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Federal Aviation Administration

PERFORMANCE SPECIFICATION
DISTANCE MEASURING EQUIPMENT (DME)
TRANSPONDER SYSTEM

FOREWORD

1. This specification is approved for use by all Departments of the Federal Aviation Administration (FAA).

2. This specification defines the minimum requirements for the Distance Measuring Equipment (DME) Transponder System.

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1. INTRODUCTION

1.1 Scope

This specification establishes the performance, design, test, manufacture, and acceptance requirements for solid-state ground station distance measuring equipment (DME) suitable for use in the National Airspace System (NAS) in conjunction with en route and terminal navigation aids. This type of DME is known as DME/N where the "N" stands for narrow spectrum characteristics.

1.2 Overview

The DME System described herein is a radio frequency (RF) transmitter-receiver combination navigation system used for the reception and transmission of information for the purpose of determining the aircraft slant range distance from a ground station. The DME transponder provides distance information and facility identification information to properly equipped users within a defined service volume.

2. APPLICABLE DOCUMENTS

2.1 General

The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification, or recommended for additional information, or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed in this section.

2.2 Government Documents

2.2.1 FAA Specifications, Standards and Handbooks

The following specifications, standards, and handbooks of the exact revision level shown below form a part of this document to the extent specified herein.

FAA-C-1217H, Chg. 2	Electrical Work, Premises Wiring (2023)
FAA-E-3039A	Protocol Specification, Common Message Handling Protocol (CMHP) (2018)
FAA-G-2100J	Electronic Equipment, General Requirements (2022)
FAA-STD-001B	Color and Texture of Finishes for NAS Equipment (1976)
FAA-HF-STD-001B	Human Factors Design Standard (2016)
FAA-STD-019G	Lightning And Surge Protection, Grounding, Bonding And Shielding Requirements For Facilities And Electronic Equipment (2024)
FAA-STD-032	Design Standards for National Airspace System Facilities (1996)
FAA-STD-049	Standard, Fiber Optic Telecommunication, Systems and Equipment (1994)
FAA Order 3900.19D	FAA Occupational Safety and Health Policy (2024)

2.2.2 Other Government Documents, Drawings and Publications

The following other Government documents, drawings, and publications of the exact revision level shown below form a part of this document to the extent specified herein.

MIL-HDBK-454C	General Guidelines for Electronic Equipment (2021)

MIL-STD-461G	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment (2015)
MIL-STD-810H	Test Method Standard, Environmental Engineering Considerations and Laboratory Tests (2019)
MIL-STD-889C	Standard Practice, Dissimilar Metals (2016)
NAS-IC-51015108-01, v0.92	FAA Interface Control Document, Remote Monitoring and Logging System (RMLS) To Remote Monitoring Subsystem (RMS) Using Common Message Handling Protocol (CMHP) (2014)

2.3 Non-Government publications

The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

American National Standards Institute

ANSI Z358.1	American National Standard for Emergency Eyewash and Shower Equipment

(Copies of this document are available online at www.ansi.org)

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

ASHRAE Standard 52.2	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (2020)

(Copies of this document are available online at www.ashrae.org.)

American Society of Mechanical Engineers (ASME)

ASME Y14.44	Reference Designations for Electrical and Electronics Parts and Equipment (2008)

(Copies of this document are available online at www.asme.org)

Electronic Components Industry Association (ECIA)

EIA/ECA-310E	Standard, Cabinets, Racks, Panels and Associated Equipment (2005)

(Copies of this document are available online at www.ecianow.org)

Health Physics Society (HPS)

N2.1-2011	Radiation Symbol (2011)

(Copies of this document are available online at www.hps.org.)

Institute of Electrical and Electronics Engineers (IEEE)

IEEE C62.41.2-2002	IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000 V and Less) AC Power Circuits (2002)
IEEE 519-2014	IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems (2014)
IEEE C95.1-2019	Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz (2019)
IEEE C95.2-2018	Standard for Radio-Frequency Energy and Current-Flow Symbols (2018)
IEEE 149-1979	Test Procedures for Antennas (1979)
IEEE 1100-2005	Recommended Practice for Powering and Grounding Electronic Equipment (2005)

(Copies of these documents are available online at www.ieee.org)

Institute for Printed Circuits (IPC)

IPC-CC-830C	Qualification and Performance of Electrical Insulating Compound for Printed Wiring Assemblies (2018)
IPC J-STD-001H	Requirements for Soldered Electrical and Electronic Assemblies (2020)
IPC-CM-770E	Guidelines for Printed Board Component Mounting (2004)
IPC-SM-780	Component Packaging and Interconnecting with Emphasis on Surface Mounting (1988)
IPC-A-600K	Acceptability of Printed Boards (2020)
IPC-A-610H	Acceptability of Electronic Assemblies (2020)

(Copies of these documents are available online at www.ipc.org)

International Electrotechnical Commission (IEC)

IEC 61000-3-2	International Standard for Electromagnetic Compatibility (EMC) – Part 3-2: Limits for harmonic current emissions (equipment input current ≤ 16 A per phase) (2020)

(Copies of this document are available online at www.iec.ch)

National Electrical Manufacturers Association (NEMA)

NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum) (2020)
NEMA C18.1M, Part 1	American National Standard for Portable Primary Cells and Batteries with Aqueous Electrolyte – General and Specifications (2021)
NEMA C18.1M, Part 2	American National Standard for Portable Primary Cells and Batteries with Aqueous Electrolyte – Safety Standard (2019)
NEMA C18.2M, Part 1	American National Standard for Portable Rechargeable Cell and Batteries – General Specifications (2019)
NEMA C18.2M, Part 2	American National Standard for Portable Rechargeable Cell and Batteries – Safety Standard (2021)
NEMA C18.3M, Part 1	American National Standard for Portable Lithium Primary Cell and Batteries – General Specifications (2019)
NEMA C18.3M, Part 2	American National Standard for Portable Lithium Primary Cell and Batteries – Safety Standard (2021)
NEMA WD 6	Wiring Devices – Dimensional Specifications (2016)
NEMA Z535.1	American National Standard for Safety Colors (2017)
NEMA Z535.2	American National Standard for Environmental and Facility Safety Signs (2017)

(Copies of these documents are available online at www.nema.org)

National Fire Protection Association (NFPA)

NFPA 70	National Electric Code 2020 Edition (2019)

(Copies of this document are available online at www.nfpa.org.)

Underwriters Laboratories Inc. (UL)

UL 268	Standard for Smoke Detectors for Fire Alarm Systems (2016)
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, Edition 13 (2016)

UL 900	Standard for Safety Air Filter Units, Edition 8 (2015)

(Copies of these documents are available online at www.ul.com)

2.4 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General Requirements

3.1.1 System Characteristics

The DME transponder shall:

a. Operate with the DME antenna types described in 3.3 using RF cables up to a maximum length of 500 ft; (See Figure 3-1 for the DME Transponder Block Diagram.)
b. Produce and radiate International Morse Code (Morse Code) identification signals, as described in 3.2.4;
c. Receive and decode interrogation signals (3.2.3.2);
d. In response to interrogation signals, radiate a properly coded reply pulse pair (3.2.6.2) after a specific reply delay time (3.2.6.3); and
e. Produce and radiate random pulse pairs as described in 3.2.3.8.

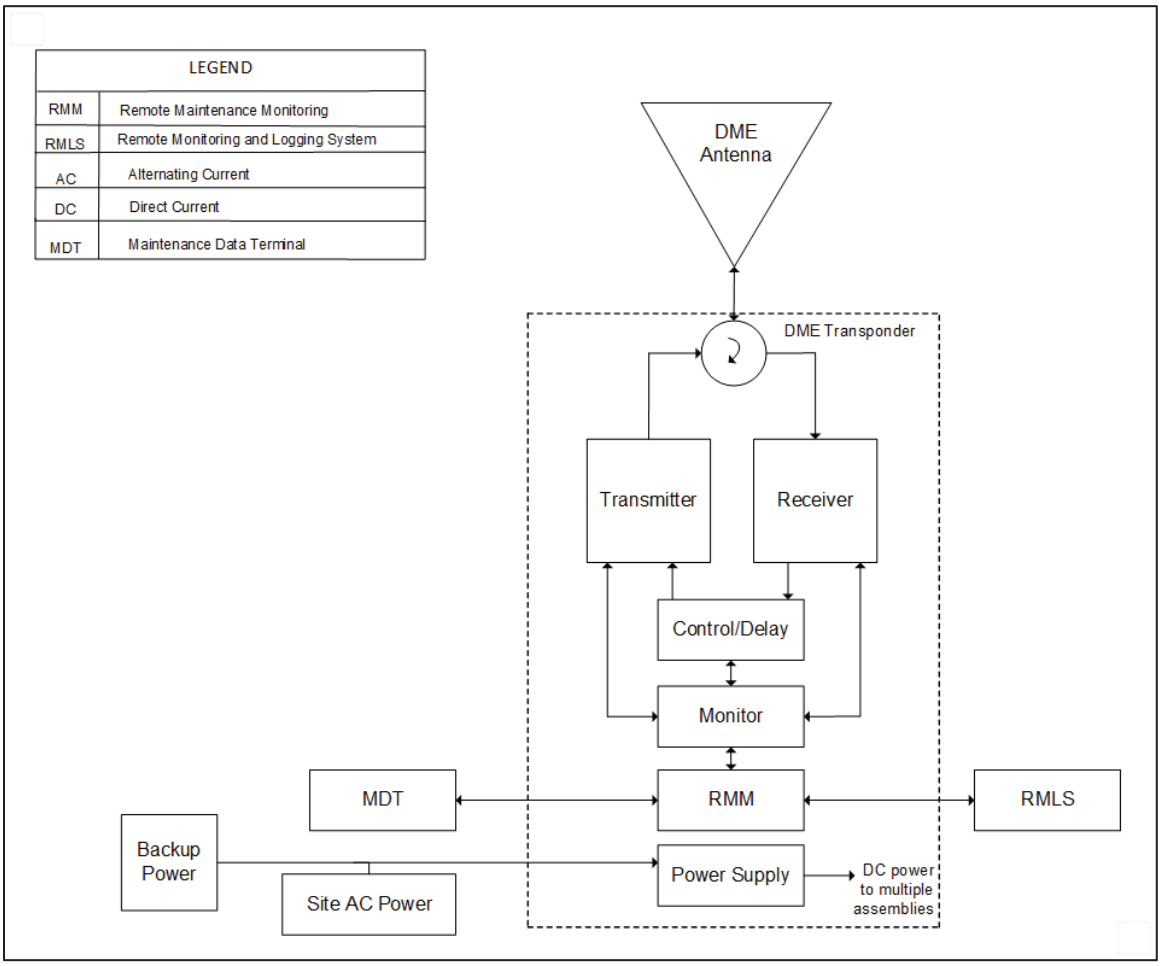

FIGURE 3-1. DME Transponder Block Diagram

3.1.2 Interlock Signal from the Instrument Landing System (ILS)

a. The transponder equipment shall be capable of accepting a dry contact remote interlock signal of up to 35V DC from an ILS localizer.
b. The transponder shall be put in standby (not radiating) when the interlock signal is absent and automatically start operating (radiate) when the signal is present, if otherwise enabled.
c. The logic of the interlock signal shall be selectable high-to-low or low-to-high trigger.

3.1.3 Integrity of Signal

a. The integrity of the signal, expressed as a probability of not transmitting false guidance signals (3.2.5.6), shall be equal to or greater than 0.9999999, which is equivalent to $1 - 10^{-7}$.
b. The implemented system design shall ensure that no single event or failure causes an out-of-tolerance range condition that persists beyond the monitor response time.
c. The implemented system design shall provide mechanisms that prevent unintended changes to parameters that could result in an out-of-tolerance range condition and/or unintended outage.

3.1.4 Assigned Channel Assurance

a. The likelihood of transmitting on an unassigned frequency (±300 kHz or more from the assigned frequency) shall be less than 1×10^{-7}.
b. The implemented system design shall ensure that no single event or failure causes transmission on an unassigned frequency that persists beyond the monitor response time.
c. The implemented system design shall provide mechanisms that prevent unintended changes to parameters that could result in transmission on an unassigned frequency.

3.1.5 Environmental Operating Conditions

Unless otherwise stated, all requirements of this specification shall be met over the full range of service conditions, derived from MIL-STD-810, described below.

3.1.5.1 Non-Operating Conditions

3.1.5.1.1 Non-Operating Temperature Range

The DME System packaged for storage, shipping, or transporting (non-operating) shall withstand a temperature range of -46°C to +71°C.

3.1.5.1.2 Non-Operating Altitude

The DME System packaged for storage, shipping, or transporting (non-operating) shall withstand atmospheric pressure of 575 to 1025 mbar (equivalent to approximately 15 000 ft above sea level in a standard atmosphere down to approximately 300 ft below sea level).

3.1.5.1.3 Vibration

The DME System shall not be damaged when subjected to the vibrations listed in Table 514.8C-I, Method 514.8 Annex C of MIL-STD-810, and the exposure durations provided in Annex C paragraph 2.1.4.

3.1.5.1.4 Shock

The DME System shall not be damaged when subjected to the mechanically induced shock as specified in Method 516.8, Procedure II of MIL-STD-810.

3.1.5.2 Operating Conditions

3.1.5.2.1 Outdoor Temperature

All outdoor equipment shall operate in the temperature range of -46°C to +50°C.

3.1.5.2.2 Indoor Temperature

All indoor equipment shall operate in the temperature range of -10°C to +50°C.

3.1.5.2.3 Rain

All outdoor equipment shall operate while exposed to wind-blown rain, at a rate of 1.7 mm/minute (4 inches/hour), and up to 18 m/s (40 mph) blowing wind.

3.1.5.2.4 Operating Altitude

All indoor and outdoor equipment shall operate over the atmospheric pressure range of 700 to 1025 mbar (equivalent to approximately 10 000 ft above sea level in a standard atmosphere down to approximately 300 ft below sea level).

3.1.5.2.5 Wind Velocity

The DME antenna shall withstand blowing wind conditions up to 100 mph.

3.1.5.2.6 Ice Loading

The DME antenna shall withstand up to 0.5 inches accumulation of clear ice on all outdoor components.

3.1.5.2.7 Humidity

a. Equipment shall operate within a relative humidity range from 5% to 100% when the temperature is 40°C or less.
b. Above 40°C, the equipment shall operate with a relative humidity based upon a dew point of 40°C.

3.1.5.2.8 Fine Sand (Dust)

The DME antenna outdoor equipment shall be impervious to sand and dust intrusion, as described in 4.4.1.2.7.

3.1.5.3 Lightning Protection

The electronic equipment shall be provided with devices that protect against atmospheric electricity and transients from nearby lightning strikes in accordance with FAA-STD-019.

3.1.6 Electromagnetic Interference (EMI) / Electromagnetic Compatibility (EMC)

a. The system shall be successfully tested in accordance with the requirements in 4.4.2.
b. The equipment manufacturer or supplier shall ensure the system meets the requirements of Federal Communication Commission (FCC) Rules and Regulations, Code of Federal Regulations (CFR) Title 47, Chapter 1: Subchapter A, Part 2 and Part 15; and Subchapter D, Part 87.
c. All components of the Remote Maintenance Monitoring (RMM) subsystem and any other computing devices shall meet the requirements for Class A computing devices in accordance with FCC Rules and Regulations, CFR Title 47, Chapter 1, Subchapter A, Part 2, subpart J, (Frequency Allocations and Radio Treaty Matters; General Rules and Regulations).

3.2 Transponder

3.2.1 Operating Channels

a. The system shall operate without modifications within the frequency band from 960 MHz to 1215 MHz.
b. The transponder shall transmit on the reply frequency that corresponds to the assigned DME X channel or Y channel without physical equipment modification or special test equipment. See Appendix A for current channelization.

3.2.1.1 Broadband Operation

Each RF component or device shall be designed to allow DME operation on any selected channel (see Appendix A for current channelization).

3.2.1.2 RF Tuning

a. The transponder shall be capable of operating on any channel assignment within its design range without the need for adjustments or tuning beyond the change of system parameter values.
b. A pre-selector (if used) shall be exempt from the requirement in a. above.

3.2.1.3 Channel Frequency and Stability

a. The transmitted frequency shall not vary more than ±0.001% from the assigned frequency.
b. A sample of the transponder output signal (reply) oscillator source shall be provided on a front panel connector as appropriate with the frequency of operation with a 50-Ω removable termination.
c. For a receiver design with an independent local oscillator source, a sample of the receiver local oscillator signal shall be provided on a front panel connector as appropriate with the frequency of operation with a 50-Ω, removable termination.

d. The output level for the required signals in b. and c. above shall be 0 ±3 dBm.

3.2.2 Duplexer

a. A duplexer shall be provided to permit automatic operation of the receiver and transmitter when connected to the single antenna.
b. The duplexer shall be of the passive type.
c. No adjustment shall be required in order to achieve the performance required for the frequencies listed in Appendix A.

3.2.3 Receiver and Associated Circuitry

All receiver performance requirements in 3.2.3 and associated subparagraphs that pertain to interrogation signals shall be met when the following conditions apply:

a. Any interrogation signals that have any combination of characteristics set forth in 3.4.4.3;
b. When interrogation signals occur from the threshold receiver sensitivity level to not less than -10 dBm as referenced to the transponder antenna transmission line connector, unless otherwise indicated.

3.2.3.1 Receiver Bandwidth and Stability

The minimum permissible bandwidth of the receiver shall be such that the transponder sensitivity level will not change by more than +3 dB (e.g., from -94 dBm to -91 dBm) when the total receiver drift is added to an incoming interrogation frequency drift of ±100 kHz in the opposite direction.

3.2.3.1.1 Receiver Bandwidth

The receiver bandwidth shall be sufficient to allow compliance with the accuracy requirement (3.2.5.6) when the input signals are those specified in 3.4.4.

3.2.3.2 Receiver Decoder

The transponder shall include a decoding circuit such that the decoder will decode and produce reply pulse pairs from interrogation signal pulse pairs occurring at spacings within 12 ±0.5 µs for X channels and 36 ±0.5 µs for Y channels.

3.2.3.2.1 Decoding Circuit Performance

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

3.2.3.2.2 Decoder Rejection Pulse Spacing

a. When the interrogation pulse pair spacing varies from the nominal value by ±1.0 µs or less, and if there is no other interrogation, the threshold sensitivity shall not be reduced by more than 1 dB.
b. An interrogation pulse pair with a spacing of ±2 µs or more from the nominal value, and with any signal level up to the value specified in 3.2.3.6.3, shall be rejected such that the transmission rate does not exceed the value obtained when interrogations are absent.

c. When the spacing differs by ±3 µs or more from the nominal value, the reduction in sensitivity shall be at least 70 dB with respect to 3.2.3.6.

3.2.3.2.3 Decoder Rejection Pulse Width

a. The reduction in sensitivity shall be at least 70 dB for paired pulses with a spacing of 11.5 µs to 12.5 µs for X channels and 35.5 µs to 36.5 µs for Y channels, where either pulse has a width of 0.8 µs or less.
b. The reduction in sensitivity shall be at least 70 dB for single pulses of any width, including widths within 11.5 µs to 12.5 µs for X channels and 35.5 µs to 36.5 µs for Y channels.

3.2.3.3 Receiver Dead Time

a. Each decoded pulse pair (3.2.3.2) shall result in the generation of a dead time interval during which time the transponder will not reply to any other signal at any and all levels up to -10 dBm.
b. The dead time interval shall be adjustable from of 50 µs to 150 µs, in increments of at least 1 µs.
c. The default interval shall be 60 µs.
d. With the exception of the number of receiver noise pulses permitted under 3.2.3.6.4, dead time shall only be generated by received and decoded interrogation pulse pairs.

3.2.3.4 Receiver Recovery Time

a. The recovery time of the receiver and its associated video circuitry shall be such that the threshold sensitivity to desired interrogations is not reduced by more than 1 dB when desired interrogations occur 8 µs and more after the reception of undesired pulses having all levels up to 60 dB above the threshold sensitivity of the receiver in the absence of such undesired pulses.
b. The desired interrogation shall be RF pulse pairs conforming to the requirements defined in 3.4.4.3, 3.4.4.4, and related subparagraphs, and the undesired pulses shall conform to the same requirements, except that the pulse spacing shall be outside the limits of 3.2.3.2 and related subparagraphs (such that dead time is not generated).
c. This requirement (a.) shall be met with echo suppression circuits rendered inoperative.

3.2.3.5 Echo Suppression

3.2.3.5.1 Short Distance Echoes

a. Synchronous pulse signals occurring between the pulse pair of the direct-path interrogation and superimposed on either the leading or trailing edge of the second pulse of direct-path interrogation shall not affect the time of decoding for the direct-path interrogation by an amount in excess of 0.15 µs.
b. The presence of such synchronous pulse signals shall not cause the reply efficiency to be reduced by more than 10% from that measured in the absence of the pulse signals.
c. These requirements (a., b.) shall be met when the RF input signal level of the direct-path pulse pair has any level from 10 dB above the sensitivity threshold triggering level to an

absolute level of -10 dBm, and the echo pulse has any level up to the level of the direct-path pulse pair and for all direct-path pulse pair spacings of 3.2.6.2.

3.2.3.5.2 Long Distance Echoes

a. Continuous wave (CW) suppression and echo suppression shall be provided for interrogations having echoes that are delayed with respect to the direct-path interrogation in excess of the receiver dead time setting.
b. The decoding of a direct-path interrogation pulse pair shall trigger echo suppression whenever the level of the direct-path pulse pairs exceeds a pre-established level (i.e., triggering level).
c. The echo suppression function includes the following:
    1. The triggering level shall be adjustable to any level between -80 dBm and -10 dBm;
    2. The nominal trigger level setting shall be -70 dBm;
    3. Triggering shall result in a receiver desensitization period that starts at the time of the pulse decoding and remains active for the duration of the echo suppression period;
    4. The duration of the receiver desensitization period shall be adjustable from 50 µs through 350 µs;
    5. The duration of the desensitization shall be nominally set at 150 µs;
    6. The degree of receiver desensitization (i.e., threshold triggering level) shall be 3.0 ±1 dB above the level of the decoded direct-path pulses and remain active for the duration of the receiver desensitization period, unless retriggered pursuant to the specifications given in items 8. and 9. below;
    7. The dynamic range of the receiver threshold triggering level shall be capable of providing the degree of desensitization specified in item 6. above for signal levels at the minimum triggering level to -10 dBm;
    8. When enabled, the echo suppression function shall be retriggered whenever a pulse pair, with a signal level that exceeds the current threshold triggering level, is decoded; and
    9. When the echo suppression is retriggered, the receiver threshold triggering level shall be re-adjusted to a level 3.0 ±1 dB above the level of the newly decoded pulses and remain for the duration of the echo suppression period unless retriggered by a signal stronger by 0 dB to 6 dB than the direct path signal and over a range of input signal from 10 dB above threshold triggering level to -10 dBm.

Note: In this context, echoes are undesired signals caused by electromagnetic scattering of the interrogator signal (e.g., multipath transmission, reflections).

3.2.3.5.3 Echo Suppression Disable

a. The long and short echo suppression features shall be individually selectable as enabled or disabled.
b. When the transponder is in normal operation, the long and short echo suppression shall be disabled for the duration of the monitor generated interrogation pulse pair.

c. The feature in b. above shall be selectable as required for echo suppression testing.

3.2.3.5.4 Traffic Load Monitoring

Outputs shall be provided for local and remote monitoring of the total number of decoded pulse pairs per second (ppps) and the number of receiver desensitization periods triggered per second.

3.2.3.6 Receiver Sensitivity

a. In the absence of all interrogation pulse pairs, except for those necessary to perform the sensitivity measurement, interrogation pulse pairs with the correct spacing and nominal frequency shall trigger the transponder if the input level is at least -94 dBm.
b. The measurements shall be referenced to the exterior cabinet connector to which the transmission line to the antenna is connected.
c. The receiver sensitivity for a reply efficiency of 70% shall be in accordance with the following subparagraphs.

3.2.3.6.1 On-Channel Sensitivity

a. For interrogation signals having a repetition rate of 30 ppps and having spacings of the constituent pulses of a pair anywhere within the limits specified in 3.2.3.2 and related subparagraphs, the receiver sensitivity in the absence of other interrogations, and with a dead time setting of 60 µs, shall be -94 dBm or better (i.e., the receiver threshold triggering level shall be -94 dBm or lower).
b. The requirement above (a.) shall be met when the Automatic Gain Reduction (AGR) (3.2.3.9) and long and short echo suppression are disabled.
c. Once set, sensitivity shall be stable within ±1.0 dB (±2.0 dB over the operational service conditions).

3.2.3.6.1.1 Sensitivity Variation with Interrogation Loading

The transponder sensitivity level shall not vary by more than ±1 dB from the value measured in 3.2.3.6.1 for transponder loading between 0% and 90% of its maximum transmission rate, with the echo suppression circuits and AGR disabled.

3.2.3.6.1.2 Desensitization by Adjacent Channel Interrogation

a. The presence of interrogation signals at ±900 kHz (adjacent channel) from the on-channel frequency which have pulse coding corresponding to that for the on-channel frequency and which occur at rates up to 1000 ppps shall not reduce the on-channel threshold sensitivity by more than 1 dB.
b. The requirement in a. above shall be met when the adjacent channel signals have levels up to -10 dBm.

3.2.3.6.1.3 Desensitization by Continuous Wave (CW)

a. The presence of a CW interference signal on the assigned channel frequency or elsewhere within the receiver passband shall not reduce the on-channel threshold sensitivity by more

than 2 dB when the level of the CW is 10 dB or more below the on-channel sensitivity level.

b. This requirement (a.) shall be met for all settings of the receiver transmission rate control which result in receiver noise decodes at a rate of no greater than 10 per second.

c. Additionally, within the range of the receiver desensitization provided by AGR, the reply efficiency to a single interrogator shall not be reduced by more than 10% when the interrogation signal level is equal to or greater than 6 dB above the level of the interfering CW signal.

3.2.3.6.1.4 Desensitization by High Repetition Rate/High Duty Cycle Pulse Signals

In the presence of an input signal with a pulse width of 8 µs where the pulse rate is 30% of the transmitter duty cycle (37 000 pulses per second) and having a peak level equal to the CW level specified in 3.2.3.6.1.3-a (i.e., 10 dB below the on-channel threshold triggering level measured in the absence of interference), the maximum reduction in receiver sensitivity and reply efficiency shall not exceed 0.5 dB and 3%, respectively.

3.2.3.6.2 Sensitivity to Adjacent Channel Interrogations

Signals ±900 kHz or greater removed from the assigned channel nominal frequency and having signal levels up to -10 dBm shall not trigger the transponder.

3.2.3.6.3 Dynamic Range

a. The performance of the transponder shall be maintained when the power of the interrogation signal at the equipment cabinet has any value between -94 dBm and -10 dBm.

b. The equipment shall not be damaged by input pulse signals at the cabinet connector of up to +20 dBm on any frequency from 960 MHz to 1215 MHz.

3.2.3.6.4 Noise-Generated Pulse Pairs

When the receiver is interrogated at -94 dBm, with the AGR circuits disabled, and at a rate to produce a transmission rate equal to 90% of the maximum, the noise-generated pulse pairs shall not exceed 5% of the maximum transmission rate.

3.2.3.7 Interference Suppression

a. Signals complying with 3.2.6.2 arriving at the intermediate frequency shall be suppressed at least 80 dB.

b. Except for the passband frequencies provided to achieve the performance required for on-channel and adjacent channel interrogation signals, and to comply with the requirements of paragraph 3.2.3.1, all other signals within the 960 MHz to 1215 MHz band, and at image frequencies, shall be suppressed by 75 dB or more.

3.2.3.8 Squitter

3.2.3.8.1 Random Squitter Pulse Pairs

a. The transmitter shall provide squitter with a nominal rate, adjustable from the Maintenance Data Terminal (MDT) from 0 ppps to at least 850 ppps.
b. The squitter pulses shall be coded in accordance with 3.2.6.2.
c. The minimum spacing between adjacent squitter pulse pairs shall be 60 µs.

3.2.3.8.2 Squitter Operation

a. Except during transponder identification transmissions, the transmitter shall operate at a transmission rate of not less than 700 ppps, including squitter pulse pairs and distance reply pulse pairs.
b. In the absence of valid interrogations, the squitter transmission rate shall be 700 ppps to 850 ppps.

Note: The minimum transmission rate should be as close as practicable to 700 ppps.

3.2.3.8.3 Squitter Decoding

a. The interrogation signal decoder shall not decode squitter pulse pairs from the squitter pulse generator.
b. Squitter pulse pairs shall not prevent the transponder from replying to interrogation signals, as long as the reply delay in Y channel operation is a minimum of 50 µs.

3.2.3.8.4 Effect of Traffic Loading

a. The squitter pulse generator shall produce the number of squitter ppps such that the total of squitter ppps plus the receiver decodes per second is within 700 ppps to 850 ppps.
b. The squitter pulse generator shall provide no output for all interrogation rates resulting in excess of 850 receiver decodes per second.

3.2.3.8.5 Priority of Reply Pulses

a. Whenever triggers due to squitters occur prior to triggers due to decodes at the input of the priority gating circuits, the squitter triggers shall be inhibited for all spacings between triggers of 25 µs or less in X mode and 10 µs or less in Y mode.
b. The requirement above (a.) shall apply to reply delay settings of 50 µs and greater.
c. Whenever triggers due to decodes occur prior to squitter triggers, the squitter triggers shall be inhibited for all spacings of 25 µs or less for X mode and 65 µs or less for Y mode.

3.2.3.9 Automatic Gain Reduction (AGR)

3.2.3.9.1 Gain Reduction Operation

a. When transponder loading exceeds 90% of the maximum transmission rate (3.2.5.1), the receiver sensitivity shall automatically reduce in increments of 10 dB or less to limit transponder replies, to ensure that the maximum permissible transmission rate is not exceeded.

b. The available range of sensitivity reduction shall be from 0 dB to at least 50 dB.
c. When transponder loading is subsequently reduced to less than 90%, the receiver sensitivity shall return to normal operation (0 dB reduction) within 5 s.

3.2.3.9.2 Interrogation Overload Signal

A signal shall be provided to the monitor to prevent receiver sensitivity alarms when sensitivity has been reduced by AGR operation.

