U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIRWORTHINESS APPROVAL OF OMEGA/VLF NAVIGATION SYSTEMS FOR USE IN THE U.S. NATIONAL AIRSPACE SYSTEM (NAS) AND ALASKA

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Initiated by: AIR-120

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Change:

1. PURPOSE. This advisory circular establishes an acceptable means, but not the only means, of obtaining airworthiness approval of an Omega/Very Low Frequency (VLF) navigation system for use under VFR (visual flight rules) and IFR (instrument flight rules) within the conterminous United States, Alaska, and surrounding United States waters. Like all advisory material, this advisory circular is not, in itself, mandatory and does not constitute a regulation. It is issued for guidance purposes and to outline one method of compliance with airworthiness requirements. As such, the terms "shall" and "must" used in this advisory circular pertain to an applicant who chooses to follow the method presented. The guidelines provided in this advisory circular supersede those of AC 90-45A, Approval of Area Navigation Systems for Use in the U.S. National Airspace System, for Omega/VLF navigation equipment.

2. CANCELLATION. Advisory Circular (AC) 20-101B, dated December 1, 1980, is canceled.

3. RELATED FAR. Federal Aviation Regulations (FAR) Parts 23, 25, 27, 29, 43, and 91.

4. RELATED READING MATERIALS.

a. Federal Aviation Administration (FAA)/Technical Standard Order (TSO) C94a, Omega Receiving Equipment Operating Within the Radio Frequency Range 10.2 to 13.6 Kilohertz, and TSO C120, Airborne Area Navigation Equipment Using Omega/VLF Inputs. Copies may be obtained from the Department of Transportation, FAA, Aircraft Certification Service, Aircraft Engineering Division (AIR-120), 800 Independence Avenue, SW., Washington, DC 20591.

b. Radio Technical Commission for Aeronautics (RTCA), Document No. RTCA/DO-160B, Environmental Conditions and Test Procedures for Airborne Equipment, Document No. RTCA/DO-164A, Airborne Omega Receiving Equipment, Document No. RTCA/DO-178A, Software Considerations in Airborne Systems and Equipment Certification, and Document No. RTCA/DO-190, Minimum Operational Performance Standards for Airborne Area Navigation Equipment using Omega/VLF Inputs. Copies may be purchased from RTCA Secretariat, One McPherson Square, Suite 500, 1425 K Street, NW., Washington, DC 20005.

c. Advisory Circular 90-82, Random Area Navigation Routes. Copies may be obtained from the Department of Transportation, Utilization and Storage Section, M-443.2, Washington, DC 20590.

d. Advisory Circular 27-1, Certification of Normal Category Rotorcraft. This document should be referenced to determine if considerations beyond those contained in this advisory circular are necessary when installing an Omega/VLF navigation system in a normal category rotorcraft. If necessary, AC 27-1 will address those items peculiar to rotorcraft installations. Copies may be ordered from: Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, or from any of the Government Printing Office bookstores located in major cities throughout the United States. Identify the publication as AC 27-1, Certification of Normal Category Rotorcraft, Stock Number 050-007-00708-6.

e. Advisory Circular 29-2, Certification of Transport Category Rotorcraft. This document should be referenced to determine if considerations beyond those contained in this advisory circular are necessary when installing an Omega/VLF navigation system in a transport category rotorcraft. If necessary, AC 29-2 will address those items peculiar to rotorcraft installations.

5. BACKGROUND.

a. System Description: Omega is a radio navigation system which uses low frequency, precisely timed pulsed signals from eight round transmitting stations spaced thousands of miles apart around the world. The VLF communications system is comprised of a series of high power very low frequency transmitters comprising the U.S. Naval VLF Telecommunications Network. Omega stations transmit in a very precise phase stable format and are synchronized with each other using atomic clocks. The VLF signals are transmitted similarly, however, are not synchronized with each other as with Omega signals. Position data is derived by measuring the phase changes of signals being received. The system solves the continuously changing geometry problem and converts the phase changes being measured from several stations into distance and direction of movement since the last phase measurements were taken. The incremental changes in distance and direction are continuously combined with previously calculated positions to determine the present position. Navigation values such as distance and bearing to a waypoint are computed from the aircraft latitude/longitude and the location of the waypoint. Course guidance is generally provided as a linear deviation from the desired track of a great circle course. The desired course may be pilot selectable or may be determined by the navigation computer by computations based on the locations of succesive waypoints.

b. System Availability and Reliability.

