

Advisory Circular

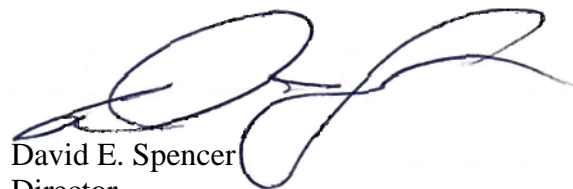
U.S. Department
of Transportation

**Federal Aviation
Administration**

Subject: AUTOMATED WEATHER OBSERVING SYSTEMS (AWOS) FOR NON-FEDERAL APPLICATIONS **Date:** 01/31/2019 **AC No:** 150/5220-16E
Initiated by: AJW-144 **Change:** 1

1. **PURPOSE.** This change contains updates that provide additional clarification and flexibility regarding technician training and responsibilities. These changes expand on the use of on site training or on the job training (OJT), based on statements regarding equivalent performance and maintenance standards in FAA Order 6700.20, Non-Federal Navigational Aids, Air Traffic Control Facilities, and Automated Weather Systems and discussion of on the job training in FAA Order 3000.57, Air Traffic Organization Technical Operations Training and Personnel Certification Programs.
2. **PRINCIPAL CHANGES.** Changed text is indicated by vertical bars in the margins. The primary revisions are contained in chapter 2, chapter 4 and the addition of appendix 2.

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David E. Spencer
Director
Operations Support, AJW-1



U.S. Department
of Transportation

**Federal Aviation
Administration**

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Subject: AUTOMATED WEATHER OBSERVING SYSTEMS (AWOS) FOR NON-FEDERAL APPLICATIONS **Date:** 03/10/2017 **AC No:** 150/5220-16E
Initiated by: AJW-144 **Change:**

1. **PURPOSE.** This advisory circular (AC) contains the Federal Aviation Administration's (FAA) standard for the non-Federal AWOS. This AC applies to anyone proposing to design, manufacture, procure, install, activate or maintain non-Federal AWOS for aviation purposes.

This advisory circular also contains site location and implementation criteria that must be met before the installed system can be commissioned and become an approved source of aviation weather information. It also contains maintenance and annual inspection criteria that must be met throughout the system's life cycle in order for the system to continue to be an approved source of aviation weather information.

2. **CANCELLATION.** AC 150/5220-16D, Automated Weather Observing Systems (AWOS) for Non-Federal Applications, dated 04/28/2011, is canceled.

3. **DEFINITION.** An AWOS is defined to be an "air navigation facility" distributing weather information, in Title 49 USC Section 40102, and consists of a computerized system that automatically measures one or more weather parameters, analyzes the data, prepares a weather observation that consists of the parameter(s) measured, provides dissemination of the observations and broadcasts the observation to the pilot in the vicinity of the AWOS, typically using an integral very high frequency (VHF) radio, an existing navigational aid (NAVAID), or Automatic Terminal Information Service (ATIS). Observations may also be available by telephone dial-up service. In addition, a Non-Federal AWOS is a Non-Federal facility as defined in the latest edition of FAA Order 6700.20, Non-Federal Navigational Aids, Air Traffic Control Facilities, and Automated Weather Systems.

4. **APPLICATION.** The provisions of this AC are effective immediately for all non-Federal AWOS systems, or portions thereof, that are submitted for type certification or for previously type-certified systems that are submitted for modification of their type certification certificate.

The Federal Aviation Administration recommends the guidance and specifications in this AC as it relates to non-Federal AWOS including but not limited to the design, manufacture, procurement, installation, activation, use and maintenance of such systems. This AC does not

constitute a regulation and is not mandatory. It provides one, but not the only, acceptable means of meeting the requirements of complying with the pertinent regulations.

Use of these guidelines is mandatory for projects that are funded under Federal grant assistance programs, including the Airport Improvement Program (AIP). It is also mandatory, as required by regulation, for projects funded by the Passenger Facility Charge program. See 14 C.F.R. part 158.25(b)(16). Mandatory terms such as “must” apply only to those proposing to design, manufacture, procure, install, activate, use or maintain an AWOS system using Federal grant funds or passenger facility charge (PFC) revenue or those who seek to demonstrate compliance by use of the specific method described by this AC.

5. USE IN THE NATIONAL AIRSPACE (NAS). An AWOS that has been manufactured, installed, and maintained according to the criteria in this AC may constitute an FAA approved source for weather information; may be approvable as a source of weather information that partially satisfies aviation regulations as identified in Title 14 of the Code of Federal Regulations (14 CFR); may be eligible to receive a broadcast frequency assignment or permission to broadcast over a NAVAID and may be eligible (subject to additional criteria) to transmit its weather information indirectly to the FAA for subsequent national dissemination.

6. CONTENT OF THIS AC. This AC provides guidance regarding the program elements that relate to a non-Federal AWOS.

7. PRINCIPAL CHANGES. Adds information for accessing a list of certified non-Federal AWOS systems and manufacturers. Updates the office of primary responsibility name and routing code. Makes content changes to clarify sentence meanings. Removes taking the entire system out of service when the altimeter is out of service. Clarifies the statutory basis of this advisory circular and the importance of commissioning and inspecting a system for the purposes of instrument approach procedures. Removes references to the FAA Concepts Bypass exam. Revises humidity, UHF radio and tri-annual scheduling criteria to be consistent with FAA AWOS criteria. Incorporates National Transportation Safety Board (NTSB) recommendations regarding present weather precipitation identification.

The updated operator terminal, environmental and present weather reporting criteria apply effectively to all new systems or systems that are submitted for modification. The updated annual inspection criteria and table, triannual maintenance check timing criteria and barometer verification methodology apply effective immediately to all systems that have been type-certified in the past.

8. HISTORICAL INFORMATION ABOUT THE PREVIOUS CHANGE DATED 04/28/11. Changed the minimum preventative maintenance interval from 90 days to tri-annual (120 days). Clarified information about connectivity to the FAA for national dissemination of AWOS data. Changed the Office of Primary Responsibility (OPR) for type certification from the Washington DC program office to the Oklahoma City Weather Processors and Sensors Team (AJW-14A). Made word changes to clarify sentence meanings. Changed the precipitation occurrence and measurement from one category into two distinct categories: 1) Present Weather Detector/Sensor and 2) Rain Gauge. Adds criteria for Ultrasonic Wind sensors and an AWOS to Automatic Terminal Information System (ATIS) switch.

9. REQUESTS FOR INFORMATION. Further information concerning AWOS standards and the FAA type certification approval process may be obtained from:

AWOS Non-Federal Engineering Office
Weather Systems (AJW-144)
6500 S. MacArthur, Bldg 196
Oklahoma City, OK 73169
Telephone: (405) 954-8427
Email: Non-Federal-Program@FAA.gov

A handwritten signature in black ink, appearing to read 'David E. Spencer', with a stylized flourish extending to the right.

David E. Spencer
Director, Operations Support

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Chapter 1. INTRODUCTION

1.1. FUNCTIONAL DESCRIPTION. An Automated Weather Observing System (AWOS) automatically measures meteorological parameters, reduces and analyzes the data via computer, and broadcasts weather reports which can be received by aircraft operating up to 10,000 feet above ground level and 25 nautical miles (nm) from the AWOS. Pilots may use the certified weather information provided by the AWOS to partially fulfill the requirements of various regulations identified in Title 14 of the Code of Federal Regulations (14 CFR).

Due to the importance weather plays in the taking off and landing of all forms of aircraft, AWOS may be located on airports, at or near ground based or roof top based heliports, as well as on offshore platforms and drill ships. For the purposes of this advisory circular, the use of the word “airport” is defined to include any place any form of aircraft may take off or land, including traditional airports, heliports, offshore platforms, drill ships, etc.

Non-Federal AWOS are owned, operated and maintained by the airport owner. For the purposes of this advisory circular, the use of the word “owner” is defined to be the organization responsible for the non-Federal AWOS and could include the airport owner, airport sponsor, airport authority, etc.

1.2. WEATHER SENSORS. The AWOS is a modular system utilizing a central processor which receives input from several sensors. A type-certified non-Federal AWOS may include additional sensors to suit individual airport needs. (For example, the AWOS AV consists of an AWOS A with a visibility sensor.) If the additional sensors are to be considered certified, they must meet the certification criteria of this AC and be installed, commissioned, inspected and maintained in accordance with this AC. All other sensors are considered advisory. Advisory sensors might not meet the criteria of this AC, might not be installed, maintained, or inspected in accordance with this AC and are not approved sources of aviation weather information.

Five types of certified non-Federal AWOS are discussed throughout this AC and are recognized in other FAA Orders. They are defined based on their certified sensors and are identified in the following paragraphs, a through e, however, non-Federal AWOS may be type-certified with any combination of certified sensors.

- a. AWOS A. The AWOS A system measures and reports altimeter only.
- b. AWOS I. The AWOS I system measures and reports wind data, e.g., speed, direction, and gusts; temperature; dew point; altimeter; and density altitude.
- c. AWOS II. The AWOS II system measures and reports all the parameters of AWOS I system plus visibility.
- d. AWOS III. The AWOS III system measures and reports all the parameters of AWOS II system plus precipitation accumulation (rain gauge) and cloud height. AWOS III can have

optional sensors such as precipitation type/intensity (present weather, P) and/or thunderstorm/lightning (T). The addition of an optional certified sensor will change the designation to AWOS III P or AWOS III T, or AWOS III P/T.

e. AWOS IV. The AWOS IV system measures and reports all the AWOS III P/T (i.e. AWOS III with both present weather and thunderstorm/lightning) parameters plus freezing rain (Z) and/or runway surface condition (R). The addition of an optional sensor will change the designation to AWOS IV Z, AWOS IV R, or AWOS IV Z/R.

f. Any advisory sensor values and parameters relying on advisory sensor values must be differentiated from certified values and parameters by being clearly identified as such and preceded by the word *advisory* in the voiced message. Any information preceded by the word *advisory*, regardless of its source, is considered advisory. When broadcast via radio or telephone, certified weather information must be broadcast first, followed by the word *advisory* and then followed by all remaining weather information that is not from an approved weather source. Advisory information cannot be included in any portion of the outgoing METAR message.

1.3. OUTPUT MEDIA FOR AWOS WEATHER INFORMATION.

a. The output of the AWOS is reported by a computer-generated voice, which is transmitted to pilots over a discrete VHF transmitter or the voice output of a Navigational Aid (NAVAID). The transmission may be continuous or may be triggered by a selectable number of clicks, e.g. three clicks, of a pilot's microphone on the AWOS broadcast frequency if the AWOS broadcasts over a VHF aeronautical advisory station frequency radio, e.g., UNICOM. System design may permit the transmission of the identification of a NAVAID by using the AWOS voice capability. In all cases where the voice output of a navigational aid is used, provision should be made so that the failure of an AWOS would in no way result in any failure of the NAVAID being used.

b. AWOS messages may be offered via other formats that the owner chooses to provide, including telephone dial-up service.

An option also allows type-certified, commissioned AWOS III and AWOS IV weather data to be disseminated by the FAA Weather Message Switching Center Replacement (WMSCR) network. This allows the site's weather information to be shared nationally for forecasting and flight planning purposes. To contribute to this network, the AWOS III or AWOS IV must provide its data to an FAA approved third party service provider or to its state aviation agency's service provider. The service provider is then responsible for providing the weather data over an FAA approved interface connection to the WMSCR network by means of file transfer protocol (ftp). The weather data provided by the AWOS III or AWOS IV should be the current one minute observation containing the current weather information for all valid, certified (not advisory) parameters in a format that is compatible with the service provider's interface. The service provider is responsible for all coordination with the WMSCR office.

A current copy of the appropriate WMSCR interface documentation can be obtained from the AWOS Non-Federal Engineering Office at the following address:

AWOS Non-Federal Engineering Office
Weather Processors and Sensors Team (AJW-144)
6500 S. MacArthur, Bldg 196
Oklahoma City, OK 73169
Telephone: (405) 954-8427
Email: Non-Federal-Program@faa.gov

c. The third party manufacturer or state agency service provider that provides non-Federal AWOS weather information to the FAA for national dissemination is required to sign a Memorandum of Understanding (MOU) with the WMSCR office that commits them:

- (1) To convert the AWOS data to the current or future WMSCR format interface.
- (2) To the current METAR content and format in accordance with the latest edition of FAA Advisory Circular 00-45, Aviation Weather Services.
- (3) To a reporting frequency, e.g., number of reports per hour, in accordance with criteria directed by the WMSCR office within the FAA.
- (4) To bear all communications, quality assurance, troubleshooting, and administrative costs to provide their non-Federal AWOS information to the WMSCR.
- (5) To provide a point of contact for use by the FAA and others to report problems with the AWOS or with the communications link to the WMSCR. The point of contact would be available by telephone and responsive during normal business hours, and is encouraged to be responsive on a 24-hour a day basis.

d. The output of the AWOS weather observation is controlled by one of four modes of operation. Mode 1 is applicable to all systems; modes 2, 3, and 4 are applicable only to systems configured with an operator terminal (OT). Modes 3 and 4 require an agreement with the FAA to maintain a Non-Federal Observer (NF Obs) program to augment and backup the AWOS system.

(1) Mode 1, Full-time Automated Operation. In this mode, the AWOS operates 24 hours/day without any manual input. The automated weather observations are updated on a minute-by-minute basis. There is no weather observer input to the AWOS. However, a manual observing capability may be maintained as backup provided that an agreement exists with the FAA to maintain a manual observing capability.

(2) Mode 2, Full-time Automated Operation with Local Notice to Airmen (NOTAM). Operation in this mode is the same as Mode 1, with the addition of the capability to append a manually recorded NOTAM to the automated voice reports (see paragraphs 3.19.a.(1)(d) and 3.20. The airport manager is responsible for the timeliness and accuracy of the NOTAM information. This NOTAM is limited to aviation related information specific to the airport in accordance with the latest edition of FAA Order 7930.2, Notice to Airmen (NOTAM), and must not include commercial announcements such as fuel prices, lodging, etc. NOTAM information is

heard on the local voice broadcast, it is not transmitted over the national network. There is no weather observer input.

(3) Mode 3, Full-time Automated Operation with Manual Weather Augmentation and Local NOTAM Option. Operation in this mode is the same as Mode 1 with the addition of the capability for a FAA certified weather observer to manually augment the automated observation by appending a weather entry to the observation during the weather observer duty hours. The addition of a local NOTAM, per paragraph 1.3.c.(2), is also permitted in this mode of operation, provided there is no interference with the observer augmentation. The weather observer is responsible for the accuracy and timeliness of the added weather information. The weather to be added is limited to thunderstorms, all types of precipitation, and obstructions to vision. The weather parameters added by the observer is to be manually recorded and appended to the automated voice reports using the operator terminal (OT) and, as applicable, entered manually into the system for transmission over the national network. The procedures in the latest edition of the Federal Meteorological Handbook No. 1 (FMH-1), and the latest edition of FAA Order 7900.5, Surface Weather Observing, apply.

(4) Mode 4, Part-time Manual Operation. Mode 4 is normally used for backup. This mode permits a FAA certified weather observer to enter a complete manual observation into the system. The procedures in the latest editions of FMH-1 and Order 7900.5 apply to the recording and formatting of these manual observations. As applicable, the manual observations are transmitted to the national network. Voice dissemination of the observations should be done manually using the OT. The manual observations include input from the automated AWOS outputs available to the weather observer on the OT display, to be modified in accordance with the latest edition of FAA Order 7900.5. For example, the manual observation includes manually derived ceiling/sky condition and visibility, using FMH-1 definitions, which differ somewhat from the AWOS algorithms. Temperature, dew point, wind direction/speed, and altimeter setting are the same and are used exactly as presented on the AWOS OT display or using FAA approved back-up instrumentation.

e. Aviation Routine Weather Report Format (METAR).

Coding of the AWOS output must meet the METAR message requirements defined in the latest edition of the Federal Meteorological Handbook No. 1 (FMH-1). National network distribution of wind direction must be in True while local dissemination, e.g., radio and telephone, must be Magnetic.

1.4. FAA's FACILITY PERFORMANCE AND INSPECTION RESPONSIBILITY. The General Aviation Revitalization Act of 1994 reaffirmed the FAA's responsibility and authority to regulate and inspect air navigation facilities, including aviation meteorological services. In accordance with Title 49 USC Section 44708, "The Administrator of the Federal Aviation Administration may inspect, classify, and rate an air navigation facility for the use of civil aircraft on the suitability of the facility for that use." Non-Federal navigation facilities, including non-Federal AWOS systems, must meet and be maintained at the same standard as FAA facilities in

accordance with the latest edition of FAA Order 6700.20, Non-Federal Navigational Aids and Air Traffic Control Facilities.

a. Chapters 3 and 4 of this AC provide the FAA's minimum acceptable commissioning and revalidation standards and references for a non-Federal AWOS system. Chapter 4 also provides the expected minimum checks and maximum maintenance intervals between checks.

b. FAA-owned meteorological/AWOS equipment tolerances are found in the latest edition of FAA Order 6560.13, Maintenance of Aviation Meteorological Systems.

c. Non-Federal AWOS systems require on-site commissioning. In accordance with the latest edition of FAA Order 6700.20, commissioning is required to be accomplished on-site by a qualified technician with the proper FAA verification authority and witnessed by a qualified FAA non-Federal inspector.

d. Non-Federal AWOS systems require annual on-site performance verification. In accordance with the latest edition of FAA Order 6700.20, this verification is required to be accomplished on-site by a qualified technician with the proper FAA verification authority and witnessed by a qualified FAA non-Federal inspector.

e. Verification is the written assurance that the facility, system, or service is providing the required/advertised service to the user. System performance checks are made to identify and correct changes or drifting of performance parameters and to provide documented assurance to the user of the validity of the published information.

f. If results of these checks are satisfactory, a maintenance technician with FAA verification authority will document this fact by making a system verification entry in the facility's FAA Form 6030-1, Facility Maintenance Log. If the checks are not satisfactory, the maintenance technician should make an appropriate entry in the Facility Maintenance Log and the system or individual sensor should not be used. (Maintenance logs should be retained on-site.) For any sensor that should not be used, it should be disabled or removed from service and the sensor and any parameters that are a function of the sensor should be NOTAMed as unreliable or out of service. For guidance on Facility Maintenance Log entries, reference 300-PML, Paper Maintenance Log, and the latest edition of FAA Order 6040.15, National Airspace Performance Reporting Service (NAPRS).