3.2.3.10 Priority of Transmission

a. The transmission of transponder output signal pulses shall conform to the following order of precedence:
    1. Identification pulse groups;
    2. Distance reply pulse pairs; and
    3. Squitter pulse pairs.
b. The transponder shall not transmit distance reply or squitter pulse pairs during the transmission (key down) of the identification signal pulse groups.

3.2.4 Identification Signals and Keying

3.2.4.1 Identification Signal

a. The identification signal shall consist of pulse pairs transmitted at a repetition rate of 1350 ±5 Hz.
b. The identification signal pulses and pulse pairs shall conform to 3.2.6.1 and 3.2.6.2.

3.2.4.2 Identification Keying Source

a. When normal identification keying is enabled, the transponder shall transmit identification signals when keyed by either the VHF facility (associated) or the internal (independent) identification keyer.
b. The DME independent keyer shall key at least once every 40 s.

3.2.4.3 Independent Identification Signal Characteristics

a. The identification signal shall consist of the transmission of the code in dots and dashes (Morse Code).
b. Reply pulses shall only be transmitted between key down times.
c. The maximum key down time shall not exceed 5 s per identification code group.
d. The dots shall have a time duration of 0.1 to 0.160 s.
e. The dashes shall be three times the duration of the dots ±10%.
f. The duration between dots and/or dashes shall be equal to that of one dot ±10%.
g. The time duration between letters shall not be less than three dots.
h. The total period for transmission of an identification code group shall not exceed 10 s.

3.2.4.4 Associated Identification Signal Characteristics

a. When associated with a VHF facility, the identification shall be transmitted synchronously with the VHF facility identification keying signal using Morse Code as stated above (3.2.4.3).
b. For keying from an associated VHF facility, an isolated solid state relay input with the following characteristics shall be provided:
    1. A two-wire input;
    2. Compatible with a driver having an output resistance of less than 250 Ω;
    3. Compatible with a driver capable of sinking a current of 20 mA; and
    4. Capable of withstanding an open circuit voltage of 50 VDC or greater.
c. The DME transponder shall start transmission of the transponder identification when the start of keying is detected at the DME keying input from the associated VHF facility or from the remote localizer keying signal (e.).
d. The DME transponder shall recognize either a Morse Code synchronization signal or the associated VHF facility keying (dots and dashes) as the source for the start of internal keying.
e. The DME transponder shall accept an additional keying signal controlled by a remote ILS localizer at the opposite end of the runway which itself transmits a different Morse Code identification signal.
f. There shall be a control that will cause the DME transponder to:
    1. Switch to internal keying upon loss or malfunction of the keying signal from associated VHF facility (if enabled);
    2. Resume normal operation when the keying signal from the associated VHF facility resumes (if enabled); and
    3. Switch keying signal and identification code from the colocated ILS localizer to an ILS localizer located at the opposite end of the runway.

3.2.4.5 Identification Keying Control

The transponder shall provide controls to:

a. Enable/disable identification keying;
b. Enable/disable external keying source;
c. Select external Morse Code synchronization signal or VHF Facility keying source;
d. Enable/disable inversion of external keying source polarity;
e. Enable/disable continuous transmission of identification signal pulse groups;
f. Select three alphanumeric Morse Code characters in normal operation;
g. Select a mode in which the identification code is automatically set to “T-E-S-T;” and
h. Automatically generate a maintenance alert when the identification code is selected as “T-E-S-T.”

3.2.5 Transmitter and Associated Circuitry

3.2.5.1 Transmission Rate

a. The transmitter shall be capable of a transmission rate of at least 4800 ppps.
b. The system shall provide an adjustable control to set the maximum transmission rate, from at least 2000 ppps to the maximum rate.

3.2.5.2 Tuning and Spurious Output

a. Spurious output or parasitic oscillations shall be at least 40 dB below the peak on-channel final output signal, for any combination of non-factory tuning control positions in any transponder amplifier stage, set to either normal or reduced power conditions (3.2.5.4.2).
b. To ensure Hazardously Misleading Information (HMI) is not radiated by the antenna, spurious output or parasitic oscillations shall be no more than -100 dBm as measured at the coaxial cable connector that provides the feed to the antenna.

NOTE: The requirement above (b.) refers to the maximum signal at the output of the transmitter cabinet when the system is in any other mode but operational (i.e., on air).

3.2.5.3 Transponder Power Output

a. The transponder shall be able to be set such that the output power can be one of two preset levels.
b. The nominal preset levels shall be 100 W (Low Power DME) and 1000 W (High Power DME), as measured at the output of the equipment cabinet when terminated into a 50-Ω load.

3.2.5.4 RF Output Power Control

The transmitter shall require no mechanical/hardware change to operate in the specified settings.

3.2.5.4.1 Initial Setting

Means shall be provided to permit setting the RF output power to within ±5% of the nominal preset levels in 3.2.5.3.

3.2.5.4.2 Test Setting

a. The range of adjustment shall be 0 dB to -4 dB from the initial level, in 0.25 dB steps.
b. Transponder output signal requirements in 3.2.6.1 and 3.2.6.2 shall be met throughout the range of power output levels without the need for readjustment of any other controls.

3.2.5.5 Reply Delay Values and Adjustments

Controls shall be provided to set the nominal reply delay time within 0.0625 µs of any desired value between the limits of 44 µs to 56 µs for X channels, or 50 µs to 62 µs for Y channels.

3.2.5.6 Accuracy

The transponder shall not contribute more than ±0.5 µs (75 m (250 ft)) to the overall system error.

3.2.6 Transponder Output Signals

3.2.6.1 Pulse Shape

The modulated RF signal envelope of each pulse shall meet the following requirements when measured using a linear detector.

3.2.6.1.1 Rise Time

Pulse rise time shall be 2.5 +0.5/-1.0 µs.

3.2.6.1.2 Pulse Top

The instantaneous voltage amplitude within the pulse top shall not fall below the 95% value of maximum amplitude of the pulse.

3.2.6.1.3 Pulse Width

Pulse width shall be 3.5 ±0.5 µs.

3.2.6.1.4 Decay Time

Pulse decay time shall be 2.5 +0.5/-1.0 µs.

3.2.6.2 Pulse Coding

Pulses shall be coded in pairs with a spacing of 12 ±0.25 µs for X channels or 30 ±0.25 µs for Y channels.

3.2.6.3 Delay Time Variation

Reply delay time variation shall not exceed the following:

a. ±0.25 µs over the range of service conditions with an input signal level having any value between -94 dBm and -79 dBm with an interrogation pulse rise time of 2.5 ±0.5 µs;
b. ±0.10 µs over the range of service conditions with an input signal level having any value between -79 dBm and -10 dBm with an interrogation pulse rise time of 0.10 ±0.10 µs;
c. A total variation of 0.10 µs with an input signal level of -60 dBm with variation interrogation pulse rise time within 0.20 µs to 3.0 µs;
d. A total variation of 0.10 µs with an input signal level of -60 dBm with a variation in interrogation pulse rate frequency from 2500 ppps through the maximum transmission rate with an interrogation pulse rise time of 0.10 ±0.10 µs.

3.2.6.4 Pulse Power Variation

a. The peak power of the constituent pulses of any pair of pulses shall not differ by more than 1 dB.
b. Amplitude modulation of the output pulse train shall not exceed 5%.

3.2.6.5 RF Pulse Signal Spectrum

a. The effective radiated power (4.4.9) of the pulse modulated signal contained in a 0.5 MHz band centered on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel

frequency in each case shall not exceed 200 mW when the transmitter output power is set to 1000 W.

b. The effective radiated power contained in a 0.5 MHz band centered on frequencies 2 MHz above and 2 MHz below the nominal channel frequency in each case shall not exceed 2 mW when the transmitter output power is set to 1000 W.
c. The effective radiated power (4.4.9) contained within any 0.5 MHz band shall decrease monotonically as the band center frequency moves away from the nominal channel frequency.

3.2.6.6 Out-of-Band Spurious Radiation

a. At all frequencies from 10 MHz to 1800 MHz, but excluding the band of frequencies from 960 MHz to 1215 MHz, the spurious output of the transponder transmitter shall not exceed -50 dBm in any one kHz of receiver bandwidth.
f. The equivalent isotropic radiated power (4.4.9) of any CW harmonic of the carrier frequency on any operating channel shall not exceed 20 dBm.

3.2.6.7 Inter-Pulse Output Level

a. During the interval between occurrences of the desired pulse pairs, the RF output level shall not exceed a level that is 80 dB below the maximum power level during the pulse.
b. Between the pulses of each pair, there shall be an interval of 1.0 µs or greater length during which the RF output level does not exceed a level that is 80 dB below the maximum power level of each pulse.

3.2.6.8 Retriggering of Transponder

The transponder shall include a decoding circuit such that the transponder can be triggered only by pairs of received pulses having pulse spacings appropriate to interrogator signals as described in 3.4.4.4 and having pulse widths as described in 3.4.4.3.3.

Note: The specific requirements for rejecting invalid pulse spacing and pulse width are addressed in 3.2.3.2.2 and 3.2.3.2.3, respectively.

3.2.7 Stabilization of Performance Characteristics

After one minute of power being applied to the transponder, and within 6 s of being switched to operational mode:

a. The transmitter output power shall be at least 90% of the nominal output, and
b. The following Primary and Secondary alarm parameters shall be within tolerance:
    1. Reply delay (3.4.5.2.3);
    2. Reply efficiency (3.4.5.2.6);
    3. Transponder Pulse Spacing (3.4.5.2.4);
    4. Transponder Pulse Rate (3.4.5.2.5);
    5. Radiated power level (3.4.5.2.8);
    6. Transponder Power Output (3.4.5.2.7);
    7. Receiver and Transmitter Frequency (3.4.5.2.10).

3.2.8 Duty Cycle Overload Protection

A means shall be provided to protect the transponder amplifier components from damage due to the effects of output duty cycles that exceed the ratings of those components.

3.2.9 Thermal Overload Protection

a. A means shall be provided to protect the equipment against operating above its thermal design limits.
b. Once the equipment has returned to a safe operating temperature, the system shall automatically be available for normal operation (i.e., ready for an automatic restart attempt as stated in 3.5.7).

3.2.10 Performance Upon Fault Condition of RF Equipment Output Circuit

a. All equipment output circuits shall be designed to include circuit protection and prevent damage to equipment upon occurrences of opens or shorts on the output terminals.
b. When operated at any voltage standing wave ratio (VSWR), including open and short conditions, the transponder output circuitry shall not be damaged or exceed dissipation limits.
c. The transponder shall shut itself down upon detection of a high VSWR.

3.3 Antenna

3.3.1 Antenna Types

The DME transponder shall operate with any one of the following types of DME antennas:

a. Standard omni-directional;
b. Uptilt omni-directional;
c. Bi-directional; or,
d. Uni-directional.

3.3.2 Frequency Range

The antenna shall operate within the frequency band of 960 MHz to 1215 MHz without the need for tuning or adjustment.

3.3.3 Polarization

The predominant energy radiated by the antenna shall be vertically polarized.

3.3.4 Characteristic Impedance and VSWR

a. The antenna shall have a characteristic impedance of 50 Ω.
b. The VSWR for omni-directional and bi-directional type antennas shall not be greater than 2:1 over the frequency band.
g. The VSWR for uni-directional type antennas shall not be greater than 2.5:1 over the frequency band.

3.3.5 Antenna Gain

h. The gain at the maximum power point of the vertical pattern for omni-directional antennas shall not be less than 8.0 dBi at all azimuths.

a. The gain at the maximum power point of the vertical pattern within the 3-dB beam width(s) for uni-directional and bi-directional antennas shall be at least 8.0 dBi.

3.3.6 Vertical Pattern

a. The standard and uptilt omni-directional antenna types shall comply with the following vertical radiation patterns, except as specified in 2. and 3. below, at all azimuths.

b. The uni-directional and bi-directional antennas shall comply with the following vertical radiation patterns, except as specified in 3. below, in the region between the half power beam widths (HPBW).

c. The radiation pattern of the antenna in the vertical plane:

    1. Shall have a lobe of energy at least 5 degrees wide at the half-power points, -3 dB (0.707 Volts);
    2. Shall have the vertical angle of maximum radiated energy between 2.0 degrees and 5.0 degrees above the horizon for the standard omni-directional, uni-directional, and bi-directional antenna types;
    3. Shall have the vertical angle of maximum radiated energy between 5.0 degrees and 9.0 degrees above the horizon for the uptilt omni-directional antenna type;
    4. Shall have a gain on the horizon of at least 2 dBi;
    5. Shall have a signal level rate of change greater than or equal to 0.10 V/V/degree from 1.0 degree below the horizon to 1.0 degree above the horizon, when the vertical pattern data is normalized to 1.0 V at the horizon;
    6. Shall have relative gain at angles between 6 and 60 degrees below the horizon lower than the relative gain at the peak of the major lobe above the horizon by at least 14 dB (0.2 Volts);
    7. Shall have relative gain at angles between 6 and 15 degrees above the horizon greater than a level that is 14 dB (0.2 Volts) below relative gain at the peak of the major lobe above the horizon;
    8. Shall have relative gain at angles between 15 and 40 degrees above the horizon greater than a level that is 20 dB (0.1 Volts) below relative gain at the peak of the major lobe above the horizon; and
    9. Shall have relative gain at angles between 40 and 60 degrees above the horizon greater than a level that is 30 dB (0.032 Volts) below relative gain at the peak of the major lobe above the horizon.

Note: These requirements are illustrated in Figure 3-2 along with a hypothetical standard omni-directional vertical radiation pattern.

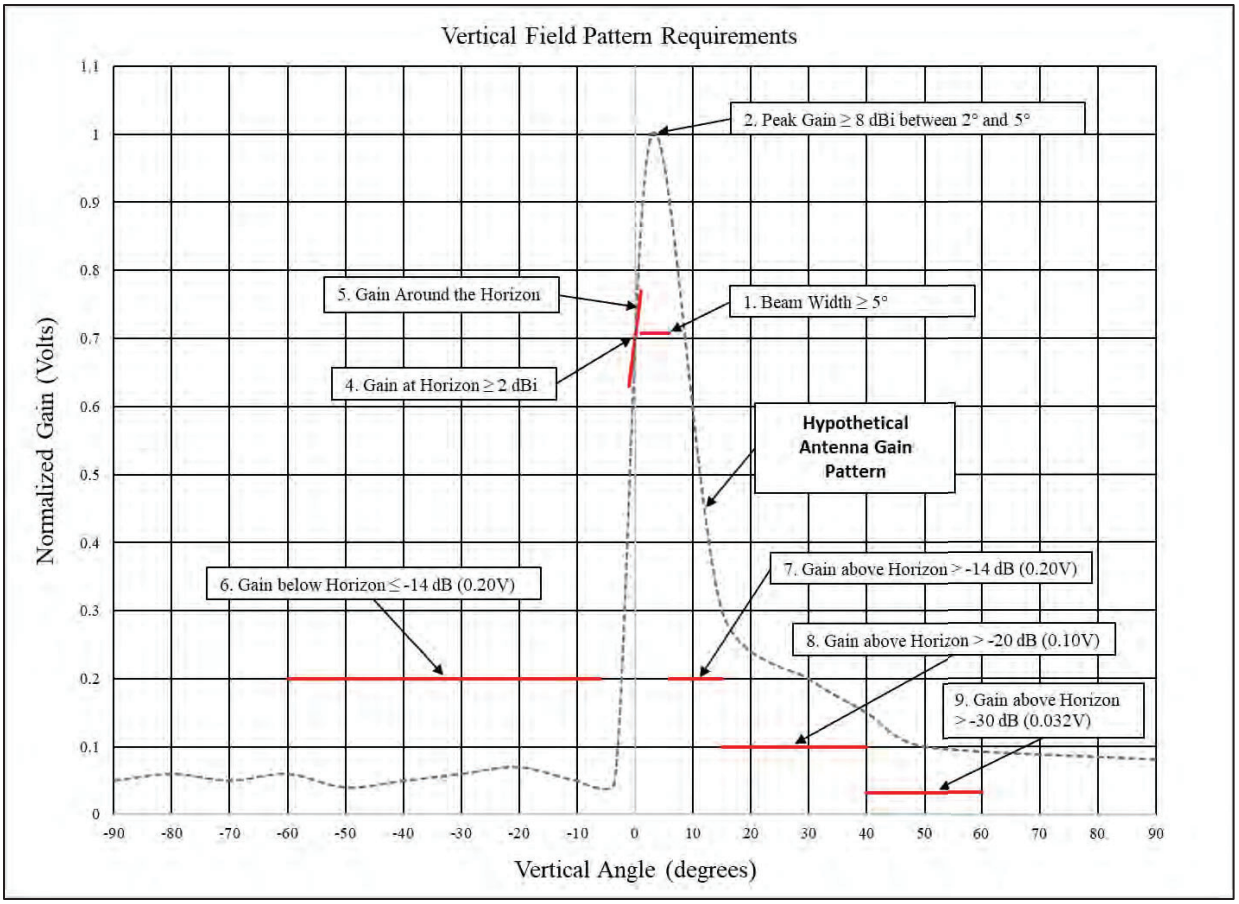

FIGURE 3-2. Application of Limits to a Vertical Field Pattern for a DME Antenna

3.3.7 Horizontal Pattern

3.3.7.1 Omni-Directional Type

The circularity shall not exceed ±1 dB.

3.3.7.2 Uni-Directional Type

a. The HPBW shall be 45 degrees or greater.
b. The ratio of the maximum gain to the minimum gain (front-to-back ratio) shall be 10 dB or greater.
c. The pattern ripple within the HPBW shall not exceed ±1 dB.

3.3.7.3 Bi-Directional Type

a. The HPBWs of each major lobe shall be 45 degrees or greater.
b. The ratio of the maximum gain of each major lobe to the minimum gain of each major null shall be 10 dB or greater.
c. The pattern ripple within each HPBW shall not exceed ±1 dB.

3.3.8 Radome and Weatherproofing

a. The radome shall be smooth to minimize wind loading and the accumulation of water, snow, and ice.
b. The entire antenna assembly including cable connectors shall be effectively sealed (weatherproofed) in such a manner as to permit removal and replacement of the radome without the necessity of sealing compounds to prevent the entrance of foreign matter.
c. The major lobe centerline(s) shall be permanently identified on the radome of directional antennas with a clearly visible orientation mark located near the base of the antenna.

3.3.9 Antenna Mount

a. The configuration of the antenna base shall be such that the antenna may be mounted directly, or indirectly, through use of an adapter furnished with each antenna, to a four-inch outside diameter steel pipe.
b. The mounting fixture shall engage not less than six inches of the pipe.
c. The mounting fixture shall include clamping screws and locknuts for securing the fixture to the pipe.
d. The design shall provide unobstructed access to all connectors.

3.3.10 Monitor Probes

a. Two coupling probes for monitoring the signal radiated by the antenna shall be provided within the antenna radome.
b. Each coupling probe shall be provided with a 50-Ω resistive load at the weatherproofed coaxial connector at the base of the antenna.
c. The RF coupling factor for each probe shall be 25 ± 2 dB.
d. The coupling factor for each probe shall not vary by more than 1.0 dB over the range of operating conditions specified in 3.1.5.2 at a specific frequency.

3.3.11 Antenna Cables

a. The cables used to connect the DME antenna to the DME System shall have a 50-Ω characteristic impedance.
b. The transmitter output cable shall have a signal attenuation of no more than 3 dB/100ft for the frequency range of 960 MHz to 1215 MHz.
c. The monitor return cable shall have a signal attenuation of no more than 7 dB/100ft for the frequency range of 960 MHz to 1215 MHz.

3.3.12 Obstruction Lights

All DME antenna types shall accommodate the mounting, power, and grounding of an obstruction light fixture on the top of the radome.

3.3.13 Power Handling

All DME antenna types shall be capable of handling DME signals with an instantaneous output power up to 2000 watts and an average power of 80 watts (4% duty cycle).

3.3.14 Grounding

The antenna shall be provided with grounding termination lug(s) on the antenna mounting base flange, in accordance with the Bolted Connections paragraphs, and Bonding paragraphs of FAA-STD-019.

3.4 Monitor

a. The monitor shall accept RF signals from the DME monitor antenna probes, transmission line directional coupler, and simulated DME signals from built-in test equipment.
b. The monitor shall provide for executive monitoring of the DME System as specified below.
c. The monitor shall not affect or interrupt the DME service, except as stated in g. below.
d. The monitor shall provide for self-testing of monitor alarm limits through the use of built-in test equipment internal to the monitor.
e. The capability of the monitor to detect and respond to HMI shall not be affected by the failure of other system functions.
f. The monitor shall indicate whether the measured signals (3.4.5.2) are within, or exceed, established alarm limits.
g. The monitor shall initiate an alarm action when the established alarm limits are exceeded, as specified in 3.4.5.1.

Note: In the event that more than one independent monitor is used, the requirements in this Section (3.4) apply to each independent monitor.

3.4.1 Operating Channels

a. The monitor shall provide the specified performance on each of the channels and modes (X or Y) listed in Appendix A, by means of a frequency synthesizer.
b. In addition to providing an output on the assigned channel interrogation frequency for the Interrogation Signal Generator (3.4.4), the frequency synthesizer shall also provide for outputs of ± 200 kHz and ± 900 kHz removed from the assigned channel interrogation frequency for test purposes.
c. A sample of the Interrogation Signal Generator oscillator output shall be provided at the front of the equipment via a connector as appropriate with the frequency of operation with a 50-Ω, removable termination.
d. The output level for the connector above (c.) shall be 0 ±3 dBm.

3.4.1.1 Broadband Operation

One single design shall be utilized for each RF device to cover operation on any selected channel.

3.4.1.2 RF Tuning

Each RF device shall be capable of operating on any channel assignment without the need for retuning.

3.4.1.3 Frequency Stability

Over the range of specified service conditions, the frequency of each output signal from the interrogation signal generator shall not vary more than ±0.001% from the assigned frequency.

3.4.2 RF Input Levels

All monitor performance requirements shall be met when the transponder has any initial RF peak output power level between 50 W and 1000 W.

3.4.3 Coupling Probe Inputs

3.4.3.1 DME Antenna

a. All monitor requirements shall be met when the RF input to the monitor has an initial peak power level between -6 dBm and +36 dBm.
b. The monitor shall continue to operate without damage with an RF input level up to +43 dBm.
c. Manually inserted attenuators shall not be utilized.
d. Amplifiers external to the monitor assembly shall not be utilized.

3.4.3.2 Transmission Line Directional Coupler

a. The directional coupler shall have a directivity of not less than 27 dB over the frequency range of 960 MHz through 1215 MHz.
b. The coupling factor shall not vary by more than ±0.5 dB over the service conditions.

3.4.4 Interrogation Signal Generator

The interrogation signal generator shall provide interrogation and timing reference signals for the relevant functions of the transponder monitor.

3.4.4.1 Operational Modes

a. In the normal mode of operation, when functioning as part of the executive monitor, the interrogation signal generator shall provide on-channel frequency RF pulse pairs at fixed levels, spacing, and interrogation rates for the monitoring of the reply delay, pulse spacing, pulse rate, and power level.
b. The interrogation signal generator shall provide the capability of interrogating at off-channel frequencies, and at alternate RF levels, pulse spacings, and interrogation rates, for the measurement and certification of other specific performance characteristics of the transponder as defined below.

3.4.4.2 Pulse Synchronization Output

a. The interrogation signal generator shall provide an output pulse, synchronized to each interrogation, to trigger external test equipment (Government Furnished Equipment (GFE)) or provide accurate pulse timing.
b. This output shall be provided on the front panel with a Bayonet Neill–Concelman (BNC) female connector.

c. This output shall generate signal pulses from a rate of 10 ppps to 7500 ppps.

3.4.4.3 RF Output Pulse Signal

The RF envelope of each pulse shall meet the following requirements when measured using a linear detector.

3.4.4.3.1 Rise Time

The rise time shall be 2.5 ±0.5 µs.

3.4.4.3.2 Pulse Top

The instantaneous voltage amplitude within the pulse top shall not fall below the 95% value of the maximum voltage amplitude.

3.4.4.3.3 Pulse Width

The pulse width shall be 3.5 ±0.5 µs.

3.4.4.3.4 Decay Time

The decay time shall be 2.5 +0.5/-1.0 µs.

3.4.4.4 Pulse Coding

a. Pulses shall be coded in pairs with a spacing of 12 ±0.2 µs for X channels and 36 ±0.2 µs for Y channels.
b. For test purposes, the spacing shall be capable of variation, within at least ±3.2 µs from the nominal assigned channel spacing, in increments of 0.1 µs.

3.4.4.5 Pulse Power Variation

The peak power of the constituent pulses of any pair of pulses shall not differ by more than 0.5 dB.

3.4.4.6 Detected RF Output Signal

A linear detected video waveform test point shall be provided via a female BNC connector on the front panel for determining the pulse characteristics and timing measurements.

3.4.4.7 RF Pulse Spectrum

a. At least 90% of the output signal RF energy shall be contained within a 0.5 MHz band centered on the interrogation frequency in use.
b. The RF energy contained within any 0.5 MHz band shall decrease monotonically as the band center frequency moves away from the nominal channel frequency.

3.4.4.8 Spurious Output

a. At all frequencies from 10 MHz to 1800 MHz, but excluding the band of frequencies from 1023 MHz to 1152 MHz, the spurious output of the signal generator, as measured at the

antenna connection at the top of the cabinet, shall not exceed -40 dBm in any 1 kHz of receiver bandwidth.

b. The power at the RF output connector during the intervals between occurrences of the desired interrogation pulse pairs shall not exceed a level of -80 dBm for all settings of the output attenuator.

3.4.4.9 Test RF Output Frequency

a. The signal generator shall provide RF output at the channel interrogation frequency, at ±200 kHz, and at ±900 kHz with respect to the nominal interrogation frequency in use.
b. All signal generator performance requirements shall be met without retuning or readjustment of any controls when each of the output frequencies referenced herein are selected.
c. The RF output at ±200 kHz and ±900 kHz shall be within 0.5 dB of the RF output at the nominal interrogation frequency.

3.4.4.10 RF Output Level Calibration

a. A means shall be incorporated for setting the RF power to a reference calibration level.
b. The RF power shall be maintained at the calibration level ±0.5 dB over the service conditions.
c. Means shall be incorporated to connect to external test equipment to measure RF power at the monitor output in an accessible location.

3.4.4.11 RF Output Level and Accuracy

a. The RF output level shall be selectable between the limits of -10 dBm and -100 dBm as measured in a 50-Ω load at the transponder receiver input.
b. The output attenuator shall provide a control resolution of ≤ 1 dB over the specified range.
c. The output level shall be within 1.0 dB of the indicated level.

3.4.5 Transponder Monitor

3.4.5.1 Monitor Alarm Action

a. Execution of monitor control actions and fault annunciation shall occur within 10 s of the commencement of an out-of-tolerance condition, except for identification alarms. For identification alarms refer to 3.4.5.2.9.
b. The monitor shall provide two separate alarm actions for purposes of automatic control and remote monitoring of the transponder: one designated “primary parameter alarm” and the other designated “secondary parameter alert”
c. The alarm condition shall remain until it clears, or a reset is performed.

3.4.5.1.1 Primary Alarm

If any primary parameter (3.4.5.2.1), or if any parameter listed in 3.4.5.2.2 that is selected as primary, produces an out-of-tolerance condition, the monitor will cause the following actions to take place:

a. A positive visual and aural indication (3.5.1.2) of the alarm condition shall be provided;
b. The main transponder shall be automatically switched off;
c. The standby transponder, if provided, shall be automatically switched into operation within 5 s of the main transponder shutdown;
d. If any out-of-tolerance conditions occur for the standby transponder, a positive visual and aural indication of the alarm condition shall be provided; and
e. The standby transponder shall be automatically switched off.

3.4.5.1.2 Secondary Parameter Alert

If any of the monitored parameters set to secondary (3.4.5.2.2) produce an out-of-tolerance condition, the monitor shall cause a positive visual and aural indication of the alert condition (3.5.1.2).

3.4.5.1.3 Pre-Alarm

If any monitored parameter exceeds the pre-alarm limit, a maintenance alert shall be generated.

3.4.5.1.4 Maintenance Alert

a. Maintenance alerts shall provide a visual indication of the abnormal condition on the equipment front panel, the MDT, and to the RMM connection.
b. The maintenance alert shall cease when the equipment returns to a normal operating condition.

3.4.5.1.5 Alarm Delay Time

a. The monitor delay time (6.1.11) for all parameters selected as primary (See 3.4.5.2.1 and 3.4.5.2.2), except for identification, shall be adjustable from 4 to 10 s. For identification alarms see 3.4.5.2.9.
b. The adjustable value selected from the MDT shall be the total monitor delay time as defined in 6.1.11.

3.4.5.1.6 Monitor Response Time

a. The requirement below (b.) shall be met under conditions in which any faults have been sensed for a continuous period of 10 s or longer.
b. Within 3 s after the application of transponder output signals, which have characteristics that are all within a range prescribed for non-fault conditions, all sensed faults and alarm indication shall end.

3.4.5.2 Monitored Parameters

a. Each monitored parameter shall have a settable nominal value with adjustable alarm and pre-alarm limits, except as stated in 3.4.5.2.10-e.
b. The pre-alarm limits shall be adjustable to any value between the associated nominal and alarm limit values.

3.4.5.2.1 Primary Parameters

The following parameters shall be monitored as primary alarms:

a. Transponder reply delay (3.4.5.2.3); and
b. Transmitter frequency (3.4.5.2.10-e).

3.4.5.2.2 Secondary Parameters

The following parameters shall be monitored and selectable as either primary parameter alarms or secondary parameter alerts:

a. Transponder pulse spacing (3.4.5.2.4);
b. Transponder pulse rate (3.4.5.2.5);
c. Reply efficiency (3.4.5.2.6);
d. Transponder power output (3.4.5.2.7);
e. Radiated power level (3.4.5.2.8);
f. Identification keying (3.4.5.2.9);
g. Transmitter frequency stability (3.4.5.2.10-c); and
h. Receiver frequency (3.4.5.2.11).