(1) The Omega station network was created solely for the purpose of providing long-range navigation. Omega system status information is available on a telephone recording from U.S. Naval Observatory, telephone (703) 866-3801. Omega status messages are also broadcast by the National Bureau of Standards on stations WWV and WWVH at 16 minutes past each hour (WWV) and 47 minutes past each hour (WWVH).

(2) Unlike the dedicated Omega network, the VLF communications system operated by the U.S. Navy is not primarily intended for navigation use. The

Navy may shut stations down, add new stations, change frequencies, etc., with no advance warning. Information on current VLF system status is not published for the aviation user.

(3) The Omega/VLF navigation system, while it may use VLF communications stations to supplement and enhance the Omega system (increase areas of coverage, improve performance, etc.), should be capable of accurate navigation using Omega signals alone.

c. Omega Position Errors. The accuracy of Omega/VLF navigation can be degraded by errors due to phase disturbances of the signals as they propagate from the station to the aircraft, improper modeling of the signal propagation changes caused by diurnal shift, errors due to poor station/aircraft geometry, surface conductivity, etc.

d. General Operational Limitations.

(1) En Route National Airspace System (NAS) Use. An Omega/VLF system may be approved for en route navigation VFR or IFR within the conterminous United States and Alaska. Other navigation equipment (i.e., Very High Frequency Range (VOR), distance measuring equipment (DME), tactical air navigation (TACAN)) appropriate to the ground facilities along the intended route to be flown should be installed and operable.

(2) Terminal and Approach Use in the NAS. An Omega/VLF system may not be approved for terminal and approach operations.

(3) IFR Navigation Equipment. Aircraft employing Omega/VLF for IFR navigation should also be equipped with an approved alternate means of navigation.

6. DEFINITIONS.

a. En Route Operations. En route operations are those flight phases conducted on charted VOR routes designated as high or low altitude routes (Jet or Victor), direct point-to-point operations between defined waypoints, or along great circle routes as described in AC 90-82.

b. Precipitation Static (P-Static). P-static is electromagnetic noise generated by the dissipation of an electrical charge from an aircraft into the atmosphere. The aircraft becomes charged by flight through particles suspended in the atmosphere such as dust, ice, rain, or snow. Unprotected aircraft may create so much noise that the Omega/VLF receiver can no longer detect the transmitted signal.

c. Synchronization. Synchronization is the process of determining which Omega station transmits which segment of the Omega format at a specific time.

7. AIRWORTHINESS CONSIDERATIONS. Omega/VLF navigation systems have been certificated for VFR and IFR use as an area navigation system for en route navigation in the NAS. This paragraph establishes acceptable criteria for Omega/VLF systems.

a. Omega/VLF Installations Used for Operations Under VFR Only. Operators wishing to use Omega/VLF for operations limited to VFR may obtain approval of the installation by Type Certificate (TC), Supplemental Type Certificate (STC), data field approved by the FAA on an FAA Form 337, Major Repair and Alteration, or by the use of previously approved data. The approval for return to service should be signed by one of the entities noted in FAR 43; i.e., repair station, manufacturer, holder of an inspection authorization, etc. The installation verification should ensure, but is not limited to, the following:

(1) The Omega/VLF Installation Does Not Interfere with the normal operation of other equipment installed in the aircraft. This is accomplished by a ground test and flight test to check that the Omega/VLF equipment is not a source of objectional electromagnetic interference (EMI), is functioning properly and safely, and operates in accordance with the manufacturer's specifications.

(2) The Structural Mounting of the Omega/VLF equipment is sufficient to ensure the restraint of the equipment when subjected to the emergency landing loads appropriate to the aircraft category.

(3) A Navigation Source Annunciator is Provided on or adjacent to the display if the Omega/VLF installation supplies any information to displays such as a horizontal situation indicator (HSI) or course deviation indicator (CDI) which can also display information from other systems normally used for aircraft navigation.

