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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: U.S. National Aviation Standard for the VORTAC System

1. PURPOSE. This advisory circular is issued to inform the aviation community of the establishment and content of the U.S. National Aviation Standard for the VORTAC (VOR-TACAN-DME) System.

2. REFERENCE. U.S. National Aviation Standards are defined in Advisory Circular No. 00-26.

3. BACKGROUND. A public Notice of Proposed Selection for the subject Standard was published as Notice 69-RD-1 in 34 F.R. 18050 on November 7, 1969. That notice stated the FAA was considering adoption of a Selection Order establishing the Standard, indicated the relationship of the Standard to possible subsequent rulemaking actions and invited interested persons to submit such written data and comments as they may desire.

   All comments received in response to the opportunity to participate in establishment of the standards were evaluated in the light of current and future needs of the system and with due consideration to the public interests. Those comments considered consistent with the scope and purpose of the Standard were accommodated to the extent practicable. The Standard was approved by the Administrator of the Federal Aviation Administration on June 1, 1970. This Advisory Circular is issued in accordance with agency procedure for informing the public of the action by the Administrator.

4. DESCRIPTION. The enclosed Standard defines the VORTAC system and the performance required of its components to the extent necessary to satisfy overall operational use requirements and provide compatibility between components of the system.

For ground components, the Standard identifies the functional, signal and performance characteristics provided and with which all airborne components must operate as specified. For airborne components, the Standard identifies signal characteristics, where applicable, and functional and performance characteristics which are necessary to satisfy system use requirements and to prevent impairment of services to other users of the airspace.

Attention is drawn to the fact that U.S. National Aviation Standards are not equipment specifications, nor are they standards pertaining to hardware, planning, programming, installation, siting, availability, reliability or maintainability.

5. HOW TO OBTAIN THIS PUBLICATION. Additional copies of this circular may be obtained from the Department of Transportation, Distribution Unit, TAD-484.3, Washington, D.C. 20590.

for John A. Weber, Director
Systems Research and
Development Service

Enclosure

U.S. NATIONAL AVIATION STANDARD FOR THE VORTAC SYSTEM

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U.S. NATIONAL AVIATION STANDARD FOR THE VORTAC (VOR-TACAN-DME) SYSTEM

1. GENERAL.

Under Public Law 85–726, the FAA (Federal Aviation Administration) is charged with providing for the regulation and promotion of civil aviation in such a manner as to best foster its development and safety, and to provide for the safe and efficient use of the airspace by both civil and military aircraft, and for other purposes. Explicitly, the Administrator shall develop, modify, test and evaluate systems, procedures, facilities and devices, as well as define the performance characteristics thereof, to meet the needs for safe and efficient navigation and traffic control of all civil and military aviation operating in a common Civil/Military System of Air Navigation and Traffic Control.

1.1 The VORTAC (VOR-TACAN-DME) System Characteristics.

Pursuant to 1, this Standard defines the VOR (VHF Omnidirectional Radio Range)—TACAN (Tactical Air Navigation)—DME (Distance Measuring Equipment) system in the United States, its application and its performance characteristics. For ground components of the system, the material identifies the functional, signal and performance characteristics provided and with which all airborne components of the system must operate as specified. For airborne components, the material identifies signal characteristics, where applicable, and functional and performance characteristics which are required to meet overall operational use requirements and to provide compatibility between components of the system.

The respective airborne component characteristics for VOR, TACAN and DME apply in entirety to those components used in aircraft operations performed under IFR (Instrument Flight Rules). However, for other aircraft operations the applicability is limited to requirements as identified in Sections 4 and 6 hereof which are essential to prevent impairment of services to other users of the airspace.

It is recognized that certain existing components do not comply with all requirements of this Standard. Since such components may impair services to other users of the system, degrade navigational accuracy or otherwise adversely affect operational use of the system, it is expected that use of nonconforming components will be discontinued as soon as practicable.

1.2 Revisions.

This Standard will be revised as needs of the National Airspace System warrant.

2. VOR-TACAN-DME SYSTEM DESCRIPTION.

The VOR-TACAN-DME system is a short distance rho-theta air navigation system which provides properly equipped aircraft with bearing, identification and distance information referenced to selected ground components. When the airborne component complement includes a suitable area navigation (RNAV) device operating from data derived from the system, non-radial routes are afforded in addition to those corresponding to radials from the selected ground component.

The system provides all civil and military aviation with an aid to navigation for the safe and efficient conduct of aircraft operations, the safe and efficient exercise of air traffic control and the efficient utilization of airspace.

2.1 Principal Components of the System.

2.1.1 Ground Components. The principal ground components, which produce and radiate signals as specified hereinafter, are: VOR providing ground to air communications and azimuth information to all civil aviation; TACAN providing azimuth information to military users and distance information to both civil and military users; and DME only providing distance information to all users of the airspace.

2.1.1.1 Facility Type Designations. Components comprising ground facilities of the system are identified in the Airman's Information Manual by type designations as follows to identify the type of service provided. VOR type designators are prefixed by the letter "B" when the component provides scheduled voice broadcasts, and are suffixed by the letter "W" when the component does not provide voice transmissions.

Designator	*Type of Facility*
VOR	VHF navigational facility, omnidirectional, azimuth only.
DME	UHF navigational facility, distance only.
TACAN	UHF navigational facility, omnidirectional, azimuth and distance.
VOR/DME	Associated VOR and DME navigational facilities.
VORTAC	Associated VOR and TACAN navigational facilities.

2.1.1.2 Facility Operational Classifications. Each ground facility is identified as to the normally anticipated interference-free service volume by one of the following classification letters applied in parentheses as a prefix to the applicable facility type designation. Such classification is without regard to the fact that the frequency-protected service volume, operational requirements and use limitations may vary between facilities at different locations, or that propagation anomalies, multipath propagation and site conditions may alter the characteristics of ground component signals available to aircraft within the normally anticipated interference-free service volume.

Class	*Normal Usable Altitudes and Radius Distance*
H	Above 45,000 ft. MSL and out to a radius of 100 NM; From 18,000 ft. to and including 45,000 ft. MSL and out to a radius of 130 NM; From 14,500 ft. to 18,000 ft. and out to a radius of 100 NM.
L	Up to 18,000 ft. MSL and out to a radius of 40 NM.
T	Up to and including 12,000 ft. MSL and out to a radius of 25 NM.

H facilities also provide L and T service volumes and L facilities also provide T service volumes. To the extent that frequency protection is in accordance with 2.1.1.6 and to the extent that the respective minimum signal power densities of 3.3 and 5.3.2 are available to aircraft, facilities may also provide expanded operational service volumes which extend: (a) beyond the normal service radius to not more than 110 NM at MSL altitudes below 18,000 feet or 185 NM at MSL altitudes, above 18,000 feet; or (b) above the normal altitude; or both.

2.1.1.2.1 Vertical Angle Coverage Limitations. Within the normally anticipated interference-free service volume of each facility, azimuth signal information permitting satisfactory performance of airborne components is normally provided from the radio horizon up to an elevation angle of not less than 60 degrees for VOR components and not less than 40 degrees for TACAN components. At higher elevation angles the azimuth signal information may not be usable. Components providing distance information permit satisfactory performance of airborne components from the radio horizon to an elevation angle of not less than 60 degrees.

2.1.1.3 Co-location of Components. A VOR and either TACAN or DME shall be considered as associated components only when:

a. operated on a standard frequency pairing in accordance with 2.1.1.5;

b. co-located within the limits prescribed for associated facilities in 2.1.1.3.1; and

c. complying with the identification provisions of 2.1.1.7.2.2.

2.1.1.3.1 Co-location Limits for Associated Components. When either TACAN or DME components are associated with a VOR, the components shall be co-located in accordance with the following:

a. *Coaxial co-location:* The VOR and TACAN or DME antennas are located on the same vertical axis; or

b. *Offset co-location:*

(1) For those facilities used in terminal areas for approach purposes or other procedures where the highest position-fixing accuracy of system capability is required, the

2.2 System Traffic Handling Capacity.

Each VOR and TACAN ground component of the system provides azimuth and facility identification information to an unlimited number of airborne components. Under conditions in which interrogating TACAN and DME components are in the track mode of operation not less than 95 percent of the time, TACAN and DME ground components provide slant range distance information adequate for the peak traffic or 100 interrogators, whichever is the lesser.