3.4.5.2.3 Reply Delay

a. The monitor shall measure the reply delay of the pulses transmitted in response to the interrogation signal generator.
b. The default alarm limit shall be set to ±0.4 µs from the nominal value (3.2.5.5).
c. Measurement of the reply delay shall not be affected by the interrogation rate of the monitor signal generator nor by the percentage of replies to monitor interrogation for reply efficiencies as low as 50%.
d. The reply delay shall be measured at the antenna coupling probe.
e. When the AGR is active, as described in 3.2.3.9, these requirements shall be met over the full range of reduction in receiver sensitivity.

3.4.5.2.4 Transponder Pulse Spacing

a. The monitor shall measure the spacing between the first and second pulses of transponder pulse pairs.
b. The default alarm limit shall be set to ±0.4 µs from the nominal value of 12.0 µs for X channels or 30.0 µs for Y channels.
c. The transponder pulse spacing shall be measured at the transmission line directional coupler.
d. When the AGR is active, as described in 3.2.3.9, these requirements shall be met over the full range of reduction in receiver sensitivity.

3.4.5.2.5 Transponder Pulse Rate

a. The default low pre-alarm limit shall be 750 ppps.
b. The default low alarm limit shall be 700 ppps.

c. The transponder pulse rate shall be measured at the transmission line directional coupler.
d. Transponder pulse rate faults shall be inhibited during transmission of the identification signal (3.2.4).

3.4.5.2.6 Reply Efficiency

a. The default low alarm limit shall be 70% when the test signal is 2 dB greater than the nominal receiver sensitivity level.
b. When the AGR is active, as described in 3.2.3.9, these requirements shall be met over the full range of reduction in receiver sensitivity.
c. The reply efficiency shall be measured at the antenna coupling probe.

3.4.5.2.7 Transponder Power Output

a. The monitor shall measure the amplitude level of transponder output pulses.
b. The default nominal value shall be equal to the preset level for the transponder (100W or 1000 W).
c. The default low alarm limit shall be 3.0 dB lower than the nominal value.
d. The low alarm limit shall be adjustable from at least 1.0 dB to 4.0 dB lower than the nominal value.
e. The default high pre-alarm limit shall be 2.0 dB higher than the nominal value.
f. The default high alarm limit shall be 6.0 dB higher than the nominal value.
g. The measured power level shall be stable to within ±0.5 dB as referenced to the input power level to the monitor over the operational service conditions.
h. The power output shall be measured at the transmission line directional coupler.

3.4.5.2.8 Radiated Power Level

a. The default low alarm limit shall be 3.0 dB lower than the nominal value.
b. The low alarm limit shall be adjustable from at least 1.0 dB to 6.0 dB lower than the nominal value.
c. The measured power level shall be stable to within ±0.5 dB as referenced to the input power level to the monitor over the operational service conditions.
d. The radiated power level shall be measured at the antenna coupling probe.

3.4.5.2.9 Identification Keying

a. The monitor shall sense the presence of periodic identification keying of the transponder by recognizing the fundamental frequency component of the identification pulse train (1350 Hz nominal).
b. The default alarm limit for time without transmission of the identification signal shall be 45 s.
c. The default alarm limit for time with continuous transmission of the identification signal shall be 10 s.
d. The default alarm limit for time of transmission of an incorrect identification code shall be 90 s.

e. The alarm internal timer shall be reset upon restart of the transponder after shutdown, or upon restart of external keying after shutdown.
f. The identification keying shall be measured at the transmission line directional coupler.

3.4.5.2.10 Transmitter Frequency

a. The monitor shall measure the transmitter frequency.
b. The pre-alarm limit shall be stated as a percentage of the nominal frequency and adjustable in increments of 0.0001%.
c. The measured frequencies shall be within ±0.0005% across the operational service conditions.
d. The pre-alarm limit shall be adjustable between ±0.0001% and ±0.002%.
e. The alarm limit shall be fixed at ±300 kHz (3.1.4).

3.4.5.2.11 Receiver Frequency

a. The monitor shall measure the receiver frequency.
b. The pre-alarm and alarm limits shall be stated as a percentage of the nominal frequency and adjustable in increments of 0.0001%.
c. The pre-alarm and alarm limits shall be adjustable between ±0.0001% and ±0.002%.
d. The measured frequencies shall be within ±0.0005% across the operational service conditions.

3.4.5.3 Test Signals and Monitoring Activities

The transponder shall not be triggered more than a total of 120 times per second for monitoring and/or automatic delay control purposes.

3.4.5.4 Transponder Tests

The following test results shall be available through the MDT and the Remote Monitoring and Logging System (RMLS) interface.

3.4.5.4.1 On-Channel Receiver Sensitivity

a. The receiver sensitivity monitor shall measure the level in dBm that results in 70% reply rate, transmitted in response to the interrogation signal generator.
b. The signal generator level shall be varied automatically from the established level to determine the level that produces a reply rate of 70%.
c. A maintenance alert fault limit shall be adjustable from the nominal sensitivity level up to +4 dB.
d. The adjustment shall be in increments of 1 dB or less.
e. The default setting shall be 2 dB above the nominal level.
f. A means shall be employed (i.e., averaging and/or hysteresis over multiple samples) to minimize nuisance maintenance alerts.
g. The receiver sensitivity monitor shall be disabled, and any alert cleared, when the interrogation overload signal AGR is active (see 3.2.3.9).

h. Receiver sensitivity monitoring shall be measured at the transmission line directional coupler.

3.4.5.4.2 Sensitivity at 200 kHz and 900 kHz

a. The monitor shall measure the efficiency when the interrogator level is set to 3 dB higher than the nominal sensitivity and ±200 kHz from the nominal interrogation frequency.
b. A maintenance alert shall be generated for an efficiency rate of less than 70% for the measurement above (a.).
c. The monitor shall measure the efficiency when the interrogator level is set to -10 dBm and ±900 kHz from the nominal interrogation frequency.
d. A maintenance alert shall be generated for an efficiency rate greater than 5% for the measurement above (c.).
e. Maintenance alerts from these measurements shall be disabled, and any alert cleared, when the interrogation overload signal AGR is active (see 3.2.3.9).
f. Receiver sensitivity monitoring at ±200 kHz and ±900 kHz shall be measured at the transmission line directional coupler.

3.4.5.4.3 Triggering Level at Other Pulse Spacings

a. The monitor shall measure the decode rate at an interrogation level 1 dB above the nominal sensitivity level and with the pulse spacing at ±1 µs from nominal.
b. A maintenance alert shall be generated if the rate is less than 70% for the measurement above (a.).
c. The monitor shall measure the decode rate at an interrogation level 70 dB above the nominal sensitivity level and with the pulse spacing at ±3 µs from nominal.
d. A maintenance alert shall be generated if the rate is greater than 5% for the measurement above (c.).
e. Maintenance alerts from these measurements shall be disabled, and any alert cleared, when the interrogation overload signal AGR is active (see 3.2.3.9).
f. Receiver sensitivity monitoring at other pulse spacings shall be measured at the transmission line directional coupler.

3.4.5.4.4 Echo Suppression

Means shall be provided to measure the echo suppression duration and threshold triggering level (3.2.3.5.2).

Note: Echo suppression measurements do not have associated alert or alarm limits.

3.4.5.4.5 Dead Time Gate

Means shall be provided to monitor the receiver dead time interval (3.2.3.3).

Note: Dead time interval measurements do not have associated alert or alarm limits.

3.4.5.4.6 Voltage Standing Wave Ratio

Means shall be provided to measure the transmitter VSWR at the transmission line directional coupler.

3.4.5.4.7 Transponder Decoder Certification Tests

a. Means shall be provided within the monitor to test the following parameters generated by the transponder:
    1. Reply delay (3.4.5.2.3);
    2. Pulse width (3.2.6.1.3);
    3. Rise time (3.2.6.1.1);
    4. Decay time (3.2.6.1.4);
    5. Pulse spacing (3.2.6.2);
    6. Reply efficiency (3.4.5.2.6);
    7. Squitter count (3.4.5.2.5);
    8. Identification code (3.4.5.2.9);
    9. Transponder power output (3.4.5.2.7);
    10. Radiated power level (3.4.5.2.8);
    11. On-channel receiver sensitivity (3.4.5.4.1);
    12. Decodes at ± 1µs (3.4.5.4.3);
    13. Decodes at ± 3 µs (3.4.5.4.3);
    14. Decodes at ± 200 kHz (3.4.5.4.2);
    15. Decodes at ± 900 kHz (3.4.5.4.2);
    16. Echo suppression duration (3.4.5.4.4);
    17. Echo suppression threshold (3.4.5.4.4);
    18. Dead time gate (3.4.5.4.5); and
    19. VSWR (3.4.5.4.6).

b. The testing limits for items 7., 8., 10., 11., 16., 17., and 18. above shall be adjustable through the MDT.
c. The certification tests shall run periodically and upon command.
d. The period in which the certification tests run shall be adjustable with a minimum period as low as practicable and a maximum period of at least 24 hours.
e. The certification tests shall be selectively enabled/disabled.
f. Execution of the certification tests shall not affect or interrupt the DME service.
g. The latest certification test results shall be available through the MDT and the RMLS interface.
h. Failure of any of the tests shall cause a maintenance alert.
i. The maintenance alert above (h.) shall be reset upon the next in-tolerance test.

3.4.5.5 Monitor Alarm Limit Certification Tests

a. Means shall be provided to test and validate alarm limits.
b. The values used for the testing shall be adjustable through the MDT.
c. The certification tests shall run periodically and upon command.

d. The period in which the certification tests run shall be adjustable with a minimum period as low as practicable and a maximum period of at least 24 hours.
e. The certification tests shall be selectively enabled/disabled.
f. Execution of the certification tests shall not affect or interrupt the DME service.
g. The test results with measured data, and monitor status for the parameter under measurement, shall be available through the MDT and the RMLS interface.
h. Failure of the reply delay test (k.1.) or the transmit frequency test (k.4) below shall result in a primary alarm (3.4.5.1.1).
i. Failure of any other tests listed below in bullets k. and l. shall result in a primary alarm when the parameter is set to primary, or a maintenance alert when set to secondary.
j. The maintenance alert above (i.) shall be reset upon the next in-tolerance test.
k. The low and high alarm limits each shall be tested for outside alarm limit (out-of-tolerance) and within alarm limit (within tolerance) conditions by injection of test signals for the following:
    1. Reply delay (3.4.5.2.3);
    2. Pulse spacing (3.4.5.2.4);
    3. Squitter count (3.4.5.2.5);
    4. Transmit frequency (3.4.5.2.10);
    5. Receive frequency (3.4.5.2.10); and
    6. Identification frequency (3.4.5.2.9).
l. The low alarm limit shall be tested for outside alarm limit (out-of-tolerance) and within alarm limit (within tolerance) conditions by injection of test signals for the following:
    1. Reply efficiency (3.4.5.2.6);
    2. Transponder power output (3.4.5.2.7); and
    3. Radiated power level (3.4.5.2.8).

3.4.5.6 Monitor Interrogator Data

a. Means shall be provided within the monitor for purposes of testing the following signals generated by the interrogator:
    1. Pulse width (3.4.4.3.3);
    2. Rise time (3.4.4.3.1);
    3. Decay time (3.4.4.3.4);
    4. Pulse spacing (3.4.4.4);
    5. Pulse rate (3.4.5.3);
    6. Interrogation RF output level (3.4.4.10); and
    7. Interrogation RF frequency (3.4.1 and 3.4.1.3).
b. The tests shall run periodically.
c. The period in which the certification tests run shall be adjustable with a minimum period as low as practicable and a maximum period of at least 24 hours.
d. The certification tests shall be selectively enabled/disabled.
e. The results shall be available through the MDT and the RMLS interface.
f. Failure of any of the tests shall cause a maintenance alert.
g. The maintenance alert above (f.) shall be reset upon the next in-tolerance test.

h. Execution of the certification tests shall not affect the monitor response time.

3.4.5.7 Monitor Failsafe

The monitor shall be failsafe such that failure of any part of the monitor subsystem, including any associated control action (transponder shutdown), either results directly in an alarm condition, or does not alter any alarm limit to allow an out-of-tolerance condition to occur without detection.

3.5 Control, Status and Indicator Functions

3.5.1 Front Panel

3.5.1.1 Controls

As a minimum, the following control functions shall be available from the front panel of the DME transponder:

a. Enable/disable remote control;
b. Disable aural alarms and alarm history when remote control is disabled;
c. Enable bypass of the monitor control, in which:
    1. Automatic monitor shutdown action in response to primary alarms is inhibited; and
    2. Transmission of the identification signal is stopped.
d. Disable bypass of the monitor control, in which:
    1. Automatic monitor shutdown action in response to primary alarms is enabled; and
    2. Transmission of the identification signal is restarted.
e. ON/OFF/RESET of the DME transponder;
f. Selection of main/standby transponder, if available;
g. Lamp/aural alarm test;
h. Alarm silence; and
i. Volume control.

3.5.1.2 Status and Indicators

a. As a minimum, the following visual indicator functions shall be provided on the equipment front panel:
    1. Transponder ON/OFF status;
    2. Monitor alarm condition;
    3. Mode of operation (monitor bypass) defined in 3.5.1.1-c;
    4. Transponder status (Main/Standby);
    5. AC power failure;
    6. On battery operation;
    7. AGR operation; and
    8. Remote control enabled/disabled.
b. The following colors shall be used for indicators: Green for normal operation/remote control enabled, Amber/Yellow for an alert condition/remote control disabled, and Red for an alarm condition.
c. An aural alarm shall be provided to indicate an alarm condition.

d. An aural representation of the detected identification transmission from the monitor shall be provided.

3.5.2 Maintenance Data Terminal (MDT) Software

a. All status and control functions available to install, configure, operate, and maintain the DME transponder, and update DME System software, shall be available from the Microsoft Windows-based MDT (GFE).
b. The MDT, running vendor provided software, shall:
    1. Display any changes to the DME System status;
    2. Display current values for all monitored parameters including environmental sensors (e.g., smoke, intrusion, temperature);
    3. Display the fault history (3.5.4);
    4. Display the results from fault diagnostics (3.5.5);
    5. Display the results from the most recent certification tests (3.4.5.4, 3.4.5.5, 3.4.5.6);
    6. Determine and report the logical, physical, and software configuration of the DME System to the extent practicable;
    7. Provide for a printable (to file) reference data display that includes selectable operational and certification parameters;
    8. Determine and report system resource utilization (such as Central Processing Unit (CPU) utilization, and Random Access Memory (RAM), Programmable Read-Only Memory (PROM), and Non-Volatile RAM (NVRAM) memory usage and availability);
    9. Display all users logged onto the DME System; and
    10. Acknowledge and indicate either successful command execution or failure, including communication faults.

3.5.3 Remote Control

Remote controls shall only be allowed when enabled from either the front panel or the MDT. See 3.6 for remote control function details.

3.5.4 Fault History

a. At the MDT and RMLS interface, there shall be access to fault history data that provides a means to quickly display individual records associated with at least the 50 most recent alarms, pre-alarms, maintenance alerts, or other out-of-tolerance conditions that are brief or transient (i.e., less than alarm delay).
b. Each record shall include the last normal parameter values and the post-fault (immediately prior to shutdown) parameter values.

3.5.5 Fault Diagnostics

a. Fault diagnostics shall provide diagnostics and system verification to facilitate fault isolation to the Line Replaceable Unit (LRU) level, including the remote maintenance monitoring subsystem(s).

b. The diagnostic routine shall be able to localize 85% of all failures to a single faulty LRU, and 95% of all failure occurrences to no more than two candidate LRUs, one of which contains the fault.
c. Fault diagnostics shall run per 3.5.7.e, and either continually or on command from the MDT.
d. If fault diagnostics run upon command, then provisions shall be made to permit the operator to stop the test cycle at any time during the test sequence.
e. All LRUs identified as failed by fault diagnostics shall be reported and listed in order of descending likelihood.
f. Fault diagnostics that run continually shall not cause an out-of-tolerance condition of the radiated signals.
g. Fault diagnostic data shall be stored in memory and accessible via the MDT or by RMLS request.

3.5.6 Trend Analysis Data Collection and Storage

a. The DME shall record and store, in non-volatile memory, system status, alarms, pre-alarms, maintenance alerts, all monitored parameter values, all results of fault diagnostics, results of certification tests, and any other system information or data that is required for corrective or preventative maintenance.
b. The rate of data recording of these parameters shall be adjustable from once every 10 s to once every 10000 s.
c. Each individual record, which consists of one sample from all parameters recorded, shall be time and date stamped to the nearest second.
d. The system memory shall be sufficient to store at least one year's worth of data, on a rolling basis (oldest data is replaced with new data, i.e., first in, first out), when set to sample and record at the fastest rate available.
e. The data shall be available in American Standard Code for Information Interchange (ASCII), formatted as a comma-separated values (.csv) file from the MDT.

3.5.7 Automatic Reset Function

The DME transponder automatic reset function shall:

a. Return the DME transponder to normal operation when input power is restored after a power interruption;
b. Reinitialize all DME transponder software in the event of a restart/reboot (i.e., a momentary loss of power) such that it is fully functional with the latest loaded software version;
c. Reset and restart the DME transponder at set intervals subsequent to a shutdown due to an alarm action, or protective actions in 3.2.8, 3.2.9, and 3.2.10;
d. Be configurable to provide a minimum of three user-defined reset/restart time intervals; and
e. Initiate fault diagnostics after the third or final restart and subsequent shutdown.

3.6 Remote Maintenance Monitoring (RMM)

RMM consists of the various sensors, microprocessor(s), and software necessary to remotely monitor, control, record, and certify proper operation of the DME System to be furnished under this specification.

3.6.1 Remote Monitoring Subsystem (RMS)

a. The RMS shall be independent from the DME monitor and shutdown control functions and circuits.
b. RMS faults shall not affect the capability of the DME monitor and control functions to detect and respond to conditions that can cause HMI.
c. Data monitored by the RMS shall be locally accessible at the MDT.

3.6.1.1 RMS Functions

The DME RMS shall provide the following functions:

a. Environmental monitoring as required in 3.6.6;
b. Monitor each of the minimum set of performance parameters required to determine the operational status of the DME;
c. Process the outputs of each of the monitoring devices as necessary to provide digital data in the appropriate engineering units for RMM;
d. Process the outputs of each of the environmental (3.6.6) and spare (3.6.5) monitoring devices to determine alert and pre-alert status by comparing the monitored outputs to user-defined limits;
e. Provide at least two limits for each monitored parameter in d. above, an alert (when the parameter reaches its established limit), and a pre-alert, which is typically 75% of the alert value;
f. In response to a poll (data request message) received from the RMLS, transmit the current value of each parameter in the group or groups of parameters indicated by the content of the request message;
g. Time stamping and local storage of the current status of alarms and alerts data values, alarm and alert limits, fault history (3.5.4) and trend analysis data (3.5.6);
h. Capability to provide 100% additional memory storage capacity of that required to meet the requirements specified herein;
i. The additional storage capacity required in h. above shall be provided in the initial design;
j. Capability to process RMM reset commands; and
k. Capability to process RMM restart commands to restore DME operation in the case of interrupted service.
l. The RMS shall utilize Simple Asynchronous Interfacing (SAI) protocol messages contained within CMHP frames to communicate with RMLS using IP protocol.

3.6.2 Alarm and Alert Messages

3.6.2.1 Alarms

a. An alarm message shall be generated and transmitted to the RMLS when a failure occurs within the DME System that causes a loss of service to the user (shutdown).
b. An alert message shall be generated and transmitted to the RMLS when a failure occurs within the DME System which does not cause a loss of service to the user.
c. When the system is commanded off, or when the system is off as a normal state, alarm messages shall be inhibited.

3.6.2.2 Maintenance Alerts

a. When the current value of a measured parameter exceeds the established alert limits, an indication of the maintenance alert condition shall be sent to the RMLS.
b. The limits for maintenance alerts shall be adjustable locally from the MDT.

3.6.3 Non-Volatile Data Storage

a. All control settings, operational parameters and limits, initialization data, data files and fault history shall be locally stored in the RMS.
b. Local storage shall be supported with sufficient battery capacity that includes built-in charging, or other technique (i.e., flash memory), to ensure the non-volatility of stored data for a period of not less than 90 days.
c. Means shall be provided to transfer stored data to another medium for permanent storage purposes.

3.6.4 RMS Data Sampling Rate

The RMS shall sample each parameter within the RMS and DME monitor no less frequently than once every second.

3.6.5 Spare Input/Output Capacity

a. The RMS shall provide at least three spare analog inputs, two spare digital inputs and two spare digital outputs.
b. All spare analog inputs shall provide user-configurable alert and pre-alert limits.
c. Data, alerts, and pre-alerts from the spare inputs shall be transmitted to the RMLS upon demand.
d. Specific requirements for the spare inputs and outputs shall be as follows:
   1. Analog inputs:
      i. Input range: Bipolar, -5.000 VDC to +5.000 VDC with respect to input ground.
      ii. Minimum accuracy: ±5% of reading, or ±0.01 V, whichever is numerically smaller.
      iii. Input impedance: 20 kΩ or greater.
      iv. Minimum A/D converter resolution: 1 part in 1000.

   2. Digital inputs:

i. TTL, low = 0.0 V to +0.8 V, high = +2.0 V to +5.5 V.
ii. Sense: Programmable such that either high or low represents alert, with the opposite sense representing normal.

3. Digital outputs:
   i. TTL with the same voltage limits as the digital inputs.
   ii. Current sink capacity: 24 mA minimum.

3.6.6 Environmental Monitoring

a. The following sensors shall be furnished with each DME System:
   1. Intrusion detector;
   2. Ionization-type smoke detector;
   3. Obstruction light current sensor;
   4. AC power; and
   5. Temperature.
b. Each sensor shall be provided with all necessary connectors, terminal boards, enclosures, mounting hardware, and installation instructions.
c. Measurements from each environmental sensor shall be processed by the RMS for output locally via the MDT and transmission to the RMLS.

3.6.6.1 Intrusion Detector

a. The intrusion detector shall detect the opening of the DME shelter door.
b. The RMS building security timer shall start when the detector senses that the door has been open for 0.25 s.
c. If an MDT is not connected within 5 minutes, the RMS shall indicate that the building security parameter is in alert.
d. The RMS shall send an alert message to the RMLS when the building security parameter is in alert.
e. If the MDT is connected within 5 minutes, the building security parameter shall return to normal.
f. If after being connected, and the MDT is then disconnected, the RMS shall inhibit sensing a building security alert for a period of 5 minutes prior to resuming normal monitoring of the building security parameter.
g. Capability shall be provided to arm and disarm (bypass) the intrusion detector locally via the MDT and through the RMLS.

3.6.6.2 Smoke Detector

a. The ionization-type smoke detector shall be powered from the DME System.
b. The smoke detector shall meet the requirements of Underwriters Laboratories (UL), Inc. Standard 268 and bearing the U.L. label showing compliance.
c. The RMS shall send an alert message to the RMLS when the smoke detector is activated.

3.6.6.3 Obstruction Light Sensor

a. The obstruction light (3.3.12) current sensor shall be capable of detecting an outage of one or more lamps.
b. The sensor shall operate correctly when either incandescent or LED bulbs are used.
c. The RMS shall send an alert message to the RMLS when one or more lamps fail.

3.6.6.4 AC Power Sensor

a. The AC power sensor shall measure the AC power (voltage and current) applied to the DME equipment.
b. The RMS shall transmit an AC power alert message to the RMLS when the DME System switches to the backup power source.

3.6.6.5 Temperature Sensors

a. Two temperature sensors shall be provided for installation: one for inside the DME shelter and one for outside the DME shelter.
b. The sensors shall measure temperature from -46°C to +70°C with an accuracy within ±4°C.
c. The RMS shall be programmable with upper and lower temperature alert limits.
d. Exceeding the temperature alert limits shall cause a temperature alert message to be transmitted to the RMLS.

3.6.7 RMS Security

Log-on security shall be implemented to ensure that only authorized personnel can enter RMS commands.

3.6.7.1 Security Implementation

The RMS security design shall:

a. Include a standard initial log-on procedure for factory-delivered systems that provides security-level access for the purpose of assigning passwords and security access levels;
b. Include a method to restore the factory log-on IDs and passwords;
c. Utilize assigned user IDs and passwords containing up to 16 alphanumeric characters with a minimum of 24 total ID/password combinations stored in the RMS non-volatile memory;
d. Echo the user ID to the MDT as non-alphanumeric characters when logging in;
e. Respond to entry of an invalid ID or password by displaying an error message to the MDT, terminating the log-in procedure (i.e., not prompt the user to try again), and returning to its idle (wait) state;
f. Provide a message identifying the logged-in user to the RMLS for all validated access entries and send a log-off message when the user logs off;
g. Inhibit the transmission of all alarm or alert messages to the RMLS after the initial log-in identification, during the time a second or third security-level user is logged in; and
h. Automatically log off the user if the terminal has been idle for more than 15 minutes or if there is no terminal activity within 15 minutes following the completion of a user-initiated test.

3.6.7.2 Security Level Definitions

Security levels for the RMS are defined as follows:

a. Level 1: Entry of a valid user ID and password shall allow READ ONLY access/display of system status, configuration, and monitored system parameters. The user has no control over the DME subsystem.
b. Level 2: Entry of a valid user ID and password shall enable read and write access/display of all system functions and adjustable parameters except for user IDs and passwords.
c. Level 3: Entry of a valid user ID and password shall enable Level 2 capabilities and also provide the ability to assign and/or modify user IDs and passwords.

3.6.8 RMS Data and Control Filtering

a. All measurements and control functions available from the front panel or MDT shall be selectively available remotely.
b. Capability to enable or disable any of these measurements and control functions shall be possible via software build procedures.
c. The local system shall not execute remote commands or transmit measurements to the remote location for each disabled parameter.
d. Enabling/disabling shall be implemented by a hard-coded configuration table listing each parameter monitored by the RMS.
e. Each parameter shall be selectable by software build procedures to send a pre-alert message, alert message, pre-alarm message, or an alarm message.
f. A similar configuration table for each remote control function shall, by software build procedures, allow the enabling or disabling of remote control functions by the RMLS.

3.6.9 RMS Failure Protection

The DME System design shall employ a failsafe mechanism such that failures in the RMS function cannot cause a loss or degradation of navigation service to the user.

3.6.10 Interface with RMM Subsystems

a. The interface from RMS to RMLS shall be compliant with NAS-IC-51015108-01; FAA-E-3039; and selectively, either IPv4 or IPv6 protocols.
b. The digital data provided at the RMLS interface shall be in the appropriate engineering units for the parameters monitored in the formats defined in NAS-IC-51015108-01, to include but not limited to:
    1. Executive parameters;
    2. System status;
    3. Environmental;
    4. Communication;
    5. Fault diagnostic results;
    6. Certification parameters/results; and
    7. Trend analysis data.

3.7 Data Security

3.7.1 Access Control

The DME System shall contain features in its design and operation that prevent unauthorized and disruptive access to the system by implementing the following requirements as a minimum:

a. Authorized user access verification;
b. User password control;
c. Restriction of access to system/operating system (OS) files/data;
d. Denying access to direct OS functions/commands;
e. Limited access to specific functions based on job category;
f. While in the normal operating mode, prevent the loading of data from removable media or network connections; and
g. Disable any unused ports during normal operation.

3.7.2 Audit Logging

a. The DME System shall generate audit logs for both operating system-level and application-level events for local, non-local, and remote sessions on all devices capable of generating event logs.
b. The following minimum events shall be captured, recorded, and reported through the Internet Protocol (IP) interface:
    1. Resource degradation alerts (e.g., 100% utilization, disk space full, volume full);
    2. Login and logout, successful and unsuccessful;
    3. Unauthorized system access attempt;
    4. Account creation/modification and permissions or configuration changes;
    5. Administrator level activities;
    6. Startup/Shutdown of System/Services/processes;
    7. Access to privileged functions (e.g., setting auditable event and intrusion detection devices) including maintenance;
    8. Results from malicious code protection;
    9. Access control list denials; and
    10. Intrusion Detection System (IDS) signature based attacks.

3.8 DME System Design Characteristics

3.8.1 Maintainability

a. The system shall utilize LRUs.
b. During routine servicing and maintenance, unsoldering of wires, removal of wire harnesses, parts, or assemblies, shall not be required.
c. When it is necessary to displace a part in order to check or remove another part, the former part shall be wired and mounted so that it can be moved without being disconnected.
d. Removal of any panels or LRUs for maintenance purposes shall be accomplished without unsoldering or soldering connections.
e. Replacement of air filters shall be accomplished without the shutdown of fans.

f. All required connection caps, covers, or loads shall be securely affixed to the equipment.

3.8.1.1 Real Time Clock/Calendar

a. The DME System shall incorporate a real time clock/calendar with date, hours, minutes, and seconds.
b. The local system time shall be readable as a data point from the RMLS and the MDT.
c. The local system time shall be adjustable locally from the MDT.
d. The local system time drift shall be within 15 s a month.
e. The local system time shall be supported by a battery independent of the subsystem backup power.
f. The system shall include a clock battery with built-in charging that is capable of maintaining the local system time for at least 180 days.

3.8.2 Reliability

The DME System shall have a mean time between failures (MTBF) of not less than 8760 hours as a serial reliability model.

3.8.3 Modular Construction

a. Construction with plug-in or easily replaceable sub-assemblies (i.e., no special tools required) shall be used throughout the equipment in order to provide the specified level of maintainability.
b. Modularization shall be based on logical functional block concepts.
c. The design shall be such as to minimize the cost and number of different types of modules required for equipment support.
d. Modules shall be printed circuit boards whenever practical from the standpoint of component size/weight and consistent with circuit performance requirements.

3.8.3.1 Equipment Mounting

a. All electronic equipment shall be mounted within a standard EIA/ECA-310 rack.
b. The outer dimensions of the equipment cabinet with doors closed shall not exceed 24 inches wide, 30 inches deep, and 76 inches in height.
c. The rack or cabinet shall be steel or aluminum.
d. The rack or cabinet shall be floor mounted, with easily accessible holes in the base for attaching the bottom of the rack to the shelter floor.
e. The rack or cabinet shall allow the installation of as many as four conduits of up to 2-1/2-inch size for AC power, battery, ground, and signal cables.

