.2.3. Sensing

Correct sensing should be verified by checking a radial other than 0^{O} or 180^{O}.

4.2.4. **Pattern accuracy**

4.2.4.1 A ground check is a means for determining course alignment errors. The actual courses produced by the VOR are compared (using monitor circuits) with simulated courses produced by a VOR test generator. Data recorded during the ground check are used to prepare a ground check error curve. Establishment of a ground check capability will enable maintenance personnel to restore a VOR to normal operation, following most repairs to the facility without a flight inspection. It is desirable to maintain the ground check error curve (maximum positive error to maximum negative error) within approximately 2.0°. If the facility cannot provide this level of performance, a broader value should be considered. The stability of the error curve spread is considered more important to the facility performance analysis than the magnitude of the error spread.

- Example of procedure for conducting a ground check for a conventional VOR:
  - a) Place a field detector into the 0° positioner bracket and feed signals to the monitor in the normal manner.
  - b) Rotate the azimuth selector of the monitor for an “on course” indication (reference and variable signals in phase).
  - c) Substitute signals from the test generator. This can be accomplished by temporarily switching the field detector and test generator cables.
  - d) Without changing monitor adjustments, rotate the test generator dial until an “on course” is again established. Read and record test generator dial reading. The difference between the dial reading of the test generator and the location of the field detector is the amount of course error at that location.
  - e) Repeat steps a) through d) for all bracket locations.
- Plot a ground check error curve (amount of error versus azimuth) on rectangular co-ordinate graph paper.

Note 1.- Positioner brackets are installed on the edge of the counterpoise at every 22.5 ± 0.1° beginning at 0 °. Alternatively, brackets could be mounted on poles appropriately spaced around the facility.

Note 2.- Course error is either plus or minus. Plus error means the course is clockwise from where it should be, minus error means the course is counterclockwise from where it should be.

Note 3.- An alternative method is to rotate the antenna through 360E and to plot the antenna characteristic from a single field monitor against the rotation angle.

4.2.4.2 Establishment of reference curve at commissioning. It is desirable to prepare a reference ground check error curve immediately following the commissioning flight inspection. This curve is no different from that described above except that it is an average of three separate ground checks conducted on the same day, if possible. The reference error curve serves as a standard for comparing subsequent ground checks. The reference error curve is updated whenever courses are realigned during a flight inspection.

4.2.5. Coverage

The coverage of the facility is established at the commissioning flight inspection. The standard operating condition of the facility should be established at this time including the carrier power level. Measure the RF power output using the wattmeter in accordance with the procedure in the equipment instruction book. Compare the level measured with the established standard operating condition at the periodic test.

4.2.6. Modulation

The preferred method is the use of a modulation meter. If a modulation meter is not available, an oscilloscope may be used instead.

4.2.6.1 9960 Hz deviation

4.2.6.1.1. The deviation in a CVOR may be measured at the output of the FM modulation stage or by direct measurement of the radiated signal using a modulation analyzer. The deviation is determined using an oscilloscope by displaying the 9 960 Hz signal and measuring the difference, Δt, in periods between the minimum frequency (9960 Hz - 480 Hz) and the maximum frequency (9960 Hz + 480 Hz). The modulation index is determined by the following equation:

Modulation Index = $\Delta t / 60T^2$

Where T = 1/9960

4.2.6.1.2. In a DVOR, the deviation of the 9960 Hz subcarrier is determined by the rotation speed of the switched antennas and the physical characteristics of the array.

4.2.6.2 9960 Hz modulation depth of the radio frequency carrier

4.2.6.2.1. The CVOR 9960 Hz modulation depth of the carrier frequency can be measured by directly using a modulation meter, modulation analyzer, or an oscilloscope. All other modulation should be inhibited unless the characteristics of the modulation analyzer allow individual separation of the modulating signals.

4.2.6.2.2. In the oscilloscope method, a portion of the RF carrier (modulated by one frequency at a time) is coupled to the oscilloscope synchronized at the modulating frequency.

4.2.6.2.3. An amplitude modulated waveform is produced from which the high (Emax) and low (Emin) points are measured. These values may be substituted in the following formula and the modulation percentage determined.

$$M = \frac{\text{Emax} - Emin}{\text{Emax} + Emin}\ x\ 100\%$$

4.2.6.2.4. The modulation of the carrier for a DVOR is achieved in space by the combination of the reference signal and the switched 9960 Hz variable signal. The modulation depth should be checked using a signal derived from a field monitor. A tuned modulation analyzer is required due to the lower signal strength available

4.2.6.3 <u>30 Hz modulation depth of the radio frequency carrier</u>

4.2.6.3.1. The CVOR variable signal modulation level (space modulation) is a function of the ratio of sideband energy to carrier energy radiated. The procedure in the equipment instruction book should be followed for adjusting the variable signal modulation level because different means (i.e. antenna systems) are employed in producing the rotating figure-of-eight radiation pattern.