2.3 System Azimuth Accuracy.

System azimuth accuracy, expressed in terms of error, is a function of the error factors associated with the ground and airborne components. For purposes of defining these errors, the following terms are used with the meanings indicated.

a. *Radial Signal Error (Eg):* Radial signal error is the difference between the nominal magnetic bearing to a point of measurement from the ground component and the bearing indicated by the ground component signal at that same point. The radial signal error is made up of (1) certain stable elements such as course displacement and most site and terrain effect errors which may be considered as fixed for long periods of time, and (2) certain random variable errors which can be expected to vary about the essentially constant remainder. The radial signal error is associated with the ground component only and excludes other error factors.

b. *Airborne Component Error (Ea):* Airborne component error is that error attributable to the inability of the equipment in the aircraft to translate correctly the bearing information contained in the radial signal. This element embraces all factors in the airborne component which introduces errors in the information presented to the pilot. (Errors resulting from the use of compass information in some VOR and TACAN displays are not included.)

c. *Aggregate Error (Es):* Aggregate error is the difference between the magnetic bearing to a point of measurement from the ground component and the bearing indicated by airborne components of stated accuracy. This is the error in the information presented to the pilot (exclusive of any errors resulting from use of compass information) taking into account not only the ground component and propagation path errors but also the error contributed by the airborne component and its instrumentation. The entire radial signal error, both fixed and variable is used.

Since the errors of (a) and (b), when considered on a total system basis (not any individual radials or components) are independent variables, they may be combined by the root-sum-square (RSS) method to calculate aggregate system error (Es) when the same probability is given to each element. For purposes of this Standard, each element is considered to have a 95% probability.

In practice, based on hundreds of thousands of accumulated data points, the radial signal error value (Eg) has been found to be ± 1.9 degrees (95% probability). Airways, routes and terminal area procedures in the United States are designed on the basis of a system use accuracy of ± 4.5 degrees (95% probability). To satisfy that operational use requirement, accuracies specified for airborne components in Sections 4 and 6 hereof provide a nominal aggregate system azimuth error value (Es) of 3.5 degrees (95% probability). The aggregate system error value is derived as follows:

Radial Signal Error (Eg): $\pm 1.9°$ (95% probability).

Airborne Component Error (Ea): $\pm 3.0°$ (95% probability).

Aggregate System Error $(Es) = \sqrt{Eg^2 + Ea^2}$ (1)

$= \sqrt{1.9^2 + 3.0^2}$ (2)

$= \sqrt{3.61 + 9.00}$ (3)

$= \sqrt{12.61}$ (4)

Rounded $= 3.5°$ (95% probability) (5)

With respect to the ± 4.5 degree system use accuracy, the aggregate system error of ± 3.5 degrees allows a factor for error in utilization of the information presented to the pilot. This utilization error, which is an independent variable and is attributable to the fact that a pilot can not or does not keep the aircraft precisely centered on the radial or bearing presented, is strictly a pilotage error contribution and does not include presentation errors.

2.4 System Distance Accuracy.

System distance accuracy is a function of the ground and airborne component accuracies. The component values in this Standard provide a system distance accuracy of ±0.5 NM or 3% of the slant range distance, whichever is greater, (95% probability) when the error values are combined by the root-sum-square method.

2.5 Area Navigation Use Accuracy.

When area navigation devices are used with inputs from components of the system, those devices must be implemented in such a manner that route dimension requirements are not increased. Any errors introduced by area navigation devices may, therefore, necessitate a compensating reduction in other error elements.

2.6 System Functional and Performance Capabilities.

The functional and performance characteristics set forth in this Standard are those needed to satisfy current system use and performance requirements. Many ground and airborne components used in the system afford accuracy values appreciably better than those stated in this Standard. The VOR-TACAN-DME system is inherently capable of greater accuracies and additional functions to meet future needs for safe and efficient air navigation, traffic control and utilization of the airspace.

3. OPERATIONAL CHARACTERISTICS FOR VOR GROUND COMPONENTS.

The subparagraphs hereto identify standard signal characteristics and tolerances for VOR components of the system. Except as noted, these characteristics represent the performance which shall normally be provided by each component subject to limitations as noted under 2.1.1.2 and 2.1.1.6.

3.1 Polarization.

The ground component antenna shall radiate horizontally polarized signals. Azimuth error in airborne components due to the vertically polarized component of the radiated signal will not exceed ±2.0 degrees at aircraft attitudes encountered in normal operational use of the system.

3.2 Radio Frequency Accuracy.

The radio frequency carrier shall be within ±0.005 percent of the assigned channel frequency.

NOTE: When VHF channels ending in odd-twentieths of a MHz are utilized for either VOR or ILS localizer components, the radio frequency carrier for all VOR and localizer components will be within ±0.002 percent of the assigned channel frequency.

3.3 Radiated Power Level.

The effective radiated power level shall not be less than that necessary to provide a signal power density of −111 dBw/m² at the minimum service altitude at the maximum specified operational service radius.

NOTE: At 118 MHz the value −111 dBw/m² corresponds to −114 dBw in an isotropic receiving antenna.

At the nearest aircraft position expected during flight, the maximum signal power density available to aircraft will be of the order of −34 dBw/m².

3.4 Azimuth Signal Characteristics.

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 magnetic bearing of the point of observation with respect to the VOR. The radio frequency carrier as observed at any point in space shall be amplitude modulated by two signals in accordance with the following.

3.4.1 Subcarrier Frequency Modulation. One signal component shall be a subcarrier of 9,960 Hz of constant amplitude, frequently modulated at 30 Hz having a deviation ratio of 16±1 (i.e., 15 to 17) as follows:

a. For the conventional VOR the 30 Hz component of the FM subcarrier is fixed without respect to azimuth and is termed the "reference phase."

b. For the Doppler VOR the phase of the 30 Hz component varies with azimuth and is termed the "variable phase."

3.4.1.1 Subcarrier Frequency and Accuracy. The subcarrier modulation mid-frequency shall be 9,960 Hz within ±1.0 percent.

3.4.1.2 Subcarrier Modulation Frequency and Accuracy. The modulation frequency shall be 30 Hz within ±1.0 percent.

3.4.1.3 Subcarrier Amplitude Modulation. Amplitude modulation of the subcarrier shall conform to the following:

a. For the conventional VOR, the percentage of amplitude modulation of the 9,960 Hz subcarrier shall not exceed 5 percent.

b. For the Doppler VOR, the percentage of amplitude modulation of the 9,960 Hz subcarrier shall not exceed 40 percent when measured at a point at least 1000 feet from the VOR.

3.4.1.4 Sideband Level of Subcarrier Harmonics. When 50 kHz VOR channel spacing is implemented, the sideband level of the harmonics of the 9,960 Hz component in the radiated signal shall not exceed the following levels referred to the level of 9,960 Hz sideband:

Subcarrier	*Level*
9,960 Hz	0 dB reference
2nd harmonic	−30 dB
3rd harmonic	−50 dB
4th harmonic	−60 dB

3.4.2 30 Hz Amplitude Modulation. The other signal component shall be 30 Hz amplitude modulation as follows:

a. 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".

b. For the Doppler VOR, this component, of constant phase with relation to azimuth and constant amplitude, is radiated omnidirectionally and is termed the "referenced phase".

3.4.2.1 Amplitude Modulation Frequency and Accuracy. The modulation frequency shall be 30 Hz within ±1.0 percent.

3.4.3 Depth of Reference and Variable Phase Modulations. The depth of modulation of the radio frequency carrier due to the 30 Hz or 9,960 Hz signals, shall for each signal, be within the limits of (a) 28 to 32 percent at all elevation angles from 0 to 5 degrees above horizon; and (b) 25 to 35 percent at all elevation angles between 5 and 60 degrees above the horizon.

3.4.4 Phase Relationships of Reference and Variable Phase Signals. The reference and variable phase modulations shall be in phase along the radial corresponding to magnetic north. 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 amplitude modulation signal occurs at the same time as the highest instantaneous frequency of the frequency modulation signal.

3.4.5 Radial Signal Characteristics. Coverage, course alignment and structure characteristics are periodically examined through flight inspection to ascertain that radial signals conform to standards prescribed for the intended operational usage. However, no component is commissioned for unrestricted use unless radial signal errors are within prescribed limits.