(4) The Omega/VLF Controls and Displays are Installed with a placard(s) which states "Omega/VLF Not Approved for IFR."

(5) The Omega/VLF May be Coupled to the "Radio Nav" Function of an autopilot provided the system has a CDI or steering output that is compatible with the autopilot, and the same installation procedures normally used for the VOR coupling are used.

b. Omega/VLF Installations Used as an Area Navigation System Under IFR. The standards for navigation within the NAS are more stringent than the requirements for long-range, over-water navigation. Omega/VLF equipment produced under TSO-C94 or TSO-C94a is not necessarily appropriate for en route area navigation under IFR since these TSO's were originally written for long-range, over-water navigation. Performance standards for Omega/VLF equipment to be used in the NAS are specified in TSO-C120. Omega/VLF equipment manufactured under TSO-C94 or TSO-C94a is also suitable for en route navigation use in the NAS provided it has been shown to meet the more stringent accuracy criteria specified in paragraph 9. Criteria for area navigation (RNAV) systems based on Omega/VLF navigation are amplified in the following paragraphs. The initial certification of an Omega/VLF system requires an engineering evaluation because of the need to verify accuracy, failure indications, approved operating areas, environmental qualifications, etc. Subsequent installations of the same Omega/VLF system in other aircraft may require additional engineering evaluation, depending upon the degree of integration of the Omega/VLF system with other aircraft systems. An engineering evaluation will be necessary to change or increase approved operating areas. Omega/VLF systems for use under IFR should provide the following:

(1) Flightcrew Inputs of:

(i) Aircraft present position in terms of latitude and longitude to at least the nearest 0.1 minute.

(ii) At least three (for to-from equipment) or four (for to-to equipment) waypoint positions in terms of latitude and longitude to at least the nearest 0.1 minute.

(iii) A means to confirm correctness of input data prior to utilization of the new data by the system.

(iv) A "direct to" function to define a route segment from present position to any waypoint.

(v) The capability for operator deselection and reselection of any station or combination of stations.

(vi) A means for manual update of system position by the pilot to permit insertion of a known present position.

(2) The System Displays Should Give No Operationally Misleading Information and Should Provide:

(i) Present position in terms of latitude and longitude to at least the nearest 0.1 minute and in terms of magnetic bearing and distance to or from a waypoint to the nearest 0.1 nautical mile (nmi) (distance to the nearest 1.0 nmi is acceptable for equipment previously approved under TSO's C94 and C94a) and nearest degree. Distances of at least 260 nmi should be capable of being displayed, but distances greater than 99.9 nmi need only be displayed to the nearest nautical mile.

(ii) Waypoint position designation in terms of latitude and longitude to at least the nearest 0.1 minute or in terms of magnetic bearing and distance from present position or another waypoint. Waypoint designation in terms of magnetic bearing and distance should be to the nearest degree of bearing and to at least 0.1 nmi for distances up to 100 nmi then at least 1.0 nmi for distances of 100 nmi or more.

NOTE: Information should be provided to the flight crew to prevent the designation of waypoints by a sequence of bearings and distances (i.e., the reference position for a waypoint designated by bearing and distance should be designated by latitude and longitude).

(iii) A display of active waypoint(s) identification (not necessarily waypoint position) used to define the navigation track being flown.

NOTE: Only systems which define the desired navigation track in terms of its endpoints can be used to navigate on published airways due to changes in magnetic variation after the commissioning of the ground facility.

(iv) A display of the desired track in terms of the appropriate magnetic course to at least the nearest 1.0 degree. Display of the appropriate magnetic course should not require the flightcrew to input the magnetic variation corresponding to the present position.

(v) A display of the distance to the active waypoint to the nearest 0.1 nmi (distance to the nearest 1.0 nmi is acceptable for equipment previously approved under TSO's C94 and C94a). Distances of at least 260 nmi should be capable of being displayed, but distances greater than 99.9 nmi need only be displayed to the nearest 1.0 nmi.

(vi) A continuous analog (i.e., non-numeric) display of crosstrack deviation with a minimum full-scale deflection of ±5.0 nmi, readability of 1.0 nmi or less, and minimum discernable movement of 0.1 nmi or less.