3.8.4 Test Points

a. Test points and controls for adjustment shall not be located in compartments with unprotected voltage points of 300 V or more.
b. All test points and controls for adjustments shall be located to avoid accidental shock to personnel engaged in normal operating or maintenance activities.

c. Protection shall be provided in the test point circuitry to prevent equipment damage caused by the external grounding of test points.
d. Test points on plug-in circuit cards shall be easily accessible inside the electronic component cabinet.
e. Each component of the ground station equipment shall contain test points and connectors, appropriately labeled and numbered as necessary, to provide for the examination of significant voltages, signal amplitudes, waveforms, and timing characteristics and to provide for the connection of test equipment for adjustment and maintenance operations.
f. The type of test points and connectors provided shall be compatible with the applications (i.e., frequency range, voltage) for which the test points and connectors are needed.
g. Connection to test points and connectors utilized in either adjusting or testing the DME System for proper performance during prescribed periodic maintenance shall not require interruption of system operation.
h. Test points on plug-in circuit cards required for periodic and field-level corrective maintenance shall be accessible without the use of extender boards, cables, or adapters.

3.8.5 Interchangeability

a. Like LRUs shall be interchangeable in form, fit, and function without mechanical adjustment.
b. LRU plug-in modules and assemblies shall be designed to prevent insertion into the incorrect location or orientation.

3.8.6 Corrective Maintenance

The following time requirements assume the following: A single maintenance technician performs the repair; the technician has had adequate equipment-specific training; the repair work is performed under normal conditions in the equipment shelter; and a full set of spares and necessary tools are located at the shelter.

a. The mean time to isolate and replace a faulty LRU on the DME System shall be less than or equal to 30 minutes.
b. The maximum time to isolate and replace an LRU shall be less than or equal to 120 minutes.

3.8.7 Preventative Maintenance

a. The period between preventative maintenance procedures shall be as long as practicable, but in no case less than every 3 months.
b. The accomplishment of a set of periodically scheduled maintenance procedures shall require less than or equal to 2 hours to be completed.

3.8.8 Software/Firmware Updates

a. Software and firmware for the DME System shall be field updatable, without adding or modifying existing hardware components.
b. The software and firmware within the first article hardware shall use less than 50% of the available volatile memory, and less than 50% of the available non-volatile memory.

3.8.9 Electrical Interfaces to DME Antenna

a. Cables and connectors used for the antenna, excluding the ground cable, shall be protected from exposure to the elements.
b. Interconnecting power cables shall terminate at one or more connectors.

3.8.10 RF Input/Output Connectors

a. The RF output connector shall be an N female type at the top of the equipment cabinet.
b. The RF input connector from the antenna coupling probe shall be a Threaded Neill–Concelman (TNC) type female at the top of the equipment cabinet.
c. The monitor interrogator RF output connection to the receiver shall be easily removable without damage.

3.8.11 Grounding and Bonding

a. The ground reference for the equipment/system shall be in accordance with FAA-STD-019, FAA-C-1217, NFPA 70 Article 250, and chapters 8 and 9 of IEEE 1100.
b. Shielding and bonding shall be per FAA-STD-019.
c. Any removable rack-mounted unit, assembly, or subassembly whose rack provides multi-point grounding shall have a flexible grounding strap, using bonding connections per FAA-STD-019.
d. Enclosure and rack doors shall have grounding straps across the hinges to ensure proper grounding per FAA-STD-019.
e. For equipment connected to an AC supply line, the DC resistance to ground for each line input shall be at least 1 MΩ.

3.8.12 Input Power

3.8.12.1 AC Power

a. The system shall operate from 120 VAC, 60 Hz, single-phase power as the primary power source.
b. The DME equipment shall be directly connected to line power.
c. Line power shall enter through the top of the cabinet.
d. In the event of the loss of the 120 VAC commercial power, the system shall operate utilizing backup power (3.8.12.10) without interruption.
e. The DME System shall maintain all functionality while operating on backup power.
f. The equipment shall interface to building wiring in accordance with FAA-C-1217, FAA-STD-032, and NFPA 70 in that order of precedence.
g. Electrical enclosures, cabling, and wiring shall be approved by the Department of Labor Occupational Safety and Health Administration's (OSHA) Nationally Recognized Testing Laboratory Program (e.g., UL listed).

3.8.12.2 Equipment Directly Connected To Line Power

a. Controls and indicators for the electrical line voltage of an equipment rack shall be located in accordance with NFPA 70.

b. When switches or circuit breakers function as main power disconnecting means, operating either directly or through a contactor, they shall break the incoming line immediately before the line filter, terminal block or connector, fuses or other parts without compromising RFI, EMI shielding integrity.

3.8.12.3 Power Plugs, Cords, and Outlets

The DME System shall include one 20 A, 125 VAC, NEMA WD 5 grounding duplex receptacle, installed and wired in accordance with the requirements of NFPA 70.

a. The receptacle shall be located on the front of the cabinet at the bottom.
b. The equipment design shall include the provisions required to provide power to this outlet from a source independent of the DME System power source.

3.8.12.4 Leakage Currents

Leakage current shall be less than 5 mA.

3.8.12.5 Power Factor

The power factor (PF) for the DME equipment shall be within 0.7 (lag) – 0.7 (lead) if the power draw of the equipment is less than 2000 W.

3.8.12.6 Inrush Current

The ratio of peak inrush current to root mean square (rms) current for loads or devices up to 40 A, measured on the phase conductor with the highest current, shall be equal to or less than the ratio defined by Figure 3-3.

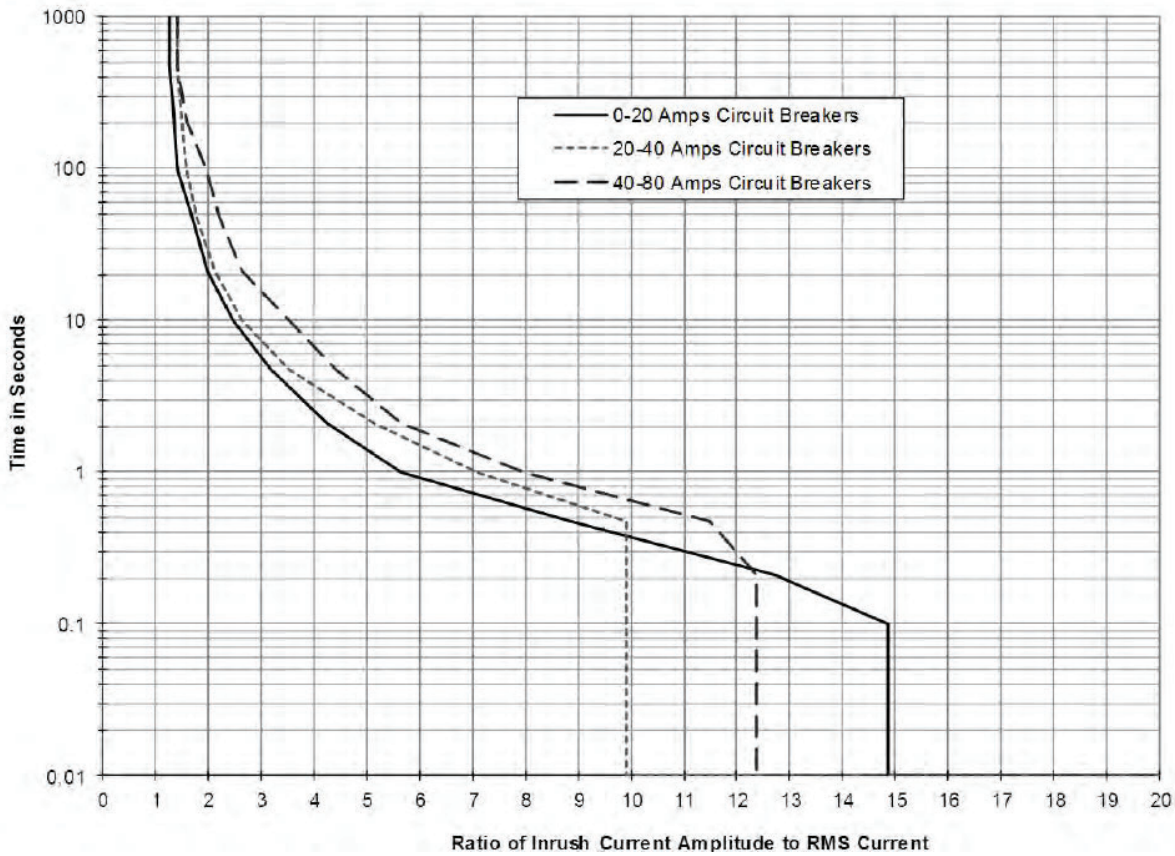

FIGURE 3-3. Inrush Current Limit Ratios

3.8.12.7 Harmonic Distortion

The system shall meet the current harmonic distortion requirements stated in International Electrotechnical Commission (IEC) 61000-3-2:2018.

3.8.12.8 Circuit Overload Protection

a. Current overload protection for the equipment shall be provided by fuses, circuit breakers, or other protective devices for primary circuits.
b. Overcurrent devices used in any AC circuits with voltages exceeding 100 V shall have a minimum of 10000 Ampere Interrupting Capacity (AIC) rating.
c. Devices/components shall be protected from damage due to a loss of power.
d. Series combination system overcurrent protection shall not be permitted.
e. Transient protection shall be provided in accordance with IEEE C62.41.2-2002, IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000 V and Less) AC Power Circuits.

3.8.12.9 Input Power Conditions

The system shall operate within tolerance when the AC input power varies according to the following:

a. The input voltage from 102–132 VAC;
b. Frequency is set to any value from 57–63 Hz (steady state);
c. Steady state frequency by ± 0.5 Hz;
d. Steady state frequency variation rate up to 1.5 Hz/s;
e. Momentary deviation of frequency from 53–65 Hz, lasting 0.5 to 3 s; and
f. Momentary changes in frequency at a 5 Hz/s rate, lasting 0.5 to 3 s.

3.8.12.10 Backup DC Power

a. The system shall be capable of operation from a facility backup power source (GFE) that provides 33–56 VDC.
b. The system shall be capable of operation from a 48 V backup battery set provided with the DME System.
    1. The transponder equipment shall have a continuously engaged battery backup power supply that enables normal operation for a minimum of 4 hours, with fully charged batteries, and operating at a rate of 4,320 ppps subsequent to a failure of the primary power source.
    2. The system shall provide the capability to charge the backup battery set.
    3. Battery backup power supply charging shall be selectively enabled or disabled.

3.8.12.11 Transformer Isolation of Non-Switching DC Power Supplies

a. All non-switching DC power supplies energized from the AC line power source shall be isolated from the AC line through a power transformer with separate primary and secondary windings.
b. The DC resistance from each input line terminal (with fuses in place and AC line control contacts closed) to the signal or chassis ground shall be greater than 1 MΩ.

3.8.13 Removable Parts and Mating Connectors

a. Electronic equipment shall be furnished with a complete set of installed fuses.
b. Parts that may be damaged by shipment in the operating sockets shall be packed in the normal part shipping container with information to identify their location in the system.
c. Removable circuit cards shall include hardware to prevent inadvertent removal by shock and vibration.
d. Mating connectors of equipment-mounted coaxial or cable connectors shall be provided.
e. Mating connectors shall be provided when two or more pieces of equipment require interconnection.
f. Circuit card guides shall support and retain the card in the guides during all phases of removal and insertion.

3.8.14 Electronic Equipment Assembly Requirements

a. Equipment assemblies, subassemblies, printed circuit board assemblies, terminal board assemblies, and electronic modules shall be Class 2 or Class 3 as defined in IPC J-STD-001.
b. Printed circuit boards exposed to uncontrolled environmental conditions shall have a conformal coating in accordance with IPC CC-830.

3.8.14.1 Component Mounting

Component mounting shall be in accordance with IPC-CM-770 or IPC-SM-780, as applicable, except the term “not recommended” shall be interpreted as “reject.”

3.8.14.2 Printed Circuit Boards

Printed circuit boards shall be in accordance with IPC-A-600.

3.8.14.3 Assembly

Assembly shall be in accordance with IPC-A-610 and IPC J-STD-001.

3.8.14.4 Wire Wrap

Wire wrap shall not be used.

3.8.15 Shelf Life

Materials, packaging, and processes shall ensure the equipment will meet performance requirements after a period of two years in a non-operational state after FAA acceptance.

3.8.16 Accessibility

3.8.16.1 General

a. All non-hinged shields or plates that are normally opened or removed in servicing equipment shall be secured with captive fasteners.
b. Captive fasteners shall be spaced on centers not exceeding 10 inches and shall be located around the entire periphery of the shields or plates.

3.8.16.2 Enclosures

a. No enclosure, or part thereof, shall support or sustain combustion in excess of the requirements of NEMA 250.
b. Enclosures for equipment or systems, up to 1000 V, installed outside a building (outdoors) shall be either NEMA Type 4 or Type 4X.
c. Enclosures for equipment or systems, up to 1000 V, installed inside a building where no dripping or splashing liquids or dust are normally expected shall be NEMA Type 1.
d. Accessibility to chassis, assemblies, or parts contained within cabinets, consoles, or other enclosures shall be provided from outside the basic equipment.

e. Mounting such items on withdrawal slides, swinging doors, through cable extenders and cable retractors, and provisions for circuit card extenders shall allow part or module operation in the open position.
f. Locks shall be provided to lock the chassis in the servicing position.
g. When withdrawal slides are used, they shall be of guided sectional construction.
h. Complete removal and access for servicing of electronic equipment contained within cabinets, consoles, or other enclosures shall be provided from either the front or rear of the equipment.
i. Guide pins (or locating pins), or the equivalent, shall be provided for mechanical alignment during mounting.

3.8.16.3 Maintenance Access

a. The system shall be equipped with doors or panels for direct access to its essential parts.
b. The removal of the doors or panels shall not compromise the structural integrity of support structures.

3.8.17 Thermal Design

a. When air filters are required with forced air cooling, the air filters shall be in accordance with UL 900 and ASHRAE 52.2.
b. The difference between the exhaust air temperature (measured inside the cabinet or console in front of the exhaust air vent) and input air temperature (measured outside the cabinet or console directly in front of the input air vent) shall be less than 15° C with the equipment operating under normal service conditions.
c. Air exhaust shall be directed away from operating personnel.
d. Cooling methods such as liquid, evaporative coolants, and vapor cycle refrigerants shall not be used.
e. Failure of a cooling device shall cause a maintenance alert.

3.8.18 Materials Processes and Parts

3.8.18.1 Dissimilar Metals

a. The selection of metals for use in electronic equipment shall be made in accordance with the requirements of MIL-STD-889.
b. Where electronic design requirements preclude the isolation from one another of incompatible metal combinations as identified in MIL-STD-889, the incompatible materials shall be isolated from exterior environments.

3.8.18.2 Metals, Corrosion Resistance

a. Metals, including those used for door hinges/fasteners, shall be corrosion resistant or coated or metallurgically processed to resist corrosion.
b. Non-corrosion resistant steel alloys, except where specifically required for electronic purposes, shall not be used.

3.8.18.3 Corrosion-Resisting Ferrous Alloys

a. Austenitic corrosion-resisting steel shall be used for all exterior structural parts.
b. Corrosion-resisting steels shall be given a passivation treatment.

3.8.18.4 Flammable Materials

Materials used in the end item configuration shall be noncombustible, fire retardant, or self-extinguishing in the most hazardous conditions of the equipment environment.

3.8.19 Equipment Manufacturing Processes

3.8.19.1 Strain Relief

Each part lead terminating at a connection point shall allow for strain relief to minimize tensile or shear stress.

3.8.19.2 Painted Finish

a. Metal surfaces not otherwise protected as described in this specification shall be painted.
b. The painted surfaces shall withstand the environmental operating conditions defined in this specification without flaking, cracking, blistering, or allowing any corrosion of the underlying surface.
c. The painted finish shall be in accordance with FAA-STD-001. (Alternate colors will be allowed upon FAA approval.)
d. Leaded paint shall not be used.

3.8.20 Electrical Parts

3.8.20.1 Batteries

a. Batteries shall be in accordance with NEMA C18.1M Part 1 and Part 2; NEMA C18.2M Part 1 and Part 2; NEMA C18.3M Part 1 and Part 2; and applicable recognized industry standards.
b. Equipment containing batteries shall be able to operate and be maintained in accordance with their formally documented maintenance procedures for a minimum of 2 years before requiring replacement.
c. Batteries shall not leak or generate toxic, corrosive, or combustible fumes.
d. Except for equipment requiring permanent battery installation, battery-powered equipment shall be labeled externally as follows: “WARNING: REMOVE BATTERIES BEFORE SHIPMENT OR INACTIVE STORAGE OF 30 DAYS OR MORE.”
e. Battery compartments shall be provided in accordance with the following:
    1. Contain devices to firmly secure the batteries.
    2. Provide access for battery installation, maintenance, testing, and removal without disassembly of equipment.
    3. Prevent the build-up of heat, gases, liquids, or chemicals released during battery operation, charging, deterioration, or rupture.
    4. Prevent build-up of heat, gases, liquids, or chemicals from entering the electronic compartment.

5. Prevent accidental battery discharge during battery installation, maintenance, testing, and removal.

f. Batteries used with or assembled to microelectronics that supply power to microelectronics shall not require a dedicated battery compartment.

g. Connections, polarity, minimum acceptable voltage for equipment operation, nominal voltage, and type(s) of batteries required shall be marked as applicable in a prominent place on or adjacent to the battery compartment.

3.8.20.2 Overcurrent Devices

3.8.20.2.1 Circuit Breakers

a. Circuit breakers shall be in accordance with the requirements of UL 489, unless they are used in an Underwriters Laboratories approved equipment item or load.

b. Each pole of all circuit breakers shall provide complete overcurrent protection by having inverse time and instantaneous tripping characteristics.

c. Circuit breakers shall be operated by a toggle type handle and have a quick-make, quick-break, over-center switching mechanism, operating all poles, that is mechanically trip-free from the handle so that the contacts cannot be closed against short circuit currents.

d. Circuit breakers shall be capable of manual operation to the open (off) and closed (on) conditions.

e. Circuit breakers shall not be used as switches unless they are specifically approved and listed for switching duty.

f. Circuit breakers operating handles shall indicate, by visual or tactile means, the open (off), closed (on), and tripped states of the breaker.

g. Equipment or system circuit breakers shall be coordinated with the circuit breaker providing power to the equipment or system circuit breakers. The coordination shall be complete so that any overcurrent condition in the equipment or system will trip one or more equipment or system circuit breakers without tripping their power feed circuit breaker protecting the facility bus.

h. Equipment and system circuit breakers shall provide complete continuous overcurrent protection for the load served and be unaffected by load harmonics and inrush current.

i. Circuit breakers shall be full size units or multiples thereof, unless used in an Underwriters Laboratories-approved equipment item or load.

j. Circuit breakers shall be permanently identified as to their continuous ampere rating.

k. Standard trip curve circuit breakers shall be used to the limits possible, unless used in an Underwriters Laboratories-approved equipment item or load.

l. Circuit breakers shall not perform the function of thermal overload relays.

3.8.20.2.2 Fuses

a. Fusing shall be coordinated so that fuses in branch circuits will open before the fuses in the main circuit.

b. Fuses shall not perform the function of thermal overload relay devices.

c. Fuse ratings shall be compatible with both starting and operating currents.

d. Connections to extractor post type fuse holders shall be such that the load is connected to the fuse terminal that terminates in the removable cap assembly.
e. Fuses shall be readily accessible for replacement (i.e., not requiring removal of unrelated equipment for access).

3.8.20.3 Connectors with Thermocouple Contacts

a. All connectors used in conjunction with thermocouples shall have their contact materials identified by one of the following methods:
   1. Nameplate securely attached to each connector half or mounted on the panel-mounted receptacles.
   2. Utilizing insulation sleeving or other markers designed for attachment around wire bundles.
b. Markers shall be attached adjacent to the plug.
c. Contact materials shall be identified using the standard abbreviations for the elements used.

3.8.20.4 Electrical Power Connectors

a. All electrical power connectors shall be UL listed for their application and use.
b. All power connectors shall be in accordance with NEMA WD 6 standards.
c. Polarized connectors shall be used to ensure the safety of equipment and personnel.

3.8.20.4.1 Protective Measures for Unmated Connectors

a. All unmated connectors shall be protected with metal or plastic caps or otherwise suitably protected during maintenance, storage, and shipment.
b. Unmated connectors with exposed contacts that may contain electrically hot circuits shall be covered with moisture-proof and vapor-proof caps.

3.8.20.5 Switches

Switches shall maintain their indicated state, i.e., open or closed, when subjected to any accidental force on the switch or the switch mounting equivalent to a 10g acceleration of either switch or mounting.

3.8.20.6 Wiring

The selection, application, and wiring practices for cable and wire shall be in accordance with the following subparagraphs.

3.8.20.6.1 Wiring – Electrical Clearance

Clearance between solder connections or bare conductors (such as terminal strips, stand-offs, or similar connections) shall not allow accidental contact between adjacent connections when subject to service conditions specified in this specification.

3.8.20.6.2 Wiring – Marking

All signal, control, and power wiring shall be uniquely identified to and within the enclosure along the wire and at each termination by either permanent insulation markings or by heat shrink labels.

3.8.20.6.3 Wiring – Protection

a. The wiring shall be secured and protected against chafing due to vibration or movement (such as slide out racks or drawers).
b. Wiring to pullout drawers shall employ cable retractors to protect the equipment.

3.8.20.6.4 Wiring – Bend Radius

The bend radius of wire and cable shall be greater than or equal to five times the cable diameter to avoid establishing a permanent set in the cable.

3.8.20.6.5 Wiring – Sleeving

a. Flexible plastic sleeving shall be used on cables subject to flexing, such as panel door cables.
b. The sleeving shall be secured under cable clamps at each end.
c. The cable shall be formed, secured, and protected so that no abrasion to the cable occurs when flexing in its normal motion.

3.8.20.6.6 Wiring – Panel Door Cables

Wiring to parts on a hinged door shall be contained in a minimum number of cables, arranged to flex without becoming damaged when the door is opened and closed.

3.8.20.6.7 Wiring – Through Hole Protection

a. Whenever wires are run through openings in metal partitions, shields, and the like, which are less than 0.125 inches in thickness, the holes shall be equipped with suitable mechanical protection (grommet) or insulation.
b. Openings in panels 0.125 inches or more in thickness shall have either grommets or the edges of the openings rounded to a minimum radius of 0.0625 inches.
c. Grommets for wires operating at RF potentials exceeding 500 V_{rms} shall be of ceramic or plastic material of suitable dielectric strength, except for coaxial cables with outside protection, where rubber or neoprene is acceptable.
d. Insulating grommets are not required for wires or groups of wires passing through shields or other metallic partitions where clearance can be maintained sufficiently to preclude the possibility of accidental contact or damage by abrasion.

3.8.20.6.8 Wiring – Arrangement

a. Signal, data, control, and other low power conductors shall not be placed adjacent to line power conductors.
b. Materials used for lacing, binding, sleeving, and strapping shall be compatible with the conductor or cable insulation or jacket.
c. Wiring shall be arranged to permit bundling or permanently mounted in cable ducts.

3.8.20.6.9 Wiring – Slack

Discretely terminated wires and cables shall be as short as practicable and still allow for maintenance and operation without damage or crimping of the wires.

3.8.20.6.10 Wiring – Entrance Cabling

Wiring from cable entrances to terminal boards, plugs, jacks, and similar devices shall be harnessed and clamped or supported in a cable duct.

3.8.20.6.11 Wire

a. Stranded wire shall be preferred; however, solid wire may be used in the equipment, provided such wire is insulated and held in place so that it does not fail or show excessive motion likely to result in failure when the equipment is subjected to vibration and shock encountered under the specified service conditions.
b. Wire shall be continuous from the point of origin, on a discrete device or terminal, to the point of destination, on a discrete device or terminal.
c. Wire and cable shall be supported and secured to prevent stress on the conductors and terminals and change in position of the wire or cable during and after subjecting the equipment to specified service conditions, or after service or repair of the equipment in a normal manner.
d. Twine or tape shall not be used for securing wire and cable.
e. Insulation sleeving of conductors shall be UL listed for the application.

3.8.20.6.12 Wiring - Fungus Protection

Materials that support fungus growth shall not be used for wiring or wiring insulation.

3.8.20.6.13 Wiring - Aluminum Conductors

Aluminum conductors shall not be used for interconnections between LRUs.

3.8.20.6.14 Wiring - Termination of Signal and Control Wiring

Except for terminations using terminal strips, all external signal and control wiring shall be terminated with a connector.

3.8.20.6.15 Wiring - Fiber Optics

The use of fiber optics shall be in accordance with FAA-STD-049.

3.8.21 Toxic Products

a. Toxic products and formulations shall be avoided to the maximum extent possible.
b. Prior FAA approval shall be required on an individual case-by-case basis for any toxic materials usage.

3.8.22 Nameplates and Markings

3.8.22.1 Nameplates

a. Each subsystem shall have one or more nameplates determined by the equipment configuration.
b. Each nameplate shall be in accordance with Figure 3-4.
c. Nameplates shall be attached by a self-adhesive backing or removable 4-40 stainless steel pan-head screws.

3.8.22.1.1 Equipment Titles

a. Unless specifically set forth in the equipment specification, the FAA shall approve titles and type designations.
b. The titles of the equipment specifications shall not be assumed to be the correct equipment titles for use on the nameplates.

3.8.22.1.2 Serial Numbers

a. Serial numbers shall start with one (1) for each equipment unit having an individual nameplate and continue consecutively up to the total number of such equipment units required.
b. Serial numbers for a given part number shall not be duplicated or reassigned.

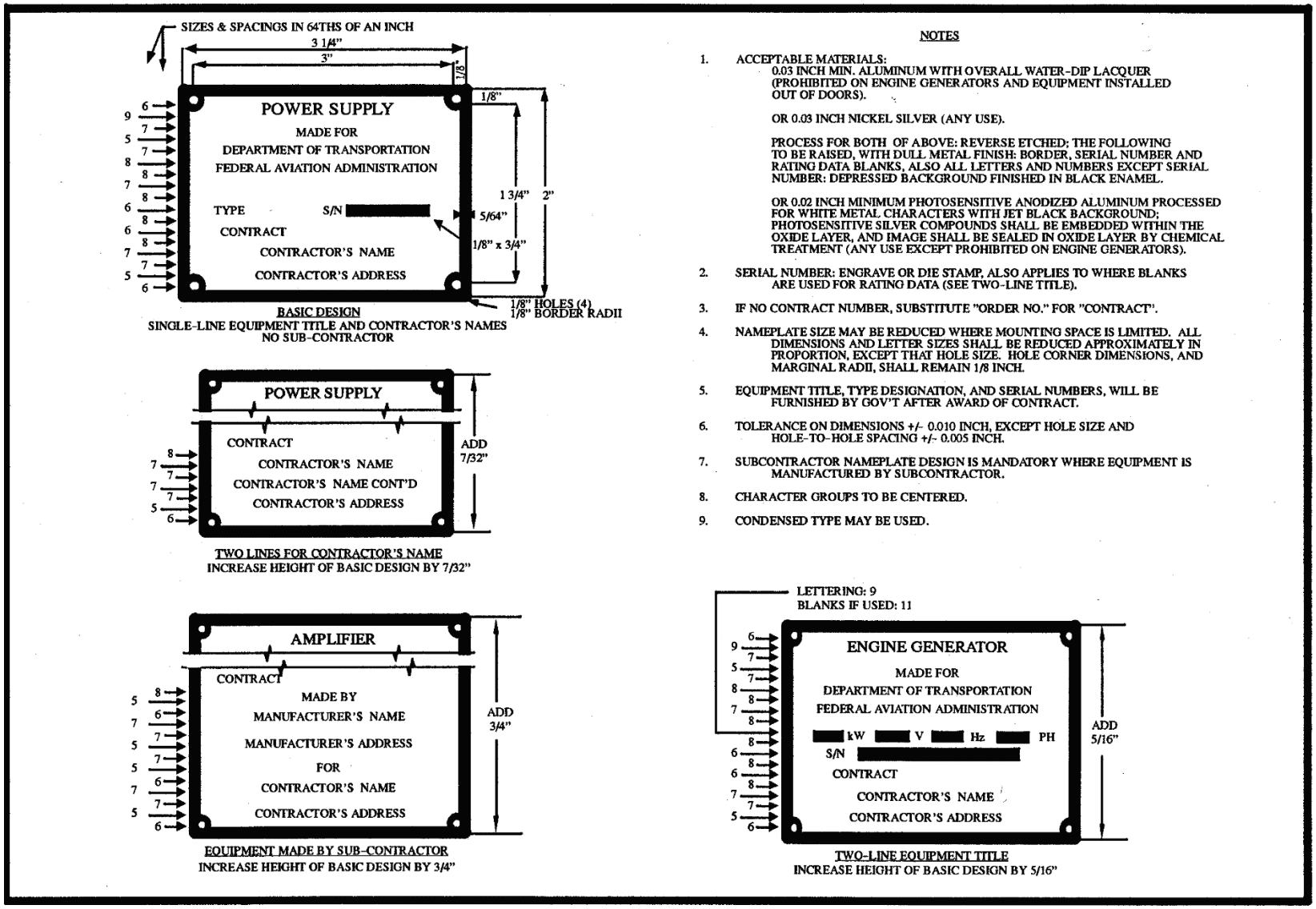

FIGURE 3-4. Nameplates

3.8.22.2 Markings

a. Markings shall be permanent and legible during normal operation and maintenance usage.
b. Markings shall be as specified in ASME Y14.44.

3.8.22.2.1 Visibility of Parts Labels

All LRU parts that have labels or markings identifying data or ratings, shall be mounted so that the data is visible to maintenance personnel without the necessity for disassembly of parts or adjacent functional or structural parts.

3.8.22.2.2 Fuse Position Markings

All fuse positions shall be marked with the rated current capacity of the fuse to be employed therein and approved by the FAA.

3.8.22.2.3 Terminal Strips, Blocks, and Wafer Switches

All terminal strips, blocks, and wafer switches shall be identified.