3.4.5.1 Ground Test Measurement. When a ground test is made in the near field of the antenna for purposes of verifying the radial signal alignment accuracy, the measurement shall be made at not less than 8 points, each of which are in the horizontal plane and at equal angular increments as referenced to the center of the antenna array. The requirements of the following subparagraph shall apply.

NOTE: Due to measurement limitations, the alignment error for Doppler VOR shall not be determined through ground test.

3.4.5.1.1 Ground Test Tolerances. The ground component shall meet the following tolerances when radial signal alignment accuracy is verified by ground tests.

a. Monitor azimuth indication within a 15 minute period shall not vary more than 0.3 degree;

b. Ground test error curves shall not deviate in excess of ±1.0 degree from the reference ground test error curve. The reference ground test error curve is the average of three successive error curves taken immediately following a basic altitude flight inspection. These curves shall not vary more than 0.3 degree from each other;

c. The maximum error spread of any ground test error curve shall not exceed 2.0 degrees; and

d. The ground test error curves for each of dual equipments shall not deviate from each other by more than 1.0 degree.

3.5 Code Identification Signal Characteristics.

The characteristics of the Code identification signal shall conform to the following.

3.5.1 Tone Modulation Frequency and Accuracy. The modulation frequency shall be 1,020 Hz ±50 Hz.

3.5.2 Depth of Modulation. The depth to which the radio frequency carrier is modulated by the Code identification signal shall:

a. Normally be 5.0±1 percent at components where voice services are provided but shall not exceed 8.0 percent; and

b. Be close to but not in excess of 10 percent at components where voice services are not provided.

3.6 Voice Identification and Communications Signal Characteristics.

The characteristics of voice identification and voice communications signals, when provided, shall conform to the following.

3.6.1 Voice Channel Frequency Response. Throughout the frequency range from 300 to 2,500 Hz, the frequency response characteristics for the voice channel shall be within 3 dB of response at 1,000 Hz.

3.6.2 Depth of Modulation. The depth to which the radio frequency carrier is modulated by voice signals shall not be greater than 30 percent.

3.7 Monitoring.

Continuous monitoring of the ground component shall be provided which causes the radiation of azimuth and identification signals to cease and a warning to be indicated at a control point when any one or a combination of the following fault conditions are sensed by the monitor:

a. The bearing of the azimuth signal at the monitored radial changes by ±1.0 degree and all greater deviations from the normal value.

b. The radio frequency signal voltage level at the monitored radial of either the subcarrier or 30 Hz amplitude modulation signal components, or both, are reduced by 15 percent and all greater reductions from the normal value.

c. The 1,020 Hz Code identification tone signal is absent.

The faults of (a) and (b) may persist for a period not to extend 15 seconds before radiation is interrupted. The fault of (c) may persist for an additional interval not to exceed 30 seconds before radiation is interrupted.

3.7.1 Monitor Failure. When the continuity of signal radiation is under the control of monitor equipment, the absence of either monitor operating power or the monitored signals at the fault sensing circuits of the monitor shall automatically cause radiation of the signals to cease and result in a warning indication at a control point.

NOTE: A high degree of fail-safe monitoring is provided. However, completely fail-safe monitoring is not possible.

4. OPERATIONAL CHARACTERISTICS FOR VOR AIRBORNE COMPONENTS.

Paragraphs hereunder specify in-use functional capability and performance characteristics required of VOR airborne components. The term "component", as used herein, includes the complete aircraft installation of all items, such as the antenna and its transmission line, the receiver, electrical power source(s), identification and voice communications signal reproduction devices, and selector and display instrumentation devices for bearing and course indication, which are necessary to provide the required functions and performance.

All requirements apply to airborne components used in the performance of aircraft operations under IFR. For other aircraft operations the requirements are limited to those of this paragraph and 4.6. Components shall be capable of performing as specified throughout the advertised operational service volume of ground facilities in which use is intended and under all expected aircraft and airborne component operating conditions. The requirements shall be met under conditions in which the performance characteristics of ground components are in accordance with Sections 2 and 3 of this Standard.

4.1 Receiver Radio Frequencies.

For each channel in use, the center radio frequency of the receiver shall be the corresponding ground component frequency listed in Table A.

4.2 Sensitivity to VOR Signals.

Based on the signal power densities of 3.3, the airborne component shall provide sensitivity as necessary for the display of navigation information to the accuracy specified and for clear and distinct reproduction of communication and identification signals.

4.3 Rejection of Undesired Signals.

The airborne component shall provide undesired signal rejection characteristics adequate to assure the specified performance. For co-channel and adjacent-channel signals, this requirement shall be met when the respective signals provide undesired to desired signal ratios up to the maximum values stated in 2.1.1.6.1.

4.4 Facility Identification and Voice Signals.

The airborne component shall provide the pilot with an intelligible and unambiguous signal which permits positive identification of the ground component from which navigation information is displayed.

The reproduction and aural level of voice signals shall be adequate to preserve and clearly convey to the pilot the intelligence transmitted by ground components.

4.5 Bearing and Course Deviation Information.

The airborne component shall provide devices for unambiguous determination of the aircraft magnetic bearing with respect to each selected ground component and for display of the aircraft deviation from the selected course.

4.5.1 Course Deviation Indicator Devices. The response, readability and resolution of course deviation indicator devices shall be such as to permit the pilot to determine the direction and extent of the aircraft deviation from the selected course.

4.5.2 Warning Function. The airborne component shall provide a warning indication which is clearly evident to the pilot whenever azimuth signals necessary for the prescribed performance are not present.

4.5.3 Accuracy of Bearing and Course Deviation Information. The total airborne component error in bearing and course deviation information, as displayed to the pilot, shall not at any bearing exceed ±3.0 degrees (95% probability).

4.6 Radiation.

Radiation from airborne components shall not result in derogation of operational use of this system to other users or in the derogation of other aeronautical services.

5. OPERATIONAL CHARACTERISTICS FOR TACAN AND DME GROUND COMPONENTS.

The subparagraphs hereto identify standard signal and performance characteristics for TACAN and DME ground components of the system. These characteristics represent the performance which shall normally be provided by each component subject to limitations as noted under 2.1.1.2.2 and 2.1.1.6. Except where a designation of either TACAN or DME is used, thus denoting that a requirement applies only to the designated component, requirements apply to both TACAN and DME components.

5.1 Polarization.

The ground component antenna shall radiate and receive vertically polarized signals. TACAN azimuth error in airborne components due to the horizontally polarized component of the radiated signal will not exceed ±2.0 degrees at aircraft attitudes encountered in normal operational use of the system.

5.2 Transponder Response to Interrogation Signals.

The response of the transponder to interrogation signals shall conform to the requirements of the following paragraphs.

NOTE: The presence at the ground component antenna of CW signals within a frequency band of ±3.0 MHz with respect to the interrogation frequency in use and which have a signal power density of −113 dBw/m² and all higher values will normally derogate the performance of the component and the system.

5.2.1 Interrogation Radio Frequency. The receiver center frequency shall be the interrogation frequency from Table A appropriate to the assigned operating channel.

5.2.2 Sensitivity to Interrogation Signals. Transponder sensitivity shall be measured in terms of a triggering level which is defined as the peak pulse power level of the weakest interrogation signal measured at the input of the receiver which will cause the transponder to reply with a specified reply efficiency. For a reply efficiency of 70 percent, the sensitivity shall conform to the following.

NOTE: Ground components may not respond to interrogations as specified if the difference in level of the constituent pulses of interrogation pulse pairs is greater than 1 dB.

5.2.2.1 On-Channel Sensitivity. For interrogation signals within ±100 kHz of the assigned channel frequency, which have a repetition rate not higher than 200 pulse pairs per second and which have spacings of the constituent pulses of a pair equal to the design center value for the channel in use, the sensitivity of the ground component shall be not less than −122 dBw (−101 dBw/m²) as referenced to a lossless isotropic radiator.

5.2.2.1.1 Sensitivity at Other Pulse Spacings. Under conditions in which the spacing of the constituent pulses of interrogation pulse pairs vary from the design center value for the channel in use by as much as ±0.5 microsecond, the sensitivity in the absence of other interrogations shall not be reduced by more than 1 dB.