(vii) A display of crosstrack deviation to the nearest 0.1 nmi up to 9.9 nmi and 1.0 nmi beyond, with a range of at least ±20 nmi. This may be a digital display, may be pilot selectable, and need not be part of the course deviation indicator.

(viii) A display of the distance and magnetic bearing (at the "from" end of the segment) between waypoints to the nearest 1.0 nmi and 1.0 degree.

(ix) The capability to indicate, on demand, the specific Omega/VLF stations currently used in the navigation calculations as well as the status of all stations being tracked.

(x) An annunciation of impending waypoint crossing.

(3) Caution Indication(s) for the System Should Be Located on or near the indicator specified in paragraph 7b(2)(vi) and should provide a readily discernible caution indication(s) to the pilot(s) for any of the following:

(i) Inadequate or invalid navigation signals or sources.

(ii) The absence of primary power.

(iii) Inadequate or invalid navigation displays or output sources.

(iv) Equipment failures.

(v) Reversion to a secondary dead reckoning mode of navigation.

NOTE: These failure/status indications shall occur independently of any operator action. Power or navigation equipment failures may be indicated in a common manner. The lack of adequate navigation signals or sources (considering signal-to-noise ratio (SNR) as well as geometry) should be annunciated when compliance with the navigation accuracy specified in paragraph 9 cannot be assured.

(4) The system shall be capable of automatic synchronization within 6.0 minutes after the application of power. Synchronization should be possible with a SNR or one station/all frequencies of at least 0 dB in a 100 Hz bandwidth with no coherent interference.

(5) Navigation Guidance Should Be Available within 5 seconds of waypoint data input.

(6) The Equipment Should Have the Capability to meet the criteria outlined in paragraph 7b(1) through 7b(6) throughout the range of environmental conditions which will be encountered in actual service. Exposure of the equipment to the environmental test conditions of TSO-C120 may be used to demonstrate this capability. Environmental testing to obtain a TSO-C94 or TSO-C94a authorization may be used, provided that the test results demonstrate compliance with the criteria of paragraphs 7b(1) through 7b(6).

(7) The Equipment Should Provide a Means for the Flightcrew to determine system status prior to flight.

(8) The Equipment Should Provide the Navigation Accuracy specified in paragraph 9 for all groundspeeds up to a maximum value to be set by the manufacturer and should provide usable navigation information necessary for holding patterns conducted with standard rate turns at speeds up to 250 knots groundspeed or at a lesser value specified by the equipment manufacturer.

(9) The Equipment Should Provide Means to Alert the Flightcrew prior to arrival at a waypoint to permit turn anticipation in accordance with the approximate formula of 1.0 nmi for each 100 knots of groundspeed. This indicator should be located on or near the indicator specified in paragraph 7b(2)(vi). For Omega/VLF systems which are not coupled to a flight director or autopilot, a procedural means based on a continuous and properly located distance to waypoint display may be used for waypoint lateral maneuver anticipation. Systems which provide steering signals for flight directors or autopilots should provide automatic turn anticipation and a waypoint alert which occurs prior to the initiation of the turn by the flight director or autopilot.

(10) If a Capabiltiy for Parallel Offset Tracks is Provided, track selection should be in increments of at least 1.0 nmi left or right up to an offset of at least 20 nmi. Means should be provided to continuously indicate that an offset track has been selected. Waypoint alerting and turn anticipation should be provided prior to arrival at the point where the offset intersects the angle bisector of the parent track. These functions should operate as described in paragraph 7b(9).