3.8.22.2.4 Controls and Indicating Devices

a. Markings shall be provided on the front of each exterior and interior panel and panel door, and also on control-mounting surfaces of each chassis, sub-panel, etc., to clearly designate the functions and operations of all controls, fuses, and indicating devices mounted thereon, protruding, or available through access holes therein.
b. All markings shall be located on the panel or chassis in the correct relationship to the respective designated items.

3.8.23 Workmanship

The following workmanship requirements were derived from MIL-HDBK-454.

3.8.23.1 Cleaning

After fabrication, parts and assembled equipment shall be cleaned of smudges; loose, spattered, or excess solder; weld metal; metal chips and mold release agents; and any other foreign material that might detract from the intended operation, function, or appearance of the equipment.

3.8.23.2 Threaded Parts or Devices

Screws, nuts, and bolts shall show no evidence of cross threading, mutilation, or detrimental or hazardous burrs, and should be firmly secured.

3.8.23.3 Shielding

a. Shielding on wires and cables shall be secured in a manner that will prevent them from contacting or shorting exposed current-carrying parts.
b. The ends of the shielding or braid shall be secured to prevent fraying.

3.8.23.4 Containment

a. The harness and cable form containment means shall be neat in appearance, uniformly applied, and positioned to retain critical form factors and breakout locations.
b. The containment means (lacing, ties, tiedown straps, clamps, etc.) shall not cause the wire or cable insulation to deform so that performance characteristics are adversely affected.

3.8.23.5 Insulation

There shall be no evidence of burns, abrading, or pinch marks in the insulation that could cause short circuits or leakage.

3.8.23.6 Clearance

The clearance between wires or cables and heat-generating parts shall be sufficient to minimize deterioration of the wires or cables.

3.8.24 Employee Safety

a. Equipment design shall provide for personnel safety in accordance with IEEE C95.1-2019, Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz.
b. Personnel shall be protected from injury by sharp edges of equipment or cabinets during maintenance.
c. Personnel shall be protected from harm of moving parts when replacing filters.
d. All equipment and enclosures shall be designed and installed so that the enclosure and the mounted LRU and/or components will remain upright and in place, and all access panels, doors, and drawers shall remain secured to the enclosure.
e. The equipment rack shall be bolted to the shelter floor to ensure positive attachment.
f. The materials installed in the equipment shall not liberate gases that, when combined with the atmosphere, form an acid or corrosive alkali, nor shall they generate toxic or corrosive dust, mists, or fumes detrimental to the performance of the equipment or health of the equipment operators.
g. Gases or fumes shall not be detrimental to plants, fish, or wildlife if vented to the outside.
h. The materials shall not liberate gases that will produce a flammable or explosive atmosphere.
i. Mercury and asbestos shall not be used.

3.8.24.1 Electrical Safety

a. A means shall be provided to protect personnel from accidental contact with voltages in excess of 30 V_{rms} or DC during normal operations or maintenance of the equipment.
b. After the power to the equipment is turned off, the system shall discharge all capacitors to 30 V or less within 2 s.
c. Personnel shall be protected from circuits carrying currents greater than 21 mA at 10.5 VAC, and 80 mA at 40 VDC.

d. The hot side of the incoming power line switch connections shall include physical protection against accidental contact.
e. Site-specific Lockout/Tagout (LO/TO) Procedures shall be followed, including zero-energy verification, when de-energizing electrical sources in accordance with OSHA 29 CFR 1910.147 and FAA Order JO 3900.67. If equipment requires revisions to existing LO/TO procedures, written LO/TO procedures shall be updated and readily available at the work area, and personnel shall receive training.
f. Equipment cables shall not cause tripping hazards in accordance with FAA Order 3900.19D and OSHA 29 CFR 1910 Subpart D.

3.8.24.2 Ground Potential

a. The design and construction of the equipment shall ensure that all external parts, surfaces, and shields, exclusive of antenna and transmission line terminals, are at ground potential at all times during normal operation.
b. Any external or interconnecting cable, excluding RF cables, where ground is part of the circuit, shall carry a ground wire in the cable terminated at both ends in the same manner as the other conductors.
c. In no case, except with coaxial cables, shall the shield be depended upon for a current-carrying ground connection.
d. Antenna and transmission line terminals shall be at ground potential, except for RF energy on their external surfaces.
e. A point on the electrically conductive chassis or equipment frame shall serve as the common tie point for the static or power ground.

3.8.24.3 Shielding

a. Except where a conflict with grounding requirements would be created, shielding on wire or cable shall be grounded to the chassis or frame.
b. The shielding shall be at a sufficient distance from exposed conductors to prevent shorting or arcing between the conductor and the shielding under normal operating conditions and worst-case environmental conditions.

3.8.24.4 Guarding of RF Voltages

Transmitter output terminals, antennas, and other devices that carry sufficient RF voltage that may burn or injure personnel shall be protected from accidental contact.

3.8.24.5 Interlocks

a. Interlocks shall be used when voltages between 70–500 V are exposed when the access door, cover, or plate is opened. No interlocks are required when all potentials in excess of 70 V are completely protected with guards or barriers to prevent accidental contact under all operational conditions or any level of maintenance.
b. Bypassable interlock switches shall be momentary action (spring-return) switches marked "INTERLOCK BYPASS" and are provided to allow interlocked access doors and covers

to be opened with a manual latch for "on" position to be operated in the exposed interlock switch, without removing power from the equipment.

c. The bypass switches shall be located so that one person can operate the switch, open the door or cover, and set the manual latch.
d. Non-bypassable interlocks shall be used for access doors, covers, and panels when the voltage accessible or exposed exceeds 500 V, and the current available exceeds 100 mA AC or 160 mA DC.

3.8.24.6 High Voltage Protection

a. Assemblies operating at potentials in excess of 500 V shall be completely enclosed from the remainder of the assembly and interlocked in accordance with the requirements herein. Test probe holes may be provided in the barriers or guards where maintenance testing is required.
b. When the operation or maintenance of equipment is employing potentials in excess of 300 V peak, the equipment shall be provided with test points so these voltages can be measured at a safe potential level.
c. The voltage provided at the test points shall not exceed 300 V peak relative to ground.
d. If a voltage divider is used, the voltage divider resistance between the test point and ground shall consist of at least two equally valued resistors in parallel.

3.8.24.7 High Current Protection

All power buses supplying 25 A or over shall be protected against accidental short circuiting by tools, jewelry, or removable conductive assemblies.

3.8.24.8 Electrical Connectors

a. The design of the connector shall be such that the operator is not exposed to electrical shock or burns when normal disconnection methods are used.
b. Exposed pin contacts shall not be energized (hot) after being disconnected from the socket contacts.

3.8.24.9 Mechanical Hazards

a. Suitable protection shall be provided to prevent contact with moving mechanical parts such as gears, fans, and belts when the equipment is operating.
b. Cabinets, doors, and similar parts shall not have sharp projections.
c. Equipment power switches shall be designed and located to prevent changing the equipment state due to accidental contact by personnel.
d. Equipment with sharp or pointed edges shall be properly guarded (e.g., foam "head-banger"/bumper guards for monitor corners, antennas, shelves/racks, pipes, I-beams, cable trays).

3.8.24.10 Mechanical Interconnection

The design shall provide positive means to prevent the inadvertent reversing or mismatching of fittings, couplings, instrument leads, and electrical connections.

3.8.24.11 Glass Fibers

a. Glass fibrous materials shall not be used as the outer covering on cables, wire, or other items where they may cause skin irritation to operating or maintenance personnel.
b. All glass used in the equipment shall be of the shatterproof type.

3.8.24.12 Safety Markings, Signs, Tags, and Symbols

3.8.24.12.1 Markings

a. Guards, barriers, and access doors, covers, or plates shall be marked to indicate the hazard that may be reached upon removal of such devices.
b. A hazard marking shall be located on the equipment such that it is not removed when the barrier or access door is removed.
c. Warnings of hazards internal to a unit shall be marked adjacent to hazards if they are significantly different from those of surrounding items.
d. Physical hazards shall be marked with color codes in accordance with ANSI Z535.1, where applicable to electronic equipment.
e. LRUs weighing more than 30 pounds shall have caution labels indicating the weight, center of gravity, and number of people recommended for lifting and carrying in accordance with FAA Standard HF-STD-001B, Human Factors Design Standard, Chapter 5.10, Personnel Safety.

3.8.24.12.2 Accident Prevention Signs and Labels

a. Accident prevention signs and labels shall be provided whenever equipment has characteristics or operating conditions that present a hazard to operators and maintenance or other personnel.
b. Signs and labels shall have the same life expectancy, or greater, as the equipment on which they are affixed.

3.8.24.12.3 Sign Design

Signs shall consist of three panels as shown on Figure 3-5.

a. The ratio of width to height of the upper panel (a:b) shall fall within 2:1 to 5:1 inclusive.
b. The lower panel shall be equal to the upper panel width (both equal to a).
c. The lower panel height shall be equal to or greater than the upper panel height, but less than twice the width of the sign ($b \leq c < 2a$).
d. The optional symbol panel shall be square with each edge equal to the sum of the upper and lower panel ($b + c$) and placed to the right.
e. The upper panel shall contain the signal or key word.
f. The lower panel shall contain additional direction or explanation.
g. The wording of this panel shall be brief, provide positive direction, and be limited to a single hazard.

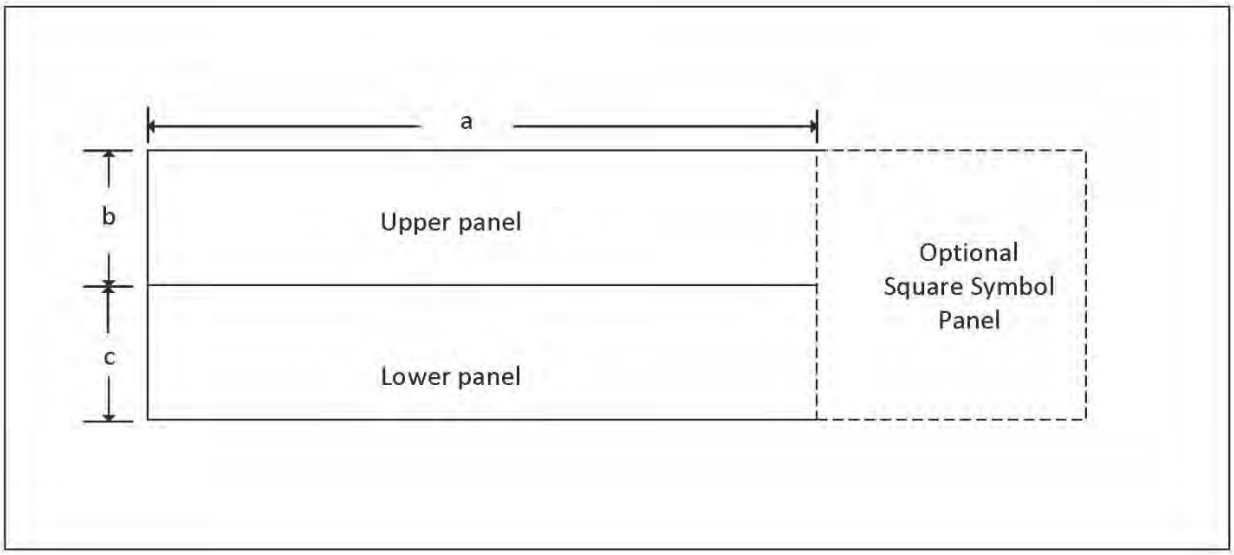

FIGURE 3-5. Personnel Safety Sign Layout

3.8.24.12.4 Sign Classifications and Detailed Design

3.8.24.12.4.1 Class I (Danger)

a. These signs indicate immediate and grave danger, peril, or hazard capable of producing irreversible damage or injury, and prohibitions against harmful activities.
b. These signs shall have the word "DANGER" in white within a red oval outline with a white on black rectangle in the upper panel.
c. The lower panel, for additional wording, shall be in black or red on a white background.

3.8.24.12.4.2 Class II (Caution)

a. These signs are used to call attention to potentially dangerous hazards capable of or resulting in severe, but not irreversible injury, or damage.
b. These signs shall have the signal word "CAUTION" in yellow on a black rectangle in the upper panel. The lower panel, for additional wording, shall be in black on a yellow background.

3.8.24.12.4.3 Class III (General Safety)

a. These signs include notice of general practice and rules relating to health, first aid, housekeeping, and general safety other than the two cases above.
b. These signs shall have the appropriate keyword in white on a green rectangle in the upper panel.
c. The lower panel, for additional wording, shall be in black or green on a white background.

3.8.24.12.4.4 Class IV (Fire and Emergency)

a. These signs shall be used only to label or point the way to fire extinguishing equipment, shutoffs, emergency switches, and emergency procedures.

b. These signs shall have the keyword in white on a red rectangle in the upper panel.
c. The lower panel, for additional wording, shall be in red on a white background.

3.8.24.12.4.5 Sign Placement

a. Signs shall be placed to alert and inform personnel to avoid the hazard or to take appropriate action.
b. Signs shall be readable from a distance commensurate with a. above, create no additional distractions, and not be hazards themselves.

3.8.24.12.5 Symbols

The following symbols shall be used as applicable:

a. Ionizing radiation hazard – ANSI/HPS N2.1.
b. Microwave and radio-frequency radiation – ANSI Z535.2 and IEEE C95.2.

3.8.24.13 Display Warnings

a. Video display warnings shall be provided on equipment with associated video displays to warn operators of impending danger, to alert operators to critical system changes or equipment status, or to remind operators of a critical action that must be taken.
b. Display alert/warnings shall be designed to incorporate clearly discriminative features that distinguish the warning (color, blink, size, etc.) from other display information.

3.8.24.14 Battery Safety

Battery systems may pose electrical safety hazards (electrical shock and arc flash) or chemical hazards if containing electrolytes/acid. An emergency eyewash/shower station shall be located immediately adjacent to strong caustics (e.g., batteries with electrolytes/acid, cleaners) and identified with a highly visible sign in accordance with ANSI Z358.1 and FAA Order 3900.19D.

3.8.24.15 Fire Life Safety

Equipment shall not block egress routes (3’ clearance), sprinklers, or fire extinguishers, and installation/removal activities shall not impact fire barriers/firestop systems (e.g., drilling through fire rated walls or floor penetrations) in accordance with FAA Order JO 6930.1B and OSHA 29 CFR 1910, Subpart E.

3.8.24.16 Seismic Anchoring

Equipment with the potential of falling shall meet the anchoring requirements for seismic activity in accordance with FAA-G-2100J and FEMA E-74.

3.8.24.17 Personal Protective Equipment (PPE)

PPE Hazard Assessments shall be conducted by a Safety and Health Specialist to determine whether hazards are present for selecting PPE (e.g., high voltage, hearing protection devices, eye protection) that will protect affected employee(s) from identified hazards and ensure employees are trained in the proper use, maintenance, and storage in accordance with FAA Order JO

3900.79, ATO Personal Protective Equipment, and FAA Order 3900.19D, Chapter 9, Personal Protective Equipment and Respiratory Protection.

3.8.25 Mechanical Parts

3.8.25.1 Controls and Switches

3.8.25.1.1 Direction of Movement

a. Controls shall be connected in the circuit, so the controlled characteristics (e.g., sensitivity, volume, or voltage) increase with clockwise rotation of the control as seen from the operating position.
b. Movement of a control forward, clockwise, right, or up, shall turn the equipment on, or cause the quantity to increase, the equipment to move forward, clockwise, to the right, or up.

3.8.25.1.2 Operating Controls

Controls necessary for the operation of the equipment shall be located on the front panel of the unit.

3.8.25.1.3 Adjustment Controls

a. Adjustment controls that are required for periodic alignment or calibration shall be mounted behind covered openings (such as access doors), and on the faces of the equipment most accessible when installed.
b. When not adjustable by hand, controls shall be designed to accept a common screwdriver blade tip.
c. Controls that are infrequently adjusted need not be accessible from the operating panel, but shall be readily accessible for servicing without the use of an extender card when the equipment is opened for maintenance purposes.
d. The adjustment range shall not be large enough to cause equipment damage.

3.8.25.1.4 Operation

a. Play and backlash in controls shall be held to a minimum commensurate with intended operational functions, maintaining electrical contact and accurate settings.
b. Controls shall operate freely and smoothly without binding, scraping, or cutting.
c. Normal settings of all continuously variable controls shall not fall in the first tenth or last tenth of angular rotation.

3.8.25.1.5 Stops

a. Mechanical stops shall be provided for all adjustable controls, except controls designed for unlimited rotation.
b. Stops shall be provided on the driving end of the shaft where flexible control shafts are employed or where stops that are integral to the adjustable control or the mechanism could be damaged by excessive torque.

3.8.25.1.6 Locking Devices

a. Control locking devices shall retain the controls in any given setting within the range of control.
b. The locking and unlocking action shall not affect the setting of the control.
c. Where vernier controls are used, the locking devices shall operate on both main and vernier controls, if necessary, to prevent damage.

3.8.25.1.7 Non-Turn Devices

All non-turning controls and bodies or cases of turning controls shall be equipped with a positive device to prevent their turning in the panel or in the assembly on which they are mounted.

3.8.25.2 Fastener Hardware

a. Fasteners shall be able to be removed and installed without damage to hardware.
b. Fasteners shall remain secure when exposed to equipment operational and environmental stresses.
c. Except for those items designed to be affixed with one fastener, parts shall be secured so the failure of a single fastener will not free the part completely.
d. Friction between mating surfaces shall not be employed as the sole means of preventing fixed parts from rotating or shifting.
e. Fasteners shall be selected to minimize the number of standard tools used during maintenance.

3.8.25.3 Ventilating Fan Motors

All ventilating fan motors (commonly called pancake type) shall:

a. Be ball bearing type;
b. Not be required to have overload protection if they are of inherently safe construction (i.e., can be continuously energized with their rotation blocked); and
c. Be of frame construction type.

3.8.25.4 Bearings

Any bearings used shall not require maintenance.

3.8.26 Human Engineering

3.8.26.1 Noise Criteria

Equipment located in general work areas (areas requiring occasional telephone use or occasional direct oral communications at distances up to 1.5 m (approximately 5 ft)) shall not exceed 65 dB(A).

3.8.26.2 Identification of Noise Hazard Areas and Equipment

a. Noise levels greater than 85 dBA or impulse/impact noise above 140 dB peak sound pressure level, regardless of exposure time, shall require hearing protection devices (HPDs) and compliant caution signage posted prior to entering areas with equipment exceeding

these noise levels according to OSHA 1910.95 and FAA Order 3900.19. Only Safety and Health Specialists can assign HPDs.

b. Noise caution signs shall be clearly visible and legible to all personnel exposed to the hazard.

3.8.26.3 Display Information

a. The information generated by the equipment shall be capable of selection by and display to an operator.
b. Information shall be limited to that which is necessary to perform specific actions or to make decisions.
c. Numeric digital displays shall not be used as the only display of information when perception of pattern or variation is important to correct comprehension of the information.
d. Numeric digital displays shall not be used when rapid or slow digital display rates inhibit proper understanding.
e. The absence of an indication on status displays shall not be used to indicate critical occurrences (i.e., indicates that the valve has actually closed and not that the button has been pushed or voltage applied).

3.8.26.4 Virtual Displays - Flash

a. The flash rate shall be two flashes per second.
b. The flash on time shall be 0.25 ± 0.025 s.
c. The flash off time shall be 0.25 ± 0.025 s.

3.9 Installation

The equipment shall be designed for installation, removal, and reinstallation without special tools unless approved by the FAA.

4. VERIFICATION

4.1 Methods of Verification

4.1.1 Inspection (I)

Inspection is a verification method that is accomplished by a visual examination of the item, reviewing descriptive documentation, and comparing the appropriate characteristics with predetermined standards to determine conformance to requirements without laboratory equipment or procedures.

4.1.2 Analysis (A)

Analysis is a verification method that consists of comparing hardware or software design with known scientific and technical principles, technical data, models, or procedures and practices to verify that the proposed design will meet the specified functional/performance requirements.

4.1.3 Demonstration (D)

Demonstration is a verification method that is accomplished by operation, adjustment, or reconfiguration of items performing their designed functions under specific scenarios. The items may be instrumented and quantitative limits of performance monitored, but only observational data rather than actual performance data is required to be recorded for verification. Demonstration is often used to verify compliance with servicing, reliability, maintainability, transportability, and human factors engineering requirements.

4.1.4 Test (T)

Test is a verification method that is accomplished, with or without instrumentation, through systematic exercising of the application item under appropriate conditions with the collection, analysis, and evaluation of quantitative data.

4.2 Test Allocation

4.2.1 Development Test (DT)

The primary objective of DT is to demonstrate that all specified technical and performance requirements for a system or service have been met. DT is typically conducted within a controlled test environment and may include the use of third-party test facilities or laboratories. DT is conducted prior to FAA acceptance of the first article units.

4.2.2 Operational Test (OT)

OT encompasses the test and evaluation of a system's or service's operational requirements. The primary objective of OT is to examine performance and determine operational readiness (effectiveness and suitability) of a new or modified system for use in the NAS and that the NAS infrastructure is ready to accept the system. The FAA conducts OT on a fully installed system at the William J. Hughes Technical Center and other designated operational sites.

4.3 General Procedures

4.3.1 Test Tools

4.3.1.1 Electronic Test Equipment

All electronic test equipment used to verify the requirements of Section 3 shall be calibrated to National Institute of Standards and Technology (NIST) traceable standards, where appropriate.

4.3.1.2 Test Simulators

Simulators used to verify the requirements of Section 3 shall be validated prior to use. Validation demonstrates that the simulator accurately represents the test conditions and scenarios necessary to verify the Section 3 requirements.

4.3.1.3 Antenna Test Range

Any antenna test range used to verify the requirements of Section 3 shall be designed and developed in accordance with the Institute of Electrical and Electronics Engineers Standard 149-1979 Test Procedures for Antennas (IEEE 149-1979). This includes both anechoic chambers and outdoor test facilities.

4.3.2 Pulse Characteristics

Measurements of pulse characteristics shall be made using a linear RF detector.

4.3.2.1 Spacing

The spacing between two pulses shall be measured from the 50% voltage amplitude point on the leading edge of the first RF pulse to the corresponding point on the leading edge of the second RF pulse.

4.3.2.2 Rise Time

The rise time of a pulse shall be measured between the 10% and 90% voltage amplitude values on the leading edge of the waveform.

4.3.2.3 Decay Time

The decay time of a pulse shall be measured between the 90% and 10% voltage amplitude values on the trailing edge of the waveform.

4.3.2.4 Pulse Top

Measurements of the characteristics of the pulse top are limited to the points of the pulse between the 95% voltage amplitude point on the leading edge of the pulse and the 95% voltage amplitude point on the trailing edge of the pulse.

4.3.2.5 Pulse Width

The pulse width shall be measured between the 50% amplitude points of the leading and trailing edges of the pulse.

4.3.3 Electrical Grounding

Grounding shall be considered satisfactory if the electrical connection between the item of interest and the system tie point exhibits a resistance of 0.1 Ω or less and has sufficient capacity to ensure the reliable and immediate tripping of equipment overcurrent protection devices.

4.4 Specific Procedures

4.4.1 Environmental Conditions

4.4.1.1 Non-Operating Conditions

Testing of the non-operational environmental conditions shall be conducted on the DME System as packaged for storage and/or transport. The DME System shall be inspected and functionality checked before and after the completion of each test. The DME System shall not be damaged and be fully operable after completion of each test.

Tests of the non-operating environmental conditions may be combined to conserve time and resources as long as the environmental exposure conditions and durations are unchanged.

4.4.1.1.1 Non-Operating High Temperature

Requirement Reference: 3.1.5.1.1

The DME System shall be tested in accordance with MIL-STD-810H. Procedure I of Method 501.7 shall be used with the high temperature cycles listed in Table 501.7-III for Induced Conditions. At least seven temperature cycles shall be completed. The dwell time at the maximum temperature of 71°C shall be at least one hour for each cycle.

4.4.1.1.2 Non-Operating Low Temperature

Requirement Reference: 3.1.5.1.1

The DME System shall be tested in accordance with MIL-STD-810H. Procedure I of Method 502.7 shall be used with the low temperature cycles listed for Cold (C2) in Table 502.7-I for Induced Environment (-37°C to -46°C). At least seven temperature cycles shall be completed. The dwell time at the minimum temperature of -46°C shall be at least one hour for each cycle.

4.4.1.1.3 Non-Operating Altitude

Requirement Reference: 3.1.5.1.2

Test or analysis shall be conducted to verify the DME System conformance to the altitude requirements. If analysis is used, then the effects of the low atmospheric pressure on each component shall be evaluated and presented for compliance. If test is used, then the DME System shall be tested in accordance with MIL-STD-810H. Procedure I of Method 500.6 shall be used with a minimum test pressure of 575 mbar (57.5 kPa or 8.3 psia, equating to an altitude of approximately 15 000 ft above sea level) and a maximum test pressure of 1025 mbar (102.5 kPa or 14.9 psia, equating to an altitude of approximately 300 ft below sea level). The DME System shall be exposed to the minimum and maximum pressures for a duration of at least one hour each.

4.4.1.1.4 Vibration

Requirement Reference: 3.1.5.1.3

The DME System shall be tested in accordance with MIL-STD-810H. Procedure I of Method 514.8 shall be used with the exposure levels and vibrational spectra given in paragraph 2.1.3 and Table 514.8C-I of Method 514.8 Annex C of MIL-STD-810H and the exposure duration of two hours (as provided in Annex C paragraph 2.1.4 for 2000 miles of road travel).

4.4.1.1.5 Shock

Requirement Reference: 3.1.5.1.4

The DME System shall be tested in accordance with MIL-STD-810H. Procedure II of Method 516.8 shall be used with the classical shock pulse described in paragraph 2.3.2.3 and the transportation shock sequence listed in Table 516.8-VII. This test may be conducted in conjunction with the vibration test.

4.4.1.2 Operating Conditions

Testing of the operational environmental conditions shall be conducted on the DME System installed in an operational configuration (upright and level). The DME antenna(s) under test shall be mounted in accordance with 3.3.9. The DME electronics cabinet (indoor) and DME antenna(s) (outdoor) may be tested separately or simultaneously. In either case, the DME electronics cabinet under test shall be connected to a DME antenna or antenna simulator to observe system functionality for the duration of the test. Likewise, the DME antenna(s) under test shall be connected to an operating DME electronics cabinet for the duration of the test.

4.4.1.2.1 Operating High Temperature

Requirement References: 3.1.5.2.1 and 3.1.5.2.2

The DME System shall be tested in accordance with MIL-STD-810H. Procedure II of Method 501.7 shall be used with the high temperature cycles listed in Table 501.7-III for Induced Conditions. However, a maximum temperature of 50°C shall be used instead of 49°C. At least seven temperature cycles shall be completed. The dwell time at the maximum temperature of 50°C shall be at least one hour for each cycle.

4.4.1.2.2 Operating Low Temperature

Requirement References: 3.1.5.2.1 and 3.1.5.2.2

The DME System shall be tested in accordance with MIL-STD-810H. Procedure II of Method 502.7 shall be used. For outdoor LRUs, the temperature cycles listed for Cold (C2) in Table 502.7-I for Induced Environment (-46°C) shall be used. For indoor LRUs, the minimum temperature shall be -10°C. At least 7 temperature cycles shall be completed for each indoor and outdoor LRUs. The dwell time at the minimum temperature shall be at least one hour for each cycle.

4.4.1.2.3 Rain

Requirement Reference: 3.1.5.2.3

The DME antenna(s) shall be tested in accordance with MIL-STD-810H. Depending on the test facility capability, either Procedure I or Procedure II of Method 506.6 shall be used. The antenna(s) shall be exposed to a minimum rain rate of 1.7 mm/minute (4 inches/hour) with variable winds of up to 18 m/s (40 mph) for a duration of at least 1 hour. The wind direction shall be rotated 90 degrees every 15 minutes. The wind speed of 18 m/s shall be achieved for at least 225 seconds for each direction.

4.4.1.2.4 Operating Altitude

Requirement Reference: 3.1.5.2.4

Test, analysis, or combination thereof shall be conducted to verify the DME System conformance to the altitude requirements. If analysis is used, then the effects of the low atmospheric pressure on each component shall be evaluated and presented for compliance. This analysis shall include heating/cooling and arcing/coronal discharge effects due to changes in atmospheric pressure. If test is used, then the DME System shall be tested in accordance with MIL-STD-810H. Procedure II of Method 500.6 shall be used with a minimum test pressure of 700 mbar (70.0 kPa or 10.2 psia, equating to an altitude of approximately 10 000 ft above sea level) and a maximum test pressure of 1025 mbar (102.5 kPa or 14.9 psia, equating to an altitude of approximately 300 ft below sea level). The DME System shall be exposed to the minimum and maximum pressures for a duration of at least one hour each.

4.4.1.2.5 Wind and Ice Loading

Requirement References: 3.1.5.2.5 and 3.1.5.2.6

Test, analysis, or combination thereof shall be conducted to verify DME antenna conformance to the wind and ice loading requirements. Analysis shall demonstrate the mechanical survivability of the antenna and radome when subjected to 100 MPH winds and covered with ½ inch of clear ice. If a dynamic test is conducted, the wind shall be applied in at least two separate directions. These two directions shall be orthogonal. The wind shall be applied for a duration of at least one minute in each direction. If a static test is conducted, then analysis shall be provided to substantiate the load levels and points of application.

4.4.1.2.6 Humidity

Requirement Reference: 3.1.5.2.7

The DME System shall be tested in accordance with MIL-STD-810H. For indoor LRUs, Procedure Ia of Method 507.6 shall be used with Induced Cycle B1 as shown on Figure 507.6-1 and Table 507.6-III. At least three humidity cycles shall be completed. For outdoor LRUs, Procedure Ib of Method 507.6 shall be used with Natural Cycle B3 – Hot Humid as shown in Figure 507.6-6 and Table 507.6-VIII. At least 7 humidity cycles shall be completed. This test may be conducted contemporaneously with temperature testing.

4.4.1.2.7 Fine Sand (Dust)

Requirement Reference: 3.1.5.2.8

The ability of the DME antenna(s) to withstand penetration of sand and dust shall be verified through analysis and demonstration.

The analysis shall evaluate the antenna(s) for potential intrusion areas and show that mitigation(s) have been implemented and designed to last the lifetime of the equipment. This analysis shall include the evaluation of any gasket or seal material for suitability of use in all environmental conditions.