5.2.2.1.2 Sensitivity Variation with Interrogation Loading. The sensitivity shall not vary by more than 1 dB for interrogation loadings between 0 to 90 percent of the maximum for which the component was designed. When the interrogation loading exceeds 90 percent of the maximum design value, the sensitivity shall, for the duration of such loading, be reduced the minimum amount necessary to limit the reply pulse rate to the maximum design value.

5.2.2.2 Sensitivity to Adjacent Channel Interrogations. Interrogation signals 900 kHz removed from the assigned channel interrogation frequency and having an amplitude up to 80 dB above the on-channel sensitivity of the component shall not trigger the transponder.

5.2.3 Transponder Dead Time. The transponder dead time immediately following the decoding of interrogation signal pulse pairs and during which the transponder will not respond to other interrogation signals shall normally be 60 microseconds. However, dead time may be increased when necessary to satisfy system performance requirements.

5.3 Transponder Output Signal Characteristics. The radio frequency output signals of the transponder shall conform to the following.

5.3.1. Transmitter Radio Frequency and Accuracy. The transponder shall transmit on the reply frequency of Table A appropriate to the assigned channel. The radio frequency of operation shall not vary more than ±0.002 percent from the assigned frequency.

5.3.2 Radiated Power Level. The effective radiated power level at the peak of the RF pulse envelope shall not be less than that necessary to provide a signal power density of −86 dBw/m² at the minimum service altitude at the maximum service radius. For TACAN, the power level is the average value of the levels produced during an integral number of revolutions of the antenna pattern.

NOTE: At 1200 MHz, the value of −86 dBw/m² corresponds to −108.5 dBw in an isotropic antenna.

At the nearest aircraft position expected during flight, the maximum signal power density available to aircraft will be of the order of −17 dBw/m².

5.3.3 Radio Frequency Signal Spectrum. The spectrum of the pulse modulated signal shall be such that during the pulse the effective radiated power contained in a 0.5 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 milliwatts, and the effective radiated power contained in a 0.5 MHz band centered on frequencies 2.0 MHz above and 2.0 MHz below the nominal channel frequency shall not exceed 2.0 milliwatts. Any lobe of the spectrum shall be of less amplitude than the adjacent lobe nearer the nominal channel frequency.

5.3.4 Spurious Radiation. During the interval between transmission of pulse pairs the power level of signals radiated by the ground component on any interrogation or reply frequency shall not exceed a level which is 50 dB below the maximum level during the pulses.

5.3.5 Pulse Shape. *The following shall apply to all radiated pulses.*

5.3.5.1 Pulse Rise Time. The time required for the leading edge of the pulse to rise from 10 to 90 percent of its maximum voltage amplitude shall be nominally 2.5 microseconds, but shall not exceed 3.0 microsenconds. The minimum rise time is govered by the spectrum requirements of 5.3.3.

5.3.5.2 Pulse Top. The instantaneous amplitude of the pulse shall not, at any instant between the point on the leading edge which is 95 percent of the maximum voltage amplitude and the point on the trailing edge which is 95 percent of the maximum voltage amplitude, fall below a value which is 95 percent of the maximum voltage amplitude of the pulse.

5.3.5.3 Pulse Duration. The pulse duration, as measured at the 50 percent maximum voltage amplitude points on the leading and trailing edge of the pulse, shall be 3.5 ± 0.5 microseconds.

5.3.5.4 Pulse Decay Time. The time required for the trailing edge of the pulse to decay from 90 to 10 percent of the maximum voltage amplitude shall nominally be 2.5 microseconds, but shall not exceed 3.0 microseconds. The minimum decay time is governed by the spectrum requirements of 5.3.3.

5.3.6 Pulse Coding. Transponder output signals shall consist of paired pulses. The spacing of the constituent pulses of each pulse pair, as measured between the 50 percent maximum voltage amplitude points on the leading edge of each RF pulse, shall be:

a. 12.0±0.25 microseconds for channel numbers ending in the suffix "X"; or

b. 30.0±0.25 microseconds for channel numbers ending in the suffix "Y".

5.3.7 Pulse Power Variation. The peak power of the constituent pulses of any pair shall not differ by more than 1 dB.

5.3.8 Distance Reply Signals. Distance reply signals shall consist of pulse pairs which, in accordance with the following, are transmitted in response to interrogations.

5.3.8.1 Reply Efficiency. Reply efficiency is defined as the percentage of interrogations to which the transponder replies under specified load conditions. Except when limited by receiver dead time, the reply efficiency for interrogation signals at and above the minimum sensitivity levels of 5.2.2 shall be at least 70 percent for all values of interrogation loading up to the maximum for which the transponder is designed.

5.3.8.2 Reply Delay Time. Reply delay time is defined as the time in microseconds of all delay introduced by the transponder component in transmitting a pair of reply pulses in response to an interrogation signal. When airborne components are to indicate distance with respect to the transponder site, the zero-distance reply delay time shall be 50.0 microseconds as measured between the 50 percent voltage point on the leading edge of the second constituent RF pulse of the interrogation pulse pair and the corresponding point on the second constituent RF pulse of the reply pulse pair. When airborne components are to indicate distance to a point which is remote from the transponder site, the 50.0 miscrosecond time delay shall be reduced by a value corresponding to the off-set distance.

NOTE: As referenced to the first constituent RF pulse of interrogation and reply pulse pairs, reply delay times of (a) 50.0 microseconds for "X" channels and (b) 56.0 microseconds for "Y" channels are considered to be equivalent to the 50.0 microsecond value stated above for timing referenced to the second pulse of the respective pairs.

5.3.9 Random Pulse Pair Signals. In addition to distance reply pulse pairs, the ground component shall radiate randomly occurring pulse pairs in a quantity as necessary to maintain a total pulse pair rate in accordance with the following.

5.3.9.1 DME Components. For ground components providing DME service only, the total pulse pair rate, exclusive of Code identification signal pulses, shall be of a value between the limits of 700 to 2850 pulse pairs per second.

5.3.9.2 TACAN Components. For TACAN ground components, the total pulse pair rate, exclusive of Code identification signal and reference burst pulses, shall be 2700±90 pulse pairs per second. For a transponder dead time of 60 microseconds, the distribution of random pulse pairs shall conform to Figure 1.

5.3.10 Distance Accuracy. Exclusive of reply delay time errors resulting from variation in the level of interrogation signals, the ground component shall not contribute more than ±0.25 microsecond to overall system error.

5.3.11 Code Identification Signal Characteristics. Subject to the provisions of 5.3.11.1, Code identification signals shall consist of groups of two pulse pairs transmitted for the duration of dots and dashes in accordance with 2.1.1.7.1. The spacing between the first and second pulse pairs constituting each pulse group, as measured between the 50 percent voltage amplitude points on the leading edge of the first pulse of each pair, shall be 100±10 microseconds. The repetition rate shall conform to the following.

5.3.11.1 DME Components. For ground components providing DME service only, the identification signal may consist of groups of either one or two pulse pairs. The repetition rate shall be 1350±10 groups per second.

5.3.11.2 TACAN Components. For TACAN ground components, the repetition rate shall be 1350±0.23 percent groups per second which are phase-locked within ±50.0 microseconds of the tenth harmonic of the 135 Hz reference bearing signal. The first pulse of each identification signal pulse group shall occur 740±50 microseconds after the first pulse of each 40 degree sector reference signal.

5.3.12 TACAN Azimuth Signal Characteristics. TACAN azimuth signals consist of north (main) and 40 degree sector (auxiliary) bearing reference signals and 15 Hz (coarse) and 135 Hz (fine) variable bearing signals. The azimuth signals radiated by the antenna shall conform to the following.

5.3.12.1 Bearing Reference Signals. Transmission of the north and 40 degree sector reference signals shall occur synchronously with antenna pattern rotation. For each consecutive complete rotation of the antenna pattern, one north reference signal shall be transmitted and followed at each of eight consecutive angular increments of 40 degrees by the transmission of a 40 degree sector reference signal. A ninth 40 degree sector reference signal, which otherwise would coincide in time with the north reference signal, shall not be transmitted. The characteristics of reference signals, shall be as follows.