c. Software Changes. The provisions of this paragraph apply to Omega/VLF equipment which utilizes a digital computer to provide navigation information or system monitoring. The computer program (software) operates the computer and provides the basic functions of these systems. The software for navigation functions of Omega/VLF equipment described in paragraph 7b (for Omega/VLF used for IFR operations) should be verified and validated to at least the level 2 requirements as defined by RTCA/DO-178A, Software Considerations in Airborne Systems and Equipment Certification. Any changes to software which affects navigational functions are considered to be major changes to the equipment. Unless software partitioning has been previously established, any change to level 1 or level 2 software of Omega/VLF navigation equipment should be verified and validated to the appropriate level and should be demonstrated as not having inadvertently affected the remaining navigational functions. Changes to software used for Omega/VLF equipment limited to VFR use or equipment having

established partitioning from software which provides navigational functions in IFR systems are considered to be minor and do not require prior approval by the FAA, providing the manufacturer of the Omega/VLF equipment has a software configuration management and quality assurance plan approved by the FAA. Software status must be identified on the outside of the associated line replaceable unit in accordance with the criteria of RTCA/DO-178A. Software changes in TSO approved equipment must be reported to the cognizant Aircraft Certification Office. If the equipment displays a software identifier to the flightcrew, the airplane or rotorcraft flight manual (or appropriate placard) should indicate the approved identifier. Software changes incorporated in equipment already installed in an aircraft may require additional evaluation and possible flight manual supplement revision prior to returning the aircraft to service, depending upon the scope of the change.

8. EQUIPMENT INSTALLATION CONSIDERATIONS FOR USE UNDER IFR.

a. Location of the Omega/VLF Display. Each display element, used as a primary flight instrument in the guidance and control of the aircraft, for maneuver anticipation, or for failure annunciation, should be located where it is clearly visible to the pilot (in the pilot's primary field of view) with the least practicable deviation from the pilot's normal position and line of vision when looking forward along the flight path.

b. Failure Protection. Any probable failure of the airborne Omega/VLF navigation system should not degrade the normal operation of other required equipment or create a flight hazard. Normal operation of the Omega/VLF installation should not adversely affect the performance of other aircraft equipment.

c. Environmental Conditions. The aircraft environment in which the Omega/VLF system is installed should be found to be compatible with environmental categories to which the equipment was tested.

d. Electromagnetic Interference. The Omega/VLF navigation system should not be the source of objectionable electromagnetic interference, nor be adversely affected by electromagnetic interference from other equipment in the aircraft.

e. P-Static Protection. If an E-Field antenna (whip, plate, or blade type) is used, the aircraft should be protected by acceptable bonding techniques and installation of static dischargers. These protective devices should be specified as part of the approved design data for the Omega/VLF installation. The capability to provide satisfactory P-static protection for the Omega/VLF system should be demonstrated as part of the initial certification program and for each subsequent installation using an E-Field antenna. This testing may be accomplished by ground or static testing if sufficient data is provided to demonstrate that the proposed technique is equivalent to flight testing. If a flight demonstration is selected, it must be conducted at speeds up to V_{ne}, V_{mo}, or M_{mo} through known P-static conditions such as a cloud of ice crystals. Momentary loss of signal when encountering heavy P-static conditions may be acceptable provided the equipment is capable of providing acceptable navigation information during such conditions.

(1) P-Static Charging/Discharging. P-static charging of the aircraft can cause degradation of the signal-to-noise ratio by one of three major mechanisms: sparkover of isolated metal panels, corona discharge, and streamer currents. Sparkover of isolated metal panels can be handled by appropriate bonding. This bonding needs to occur on all control and trim surfaces as well as isolated access panels. Bonding should be evaluated by a careful ohmic survey (an electrical bonding limit of 10 milliohms is considered acceptable) of each aircraft in which the Omega/VLF system is installed or by other suitable techniques. The effects caused by streamer currents can be reduced by placing the receiving antenna as far as possible from any nonconductive surfaces such as windshields. The nonconductive surfaces may be coated with a conductive coating. Temporary spray coatings are not satisfactory. Corona discharge can be reduced by the appropriate placing of orthodecoupled static dischargers on the extremities of the aircraft. A number of recent studies have shown that the frayed-wick types of discharger rapidly lose their effectiveness as a result of use. Therefore, dischargers constructed with a high resistance rod and metal pins are recommended although other types may also be used if they can demonstrate ability to provide protection from radio frequency (RF) coupling to the Omega/VLF antenna. The number, type, and location of these static dischargers to be installed on a particular aircraft model should be determined by following the instructions provided by the manufacturer of the static discharger for P-static protection.