4.2.6.3.2. A procedure for adjusting the variable signal level that can be adapted to most VOR facilities is as follows:

a) Stop rotation of the figure-of-eight pattern.

b) Measure and record the relative field intensity (using monitor field intensity meter indications) at the two maximum field intensity points (180 ^{O} apart) in the figure-of-eight radiation pattern. One of these points will be in-phase (Max) and the other out-of-phase (Min) with the carrier RF energy.

c) Compute the modulation percentage by substituting the Max and Min quantities obtained by applying b) above in the formula in 4.2.6.2.3.

d) Vary sideband power until the desired modulation level is attained.

4.2.6.3.3. Accuracy will require corrected field intensity readings obtained from a calibration curve (transmitter power output versus field detector meter indication) either furnished with the equipment or prepared by field maintenance personnel. The final setting of the 30 Hz variable signal level (course width) is determined by flight inspection.

4.2.6.3.4. DVOR carrier modulation depth by the 30 Hz can be measured directly using a modulation meter, modulation analyzer, or an oscilloscope. All other modulation should be inhibited unless the characteristics of the modulation analyzer allow individual separation of the modulating signals.

4.2.6.4 CVOR AM modulation of 9960 Hz subcarrier

Observe the 9960 Hz subcarrier using an oscilloscope at the output of the FM modulator or after detection from a field monitor. Use the method described above to determine the AM modulation of the subcarrier with all other modulation off.

4.2.6.5 DVOR AM modulation of 9 960 Hz subcarrier

Observe the composite signal with an oscilloscope connected to a test receiver or monitor and all other modulation off. Determine the percentage of amplitude modulation using the method described above.

Note - The limit for AM on the subcarrier in the far field, further than 300 m (1000 ft.) away, is less than 40 per cent. This limit corresponds to a limit of 55 per cent when the signal from a monitor antenna at the 80 m (260 ft.) distance is used. Refer to the manufacturer's equipment instruction book for additional guidance on particular equipment.

4.2.6.6 Sideband level of the harmonics of the 9960 Hz component

The level of the 9960 Hz harmonics can be determined by using a spectrum analyzer and observing the radiated signal of the VOR from a field monitor probe. CVOR measurements can also be made at the antenna feed point of the reference signal.

4.2.7. **Voice channel**

4.2.7.1 Peak modulation of voice channel.

Connect an audio generator set to the nominal line level to the audio input of the VOR. Measure the peak modulation using a modulation meter or the oscilloscope method described above.

4.2.7.2 Audio frequency characteristics.

Select a frequency of 1000 Hz using an audio generator and establish a reference modulation level. Maintain the same output level from the audio generator and vary the audio frequency between 300 Hz and 3000 Hz noting the modulation characteristics over the range.

4.2.7.3 Speech effect on normal navigation function.

Operate the VOR in normal mode with all navigation modulation present. Apply the normal audio program and observe the station monitor for any effect on the navigation performance

4.2.8. **Identification**

4.2.8.1 Speed.

Observe the identification signal envelope using an oscilloscope. The code transmission speed can be established by measuring the period of a “dot”.

4.2.8.2 Repetition.

The repetition rate can be established by counting the repetition of the code cycle over a fixed period or by measuring the time required for the completion of several cycles.

4.2.8.3 Tone.

The identification tone can be measured directly using a frequency counter.

4.2.8.4 Modulation depth.

Measure the modulation depth using a modulation meter or the oscilloscope method with the identification tone continuously on and no other modulation present.

4.2.9. Monitoring

Two methods are available to test the monitor performance. The first method is the simulation of the monitor input signal by the use of test equipment; and the second method is the adjustment of the transmitter to provide the required test signals. The use of discrete test equipment is the preferred method. Additional monitors may be provided in different equipment types. The manufacturer's test procedures should be followed in such cases.

4.2.9.1 Bearing.

Generate a VOR signal that equates to the monitored radial. Vary the phase of the variable signal relative to the reference signal to generate a positive and negative bearing alarm. Record the phase difference.

4.2.9.2 Modulation.

Apply a standard monitor input signal and vary the modulation of the 9960 Hz and the 30 Hz signals to cause alarm conditions for either or both of the navigation tones.

4.2.10. Polarization

This parameter is normally measured by flight inspection, but may be measured on the ground if suitable equipment is available.