5.3.12.1.1 North Reference Signal. The north reference signal shall consist of:

a. a group of 12 pulse pairs having a spacing of the constituent pulses of a pair in accordance with 5.3.6 (a) and a pulse pair spacing, as measured between the 50 percent voltage amplitude points on the leading edge of the first pulse of each pair, of 30.0±0.3 microseconds for channel numbers ending in the suffix "X"; or

b. a group of 13 single pulses having a spacing, as measured between the 50 percent voltage amplitude points on the leading edge of consecutive pulses, of 30.0±0.3 microseconds for channel numbers ending in the suffix "Y".

5.3.12.1.2 40 Degree Sector Reference Signal. The 40 degree sector reference signal shall consist of:

a. a group of 6 pulse pairs having a spacing of the constituent pulses of a pair in accordance with 5.3.6 (a) and a pulse pair spacing, as measured between the 50 percent amplitude points on the leading edge of the first pulse of each pair, of 24.0±0.25 microseconds for channel numbers ending in the suffix "X"; or

b. a group of 13 single pulses having a spacing, as measured between the 50 percent voltage amplitude points on the leading edge of consecutive pulses, of 15.0±0.25 miscroseconds for channel numbers ending in the suffix "Y".

5.3.12.2 · Variable Bearing Signals. The variable bearing signals shall be a rotating directional antenna pattern which produces a composite amplitude modulation of the transponder radio frequency pulse signals at 15 and 135 Hz. The characteristics of the variable bearing signals shall be as follows.

5.3.12.2.1 Amplitude Modulation Frequencies and Accuracy. The amplitude modulation frequencies shall nominally be 15.0 and 135.0 Hz. Each frequency shall vary from the nominal value in exact synchronism with the antenna pattern rotation rate.

5.3.12.2.1.1. Antenna Pattern Rotation Rate. The antenna radiation pattern shall rotate in a clockwise direction as viewed from above at a rate of 15.0 revolutions per second ±0.23 percent.

5.3.12.2.2 Depth of Modulation. Within the vertical angle from 0 to 40 degrees above the horizon, the normal range of 15 and 135 Hz modulation depths produced by the antenna will be 21±9 percent for each frequency with a sum for both frequencies equal to or less than 55 percent. At elevation angles between 40 and 50 degrees above the horizon, 15 Hz modulation depths will be within the range from 7 to 35 percent and 135 Hz modulation depths will be within the range from 7 to 45 percent. However, the sum of depths for both frequencies will not exceed 65 percent.

5.3.12.2.3 Harmonic Content. At all angles from 0 to 45 degrees above the horizon:

a. the root-sum-square of the second through the seventh harmonics of the 15 Hz signal component will not exceed 30 percent of the 15 Hz modulation coefficient; and

b. the root-sum-square of the second through the fourth harmonics of the 135 Hz signal component will not exceed 20 percent of the 135 Hz modulation coefficient.

5.3.12.3 Relationships of Reference and Variable Bearing Signals. On the magnetic north radial from the antenna, the relationships of the reference and variable bearing signals shall conform to the requirements of the subparagraphs hereto.

5.3.12.3.1 Coarse Bearing Signal. The negative slope point of inflection of the 15 Hz amplitude modulation component shall coincide within ±2.0 azimuth degrees of:

a. the tenth pulse of the north reference signals for channels ending in the suffix "X"; or

b. the sixth pulse of the north reference signal for channels ending in the suffix "Y".

5.3.12.3.2 Fine Bearing Signal. The negative slope point of inflection of the 135 Hz amplitude modulation component shall coincide within ±0.33 azimuth degrees of the average position of:

a. the twelfth pulse of the 40 degree reference signal for channels ending in the suffix "X"; or

b. the eleventh pulse of the 40 degree reference signal for channels ending in the suffix "Y".

5.3.12.4 Radial Signal Characteristics. Coverage, course alignment and structure characteristics are periodicaly examined through flight inspection to ascertain that radial signals conform to standards prescribed for the intended operational usage. However, no component is commissioned for unrestricted use unless radial signal errors are within prescribed limits.

5.3.13 Precedence of Pulse Transmissions. The order of precedence for transmission of transponder pulse signals shall be in accordance with the following.

5.3.13.1 DME Components. For ground components providing DME service only, the precedence shall be:

1. Code Identification Signals;
2. Distance Reply Signals; and
3. Random Pulse Pair Signals.

Neither distance reply nor random pulse pair signals shall be transmitted during the "key-down" interval of Code identification signal transmissions.

5.3.13.2 TACAN Components. For TACAN components, the precedence shall be:

1. Bearing Reference Signals;
2. Code Identification Signals;
3. Distance Reply Signals; and
4. Random Pulse Pair Signals.

Neither Code identification, distance reply, nor random pulse pair signals shall be transmitted during the interval required for transmission of all pulses in each bearing reference signal. Distance reply and random pulse pair signals shall not bet ransmitted during the "key-down" interval of Code identification signal transmission.

5.4 Monitoring.

Continuous monitoring of the ground component shall be provided which causes the radiation of transponder output signals to cease and a warning to be indicated at a control point when any one or a combination of the fault conditions identified in the subparagraphs hereto are sensed by the monitor.

5.4.1 DME and TACAN Components. For DME and TACAN components, a fault condition shall exist when:

a. The reply efficiency of the transponder to monitor interrogation signals at the minimum sensitivity level of 5.2.2.1 is less than 60 percent.

b. The reply delay time of the transponder to monitor interrogation signals differs from the assigned value by ±1.0 microsecond and all greater values.

c. The spacing of the constituent pulses of transponder output signal pulse pairs differs from the design center value of 5.3.6 by 1.0 microsecond and all greater values.

d. The radiated power level of transponder output signals decreases from the normal level by 3 dB and all greater reductions.

e. The Code identification signal of 2.1.1.7

(1) Is transmitted as a continuous tone (i.e., signals not in the form of dots or dashes) for a period of 5 seconds or more; or

(2) Is not repeated within a nominal period of 75 seconds from the last transmission.

The faults of (a) through (e–1) may persist for a period not to exceed 8 seconds before radiation is interrupted. For fault (e–2), radiation shall be interrupted upon expiration of the 75 second period.

NOTE: When radiation of signals commences, monitor action to interrupt radiation in the event of a fault may be delayed for approximately 40 seconds from the time radiation begins.

5.4.2 TACAN Components. In addition to the conditions of 5.4.1, a fault condition shall exist when:

a. The sum of distance reply and randomly occurring pulse pairs deviates from the design center value of 5.3.9.2 by more than ±150 pulse pairs per second.

b. The number of pulse pairs in either the north or 40 degree reference signals, or both, are one or more pairs less than the number respectively specified in paragraphs 5.3.12.1.1 and 5.3.12.1.2.

c. The fine bearing signals at the monitored radial changes by ±1.0 degree and all greater deviations from the correct value.

d. The antenna pattern rotation rate differs from the design center value of 5.3.12.2.1.1 by a value greater than ±0.23 percent.

The faults of (a), (b) and (c) may persist for a period not to exceed 8 seconds before radiation is interrupted. Fault (d) may persist for not more than 20 seconds before radiation is interrupted.

NOTE: When radiation of signals commences, monitor action to interrupt radiation in the event of a fault may be delayed for approximately 40 seconds from the time radiation begins.

NOTE: After the monitor has sensed one or more of the above faults, radiation may be restored to provide only distance and identification signals.

5.4.3 Monitor Failure. When the continuity of signal radiation is under the control of monitor equipment the absence of either monitor operating power or the monitored signals at the fault sensing circuits of the monitor shall automatically cause radiation of the signals to cease and result in a warning indication at a control point.

NOTE: A high degree of fail-safe monitoring is provided. However, completely fail-safe monitoring is not possible.

6. OPERATIONAL CHARACTERISTICS FOR TACAN AND DME AIRBORNE COMPONENTS.

Paragraphs hereunder specify in-use functional capability and performance characteristics required of DME and TACAN airborne components. The term "component" as used herein, includes the complete aircraft installation of all items, such as the antenna and its transmission line, the interrogator-receiver, electrical power source(s), identification signal reproduction or display devices, distance indicator and, when applicable, selector and display instrumentation devices for bearing and course indication, which are necessary to provide the required functions and performance.