1.5. LIST OF CERTIFIED NON-FEDERAL AWOS SYSTEMS. A current list of FAA type-certified non-Federal AWOS systems and manufacturers is available on the Internet at https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/safety_ops_support/nonfedawos/. This list will be updated periodically.

Further information concerning AWOS criteria and the FAA type certification approval process may be obtained from the AWOS Non-Federal Engineering office:

AWOS Non-Federal Engineering Office
Weather Systems (AJW-144)
6500 S. MacArthur, Bldg 196
Oklahoma City, OK 73169
Telephone: (405) 954-8427
Email: Non-Federal-Program@FAA.gov

Chapter 2. CERTIFICATION AND COMMISSIONING PROCESS

2.1. PROCESS OVERVIEW. In order to provide confidence in the quality of the meteorological data that the AWOS provides to users in the aviation community, the FAA has initiated a three-part AWOS quality assurance process consisting of type certification, site-specific commissioning and annual revalidation.

a. Type Certification. The manufacturer should provide the FAA with the test data and other system documentation to demonstrate that the AWOS system meets the criteria of this AC. Reference paragraph 2.2, Manufacturers Submittals for Type Certification Approval. Upon completion of all the requirements set forth in this AC, the FAA will grant type certification approval to the specific system configuration documented in the request.

b. Site-Specific Approval. Installation and FAA approval of a site's non-Federal AWOS involves several major elements, including:

(1) Prospective owners, wanting to install an AWOS system for public use should closely coordinate their plans with the FAA Service Center non-Federal Program Implementation Manager (PIM) or coordinator and follow the procedures they provide.

It is strongly recommended that airport owners and consultants coordinate their plans with the FAA Service Center non-Federal Program Implementation Manager (PIM) or coordinator and become familiar with the current revisions of the FAA Non-Federal AWOS Advisory Circular 150/5220-16, FAA Order 6560.20, Siting Criteria for Automated Weather Observing Systems (AWOS), the 7460-1 obstruction approval process, the system meteorological siting approval process and the VHF frequency assignment process before starting to acquire or install a non-Federal AWOS.

(2) The latest edition of FAA Order 6700.20 requires that a Memorandum of Agreement (MOA) and an Operations and Maintenance Manual (OMM) be established between the owner and the FAA and agreed to, i.e., signed, prior to commissioning the AWOS for public use. The MOA/OMM is used to ensure that there is a mutual understanding of what is required to operate and maintain a commissioned AWOS system over the life of the system.

(3) After the AWOS is installed and the MOA/OMM is signed, the FAA conducts a commissioning ground inspection to verify that the system is located, installed and operating correctly and that the owner has the resources to maintain the system in proper operating condition for the life of the system. Reference paragraph 2.7 for information on facility commissioning.

(4) The commissioning inspection must be successfully completed for the AWOS to be commissioned by the FAA and authorized to operate. Subject to the additional criteria identified elsewhere in this advisory circular, a site must be commissioned in order for the airport to receive instrument approach procedures, provide weather information for aviation purposes and, for AWOS III and IV systems, provide information to the national weather network.

c. FAA Inspections. Finally, in addition to the annual revalidation inspection, there will be periodic visits to the operational AWOS by the FAA and other technical representatives to verify that the system continues to operate correctly. Guidance for these visits may be found in paragraph 2.10, Ongoing System Validation, and Chapter 4, AWOS System Maintenance and Operating Requirements, of this AC, the facility MOA/OMM, and the latest edition of FAA Order 6700.20. A site must be physically inspected by the non-Federal technician as witnessed by the FAA inspector annually to maintain the airport's instrument approach procedures, and, for AWOS III and IV systems, provide information to the national weather network.

2.2. SUBMITTALS FOR TYPE CERTIFICATION APPROVAL.

a. The AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b will grant the appropriate approvals after review and approval of various submittals from the various providers.

These submittals should include:

(1) Test procedures and data sheets that demonstrate that the proposed AWOS sensors and system configuration meets the criteria of this AC. This submittal should include a matrix showing each specific requirement from this AC, cross-referenced to the specific location (e.g., paragraph, page, etc.) within the provider's documentation where the requirement has been addressed.

(2) System user and maintenance documents intended to support the AWOS system owner, the system user, the owner's local maintenance technician and the maintenance technician holding FAA verification authority.

(3) The warranty.

(4) A configuration control plan that identifies the components and options approved for use with the system.

(5) Technician training programs and materials as described in paragraph 2.4.f and designed to train the technician to assume the duties and responsibilities of the maintenance technician holding FAA verification authority.

b. Requests for type certification approval should be sent to the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b.

c. Product approval (including type certification, commissioning, or annual revalidation) may be revoked or an individual site may be removed from service if:

(1) The equipment is not maintained or inspected in accordance with this AC.

(2) The equipment has an unacceptable failure rate.

(3) There is a deficiency that precludes or hampers valid performance verification of the system operation.

(4) Changes are made to the software, firmware or hardware without FAA approval.

(5) Transmitted data does not conform to the latest editions of the Federal Meteorological Handbook (FMH-1) or FAA Order 7900.5.

(6) The manufacturer fails to honor the warranty.

2.3. TEST PROGRAM. Chapter 3 of this AC contains the performance and testing standards for each component of the AWOS. The manufacturer should demonstrate compliance with these standards through performance testing where a test is specified or by analysis and inspection. The manufacturer provides all necessary equipment and bears all testing costs. Prior to performing tests the manufacturer should propose a test plan to the FAA containing detailed procedures for conducting the tests, as well as the name and location of the facility where the tests are to be conducted. Prior FAA review of the test plan should minimize the likelihood of improper test procedures that might result in rejection of the data. It is the responsibility of the manufacturer to provide credible test data to the FAA that is based on fact and representative of the equipment being type-certified. Submissions should include all data collected during a test; data should not be omitted because it falls outside of the recommended acceptable limits of this AC. After completion of the tests, the manufacturer should reduce the data to an easily understood format to demonstrate conformity with this AC. If the manufacturer has previously performed testing, the test procedures and data sheets from these tests may be submitted for consideration. However, the FAA reserves the right to witness testing, request additional testing, and examine raw data.

2.4. SYSTEM DOCUMENTATION.

a. The manufacturer should submit one hard copy and one permanent media (CD, DVD or similar) electronic copy of the draft documentation described in this paragraph to the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b for review and approval. The System Description Manual, Maintenance Manual, Installation and Checkout Manual, Operating Instructions Manual, applicable schematics, and Annual System Revalidation Plan Manual should be provided as separate manuals. These documents are intended to assist the AWOS owner in the installation, operation, and maintenance of the system. The items may be cross-referenced to avoid duplication, but the elements of each portion of each document should be clear. For example, the maintenance procedures that are performed during the annual system revalidation should be explicitly referenced.

b. After the FAA has approved these manuals, five permanent media (CD, DVD or similar) electronic copies and five hard copies of these approved documents should be submitted to the FAA as follows:

(1) One electronic copy and one hard copy to:

AWOS Non-Federal Engineering Office
Weather Systems (AJW-144)
6500 S. MacArthur, Bldg 196
Oklahoma City, OK 73125

(2) One electronic copy and one hard copy to:

Non-Federal Program Manager (AJW-137)
ATO Technical Operations, Operations Support
NAS Integration and Support Group
10101 Hillwood Parkway
Ft. Worth, TX 76177

(3) Four electronic copies and four hard copies to:

Non-Federal AWOS Program (AJW-137)
Orville Wright Bldg. (FOB10A)
800 Independence Ave., SW
Washington, DC 20591

c. The following documents must be submitted to the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b and approved before type certification approval of any system or any system modification requiring a change in any of these documents will be granted. These documents are distributed to each FAA service area and other appropriate FAA offices to keep them apprised of all type-certified systems, sensors, and changes. If a manufacturer modifies the initially approved configuration, the submission process must be repeated before type certification approval is granted for the modified system, and the system is offered for sale.

(1) System Description. The system description document should identify and catalog the hardware components to the level of the smallest field-replaceable unit (FRU) module and should describe system software and firmware. The principles of system operation should be described using schematics, block diagrams, flow diagrams and pseudocode as appropriate. Sensor processing should be described using pseudocode. For peripheral devices, the performance parameters should be included along with the name and address of the original manufacturer.

(2) Manufacturer's Maintenance Manual. The manufacturer's maintenance manual should contain a comprehensive maintenance program to be implemented by the owner to ensure reliable and accurate performance over the life of the system. As a minimum, the program should define all maintenance activities that are required within a period of 5 years and a recommended frequency, e.g., tri-annually, i.e. three times per year, annually for each operation. The following topics should be addressed in the Maintenance Manual.

(a) Maintenance Procedures. The maintenance procedures manual should contain a step-by-step procedure for each scheduled, i.e., periodic, and unscheduled, i.e., repair, maintenance operation. It should discuss calibration methods including the importance of using collocated National Institute Standards & Technology (NIST) traceable calibrated test equipment; troubleshooting procedures; suggested spare parts; and identify all test equipment required. This document should also include the detailed procedures, e.g., the keystrokes, the

authorized maintenance technician follows when using the operator terminal to perform maintenance on the system.

(b) System Performance Parameters. The system performance parameters manual should contain a complete listing of the test points, sensor outputs, waveforms, and other parameters which indicate system performance that may be measured in the field as described in Chapter 4. If these quantities are field adjustable, then an initial value for use during initial commissioning certification and an operating tolerance for use during the annual verification should be given. The key system parameters should also be identified; i.e., those values which best indicate system performance and to be checked most frequently. The frequency of scheduled maintenance action, e.g., tri-annually and annually, should also be given.

(c) Data Recording Forms. This manual should contain three types of forms designed to aid the system owner in recording the system performance data described in paragraph 2.4.b.

(i) The Comprehensive Facility Performance and Adjustment Data Form. This form is similar to FAA Form 6030-17, Technical Reference Data Record, and is an initial facility commissioning data form which should be completed at system commissioning and after major repair work, i.e., after a major component has been replaced. The form should contain the standards and tolerances of each component, all of the initial commissioning checks required, space to record the actual result of each performance check, and another space to enter the standard or reference value expected from each check.

(ii) The Technical Performance Record (TPR). The TPR is similar to FAA Form 6000-8, Technical Performance Record, and is a data record form that is used to record the results of performance checks accomplished during routine and non-routine maintenance visits. It may also be used as a checklist of all of the scheduled maintenance to be done at the facility during a specific routine scheduled maintenance (SM) visit, e.g., during a visit to accomplish scheduled tri-annual or annual performance maintenance (PM). The form should also include the standards and tolerances required to be measured with a space to record each result. It is to be used to record the actions during the tri-annual maintenance visit, the annual validation inspection, during non-routine maintenance performed to capture any changes to sensor or system parameters, and to log the results of tests conducted after an aviation accident. Separate forms may be established and used to cover different PM visits.

(iii) FAA Form 6030-1. The third form is the FAA Form 6030-1, Facility Maintenance Log. The FAA will provide this form. Instructions for its use should be included in the FAA/owner MOA/OMM. The maintenance log should be retained on site. All site visits should be documented on this form. It will provide a historical record of all maintenance actions accomplished on the AWOS. The technician should list all maintenance actions accomplished, e.g., tri-annual scheduled maintenance actions completed, dew point sensor replaced; any damage should be logged, e.g., bullet hole in vertical fin of the wind sensor, needs replacement; and any problem with the AWOS should be noted, e.g., dew point sensor disconnected, replacement required. When a system or component repair or adjustment has been accomplished, the

maintenance technician should make a performance verification statement on this form. In all cases, the technician completing the action and making the form entry should be identified on the form. These forms also contain the date of the action, the facility name and location, and other identifying data. More information on completion of the Form 6030-1 may be found in the MOA/OMM or the latest edition of FAA Order 6700.20.

d. Installation and Checkout Manual. This document should thoroughly describe the installation and checkout procedures to be followed by the technician at the installation site.

e. Operating Instructions (i.e., an Observer Handbook). This document should provide detailed instructions for a FAA certified weather observer to operate the system. This document should describe and provide instructions for operation in each of the four modes described in paragraph 1.3.d, and it should explain the procedures when using the operator terminal to augment or to backup the AWOS, or to disseminate NOTAM information.

f. FAA Authorized Maintenance Technician Training Program.

Please refer to Appendix 2, Technician Training.

g. Annual System Revalidation Plan. This plan should contain the recommended procedures to conduct an annual inspection of the facility to revalidate the system and document that it is in the approved configuration and operating within tolerance. Reference paragraph 2.10 for information on system revalidation.

h. Warranty. The manufacturer should submit to the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b a statement certifying the following minimum warranty for the equipment:

This equipment has been manufactured and should perform in accordance with requirements of this AC. Any defect in design, materials, or workmanship which may occur during proper and normal use during a period of 1 year from date of installation or a maximum of 2 years from date of shipment should be corrected by repair or replacement by the manufacturer.

2.5. CONFIGURATION CONTROL PLAN. Due to the modular nature of the AWOS, many system components such as sensors and peripheral devices may be interchangeable. Since type certification approval is given only to specific combinations of components, the manufacturer should establish a configuration control mechanism that would uniquely identify each FAA-approved system, its hardware, software and firmware components (including revision levels) and its documentation (including revision levels). Before type certification approval is granted, the manufacturer should submit a Configuration Control Plan to the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b for approval. The configuration control plan should explain and include the procedures for configuration control of all hardware, software, firmware and documentation. The identifying information for each system should be permanently inscribed on a system name plate.

Changes to an approved configuration should be submitted for FAA approval to the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b. The manufacturer may incorporate minor product improvement changes after notifying and obtaining approval from the FAA AWOS Non-Federal Engineering Office. Major changes, such as a sensor or a major hardware, software or firmware change should be fully supported by documentation and appropriate test data. Major changes normally require the assignment of a new configuration number. The FAA will determine the scope of the change, i.e., major vs. minor. Every change to an approved AWOS should be supported by revised configuration controlled documentation. The plan should also address:

- a. The manufacturer's arrangement for assigning a configuration identification number/symbol/etc., and the means used to identify which system components, e.g., hardware, software, firmware and documentation, are included in a particular system configuration.
- b. Procedures for notifying system owners of changes in the approved configuration of their AWOS.
- c. Procedures for identifying and maintaining a record of the configuration of each operational system that has been sold by the manufacturer.
- d. Procedures for the configuration control of documentation, to include procedures for issuing changes, numbering, and dating pages.

2.6. PLANNING THE AWOS INSTALLATION.

a. All airport owners or other parties contemplating purchase and installation of a non-Federal AWOS should coordinate with the FAA before the equipment is ordered. The FAA Service Center non-Federal PIM is the official FAA point of contact in the Service Center Planning and Requirements Group and is responsible for the overall project coordination between the owner and other elements in the FAA. The FAA non-Federal Program Implementation Manager should coordinate the proposal with the Flight Procedures Office, Operations Support Group, Frequency Management Office, Airport District Office and other FAA offices as needed.

b. The selection of a voice outlet frequency for the AWOS is a critical issue since there are a limited number of frequencies available for this purpose. In accordance with the latest edition of FAA Order 90-42, Multicom frequencies are not intended for automated weather broadcasts. Therefore, before applying to the FCC for a frequency license, it is advisable to coordinate with the FAA in the early planning stages of the facility. When requesting a frequency, consider using the following collocated facilities, if applicable, to satisfy the AWOS requirement for a ground-to-air communication outlet.

(1) Assigned Automatic Terminal Information Service (ATIS) Frequency. At part-time towered locations, the AWOS utilizes the existing ATIS voice outlet frequency to provide weather information when the tower is closed. Frequency sharing coordination is discussed further in paragraph 3.21, AWOS ATIS Switch (AAS).

(2) VHF omnidirectional radio range (VOR) or VHF omnidirectional radio range/tactical air navigation (VORTAC) except Doppler VOR, with voice capability. (The VOR/VORTAC must be located within 3 nautical miles (nm) of the airport and must not be used to broadcast other information such as Enroute Flight Advisory Service (EFAS).)

(3) Nondirectional Radio Beacon (NDB) With Voice Capability. The NDB must be located within 3 nm of the airport. At locations where frequency congestion in the VHF air-ground band is not expected to be a problem, the use of an NDB should be considered as the fourth priority. The NDB frequency may have to be changed if the existing frequency is not in the 325 to 415 kilohertz (kHz) range.

(4) If none of the listed facilities exist on or near an airport, the FAA will work to engineer a 25 kHz spaced discrete VHF air-ground communications channel in the air traffic control band (118-137 MHz). If an airport is equipped with an NDB or VOR/VORTAC, a request for a discrete frequency assignment should include a justification statement as to why it is not used for the AWOS transmission.

c. The service volume for an AWOS voice outlet, excluding those broadcasts over existing ATIS systems, is normally limited to 10,000 feet above ground level and 25 nm from the AWOS. The owner should provide a justification to the FAA if there is a requirement to exceed this service volume. Under no circumstances should the radius of the service volume exceed the terminal control area.

d. If the AWOS system proposed for installation does not meet the requirements of this AC or the radio does not meet the requirements of the FCC-approved standards, the FCC may not assign a broadcast frequency.

e. After an AWOS III or IV has been granted type certification approval and commissioned by the FAA, it becomes the weather source for the airport. Any existing manual weather observation program whose hours conflict with the AWOS III or IV should be terminated. However, as specified in paragraph 1.3.d, the AWOS owner may elect to maintain a manual observation capability to back up the AWOS in the event the system, or any critical parameter, e.g., windspeed/direction, ceiling/sky condition, visibility, altimeter setting, fails. In

addition, the AWOS owner may elect to augment the AWOS output with observed parameters, e.g., thunderstorms or precipitation that are not within the capability of the non-Federal AWOS.