The ability of the antenna system to withstand penetration of sand and dust shall be demonstrated by successful completion of the rain test as described in paragraph 4.4.1.2.3.

4.4.2 Electromagnetic Compatibility (EMC)

Requirement Reference: 3.1.6

The DME System shall be tested in accordance with the applicable requirements and associated procedures of MIL-STD-461G *Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment* listed in the table below. For the purpose of requirements applicability, testing shall be consistent with Navy Ground equipment. The testing shall be conducted using a specialized test facility designed to make such measurements.

Table 4-1 Applicable Requirements From MIL-STD-461G

Test ID	MIL-STD-461G Paragraph	Title	Applicability	Performance Requirement
CE102	5.5	Conducted Emissions, Radio Frequency Potential, Power Leads	10 kHz to 10 MHz for all power leads.	Conducted emissions shall not exceed those on Figure CE102-1 of MIL-STD-461G.
CE106	5.6	Conducted Emissions, Antenna Port	1 MHz to 18 GHz	1. Receivers: 34 dBµV 2. Transmitters and amplifiers (standby): 34 dBµV 3. Transmitters and amplifiers (transmit): Harmonics, except the second and third, and all other spurious emissions shall be at least 80 dB down from the level at the fundamental. The second and third harmonics shall be suppressed to a level of -20 dBm or 80 dB below the fundamental, whichever requires less suppression.

Test ID	MIL-STD-461G Paragraph	Title	Applicability	Performance Requirement
CS101	5.7	Conducted Susceptibility, Power Leads	30 Hz to 150 kHz for equipment and subsystem AC and DC power leads.	No out-of-tolerance (OOT) performance or malfunction when subjected to voltages on Figure CS101-1 or powers on Figure CS101-2 of MIL-STD-461G.
CS103	5.8	Conducted Susceptibility, Antenna Port, Intermodulation	10 MHz to 3 GHz	66 dB above the level required to obtain the standard reference output for the receiver.
CS104	5.9	Conducted Susceptibility, Antenna Port, Reject of Undesired Signals	30 Hz to 20 GHz Excluding the on-channel frequency band. This is applicable to both the transceiver and monitor inputs.	No OOT performance or malfunction when subjected to the specified maximum input levels.
CS114	5.12	Conducted Susceptibility, Bulk Cable Injection	10 kHz to 200 MHz for all interconnecting cables, including power cables.	No OOT performance or malfunction when subjected to injection probe levels shown on Figure CS114-1 of MIL-STD-461G utilizing the Navy-Ground limits.
CS115	5.13	Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation	All interconnecting cables, including power cables.	No OOT performance or malfunction when subjected to a pre-calibrated signal having the rise and fall times, pulse width, and amplitude as specified on Figure CS115-1 of MIL-STD-461G, at a 30 Hz rate for one minute.
CS116	5.14	Conducted Susceptibility, Damped Sinusoidal Transients, Cables And Power Leads	10 kHz to 100 MHz for all interconnecting cables, including power cables and individual high side power leads.	No OOT performance or malfunction when subjected to a signal having the waveform shown on Figure CS116-1 and having a maximum current as specified on Figure CS116-2 of MIL-STD-461G. The limit is applicable across the entire specified frequency range. Compliance shall be demonstrated at the following frequencies: 0.01, 0.1, 1, 10, 30, and 100 MHz.

Test ID	MIL-STD-461G Paragraph	Title	Applicability	Performance Requirement
CS117	5.15	Conducted Susceptibility, Lightning Induced Transients, Cables And Power Leads	All interconnecting equipment cables including complete power cables, and individual high side power leads.	No OOT performance or malfunction when subjected to the levels and lightning transients specified in Table VII of MIL-STD-461G and supplemented by the waveform and timing definitions shown on Figures CS117-1 through CS117-8 of MIL-STD-461G.
CS118	5.16	Personnel Borne Electrostatic Discharge	All electrical, electronic, and electromechanical subsystems and equipment that have a man-machine interface.	No OOT performance or malfunction when subjected to the values shown in Table VIII of MIL-STD-461G while discharging from a 150 pF capacitor through a 330 Ω resistor with a circuit inductance not to exceed 5 microhenry (µH). Contact discharge at 8 kV is required for conductive surfaces.
RE102	5.18	Radiated Emissions, Electric Field	2 MHz to 18 GHz for equipment and subsystem enclosures, and all interconnecting cables.	Electric field emissions shall not be radiated in excess of those shown for "Navy-Fixed" on Figure RE102-4 of MIL-STD-461G.
RS103	5.21	Radiated Susceptibility, Electric Field	30 MHz to 18 GHz for equipment and subsystem enclosures and all interconnecting cables.	No OOT performance or malfunction when subjected to the radiated electric fields listed for Ground-Navy applications in Table XI of MIL-STD-461G.

4.4.3 Receiver Recovery Time

Requirement Reference: 3.2.3.4

The 8 µs spacing referenced in 3.2.3.4-a shall be measured between the 50% voltage point on the leading edge of the second pulse of the undesired pulse pair and the corresponding point in the leading edge of the first pulse of the desired pulse pair.

4.4.4 Receiver Sensitivity

4.4.4.1 Variation with Interrogation Loading

Requirement Reference: 3.2.3.6.1.1

The minimum interrogation rate used to measure sensitivity shall be 30 ppps. Measuring sensitivity would not be possible if the transmission rate were 0% (i.e., 0 interrogations). Therefore, the minimum rate used during test corresponds to the approximate interrogation rate from one user.

4.4.4.2 Adjacent Channel Interrogations

Requirement Reference: 3.2.3.6.1.2

When interrogated by signals ±900 kHz or greater removed from the assigned channel nominal frequency, noise may cause the transmitter to generate pulse pairs up to 5% of the of the off-channel interrogation rate. These noise-generated pulse pairs may be indistinguishable from pulse pairs generated in response to the off-channel interrogation (i.e., triggered). The test limits shall account for the noise-generated pulse pair allowance.

4.4.5 Reserved

4.4.6 Tuning and Spurious Output

Requirement Reference: 3.2.5.2

The requirement of 3.2.5.2-a shall be verified with the equipment cabinet doors in both the open and closed positions.

The requirement of 3.2.5.2-b shall be verified by measuring the maximum signal at the output of the transmitter signal cabinet when the system is powered on, but not transmitting.

4.4.7 Pulse Shape

Requirement References: 3.2.5.4.2-b and 3.2.6.1

The rise time, pulse top, pulse width, and decay time requirements shall be verified at both of the initial power output settings identified in 3.2.5.4.1 and at the lowest test setting power output identified in 3.2.5.4.2-a.

4.4.8 Pulse Coding

Requirement References: 3.2.5.4.2-b and 3.2.6.2

The pulse coding (spacing) shall be verified at both of the initial power output settings identified in 3.2.5.4.1 and at the lowest test setting power output identified in 3.2.5.4.2-a. The spacing shall be measured between the 50% maximum voltage amplitude point on the leading edge of the first RF pulse to the corresponding point on the leading edge of the second RF pulse.

4.4.9 RF Pulse Spectrum

Requirement Reference: 3.2.6.5

For determining the effective radiated power (ERP), the gain of the antenna shall be assumed to be 8 dBi and cable losses shall be assumed to be 3 dB.

4.4.10 Out-of-Band Spurious Radiation

Requirement Reference: 3.2.6.6

Verification of the out-of-band spurious radiation requirement in 3.2.6.6-b shall be evaluated by using a receiver having a 6 dB bandwidth of 100 kHz or less. For determining the equivalent

isotropically radiated power (EIRP), the gain of the antenna shall be assumed to be 8 dBi and cable losses shall be assumed to be 3 dB.

4.4.11 Antenna Procedures

4.4.11.1 Polarization

Requirement Reference: 3.3.3

Measurement of the horizontal component of the radiated signal shall be accomplished using an antenna test range specifically designed to make such measurements. The range shall be an outdoor facility or an anechoic chamber. In either case, the effects of multipath and external interference shall be mitigated and as low as practicable. The measurement shall demonstrate that the vertically polarized radiated energy is greater than the horizontally polarized radiated energy.

4.4.11.2 VSWR

Requirement Reference: 3.3.4

The VSWR shall be measured at the end of a 50-Ω low loss cable that is less than 20 ft in length.

4.4.11.3 Gain

Requirement Reference: 3.3.5

Measurement of the peak antenna gain shall be accomplished using an antenna test range specifically designed to make such measurements. Either the absolute-gain or the gain-transfer method, as described in IEEE STD 149-1979, shall be used. The range shall be an outdoor facility or an anechoic chamber. In either case, the effects of multipath and external interference shall be mitigated and as low as practicable.

4.4.11.4 Vertical Field Pattern

Requirement Reference: 3.3.6

Measurement of vertical field pattern shall be accomplished using an antenna test range specifically designed to make such measurements. The range shall be an outdoor facility or an anechoic chamber. In either case, the effects of multipath and external interference shall be mitigated and as low as practicable. The vertical pattern shall be measured from 90 degrees below the horizon to 90 degrees above the horizon. Measurements shall be taken in azimuth increments less than or equal to 1 degree.

4.4.11.5 Horizontal Field Pattern

Requirement Reference: 3.3.7

Measurement of horizontal field pattern shall be accomplished using an antenna test range specifically designed to make such measurements. The range shall be an outdoor facility or an anechoic chamber. In either case, the effects of multipath and external interference shall be mitigated and as low as practicable. The full 360-degree horizontal pattern shall be measured. Measurements shall be taken in azimuth increments less than or equal to 1 degree.

4.4.12 Power Quality Requirements

Requirement Reference 3.8.12.5 and 3.8.12.6

Power quality is described by a set of parameters such as continuity of service, variation in voltage magnitude, transient voltages and currents, and harmonic content in waveforms.

The main test measurements on the supply or the load that can be made to determine these factors are:

- Harmonics and Total Harmonic Distortion (THD)
- Power Factor Displacement
- Inrush currents (start-up effects of motors and inductive loads)

Figure 4-1 shows the mandated power test and measurement decision flow.

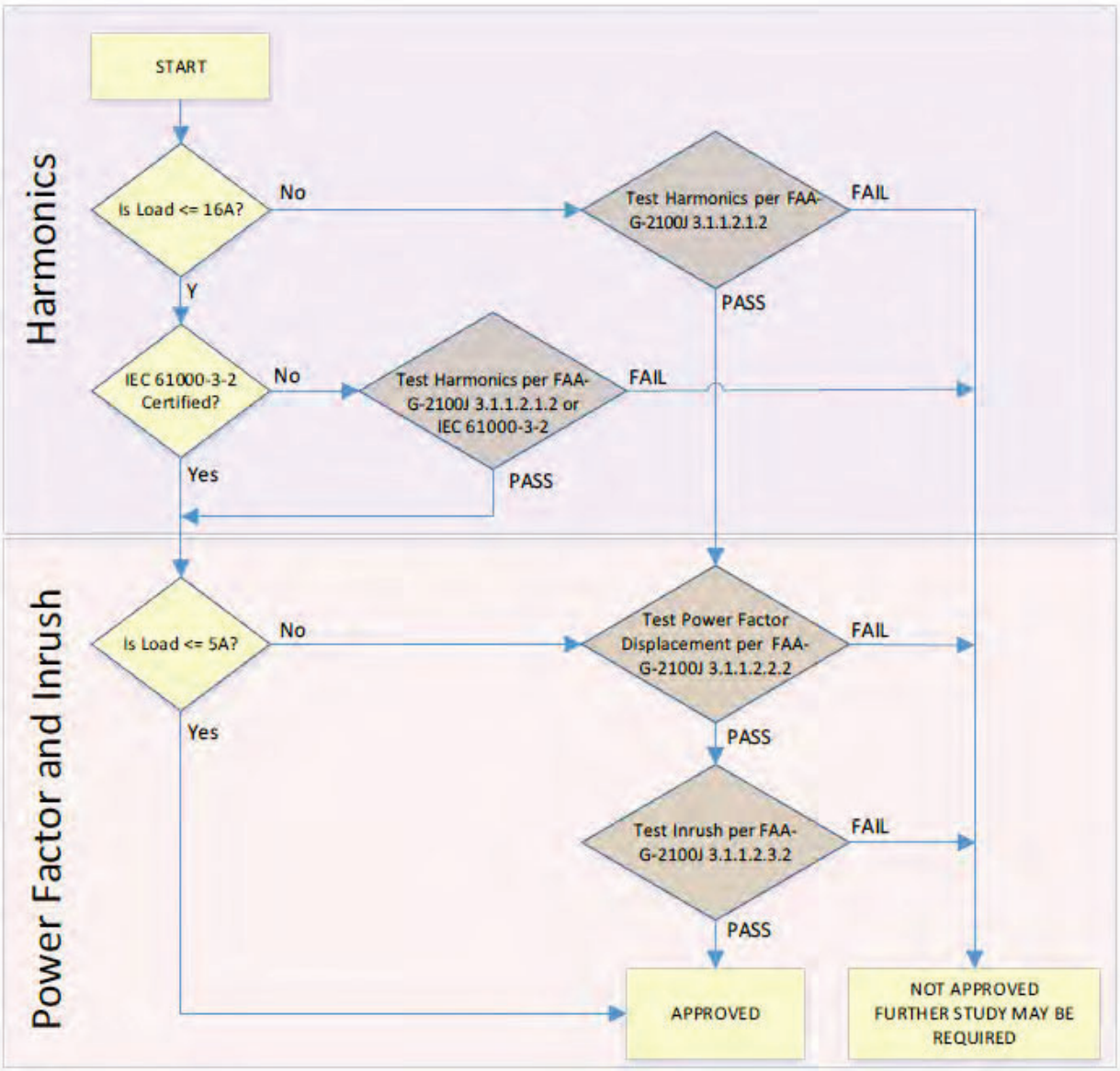

FIGURE 4-1. Power Quality Tests and Measurements Flow

4.4.12.1 Power Factor

Requirement Reference: 3.8.12.5

The following power factor measurements and definitions are adapted from FAA-G-2100J, Section 3.1.1.2.

All rack power measurements shall be taken at the distribution panel circuit breaker feeding the rack being tested. All standalone equipment power measurements shall be taken at the distribution panel circuit breaker feeding the equipment being tested. For system level, testing shall be performed at the circuit breaker controlling all power for each main power bus system under test.

Power factor (PF) shall be defined as the absolute value of the product of the displacement component of power factor and the distortion component of power factor.

$PF = |PF_{disp} \times PF_{dist}|$

The displacement component of the power factor, PF_{disp}, is equal to the cosine of the angle (θ) between voltage and current, which can be calculated by dividing the power dissipation in watts by the apparent power in volt-amperes (VA).

$PF_{disp} = COS(\theta) = Watts/VA$

The distortion component of the power factor, PF_{dist}, is equal to the reciprocal of the square root of one plus the square of the total harmonic distortion of the equipment (THD) as defined in IEEE 519.

$$PF_{dist} = \frac{1}{\sqrt{1 + (THD)^2}}$$

4.4.12.2 Inrush Currents

Requirement Reference: 3.8.12.6

The following inrush current measurements and definitions are adapted from FAA-G-2100J, Section 3.1.1.2.3.

All rack power measurements shall be taken at the distribution panel circuit breaker feeding the rack being tested. All standalone equipment power measurements shall be taken at the distribution panel circuit breaker feeding the equipment being tested. For system level, testing shall be performed at the circuit breaker controlling all power for each main power bus system under test.

Inrush current shall be measured by energizing the load or device within 10 degrees of the positive (80 to 90 degrees), and the negative (260 to 270 degrees) peaks of the sine wave of applied voltage as shown on Figure 4-2.

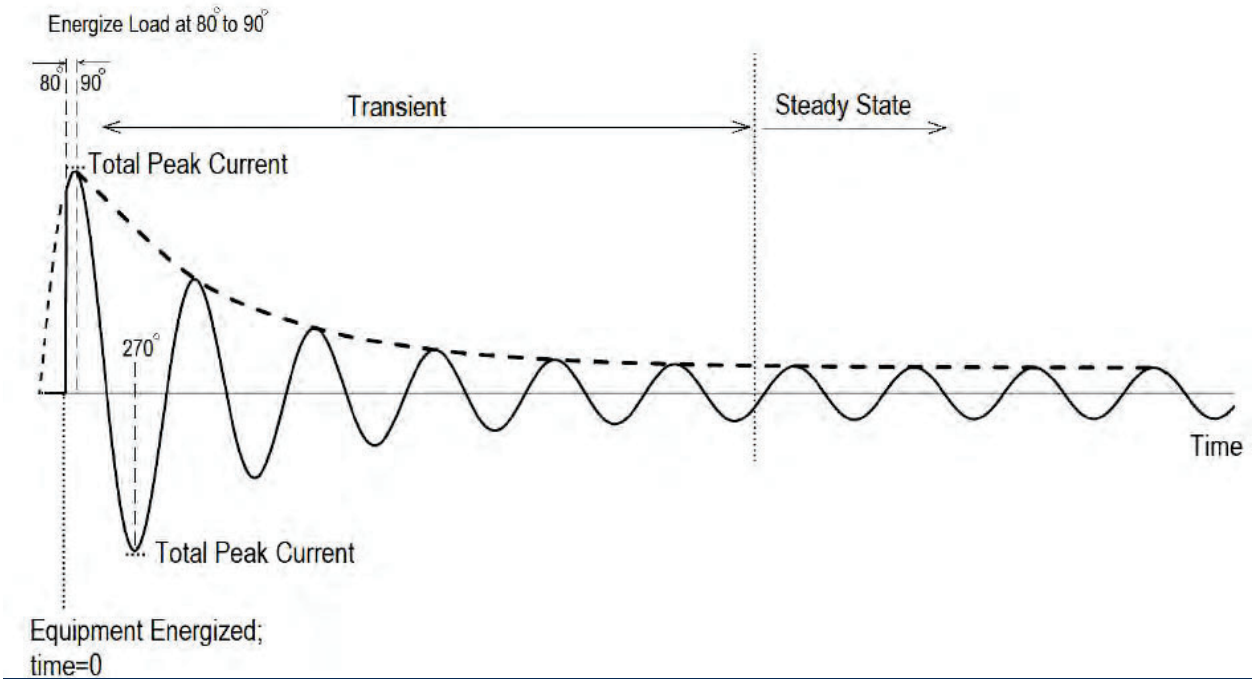

FIGURE 4-2. Inrush Current Limit Measurements

The steady-state values of rms current shall be measured.

The test voltage source shall have at least five times the full load or steady-state rms current rating of the load or device under test at the point of connection of the device or load under test. Total voltage distortion of the source shall not exceed 3%.

Cord connected equipment shall be connected to the test voltage source with the same size, type and length of cord to be furnished with the load or device under test. All other devices or loads shall be connected to the test voltage source with conductors that are four feet long, sized for their rms current in accordance with NFPA 70. All cords and conductors shall be directly connected to the test voltage source.

4.5 Verification Requirements Traceability Matrix

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3	Requirements	N/A – header only				Header only, no IADT
3.1	General Requirements	N/A – header only				Header only, no IADT
3.1.1	System Characteristics	The DME transponder shall:	D, T			Lead-in shall statement.
3.1.1-a		Operate with the DME antenna types described in 3.3 using RF cables up to a maximum length of 500 ft;	D, T			
3.1.1-b		Produce and radiate International Morse Code (Morse Code) identification signals, as described in 3.2.4;	D, T			
3.1.1-c		Receive and decode interrogation signals (3.2.3.2);	D, T			
3.1.1-d		In response to interrogation signals, radiate a properly coded reply pulse pair (3.2.6.2) after a specific reply delay time (3.2.6.3); and	D, T			
3.1.1-e		Produce and radiate random pulse pairs as described in 3.2.3.8.	D, T			
3.1.2-a	Interlock Signal from the Instrument Landing System (ILS)	The transponder equipment shall be capable of accepting a dry contact remote interlock signal of up to 35V DC from an ILS localizer.	D			
3.1.2-b		The transponder shall be put in standby (not radiating) when the interlock signal is absent and automatically start operating (radiate) when the signal is present, if otherwise enabled.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.1.2-c		The logic of the interlock signal shall be selectable high-to-low or low-to-high trigger.	D			
3.1.3-a	Integrity of Signal	The integrity of the signal, expressed as a probability of not transmitting false guidance signals (3.2.5.6), shall be equal to or greater than 0.9999999, which is equivalent to $1 - 10^{-7}$.	A			
3.1.3-b		The implemented system design shall ensure that no single event or failure causes an out-of-tolerance range condition that persists beyond the monitor response time.	A			
3.1.3-c		The implemented system design shall provide mechanisms that prevent unintended changes to parameters that could result in an out-of-tolerance range condition and/or unintended outage.	A			
3.1.4-a	Assigned Channel Assurance	The likelihood of transmitting on an unassigned frequency (±300 kHz or more from the assigned frequency) shall be less than 1×10^{-7}.	A			
3.1.4-b		The implemented system design shall ensure that no single event or failure causes transmission on an unassigned frequency that persists beyond the monitor response time.	A			
3.1.4-c		The implemented system design shall provide mechanisms that prevent unintended changes to parameters that could result in transmission on an unassigned frequency.	A			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.1.5	Environmental Operating Conditions	Unless otherwise stated, all requirements of this specification shall be met over the full range of service conditions, derived from MIL-STD-810, described below.	I, A, T	D		Roll-up req.
3.1.5.1	Non-Operating Conditions	N/A Header only.				Header only, no IADT
3.1.5.1.1	Non-Operating Temperature Range	The DME System packaged for storage, shipping, or transporting (non-operating) shall withstand a temperature range of -46°C to +71°C.	T		4.4.1.1.1 4.4.1.1.2	
3.1.5.1.2	Non-Operating Altitude	The DME System packaged for storage, shipping, or transporting (non-operating) shall withstand atmospheric pressure of 575 to 1025 mbar (equivalent to approximately 15 000 ft above sea level in a standard atmosphere down to approximately 300 ft below sea level).	T, A		4.4.1.1.3	
3.1.5.1.3	Vibration	The DME System shall not be damaged when subjected to the vibrations listed in Table 514.8C-I, Method 514.8 Annex C of MIL-STD-810, and the exposure durations provided in Annex C paragraph 2.1.4.	T		4.4.1.1.4	
3.1.5.1.4	Shock	The DME System shall not be damaged when subjected to the mechanically induced shock as specified in Method 516.8, Procedure II of MIL-STD-810.	T		4.4.1.1.5	
3.1.5.2	Operating Conditions	N/A Header only.				Header only, no IADT

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.1.5.2.1	Outdoor Temperature	All outdoor equipment shall operate in the temperature range of -46°C to +50°C.	T		4.4.1.2.1 4.4.1.2.2	
3.1.5.2.2	Indoor Temperature	All indoor equipment shall operate in the temperature range of -10°C to +50°C.	T		4.4.1.2.1 4.4.1.2.2	
3.1.5.2.3	Rain	All outdoor equipment shall operate while exposed to wind-blown rain, at a rate of 1.7 mm/minute (4 inches/hour), and up to 18 m/s (40 mph) blowing wind.	T		4.4.1.2.3	
3.1.5.2.4	Operating Altitude	All indoor and outdoor equipment shall operate over the atmospheric pressure range of 700 to 1025 mbar (equivalent to approximately 10 000 ft above sea level in a standard atmosphere down to approximately 300 ft below sea level).	T, A		4.4.1.2.4	
3.1.5.2.5	Wind Velocity	The DME antenna shall withstand blowing wind conditions up to 100 mph.	T, A		4.4.1.2.5	
3.1.5.2.6	Ice Loading	The DME antenna shall withstand up to 0.5 inches accumulation of clear ice on all outdoor components.	T		4.4.1.2.5	
3.1.5.2.7-a	Humidity	Equipment shall operate within a relative humidity range from 5% to 100% when the temperature is 40°C or less.	T		4.4.1.2.6	
3.1.5.2.7-b		Above 40°C, the equipment shall operate with a relative humidity based upon a dew point of 40°C.	T		4.4.1.2.6	
3.1.5.2.8	Fine Sand (Dust)	The DME antenna outdoor equipment shall be impervious to sand and dust intrusion, as described in 4.4.1.2.7.	T		4.4.1.2.3 4.4.1.2.7	

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.1.5.3	Lightning Protection	The electronic equipment shall be provided with devices that protect against atmospheric electricity and transients from nearby lightning strikes in accordance with FAA-STD-019.	I			
3.1.6-a	Electromagnetic Interference (EMI) / Electromagnetic Compatibility (EMC)	The system shall be successfully tested in accordance with the requirements in 4.4.2.	T		4.4.2	
3.1.6-b		The equipment manufacturer or supplier shall ensure the system meets the requirements of Federal Communication Commission (FCC) Rules and Regulations, Code of Federal Regulations (CFR) Title 47, Chapter 1: Subchapter A, Part 2 and Part 15; and Subchapter D, Part 87.	I		4.4.2	
3.1.6-c		All components of the Remote Maintenance Monitoring (RMM) subsystem and any other computing devices shall meet the requirements for Class A computing devices in accordance with FCC Rules and Regulations, CFR Title 47, Chapter 1, Subchapter A, Part 2, subpart J, (Frequency Allocations and Radio Treaty Matters; General Rules and Regulations).	I		4.4.2	
3.2	Transponder	N/A Header only.				Header only, no IADT
3.2.1-a	Operating Channels	The system shall operate without modifications within the frequency band from 960 MHz to 1215 MHz.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.1-b		The transponder shall transmit on the reply frequency that corresponds to the assigned DME X channel or Y channel without physical equipment modification or special test equipment. See Appendix A for current channelization.	D			
3.2.1.1	Broadband Operation	Each RF component or device shall be designed to allow DME operation on any selected channel (see Appendix A for current channelization).	D			
3.2.1.2-a	RF Tuning	The transponder shall be capable of operating on any channel assignment within its design range without the need for adjustments or tuning beyond the change of system parameter values.	D			
3.2.1.2-b		A pre-selector (if used) shall be exempt from the requirement in a. above.	I			
3.2.1.3-a	Channel Frequency and Stability	The transmitted frequency shall not vary more than ±0.001% from the assigned frequency.	D			
3.2.1.3-b		A sample of the transponder output signal (reply) oscillator source shall be provided on a front panel connector as appropriate with the frequency of operation with a 50-Ω, removable termination.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.1.3-c		For a receiver design with an independent local oscillator source, a sample of the receiver local oscillator signal shall be provided on a front panel connector as appropriate with the frequency of operation with a 50-Ω, removable termination.	D			
3.2.1.3-d		The output level for the required signals in b. and c. above shall be 0 ±3 dBm.	T			
3.2.2-a	Duplexer	A duplexer shall be provided to permit automatic operation of the receiver and transmitter when connected to the single antenna.	I			
3.2.2-b		The duplexer shall be of the passive type.	I			
3.2.2-c		No adjustment shall be required in order to achieve the performance required for the frequencies listed in Appendix A.	D			
3.2.3	Receiver and Associated Circuitry	All receiver performance requirements in 3.2.3 and associated subparagraphs that pertain to interrogation signals shall be met when the following conditions apply:	T			Lead-in shall statement.
3.2.3-a		Any interrogation signals that have any combination of characteristics set forth in 3.4.4.3;	T			Roll-up req.
3.2.3-b		When interrogation signals occur from the threshold receiver sensitivity level to not less than -10 dBm as referenced to the transponder antenna transmission line connector, unless otherwise indicated.	T			Roll-up req.