All requirements apply to airborne components used in the performance of aircraft operations under IFR. For other aircraft operations the requirements are limited to those of this paragraph and paragraphs 6.1.4, 6.1.4.1 and 6.1.7. Except where a designation of either DME or TACAN is used, thus denoting that the requirement applies only to the designated component, requirements apply to both DME and TACAN components. Components shall be capable of performing as specified throughout the advertised operational service volume of ground facilities in which use is intended and under all expected aircraft and airborne component operating conditions. The requirements shall be met under conditions in which the performance characteristics of ground components are in accordance with Sections 2 and 5 of this Standard.

6.1 Interrogator Signal Characteristics.

The subparagraphs hereto identify interrogation signal characteristics and tolerances therefor which are applicable to the radiated radio frequency signal.

6.1.1 Interrogation Radio Frequencies and Accuracy. The interrogator shall transmit interrogation signals on the frequency appropriate to the channel in use. For each channel in use, the center radio frequency of the interrogation signal shall be within ±100 kHz of the channel interrogation frequency listed in Table A.

6.1.2 Pulse Shape. The radio frequency pulse envelope shall have a shape as follows.

6.1.2.1 Pulse Rise Time. The time required for the leading edge of the pulse to rise from 10 to 90 percent of its maximum voltage amplitude shall be nominally 2.5 microseconds, but shall not exceed 3.0 microseconds. The minimum rise time is governed by the spectrum requirements of 6.1.6.

6.1.2.2 Pulse Top. The instantaneous amplitude of the pulse shall not, at any instant between the point on the leading edge which is 95 percent of the maximum voltage amplitude and the point on the trailing edge which is 95 percent of the maximum voltage amplitude, fall below a value which is 95 percent of the maximum voltage amplitude of the pulse.

6.1.2.3 Pulse Duration. The pulse duration, as measured at the 50 percent maximum voltage amplitude, points on the leading and trailing edges of the pulse, shall be 3.5±0.5 microseconds.

6.1.2.4 Pulse Decay Time. The time required for the trailing edge of the pulse to fall from 90 to 10 percent of the maximum voltage amplitude shall nominally be 2.5 microseconds, but shall not exceed 3.5 microseconds. The minimum decay time is governed by the spectrum requirements of 6.1.6.

6.1.3 Pulse Coding. Interrogation signals shall consist of paired puses. The spacing of the constituent pulses of each pulse pair, as measured between the 50 percent maximum voltage amplitude points on the leading edge of each RF pulse, shall be:

a. 12.0±0.5 microseconds for channel numbers ending in the suffix "X"; or

b. 36.0±0.5 microseconds for channel numbers ending in the suffix "Y".

6.1.4 Interrogation Signal Repetition Rate. The interrogator average pulse pair repetition rate shall not exceed 30 pairs of pulses per second based on the assumption that at least 95 percent of the time is occupied for tracking reply signals. The repetition rate may be increased during search for replies, but the maximum repetition rate shall not exceed 150 pairs of pulses per second.

6.1.4.1 Variation of Repetition Rate. The variation in time between successive pairs of interrogation pulses shall be sufficient to preclude the airborne component from locking on to distance reply pulses intended for another airborne component tuned to the same ground facility, and to preclude capture of the interrogations of one interrogator within the ground component dead time caused by the interrogations of other interrogators.

6.1.5. Radiated Power Level. The effective radiated power level at the peak of the RF pulse envelope shall not be less than that necessary, under line of sight conditions, to provide a signal power density of −101 dBw/m² (95% probability) at the ground component antenna. The design center effective radiated power level, as referenced to an isotropic radiator, shall not exceed a value of +33 dBw.

NOTE: EIRP levels higher than +33 dBw may impair system performance.

6.1.6 Radio Frequency Signal Spectrum. The spectrum of the RF interrogation signal shall be such that at least 90 percent of the energy in each pulse shall be within a 0.5 MHz band centered on the nominal channel frequency.

6.1.7 Spurious Radiation. At all frequencies between 960 and 1215 MHz, the level of radiated CW signals, as referenced to an isotropic radiator, shall not exceed −60 dBw. Spurious radiation from airborne components shall not result in derogation of operational use of this system to other users or in the derogation of other aeronautical services.

6.2 Component Functional Capabilities and Performances.

The subparagraphs hereto identify functional and operational performance requirements applicable to the airborne component.

6.2.1 Receiver Radio Frequencies. For each channel in use, the center radio frequency of the receiver shall be the corresponding ground component reply frequency listed in Table A.

6.2.2 Sensitivity to Ground Component Signals. Based on the signal power densitites of 5.3.2, the airborne component shall provide sensitivity as necessary for the acquisition and display of navigation information to the accuracy specified and for clear and distinct reproduction of identification signals.

6.2.3 Rejection of Undesired Signals. The airborne component shall provide undesired signal rejection characteristics adequate to assure the specified performance. For co-channel and adjacent-channel signals, this requirement shall be met when the respective signals provide undesired to desired signal ratios up to the maximum values stated in 2.1.1.6.2. When the maximum range capability of the airborne component is such as to permit receipt of two co-channel signals within the frequency protected service volume of a selected ground component, and when one co-channel signal is 8 dB or greater in amplitude than the other, the navigation information provided shall be that of the stronger signal and a positive identification signal shall be provided to identify the ground component from which navigational information is provided.

6.2.4 Distance Information. The airborne component shall function to measure and display the distance in nautical miles between the aircraft and the selected ground component.

6.2.4.1 Warning Function. The airborne component shall provide an indacation which is clearly evident to the pilot whenever the airborne component is either not tracking a distance reply signal or is not in memory.

6.2.4.2 Accuracy of Distance Information. When the airborne component error is combined by root-sum-square with a ground component error of 0.1 NM, the total error in slant range distance information, as displayed to the pilot, shall not (except during memory) exceed ±0.5 NM or 3 percent of the actual distance, whichever is greater (95% probability).

6.2.4.3 Memory Function. The airborne component shall provide a memory function which upon loss of a suitable reply signal while tracking, will cause continuation of the display of distance information for a period not to exceed 15 seconds. The minimum distance memory shall be sufficient to cover the loss of distance reply signals during transmission of the ground component identification signal. The distance displayed during memory shall be within the range between ±1.0 NM of the last indicated distance and ±1.0 NM of the distance indicated upon resumption of the tracking function on the same signal.

6.2.5 TACAN Bearing and Course Deviation Information. The airborne component shall provide devices for unambiguous determination of the aircraft magnetic bearing with respect to each selected ground component and for display of the aircraft deviation from the selected course.

6.2.5.1 Course Deviation Indicator Devices. The response, readability and resolution of course deviation indicator devices shall be such as to permit the pilot to determine the direction and extent of the aircraft deviation from the selected course.

6.2.5.2 Warning Function. The airborne component shall provide a warning indication which is clearly evident to the pilot whenever the azimuth signals necessary for the prescribed operation of the component are not present and when the component is not operating in memory.

6.2.5.3 Accuracy of Bearing and Course Deviation Information. The total airborne component error in bearing and course deviation information, as displayed to the pilot, shall not at any bearing exceed ±3.0 degrees (95% probability).