2.7. FACILITY COMMISSIONING. The FAA should formally commission the AWOS facility before it becomes available for public use. After receiving approval of a broadcast frequency, the owner may procure and install the AWOS facility. As the system approaches operational readiness, the owner should request a commissioning ground inspection by an FAA non-Federal inspector. This inspection should include participation by the owner or owner's maintenance representative. The commissioning inspection consists of the tests and checks identified in the following paragraphs, a review of the operations and maintenance documents on file at the facility, and the recording of the initial facility performance data which should be retained as commissioning documentation in the Facility Reference Data (FRD), or similar historic record locations.

a. Siting, Installation, and Commissioning.

(1) Siting. Contact the non-Federal facilities PIM for approval of proposed AWOS location. This location should be in accordance with the siting criteria contained in the latest edition of FAA Order 6560.20, Siting Criteria for Automated Weather Observing Systems (AWOS). Following installation, the FAA Tech Ops District non-Federal inspector should also verify that the AWOS equipment is installed in accordance with the siting order and that the checkout procedures have been performed. Any exceptions to the siting order should be justified and documented in the OMM as being the best practical solution for meeting the intent of the siting criteria. Any discrepancies found during the inspection should be rectified before the facility can be commissioned.

(2) Installation. The AWOS is a permanent facility and is located, constructed, and installed in accordance with applicable code requirements. It should be installed by a technician who is fully qualified in electronic applications; has a working knowledge of the operation, testing, and maintenance of the AWOS; and is either a maintenance technician employed at the manufacturer's factory or has been certified by the FAA. The procedures in the FAA-approved Installation and Checkout Manual should be performed. Reference paragraph 2.4.d for a description of the manual.

(3) Commissioning. Once the AWOS has been properly installed in accordance with the siting criteria and demonstrates that it meets the criteria established by this AC, it is commissioned to operate in the National Airspace System (NAS).

b. Performance Test. The AWOS owner's FAA-approved maintenance representative should operate the system and measure all system performance parameters described in this AC and the manufacturer's Maintenance Manual. The initial commissioning data are witnessed by the FAA Non-Federal Inspector and recorded on Comprehensive Facility Performance and Adjustment Data forms, or other approved commissioning data forms and retained at the facility in the FRD as commissioning documentation.

c. Flight Inspection. All NAVAID facilities, e.g., VOR, NDB, used as a voice outlet to broadcast weather information should be flight inspected to assure that operation of the NAVAID has not been derogated. If, during flight inspection, it is determined that performance of the NAVAID has been affected, the AWOS should not be activated until the malfunction has been corrected, e.g., through modification or by employing a separate discrete frequency transmitter to broadcast the weather. An AWOS utilizing a discrete frequency transmitter is not required to undergo a flight inspection.

d. Notification of the Commissioning. Following successful completion of the commissioning inspection, the FAA non-Federal PIM should notify the appropriate FAA Offices, e.g., NFDC, FPO, OCC, national non-Federal office, etc., of the appropriate information, which may include the commissioning date, broadcast frequency, voice access telephone number, system owner, and maintenance arrangements.

e. Relocation of an AWOS. In the event that an AWOS is removed from service to be relocated, a decommissioning NOTAM should be issued, instead of a facility out-of-service NOTAM. After relocation, a complete facility commissioning inspection should be performed.

2.8. ON-SITE DOCUMENTATION. The following documentation should be kept and maintained at the AWOS facility. It should contain all pertinent up to date on-site documentation, including the following documentation. The FAA should review the documentation at the commissioning inspection and during annual revalidation.

a. Type Certification Approval. A copy of the FAA letter to the manufacturer granting type certification approval for the AWOS system design should be included. The subsystems should be inspected to verify that the installed AWOS configuration is consistent with the type certification approval that was given.

b. Frequency Allocation Approval. A copy of the frequency FCC station license that was obtained assigning the approved operating UHF and VHF frequencies if appropriate.

c. Manufacturer's Documentation. Copies of the AWOS operating instructions, manufacturer's Maintenance Manual, and System Description. When changes are made to the manufacturer's documents, the manufacturer should forward revisions to the AWOS owner who is responsible for inserting them into the appropriate on site documentation.

d. Operational Procedures. Site-specific operational procedures that set forth mandatory site procedures for both routine and nonscheduled situations should be kept at the AWOS site. These procedures may incorporate appropriate sections of the manufacturer's manuals. The following items should be covered.

(1) Physical security of the facility.

(2) Maintenance and operations by authorized persons, including who to notify if a weather parameter is discovered out of tolerance or other maintenance is necessary.

- (3) Posting of licenses and signs.
- (4) Notice to the FAA PIM or coordinator/inspector must be made when any AWOS service has been suspended, or when a critical weather parameter is out of tolerance.
- (5) Keeping of station logs and other technical reports.
- (6) Names, addresses, and telephone numbers of persons to be notified in the event of system failure.
- (7) Procedures for periodic scheduled shutdown maintenance, including the office responsible for generating NOTAMs for routine or nonscheduled shutdowns.
- (8) Procedures for amending or revising the site instructions.
- (9) Procedures to be followed to freeze the 96 hours worth of AWOS data that were gathered prior to the time of an aircraft accident or incident, and the procedures to be followed to retrieve these data files for off-line analysis. These procedures should describe the responsibility for accomplishing these actions. They should be accomplished immediately following an accident, incident, or upon the request of a member of the FAA or NTSB.
- (10) Locations of AWOS components on the airport. This includes the result of the survey to establish the site elevation, the elevation of the barometric pressure sensors and a true North reference point.
- (11) Copy of all software and firmware licenses with revision identification.
- (12) A MOA signed by the owner and the FAA Service Area Technical Operations Director or designee. This memorandum should state that the owner agrees to maintain, repair, and modify the AWOS in accordance with the requirements, standards, or criteria governing AWOS, particularly those contained or defined in the agreed to FAA/Owner OMM. The owner understands that noncompliance with the specific site's FAA/Owner MOA/OMM may result in the AWOS's removal from service or decommissioning.
- (13) A copy of any agreement with the FAA to maintain a manual observation capability to augment or back up the AWOS.

e. Commissioning Documentation. The initial commissioning documentation form such as the Comprehensive Facility Performance and Adjustment Data form should be completed during commissioning to record initial values and the respective standard or reference values as described in Chapter 4.

2.9. MAINTENANCE PROGRAM. The maintenance program should cover a minimum period of 5 years as established in paragraph 2.4.c.(2), and should consist of properly trained authorized personnel meeting all FCC and FAA requirements, adequate calibrated test

equipment, and resources to fulfill the manufacturer's recommended scheduled maintenance and calibration procedures as defined in the manufacturer's Maintenance Manual. The maintenance program is the responsibility of the owner, but may only be performed by personnel meeting manufacturer specific, FAA and FCC requirements.

a. Maintenance Personnel. The owner should show that their maintenance program has qualified personnel available to maintain the AWOS system. This includes the owner's assigned local maintenance technician to perform the tri-annual maintenance checks and the FAA authorized maintenance technician holding verification authority. The maintenance technician seeking FAA verification authority should refer to the current edition of FAA Order 6700.20, Non-Federal Navigational Aids, Air Traffic Control Facilities, and Automated Weather Systems, for the qualifications maintenance technicians need to have in order to maintain non-Federal facilities. They should have the special knowledge and skills needed to maintain the AWOS facility and should have either completed the appropriate approved training or completed acceptable previous training and have acceptable previous experience. As part of the FAA authorized technician verification process, the FAA will administer a performance examination to any technician seeking verification authority on the system. This exam will demonstrate they have the necessary proficiency, special knowledge and skills to accomplish all commissioning, annual reverification and required maintenance procedures including troubleshooting, validation of test equipment calibration and using the specialized test equipment. The FAA will issue a site and system specific verification authority letter to the candidate maintenance person if he/she is able to meet the concepts and performance requirements of the AWOS system, and has a FCC general radiotelephone operator license (GROL) for maintenance of the system's discrete frequency (UHF or VHF) or aeronautical advisory station (Unicom) transmitter.

b. Test Equipment. The owner should have available at the facility, at the time of commissioning, all test equipment required by the approved maintenance plan for maintenance and calibration of the facility. Test equipment must be capable of accurately measuring the appropriate performance parameters to verify technical standards and tolerances needed for facility verification, and must be collocated with the AWOS. Test equipment should be calibrated to NIST traceable standards in accordance with the calibration schedule submitted to and approved by the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b during type certification acceptance. In case an acceptable test equipment calibration schedule was not included, test equipment will be calibrated as per the test equipment manufacturer's recommendations. Test equipment calibration should be traceable to national standards, and proof of calibration, e.g., a current calibration sticker should accompany each piece of test equipment when it is being used. The test equipment should be available when required for commissioning, scheduled system maintenance and calibration, or for repairs following system failure. All measurements should be made with test equipment collocated with the AWOS equipment being measured.

c. Annual Performance/Configuration Revalidation. The owner should plan for complying with the manufacturer's recommended and FAA approved plan for annual system revalidation. This plan should identify the appropriate FAA Tech Ops Non-Federal District Office to notify to witness the on-site revalidation and include a list of the procedures to be followed during the on-site revalidation as well as the source of the FAA qualified non-Federal technician to perform the inspection.

2.10. ONGOING SYSTEM VALIDATION. To verify that the system is being properly maintained and that the system retains an approved configuration, the following ongoing validation program should be conducted.

a. Performance/Configuration Revalidation. An FAA Service Area non-Federal coordinator or inspector should perform an on-site verification inspection of each AWOS annually in accordance with the manufacturer's approved Annual System Revalidation Plan. This inspection should include the items in the following paragraphs, and the results should be recorded on an Annual Technical Performance Record form or on a Comprehensive Facility Performance and Adjustment Data form identified as being used for annual revalidation and retained on file at the facility.

(1) Verify that the maintenance program is being followed and properly documented.

(2) Witness the owner's maintenance technician performance of a comprehensive check and calibration to verify that system performance is within the limits specified by the manufacturer's documentation and to ensure that every component of the system is operating properly.

(3) Verify that the AWOS configuration is the same as approved at the time of commissioning or as formally modified in accordance with approved configuration control procedures. Additionally, it should be determined that all mandatory configuration changes approved by the FAA have been accomplished and documented.

(4) Verify that a summary of all maintenance, hardware and software, performed since the last report is on file at the facility.

b. FAA Site Visits. FAA inspectors will periodically visit certified non-Federal AWOS facilities. During the visit, the FAA inspector will verify, with the assistance of the owner's maintenance technician, that the system operates within tolerance, that all maintenance tasks have been properly performed and documented, and that the FAA has approved the AWOS configuration. The inspector will review the facility's FAA Form 6030-1 log and other documentation to verify that scheduled and unscheduled maintenance has been accomplished and documented in accordance with this AC, the approved FAA/owner MOA/OMM, the approved manufacturer's Maintenance Manual, and the approved annual system revalidation plan. The owner's maintenance technician holding FAA verification authority should provide access to the site and accomplish any tests on the facility requested by the FAA representative during the visit. The FAA will provide the owner a written inspection report following completion of the inspection. The FAA representative may visit the site with an owner's representative without the non-Federal technician's presence provided no tests or adjustments are planned or accomplished on the AWOS equipment.

c. Mandatory Configuration Changes. If the FAA determines that an AWOS system, or any element of the system, is providing data that could be in error, the FAA may direct the system manufacturer to issue a mandatory configuration change order to the owners of similar

systems. The system owner should disable the appropriate part of the system and should request that the FAA issue a NOTAM describing the missing parameter and give an estimate of the time for which it will be disabled.

d. Unacceptable Failure Rate. Equipment that proves unreliable is to be removed from the type certification approval listing. The determination of unreliability should be based on judgment and experience with similar equipment. Where equipment is determined to have an unsatisfactory failure rate or is deficient in workmanship or materials, the manufacturer is to be notified in writing as to the basis for this determination. The manufacturer should then notify the FAA in writing as to its plan of action for resolving the issue. If the manufacturer does not resolve the problem within a reasonable time, the equipment would be removed from the type certification approval listing. The timeframe would, of necessity, be based on safety considerations and the nature of the problem. The FAA reserves the right to require the equipment to undergo any or all qualification and calibration tests when the equipment has been determined unreliable or deficient in design, materials, or workmanship. Owners of similar AWOS installations should be notified of any problems uncovered during this retesting through the configuration control procedure discussed in paragraph 2.10.c, and paragraph 2.5, Configuration Control Plan.

e. Note. Failure to meet the criteria of this AC may result in decommissioning the AWOS facility, i.e., withdrawal of the FCC license, and withdrawal of type certification approval.

Chapter 3. PERFORMANCE AND TESTING SPECIFICATIONS FOR AWOS

3.1. GENERAL. This chapter contains the performance standards and testing specifications for components of the AWOS. Equipment should comply with these standards to establish partial compliance with the Code of Federal Regulations (CFR). However, some of the following tests are intended to be performed in a laboratory environment and may not be able to be duplicated in the field. Current standards and tolerances are those which were approved during type certification acceptance. These are intended only as guidelines based on standards approved at type acceptance. If a manufacturer has specified additional checks to be performed, requested and received approval for different checks to be performed, or specified that tighter tolerances be required, then these will be detailed by the manufacturer in the FAA-approved Maintenance Manual for that specific type-certified AWOS.

3.2. DEFINITIONS.

a. Root Mean Square Error (RMSE). RMSE is determined by comparing the output value with the true value of a parameter according to the following equation:

$$RMSE = \sqrt{\frac{\sum_{N=1}^N (T - M)^2}{N}}$$

Where:

N = Number of independent comparisons

M = Measured value

T = True value

(RMSE is in the same units as the measured and true values)

b. Time Constant. After a step change in the value of a parameter measured by a sensor, the time constant is the length of time it takes the sensor to register a given percentage (63 percent unless otherwise specified) of the change.

c. Resolution. The resolution of a sensor is the value of the least significant digit that is given as sensor output.

d. Variance. For the purposes of this AC, variance is defined as the difference between the value of the reference sensor and the sensor under test.

e. Thunderstorm. For purposes of this AC, a thunderstorm occurs when a single cumulonimbus cloud (cell) generates one or more flashes of lightning which can be cloud-to-

ground, in-cloud, or cloud-to-cloud. At any one time, a period of storm activity may consist of a number of thunderstorms or cells within the area surrounding the reference point.

3.3. GENERAL PERFORMANCE STANDARDS. This paragraph addresses aspects of performance that are applicable to the AWOS as a whole. The electromagnetic interference, transient, and lightning protection standards are also applicable to the entire system and are addressed in paragraphs 3.22 and 3.23.

a. Input Power. AWOS equipment should operate from a 120/240 V (± 10 percent), 60 Hz ac (± 5 Hz), 3-wire single-phase service.

b. Loss of Power. The AWOS system should return to normal operation without human intervention after a power outage. When power is restored, the system should not output erroneous data.

c. Wind Sensor Tower. If a separate tower is used for the wind sensor, daytime marking and nighttime lighting should be provided in accordance with the guidelines set forth in the latest edition of AC 70/7460-1, Specification for Obstruction Marking and Lighting.

(1) It should be lighted with a dual obstruction light L-810 fixture placed within five feet of the top of the tower. The two lamps on the L-810 should be wired in parallel. The standards for the L-810 fixtures may be found in latest edition of AC 150/5345-43, Specification for Obstruction Lighting Equipment. Use of a single light emitting diode (LED) obstruction light fixture is encouraged for efficiency and endurance.

(2) Since the nominal height for this tower is 30 to 33 feet and since most towers are manufactured in 10 foot sections, a waiver to AC 70/7460-1 has been granted to permit a six-band marking, with the bands alternating between aviation orange (the top band) and aviation white. This pattern will permit dip painting the tower at the factory without sacrificing the level of safety provided by the standard tower.

d. VHF Transmitter. It is the FAA policy that the output of the AWOS be transmitted on an existing NAVAID voice outlet whenever practical. When the AWOS is broadcast over a NAVAID, that NAVAID will be given a flight check during the initial commissioning procedure and will be given an annual flight check in conjunction with the annual AWOS verification. If there is no NAVAID available, then the output will be broadcast via a separate VHF transmitter that will be licensed by the FCC. The transmitter operates in the 118-137 MHz band on a frequency assigned by the FCC. The transmitter will have a FCC type-acceptance with the following operational parameters:

(1) Channel Spacing: 25 kHz

(2) Normal radio frequency (RF) Power Output: Nominal 2.5 watts (± 0.50 watts), at the transmitter output.

Note: Other transmitter powers between 1 and 10 watts may be authorized by the FCC based on unusual circumstances. However, the FCC license always lists the maximum effective radiated power authorized for any AWOS.

e. Coaxial Cable. The manufacturer should use coaxial cable with less than 3 dB line loss per 100 feet for cable runs exceeding 30-feet. The manufacturer may use coax with up to 10 dB loss per 100 feet for lines less than 30-feet long. All critical VHF radio parameters should be measured, using properly calibrated collocated test equipment, and recorded during initial and annual reverification checks. These measurements apply to both discrete frequencies as well as shared frequencies. Table 1, VHF Radio Specifications, provides the critical radio parameters.

Table 1. VHF Radio Specifications

Parameter	Specifications
Frequency stability	±0.001 percent (-30° to +60° C)
Percentage of modulation of generated tone	65 percent to 95 percent
Voltage standing wave ratio (VSWR) at transmitter	3.0 to 1
VSWR at antenna for cable runs exceeding 50 feet	3.0 to 1
Line Loss for cable runs exceeding 50 feet	< 3 dB of line loss per 100 feet
Spurious and harmonic emission for cable runs exceeding 50 feet	80 dB down from the carrier minimum up to 90 percent modulation
Emission type	6A3E
Antenna	Omnidirectional
Occupied Bandwidth	No less than 99 percent of the emitted signal energy should be contained within a 25 kHz bandwidth

f. Generation of the NAVAID Identifier by the AWOS. When the AWOS message is broadcast over a NAVAID, the AWOS should be designed to provide both the NAVAID tone identifier and the AWOS weather data over the NAVAID frequency. The tone should be generated between every AWOS voiced weather message and should only be generated between messages. This design should eliminate the interference between the AWOS voice and the NAVAID generated tone identifier and provides for better identification of the NAVAID in marginal conditions. If this design is adopted, it is imperative that the NAVAID automatically return to using its internal tone generator to provide the identifier if the AWOS capability to provide the NAVAID identifier has been lost.

g. UHF Data Link Radio Transmitter. When a UHF radio is used to transfer data between components of the system, the transmitter will have FCC type-acceptance, and the power output should be limited to the minimum necessary to accomplish the job and should not exceed 1 watt. The FCC issues the license for the use of the facility and assigns the frequency. Frequency stability, deviation/percent modulation, VSWR, and initial/operating power output should be in accordance with FCC regulations and should be clearly defined in the manufacturer's Maintenance Manual. AM and FM data link radio transmitter specifications are contained in the latest edition of FAA Order 6560.13.

h. Data Link Radios. No data link radios authorized under Part 15 of the FCC rules identified in Title 47 of the Code of Federal Regulations (47 CFR, Part 15) or other unlicensed transmitters, including spread spectrum devices, may be used in any part of a non-Federal AWOS system.

i. Code Requirements. The AWOS should be designed in accordance with applicable paragraphs of the latest edition of the National Electrical Code (NEC) and should be installed in accordance with local code requirements.