f. Anti-Ice Protection. If the aircraft in which the Omega/VLF is installed is approved for flight into known icing conditions, the antenna should have anti-ice protection or be found not to be susceptible to ice buildup. Alternatively, if the Omega/VLF system can be shown to operate satisfactorily when the antenna is subject to icing, or if the system is limited via placard or flight manual to indicate that it is not to be used for navigation during flight in icing conditions, then anti-ice protection is not required.

g. Dynamic Responses. The system shall continue to indicate aircraft position to the accuracy specified in paragraph 9 during aircraft maneuvering or changes in attitude encountered in normal operations, assuming secondary inputs are not lost during the maneuver.

h. System Controls. The system controls should be arranged to provide adequate protection against inadvertent system turnoff. The controls for system operation should be readily accessible to, and usable by, the flightcrew and be visible under all expected lighting conditions, including night and direct sunlight.

i. System Tests. The initial approval of an Omega/VLF system for IFR use involves extensive testing to demonstrate system performance, operational areas, environmental qualifications, etc., as described in paragraph 7b(6). Subsequent installations in other aircraft need only be tested to the extent necessary to demonstrate proper operation of interfacing aircraft equipment such as autopilots, flight directors and instrument displays, satisfactory antenna installations as evidenced by the reception of Omega/VLF signals during normal flight maneuvers (including P-static conditions for E-Field antennas), satisfactory clearance of EMI, and functional check of the Omega/VLF equipment.

j. Manufacturer's Instructions. Omega/VLF equipment should be installed in accordance with instructions and limitations provided by the manufacturer of the equipment.

9. SYSTEM ACCURACY.

a. En route IFR Operation Along Random (Off Airways) RNAV Routes with Radar Coverage. The error of the airborne Omega/VLF equipment should be less than ±3.8 nmi of crosstrack error on a 95 percent probability basis and ±3.8 nmi of along-track error on a 95 percent probability basis.

b. En route IFR Operation on Airways in the NAS. The error of the airborne Omega/VLF equipment should be less than ±2.8 nmi of crosstrack error on a 95 percent probability basis and ±2.8 nmi of along-track error on a 95 percent probability basis for approval of en route IFR operations on airways.

c. Flight Technical (Pilotage) Errors. With satisfactory displays of crosstrack position, the FAA has determined that flight technical errors can be expected to be less than the values shown below on a two-sigma basis.

Flight Condition	Flight Technical Error
En route	±1.0 nmi

Sufficient flight tests of the installation should be conducted to verify that these values can be maintained. Smaller values for flight technical errors should not be expected, unless the Omega/VLF system is to be used only when coupled to an autopilot; however, at least the total system crosstrack accuracy shown below should be maintained.

If an installation results in larger flight technical errors, the total crosstrack error of the system should be determined by combining equipment and flight technical errors using the root sum square (RSS) method. The result should be less than the values listed below.

Flight Condition	Total Crosstrack Error
Random RNAV Routes	±4.0 nmi
En route, on Airways	±3.0 nmi

10. IFR AIRWORTHINESS APPROVAL. There are two types of approval which differ greatly as to test requirements and data analysis.

a. First-Time Airworthiness Approval. This type of approval refers to the very first time an applicant presents a particular model Omega/VLF equipment for FAA airworthiness installation approval and certification for an IFR navigation system. Any new models of Omega/VLF equipment by the same manufacturer should undergo the same approval process as the original equipment unless it can be shown by analysis and tests that the new model will function as well or better than the approved equipment. A first-time approval is conducted in three phases:

(1) Lab/Bench Tests and Equipment Data Evaluation. This phase consists of the following:

(i) Analysis of the manufacturer's procedures for verification and validation of software and review of supporting documentation in accordance with the guidelines of RTCA/DO-178A where system performs navigational functions.

(ii) Verification of compliance with appropriate environmental qualification standards such as RTCA/DO-160B.

(iii) Examination of the equipment's display capabilities with emphasis on warning, caution, and advisory annunciations.

(iv) Analysis of failure modes.

(v) Review of reliability data to establish that all probable failures are detected.

(vi) Evaluation of the ease of use of the controls and of the viewing ease of the displays and annunciations from a human factors point of view.

(vii) Review of installation and maintenance manuals.