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.1	Receiver Bandwidth and Stability	The minimum permissible bandwidth of the receiver shall be such that the transponder sensitivity level will not change by more than +3 dB (e.g., from -94 dBm to -91 dBm) when the total receiver drift is added to an incoming interrogation frequency drift of ±100 kHz in the opposite direction.	T			
3.2.3.1.1	Receiver Bandwidth	The receiver bandwidth shall be sufficient to allow compliance with the accuracy requirement (3.2.5.6) when the input signals are those specified in 3.4.4.	D			
3.2.3.2	Receiver Decoder	The transponder shall include a decoding circuit such that the decoder will decode and produce reply pulse pairs from interrogation signal pulse pairs occurring at spacings within 12 ±0.5 µs for X channels and 36 ±0.5 µs for Y channels.	D			
3.2.3.2.1	Decoding Circuit Performance	The decoding circuit performance shall not be degraded by single pulses arriving before, between, or after the constituent pulses of a pair of the correct spacing.	D			
3.2.3.2.2-a	Decoder Rejection Pulse Spacing	When the interrogation pulse pair spacing varies from the nominal value by ±1.0 µs or less, and if there is no other interrogation, the threshold sensitivity shall not be reduced by more than 1 dB.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.2.2-b		An interrogation pulse pair with a spacing of ±2 µs or more from the nominal value, and with any signal level up to the value specified in 3.2.3.6.3, shall be rejected such that the transmission rate does not exceed the value obtained when interrogations are absent.	T			
3.2.3.2.2-c		When the spacing differs by ±3 µs or more from the nominal value, the reduction in sensitivity shall be at least 70 dB with respect to 3.2.3.6.	T			
3.2.3.2.3-a	Decoder Rejection Pulse Width	The reduction in sensitivity shall be at least 70 dB for paired pulses with a spacing of 11.5 µs to 12.5 µs for X channels and 35.5 µs to 36.5 µs for Y channels, where either pulse has a width of 0.8 µs or less.	T			
3.2.3.2.3-b		The reduction in sensitivity shall be at least 70 dB for single pulses of any width, including widths within 11.5 µs to 12.5 µs for X channels and 35.5 µs to 36.5 µs for Y channels.	T			
3.2.3.3-a	Receiver Dead Time	Each decoded pulse pair (3.2.3.2) shall result in the generation of a dead time interval during which time the transponder will not reply to any other signal at any and all levels up to -10 dBm.	T			
3.2.3.3-b		The dead time interval shall be adjustable from of 50 µs to 150 µs, in increments of at least 1 µs.	D			
3.2.3.3-c		The default interval shall be 60 µs.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.3-d		With the exception of the number of receiver noise pulses permitted under 3.2.3.6.4, dead time shall only be generated by received and decoded interrogation pulse pairs.	D			
3.2.3.4-a	Receiver Recovery Time	The recovery time of the receiver and its associated video circuitry shall be such that the threshold sensitivity to desired interrogations is not reduced by more than 1 dB when desired interrogations occur 8 µs and more after the reception of undesired pulses having all levels up to 60 dB above the threshold sensitivity of the receiver in the absence of such undesired pulses.	T		4.4.3	
3.2.3.4-b		The desired interrogation shall be RF pulse pairs conforming to the requirements defined in 3.4.4.3, 3.4.4.4, and related subparagraphs, and the undesired pulses shall conform to the same requirements, except that the pulse spacing shall be outside the limits of 3.2.3.2 and related subparagraphs (such that dead time is not generated).	T			
3.2.3.4-c		This requirement (a.) shall be met with echo suppression circuits rendered inoperative.	D			
3.2.3.5	Echo Suppression	N/A Header only.				Header only, no IADT

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.5.1-a	Short Distance Echoes	Synchronous pulse signals occurring between the pulse pair of the direct-path interrogation and superimposed on either the leading or trailing edge of the second pulse of direct-path interrogation shall not affect the time of decoding for the direct-path interrogation by an amount in excess of 0.15 µs.	T			
3.2.3.5.1-b		The presence of such synchronous pulse signals shall not cause the reply efficiency to be reduced by more than 10% from that measured in the absence of the pulse signals.	T			
3.2.3.5.1-c		These requirements (a., b.) shall be met when the RF input signal level of the direct-path pulse pair has any level from 10 dB above the sensitivity threshold triggering level to an absolute level of -10 dBm, and the echo pulse has any level up to the level of the direct-path pulse pair and for all direct-path pulse pair spacings of 3.2.6.2.	T			
3.2.3.5.2-a	Long Distance Echoes	Continuous wave (CW) suppression and echo suppression shall be provided for interrogations having echoes that are delayed with respect to the direct-path interrogation in excess of the receiver dead time setting.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.5.2-b		The decoding of a direct-path interrogation pulse pair shall trigger echo suppression whenever the level of the direct-path pulse pairs exceeds a pre-established level (i.e., triggering level).	T			
3.2.3.5.2-c		The echo suppression function includes the following:	I, D, T			Lead-in statement – no IADT
3.2.3.5.2-c.1		The triggering level shall be adjustable to any level between -80 dBm and -10 dBm;	D			
3.2.3.5.2-c.2		The nominal trigger level setting shall be -70 dBm;	I			
3.2.3.5.2-c.3		Triggering shall result in a receiver desensitization period that starts at the time of the pulse decoding and remains active for the duration of the echo suppression period;	D			
3.2.3.5.2-c.4		The duration of the receiver desensitization period shall be adjustable from 50 µs through 350 µs;	D			
3.2.3.5.2-c.5		The duration of the desensitization shall be nominally set at 150 µs;	I			
3.2.3.5.2-c.6		The degree of receiver desensitization (i.e., threshold triggering level) shall be 3.0 ±1 dB above the level of the decoded direct-path pulses and remain active for the duration of the receiver desensitization period, unless retriggered pursuant to the specifications given in items 8. and 9. below;	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.5.2-c.7		The dynamic range of the receiver threshold triggering level shall be capable of providing the degree of desensitization specified in item 6. above for signal levels at the minimum triggering level to -10 dBm;	T			
3.2.3.5.2-c.8		When enabled, the echo suppression function shall be retriggered whenever a pulse pair, with a signal level that exceeds the current threshold triggering level, is decoded; and	D			
3.2.3.5.2-c.9		When the echo suppression is retriggered, the receiver threshold triggering level shall be re-adjusted to a level 3.0 ±1 dB above the level of the newly decoded pulses and remain for the duration of the echo suppression period unless retriggered by a signal stronger by 0 dB to 6 dB than the direct path signal and over a range of input signal from 10 dB above threshold triggering level to -10 dBm.	T			
3.2.3.5.3-a	Echo Suppression Disable	The long and short echo suppression features shall be individually selectable as enabled or disabled.	D			
3.2.3.5.3-b		When the transponder is in normal operation, long and short echo suppression shall be disabled for the duration of the monitor generated interrogation pulse pair.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.5.3-c		The feature in b. above shall be selectable as required for echo suppression testing.	D			
3.2.3.5.4	Traffic Load Monitoring	Outputs shall be provided for local and remote monitoring of the total number of decoded pulse pairs per second (ppps) and the number of receiver desensitization periods triggered per second.	I			
3.2.3.6-a	Receiver Sensitivity	In the absence of all interrogation pulse pairs, except for those necessary to perform the sensitivity measurement, interrogation pulse pairs with the correct spacing and nominal frequency shall trigger the transponder if the input level is at least -94 dBm.	D			Roll-up req.
3.2.3.6-b		The measurements shall be referenced to the exterior cabinet connector to which the transmission line to the antenna is connected.	D			
3.2.3.6-c		The receiver sensitivity for a reply efficiency of 70% shall be in accordance with the following subparagraphs.	D, T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.6.1-a	On-Channel Sensitivity	For interrogation signals having a repetition rate of 30 ppps and having spacings of the constituent pulses of a pair anywhere within the limits specified in 3.2.3.2 and related subparagraphs, the receiver sensitivity in the absence of other interrogations, and with a dead time setting of 60 µs, shall be -94 dBm or better (i.e., the receiver threshold triggering level shall be -94 dBm or lower).	T			
3.2.3.6.1-b		The requirement above (a.) shall be met when the Automatic Gain Reduction (AGR) (3.2.3.9) and long and short echo suppression are disabled.	D			
3.2.3.6.1-c		Once set, sensitivity shall be stable within ±1.0 dB (±2.0 dB over the operational service conditions).	D			
3.2.3.6.1.1	Sensitivity Variation with Interrogation Loading	The transponder sensitivity level shall not vary by more than ±1 dB from the value measured in 3.2.3.6.1 for transponder loading between 0% and 90% of its maximum transmission rate, with the echo suppression circuits and AGR disabled.	D		4.4.4.1	

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.6.1.2-a	Desensitization by Adjacent Channel Interrogation	The presence of interrogation signals at ±900 kHz (adjacent channel) from the on-channel frequency which have pulse coding corresponding to that for the on-channel frequency and which occur at rates up to 1000 ppps shall not reduce the on-channel threshold sensitivity by more than 1 dB.	D		4.4.4.2	
3.2.3.6.1.2-b		The requirement in a. above shall be met when the adjacent channel signals have levels up to -10 dBm.	T			
3.2.3.6.1.3-a	Desensitization by Continuous Wave (CW)	The presence of a CW interference signal on the assigned channel frequency or elsewhere within the receiver passband shall not reduce the on-channel threshold sensitivity by more than 2 dB when the level of the CW is 10 dB or more below the on-channel sensitivity level.	T			
3.2.3.6.1.3-b		This requirement (a.) shall be met for all settings of the receiver transmission rate control which result in receiver noise decodes at a rate of no greater than 10 per second.	T			
3.2.3.6.1.3-c		Additionally, within the range of the receiver desensitization provided by AGR, the reply efficiency to a single interrogator shall not be reduced by more than 10% when the interrogation signal level is equal to or greater than 6 dB above the level of the interfering CW signal.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.6.1.4	Desensitization by High Repetition Rate/High Duty Cycle Pulse Signals	In the presence of an input signal with a pulse width of 8 µs where the pulse rate is 30% of the transmitter duty cycle (37 000 pulses per second) and having a peak level equal to the CW level specified in 3.2.3.6.1.3-a (i.e., 10 dB below the on-channel threshold triggering level measured in the absence of interference), the maximum reduction in receiver sensitivity and reply efficiency shall not exceed 0.5 dB and 3%, respectively.	T			
3.2.3.6.2	Sensitivity to Adjacent Channel Interrogations	Signals ±900 kHz or greater removed from the assigned channel nominal frequency and having signal levels up to -10 dBm shall not trigger the transponder.	T			
3.2.3.6.3-a	Dynamic Range	The performance of the transponder shall be maintained when the power of the interrogation signal at the equipment cabinet has any value between -94 dBm and -10 dBm.	D			
3.2.3.6.3-b		The equipment shall not be damaged by input pulse signals at the cabinet connector of up to +20 dBm on any frequency from 960 MHz to 1215 MHz.	T			
3.2.3.6.4	Noise-Generated Pulse Pairs	When the receiver is interrogated at -94 dBm, with the AGR circuits disabled, and at a rate to produce a transmission rate equal to 90% of the maximum, the noise-generated pulse pairs shall not exceed 5% of the maximum transmission rate.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.7-a	Interference Suppression	Signals complying with 3.2.6.2 arriving at the intermediate frequency shall be suppressed at least 80 dB.	T			
3.2.3.7-b		Except for the passband frequencies provided to achieve the performance required for on-channel and adjacent channel interrogation signals, and to comply with the requirements of paragraph 3.2.3.1, all other signals within the 960 MHz to 1215 MHz band, and at image frequencies, shall be suppressed by 75 dB or more.	T			
3.2.3.8	Squitter	N/A Header only.				Header only, no IADT
3.2.3.8.1-a	Random Squitter Pulse Pairs	The transmitter shall provide squitter with a nominal rate, adjustable from the Maintenance Data Terminal (MDT) from 0 ppps to at least 850 ppps.	D			
3.2.3.8.1-b		The squitter pulses shall be coded in accordance with 3.2.6.2.	D			
3.2.3.8.1-c		The minimum spacing between adjacent squitter pulse pairs shall be 60 µs.	D			
3.2.3.8.2-a	Squitter Operation	Except during transponder identification transmissions, the transmitter shall operate at a transmission rate of not less than 700 ppps, including squitter pulse pairs and distance reply pulse pairs.	D			
3.2.3.8.2-b		In the absence of valid interrogations, the squitter transmission rate shall be 700 ppps to 850 ppps.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.8.3-a	Squitter Decoding	The interrogation signal decoder shall not decode squitter pulse pairs from the squitter pulse generator.	D			
3.2.3.8.3-b		Squitter pulse pairs shall not prevent the transponder from replying to interrogation signals, as long as the reply delay in Y channel operation is a minimum of 50 µs.	D			
3.2.3.8.4-a	Effect of Traffic Loading	The squitter pulse generator shall produce the number of squitter ppps such that the total of squitter ppps plus the receiver decodes per second is within 700 ppps to 850 ppps.	T			
3.2.3.8.4-b		The squitter pulse generator shall provide no output for all interrogation rates resulting in excess of 850 receiver decodes per second.	T			
3.2.3.8.5-a	Priority of Reply Pulses	Whenever triggers due to squitters occur prior to triggers due to decodes at the input of the priority gating circuits, the squitter triggers shall be inhibited for all spacings between triggers of 25 µs or less in X mode and 10 µs or less in Y mode.	T			
3.2.3.8.5-b		The requirement above (a.) shall apply to reply delay settings of 50 µs and greater.	D			
3.2.3.8.5-c		Whenever triggers due to decodes occur prior to squitter triggers, the squitter triggers shall be inhibited for all spacings of 25 µs or less for X mode and 65 µs or less for Y mode.	T			
3.2.3.9	Automatic Gain Reduction (AGR)	N/A Header only.				Header only, no IADT

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.3.9.1-a	Gain Reduction Operation	When transponder loading exceeds 90% of the maximum transmission rate (3.2.5.1), the receiver sensitivity shall automatically reduce in increments of 10 dB or less to limit transponder replies, to ensure that the maximum permissible transmission rate is not exceeded.	T			
3.2.3.9.1-b		The available range of sensitivity reduction shall be from 0 dB to at least 50 dB.	D			
3.2.3.9.1-c		When transponder loading is subsequently reduced to less than 90%, the receiver sensitivity shall return to normal operation (0 dB reduction) within 5 s.	T			
3.2.3.9.2	Interrogation Overload Signal	A signal shall be provided to the monitor to prevent receiver sensitivity alarms when sensitivity has been reduced by AGR operation.	D			
3.2.3.10-a	Priority of Transmission	The transmission of transponder output signal pulses shall conform to the following order of precedence:	D			Lead-in shall statement.
3.2.3.10-a.1		Identification pulse groups;	D			
3.2.3.10-a.2		Distance reply pulse pairs; and	D			
3.2.3.10-a.3		Squitter pulse pairs.	D			
3.2.3.10-b		The transponder shall not transmit distance reply or squitter pulse pairs during the transmission (key down) of the identification signal pulse groups.	D			
3.2.4	Identification Signals and Keying	N/A Header only.				Header only, no IADT

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.4.1-a	Identification Signal	The identification signal shall consist of pulse pairs transmitted at a repetition rate of 1350 ±5 Hz.	D			
3.2.4.1-b		The identification signal pulses and pulse pairs shall conform to 3.2.6.1 and 3.2.6.2.	D		4.3.2	
3.2.4.2-a	Identification Keying Source	When normal identification keying is enabled, the transponder shall transmit identification signals when keyed by either the VHF facility (associated) or the internal (independent) identification keyer.	D			
3.2.4.2-b		The DME independent keyer shall key at least once every 40 s.	D			
3.2.4.3-a	Independent Identification Signal Characteristics	The identification signal shall consist of the transmission of the code in dots and dashes (Morse Code).	D			
3.2.4.3-b		Reply pulses shall only be transmitted between key down times.	D			
3.2.4.3-c		The maximum key down time shall not exceed 5 s per identification code group.	D			
3.2.4.3-d		The dots shall have a time duration of 0.1 to 0.160 s.	D			
3.2.4.3-e		The dashes shall be three times the duration of the dots ±10%.	D			
3.2.4.3-f		The duration between dots and/or dashes shall be equal to that of one dot ±10%.	D			
3.2.4.3-g		The time duration between letters shall not be less than three dots.	D			
3.2.4.3-h		The total period for transmission of an identification code group shall not exceed 10 s.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.4.4-a	Associated Identification Signal Characteristics	When associated with a VHF facility, the identification shall be transmitted synchronously with the VHF facility identification keying signal using Morse Code as stated above (3.2.4.3).	D			
3.2.4.4-b		For keying from an associated VHF facility, an isolated solid state relay input with the following characteristics shall be provided:	D			
3.2.4.4-b.1		A two-wire input;	D			
3.2.4.4-b.2		Compatible with a driver having an output resistance of less than 250 Ω;	D			
3.2.4.4-b.3		Compatible with a driver capable of sinking a current of 20 mA;	D			
3.2.4.4-b.4		Capable of withstanding an open circuit voltage of 50 VDC or greater.	D			
3.2.4.4-c		The DME transponder shall start transmission of the transponder identification when the start of keying is detected at the DME keying input from the associated VHF facility or from the remote localizer keying signal (e.).	D			
3.2.4.4-d		The DME transponder shall recognize either a Morse Code synchronization signal or the associated VHF facility keying (dots and dashes) as the source for the start of internal keying.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.4.4-e		The DME transponder shall accept an additional keying signal controlled by a remote ILS localizer at the opposite end of the runway which itself transmits a different Morse Code identification signal.	D			
3.2.4.4-f		There shall be a control that will cause the DME transponder to:	D			Lead-in shall statement.
3.2.4.4-f.1		Switch to internal keying upon loss or malfunction of the keying signal from associated VHF facility (if enabled);	D			
3.2.4.4-f.2		Resume normal operation when the keying signal from the associated VHF facility resumes (if enabled); and	D			
3.2.4.4-f.3		Switch keying signal and identification code from the colocated ILS localizer to an ILS localizer located at the opposite end of the runway.	D			
3.2.4.5	Identification Keying Control	The transponder shall provide controls to:	D			Lead-in shall statement.
3.2.4.5-a		Enable/disable identification keying;	D			
3.2.4.5-b		Enable/disable external keying source;	D			
3.2.4.5-c		Select external Morse Code synchronization signal or VHF Facility keying source;	D			
3.2.4.5-d		Enable/disable inversion of external keying source polarity;	D			
3.2.4.5-e		Enable/disable continuous transmission of identification signal pulse groups;	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.4.5-f		Select three alphanumeric Morse Code characters in normal operation;	D			
3.2.4.5-g		Select a mode in which the identification code is automatically set to "T-E-S-T;" and	D			
3.2.4.5-h		Automatically generate a maintenance alert when the identification code is selected as "T-E-S-T."	D			
3.2.5	Transmitter and Associated Circuitry	N/A Header only.				Header only, no IADT
3.2.5.1-a	Transmission Rate	The transmitter shall be capable of a transmission rate of at least 4800 ppps.	D			
3.2.5.1-b		The system shall provide an adjustable control to set the maximum transmission rate, from at least 2000 ppps to the maximum rate.	D			
3.2.5.2-a	Tuning and Spurious Output	Spurious output or parasitic oscillations shall be at least 40 dB below the peak on-channel final output signal, for any combination of non-factory tuning control positions in any transponder amplifier stage, set to either normal or reduced power conditions (3.2.5.4.2).	D		4.4.6	
3.2.5.2-b		To ensure Hazardously Misleading Information (HMI) is not radiated by the antenna, spurious output or parasitic oscillations shall be no more than -100 dBm as measured at the coaxial cable connector that provides the feed to the antenna.	D		4.4.6	

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.5.3-a	Transponder Power Output	The transponder shall be able to be set such that the output power can be one of two preset levels.	D			
3.2.5.3-b		The nominal preset levels shall be 100 W (Low Power DME) and 1000 W (High Power DME), as measured at the output of the equipment cabinet when terminated into a 50-Ω load.	D			
3.2.5.4	RF Output Power Control	The transmitter shall require no mechanical/hardware change to operate in the specified settings.	D			
3.2.5.4.1	Initial Setting	Means shall be provided to permit setting the RF output power to within ±5% of the nominal preset levels in 3.2.5.3.	D			
3.2.5.4.2-a	Test Setting	The range of adjustment shall be 0 dB to -4 dB from the initial level, in 0.25 dB steps.	D			
3.2.5.4.2-b		Transponder output signal requirements in 3.2.6.1 and 3.2.6.2 shall be met throughout the range of power output levels without the need for readjustment of any other controls.	T		4.4.7 4.4.8	Role-up req. 3.2.6.1 and 3.2.6.2 shall be measured at highest and lowest power setting available.
3.2.5.5	Reply Delay Values and Adjustments	Controls shall be provided to set the nominal reply delay time within 0.0625 µs of any desired value between the limits of 44 µs to 56 µs for X channels, or 50 µs to 62 µs for Y channels.	D			
3.2.5.6	Accuracy	The transponder shall not contribute more than ±0.5 µs (75 m (250 ft)) to the overall system error.	D	D		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.6	Transponder Output Signals	N/A Header only.				Header only, no IADT
3.2.6.1	Pulse Shape	The modulated RF signal envelope of each pulse shall meet the following requirements when measured using a linear detector.	D		4.3.2	
3.2.6.1.1	Rise Time	Pulse rise time shall be 2.5 +0.5/-1.0 µs.	D		4.3.2.2 4.4.7	
3.2.6.1.2	Pulse Top	The instantaneous voltage amplitude within the pulse top shall not fall below the 95% value of maximum amplitude of the pulse.	D		4.3.2.4 4.4.7	
3.2.6.1.3	Pulse Width	Pulse width shall be 3.5 ±0.5 µs.	D		4.3.2.5 4.4.7	
3.2.6.1.4	Decay Time	Pulse decay time shall be 2.5 +0.5/-1.0 µs.	D		4.3.2.3 4.4.7	
3.2.6.2	Pulse Coding	Pulses shall be coded in pairs with a spacing of 12 ±0.25 µs for X channels or 30 ±0.25 µs for Y channels.	D		4.3.2.1 4.4.8	
3.2.6.3	Delay Time Variation	Reply delay time variation shall not exceed the following:	T, D			Lead-in shall statement.
3.2.6.3-a		±0.25 µs over the range of service conditions with an input signal level having any value between -94 dBm and -79 dBm with an interrogation pulse rise time of 2.5 ±0.5 µs;	T, D			
3.2.6.3-b		±0.10 µs over the range of service conditions with an input signal level having any value between -79 dBm and -10 dBm with an interrogation pulse rise time of 0.10 ±0.10 µs;	T, D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.6.3-c		A total variation of 0.10 µs with an input signal level of -60 dBm with variation interrogation pulse rise time within 0.20 µs to 3.0 µs;	T			
3.2.6.3-d		A total variation of 0.10 µs with an input signal level of -60 dBm with a variation in interrogation pulse rate frequency from 2500 ppps through the maximum transmission rate with an interrogation pulse rise time of 0.10 ±0.10 µs.	T			
3.2.6.4-a	Pulse Power Variation	The peak power of the constituent pulses of any pair of pulses shall not differ by more than 1 dB.	D			
3.2.6.4-b		Amplitude modulation of the output pulse train shall not exceed 5%.	D			
3.2.6.5-a	RF Pulse Signal Spectrum	The effective radiated power (4.4.9) of the pulse modulated signal contained in a 0.5 MHz band centered on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel frequency in each case shall not exceed 200 mW when the transmitter output power is set to 1000 W.	T		4.4.9	
3.2.6.5-b		The effective radiated power contained in a 0.5 MHz band centered on frequencies 2 MHz above and 2 MHz below the nominal channel frequency in each case shall not exceed 2 mW when the transmitter output power is set to 1000 W.	T		4.4.9	

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.6.5-c		The effective radiated power (4.4.9) contained within any 0.5 MHz band shall decrease monotonically as the band center frequency moves away from the nominal channel frequency.	D		4.4.9	
3.2.6.6-a	Out-of-Band Spurious Radiation	At all frequencies from 10 MHz to 1800 MHz, but excluding the band of frequencies from 960 MHz to 1215 MHz, the spurious output of the transponder transmitter shall not exceed -50 dBm in any one kHz of receiver bandwidth.	T		4.4.10	
3.2.6.6-b		The equivalent isotropically radiated power (4.4.9) of any CW harmonic of the carrier frequency on any operating channel shall not exceed -20 dBm.	T		4.4.10	
3.2.6.7-a	Inter-Pulse Output Level	During the interval between occurrences of the desired pulse pairs, the RF output level shall not exceed a level that is 80 dB below the maximum power level during the pulse.	T			
3.2.6.7-b		Between the pulses of each pair, there shall be an interval of 1.0 µs or greater length during which the RF output level does not exceed a level that is 80 dB below the maximum power level of each pulse.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.6.8	Retriggering of Transponder	The transponder shall include a decoding circuit such that the transponder can be triggered only by pairs of received pulses having pulse spacings appropriate to interrogator signals as described in 3.4.4.4 and having pulse widths as described in 3.4.4.3.3.	D			
3.2.7	Stabilization of Performance Characteristics	After one minute of power being applied to the transponder, and within 6 s of being switched to operational mode:				Lead-in statement – no IADT
3.2.7-a		The transmitter output power shall be at least 90% of the nominal output, and	D			
3.2.7-b		The following Primary and Secondary alarm parameters shall be within tolerance:	D			Lead-in shall statement.
3.2.7-b.1		Reply delay (3.4.5.2.3);	D			
3.2.7-b.2		Reply efficiency (3.4.5.2.6);	D			
3.2.7-b.3		Transponder Pulse Spacing (3.4.5.2.4);	D			
3.2.7-b.4		Transponder Pulse Rate (3.4.5.2.5);	D			
3.2.7-b.5		Radiated power level (3.4.5.2.8);	D			
3.2.7-b.6		Transponder Power Output (3.4.5.2.7);	D			
3.2.7-b.7		Receiver and Transmitter Frequency (3.4.5.2.10).	D			
3.2.8	Duty Cycle Overload Protection	A means shall be provided to protect the transponder amplifier components from damage due to the effects of output duty cycles that exceed the ratings of those components.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.2.9-a	Thermal Overload Protection	A means shall be provided to protect the equipment against operating above its thermal design limits.	D			
3.2.9-b		Once the equipment has returned to a safe operating temperature, the system shall automatically be available for normal operation (i.e., ready for an automatic restart attempt as stated in 3.5.7).	D			
3.2.10-a	Performance Upon Fault Condition of RF Equipment Output Circuit	All equipment output circuits shall be designed to include circuit protection and prevent damage to equipment upon occurrences of opens or shorts on the output terminals.	D			
3.2.10-b		When operated at any voltage standing wave ratio (VSWR), including open and short conditions, the transponder output circuitry shall not be damaged or exceed dissipation limits.	D			
3.2.10-c		The transponder shall shut itself down upon detection of a high VSWR.	D			
3.3	Antenna	N/A Header only.				Header only, no IADT
3.3.1	Antenna Types	The DME transponder shall operate with any one of the following types of DME antennas:	D			Lead-in shall statement.
3.3.1-a		Standard omni-directional;	D			
3.3.1-b		Uptilt omni-directional;	D			
3.3.1-c		Bi-directional; or,	D			
3.3.1-d		Uni-directional.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.3.2	Frequency Range	The antenna shall operate within the frequency band of 960 MHz to 1215 MHz without the need for tuning or adjustment.	D			
3.3.3	Polarization	The predominant energy radiated by the antenna shall be vertically polarized.	D		4.4.11.1	
3.3.4-a	Characteristic Impedance and VSWR	The antenna shall have a characteristic impedance of 50 Ω.	D		4.4.11.2	
3.3.4-b		The VSWR for omni-directional and bi-directional type antennas shall not be greater than 2:1 over the frequency band.	T		4.4.11.2	
3.3.4-c		The VSWR for uni-directional type antennas shall not be greater than 2.5:1 over the frequency band.	T		4.4.11.2	
3.3.5-a	Antenna Gain	The gain at the maximum power point of the vertical pattern for omni-directional antennas shall not be less than 8.0 dBi at all azimuths.	T		4.4.11.3	
3.3.5-b		The gain at the maximum power point of the vertical pattern within the 3-dB beam width(s) for uni-directional and bi-directional antennas shall be at least 8.0 dBi.	T		4.4.11.3	
3.3.6-a	Vertical Pattern	The standard and uptilt omni-directional antenna types shall comply with the following vertical radiation patterns, except as specified in 2. and 3. below, at all azimuths.	T		4.4.11.4	

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.3.6-b		The uni-directional and bi-directional antennas shall comply with the following vertical radiation patterns, except as specified in 3. below, in the region between the half power beam widths (HPBW).	T		4.4.11.4	
3.3.6-c		The radiation pattern of the antenna in the vertical plane:	T		4.4.11.4	
3.3.6-c.1		Shall have a lobe of energy at least 5 degrees wide at the half-power points, -3 dB (0.707 Volts);	T		4.4.11.4	
3.3.6-c.2		Shall have the vertical angle of maximum radiated energy between 2.0 degrees and 5.0 degrees above the horizon for the standard omni-directional, uni-directional, and bi-directional antenna types;	T		4.4.11.4	
3.3.6-c.3		Shall have the vertical angle of maximum radiated energy between 5.0 degrees and 9.0 degrees above the horizon for the uptilt omni-directional antenna type;	T		4.4.11.4	
3.3.6-c.4		Shall have a gain on the horizon of at least 2 dBi;	T		4.4.11.4	
3.3.6-c.5		Shall have a signal level rate of change greater than or equal to 0.10 V/V/degree from 1.0 degree below the horizon to 1.0 degree above the horizon, when the vertical pattern data is normalized to 1.0 V at the horizon;	T		4.4.11.4	

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.3.6-c.6		Shall have relative gain at angles between 6 and 60 degrees below the horizon lower than the relative gain at the peak of the major lobe above the horizon by at least 14 dB (0.2 Volts);	T		4.4.11.4	
3.3.6-c.7		Shall have relative gain at angles between 6 and 15 degrees above the horizon greater than a level that is 14 dB (0.2 Volts) below relative gain at the peak of the major lobe above the horizon;	T		4.4.11.4	
3.3.6-c.8		Shall have relative gain at angles between 15 and 40 degrees above the horizon greater than a level that is 20 dB (0.1 Volts) below relative gain at the peak of the major lobe above the horizon; and	T		4.4.11.4	
3.3.6-c.9		Shall have relative gain at angles between 40 and 60 degrees above the horizon greater than a level that is 30 dB (0.032 Volts) below relative gain at the peak of the major lobe above the horizon.	T		4.4.11.4	
3.3.7	Horizontal Pattern	N/A Header only.				Header only, no IADT
3.3.7.1	Omni-Directional Type	The circularity shall not exceed ±1 dB.	T		4.4.11.5	
3.3.7.2-a	Uni-Directional Type	The HPBW shall be 45 degrees or greater.	T		4.4.11.5	
3.3.7.2-b		The ratio of the maximum gain to the minimum gain (front-to-back ratio) shall be 10 dB or greater.	T		4.4.11.5	
3.3.7.2-c		The pattern ripple within the HPBW shall not exceed ±1 dB.	T		4.4.11.5	