3.4. OPERATING ENVIRONMENT. All AWOS equipment and sensors should demonstrate that they meet all operating tolerances under the operational environmental conditions described in this AC.

a. Site Elevation. From 100 feet below sea level to 10,000 feet above sea level.

b. Equipment Installed Indoors in a Conditioned Space.

(1) Temperature. From +40° to +105° F (+5° to +40° C).

(2) Relative Humidity. 5 percent to 90 percent (non-condensing).

c. Equipment Installed Outdoors.

(1) Temperature. Two operational environmental temperature ranges are defined for the outdoor equipment. Class 1 is the minimum environment all outdoor equipment must operate in. Class 2 is the harsh environment the outdoor equipment must operate in when installed in locations known to exceed the Class 1 criteria.

Class 1: -30° to +130° F (-35° to +55° C)

Class 2: -65° to +130° F (-55° to +55° C)

(2) Relative Humidity. 5 percent to 95 percent over the entire temperature range in increments of 10° C.

(3) Wind. Up to 85 knots.

(4) Hail. Up to 1/2 inch in diameter.

(5) Ice Buildup. Freezing rain rate equivalent to a buildup of 1/2 inch per hour, lasting for a period of 1 hour with 40 knot winds.

(6) Rain. Up to 3-inches per hour, with 40 knot winds.

3.5. MECHANICAL WINDSPEED AND DIRECTION SENSOR.

a. Performance Standard.

(1) Windspeed Sensor.

(a) Range. The sensor should respond to a threshold of 2 knots and a maximum of at least 85 knots.

(b) Accuracy. The windspeed sensor should provide an accuracy of ± 2 knots up to 40 knots. Above 40 knots, RMSE should be within ± 5 percent.

(c) Resolution. The resolution should be 1 knot.

(d) Distance Constant. The distance constant should be less than 10 meters. The method for calculation is given in paragraph 3.5.b.(1)(b).

(e) Threshold. 2 knots.

(2) Wind Direction Sensor. This sensor should be aligned to true north.

(a) Range. 1° to 360° in azimuth.

(b) Threshold. 2 knots.

(c) Accuracy. Within $\pm 5^\circ$ (RMSE)

(d) Resolution. To nearest 1° ; dead band not to exceed 7° wide.

(e) Time constant. Less than 2 seconds.

b. Performance Testing. Testing should be conducted in a calibrated wind tunnel, except for the wind direction accuracy test that is conducted on a bench test fixture. The windspeed sensor should be compared against a calibrated Pitot - static tube or transfer reference standard traceable to the National Institute of Standards and Technology (NIST).

(1) Windspeed.

(a) Accuracy and Resolution. The test is conducted under no rain conditions. Four full-test cycles (2-85 knots) should be conducted in increments of 2 knots between 2 and 10 knots, in increments of 10 knots between 10 and 80 knots, and at 85 knots. During these test runs, data should be gathered to demonstrate compliance with the requirements for accuracy and resolution. Tests demonstrating acceptable accuracy during environmental extremes as listed in paragraph 3.4 should be conducted.

(b) Distance Constant. The distance constant should be computed according to the following formula:

$$D = T \times W$$

Where:

D = Distant constant (in meters).

T = Time constant.

W = Windspeed (meters per second) in the wind tunnel.

The distance constant should be determined from an average of 10 runs, 5 runs each with the tunnel windspeed at 10 knots (5 meter/sec) and at 20 knots (10 meter/sec) with the sensor propeller speed at the zero at time zero. The distance constant should be less than 10 meters for the sensor to pass this test.

(2) Wind Direction.

(a) Accuracy. This test should be conducted on a bench test fixture under no rain conditions. The accuracy of the sensor should be checked at each 10° increment. The accuracy should be checked in 2° increments between 350° and 010°. A dead band of up to 7° wide is permissible. Two complete test cycles should be conducted, and RMSE accuracy should be within specified limits. Tests demonstrating acceptable accuracy during environmental extremes as listed in paragraph 3.4 should be conducted.

(b) Time Constant. The time constant should be determined from an average of 10 runs, 5 runs each with the tunnel speed at 10 knots and at 20 knots. The vane should be displaced 10° from the indicated wind direction and released. The time constant should be less than 2 seconds to reach within 5° of the indicated wind direction.

3.6. ULTRASONIC WIND SENSOR.

a. Performance Standard.

(1) Windspeed.

(a) Range. The sensor should respond to a threshold of 1 knot and a maximum of at least 85 knots.

(b) Accuracy. The windspeed sensor should provide an accuracy of ± 1 knot up to 40 knots. Above 40 knots, RMSE should be within ± 3 percent.

(c) Resolution. The resolution should be 1 knot.

(d) Distance Constant. The distance constant should be less than 1 meter. The method for calculation is given in paragraph 3.5.b.(1)(b).

(e) Threshold. 1 knot.

(2) Wind Direction Sensor. This sensor should be aligned to true north and withstand a windspeed of 85 knots without damage.

(a) Range. 0° to 359° in azimuth.

(b) Threshold. 1 knot.

(c) Accuracy. Within $\pm 3^{\circ}$ (RMSE)

(d) Resolution. To nearest 1°

b. Performance Testing. Testing should be conducted in a calibrated wind tunnel. The ultrasonic sensor should be compared against a calibrated pitot-static tube or transfer reference standard traceable to the National Institute of Standards and Technology. Ultrasonic anemometers should be tested in a wind tunnel for directions using a rotating base. The mounting base should be able to be rotated as the test progresses. The following test procedures should be used.

(1) Windspeed Accuracy and Resolution. The test is conducted under no rain conditions. Four full-test cycles (2-85 knots) should be conducted in increments of 2 knots between 2 and 10 knots, in increments of 10 knots between 10 and 80 knots, and at 85 knots. During these test runs, data should be gathered to demonstrate compliance with the requirements for accuracy and resolution. Tests demonstrating acceptable accuracy during environmental extremes as listed in paragraph 3.4 should be conducted.

(2) Wind Direction Accuracy. The accuracy of the sensor should be checked at each 10° increment. The accuracy should be further checked in 2° increments between any 20° span. Two complete test cycles should be conducted, and RMSE accuracy should be within specified limits. Tests demonstrating acceptable accuracy during environmental extremes as listed in paragraph 3.4 should be conducted.

3.7. TEMPERATURE SENSOR.

a. Performance Standards. The sensor should be thermally isolated to accurately measure environments below:

- (1) Range. From -35° to $+55^{\circ}\text{C}$ (-30° to $+130^{\circ}\text{F}$) for Class 1 systems.
From -55° to $+55^{\circ}\text{C}$ (-65° to $+130^{\circ}\text{F}$) for Class 2 systems.
- (2) Accuracy. 1°F RMSE for the entire range of the sensor, with a maximum error of 2°F .

(3) Resolution. Not greater than 1°F .

(4) Time Constant. Not greater than 2 minutes.

b. Performance Testing.

(1) Accuracy. Temperature accuracy should be verified using a calibrated reference instrument traceable to the National Institute of Standards and Technology (NIST). The temperature sensor should be exercised through the full range of the device in 10°F increments. This 10° change in chamber temperature should be accomplished within 5 minutes of the test, and the sensor reading should be taken 5 minutes after the chamber temperature is stable. This test cycle should be performed a total of eight times or four times with two sensors in the chamber. These cycles should include two increasing and two decreasing temperature cycles without radiation heating and two increasing and two decreasing temperature cycles with radiation heating on the aspirated enclosure of 1.6 gram-calories per square centimeter per minute (1120 W/m^2). The accuracy of the sensor should be within 1°F (RMSE) for each test cycle, a total of 9 data points for each Class 1 system cycle; 11 data points for each Class 2 system cycle. Tests demonstrating acceptable accuracy during environmental extremes as listed in paragraph 3.4 should be conducted.

(2) Time Constant. The sensor should be placed in a chamber and stabilized at 85°F . The temperature should be rapidly raised (within 1 minute) 5°F (to 90°F); the time constant should be 2 minutes or less. The same test should be repeated with a 5°F decrease in temperature within 1 minute. The time constant should be 2 minutes or less.

3.8. HUMIDITY SENSOR. A single thermal shield and aspirator unit may include both the humidity and temperature sensors.

a. Performance Standards.

- (1) Range. From -35° to $+55^{\circ}\text{C}$ (-30° to $+130^{\circ}\text{F}$) for Class 1 systems.
From -55° to $+55^{\circ}\text{C}$ (-65° to $+130^{\circ}\text{F}$) for Class 2 systems

(2) Sensor Protection. The humidity sensor should not be damaged if the sensor becomes excessively wet, e.g., from precipitation or from absorption of moisture after a loss of power. The humidity sensor probe should return to normal operation, without damage and without human intervention, within 30 minutes after the abnormal, excessively wet condition is alleviated, i.e., after precipitation ends, or after restoration of power.

- (3) Resolution. Not greater than 1%.

(4) Time constant. Less than 2 minutes.

(5) Accuracy. The accuracy should be less than or equal to 5% of the measured value.

b. Performance Testing.

(1) Accuracy. All tests should be performed with the sensor in the aspirated enclosure supplied with the sensor. Temperature and relative humidity accuracy should be verified using calibrated reference instruments traceable to the National Institute of Standards and Technology. The data points given in paragraphs 3.9.b.(1) should be taken during four test runs, two with increasing humidity and two with decreasing humidity. This may be reduced to two test runs if two sensors are placed in the chamber. During the test run, the change in temperature/relative humidity should be accomplished within 5 minutes, and the sensor reading should be taken 5 minutes after the temperature and humidity have stabilized. Tests demonstrating acceptable accuracy during environmental extremes as listed in paragraph 3.4 should be conducted.

(2) Time Constant. At ambient temperature and 50 percent relative humidity, change the humidity equal to a dew point increase of 5°F within 1 minute, and then decrease the humidity equal to a dew point decrease of 5°F within 1 minute. In each case, the time constant should be less than 2 minutes.

(3) Power Interruption. At ambient temperature and 90 percent relative humidity, with the sensor operating normally, disconnect the power from the sensor for a period of 1 hour. Power should then be reapplied and the sensor should return to normal operation and accuracy within 30 minutes.

3.9. DEW POINT SENSOR. A single thermal shield and aspirator unit may include both the dew point and temperature sensors.

a. Performance Standards.

(1) Range. From -35° to +55°C (-30° to +130°F) for Class 1 systems.
From -55° to +55°C (-65° to +130°F) for Class 2 systems

(2) Dewcell Protection. If the dew point sensor is a dewcell, it should not be damaged if the sensor becomes excessively wet, e.g., from precipitation or from absorption of moisture after a loss of power. The dewcell probe should return to normal operation, without damage and without human intervention, within 30 minutes after the abnormal, excessively wet condition is alleviated i.e., after precipitation ends or after restoration of power.

(3) Resolution. Not greater than 1°F.

(4) Time constant. Less than 2 minutes.

(5) Accuracy. The accuracy should be as follows. All errors are RMSE.

(a) 2°F dew point for dry bulb temperatures of +30° to +90°F, 80 to 100 percent relative humidity, with a maximum error of 3°F at any dry bulb temperature.

(b) 3°F dew point for dry bulb temperature of +30° to +120°F, 15 to 75 percent relative humidity, with a maximum error of 4°F at any dry bulb temperature.

(c) 4°F dew point for dry bulb temperatures of -20° to +20°F, 25 to 95 percent relative humidity with a maximum error of 5° at any dry bulb temperature. The minimum dew point required is -30°F.

b. Performance Testing.

(1) Accuracy. All tests should be performed with the sensor in the aspirated enclosure supplied with the sensor. Temperature and dew point accuracy should be verified using calibrated reference instruments traceable to the National Institute of Standards and Technology. The data points given in paragraph 3.9.b.(1)(a) through 3.9.b.(1)(c) should be taken during four test runs, two with increasing humidity and two with decreasing humidity. This may be reduced to two test runs if two sensors are placed in the chamber. During the test run, the change in temperature/relative humidity should be accomplished within 5 minutes, and the sensor reading should be taken 5 minutes after the temperature and humidity have stabilized. The following data points should be demonstrated and the RMSE calculated to demonstrate the error in each category. Tests demonstrating acceptable accuracy during environmental extremes as listed in paragraph 3.4 should be conducted.

(a) With an error not to exceed 2°F (RMSE) dew point

30°F temperature; 80, 90, 100 percent relative humidity
60°F temperature; 80, 90, 100 percent relative humidity
90°F temperature; 80, 90, 100 percent relative humidity

(b) With an error not to exceed 3°F (RMSE) dew point

30°F temperature; 15, 45, 75 percent relative humidity
60°F temperature; 15, 45, 75 percent relative humidity
90°F temperature; 15, 45, 75 percent relative humidity
120°F temperature; 15, 40 percent relative humidity

(c) With an error not to exceed 4°F (RMSE) dew point

-30°F temperature; between 65 and 95 percent relative humidity
0°F temperature; 25, 60, 95 percent relative humidity
+20°F temperature; 25, 60, 95 percent relative humidity

(2) Time Constant. At ambient temperature and 50 percent relative humidity, change the dew point +5°F (within 1 minute), and then -5°F (within 1 minute). In each case, the time constant should be less than 2 minutes.

(3) Power Interruption. At ambient temperature and 90 percent relative humidity, with the sensor operating normally, disconnect the power from the sensor for a period of 1 hour. Power should then be reapplied and the sensor should return to normal operation and accuracy within 30 minutes.

3.10. PRESSURE SENSOR. Two or three pressure sensors should be provided for each AWOS system. All pressure sensors should have provisions for venting to the outside through a pressure port. Pressure variations due to airflow over the pressure port should be avoided. Sensor venting should be designed to avoid any damp pressure variation and oscillation due to pumping or breathing of the pressure sensor, venting, and porting equipment. Means should be provided to avoid insect nesting and moisture entrapment in the venting.

a. Performance Standards.

(1) Altitude Ranges. High pressure should be standard atmospheric pressure at -100 feet plus 1.5 inches of mercury (inHg) ($30.03 + 1.5 = 31.53$ inHg). Low pressure should be standard atmospheric pressure at +10,000 feet minus 3.0 inHg ($20.58 - 3.00 = 17.58$ inHg).

(2) Pressure Range. Each sensor should be capable of measuring a pressure range at any fixed location (station) of +1.5 to -3.0 inHg from the standard atmospheric pressure at that location.

(3) Accuracy. The accuracy should be ± 0.02 inHg RMSE at all altitudes from -100 to +10,000 feet mean sea level (MSL), maximum error 0.02 inHg at any one pressure.

(4) Resolution. The resolution of the barometer should be displayed in 0.001 inHg increments or better.

(5) Differential Accuracy. Each sensor should exhibit an average differential accuracy of 0.02 inHg or less between a series of two pressure measurements taken from the same sensor 3 hours apart. Ambient temperature over this 3-hour period should not change more than 5°F. Ambient pressure should not vary more than 0.04 inHg (RMSE) over the 3-hour period.

(6) Maximum Drift With Time. Each sensor should be stable and continuously accurate within 0.02 inHg RMSE for a period of not less than 6 months. The maximum error should be 0.02 inHg.

b. Performance Tests.

(1) Accuracy. Each pressure sensor should successfully complete the following accuracy test. A calibrated barometer or transfer standard with an accuracy of at least 0.004 inHg, that is traceable to the National Institute of Standards and Technology (NIST), should be used as a standard during testing. Two test cycles should be performed on each pressure sensor. One test cycle is defined as running the sensor through the full pressure range at each of three

ambient temperatures. Before taking measurements, allow sufficient time for the sensor to achieve steady state at each data point not to exceed 5 minutes. The RMSE should be within the specified limits. Tests demonstrating acceptable accuracy during environmental extremes as listed in paragraph 3.4 should be conducted.

(a) Pressure Range. The pressure sensors should be tested through the full range of performance, normally 17.5 to 32.0 inHg, in 1-inHg increments of both increasing and decreasing pressure.

(b) Temperature Range. The sensor should be tested at ambient (approximately +85°) and at the hot and cold extremes called for in the environmental requirements.

(2) Differential Accuracy. Differential accuracy, i.e., change in accuracy, of the pressure sensor should be tested at ambient temperature (approximately 85°F) and ambient barometric pressure.

(a) Take 14 measurements of pressure on the pressure sensor under test and 14 measurements of pressure on the reference barometer. These measurements should be taken about 5 seconds apart and all 14 measurements should be completed within 90 seconds. This time should be called $t=0$.

(b) Repeat the 14 measurements on the pressure sensor under test and 14 measurements of pressure on the reference barometer after an elapsed time of 3 hours. The ambient temperature should have changed less than 5°F, and the ambient pressure should have changed not more than 0.1 inHg. This time should be called $t=3$.

(c) Compute the average reading of the reference barometer at $t=0$. Compute the average reading of the reference barometer at $t=3$. Determine the difference in the two averages. If the difference is greater than 0.1 inHg, or if the average difference between the reference and the test barometer at either $t=0$ or $t=3$ is greater than 0.02 inHg, repeat steps (a) and (b).

(d) Compute the 14 errors in reading between the sensor and reference barometer at $t=0$.