TABLE A.—VOR-TACAN-DME CHANNEL FREQUENCIES AND PAIRING

VHF Chan. Freq. MHz	DME-TACAN Chan. No.	DME-TACAN Inter. Freq. MHz	DME-TACAN Reply Freq. MHz	VHF Chan. Freq. MHz	DME-TACAN Chan. No.	DME-TACAN Inter. Freq. MHz	DME-TACAN Reply Freq. MHz
—	1X	1025	962	109.15 ILS	28Y	1052	1115
—	1Y	1025	1088	109.20 VOR	29X	1053	990
—	2X	1026	963	109.25 VOR	29Y	1053	1116
—	2Y	1026	1089	109.30 ILS	30X	1054	991
—	3X	1027	964	109.35 ILS	30Y	1054	1117
—	3Y	1027	1090	109.40 VOR	31X	1055	992
—	4X	1028	965	109.45 VOR	31Y	1055	1118
—	4Y	1028	1091	109.50 ILS	32X	1056	993
—	5X	1029	966	109.55 ILS	32Y	1056	1119
—	5Y	1029	1092	109.60 VOR	33X	1057	994
—	6X	1030	967	109.65 VOR	33Y	1057	1120
—	6Y	1030	1093	109.70 ILS	34X	1058	995
—	7X	1031	968	109.75 ILS	34Y	1058	1121
—	7Y	1031	1094	109.80 VOR	35X	1059	996
—	8X	1032	969	109.85 VOR	35Y	1059	1122
—	8Y	1032	1095	109.90 ILS	36X	1060	997
—	9X	1033	970	109.95 ILS	36Y	1060	1123
—	9Y	1033	1096	110.00 VOR	37X	1061	998
—	10X	1034	971	110.05 VOR	37Y	1061	1124
—	10Y	1034	1097	110.10 ILS	38X	1062	999
—	11X	1035	972	110.15 ILS	38Y	1062	1125
—	11Y	1035	1098	110.20 VOR	39X	1063	1000
—	12X	1036	973	110.25 VOR	39Y	1063	1126
—	12Y	1036	1099	110.30 ILS	40X	1064	1001
—	13X	1037	974	110.35 ILS	40Y	1064	1127
—	13Y	1037	1100	110.40 VOR	41X	1065	1002
—	14X	1038	975	110.45 VOR	41Y	1065	1128
—	14Y	1038	1101	110.50 ILS	42X	1066	1003
—	15X	1039	976	110.55 ILS	42Y	1066	1129
—	15Y	1039	1102	110.60 VOR	43X	1067	1004
—	16X	1040	977	110.65 VOR	43Y	1067	1130
—	16Y	1040	1103	110.70 ILS	44X	1068	1005
108.00 *	17X	1041	978	110.75 ILS	44Y	1068	1131
108.05 VOR	17Y	1041	1104	110.80 VOR	45X	1069	1006
108.10 ILS	18X	1042	979	110.85 VOR	45Y	1069	1132
108.15 ILS	18Y	1042	1105	110.90 ILS	46X	1070	1007
108.20 VOR	19X	1043	980	110.95 ILS	46Y	1070	1133
108.25 VOR	19Y	1043	1106	111.00 VOR	47X	1071	1008
108.30 ILS	20X	1044	981	111.05 VOR	47Y	1071	1134
108.35 ILS	20Y	1044	1107	111.10 ILS	48X	1072	1009
108.40 VOR	21X	1045	982	111.15 ILS	48Y	1072	1135
108.45 VOR	21Y	1045	1108	111.20 VOR	49X	1073	1010
108.50 ILS	22X	1046	983	111.25 VOR	49Y	1073	1136
108.55 ILS	22Y	1046	1109	111.30 ILS	50X	1074	1011
108.60 VOR	23X	1047	984	111.35 ILS	50Y	1074	1137
108.65 VOR	23Y	1047	1110	111.40 VOR	51X	1075	1012
108.70 ILS	24X	1048	985	111.45 VOR	51Y	1075	1138
108.75 ILS	24Y	1048	1111	111.50 ILS	52X	1076	1013
108.80 VOR	25X	1049	986	111.55 ILS	52Y	1076	1139
108.85 VOR	25Y	1049	1112	111.60 VOR	53X	1077	1014
108.90 ILS	26X	1050	987	111.65 VOR	53Y	1077	1140
108.95 ILS	26Y	1050	1113	111.70 ILS	54X	1078	1015
109.00 VOR	27X	1051	988	111.75 ILS	54Y	1078	1141
109.05 VOR	27Y	1051	1114	111.80 VOR	55X	1079	1016
109.10 ILS	28X	1052	989	111.85 VOR	55Y	1079	1142

*108.0 MHz is not scheduled for facilities. The frequencies of channel 17X are assigned to facilities for testing airborne system components.

TABLE A.—VOR-TACAN-DME CHANNEL FREQUENCIES AND PAIRING—Continued

VHF Chan. Freq. MHz		DME-TACAN Chan. No.	Inter. Freq. MHz	Reply Freq. MHz	VHF Chan. Freq. MHz		DME-TACAN Chan. No.	Inter. Freq. MHz	Reply Freq. MHz
111.90	ILS	56X	1080	1017	113.70	VOR	84X	1108	1171
111.95	ILS	56Y	1080	1143	113.75	VOR	84Y	1108	1045
112.00	VOR	57X	1081	1018	113.80	VOR	85X	1109	1172
112.05	VOR	57Y	1081	1144	113.85	VOR	85Y	1109	1046
112.10	VOR	58X	1082	1019	113.99	VOR	86X	1110	1173
112.15	VOR	58Y	1082	1145	113.95	VOR	86Y	1110	1047
112.20	VOR	59X	1083	1020	114.00	VOR	87X	1111	1174
112.25	VOR	59Y	1083	1146	114.05	VOR	87Y	1111	1048
——		60X	1084	1021	114.10	VOR	88X	1112	1175
——		60Y	1084	1147	114.15	VOR	88Y	1112	1049
——		61X	1085	1022	114.20	VOR	89X	1113	1176
——		61Y	1085	1148	114.25	VOR	89Y	1113	1050
——		62X	1086	1023	114.30	VOR	90X	1114	1177
——		62Y	1086	1149	114.35	VOR	90Y	1114	1051
——		63X	1087	1024	114.40	VOR	91X	1115	1178
——		63Y	1087	1150	114.45	VOR	91Y	1115	1052
——		64X	1088	1151	114.50	VOR	92X	1116	1179
——		64Y	1088	1025	114.55	VOR	92Y	1116	1053
——		65X	1089	1152	114.60	VOR	93X	1117	1180
——		65Y	1089	1026	114.65	VOR	93Y	1117	1054
——		66X	1090	1153	114.70	VOR	94X	1118	1181
——		66H	1090	1027	114.75	VOR	94Y	1118	1055
——		67X	1091	1154	114.80	VOR	95X	1119	1182
——		67Y	1091	1028	114.85	VOR	95Y	1119	1056
——		68X	1092	1155	114.90	VOR	96X	1120	1183
——		68Y	1092	1029	114.95	VOR	96Y	1120	1057
——		69X	1093	1156	115.00	VOR	97X	1121	1184
——		69Y	1093	1030	115.05	VOR	97Y	1121	1058
112.30	VOR	70X	1094	1157	115.10	VOR	98X	1122	1185
112.35	VOR	70Y	1094	1031	115.15	VOR	98Y	1122	1059
112.40	VOR	71X	1095	1158	115.20	VOR	99X	1123	1186
112.45	VOR	71Y	1095	1032	115.25	VOR	99Y	1123	1060
112.50	VOR	72X	1096	1159	115.30	VOR	100X	1124	1187
112.55	VOR	72Y	1096	1033	115.35	VOR	190Y	1124	1061
112.60	VOR	73X	1097	1160	115.40	VOR	101X	1125	1188
112.65	VOR	73Y	1097	1034	115.45	VOR	101Y	1125	1062
112.70	VOR	74X	1098	1161	114.50	VOR	102X	1126	1189
112.75	VOR	74Y	1098	1035	115.55	VOR	102Y	1126	1063
112.80	VOR	75X	1099	1162	115.60	VOR	103X	1127	1190
112.85	VOR	75Y	1099	1036	115.65	VOR	103Y	1127	1064
112.90	VOR	76X	1100	1163	115.70	VOR	104X	1128	1191
112.95	VOR	76Y	1100	1037	115.75	VOR	104Y	1128	1065
113.00	VOR	77X	1101	1164	115.80	VOR	105X	1129	1192
113.05	VOR	77Y	1101	1038	115.85	VOR	105Y	1129	1066
113.10	VOR	78X	1102	1165	115.90	VOR	106X	1130	1193
113.15	VOR	78Y	1102	1039	115.95	VOR	106Y	1130	1067
113.20	VOR	79X	1103	1166	116.00	VOR	107X	1131	1194
113.25	VOR	79Y	1103	1040	116.05	VOR	107Y	1131	1068
113.30	VOR	80X	1104	1167	116.10	VOR	108X	1132	1195
113.35	VOR	80Y	1104	1041	116.15	VOR	108Y	1132	1069
113.40	VOR	81X	1105	1168	116.20	VOR	109X	1133	1196
113.45	VOR	81Y	1105	1042	116.25	VOR	109Y	1133	1070
113.50	VOR	82X	1106	1169	116.30	VOR	110X	1134	1197
113.55	VOR	82Y	1106	1043	116.35	VOR	110Y	1134	1071
113.60	VOR	83X	1107	1170	116.40	VOR	111X	1135	1198
113.65	VOR	83Y	1107	1044	116.45	VOR	111Y	1135	1072