4.2.11. Spurious modulation

Spurious (unwanted) modulation should be as low as possible (0.5 per cent or less) to prevent possible course errors. This modulation level may be determined by comparing AC voltage indications required to produce a known modulation level (only one modulation frequency applied) with the AC voltage indications, while audio input level controls (1020 Hz, 10 kHz, and voice) are adjusted to zero. The modulation output meter may be used for these readings. Record the modulation value obtained.

4.2.12. Site infringement

The site surrounding the VOR should be inspected at each maintenance visit for infringements of the clear area surrounding the facility.

4.2.13. Maintenance activities that require flight inspection

4.2.13.1 Flight inspection is not required for all maintenance procedures or modifications to the transmitting and monitoring equipment if field measurement and monitoring indications can be restored to the conditions that existed at commissioning or during the last satisfactory flight test.

4.2.13.2 A flight test is required in the following situations before returning the VOR to service:

a) Realignment of magnetic north reference;
b) Replacement of the antenna;
c) Repositioning the field monitor antenna;
d) Replacement of transmission lines of critical length;
e) Change of operating frequency; and
f) Environmental changes.

4.3. **VOR Flight Inspection Types and Requirements**

4.3.1. It is a requirement that all VOR systems and associated Instrument Flight Procedures are checked by flight inspection at prescribed intervals.

4.3.2. Flight inspection ensures that the VOR provides an accurate and uncorrupted source of guidance information within the DOC.

4.3.3. Flight test requirements are listed in Table II

Table II - Summary of flight inspection requirements – VOR

Parameter	Annex 10 Volume I Reference	Doc 8071 Volume I Reference	Measured	Tolerance	Uncertainty	Inspection type (See Notes 1-3)
Rotation	3.3.1.1	2.3.4	Clockwise	Correct		S, C, P
Sensing	3.3.1.3	2.3.3	Correctness	Correct		S, C, P
Polarization	3.3.3.1	2.3.5	Deviation	±2°	0.3°	S, C, P
Pattern accuracy						S, C, P
Alignment		2.3.9-2.3.11		±2°	0.6°	
Bends		2.3.12		±3.5°	0.6°	
Roughness and Scalloping		2.3.13		±3°	0.3°	
Flyability		2.3.14		Flyable	Subjective	
Coverage	3.3.4	2.3.15 2.3.16	Field strength	90 µV/m *(–107 dBW/m²)*	3 dB	C
Modulation	3.3.5	2.3.17		25 to 35%	1%	S, C, P
9960 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		No effect		C, P
Bearing			Deviation		0.3°	
Modulation			Modulation		1%	
Bearing monitor	3.3.7.1	2.3.22 to 2.3.25	Deviation	±1.0°	0.3°	C
Reference checkpoint		2.3.26 to 2.3.27	As required			C, P

Table II - Summary of flight inspection requirements – VOR

Parameter	Annex 10 Volume I Reference	Doc 8071 Volume I Reference	Measured	Tolerance	Uncertainty	Inspection type (See Notes 1-3)
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

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 VOR 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.

4.3.4. Measurement Method

4.3.4.1 A checkpoint shall be selected during the commissioning inspection at a point in space where the signal is stable. This checkpoint shall be used in establishing course alignment, 30 Hz Modulation Depth, 9960Hz Modulation Depth and Field Strength to be recorded on the Flight Inspection report.

4.3.4.2 The position of the reference checkpoint should be recorded in terms of azimuth, distance from the facility, and the mean sea level (MSL) altitude.

4.3.5. Rotation

Begin an orbit. The radial bearing as indicated should continually decrease for a counterclockwise orbit, or increase for a clockwise orbit. Sensing should be checked before rotation. Incorrect sensing might cause the station rotation to appear reversed.

4.3.6. Sensing

This check is required at the beginning of the flight inspection and need not be repeated. The bearing of the aircraft from the station must be known. Select an appropriate radial and when the cross-pointer is centered, the indicator should indicate "FROM".

4.3.7. Polarization

4.3.7.1 The polarization effect results from vertically polarized RF energy being radiated from the antenna system.

4.3.7.2 The vertical polarization effect shall be checked when flying a radial at a distance of 18.5 to 37 km (10 to 20 NM). The aircraft should be rolled to a 30 degree bank, first to one side, then to the other, and returned to a straight level flight. Track and heading deviations should be kept to a minimum. Course deviation, as measured on the recording, is the indication of vertical polarization effect.

4.3.8. Alignment

4.3.8.1 The mean alignment shall be determined by flying a 360 degree orbit or by flying a series of radials. The altitude selected for the flight should place the aircraft in the main lobe of the VOR.

4.3.8.2 The orbit should be flown at a height and range that allows the position reference system to accurately determine the position of the aircraft.