(e) Compute the 14 errors in reading between the sensor and reference barometer at $t=3$.

(f) Subtract the 14 $t=0$ errors from the 14 $t=3$ errors determined in steps (d) and (e). Preserve the order of subtraction such that the first $t=0$ error is subtracted from the first $t=3$ error. These differences are the changes in accuracy, i.e., the differential accuracy.

(g) Compute the average and standard deviation of the 14 changes in accuracy determined in step (f). The average differential accuracy should be no greater than 0.02 inHg. The standard deviation should be less than 0.004 inHg.

(3) Resolution. The manufacturer should demonstrate that the barometer resolution is displayed in 0.001 inHg increments or greater.

(4) Drift Over Time. Testing should be accomplished to determine maximum drift, paragraph 3.10.a.(6), over a 6-month period and should not exceed 0.02 inHg.

3.11. CLOUD HEIGHT SENSOR. The cloud height sensor should have a design range of at least 12,500 feet. The sensor should provide an output of at least three cloud layers representative of the sky conditions when surface visibilities are equal to or greater than 1/4 mile. The sensor should comply with the performance standards throughout its design range.

a. Performance Standards. The sensor should detect the height of atmospheric phenomena, i.e., clouds and obscuring phenomena aloft, or in the event the phenomena are surface based, e.g., fog, provide an estimate of the contact height (CH) or vertical visibility (VV). CH is defined as the vertical height above ground at which visual reference to recognized lights or objects on the surface can be established sufficiently to permit visual determination of the ground plane and position. VV is defined as the vertical distance that an observer can see vertically into surface-based obscuring phenomena, e.g., dust, fog, sand, etc., or the height corresponding to the upper limit of the return of the ceilometer signal, or the height corresponding to the height at which a balloon would completely disappear during the presence of surface-based phenomena, i.e., an obscured sky. The sensor should have the capability of discriminating between a negative response, i.e., no hit, resulting from no phenomena within the sensor's design range, and a sensor error/fault. The sensor should not indicate a response, i.e., hit, that is not the result of the detection of atmospheric phenomena.

(1) Range. The sensor should measure cloud heights and the heights of obscuring phenomena aloft to a minimum of 12,500 feet.

(2) Accuracy. Under laboratory conditions, the sensor should provide an accuracy of 100 feet or 5 percent, whichever is greater.

(3) Resolution. Not greater than: 50-foot surface to 5,500 feet; 250 feet from 5,501 to 10,000 feet; 500 feet above 10,000 feet.

(4) Detection Performance. The sensor should perform within the limits specified in paragraphs 3.11.b.(2) and 3.11.b.(3).

(5) Sampling. The sensor should provide an output at least once every 30 seconds. However, to extend sensor life, this sampling rate may be reduced to provide at least one sample every 3 minutes when no cloud, obscuring phenomena aloft, or CH/VV values, i.e., hits, are detected for the preceding 15 minutes.

(6) Eye Safety. The cloud height sensor should be designed to conform to laser radiation Class IIIb as defined in ANSI-Z 136.1, Accessible Emission Limits for Laser Radiation, with the maximum accessible emission level applied to direct viewing without optical

instruments excluding ordinary eye glasses. This document may be obtained from the American National Standards Institute, 1430 Broadway, New York, New York, 10018. Interlock device(s) in the laser power circuit should be provided to disable the laser when any doors are open or the cover is removed to prevent inadvertent exposure of the laser emission to the eyes of the technician or others. The interlock(s) may have a manual override in order that power can be purposely restored during maintenance.

(7) Laser Power Stability. The sensor should contain a self-check, self-adjusting feature that should maintain laser output power at the level necessary to sustain sensor detection and accuracy. When this adjustment can no longer provide the compensation necessary to maintain the sensor within specified operational limits, sensor operation should be terminated.

(8) Optics Contamination. An air blower or other device should be used to reduce the contamination of the sensor optics. A signal should be generated to indicate the amount of optics contamination, thereby indicating the need for optics cleaning.

(a) Snow. The ceilometer window should demonstrate an ability to remain clear of snow under the condition of snow accumulating at a rate of 2 inches per hour for 1 hour at a temperature of 20°F.

(b) Ice. The ceilometer window should remain clear of ice for 60 minutes under conditions of freezing rain with a maximum accretion rate of ½-inch per hour radial thickness of clear ice.

b. Performance Testing.

(1) Accuracy Test. The signal should be projected horizontally to a target at known distances, two distances, separated by at least 1,000 feet, from 100 to 5,500 feet; two distances, separated by at least 1,000 feet, from 5,600 to 10,000 feet; and one distance beyond 10,000 feet. All range points should be within the accuracies specified in paragraph 3.11.a.(2). This test is a laboratory test conducted at full rated power output. It is not intended to be duplicated when the AWOS is installed in the field.

(2) Detection Tests Under Uniform Sky Conditions.

(a) Test Conditions. The sensor should be tested under the following conditions.

(i) Group A. Visibility greater than 3 miles, with a minimum of 10 percent of the data sets in each subgroup as shown in Table 2, collected with light precipitation, i.e., rain and snow, occurring, and a minimum of 10 percent with moderate precipitation, i.e., rain and snow, occurring.

Table 2. Group A Test Conditions

Subgroup	Cloud Height (feet)
1	100-700
2	800-1500
3	1600-3000
4	3100-5500
5	5600-12500

(ii) Group B. Visibility equal to or less than 3 miles, but equal to or greater than 1 mile, with a minimum of 10 percent of the data sets in each subgroup as shown in Table 3, with light precipitation, i.e., rain and snow, occurring, and a minimum of 10 percent with moderate precipitation, i.e., rain and snow, occurring.

Table 3. Group B Test Conditions

Subgroup	Cloud Height (feet)
1	100-700
2	800-1500
3	1600-3000
4	3100-5500
5	5600-12500

(iii) Group C. Visibility equal to or greater than 1/4, but less than 1 mile, with a minimum of 10 percent of the data sets in each subgroup as shown in Table 4, collected with light precipitation, i.e., rain and snow, occurring, and a minimum of 10 percent with moderate precipitation, i.e., rain and snow, occurring.

Table 4. Group C Test Conditions

Subgroup	Cloud Height (feet)
1	100-700
2	800-1500
3	1600-3000
4	3100-5500
5	5600-12500

(iv) Group D. Not more than 3/10 total sky coverage with the lowest cloud layer at 2,000 feet or higher under the visibility conditions shown in Table 5, with a maximum of 80 percent of the data in each subgroup collected under daytime conditions.

Table 5. Group D Test Conditions

Subgroup	Visibility (miles)
1	Equal to or greater than 1, but less than 3
2	Equal to or greater than 3, but less than 7
3	Equal to or greater than 7

(b) Collection of Test Data.

(i) A minimum of 25 data sets should be collected for each subgroup in Groups A through C, i.e., a minimum of 125 data sets should be collected under each group. However, if weather conditions at the test site over a period of 1 year make collection of at least 25 data sets in every subgroup impossible, the FAA should consider approval of a lesser number of data sets in the affected subgroups after analysis of available data. Further, for test data to be acceptable, a continuous test period should be selected to allow for collection of representative data.

(ii) Also, it should be clear that all data collected during the test period were considered. Any data not used should be explained. For example, if data analysis in a subgroup is truncated after 25 data sets are analyzed, this fact should be documented and explained.

(iii) One data set is defined as the second 10-minute period during which a uniform cloud or obscuration is detected by a recently calibrated collocated Federal AWOS ceilometer or is determined by a qualified weather observer. In order to be classified as a uniform cloud or obscuration, the Federal AWOS should continuously measure or a qualified weather observer should determine a cloud, obscuration aloft, or vertical visibility height for a 30-minute period that does not vary from its mean height by more than the variance shown in Table 6 more than 5 percent of the time.

(iv) A minimum of 25 data sets should be collected for each subgroup under Group D. One data set is defined as the second 10-minute period of any consecutive 30-minute period during which the cloud/sky coverage/visibility conditions specified for group D are met.

Table 6. Criteria for Determining Uniform Cloud Layers

Mean Height (as determined by observer or as measured by a Federal AWOS ceilometer)	Variance (feet)
Equal to or less than 1,000 ft.	200
Greater than 1,000 ft., but equal to or less than 2,000 ft.	300
Greater than 2,000 ft., but equal to or less than 3,000 ft.	400
Greater than 3,000 ft., but equal to or less than 5,000 ft.	500
Greater than 5,000 ft., but equal to or less than 7,000 ft.	600
Greater than 7,000 ft., but equal to or less than 9,000 ft.	700
Greater than 9,000 ft., but equal to or less than 12,500 ft.	800

(c) Test Standards

(i) A collocated, recently calibrated Federal AWOS ceilometer or observations taken by a qualified weather observer should be the standard for determining heights and sky conditions.

(ii) A collocated, recently calibrated Federal AWOS visibility sensor should be the standard for determining visibilities.

(iii) Liquid precipitation measurements should be made using an FAA-approved 0.01 inch per tip tipping bucket precipitation gauge. Light precipitation is defined as one, but not more than two buckets tips in a 10-minute period. Moderate precipitation is defined as more than two, but not more than five tips in a 10-minute period. Heavy precipitation is defined as more than five tips in a 10-minute period. A qualified weather observer should determine the intensity of frozen precipitation.

(d) Criteria for Acceptance Under Uniform Sky Conditions.

Groups A, B, and C Conditions. The mean height of the cloud, obscuration aloft, or vertical visibility measured by the Federal AWOS or determined by a qualified weather observer should be determined for each data set. The variance for each cloud, obscuration aloft, and CH/VV height, i.e., hit, detected by the candidate sensor in each data set should be computed. Eighty-eight percent of the data sets within a subgroup, e.g., 22 out of 25 minimum, should satisfy the following condition: 90 percent of the heights determined by the candidate sensor in each data set should agree with the mean height measured by the Federal AWOS or determined by a qualified weather observer within the variance limits as shown in Table 7, Criteria to Satisfy Groups A, B, and C Conditions. Negative responses, i.e., no hits by the candidate sensor, should be included as data points and considered to be outside the variance limits. Also, the no-hit percentage in each subgroup should not exceed 5 percent. The candidate sensor should successfully

demonstrate the conditions in Table 7, Criteria to Satisfy Groups A, B, and C Conditions, for each subgroup to pass this test. Failure of any subgroup constitutes failure of the test.

Table 7. Criteria to Satisfy Groups A, B, and C Conditions

Mean Height (as determined by observer or as measured by Federal AWOS ceilometer)	Variance (feet) for Cloud and Obscuration Aloft Heights (feet)	Variance for CH/VV Values (feet)
Equal to or less than 1,000 ft.	200	400
Greater than 1,000 ft., but equal to or less than 2,000 ft.	300	600
Greater than 2,000 ft., but equal to or less than 3,000 ft.	400	800
Greater than 3,000 ft., but equal to or less than 5,000 ft.	500	1,000
Greater than 5,000 ft., but equal to or less than 7,000 ft.	600	1,200
Greater than 7,000 ft., but equal to or less than 9,000 ft.	700	1,400
Greater than 9,000 ft., but equal to or less than 12,500 ft.	800	1,600

(i) Group D Conditions. Not more than one false hit per data set in each subgroup. More than one false hit per data set should constitute failure of the test.

(3) Detection Tests Under Ragged Overcast or Obscured Sky Conditions.

(a) Heights, cloud/obscuration aloft or CH/VV, measured by the candidate sensor should be compared with heights measured by the Federal AWOS or determined by a qualified weather observer during ragged overcast or obscured sky conditions. Valid data should be that collected during overcast or obscured sky conditions below 12,500 feet as verified by a Federal AWOS hit percentage of 95 percent or more, or as determined by a qualified weather observer, during a 20-minute period. Negative responses, i.e., no hits, should be included as data points and considered to be outside the variance limits. Calculate the percent of heights, i.e., hits, by the candidate sensor falling within the ranges identified in paragraph 3.11.b.(3)(b) under each of the conditions specified in paragraph 3.11.b(3)(c) with allowable height variances as specified as in Table 7. Data should be collected under as many of the conditions as possible; however, the FAA may accept less than the specified requirement after evaluation of the available data. For test data to be accepted, a continuous test period should be selected to allow for representative data collection. It should also be clear that all data collected during the test period were considered. Any data not used should be explained.

(b) Height ranges (as determined by Federal AWOS ceilometer or qualified observer)

- (i) 100 - 700 feet
- (ii) 800 - 1,500 feet
- (iii) 1,600 - 3,000 feet
- (iv) 3,100 - 5,500 feet
- (v) 5,600 - 12,500 feet

(c) Conditions:

(i) No precipitation. Visibilities 1/4 to 1 mile, 1 to 3 miles, and greater than 3 miles.

(ii) Light or moderate precipitation (rain and snow). Visibilities 1/4 to 1 mile, 1 to 3 miles, and greater than 3 miles.

(iii) Heavy precipitation (rain and snow). Visibilities 1/4 to 1 mile, 1 to 3 miles, and greater than 3 miles.

(d) A minimum of 90 percent weighted average of the hits by the candidate sensor should fall within the range of the Federal AWOS ceilometer or within the height range determined by a qualified weather observer. Also, the weighted negative response, i.e., no hit, percentage should not exceed 5 percent.

3.12. VISIBILITY SENSOR.

a. Performance Standards.

(1) Range. The visibility sensor should be capable of determining visibilities from less than 1/4 mile to 10 miles. A method of calibration traceable to the FAA-approved standards in paragraph 3.12.b should be provided.

(2) Resolution. In terms of equivalent visibility, the sensor should provide data to report visibility values as follows in statute miles: less than 1/4, 1/4, 1/2, 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 4, 5, 7, 10 and greater than 10 miles. For information, refer to Federal Meteorological Handbook 1 (FMH-1).

(3) Accuracy. The sensor should agree with the visibility standards as shown in Table 8, Visibility Sensor Accuracy Requirement.

Table 8. Visibility Sensor Accuracy Requirement.

Reference Visibility Standard Reading	Acceptable Sensor Variance
1/4 through 1-1/4 miles	± 1/4 mile
1-1/2 through 1-3/4 miles	+ 1/4, -1/2 mile
2 through 2-1/2 miles	± 1/2 mile
3 through 3-1/2 miles	+ 1/2, -1 mile
4, and greater than 4 miles	± 1 mile

(4) Time Constant. The time constant should not exceed 3 minutes.

(5) Ambient Light Sensor. The visibility sensor should contain an ambient light sensor, i.e., a photocell, to measure the ambient luminance within its field of view and generate a signal to the visibility sensor to indicate whether the ambient light level is day or night. It should indicate day for increasing illumination between 0.5 and 3 foot-candles (FC) and night for decreasing illumination between 3 and 0.5 FC. This sensor may be exposed to ambient light levels as high as 50 FC.

b. FAA-Approved Visibility Standards. The visibility reference standard should be a recently calibrated, collocated Federal AWOS. The sensor under test should be within 100 feet of the reference standard. High resolution visibility data should be collected from the Federal AWOS and the sensor under test once a minute.

c. Performance Tests. The visibility sensor should be tested using a recently calibrated, collocated Federal AWOS as the reference visibility standard.

(1) Accuracy Testing.

(a) At least 2 months of accuracy test data should be accumulated, assuring that a representative number of valid test points are experienced at each of the reporting increments provided in paragraph 3.12.a.(2), and under conditions of both with and without precipitation. All data collected during the test should be included in the test report. Any samples not included in determining the candidate sensor's accuracy should be fully explained. For example, data collected under inhomogeneous conditions may be excluded from the accuracy analysis, if so explained. The test data should consist of a number of independent samples of 10 minutes each, with at least 5 minutes between each sample. Samples should consist of visibilities from less than 1/4 mile, to greater than 10 miles, and should be weighted in the following ratio:

(i) 70 percent without precipitation, i.e., with fog, under clear conditions, and with approximately 5 percent of the data points collected under summer haze conditions.

(ii) 30 percent with precipitation, e.g., 15 percent with rain, 15 percent with snow.

(b) Eighty percent (overall weighted average) of the total of all sensor test data points should agree with the visibility standard within the allowed variances from less than 1/4 through 5 miles.

(c) Eighty percent of the sensor test samples that are obtained when the visibility standard reads greater than 5 miles should be 5 miles or greater.

(2) Time Constant Demonstration. Under conditions of 10-mile visibility, a technique should be used to reduce the sensor detector output to 1 mile or less. After the restriction is applied, the time constant should be measured to reflect the reduction of visibility. After a period of 10 minutes, the artificial restriction to visibility should be removed, and the sensor time constant should be measured to reflect the increase in visibility. The time constant should be equal to or less than 3 minutes.

(3) Ambient Light Sensor Testing. The manufacturer should demonstrate that the ambient light sensor complies with paragraph 3.12.a.(5) and the visibility output is updated accordingly when the light sensor changes status from day-to-night or night-to-day.

3.13. PRECIPITATION ACCUMULATION SENSOR. The term *precipitation* is defined as including all forms, i.e., liquid, freezing, frozen, or combinations thereof. The term *precipitation amount* is the liquid or liquid equivalent amount. There are generally two types of precipitation accumulation sensors, the tipping bucket rain gauge and the precision scale. The tipping bucket design measures every tip, e.g., 0.01 inches. The precision scale, sometimes referred to as an all weather precipitation accumulation gauge (AWPAG), measures the weight of the precipitation and reports it as inches of rain.

a. Performance Standards. The sensor should be capable of estimating the precipitation amount with a range of 0.01 to 5-inches per hour, with a resolution of 0.01 inches and an accuracy of 0.002 inches per hour (RMSE), or 4 percent of actual, whichever is greater.

b. Performance Testing. The manufacturer should conduct a test program to demonstrate that the precipitation accumulation sensor(s) meet the performance requirements under the environmental conditions found in paragraph 3.4.