(viii) Evaluation of operator's manual (pilot's guide).

(2) Aircraft Installation Data Evaluation. Normally the manufacturer of the Omega/VLF equipment will provide an aircraft as a test bed for a first-time installation approval. This first-time installation approval will serve as a basis for any subsequent installation approvals regardless of aircraft type or model. The following assessments are to be made:

(i) Review of installation drawings, wiring diagrams, and descriptive wiring routing.

(ii) Evaluation of the cockpit layout of the installed equipment with emphasis on equipment controls, applicable circuit breakers (labels and accessibility), switching arrangement and related indicators, displays, and annunciators.

(iii) Analysis of a data flow diagram in order to review which equipment transmits what data to which other equipment.

(iv) Review of a structural analysis of the equipment installation in order to ascertain whether all Omega/VLF components are satisfactorily attached to the basic aircraft structure.

(v) Examination of an electrical load analysis in order to verify that the added electrical power requirements of the Omega/VLF installation will not cause overloading of the aircraft's electrical generating capacity.

(vi) Evaluation of the antenna installation. A critical aspect of any Omega/VLF installation is the installation of the antenna. The Omega/VLF

signal is quite weak, typically much less than one-third the value of the background noise. Electrical noise in the vicinity of the antenna can render the Omega/VLF equipment useless.

A E-Field antenna (whip, plate, or blade type). Precipitation static has an adverse effect upon the signal receiving capability of this type of antenna. The adverse effects of precipitation static can be minimized by use of the proper antenna type and location, by installation of high-quality static dischargers, by proper bonding, and by application of anti-static paint on all plastic nonconducting surfaces. The manufacturer's installation or maintenance manual usually describes "good" E-Field antenna installation practices.

NOTE: Each aircraft should be subjected to a careful ohmic survey of bonding (an electrical bonding limit of 10 milliohms is considered acceptable). The P-static protection is a required part of the Omega/VLF installation and must be maintained for proper system operations.

B H-Field antenna (loop type). The signal receiving quality of this type of antenna is adversely affected by aircraft electrical skin currents, particularly by 400 Hz ac. P-static has no appreciable effect on an H-Field antenna, and its effects can usually be ignored. A procedure called "skin mapping" is normally employed to determine a good mounting location. It should be noted that shifting major aircraft electrical components to different locations within the aircraft may render a previously determined skin map location unsuitable.

NOTE: The following is a simple test to verify the effectiveness of an H-Field antenna installation located by skin mapping. Park the aircraft away from any external electrical noise source. Using only the aircraft's battery, and with all other electrical equipment off, activate the Omega/VLF equipment and record signal-to-noise values (or quality factors) for all receivable stations. Repeat this process of recording signal-to-noise values (or quality factors) with engine(s) running and all electrical/electronic equipment operating on aircraft power. If the antenna installation is satisfactory, there should not be any significant degradation in signal-to-noise ratio values or quality factors.

(3) Flight Test Evaluations. Flight tests are conducted in two stages:

(i) Functional Flight Tests Consist of:

A Evaluation of all operating modes of the Omega/VLF equipment.

B Examination of the interface (function) of other equipment connected to the Omega/VLF.

C Review of various failure modes and associated annunciations such as loss of electrical power, loss of signal reception, Omega/VLF equipment failure, etc.

D Evaluation of steering response while autopilot is coupled to the Omega/VLF equipment during a variety of different track changes.

E Evaluation of displayed Omega/VLF navigation parameters on interfaced flight deck instruments such as HSI, CDI, etc.

F Assessment of all switching and transfer functions pertaining to the Omega/VLF installation including high-power electrical loads and electrical bus switching.

G Evaluation to determine whether there exists any electromagnetic or radio frequency interference between the Omega/VLF installation and other onboard equipment, or vice versa.

H Evaluation of the acessibility of all controls pertaining to the Omega/VLF installation.

I Evaluation of the visibility of the displays and annunciators pertaining to the Omega/VLF installation during day and night lighting conditions. No distracting cockpit glare or refections may be introduced.

J Analysis of crew workload when operating the Omega/VLF equipment.

K Evaluation of diurnal effects on the performance of the Omega/VLF system.