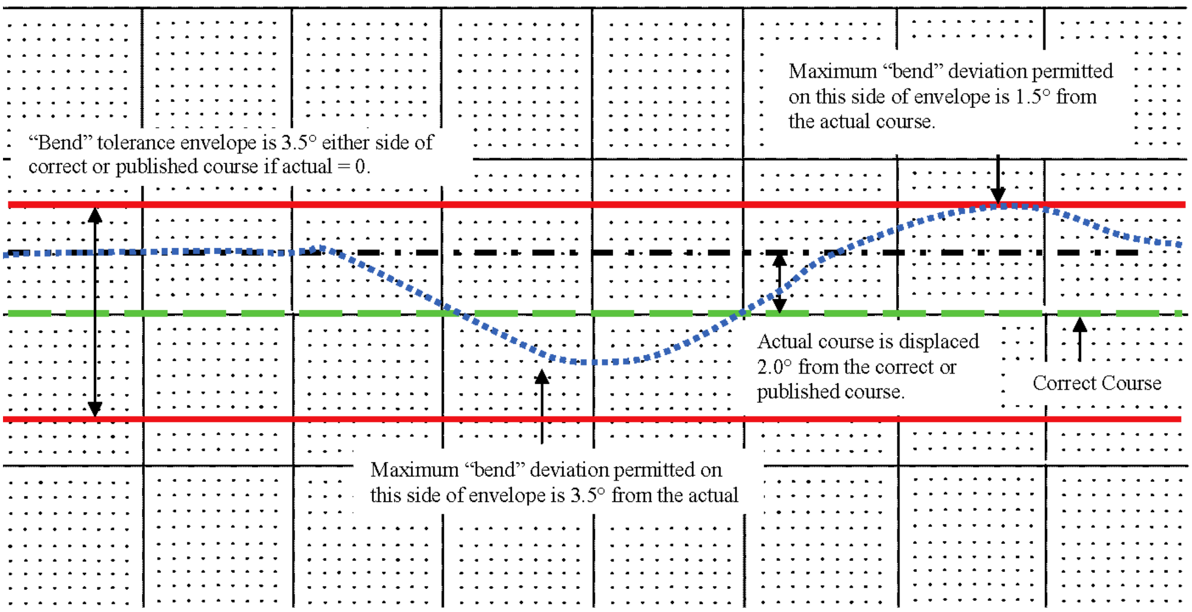
4.3.8.3 Alignment shall be recorded at the reference check point.

4.3.9. Bends

4.3.9.1 A bend is determined by flying a radial pattern and comparing the indicated course against a position reference system. The error is measured against the correct magnetic azimuth of the radial. Deviations of the course due to bends should not exceed 3.5° from the computed average course alignment and should remain within 3.5° of the correct magnetic azimuth.

4.3.9.2 Bends shall be determined on all flown radials.

(Example – not drawn to scale)