TABLE A.—VOR-TACAN-DME CHANNEL FREQUENCIES AND PAIRING—Continued

VHF Chan. Freq. MHz	DME-TACAN			VHF Chan. Freq. MHz	DME-TACAN		
	Chan. No.	Inter. Freq. MHz	Reply Freq. MHz		Chan. No.	Inter. Freq. MHz	Reply Freq. MHz
116.50 VOR	112X	1136	1199	117.25 VOR	119Y	1143	1080
116.55 VOR	112Y	1136	1073	117.30 VOR	120X	1144	1207
116.60 VOR	113X	1137	1200	117.35 VOR	120Y	1144	1081
116.65 VOR	113Y	1137	1074	117.40 VOR	121X	1145	1208
116.70 VOR	114X	1138	1201	117.45 VOR	121Y	1145	1082
116.75 VOR	114Y	1138	1075	117.50 VOR	122X	1146	1209
116.80 VOR	115X	1139	1202	117.55 VOR	122Y	1146	1083
116.85 VOR	115Y	1139	1076	117.60 VOR	123X	1147	1210
116.90 VOR	116X	1140	1203	117.65 VOR	123Y	1147	1084
116.95 VOR	116Y	1140	1077	117.70 VOR	124X	1148	1211
117.00 VOR	117X	1141	1204	117.75 VOR	124Y	1148	1085
117.05 VOR	117Y	1141	1078	117.80 VOR	125X	1149	1212
117.10 VOR	118X	1142	1205	117.85 VOR	125Y	1149	1086
117.15 VOR	118Y	1142	1079	117.90 VOR	126X	1150	1213
117.20 VOR	119X	1143	1206	117.95 VOR	126Y	1150	1087

ERRATA

AC 00-31 U. S. National Aviation Standard for the VORTAC System

In printing the subject AC, page 20 containing Figure 1 was inadvertently omitted. This errata transmits the missing page 20.

Please remove page 19 and insert the attached pages 19 and 20.

TABLE A.—VOR-TACAN-DME CHANNEL FREQUENCIES AND PAIRING—Continued

VHF Chan. Freq. MHz	DME-TACAN Chan. No.	DME-TACAN Inter. Freq. MHz	DME-TACAN Reply Freq. MHz	VHF Chan. Freq. MHz	DME-TACAN Chan. No.	DME-TACAN Inter. Freq. MHz	DME-TACAN Reply Freq. MHz
116.50 VOR	112X	1136	1199	117.25 VOR	119Y	1143	1080
116.55 VOR	112Y	1136	1073	117.30 VOR	120X	1144	1207
116.60 VOR	113X	1137	1200	117.35 VOR	120Y	1144	1081
116.65 VOR	113Y	1137	1074	117.40 VOR	121X	1145	1208
116.70 VOR	114X	1138	1201	117.45 VOR	121Y	1145	1082
116.75 VOR	114Y	1138	1075	117.50 VOR	122X	1146	1209
116.80 VOR	115X	1139	1202	117.55 VOR	122Y	1146	1083
116.85 VOR	115Y	1139	1076	117.60 VOR	123X	1147	1210
116.90 VOR	116X	1140	1203	117.65 VOR	123Y	1147	1084
116.95 VOR	116Y	1140	1077	117.70 VOR	124X	1148	1211
117.00 VOR	117X	1141	1204	117.75 VOR	124Y	1148	1085
117.05 VOR	117Y	1141	1078	117.80 VOR	125X	1149	1212
117.10 VOR	118X	1142	1205	117.85 VOR	125Y	1149	1086
117.15 VOR	118Y	1142	1079	117.90 VOR	126X	1150	1213
117.20 VOR	119X	1143	1206	117.95 VOR	126Y	1150	1087

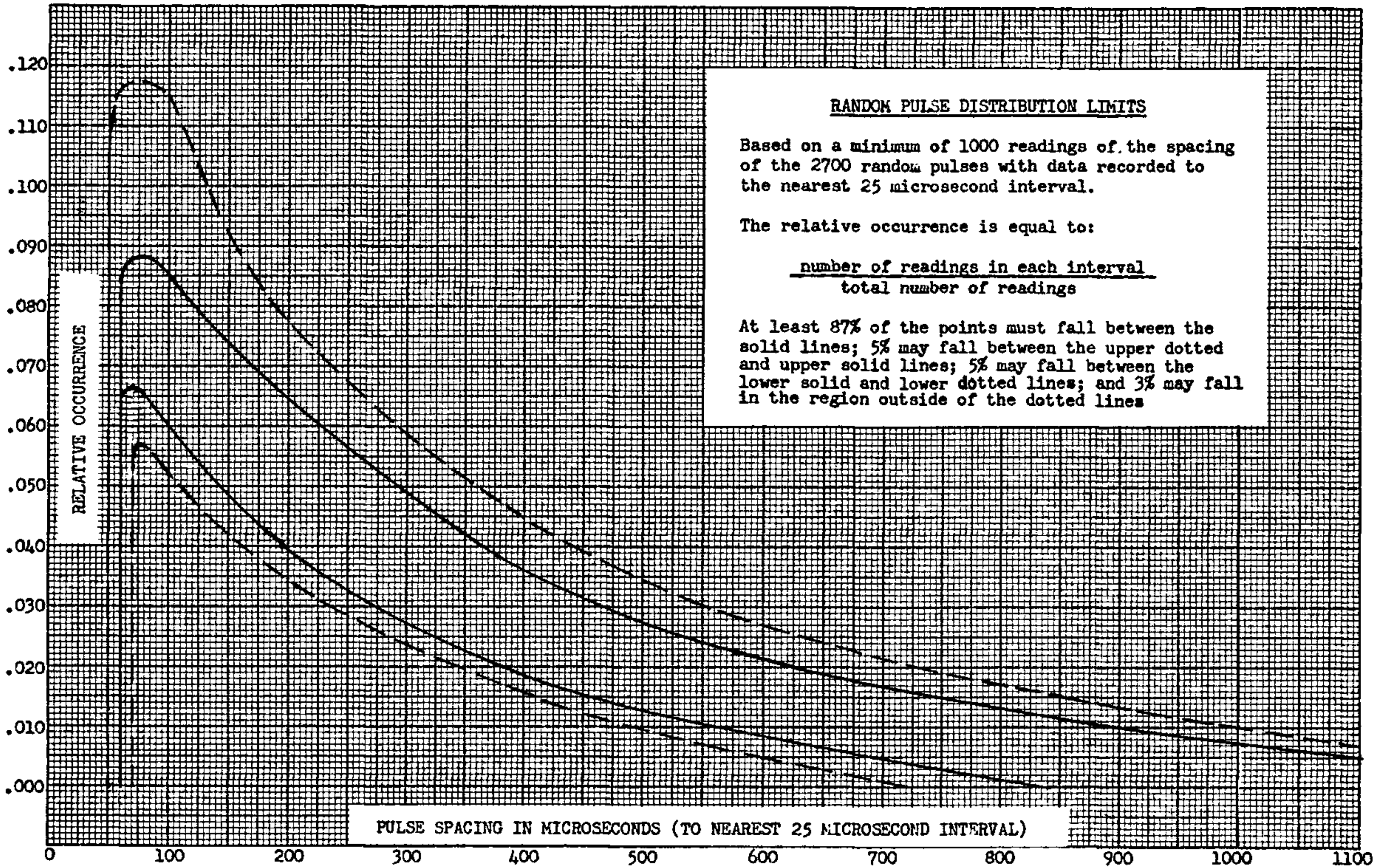
RANDOM PULSE DISTRIBUTION LIMITS
Based on a minimum of 1000 readings of the spacing of the 2700 random pulses with data recorded to the nearest 25 microsecond interval.
The relative occurrence is equal to:
number of readings in each interval / total number of readings
At least 87% of the points must fall between the solid lines; 5% may fall between the upper dotted and upper solid lines; 5% may fall between the lower solid and lower dotted lines; and 3% may fall in the region outside of the dotted lines
RELATIVE OCCURRENCE
.120
.110
.100
.090
.080
.070
.060
.050
.040
.030
.020
.010
.000
PULSE SPACING IN MICROSECONDS (TO NEAREST 25 MICROSECOND INTERVAL)
0
100
200
300
400
500
600
700
800
900
1000
1100

FIGURE 1