(ii) Determination of Navigation Error Flight Test. The initial certification of each Omega/VLF system to be used for IFR operations should be based on a demonstration of system accuracy by recording the Omega/VLF equipment position and comparing it to the actual position of at least 100 locations distributed throughout the Omega/VLF operational area. These measures should be recorded in flight by overflight of a known ground reference point at low altitude (less than 3,000' above ground level (AGL)) or comparison with a good multiple DME fix. The data should demonstrate that the appropriate accuracy criteria of paragraph 9 are met on a 95 percent probability basis. Flights into known poor signal areas should be conducted to verify that the caution indications for bad geometry and poor signal quality function properly. A ground or flight test for P-static protection, if appropriate, should be conducted. Normal flight manuevers should not cause loss of the Omega/VLF signal and the system dynamic response should be confirmed. Any unusual flight technical errors or errors resulting from use of the autopilot and flight director should be evaluated and examined. At least 50 percent of the accuracy measurements should be accomplished in areas of marginal performance. The system should demonstrate its ability to re-acquire the Omega/VLF signal after power interruption and in areas of marginal performance.

b. Follow-On Airworthiness Installation Approvals. This type of approval refers to installation approvals in any model or type of aircraft after a first-time airworthiness approval of the particular Omega/VLF equipment has been issued. Follow-on approvals may use the first-time airworthiness approval, which was either a TC or an STC, as a basis for installation approval. Follow-on installation approvals may be accomplished by TC or STC, or may be in the form of a field approval on an FAA Form 337. The applicant or installing agency requesting a follow-on Omega/VLF installation utilizing this method of data approval should:

(1) Contact either the manufacturer or organization responsible for obtaining the first-time airworthiness approval in order to:

(i) Obtain a sample airplane flight manual (AFM) or rotorcraft flight manual (RFM) supplement (or supplemental flight manual, as appropriate).

(ii) Obtain verification of the equipment approval status, including the model of the antenna and software program identification.

(iii) Discuss any problem areas and seek assistance in their solution.

(2) Conduct a similar data evaluation as outlined in paragraph 10a(2).

(3) Conduct flight evaluations similar to the flight tests outlined in paragraph 10a(3)(i).

(4) Verify that the ohmic bonding check of the aircraft has been conducted and that appropriate numbers and types of static dischargers are installed if an E-Field antenna is used, or that a skin map has determined the appropriate location for the antenna if an H-Field antenna is used.

(5) Verify that the maximum expected groundspeed of the aircraft is less than the maximum operating speed for which the Omega/VLF equipment is qualified.

(6) Spot-check en route navigation accuracy and verify proper system operation by conducting an evaluation flight. The flight test should be of sufficient length and should follow a plan which permits proper functional evaluation of the Omega/VLF system installation. Accuracy should be verified by conducting at least two low-level overflights of known landmarks (i.e., a VOR station). (A DME-DME position fix may be substituted for one of the low-level overflights.) During this flight, the most significant (to the navigation solution) Omega and VLF communication stations (one Omega and one VLF station) should be deselected approximately 50 percent of the time. The purpose of this test flight is not to validate navigation error values, but rather to verify that in the course of this installation nothing was done to compromise the accuracy of the system as determined by the first-time approval. Errors in excess of the values listed in paragraph 9 should be evaluated to determine possible causes. If a logical explanation is not available, additional flight test data points should be collected in the area(s) where the excessive error occurred. If such error(s) persists, approval of the installation should be withheld.

11. OPERATIONAL CONSIDERATIONS.

a. Operation in the NAS. The aircraft should have navigational equipment installed and operating appropriate to the ground facilities to be used (not including Omega/VLF systems). Within the conterminous United States, this requirement may be met with the installation of a VOR receiver in addition to the Omega/VLF system approved for IFR operation.

b. Operational Area. Operators and their flightcrews should consult the approved flight manual supplement for their aircraft to determine approved operational areas that may apply to their aircraft. Flightcrews must be aware that operational areas may be different for different Omega/VLF systems, and the appropriate operating area(s) for a particular system can only be determined by reference to the approved flight manual or other FAA approved documents.

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Certification Service