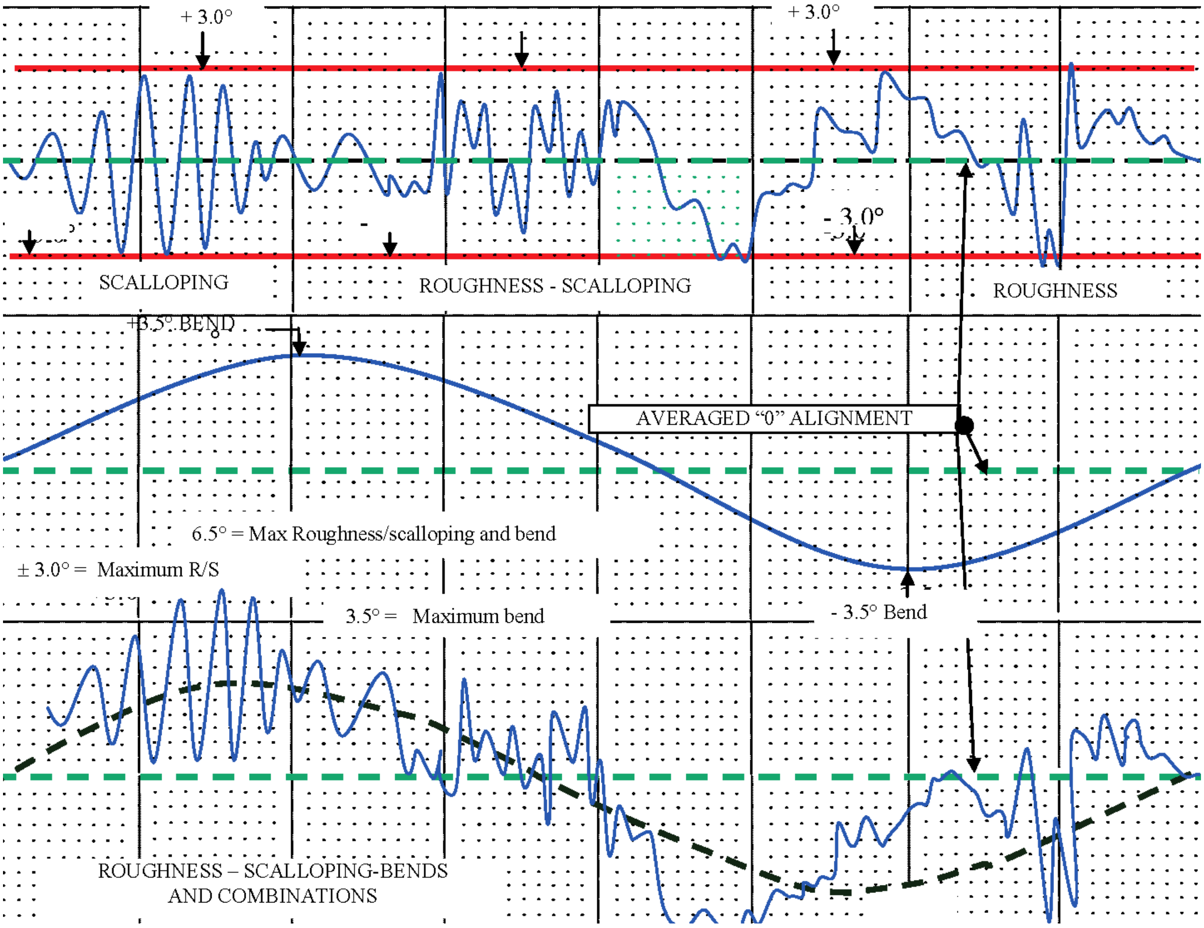
4.3.10. **Roughness and Scalloping**

4.3.10.1 Scalloping is a cyclic deviation of the course line. The frequency is high enough so that the deviation is averaged out and will not cause aircraft displacement.

4.3.10.2 Roughness is a ragged irregular series of deviations. Momentary deviations of the course due to roughness, scalloping or combinations thereof should not exceed 3.0º from the average course.

4.3.10.3 Roughness and Scalloping shall be determined on all flown radials

(Example – not drawn to scale)



4.3.11. **Flyability**

Flyability is a subjective assessment by the pilot flying the inspection. Assessment of flyability should be performed on operational radials and during procedures based on the VOR

4.3.12. **Coverage**

4.3.12.1 Coverage of the VOR is the usable area with in the operational service volume and is determined during the various checks of the VOR. Additional flight checks are required to determine the distance from the facility at which satisfactory coverage is obtained at the specified altitudes.

4.3.12.2 Measured as close to the edge of DOC as possible whilst flying either a radial or an orbit.

4.3.12.3 Field strength shall be recorded at the reference check point.

4.3.13. Modulation 30 Hz and 9960 Hz

4.3.13.1 The modulation of the 30 Hz reference, 30 Hz variable and 9 960 Hz subcarrier should be measured during the flight inspection. Note that the roles of the FM and AM signals are reversed between the CVOR and the DVOR.

4.3.13.2 The mean modulation depth shall be determined by flying a 360 degree orbit of the VOR. The altitude selected for the flight should place the aircraft in the main lobe of the VOR.

4.3.13.3 Modulation shall be recorded at the reference check point

4.3.14. Voice

4.3.14.1 Voice communications on the VOR frequency should be checked for clarity, signal strength, and effect on the course structure in the same manner as described for identification checks. The audio level of voice communications is the same as the level of the voice identification feature.

4.3.14.2 Speech effect on normal navigation functions.

Observe the indicated bearing information during a stable approach flight and determine if the bearing information is affected by the voice transmission.

4.3.14.3 Checked as close to the edge of DOC whilst flying either a radial or an orbit

4.3.15. Identification

4.3.15.1 The identification signal should be inspected for correctness, clarity, and possible detrimental effect on the course structure. This check should be performed while flying on-course and within radio line-of-sight of the station.

4.3.15.2 Observe the course recording to determine if either code or voice identification affects the course structure.

4.3.15.3 If course roughness is suspected, the identical track should be flown again with the identification turned off.

4.3.15.4 Maintenance personnel should be advised immediately if it is determined that the course characteristics are affected by the identification signal.

4.3.15.5 Checked as close to the edge of DOC whilst flying either a radial or an orbit.

4.3.16. **Bearing monitor**

4.3.16.1 The requirements for checking the monitor are as follows:

4.3.16.1.1. During commissioning inspections; and

4.3.16.1.2. During subsequent inspections, if the alignment at the reference checkpoint has changed more than one degree from the alignment last established and the monitor has not alarmed.