3.14. PRESENT WEATHER DETECTOR/SENSOR. The term *precipitation type* as used herein includes the following: rain, drizzle and snow. The precipitation type sensor should provide an indication of the type of precipitation occurring, or should output *precipitation* for any precipitation, e.g., liquid, freezing, frozen, or combinations thereof, when a type cannot be identified. However, recognizing that the sensor technology is not yet available to identify ice pellets and hail, a precipitation type sensor may qualify by identifying only rain, drizzle, and snow while outputting *precipitation* for those types not identified. The sensor unit may be designed as a separate unit or may be combined with the requirements of other parts of this AC, e.g., paragraph 3.12, Visibility Sensor, so that one unit fulfills the requirements of two or more paragraphs.

a. The sensor should identify the type of precipitation when the rate of precipitation equals or exceeds 0.002 inches per hour, with the goals for accuracy as follows:

(1) Within the temperature range of:

(a) +28°F to +38°F, identify precipitation type correctly as:

(i) Rain: 90 percent of the cases.

(ii) Drizzle: 80 percent of the cases.

(iii) Snow: 90 percent of the cases.

(b) Less than +28°F. Identify precipitation type correctly as snow in 99 percent of the cases.

(c) Greater than +38°F, identify precipitation type correctly as:

(i) Rain: 99 percent of the cases.

(ii) Drizzle: 90 percent of the cases.

(2) Priority: Only one precipitation type should be reported, with the reporting priority established in the following order.

(a) Snow.

(b) Rain.

(c) Drizzle.

(d) Precipitation, unidentified.

b. Performance Tests. The manufacturer should conduct a test program to demonstrate that the sensor satisfies the performance standards under the environmental conditions in paragraph 3.4. As a minimum, the following test conditions should be satisfied.

(1) Prior to testing, the AWOS manufacturer should develop and submit a test plan to the FAA AWOS Non-Federal Engineering Office for approval at the address provided in paragraph 1.3.b. The test plan should clearly outline the tests to be performed, it should define the capabilities of the sensor to be tested, and it should include a detailed description of the test procedures. It should contain a clear statement of pass/fail criteria. The test plan should identify the location(s) and the proposed time planned for the tests. All data collected during the test should be incorporated into the test report. Any data not included in determining the candidate sensor's compliance with the requirements of this circular should be fully explained.

(2) The test should be conducted in two phases. One phase should be conducted in a test chamber with varying conditions simulated to generate drizzle, rain, and snow. At least 9 events at various rates of accumulation should be simulated for each of these conditions to demonstrate the above requirements and the results should be included in the test report.

(3) The second phase of the test should be conducted at a location(s) and during times when there is a propensity for drizzle, rain, snow, hail, and ice pellets and where there is a qualified weather observer on duty. The test report should compare the performance of the sensor under test with the log maintained by the official observer at the test location. Hail and ice pellets as reported by the official observer should be reported as *precipitation*.

3.15. THUNDERSTORM DETECTION SENSOR OR NETWORK. This stand-alone sensor or thunderstorm detection network should detect the presence of a thunderstorm within 30 nm of an airport, should locate the thunderstorm, and should provide this data in such a form that the information can be incorporated into the AWOS display and voiced weather message.

a. Performance Standards.

(1) Range and direction. Thunderstorms within 30 nm of the reference point on the airport should be reported. Direction is expressed in compass octants for distances from 10 to 30 nm.

(2) Resolution. The thunderstorm location should be defined within 1 nm of the location of the actual location of the thunderstorm/lightning.

(3) Accuracy.

(a) The standard detects strikes within 10 nm of the reference point:

(i) Detection Accuracy. Ninety percent of all thunderstorms identified and located within this area by the thunderstorm sensor/network standards should be detected by the thunderstorm sensor/network under test.

(ii) Location Accuracy. The location from each thunderstorm detected by the sensor standard within 10 nm of the reference point, and the corresponding thunderstorm detected by the sensor/network under test, should be computed. The RMSE of these locations accumulated during the test period should not exceed 3 nm.

(b) The standard detects strikes between 10 nm and 30 nm of the reference point:

(i) Detection Accuracy. Eighty percent of all thunderstorms identified and located within this area by the thunderstorm sensor/network standards should have been detected by the thunderstorm sensor/network under test.

(ii) Location Accuracy. The distance from each thunderstorm located by the sensor standard between 10 nm and 30 nm of the reference point, and the corresponding thunderstorm located by the sensor/network under test, should be computed. The RMSE of these distances accumulated during the test period should not exceed 6 nm.

(c) False Reports. Not more than 2 percent of all thunderstorms reported by the sensor under test should have been caused by sources other than a naturally occurring thunderstorm.

(4) Sensor/System Reporting to the AWOS. The thunderstorm sensor/network should update the AWOS once each minute.

b. Performance Tests. The manufacturer should conduct a test program to demonstrate that the thunderstorm sensor/network meets the performance standards under the environmental conditions identified in paragraph 3.4.

(1) Prior to Testing. The AWOS manufacturer should develop and submit a test plan to the FAA AWOS Non-Federal Engineering Office for approval at the address provided in paragraph 1.3.b. The test plan should outline the tests to be performed, it should clearly define the capabilities of the sensor/network to be tested, and it should include a detailed description of, and the capabilities of, the method that should be used to prove that the sensor is performing in accordance with the performance standards provided in paragraph 3.15.a. It should define the criteria necessary for the standard(s), as well as the sensor/network under test, to recognize a thunderstorm. A clear statement of pass/fail criteria should be included. If the sensor/network proposed should only detect cloud-to-ground lightning or if it should detect other evidence of a thunderstorm, this fact should be clearly identified. The test plan should identify the locations and the proposed time planned for the tests. The test should be conducted in at least two locations, i.e., reference points, where there is a propensity for thunderstorms.

(2) Duration of the Test. The test should encompass a sufficient period of time to accomplish the following minimum detection/location events to prove that the sensor/network under test conforms to the requirements of this circular. A *thunderstorm day* is a day during which thunderstorm data are accumulated from the standard(s) and the sensor/network under test.

(a) Summer Environment. Thunderstorms should have been detected during at least 25 *thunderstorm days* during the summer months at a location where there is a high level of thunderstorms generated by summertime convection activity. It is desirable that at least 100 thunderstorms, i.e., cells, should have been detected and located by the standard(s) during the summer test.

(b) Winter Environment. Thunderstorms should have been detected during at least 10 *thunderstorm days* during the months of November through February at a cold weather location where there is a propensity for thunderstorms associated with mid-latitude winter storms. It is desirable that at least 20 thunderstorms, i.e., cells, should have been detected and located by the standard(s) during the winter test.

(3) Thunderstorm Detection Standards. All means available within the test area to identify and locate thunderstorms should be used. These thunderstorm detection standards should include:

(a) Qualified Weather Observer(s). Qualified weather observers should be used to identify and locate thunderstorms within the vicinity of the reference point. The observer should identify a thunderstorm in accordance with the criteria in FMH-1. The time and the estimated location (bearing and distance) should be logged when identifying the existence (beginning time) of a thunderstorm. Once a thunderstorm has been identified, observations should be recorded every 10 minutes. The ending time of the thunderstorm should be identified. The results of these observations should be plotted on a grid of approximately 3 nm squares, with the reference point in the center, and an area encompassing a circle with a radius of 10 nm. The scale of this plot should be the same as the scale of the radar echo plot. A plot should be made every 10 minutes. All plots for these tests, e.g., observer, radar, network, system/network under test, should be based upon the same time periods, e.g., beginning on the same minute.

(b) Weather Radar. Weather radar may be used to identify and locate thunderstorms within the area under test. The radar antenna should be located within 30 nm of the reference point. Level three and greater intensity radar echoes should, by themselves, constitute the detection of a thunderstorm. Level two radar echoes, when correlated with another standard observation of a thunderstorm or with a report from the sensor/network under test, should constitute detection of a thunderstorm. However, if the sensor/network under test does not recognize a level two radar echo as a thunderstorm, and the level two echo is the only evidence of a thunderstorm, a thunderstorm should not be assumed to be present. Plots of the area under test from the radar screen should be made every 10 minutes and should depict levels two through six radar echoes. Plots should be made on a grid of approximately 3 nm squares with the reference point as the center. The highest intensity level should be marked in each grid square.

(c) Thunderstorm Network(s) as a Reference Standard. Network(s) may be used to identify and locate thunderstorms. Thunderstorms identified and located by a thunderstorm sensor network should be plotted on a grid identical to the grid used for the radar echo plot, i.e., approximately 3 nm squares on a 30 nm radius circle, with the reference point as the center. Plots should be made of the area under test every 10 minutes.

(d) Secondary Reference Systems. The use of secondary reference systems should be fully defined in the test plan.

(4) Execution of the Test. After the test plan is approved, the manufacturer should perform the test in accordance with the test plan. All data collected during the test should be included in the test results. Any data omitted from the results should be fully explained. Thunderstorms identified and located by the thunderstorm sensor/network under test should be plotted on a grid identical to the grid used for the radar echo plot, i.e., approximately 3 nm squares on a 30 nm radius circle, with the reference point as the center. Plots should be made of the area under test every 10 minutes. The test plan should establish the criteria for the system

that is tested, as well as all of the sensor/network standards, to be operational. As a minimum, in order for a thunderstorm day to be counted in the test results, a qualified weather observer should take observations and the weather radar should be operational when testing.

(5) Test Report. A report should be prepared and submitted to the FAA AWOS Non-Federal Engineering Office by the AWOS manufacturer, in accordance with the requirements of this AC, to obtain type certification of its AWOS with a thunderstorm detection, location, and reporting capability. Data obtained during this test should be analyzed as follows.

(a) Within 10 nm of the reference point. The grid plots obtained from the sensor under test should be matched with the grid plots obtained from the standards, i.e., qualified weather observer, the weather radar, thunderstorm sensor network, etc., for each 10 minute increment. Thunderstorm occurrences should be matched as previously described in paragraphs 3.15.b.(3) and 3.15.b.(4), and anomalies explained.

(i) The number of test sensor/network identifications should be compared with the number of thunderstorms identified by the standards. The percentage detection accuracy should be computed and compared with the requirement in 3.15.a.(3)(a).

(ii) The number of test sensor/network identifications that are in the same or an adjacent 3 nm grid square as the thunderstorm identified by the observer/sensor/ network standard should be compared with the number of thunderstorms identified by the standards. The percentage location accuracy should be computed and compared with the requirement in paragraph 3.15.a.(3)(a).

(b) Between 10 nm and 30 nm of the reference point. The grid plots obtained from the sensor under test should be matched with the grid plots obtained from the standards, i.e., qualified weather observer, the weather radar, thunderstorm sensor network, etc., for each 10-minute increment. Thunderstorm occurrences should be matched and anomalies explained.

(i) The number of test sensor/network identifications should be compared with the number of thunderstorms identified by the standards. The percentage detection accuracy should be computed and compared with the requirements in paragraph 3.15.a.(3).

(ii) The number of test sensor/network thunderstorm identifications should be counted that are in the same, an adjacent, or in a grid square separated by one square from the 3 nm grid square where an observer/sensor/network standard located a thunderstorm. This number should be compared with the number of thunderstorms identified by the standards. The percentage location accuracy should be computed and compared with the requirements in paragraph 3.15.a.(3)(b).

(c) The number of thunderstorms identified by the sensor/network under test that cannot be matched with a thunderstorm identified by the standards, i.e., false signals, should be counted and compared with the total number of thunderstorms identified by the standards. The

percentage of false signals should not be greater than the percentage identified in paragraph 3.15.a.(3)(c).

(6) Basis of the Reporting Algorithm. The AWOS sensor/system should locate and report a thunderstorm within one of 10 areas of a circle with the reference point as the center and a radius of 30 nm, as follows.

(a) Within a circle with a radius of 5 nm, with the reference point at the center.

(b) Within the circular area between 5 nm and 10 nm from the reference point.

(c) Within one of eight 45-degree clockwise sectors of the circular area between 10 nm and 30 nm from the reference point, beginning with the 22.5 degree radial from the reference point.

(7) AWOS Report of a Thunderstorm (TS). The AWOS voice and data report should be in accordance with the criteria in FMH-1. This algorithm processes lightning strike data through a 15-minute moving window, i.e., each strike expires 15 minutes after it is received. With certain exceptions, the algorithm should report a thunderstorm when two lightning strikes have been received within the 30 nm radius circle within 15 minutes.

(a) Within the 5 nm radius, the voiced report is *TS at the airport*.

(b) Between 5 and 10 nm of the airport, the voiced report is *TS in the vicinity*.

(c) Between 10 and 30 nm of the airport, the thunderstorm is reported using the appropriate sector designation. For example, *LIGHTNING NORTHEAST; LIGHTNING SOUTHWEST AND NORTH; LIGHTNING EAST THROUGH SOUTH; or LIGHTNING ALL QUADRANTS*.

(d) When no activity is detected within the area, no report should be voiced.

(e) If the thunderstorm sensor/system is inoperative, the message should be *THUNDERSTORM DETECTION INOPERATIVE*.

3.16. FREEZING RAIN OCCURRENCE SENSOR. This sensor should be capable of detecting the occurrence of freezing rain.

a. Performance Standards. Freezing rain should be reported when a minimum 0.01 inch radial thickness freezing rain has accumulated.

(1) Accuracy.

(a) The sensor should correctly detect the occurrence of freezing rain 95 percent of the time.

(b) The sensor should not false alarm on frost. The sensor false alarm rate should not exceed 0.1 percent when there is rain at temperatures above 40°F, or when there is no precipitation. During snow, the false alarm rate should not exceed 1 percent.

b. Performance Tests. The manufacturer should conduct a test program to demonstrate that the sensor meets the performance standards under the environmental conditions identified in paragraph 3.4. As a minimum, the following test conditions should be satisfied:

(1) Prior to testing, the AWOS manufacturer should develop and submit a test plan for approval to the FAA AWOS Non-Federal Engineering Office for approval at the address provided in paragraph 1.3.b. The test plan should clearly outline the tests to be performed, it should define the capabilities of the sensor to be tested, it should include a detailed description of the test procedures, and it should contain a clear statement of pass/fail criteria. The test plan should identify the location(s) and the proposed time planned for the tests. All data collected during the test should be incorporated into the test report. Any data not included in determining the candidate sensor's compliance with the requirements of this circular should be fully explained.

(2) The test should be conducted in two phases. One phase should be conducted in a test chamber with varying conditions simulated to generate freezing rain. At least 25 freezing rain events, at various accumulation rates beginning at 0.01 inch per hour up to 0.5 inches per hour, should be simulated to demonstrate the requirements in paragraph 3.16.a.(1), and the results should be included in the test report. Additionally, at least 10 snow events at temperatures of 28°F or less and 10 rain events at temperatures of 40°F should be conducted at various accumulation rates to demonstrate that the sensor does not provide false reports. If false reports are generated during the tests, additional testing should be accomplished to demonstrate the requirements in paragraph 3.16.a.(1)(b).

(3) The second phase of the test should be conducted during the months of November through February at a location where there is a propensity for freezing rain and where there is a qualified weather observer on duty. The test report should compare the performance of the sensor under test with the log maintained by the official observer at the test location.

3.17. RUNWAY SURFACE CONDITION SENSOR. This sensor provides real-time information on runway conditions to alert the pilot if the runway is wet or if there are possible icing conditions.

a. Performance Standards. The sensor should be capable of detecting three runway conditions: dry runway, i.e., no perceptible moisture; wet runway, i.e., visible moisture on the surface; and possible freezing conditions, i.e., pavement temperature below freezing and moisture present on the surface.

b. Performance Testing.

(1) The testing should be performed on a sensor installed in a runway or other suitable pavement section which is free from chemicals, rubber buildup, or other contamination. The pavement temperature should be measured with an infra-red thermometer, or other approved method. The sensor should be accurate within $\pm 1^\circ\text{F}$ within the temperature band of 25° to 35°F . At least 10 observations should be made under each of the conditions in the following paragraphs.

(a) Dry Runway. No visible moisture is present on the sensor.

(b) Wet Runway. The sensor is damp, wet, or flooded, and the surface temperature is above 32°F .

(c) Possible Freezing Conditions. The sensor is damp, wet, flooded, covered with ice, or packed snow, while the surface temperature is at or below 32°F .

(2) The sensor should be operationally tested during an entire winter season. The sensor reports should be visually verified with consideration of the effects of wind and any chemicals on the surface, and should be accurate at least 80 percent of the time in each of the three conditions, i.e., dry, wet, and possible freezing.

3.18. AWOS DATA PROCESSOR. The four principal functions of the AWOS data processor are data acceptance, data reduction, data processing, and product dissemination both digital and voice. The processor typically accepts data inputs, performs various data reduction functions, implements the AWOS algorithms, and prepares weather observation reports. The processor should have the ability to provide a computer generated voice weather observation to a ground-to-air radio, e.g., VOR, NDB, VHF discrete, etc., for transmission to pilots. As an option, this voice message may also be provided to users via an integral automatic telephone-answering device.

a. Performance Standards.

(1) Data Reduction. The data reduction function consists of the processing of information prior to the actual algorithm processing. The AWOS data reduction software should include quality control checks to ensure that the data received are reasonable and complete and that the associated equipment is working properly before the weather algorithms are performed. The processor should perform the tasks identified in paragraphs 3.18.a.(1)(a) through 3.18.a.(1)(e). If data from any sensor are erroneous, functionally inoperative, or totally missing, e.g., the sensor loses power, etc., that parameter should be reported missing or removed from the weather observation outputs. The processor should continue to sample the data and, if the error condition is corrected, the weather parameter should be reinserted in the AWOS report. As an optional feature, an error indication light may be provided which should be located in an attended location and should be energized when a parameter is reported missing by the AWOS. If the examples of data reduction checks provided in paragraphs 3.18.a.(1)(a) through 3.18.a.(1)(e) are

not applicable to a sensor's output, the manufacturer should propose suitable criteria. Additional criteria are encouraged.

(a) Periodically check reference or calibration points within the system, e.g., reference voltage, aspirator airflow, sensor heater current, etc., to monitor system operation.

(b) Set upper and lower limits on the sensor output which correspond to the normal operating limits of the sensor or to the real-world limits of the site. This is a gross error check that should prevent reporting the presence of clouds below ground level, negative windspeed, etc. For example, set the temperature sensor's upper and lower limits to +130°F and -60°F.

(c) Set rate-of-change limits on the sensor's output. Determining the maximum acceptable change in temperature or signal characteristics allowable over a given period of time might set a rate-of-change limit.