4.3.16.2 The check is made over the reference checkpoint at the same altitude as that used to establish the reference checkpoint. Position the aircraft inbound or outbound and activate the event mark exactly over the checkpoint while the following course conditions exist:

4.3.16.2.1. With the course in the normal operating condition;

4.3.16.2.2. With the course shifted to the alarm point;

4.3.16.2.3. With the course shifted to the alarm point to the opposite direction from 4.3.16.2.2 above; or

4.3.16.2.4. With the course returned to the normal operating condition.

4.3.16.3 The course alignment should be compared, in each of these conditions, by reference to the recordings to determine the amplitude of shift to the alarm point and to verify the return to normal.

4.3.16.4 Check both transmitters in the same manner when dual monitors are installed. Both should be checked on a systematic basis. Follow the procedure for single monitor check above, except in steps 4.3.16.2.2 and 4.3.16.2.3 the course should be shifted in each direction until both monitors alarm. Determine the amplitude of course-shift required to alarm both monitors.

4.3.17. **Reference checkpoint**

4.3.17.1 A checkpoint should be selected during the commissioning inspection on or close to the monitor radial (usually 090 or 270 degrees) and located within 18.5 to 37 km (10 to 20 NM) of the antenna. This checkpoint should be used in establishing course alignment and should serve as a reference point for subsequent inspections of alignment, monitors, course sensitivity and modulation measurements. Course alignment and sensitivity should normally be adjusted with reference to this checkpoint. Adjustments made elsewhere will require a recheck of these parameters at this reference checkpoint.

4.3.17.2 The flight inspector should record a description of the reference checkpoint that includes the azimuth to the nearest tenth of a degree, the distance from the facility, and the mean sea level (MSL) altitude, which is usually 460 m (1500 ft.) above the antenna. This data should be revised any time the reference checkpoint is re-established. The final course alignment error, measured at the reference checkpoint, should be recorded on the facility data sheet for subsequent reference in order to determine the necessity for a complete monitor check.

4.3.18. **Standby power**

4.3.18.1 Standby power, when installed, should be checked during the commissioning inspection. This is not necessary for some types of standby power installations, e.g. float-charged battery supplies where there is no possibility of performance variation when operating on standby power.

4.3.18.2 Subsequent inspections should not be required unless there is reported evidence of facility deterioration while this source of power is in use.

4.3.18.3 The following items should be evaluated while operating on standby power:

4.3.18.3.1. Course alignment (one radial);

4.3.18.3.2. Course structure; and

4.3.18.3.3. Modulations.

4.3.18.4 The inspections are to be performed when flying a portion of a radial with the station operating on normal power, and then repeating the check at the same altitude and over the same ground track with the station operating on standby power.

4.3.19. **Standby equipment**

Both transmitters should be checked against each required item of Table I. These checks may be performed using radial flights and a single alignment orbit.

4.3.20. **Complementary facilities**

Facilities associated with the VOR that complement operational use (such as DME, lighting aids that support the visibility minima of an approach procedure, communications, etc.) should be inspected concurrently with the VOR and in accordance with applicable procedures.

4.3.21. **Evaluation of operational procedures**

The following table gives details of the operational procedures & Profiles, which shall be checked.

Profile	Commissioning	Routine
	Transmitter to be checked	
Radials	1 or 2	1 or 2
Intersections	1 or 2 as required	None

** For routine inspection of dual transmitter Doppler VORs, where it can be demonstrated that the alignment error between the transmitters is small i.e. <=0.5 degrees, then only one transmitter needs to be checked.

* Flight inspection of cross-check radials is not required provided there is sufficient flight inspection data to support the use of those radials.

4.3.22. **Radials**

4.3.22.1 Commissioning flights

4.3.22.1.1. Radials used, or proposed for use, for IFR should be inspected to determine their capability to support the procedure. On commissioning inspections, a selection of radials proposed for IFR use should be inspected.

4.3.22.1.2. The selection should be based on the following criteria:

- All radials supporting instrument approach procedures should be selected.
- Radials should be selected from areas of poor performance indicated by the orbit inspection.
- Any radials where the coverage may be affected by terrain should be selected.
- At least one radial should be selected from each quadrant, if appropriate. In general, this should include the longest and lowest radials.

4.3.22.2 Routine inspection

Routine inspection requirements are contained in the following paragraphs.

4.3.22.2.1. En-route radials (airways, off-airway routes, substitute routes)

- En-route radials should be flown either inbound or outbound, along their entire length from the facility to the extremity of their intended use, at the minimum altitude for the associated airway or route as published. The minimum altitude for flying en-route radials, predicated on terminal facilities, is 300 m (1000 ft) above the highest terrain or obstruction along the radial to a distance of 46.3 km (25 NM). The aircraft should be flown on the electronic radial and the position of the aircraft should be recorded using a position reference system.
- Reference, variable and 9960 Hz modulations and the vertical polarization effect should be checked at least once on each airway and direct-route radial. Signal strength, course deviation and aircraft position should be recorded throughout the radial flight.
- Course structure and alignment should be determined by analysis of the recordings. The recordings should also be analyzed for possible undesirable close-in or over-station characteristics to determine that use of the facility for approach, holding, etc., is not adversely affected.

4.3.22.2.2. Terminal radials (approach, missed approach, standard instrument departure (SID)

- Approach radials should be evaluated at a distance that includes the procedure turn, holding pattern and missed approach on commissioning inspections. The approach radial should be flown 30 m (100 ft.) below specified altitudes. Site and commissioning inspections require two additional radials 5E either side of the approach radial to be flown and analyzed with the same criteria as the approach radial. Radials used to support SID procedures should be evaluated to the extent to which they are used.

4.3.23. Intersections

4.3.23.1 Adjacent facilities that provide intersections should be inspected to determine their capability to support the intersection.

4.3.23.2 Minimum signal strength should exist for the radial(s) forming the intersection within 7.4 km (4 NM) or 4.5°, whichever is greater, each side of the geographical location of the intersection fix.

4.3.23.3 Identification from each facility forming the intersection should be clear and distinct. Voice communications should be adequate at the minimum holding altitude. The signal from each facility should be free from interference at all altitudes below the maximum authorized altitude for holding. A minimum reception altitude should be established for the intersection, which is normally determined by the facility providing the weakest signal.

4.3.24. Flight Inspection Interval

4.3.24.1 The prescribed interval between successive inspections is 12 months.

4.3.24.2 This interval may be extended if the service provider can demonstrate that the system is stable and that multipath interference does not affect the guidance signals.

4.3.25. Flight Inspection Organizations

All VOR flight inspections shall be made by an organization having CAAI approval for VOR inspection..

4.3.26. Analysis of Flight Inspection Records

4.3.26.1 The ATS Provider shall analyses the flight inspection report at the earliest opportunity for operational systems and prior to entering a facility into operational service, to ensure that the flight inspection requirements are met.

4.3.26.2 The ATS Provider shall address any deficiencies or non-compliance to ensure a safe service is provided.

4.3.26.3 An ATS Provider may delegate the task of analyzing the flight inspection report to a third party specialist organization. This may be the flight inspection organization that provided the report.

4.3.26.4 The responsibility for addressing any deficiencies identified remains with the ATS Provider.

4.3.26.5 The person who conducts the analysis shall be competent to do so.

Note: This may include training on a specific flight inspection report format

4.4. Summary of testing requirements — VOR

Table III Summary of testing requirements — VOR

Parameter	Annex 10, Volume I, reference	Testing
Rotation	3.3.1.1	F/G
Sensing	3.3.1.3	F/G
Frequency	3.3.2	G
Polarization	3.3.3.1	F/G
Pattern accuracy	3.3.3.2	F/G
Coverage	3.3.4	F/G
9 960 Hz deviation	3.3.5.1	F/G
9 960 Hz modulation depth	3.3.5.2	F/G
30 Hz modulation depth	3.3.5.3	F/G
30 Hz modulation frequency	3.3.5.4	F/G
9 960 Hz subcarrier frequency	3.3.5.5	F/G
CVOR AM modulation of 9 960 Hz subcarrier	3.3.5.6	F/G
DVOR AM modulation of 9 960 Hz subcarrier	3.3.5.6	F/G
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	F/G
Speech effect on normal navigation function	3.3.6.7	F/G
Bearing monitor	3.3.7.1	F/G
Modulation monitor	3.3.7.1	G

Legend: F = Flight test/inspection

G = Ground test

4.5. Maintenance of CVOR/DVOR Navigation Radio Stations

4.5.1. General Requirements

4.5.1.1 Maintenance arrangements shall be established to ensure the continued availability and reliability of all CVOR/DVOR Navigation Radio Stations, associated with the provision of an ATC service.

4.5.1.2 In addition to the requirements below, CVOR/DVOR Navigation Radio Stations systems maintenance shall comply with ICAO Doc 8071 Volume I – Testing of Ground-Based Radio Navigation System

4.5.1.3 All the technicians will be properly trained on the CVOR/DVOR Navigation Radio Stations.

4.5.1.4 A record of any functional test, flight checks and particulars of any maintenance, repair, overhaul, replacement or modification shall be kept in respect of the equipment and systems at CVOR/DVOR Navigation Radio Stations, as or a period of two years.

4.5.1.5 Provision is made in the certificates for a record of an individual's proficiency. This may be used to record how often an individual performs maintenance duties on specific equipment and/or lapses in competency on specific equipment.