(d) Examine the history of the sensor output to detect sensor problems. As an example, the mean and standard deviation of a sensor measurement may be calculated every hour and compared to established upper and lower limits. If the windspeed sensor has a mean greater than 3 knots but, a standard deviation less than 0.5 knot, the sensor has probably malfunctioned. Likewise, the wind direction sensor is probably inoperative if the windspeed is above 5 knots and the standard deviation is less than 1 degree. Other examples of data checks include consistently low windspeed, unvarying windspeed or direction, lack of visibility of more than 5 miles for long periods, a consistent cloud layer or a lack of clouds for long periods, and so forth.

(e) Recognize the absence of or longer than expected continual static data output for each sensor, examine the sensor without or after examining other sensor's outputs, and be able to diagnose a sensor malfunction. If the sensor is diagnosed as malfunctioning, its output should continue to be monitored, but its system output should be removed from use. For example, if the wind direction output does not vary for a long period of time, or if it does not move for a much shorter period of time while the windspeed indicates over 3 to 6 knots of wind motion, it would be assumed that the windspeed direction is frozen or otherwise inoperative. If the wind direction showed changing wind directions and yet, the windspeed sensor showed no windspeed changes for a set period, the windspeed sensor has probably failed.

(2) Weather Algorithms. The AWOS data processor should implement FAA algorithms to generate the elements of the weather observation (e.g. altimeter setting, density altitude, wind gusts, variable wind directions, variable visibility, etc.). An observation should be generated each minute containing the current weather information for all the valid parameters observed by the AWOS. The algorithm output should adhere to FAA algorithm standards for output frequency of the specific product, e.g., 2-minute wind average, etc. If the output is to be supplied to the FAA for national dissemination, it should be in accordance with the appropriate interface documents. Copies of the FAA algorithms and the interface documents may be obtained from the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b.

The weather algorithms define altimeter setting as a function of field pressure, field elevation (MSL), sensor elevation and (optionally) AWOS reported air temperature.

In order to comply with an April, 2014 National Transportation Safety Board (NTSB) recommendation, AWOS used in the National Airspace System must report only snow or “unknown precipitation” when the present weather sensor detects precipitation and the AWOS reported air temperature is 32°F or less. (Note: this does not impact the reporting of freezing rain conditions as determined by a freezing rain occurrence sensor.)

(3) System Output. Using the most recent one minute observations of current weather information, the system should generate the output listed in paragraph 3.18.a.(3)(a)-(b) with the other system outputs listed in 3.18.a.(3)(c)-(e) being provided at the manufacturer's option.

(a) Computer-generated voice transmitted to pilots over radio, e.g., VOR, NDB, discrete frequency, etc.

(b) Input/output port for an operator terminal.

(c) Optional output port for a video display.

(d) Optional telephone port for dial-up service.

(e) Optional output port to the national weather network, via third party manufacturer or state aviation agency service provider, for type-certified, commissioned AWOS III or IV only as established in paragraph 1.3.

(4) Remote Maintenance Monitoring (RMM). All systems should include a secure dial-up or Ethernet input/output port that provides the FAA authorized maintenance technician holding verification authority with remote access to locally archived and real-time operational, weather reports, and maintenance data. RMM access security should be to appropriate industrial standards. The RMM should remotely enable or disable the system or a specific sensor(s), set the clock, etc. The RMM should effectively and efficiently maintain the proper operation of the AWOS. The information provided by the RMM should be identical to the archived and real-time operational and weather information available locally at the system. Any built in test equipment used in the remote monitoring of the system should be calibrated as defined in the latest edition of FAA Order 6700.20. Monitoring of the system should be performed by FAA authorized maintenance personnel to regularly review and analyze the locally archived operational and maintenance data. The technician should determine that all system parameters are being correctly reported, and that the real time clock is within the specified tolerance.

(5) Real-Time Clock. The processor should generate time as coordinated universal time (UTC). Typically, days, hours, minutes, and seconds are provided as a system output for use in system displays, computer-generated voice output, etc. The day should be expressed in the Gregorian calendar. Hours and minutes should be indicated numerically from 0000 to 2359. The clock function should be accurate within 15 seconds each month compared to an official time source, e.g., WWV. For those type-certified, commissioned systems whose output is provided to

the national weather network, i.e., AWOS III or IV only, AWOS clock errors in excess of 5 minutes may result in rejection of all data.

(6) Power Outage. The system should return to normal operation without human intervention after a power outage. The system should not output erroneous data when power is restored, and all weather parameters should achieve normal indications or should indicate *missing* within 30 minutes.

(7) Data Archiving. The processor should retain a local record of the automated weather reports, as well as the data entered through the keyboard or via RMM, for use by accident investigators. The interval between archived reports should not be more than 20 minutes, and the report should be retained for at least 96 hours (4 days), i.e., 96 hours of data are archived on a first in, first out sequence. A method should be provided for the local and RMM retrieval of locally archived reports using a removable media, e.g., floppy disk, CD, DVD or similar, or a permanent record, e.g., a hard copy print out. If necessary, the operator should be able to suspend the updates of the archived weather reports to freeze the data until retrieval may be accomplished.

(8) System Constants. The following system constants should be either permanently installed in the processor at the factory or protected from unauthorized or accidental modification so that they may not be changed after initial adjustment at the site without proper authorization from the factory.

(a) Elevation of the pressure sensors (MSL) and the ceilometer (AGL) at the installation site.

(b) Magnetic variation of the installation site to the nearest degree.

(c) AWOS facility identification.

(d) Algorithm constants.

(e) Alert criteria, including site unique criteria. The airport manager or other individual responsible to airport management may change this feature locally.

(f) System and sensor software and firmware revision level identification.

b. Performance Testing. System processing validation tests should be performed in three stages.

(1) Fixed and variable data sets should be provided to exercise the processor over the full range of possible sensor inputs and should include various over range and abruptly changing data to check the data reduction quality control routines. Smaller data subsets should be run with the processing unit operating in extreme environmental conditions.

(2) Analog data sets, or digital data sets if sensor output is digital, corresponding to the digital data in paragraph (1) above should be input at the sensor input ports to verify accurate and correct operation of the data acquisition process.

(3) A full complement of actual sensor devices should be connected to the processor through the data collection unit if part of the design, and driven by actual or simulated weather conditions to verify accurate and correct operation of the entire AWOS unit. The sensors should have passed their individual performance/acceptance tests. Data outputs from the AWOS data processor should meet the same standards of accuracy as have been established for the sensors in their individual parts of this document.

3.19. OPERATOR TERMINAL (OT). The OT should include a video display terminal and keyboard, as well as a microphone and speaker that permit the manual addition of a voice message to the end of the computer generated voice message.

a. Performance Standards.

(1) Product Augmentation. The product augmentation function allows an observer to initiate or change any observation product. A specific editing password should control access to this function. Manual entries of weather phenomena not automatically observed should be placed in the remarks section of the observation. A qualified weather observer should have the capability to:

(a) Prepare a manual observation using the latest known weather parameters.

(b) Manually prepare a corrected observation, either from scratch or by editing a previously disseminated product still accessible in memory.

(c) Turn off report processing for a sensor in case the sensor fails or outputs incorrect data, which in turn places a missing symbol in that field.

(d) Manually edit any observation before release for dissemination by overriding the AWOS parameters, or cancellation of AWOS parameters, addition of new data, or cancellation of the entire product.

(e) Add to the voice message. Typically, the OT should have the capability to manually input a voice message, 30 seconds minimum, to the end of the computer-generated voice message when the AWOS is installed at a nontowered airport. However, when installed at a towered airport, the AWOS should have the capability to manually input a voice message, i.e., weather remarks plus NOTAM information, of at least 90 seconds duration to the end of the computer-generated message.

(2) Security. If an OT is a part of the AWOS system, it should be designed to prevent unauthorized persons from entering data into the system. The system should require the operator to enter a User ID and Password or a successive series of codes prior to allowing him/her to proceed with the entry of data.

(3) Periodic Data Validation. Where an OT is used to modify the weather report, all manually entered data should be automatically time tagged by the system. The data should be valid until the next hourly or manually input observation. In order to retain the manually entered data in the system, the operator should be required to revalidate his/her on-the-hour observation. If no data is to be changed, the operator should be able to accomplish the revalidation using a simple procedure. The data should then be tagged with a new 1-hour limit. If the AWOS is installed at a towered airport and has the capability for input of at least 90 seconds of voice to the end of the weather observation as described in paragraph 3.19.a.(1)(e), the manually entered NOTAM information should not be automatically time tagged by the system. This NOTAM is limited to aviation related information specific to the airport and must not include commercial announcements such as fuel prices, lodging, etc. The NOTAM information is heard on the local voice broadcast, VHF or phone.

b. Performance Testing. The AWOS manufacturer should test the OT to demonstrate that the unit:

- (1) Displays the most current AWOS observation.
- (2) Retrieves archived data.
- (3) Has an editing capability to include rejection of erroneous inputs.
- (4) Should provide maintenance diagnostics data and perform maintenance diagnostics when called for in the system design.
- (5) Has adequate AWOS/OT communications security.
- (6) Has a manual voice entry capability.

3.20. VOICE SUBSYSTEM. The voice subsystem should provide high quality computer-generated speech for output of the AWOS observation. The voice subsystem should also provide the speech for the local ground-air radio broadcast and for telephone dial-up users. An optional feature is the capability for the addition of a manually input, i.e., analog, voice message from the OT at the end of the computer-generated voice message described in paragraph 3.19.a.(1)(e).

a. Performance Standards. The voice subsystem should have the following features.

- (1) The voice output should be a balanced, low-impedance driver providing a minimum of one milliwatt of power into a 600-ohm line. The output amplitude should be adjustable to a nominal 0 dBm output or a nominal minus 13 dBm output. (dBm is the measured power level in decibels)
- (2) The voice message should be output continuously with approximately a 5-second delay between the completion of one message and the beginning of the next.

(3) If the voice message is in process of output when the new AWOS observation is received, the output message should be completed without interruption. Voice transmission of the new AWOS observation should begin upon completion of the next delay time.

(4) The quality, i.e., clarity and phrasing, of the automated speech should provide high intelligibility when broadcasting using telephone and ground-air radio transmitters.

(5) If the voice message is to be broadcast on a discrete, non-Unicom, frequency, the format and sequence of the voice message should be in accordance with the latest edition of Order 7110.10, Flight Services Handbook. This document is available on the Internet at: https://www.faa.gov/regulations_policies/orders_notices/. Use the search box to find the latest edition of 7110.10. If the voice message is to be broadcast on a Unicom frequency, the format and sequence of the voice message should be in accordance with the latest revision of FCC 47 CFR 87.219(b)(1, 2, 3 and 5). When any weather parameter is reported missing or omitted due to a disabled or inoperative sensor, as determined by internal AWOS checks, the voice report should be *(parameter) MISSING*; e.g., *WINDSPEED MISSING*; *CLOUD HEIGHT MISSING*; etc. The UTC time of the observation should be given after the location identification. The word *advisory* should precede all weather information that comes from or is derived from advisory sensors. In accordance with the latest edition of the Aeronautical Information Manual, the word *test* should follow the words *automated weather observation* when the system is not in commissioned status.

(6) If a valid data update of certified sensor data is not received prior to the start of the next voice transmission, the last valid data set received should be used to compose the voice message. Failure to receive an update of certified sensor data for more than 5 minutes should result in the termination of the voice output and the generation of a failure message. In this event, the AWOS should output the message: *(station identification) automated weather observing system temporarily inoperative*.

(7) As an option, the voice system may contain an automatic telephone answering device that should permit user access to the voice message via the public telephone system. The incoming call should be answered prior to completion of the second ring, and the audio signal in progress at the time the call is received should be placed on line. The voice subsystem should automatically disconnect when the weather observation has been completely transmitted twice. Typically, the telephone-answering device should have the capability to answer five calls at a time with no loss of audio signal strength or intelligibility. The minimum requirement is that the system answers a single call.

(8) The voice system should contain a headset/speaker jack for monitoring the voice output.

(9) The voice quality should not be degraded when output on a VOR, NDB, or other NAVAIID.

b. Performance Testing. As a minimum, the manufacturer should demonstrate the following voice unit capabilities.

(1) A capability to generate all combinations of words corresponding to possible AWOS output reports.

(2) The ability to detect communication transmission errors, data loss, and that it should cease voice transmission after loss of updates.

(3) It should respond to dial-up requests for voice data.

(4) It should transmit manually input voice messages at the end of the AWOS observation.

(5) The frequency response of the computer-generated speech, i.e., voice quality, should be compatible with the frequency of the intended transmission medium, i.e., VOR, NDB, VHF radio or telephone.

3.21. AWOS ATIS SWITCH (AAS). There is only one discrete VHF frequency per site to broadcast weather information. A need exists for airports equipped with an ATIS to switch to an automated AWOS broadcast during non-operational hours. An AAS should provide the means to safely switch between the audio from an AWOS or an ATIS to be fed to a single VHF transmitter. A current copy of the complete AAS criteria can be obtained from the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b.

a. Performance Standards. The AAS should have the following features.

(1) The voice output should be a balanced, low-impedance driver providing a minimum of one milliwatt of power into a 600-ohm line. The output amplitude should be adjustable to a nominal 0 dBm output or a nominal minus 13 dBm output.

(2) The AAS should have circuitry or isolation transformers built in so as to not load the sources.

(3) The AAS should have the circuitry built in to adjust the output volume to the VHF transmitter.

(4) The quality (clarity and phrasing) of the automated speech should not be degraded after passing through the AAS.

(5) As an option, the AAS may provide phone line switching between the AWOS message and the ATIS recording.

b. Performance Testing.

(1) The AAS manufacturer should demonstrate that the device does not interfere with the operation of AWOS or ATIS.

(2) The AAS should demonstrate that the aural/audio quality of the output signal is the same as the input aural/audio quality for both the AWOS and the ATIS.

3.22. ELECTROMAGNETIC INTERFERENCE (EMI) PROTECTION. The AWOS should be designed to minimize susceptibility to EMI and operate successfully in the complex electromagnetic environment of an airport. The AWOS should not cause interference to existing systems. Should interference caused by the AWOS occur, the system must be shutdown until the problem is resolved by the owner/installer/manufacture.

3.23. TRANSIENT AND LIGHTNING PROTECTION. AWOS equipment should be protected against damage or operational upset due to lightning-induced surges on all sensor input lines, sensor supply lines, and incoming power and data communications lines as well as audio and keying circuits when transmission of the voice message is provided by other than an integral VHF transmitter. Equipment, including the electrical circuits of fiber optics modems, and personnel should be protected from lightning currents and voltages; from power line transients and surges; and from other electromagnetic fields and charges. AWOS manufacturers are encouraged to design and install lightning protection systems in accordance with this AC, as well as the latest editions of FAA Standard FAA-STD-019, Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment and the Lightning Protection Code, NFPA 780, for all equipment and structures. NFPA 780 may be obtained from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

a. General.

(1) Cone of Protection. All equipment, including antennas, sensors, and obstruction lights that are tower mounted, should be within a maximum 45 degree cone of protection provided by an air terminal. The air terminal should be connected to the earth electrode grounding system. The structure of steel towers may serve the function of down conductors provided the air terminal and grounding cable connections are made as defined herein.

(2) Materials. All materials should be Underwriters Laboratory (UL)-approved for the purpose used, except where specific requirements or exceptions given herein apply. Down conductors should be a soft-drawn stranded, bare copper cable weighing approximately 215 pounds per 1,000 feet. Down conductors should always be routed in a downward direction and bends should have an 8-inch or greater radius. Down conductors should be attached to the tower at approximately 3-foot intervals. Substantial electrical and mechanical connections are required between air terminals and down conductors, and between down conductors and the below grade earth electrode grounding system.

b. Earth Electrode Grounding System. New earth grounding systems should be provided and installed, or existing earth grounding systems should be upgraded as necessary. These grounding systems should consist of driven ground rods or buried plates and buried interconnecting cables. All site grounding conductors should terminate or directly connect to the

earth ground system. Buried cables should interconnect adjacent earth grounding systems within 30 feet of each other. The earth electrode grounding system configurations should depend upon the geological conditions at the site, with very extensive systems justifiable in areas with high soil resistivity and frequent lightning damage. Ground rods should be copper clad steel, UL-approved, 10-foot minimum length, 3/4-inch minimum diameter, pointed end or coupling type, as necessary. Tops of driven rods should be at least 18 inches below grade level. Separation between rods at a site should be at least equal to their driven depth and preferably at twice their depth where space permits. Grounding plates should be 20-gauge minimum sheet copper and at least 2 feet by 2 feet in size. Grounding cables used to interconnect ground rods or plates should be bare copper of the same size as the largest down conductor required for the site. Grounding cables should be installed a minimum of 18 inches below grade level. All steel materials used to anchor guy wires should be interconnected using split bolt connectors and No. 6 AWG bare copper grounding wire. Similar bonding jumpers should be connected around guy wire couplings and fittings. Where driven poles or foundation piers are required to support towers, earth grounding cables should be installed.

c. Grounding. Grounding should be provided to conduct lightning charges, power faults, and unbalanced currents, to eliminate static and electromagnetic charges, and to provide an equal potential reference for the operation of equipment. All metallic structures, enclosures, conduit, cable armor, and conductor shielding should have a direct, identified path to the earth electrode grounding system. The grounding path should be provided by a separate grounding conductor or by bonding metallic structures or enclosures with a separate conductor to the earth electrode grounding system. All grounding conductors should be routed as directly as possible without loops, excess length, or sharp, i.e., less than 8-inch radius, bends. All equipment enclosures, housings, cases, cabinets, and racks should be grounded by an equipment grounding conductor provided and installed in accordance with the latest edition of the National Electrical Code, NEC (NFPA 70), except that conduit and other power circuit enclosures should not be used to serve the purpose. A separate equipment grounding conductor should be provided and installed with each power circuit. The neutral conductors for power circuits should not be grounded in or by any equipment or at any point in the system, except at service entrances as defined by the NEC. At service entrances and at main disconnect circuit breaker boxes serving this purpose, the power neutral conductor and the equipment grounding conductor should be common and connected directly to the earth electrode grounding system. The grounding electrode conductor should be unspliced and routed separately without loops, excess length, or sharp, i.e., less than 8-inch radius, bends. All signals transmitted by interface lines or landlines should be balanced two-wire signal lines or an individual ground return conductor should be routed with each signal line. A third wire may be routed with two-wire signal lines to serve as ground return or reference. The outer conductors for all coaxial, twinaxial, and triaxial cable should be grounded at equipment, antennas, and bulkheads and not isolated at any point.

d. Bonding. Bonding is the mechanical and electrical connection of metal materials, wires, and cables for the low impedance conduction of currents and electromagnetic energy. The effectiveness of lightning protection, transient protection, grounding and shielding depends upon the quality of bonding connections. Therefore, high quality bonding should be designed and implemented into the AWOS and its installations.

e. Shielding. Shielding should be provided to protect equipment and interface lines, i.e., all signal data, control, monitoring, power lines, and cables, from lightning currents and discharges. Shielding should also provide for the containment of interference and signals produced by equipment and to protect susceptible equipment from related environmental signals and interference.

f. Conductor Segregation, Separation, and Routing. The segregation, separation, and routing of all lines, cables, and conductors should be designed by the installer to minimize the coupling of lightning currents, transients, surges, and interference. AC power lines, signal lines, and grounding cables should be segregated and routed separately and not installed in the same trench or conduit. The parallel routing of these types of cables should be avoided and, where necessary, should conform to the latest edition of the NFPA-780 code. To the extent feasible, all crosses should be at right angles.

g. Transient and Surge Suppression. All transients and surge arrestors, circuits, and suppressors required at service entrances to existing buildings and shelters, and components required for the system and equipment should be furnished and installed by the manufacturer.