4.5.2. Training

4.5.2.1 A training program ensuring that the employees shall execute their positions and the activities laid upon them in an appropriate professional level according to the service provider procedures;

4.5.2.2 The training will be according to ICAO Doc 7192

4.5.2.3 The training program is accepted by the CAAI

4.5.2.4 The training program shall include separate parts according to these details:

4.5.2.4.1. Initial training;
4.5.2.4.2. Periodic training;
4.5.2.4.3. Special training;
4.5.2.4.4. Human factor training;
4.5.2.4.5. Work safety;

4.5.3. **Maintenance program**

4.5.3.1 A maintenance program is the source of scheduled inspections, relevant controls and supporting data. The Maintenance Program should always be active (subject to review and amendment) and utilized such as to enable effective maintenance to be carried out in a logical, concise, clear and controllable manner.

4.5.3.2 The CAAI approval of the Maintenance Program provides a mechanism to record minimum standards that the service provider must comply with.

4.5.3.3 The maintenance program may be applicable to more than one CVOR/DVOR Navigation Radio Stations of the same type.

4.5.3.4 The inspector will review the maintenance program according to applicable supporting information provided by the service provider.

4.5.3.5 The maintenance program will be design to meet Human Factors principles.

4.5.3.6 Consideration should be given to routinely monitoring equipment at adverse weather conditions (i.e. salt laden atmosphere, high humidity, extreme heat etc.). These considerations should include increasing maintenance inputs for cleaning, lubrication and inspection of protective finishes as an example.

4.5.3.7 The maintenance program should include:

4.5.3.7.1. Preface that include the following:

- The type/model of the equipment and, where applicable, power systems.
- A list of the manuals (reference, revision numbers) that were used to prepare the maintenance manual (supporting information).
- A statement signed by the service provider accountable manager that:
    - The specified equipment will be maintained according to the maintenance program; and
    - The program will be reviewed and updated as required; and
    - Practices and procedures to satisfy the maintenance program will be to the standards specified in the manufacture Maintenance Instructions. In the case of approved practices and procedures that differ, the statement should refer to them.

4.5.3.7.2. List of scheduled inspections that include for each task the following information:

- Task description
- Interval
- Reference to manufacturer manual or other supporting information.

- Skill of technician – if required.
- Applicability – if the maintenance program is used for more than one facility.
- List of items with life limitation (including the life limitation for each item).
- List of items with life limitation (including the life limitation for each item).

4.5.3.7.3. Forms

- All the forms/log books that are going to be used will be part of the maintenance program.

4.5.3.7.4. Additional procedures if required

4.5.3.7.5. Permitted variations to maintenance periods

4.6. Additional information

The inspector will review all the other documents required by CAAI AP 1.7.005 / 2.7.005 (ATS equipment installation, maintenance, operation & approval)

4.7. Demonstration and Inspection Phase

4.7.1. CAAI requires service providers to demonstrate their ability to comply with regulations and safe operating practices before issuing approval to the ATS equipment.

4.7.2. These demonstrations include actual performance of activities and/or operations while being observed by the inspector.

4.7.3. The demonstration will include:

4.7.3.1 Compliance checklist of ground test requirements to ICAO annex 10 volume I and ICAO doc 8071 Volume I, including all the supporting documents (if applicable):

4.7.3.1.1. Manufacture compliance check list to ICAO documents.

4.7.3.1.2. Compliance for the specific Model and S/N

4.7.3.1.3. Factory Acceptance Test (FAT)

4.7.3.1.4. Customer Acceptance Test (CAT)

4.7.3.1.5. Site Acceptance Test (SAT)

4.7.3.1.6. Any other document that supporting the compliance.

4.7.3.2 Compliance checklist of flight test requirements to ICAO annex 10 volume I and ICAO doc 8071 Volume I, including all the supporting documents

4.7.3.3 Compliance checklist of maintenance program requirements to ICAO annex 10 volume I and ICAO doc 8071 Volume I

4.7.4. The demonstration will include on-site evaluations of equipment maintenance and support facilities.

4.7.5. During these demonstrations and inspections, the inspector will evaluate the effectiveness of the policies, methods, procedures, and instructions as described in the Service provider manuals and other documents.

4.7.6. Deficiencies will be brought to the attention of the service provider and corrective action must be taken before an approval is issued.

5. Task Outcomes

5.1. After the document compliance and the demonstration and inspection phases have been completed satisfactorily, the inspector will prepare the navigation aid Certificate that include all the information (equipment model, frequencies, identification, location, limitations etc.).

5.2. The service provider must acknowledge receipt of these documents.

5.3. The process above should be documented in the Sharedocs/Saar system.