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Chapter 4. AWOS SYSTEM MAINTENANCE AND OPERATING REQUIREMENTS

4.1. INTRODUCTION. This chapter, along with the information in Chapter 3, provides the FAA's minimum desired and maximum acceptable operating standards, tolerances, and references for a commissioned non-Federal AWOS system. It also provides the minimum checks that should be made and the maximum intervals between checks.

4.2. SYSTEM PERFORMANCE VERIFICATION TESTING. System performance verification testing is accomplished to ensure that the system is meeting its desired performance parameters and assure others that it is doing so.

a. To be able to ensure and assure, the AWOS manufacturer should provide an accurate, reliable system through type certification acceptance procedures and, then, the system owner should maintain the systems by accomplishing valid performance verification checks at sufficient intervals to maintain user confidence in the system's performance.

b. To provide and maintain a system that the user accepts as a source of dependable and reliable information, the system owner, in the presence of a qualified FAA non-Federal inspector, should accomplish valid system performance verification checks and be able to compare the results to National Institute of Standards and Technology (NIST) traceable standards.

c. The FAA recognizes that practical and economic considerations impact the accomplishment of system verification testing, but if compromise is necessary, it needs to be decided on the side of performance assurance and user safety.

d. If additional background information about the FAA's maintenance or preventive maintenance concepts for FAA-owned systems is desired, please refer to the latest editions of FAA Order 6700.20 or Order 6000.15, General Maintenance Handbook for Airway Facilities.

4.3. NON-FEDERAL AWOS STANDARDS, TOLERANCES, AND REFERENCES.

a. Non-Federally owned AWOS systems are not expected to meet tighter tolerances than are required for similar FAA-owned AWOS equipment. FAA-owned meteorological AWOS equipment tolerances are found in the latest edition of FAA Order 6560.13.

b. Table 9 provides non-Federal AWOS standards, tolerances, and references for use during commissioning, annual revalidation and equipment replacement.

c. If a manufacturer has specified and received approval from the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b for tighter tolerances to be met, these will be checked and recorded as found.

d. The tolerances provided in Table 9 should be used to demonstrate that the AWOS meets the minimum commissioning and operating requirements for each parameter. The desired initial tolerances should be used during initial commissioning and whenever a component is replaced. The maximum operating tolerances should be used during annual revalidation.

Table 9. Standards, Tolerances, and References

Check	Reference or Standard	Desired Initial Tolerance	Maximum Operating Tolerance
Obstruction Lights	Visual	All lighted	At least one lit
Mechanical Windspeed – Generator Based (with moving parts)	WS calibrator for WS ref. & bearings	Ref. speed ± 1.5 knots	Ref. speed $\pm 5\%$
Mechanical Windspeed - Tachometer/Beam Splitter Based (with moving parts)	Turns freely	Same as standard	Same as initial
Mechanical Wind Direction (with moving parts)	Align vane with ref. direction benchmark.	± 3 degrees	± 5 degrees
Ultrasonic Windspeed	N/A	Less than 0.5 knots with calibrator	Less than 0.5 knots with calibrator
Ultrasonic Wind Direction	Align with ref. direction benchmark.	± 3 degrees	± 5 degrees
Temperature	Compare with Std.	± 1 degree F	± 2 degrees F
Dew Point	Compare with Std.	± 2 degrees F	± 3 degrees F
Humidity	Compare with Std.	$\pm 2\%$	$\pm 5\%$

Table 9. Standards, Tolerances, and References (Continued)

Check	Reference or Standard	Desired Initial Tolerance	Maximum Operating Tolerance
Day/Night	Manual result	Block optics & see vis distance chg	Block optics & see vis distance chg
Visibility	Vis. Cal. standard ref.	± 3 percent of ref.	± 3 percent of ref.
Tipping Bucket	Manual check	2 tips=2 counts, level bucket	2 tips = 2 counts, level bucket
Ceiling	Manual observation/ PIREP	± 50 ft.	±100 ft.
Barometer	Compare with Std.	± .02 inHg	± .02 inHg
System Clock (Time)	Compare with UTC, GPS or WWV	± 15 sec.	± 45 sec.
VHF Transmitter Frequency	Assigned frequency	± 1 kHz	Same as initial
VHF Transmitter Output Power	2.5 watts	± 0.50 watts	Same as initial
VHF Transmitter Modulation	80%	65% to 95%	Same as initial
VHF Transmitter VSWR (at transmitter)	1.0 : 1	3.0 : 1	Same as initial
UHF Radios (throughout system) Frequency	Assigned frequency	± 2 kHz	Same as initial

Table 9. Standards, Tolerances, and References (Continued)

Check	Reference or Standard	Desired Initial Tolerance	Maximum Operating Tolerance
UHF Radios (throughout system) Output Power	1.0 watt	± 0.25 watt	Same as initial
UHF Radios (throughout system) Frequency Deviation	≤ 3.0 kHz	Same as Standard	Same as Standard
UHF Radios (throughout system) VSWR (at transmitter)	1.0 : 1	3.0 : 1	Same as initial

4.4. MAINTENANCE CHECKS AND SCHEDULES.

a. Minimum Tri-Annual Preventive Maintenance (PM) Checks. The following preventive maintenance checks should be accomplished by the owner's assigned local maintenance technician in accordance with the provider's FAA approved maintenance manual at tri-annual intervals. These checks are limited to cleaning, inspecting, comparing, preventing deterioration and helping ensure reliable operation. They are not intended to include the equipment calibration tasks found in the initial and annual verification checks. Tri-annual PM is scheduled on a 4 month interval and should be accomplished at the time it is scheduled. The maximum tolerance is ± 15 days from the scheduled tri-annual preventive maintenance check. The results of these checks should be recorded in the Facility Maintenance Log.

(1) Visit facility and accomplish a visual inspection to ensure integrity of the AWOS equipment and site location.

(2) Visual check of obstruction lights.

(3) Visually inspect all sensors and AWOS assemblies. Clean all sensors, lenses, and other parts, as needed.

(4) Check all sensors for reasonableness with respect to existing conditions.

(5) Check video display terminal, keyboard, and archiving.

(6) Check system time and reset as needed.

(7) Check AWOS telephone operation.

(8) Aurally check AWOS radio transmission.

(9) Make other checks as necessary or requested by the manufacturer or the FAA to ensure continued reliable operation of the specific system equipment involved.

b. Minimum initial and annual verification checks. The following preventive maintenance checks should be accomplished in accordance with manufacturer's provided and FAA approved maintenance manual by the assigned maintenance technician holding verification authority for the system during initial commissioning checks and on an annual basis. The acceptable tolerances are identified in Table 9. Annual PM is scheduled on a 12 month interval and should be accomplished during the month it is scheduled or, if necessary, during the preceding or following month. The maximum tolerance is ± 31 days from the scheduled annual verification check.

(1) Accomplish all tri-annual preventive maintenance checks identified in paragraph 4.4.a.

(2) Mechanical Wind Direction. Check freedom of movement manually. Record SAT or UNSAT operation.

(3) Mechanical Windspeed. For generator based sensors, check freedom of movement and a reference speed near the mid-to-upper-range of the sensor. Record both the windspeed reference and sensor readings. For tachometer/beam splitter based sensors, check freedom of movement. Record acceptability of movement.

(4) Ultrasonic Windspeed and Direction. Check the manufacturer's defined reference condition of the sensor. Record both the reference and the sensor's readings.

(5) Temperature. Compare against a collocated calibrated standard. Compare and record both the standard temperature reading and the AWOS temperature reading.

(6) Dew point/Humidity. Compare against a collocated calibrated standard. Compare and record both the standard humidity/dew point and the AWOS dew point.

(7) Aspirator Fan (if present). If the fan fails, the temperature and dew point sensor readings should go *missing*. Record SAT or UNSAT operation.

(8) Barometer. Compare the raw pressure sensor readings to a collocated calibrated pressure standard. Compute the standard altimeter reading and compare to the AWOS altimeter reading. Record the standard and the raw sensor readings as well as the altimeter readings. Each raw sensor reading may deviate from the standard reading by the amount allowed in Table 9, and still be within tolerance. However, the raw sensor reading should be adjusted to meet the BP standard. Adjustments of more than the Table 9 tolerance are not allowed. The current adjustment value and the updated cumulative adjustment value for each sensor should be recorded. The maximum cumulative adjustment value allowable over the life of each barometric pressure sensor is 0.10 inHg. The BP sensors should be replaced when any of the raw sensors differ from the standard by more than the allowed tolerance (Table 9) or after the maximum cumulative adjustment value has been exceeded.

(9) Visibility. Compare visibility readings to blocked receiver and calibration device reference readings. Record all readings and references. Check day/night sensor to see if it changes state and actually changes visibility distance indicated.

(10) Heated Tipping Bucket. Ensure sensor is clean and level and number of tips recorded equals number of tips generated. Record number of tips used as a reference and number of tips reported.

(11) Present Weather. Ensure that present weather sensor is operating properly. The only check that can be accomplished is to spray water in the space between the heads and verify that it reports precipitation.

(12) Ceilometer. Check reference target distance if system is designed to enable this check. Reflect transmitted signal back into receiver to check system for minimum ceiling. Record reading seen and reading expected. If needed, blocking the receiver may check the maximum ceiling. In addition, local pilot reports may be used to verify performance.

(13) Remarks Capabilities. Enter test remarks, ensure they are accepted and provided to user, and then delete.

(14) VHF Transmitter Operation. Check frequency, power output, VSWR, percent of modulation, and aural/audio quality.

(15) UHF Transmitter Operation. Check frequency, power output, VSWR, and percent of modulation.

(16) Telephone. Check to ensure it answers on second ring; is clear; provides two complete messages and disconnects; and verify aural/audio quality.

(17) UHF Transmitter/Transceiver (if used). Check frequency, power output, VSWR, percent of modulation, receiver sensitivity, receiver quieting, etc.

(18) Other Sensors. Check other sensors, e.g., freezing rain, runway surface, or thunderstorm, as required.

(19) Other Checks. Make other checks requested by the manufacturer, the owner, or the FAA as required by the specific system. To obtain valid references ensure the readings continue to meet these references.

c. Triennial Verification Checks. The following maintenance checks should be accomplished by the assigned maintenance technician holding verification authority for the system during initial commissioning checks and on a triennial (3 year) basis. Triennial maintenance should be accomplished in accordance with manufacturer's provided and FAA approved maintenance manual during the month it is scheduled or, if necessary, during the preceding or following month. The maximum tolerance is ± 90 days from the scheduled

maintenance event. The results of this maintenance check should be recorded in the Facility Maintenance Log.

(1) Mechanical Wind Direction. Check direction accuracy by holding vane on reference direction mark. Record the wind direction reference and the wind direction reading.

(2) Ultrasonic Wind Direction. Check direction accuracy on reference direction mark. Record the wind direction reference and the wind direction reading.

4.5. REQUESTING EXCEPTIONS TO MINIMUM MAINTENANCE REQUIREMENTS.

a. Manufacturers are encouraged to improve system reliability, accuracy, and verification method testing. A manufacturer may request an exception or variance from an FAA minimum desired maintenance check or interval. The request should include supportive documentation showing performance information obtained during actual field use of the system or sensor. The manufacturer should submit requests and supporting documentation with regard to paragraph 2.4 of this AC to the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b. The FAA may also reevaluate these checks and intervals with respect to actual documented system performance.

b. The FAA's intent is to ensure that dependable AWOS systems are provided for our users. The FAA will strive to issue type certification approval only to systems that meet functional needs and recommend that they be maintained in a manner that will provide user confidence. The FAA encourages cooperation in that endeavor from the manufacturers and system owners.

c. The FAA will review these requests with respect to the actual documented field performance data and, at the same time, with an understanding of and proper regard for system assurance documentation needs. Manufacturers are to understand that it is the FAA's intent to improve system reliability and reduce maintenance costs. Also, the FAA may not be able to approve a request because of the need for the manufacturer to provide recurring system assurance documentation.

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APPENDIX 1. ACRONYMS USED IN THIS ADVISORY CIRCULAR

AAS	AWOS ATIS Switch
AC	Advisory Circular
AIP	Airport Improvement Program
ANSI	American National Standards Institute
ATIS	Automatic Terminal Information Service
AWOS	Automated Weather Observing System
AWPAG	All Weather Precipitation and Accumulation Gauge
CFR	Code of Federal Regulations Part 14 contains the aviation regulations. Part 47 contains the FCC regulations.
CH	Contact Height
dBm	Represents a measured power level in decibels relative to 1 milliwatt
EFAS	Enroute Flight Advisory Service
EMI	Electromagnetic Interference
FAA	Federal Aviation Administration
FC	Foot-Candles
FCC	Federal Communications Commission
FMH-1	Federal Meteorological Handbook No. 1
FMO	Frequency Management Office
FPO	Flight Procedures Office
FRD	Facility Reference Data
FRU	Field Replaceable Unit
FTP or ftp	File Transfer Protocol
GPS	Global Positioning System
GROL	General Radiotelephone Operator License
inHg	Inches of Mercury
LED	Light Emitting Diode
METAR	Aviation Routine Weather Report
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MSL	Mean Sea Level
NAPRS	National Airspace Performance Reporting Service (NAPRS)
NAS	National Airspace System
NAVAID	Navigational Aid
NDB	Nondirectional Radio Beacon
NEC	National Electrical Code
NF Obs	Non-Federal Observer
NFDC	National Flight Data Center
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology

APPENDIX 1. ACRONYMS USED IN THIS ADVISORY CIRCULAR (Continued)

NM or nm	Nautical Mile
Non-Fed	Non-Federal
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board
OCC	Operations Control Center
OJT	On the Job Training
OMM	Operations and Maintenance Manual
OPR	Office of Primary Responsibility
OT	Operator Terminal
PFC	Passenger Facility Charges
PIM	Program Implementation Manager
PIREP	Pilot Report
PM	Performance Maintenance
RMM	Remote Maintenance Monitoring
RMSE	Root Mean Square Error
SM	Scheduled Maintenance
TPR	Technical Performance Record
TS	Thunderstorm
UHF	Ultra High Frequency
UL	Underwriters Laboratories
UTC	Coordinated Universal Time
VHF	Very High Frequency
VSWR	Voltage Standing Wave Ratio
VOR	VHF Omnidirectional Radio Range
VORTAC	VOR Tactical Air Navigation
VV	Vertical Visibility
WMSCR	Weather Message Switching Center Replacement
WS	Windspeed
WWV	National Institute of Standards and Technology Time Standard Radio Station

APPENDIX 2. TECHNICIAN TRAINING

FAA Authorized Maintenance Technician Training Program.

The FAA authorized maintenance technician training program should provide the knowledge and skills needed to service the airport's AWOS system. This program should familiarize the technician with the maintenance and operation of the entire AWOS. The training program may be conducted using a combination of means, including on-site, at the provider's facility, via home study, or by other means proposed by the training provider.

The training program, regardless of its format, should be a planned activity conducted to provide theory of operation, system concepts, safety and NAS coordination procedures, troubleshooting, test equipment usage and hands on practical experience in the work environment where the technician is required to perform his/her duties. On the job training (OJT) is an important bridge from theory-of-operations of a system to developing the requisite skills and knowledge to perform work on the AWOS. (OJT should be performed under the direct supervision of the site's FAA authorized maintenance technician holding verification authority.) Upon successful completion of the training program, the student should receive a document (letter or certificate) recognizing this accomplishment. This document should identify the training organization and/or instructor, the completion date and the system(s) the student has been trained on.

The training program will be evaluated on the organization's/instructor's capabilities and on the course material. The following documents must be submitted to the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b for approval by the FAA.:

- The organization and instructor credentials should demonstrate the necessary knowledge, experience, and backgrounds. These credentials will be evaluated from a technical perspective as well as from an instructor's capability perspective.
- The course materials should include a description of any necessary prerequisites, copies of the syllabus detailing classroom, lab and field/OJT exercises, copies of the materials provided to the student, student tests and a timeline for the course. The discussion of the lab and field/OJT exercises should include details regarding safety procedures to be followed as well as the actual or simulated faults to be used in the training environment. (The training provider is responsible for honoring the system provider's copyright and intellectual property rights.) The tests should consist of two equivalent, comprehensive 50-question open book tests to measure a technician's knowledge of the system, complete with answer sheets. The FAA will use the tests interchangeably to test the competence of a site's technician.

FAA online and academy training resources may be available to augment this training. Additional information can be obtained from the AWOS Non-Federal Engineering Office at the address provided in paragraph 1.3.b.

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