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.3.7.3-a	Bi-Directional Type	The HPBWs of each major lobe shall be 45 degrees or greater.	T		4.4.11.5	
3.3.7.3-b		The ratio of the maximum gain of each major lobe to the minimum gain of each major null shall be 10 dB or greater.	T		4.4.11.5	
3.3.7.3-c		The pattern ripple within each HPBW shall not exceed ±1 dB.	T		4.4.11.5	
3.3.8-a	Radome and Weatherproofing	The radome shall be smooth to minimize wind loading and the accumulation of water, snow, and ice.	I			
3.3.8-b		The entire antenna assembly including cable connectors shall be effectively sealed (weatherproofed) in such a manner as to permit removal and replacement of the radome without the necessity of sealing compounds to prevent the entrance of foreign matter.	T			
3.3.8-c		The major lobe centerline(s) shall be permanently identified on the radome of directional antennas with a clearly visible orientation mark located near the base of the antenna.	I			
3.3.9-a	Antenna Mount	The configuration of the antenna base shall be such that the antenna may be mounted directly, or indirectly, through use of an adapter furnished with each antenna, to a four-inch outside diameter steel pipe.	I			
3.3.9-b		The mounting fixture shall engage not less than six inches of the pipe.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.3.9-c		The mounting fixture shall include clamping screws and locknuts for securing the fixture to the pipe.	I			
3.3.9-d		The design shall provide unobstructed access to all connectors.	I			
3.3.10-a	Monitor Probes	Two coupling probes for monitoring the signal radiated by the antenna shall be provided within the antenna radome.	I			
3.3.10-b		Each coupling probe shall be provided with a 50-Ω resistive load at the weatherproofed coaxial connector at the base of the antenna.	I			
3.3.10-c		The RF coupling factor for each probe shall be 25 ± 2 dB.	T			
3.3.10-d		The coupling factor for each probe shall not vary by more than 1.0 dB over the range of operating conditions specified in 3.1.5.2 at a specific frequency.	D			
3.3.11-a	Antenna Cables	The cables used to connect the DME antenna to the DME System shall have a 50-Ω characteristic impedance.	I			
3.3.11-b		The transmitter output cable shall have a signal attenuation of no more than 3 dB/100ft for the frequency range of 960 MHz to 1215 MHz.	I			
3.3.11-c		The monitor return cable shall have a signal attenuation of no more than 7 dB/100ft for the frequency range of 960 MHz to 1215 MHz.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.3.12	Obstruction Lights	All DME antenna types shall accommodate the mounting, power, and grounding of an obstruction light fixture on the top of the radome.	D			
3.3.13	Power Handling	All DME antenna types shall be capable of handling DME signals with an instantaneous output power up to 2000 watts and an average power of 80 watts (4% duty cycle).	T			
3.3.14	Grounding	The antenna shall be provided with grounding termination lug(s) on the antenna mounting base flange, in accordance with the Bolted Connections paragraphs, and Bonding paragraphs of FAA-STD-019.	I			
3.4-a	Monitor	The monitor shall accept RF signals from the DME monitor antenna probes, transmission line directional coupler, and simulated DME signals from built-in test equipment.	D			
3.4-b		The monitor shall provide for executive monitoring of the DME System as specified below.	D			
3.4-c		The monitor shall not affect or interrupt the DME service, except as stated in g. below.	D			
3.4-d		The monitor shall provide for self-testing of monitor alarm limits through the use of built-in test equipment internal to the monitor.	D			
3.4-e		The capability of monitor to detect and respond to HMI shall not be affected by the failure of other system functions.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4-f		The monitor shall indicate whether the measured signals (3.4.5.2) are within, or exceed, established alarm limits.	D			
3.4-g		The monitor shall initiate an alarm action when the established alarm limits are exceeded, as specified in 3.4.5.1.	D			
3.4.1-a	Operating Channels	The monitor shall provide the specified performance on each of the channels and modes (X or Y) listed in Appendix A, by means of a frequency synthesizer.	D			
3.4.1-b		In addition to providing an output on the assigned channel interrogation frequency for the Interrogation Signal Generator (3.4.4), the frequency synthesizer shall also provide for outputs of ± 200 kHz and ± 900 kHz removed from the assigned channel interrogation frequency for test purposes.	D			
3.4.1-c		A sample of the Interrogation Signal Generator oscillator output shall be provided at the front of the equipment via a connector as appropriate with the frequency of operation with a 50-Ω, removable termination.	D			
3.4.1-d		The output level for the connector above (c.) shall be 0 ±3 dBm.	T			
3.4.1.1	Broadband Operation	One single design shall be utilized for each RF device to cover operation on any selected channel.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.1.2	RF Tuning	Each RF device shall be capable of operating on any channel assignment without the need for retuning.	D			
3.4.1.3	Frequency Stability	Over the range of specified service conditions, the frequency of each output signal from the interrogation signal generator shall not vary more than ±0.001% from the assigned frequency.	D			
3.4.2	RF Input Levels	All monitor performance requirements shall be met when the transponder has any initial RF peak output power level between 50 W and 1000 W.	T			
3.4.3	Coupling Probe Inputs	N/A Header only.				Header only, no IADT
3.4.3.1-a	DME Antenna	All monitor requirements shall be met when the RF input to the monitor has an initial peak power level between -6 dBm and +36 dBm.	T			
3.4.3.1-b		The monitor shall continue to operate without damage with an RF input level up to +43 dBm.	T			
3.4.3.1-c		Manually inserted attenuators shall not be utilized.	I			
3.4.3.1-d		Amplifiers external to the monitor assembly shall not be utilized.	I			
3.4.3.2-a	Transmission Line Directional Coupler	The directional coupler shall have a directivity of not less than 27 dB over the frequency range of 960 MHz through 1215 MHz.	T			
3.4.3.2-b		The coupling factor shall not vary by more than ±0.5 dB over the service conditions.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.4	Interrogation Signal Generator	The interrogation signal generator shall provide interrogation and timing reference signals for the relevant functions of the transponder monitor.	D			
3.4.4.1-a	Operational Modes	In the normal mode of operation, when functioning as part of the executive monitor, the interrogation signal generator shall provide on-channel frequency RF pulse pairs at fixed levels, spacing, and interrogation rates for the monitoring of the reply delay, pulse spacing, pulse rate, and power level.	D			
3.4.4.1-b		The interrogation signal generator shall provide the capability of interrogating at off-channel frequencies, and at alternate RF levels, pulse spacings, and interrogation rates, for the measurement and certification of other specific performance characteristics of the transponder as defined below.	D			
3.4.4.2-a	Pulse Synchronization Output	The interrogation signal generator shall provide an output pulse, synchronized to each interrogation, to trigger external test equipment (Government Furnished Equipment (GFE)) or provide accurate pulse timing.	D			
3.4.4.2-b		This output shall be provided on the front panel with a Bayonet Neill–Concelman (BNC) female connector.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.4.2-c		This output shall generate signal pulses from a rate of 10 ppps to 7500 ppps.	T			
3.4.4.3	RF Output Pulse Signal	The RF envelope of each pulse shall meet the following requirements when measured using a linear detector.	D			
3.4.4.3.1	Rise Time	The rise time shall be 2.5 ±0.5 µs.	D			
3.4.4.3.2	Pulse Top	The instantaneous voltage amplitude within the pulse top shall not fall below the 95% value of the maximum voltage amplitude.	D			
3.4.4.3.3	Pulse Width	The pulse width shall be 3.5 ±0.5 µs.	D			
3.4.4.3.4	Decay Time	The decay time shall be 2.5 +0.5/-1.0 µs.	D			
3.4.4.4-a	Pulse Coding	Pulses shall be coded in pairs with a spacing of 12 ±0.2 µs for X channels and 36 ±0.2 µs for Y channels.	D			
3.4.4.4-b		For test purposes, the spacing shall be capable of variation, within at least ±3.2 µs from the nominal assigned channel spacing, in increments of 0.1 µs.	D			
3.4.4.5	Pulse Power Variation	The peak power of the constituent pulses of any pair of pulses shall not differ by more than 0.5 dB.	D			
3.4.4.6	Detected RF Output Signal	A linear detected video waveform test point shall be provided via a female BNC connector on the front panel for determining the pulse characteristics and timing measurements.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.4.7-a	RF Pulse Spectrum	At least 90% of the output signal RF energy shall be contained within a 0.5 MHz band centered on the interrogation frequency in use.	T			
3.4.4.7-b		The RF energy contained within any 0.5 MHz band shall decrease monotonically as the band center frequency moves away from the nominal channel frequency.	T			
3.4.4.8-a	Spurious Output	At all frequencies from 10 MHz to 1800 MHz, but excluding the band of frequencies from 1023 MHz to 1152 MHz, the spurious output of the signal generator, as measured at the antenna connection at the top of the cabinet, shall not exceed -40 dBm in any 1 kHz of receiver bandwidth.	T			
3.4.4.8-b		The power at the RF output connector during the intervals between occurrences of the desired interrogation pulse pairs shall not exceed a level of -80 dBm for all settings of the output attenuator.	T			
3.4.4.9-a	Test RF Output Frequency	The signal generator shall provide RF output at the channel interrogation frequency, at ±200 kHz, and at ±900 kHz with respect to the nominal interrogation frequency in use.	D			
3.4.4.9-b		All signal generator performance requirements shall be met without retuning or readjustment of any controls when each of the output frequencies referenced herein are selected.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.4.9-c		The RF output at ±200 kHz and ±900 kHz shall be within 0.5 dB of the RF output at the nominal interrogation frequency.	T			
3.4.4.10-a	RF Output Level Calibration	A means shall be incorporated for setting the RF power to a reference calibration level.	D			
3.4.4.10-b		The RF power shall be maintained at the calibration level ±0.5 dB over the service conditions.	D			
3.4.4.10-c		Means shall be incorporated to connect to external test equipment to measure RF power at the monitor output in an accessible location.	D			
3.4.4.11-a	RF Output Level and Accuracy	The RF output level shall be selectable between the limits of -10 dBm and -100 dBm as measured in a 50-Ω load at the transponder receiver input.	D			
3.4.4.11-b		The output attenuator shall provide a control resolution of ≤ 1 dB over the specified range.	D			
3.4.4.11-c		The output level shall be within 1.0 dB of the indicated level.	T			
3.4.5	Transponder Monitor	N/A Header only.				Header only, no IADT
3.4.5.1-a	Monitor Alarm Action	Execution of monitor control actions and fault annunciation shall occur within 10 s of the commencement of an out-of-tolerance condition, except for identification alarms. For identification alarms refer to 3.4.5.2.9.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.1-b		The monitor shall provide two separate alarm actions for purposes of automatic control and remote monitoring of the transponder: one designated “primary parameter alarm” and the other designated “secondary parameter alert”	D			
3.4.5.1-c		The alarm condition shall remain until it clears, or a reset is performed.	T			
3.4.5.1.1	Primary Alarm	If any primary parameter (3.4.5.2.1), or if any parameter listed in 3.4.5.2.2 that is selected as primary, produces an out-of-tolerance condition, the monitor will cause the following actions to take place:				Lead-in statement – no IADT
3.4.5.1.1-a		A positive visual and aural indication (3.5.1.2) of the alarm condition shall be provided;	D			
3.4.5.1.1-b		The main transponder shall be automatically switched off;	D			
3.4.5.1.1-c		The standby transponder, if provided, shall be automatically switched into operation within 5 s of the main transponder shutdown;	D			
3.4.5.1.1-d		If any out-of-tolerance conditions occur for the standby transponder, a positive visual and aural indication of the alarm condition shall be provided; and	D			
3.4.5.1.1-e		The standby transponder shall be automatically switched off.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.1.2	Secondary Parameter Alert	If any of the monitored parameters set to secondary (3.4.5.2.2) produce an out-of-tolerance condition, the monitor shall cause a positive visual and aural indication of the alert condition (3.5.1.2).	D			
3.4.5.1.3	Pre-Alarm	If any monitored parameter exceeds the pre-alarm limit, a maintenance alert shall be generated.	D			
3.4.5.1.4-a	Maintenance Alert	Maintenance alerts shall provide a visual indication of the abnormal condition on the equipment front panel, the MDT, and to the RMM connection.	D			
3.4.5.1.4-b		The maintenance alert shall cease when the equipment returns to a normal operating condition.	T			
3.4.5.1.5-a	Alarm Delay Time	The monitor delay time (6.1.11) for all parameters selected as primary (See 3.4.5.2.1 and 3.4.5.2.2), except for identification, shall be adjustable from 4 to 10 s. For identification alarms see 3.4.5.2.9.	D			
3.4.5.1.5-b		The adjustable value selected from the MDT shall be the total monitor delay time as defined in 6.1.11.	T			
3.4.5.1.6-a	Monitor Response Time	The requirement below (b.) shall be met under conditions in which any faults have been sensed for a continuous period of 10 s or longer.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.1.6-b		Within 3 s after the application of transponder output signals, which have characteristics that are all within a range prescribed for non-fault conditions, all sensed faults and alarm indication shall end.	D			
3.4.5.2-a	Monitored Parameters	Each monitored parameter shall have a settable nominal value with adjustable alarm and pre-alarm limits.	I			
3.4.5.2-b		The pre-alarm limits shall be adjustable to any value between the associated nominal and alarm limit values.	D			
3.4.5.2.1	Primary Parameters	The following parameters shall be monitored as primary alarms:				
3.4.5.2.1-a		Transponder reply delay (3.4.5.2.3); and	D			
3.4.5.2.1-b		Transmitter frequency (3.4.5.2.10-e).	D			
3.4.5.2.2	Secondary Parameters	The following parameters shall be monitored and selectable as either primary parameter alarms or secondary parameter alerts:	D			Lead-in shall statement.
3.4.5.2.2-a		Transponder pulse spacing (3.4.5.2.4);				
3.4.5.2.2-b		Transponder pulse rate (3.4.5.2.5);	D			
3.4.5.2.2-c		Reply efficiency (3.4.5.2.6);	D			
3.4.5.2.2-d		Transponder power output (3.4.5.2.7);	D			
3.4.5.2.2-e		Radiated power level (3.4.5.2.8);	D			
3.4.5.2.2-f		Identification keying (3.4.5.2.9);	D			
3.4.5.2.2-g		Transmitter frequency stability (3.4.5.2.10-c); and				
3.4.5.2.2-h		Receiver frequency (3.4.5.2.11).	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.2.3-a	Reply Delay	The monitor shall measure the reply delay of the pulses transmitted in response to the interrogation signal generator.	D			
3.4.5.2.3-b		The default alarm limit shall be set to ±0.4 µs from the nominal value (3.2.5.5).	I			
3.4.5.2.3-c		Measurement of the reply delay shall not be affected by the interrogation rate of the monitor signal generator nor by the percentage of replies to monitor interrogation for reply efficiencies as low as 50%.	T			
3.4.5.2.3-d		The reply delay shall be measured at the antenna coupling probe.	I			
3.4.5.2.3-e		When the AGR is active, as described in 3.2.3.9, these requirements shall be met over the full range of reduction in receiver sensitivity.	D			
3.4.5.2.4-a	Transponder Pulse Spacing	The monitor shall measure the spacing between the first and second pulses of transponder pulse pairs.	D			
3.4.5.2.4-b		The default alarm limit shall be set to ±0.4 µs from the nominal value of 12.0 µs for X channels or 30.0 µs for Y channels.	I			
3.4.5.2.4-c		The transponder pulse spacing shall be measured at the transmission line directional coupler.	I			
3.4.5.2.4-d		When the AGR is active, as described in 3.2.3.9, these requirements shall be met over the full range of reduction in receiver sensitivity.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.2.5-a	Transponder Pulse Rate	The default low pre-alarm limit shall be 750 ppps.	I			
3.4.5.2.5-b		The default low alarm limit shall be 700 ppps.	I			
3.4.5.2.5-c		The transponder pulse rate shall be measured at the transmission line directional coupler.	I			
3.4.5.2.5-d		Transponder pulse rate faults shall be inhibited during transmission of the identification signal (3.2.4).	D			
3.4.5.2.6-a	Reply Efficiency	The default low alarm limit shall be 70% when the test signal is 2 dB greater than the nominal receiver sensitivity level.	I			
3.4.5.2.6-b		When the AGR is active, as described in 3.2.3.9, these requirements shall be met over the full range of reduction in receiver sensitivity.	D			
3.4.5.2.6-c		The reply efficiency shall be measured at the antenna coupling probe.	I			
3.4.5.2.7-a	Transponder Power Output	The monitor shall measure the amplitude level of transponder output pulses.	D			
3.4.5.2.7-b		The default nominal value shall be equal to the preset level for the transponder (100W or 1000 W).	I			
3.4.5.2.7-c		The default low alarm limit shall be 3.0 dB lower than the nominal value.	I			
3.4.5.2.7-d		The low alarm limit shall be adjustable from at least 1.0 dB to 4.0 dB lower than the nominal value.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.2.7-e		The default high pre-alarm limit shall be 2.0 dB higher than the nominal value.	I			
3.4.5.2.7-f		The default high alarm limit shall be 6.0 dB higher than the nominal value.	I			
3.4.5.2.7-g		The measured power level shall be stable to within ±0.5 dB as referenced to the input power level to the monitor over the operational service conditions.	D			
3.4.5.2.7-h		The power output shall be measured at the transmission line directional coupler.	I			
3.4.5.2.8-a	Radiated Power Level	The default low alarm limit shall be 3.0 dB lower than the nominal value.	I			
3.4.5.2.8-b		The low alarm limit shall be adjustable from at least 1.0 dB to 6.0 dB lower than the nominal value.	D			
3.4.5.2.8-c		The measured power level shall be stable to within ±0.5 dB as referenced to the input power level to the monitor over the operational service conditions.	D			
3.4.5.2.8-d		The radiated power level shall be measured at the antenna coupling probe.	I			
3.4.5.2.9-a	Identification Keying	The monitor shall sense the presence of periodic identification keying of the transponder by recognizing the fundamental frequency component of the identification pulse train (1350 Hz nominal).	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.2.9-b		The default alarm limit for time without transmission of the identification signal shall be 45 s.	I			
3.4.5.2.9-c		The default alarm limit for time with continuous transmission of the identification signal shall be 10 s.	I			
3.4.5.2.9-d		The default alarm limit for time of transmission of an incorrect identification code shall be 90 s.	I			
3.4.5.2.9-e		The alarm internal timer shall be reset upon restart of the transponder after shutdown, or upon restart of external keying after shutdown.	D			
3.4.5.2.9-f		The identification keying shall be measured at the transmission line directional coupler.	I			
3.4.5.2.10-a	Transmitter Frequency	The monitor shall measure the transmitter frequency.	D			
3.4.5.2.10-b		The pre-alarm limit shall be stated as a percentage of the nominal frequency and adjustable in increments of 0.0001%.	D			
3.4.5.2.10-c		The measured frequencies shall be within ±0.0005% across the operational service conditions.	D			
3.4.5.2.10-d		The pre-alarm limit shall be adjustable between ±0.0001% and ±0.002%.	D			
3.4.5.2.10-e		The alarm limit shall be fixed at ±300 kHz (3.1.4).	D			
3.4.5.2.11-a	Receiver Frequency	The monitor shall measure the receiver frequency.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.2.11-b		The pre-alarm and alarm limits shall be stated as a percentage of the nominal frequency and adjustable in increments of 0.0001%.	D			
3.4.5.2.11-c		The pre-alarm and alarm limits shall be adjustable between ±0.0001% and ±0.002%.	D			
3.4.5.2.11-d		The measured frequencies shall be within ±0.0005% across the operational service conditions.	D			
3.4.5.3	Test Signals and Monitoring Activities	The transponder shall not be triggered more than a total of 120 times per second for monitoring and/or automatic delay control purposes.	D			
3.4.5.4	Transponder Tests	The following test results shall be available through the MDT and the Remote Monitoring and Logging System (RMLS) interface.	D	D		
3.4.5.4.1-a	On-Channel Receiver Sensitivity	The receiver sensitivity monitor shall measure the level in dBm that results in 70% reply rate, transmitted in response to the interrogation signal generator.	D			
3.4.5.4.1-b		The signal generator level shall be varied automatically from the established level to determine the level that produces a reply rate of 70%.	D			
3.4.5.4.1-c		A maintenance alert fault limit shall be adjustable from the nominal sensitivity level up to +4 dB.	D			
3.4.5.4.1-d		The adjustment shall be in increments of 1 dB or less.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.4.1-e		The default setting shall be 2 dB above the nominal level.	I			
3.4.5.4.1-f		A means shall be employed (i.e., averaging and/or hysteresis over multiple samples) to minimize nuisance maintenance alerts.	A, D			
3.4.5.4.1-g		The receiver sensitivity monitor shall be disabled, and any alert cleared, when the interrogation overload signal AGR is active (see 3.2.3.9).	T			
3.4.5.4.1-h		Receiver sensitivity monitoring shall be measured at the transmission line directional coupler.	I			
3.4.5.4.2-a	Sensitivity at 200 kHz and 900 kHz	The monitor shall measure the efficiency when the interrogator level is set to 3 dB higher than the nominal sensitivity and ±200 kHz from the nominal interrogation frequency.	T			
3.4.5.4.2-b		A maintenance alert shall be generated for an efficiency rate of less than 70% for the measurement above (a.).	D			
3.4.5.4.2-c		The monitor shall measure the efficiency when the interrogator level is set to -10 dBm and ±900 kHz from the nominal interrogation frequency.	T			
3.4.5.4.2-d		A maintenance alert shall be generated for an efficiency rate greater than 5% for the measurement above (c.).	D			
3.4.5.4.2-e		Maintenance alerts from these measurements shall be disabled, and any alert cleared, when the interrogation overload signal AGR is active (see 3.2.3.9).	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.4.2-f		Receiver sensitivity monitoring at ±200 kHz and ±900 kHz shall be measured at the transmission line directional coupler.	I			
3.4.5.4.3-a	Triggering Level at Other Pulse Spacings	The monitor shall measure the decode rate at an interrogation level 1 dB above the nominal sensitivity level and with the pulse spacing at ±1 µs from nominal.	T			
3.4.5.4.3-b		A maintenance alert shall be generated if the rate is less than 70% for the measurement above (a.).	D			
3.4.5.4.3-c		The monitor shall measure the decode rate at an interrogation level 70 dB above the nominal sensitivity level and with the pulse spacing at ±3 µs from nominal.	T			
3.4.5.4.3-d		A maintenance alert shall be generated if the rate is greater than 5% for the measurement above (c.).	D			
3.4.5.4.3-e		Maintenance alerts from these measurements shall be disabled, and any alert cleared, when the interrogation overload signal AGR is active (see 3.2.3.9).	T			
3.4.5.4.3-f		Receiver sensitivity monitoring at other pulse spacings shall be measured at the transmission line directional coupler.	I			
3.4.5.4.4	Echo Suppression	Means shall be provided to measure the echo suppression duration and threshold triggering level (3.2.3.5.2).	D			
3.4.5.4.5	Dead Time Gate	Means shall be provided to monitor the receiver dead time interval (3.2.3.3).	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.4.6	Voltage Standing Wave Ratio	Means shall be provided to measure the transmitter VSWR at the transmission line directional coupler.	D			
3.4.5.4.7-a	Transponder Decoder Certification Tests	Means shall be provided within the monitor to test the following parameters generated by the transponder:	D			Lead-in shall statement.
3.4.5.4.7-a.1		Reply delay (3.4.5.2.3);	D			
3.4.5.4.7-a.2		Pulse width (3.2.6.1.3);	D			
3.4.5.4.7-a.3		Rise time (3.2.6.1.1);	D			
3.4.5.4.7-a.4		Decay time (3.2.6.1.4);	D			
3.4.5.4.7-a.5		Pulse spacing (3.2.6.2);	D			
3.4.5.4.7-a.6		Reply efficiency (3.4.5.2.6);	D			
3.4.5.4.7-a.7		Squitter count (3.4.5.2.5);	D			
3.4.5.4.7-a.8		Identification code (3.4.5.2.9);	D			
3.4.5.4.7-a.9		Transponder power output (3.4.5.2.7);	D			
3.4.5.4.7-a.10		Radiated power level (3.4.5.2.8);	D			
3.4.5.4.7-a.11		On-channel receiver sensitivity (3.4.5.4.1);	D			
3.4.5.4.7-a.12		Decodes at ± 1µs (3.4.5.4.3);	D			
3.4.5.4.7-a.13		Decodes at ± 3 µs (3.4.5.4.3);	D			
3.4.5.4.7-a.14		Decodes at ± 200 kHz (3.4.5.4.2);	D			
3.4.5.4.7-a.15		Decodes at ± 900 kHz (3.4.5.4.2);	D			
3.4.5.4.7-a.16		Echo suppression duration (3.4.5.4.4);	D			
3.4.5.4.7-a.17		Echo suppression threshold (3.4.5.4.4);	D			
3.4.5.4.7-a.18		Dead time gate (3.4.5.4.5); and	D			
3.4.5.4.7-a.19		VSWR (3.4.5.4.6);	D			
3.4.5.4.7-b		The testing limits for items 7., 8., 10., 11., 16., 17., and 18. above shall be adjustable through the MDT.	D			
3.4.5.4.7-c		The certification tests shall run periodically and upon command.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.4.7-d		The period in which the certification tests run shall be adjustable with a minimum period as low as practicable and a maximum period of at least 24 hours.	D			
3.4.5.4.7-e		The certification tests shall be selectively enabled/disabled.	D			
3.4.5.4.7-f		Execution of the certification tests shall not affect or interrupt the DME service.	T			
3.4.5.4.7-g		The latest certification test results shall be available through the MDT and the RMLS interface.	D	D		
3.4.5.4.7-h		Failure of any of the tests shall cause a maintenance alert.	T			
3.4.5.4.7-i		The maintenance alert above (h.) shall be reset upon the next in-tolerance test.	T			
3.4.5.5-a	Monitor Alarm Limit Certification Tests	Means shall be provided to test and validate alarm limits.	D			
3.4.5.5-b		The values used for the testing shall be adjustable through the MDT.	D			
3.4.5.5-c		The certification tests shall run periodically and upon command.	I			
3.4.5.5-d		The period in which the certification tests run shall be adjustable with a minimum period as low as practicable and a maximum period of at least 24 hours.	D			
3.4.5.5-e		The certification tests shall be selectively enabled/disabled.	D			
3.4.5.5-f		Execution of the certification tests shall not affect or interrupt the DME service.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.5-g		The test results with measured data, and monitor status for the parameter under measurement, shall be available through the MDT and the RMLS interface.	D	D		
3.4.5.5-h		Failure of the reply delay test (k.1.) or the transmit frequency test (k.4) below shall result in a primary alarm (3.4.5.1.1).	T			
3.4.5.5-i		Failure of any other tests listed below in bullets k. and l. shall result in a primary alarm when the parameter is set to primary, or a maintenance alert when set to secondary.	T			
3.4.5.5-j		The maintenance alert above (i.) shall be reset upon the next in-tolerance test.	T			
3.4.5.5-k		The low and high alarm limits each shall be tested for outside alarm limit (out-of-tolerance) and within alarm limit (within tolerance) conditions by injection of test signals for the following:	D			Lead-in shall statement.
3.4.5.5-k.1		Reply delay (3.4.5.2.3);	D			
3.4.5.5-k.2		Pulse spacing (3.4.5.2.4);	D			
3.4.5.5-k.3		Squitter count (3.4.5.2.5);	D			
3.4.5.5-k.4		Transmit frequency (3.4.5.2.10);	D			
3.4.5.5-k.5		Receive frequency (3.4.5.2.10); and	D			
3.4.5.5-k.6		Identification frequency (3.4.5.2.9).	D			
3.4.5.5-l		The low alarm limit shall be tested for outside alarm limit (out-of-tolerance) and within alarm limit (within tolerance) conditions by injection of test signals for the following:	D			Lead-in shall statement.

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.5-l.1		Reply efficiency (3.4.5.2.6);	D			
3.4.5.5-l.2		Transponder power output (3.4.5.2.7); and	D			
3.4.5.5-l.3		Radiated power level (3.4.5.2.8).	D			
3.4.5.6-a	Monitor Interrogator Data	Means shall be provided within the monitor for purposes of testing the following signals generated by the interrogator:	I,D			Lead-in shall statement.
3.4.5.6-a.1		Pulse width (3.4.4.3.3);	D			
3.4.5.6-a.2		Rise time (3.4.4.3.1);	D			
3.4.5.6-a.3		Decay time (3.4.4.3.4);	D			
3.4.5.6-a.4		Pulse spacing (3.4.4.4);	D			
3.4.5.6-a.5		Pulse rate (3.4.5.3);	D			
3.4.5.6-a.6		Interrogation RF output level (3.4.4.10); and	D			
3.4.5.6-a.7		Interrogation RF frequency (3.4.1 and 3.4.1.3).	D			
3.4.5.6-b		The tests shall run periodically.	I			
3.4.5.6-c		The period in which the certification tests run shall be adjustable with a minimum period as low as practicable and a maximum period of at least 24 hours.	D			
3.4.5.6-d		The certification tests shall be selectively enabled/disabled.	D			
3.4.5.6-e		The results shall be available through the MDT and the RMLS interface.	D	D		
3.4.5.6-f		Failure of any of the tests shall cause a maintenance alert.	T			
3.4.5.6-g		The maintenance alert above (f.) shall be reset upon the next in-tolerance test.	T			
3.4.5.6-h		Execution of the certification tests shall not affect the monitor response time.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.4.5.7	Monitor Failsafe	The monitor shall be failsafe such that failure of any part of the monitor subsystem, including any associated control action (transponder shutdown), either results directly in an alarm condition, or does not alter any alarm limit to allow an out-of-tolerance condition to occur without detection.	D			
3.5	Control, Status and Indicator Functions					Header only, no IADT
3.5.1	Front Panel					Header only, no IADT
3.5.1.1	Controls	As a minimum, the following control functions shall be available from the front panel of the DME transponder:	D			Lead-in shall statement.
3.5.1.1-a		Enable/disable remote control;	D			
3.5.1.1-b		Disable aural alarms and alarm history when remote control is disabled;	D			
3.5.1.1-c		Enable bypass of the monitor control, in which:	D			
3.5.1.1-c.1		Automatic monitor shutdown action in response to primary alarms is inhibited; and	D			
3.5.1.1-c.2		Transmission of the identification signal is stopped.	D			
3.5.1.1-d		Disable bypass of the monitor control, in which:	D			
3.5.1.1-d.1		Automatic monitor shutdown action in response to primary alarms is enabled; and	D			
3.5.1.1-d.2		Transmission of the identification signal is restarted.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.5.1.1-e		ON/OFF/RESET of the DME transponder;	D			
3.5.1.1-f		Selection of main/standby transponder, if available;	D			
3.5.1.1-g		Lamp/aural alarm test;	D			
3.5.1.1-h		Alarm silence; and	D			
3.5.1.1-i		Volume control.	D			
3.5.1.2-a	Status and Indicators	As a minimum, the following visual indicator functions shall be provided on the equipment front panel:	I			Lead-in shall statement.
3.5.1.2-a.1		Transponder ON/OFF status;	I			
3.5.1.2-a.2		Monitor alarm condition;	I			
3.5.1.2-a.3		Mode of operation (monitor bypass) defined in 3.5.1.1-c;	I			
3.5.1.2-a.4		Transponder status (Main/Standby);	I			
3.5.1.2-a.5		AC power failure;	I			
3.5.1.2-a.6		On battery operation;	I			
3.5.1.2-a.7		AGR operation; and	I			
3.5.1.2-a.8		Remote control enabled/disabled.	I			
3.5.1.2-b		The following colors shall be used for indicators: Green for normal operation/remote control enabled, Amber/Yellow for an alert condition/remote control disabled, and Red for an alarm condition.	I, D			
3.5.1.2-c		An aural alarm shall be provided to indicate an alarm condition.	D			
3.5.1.2-d		An aural representation of the detected identification transmission from the monitor shall be provided.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.5.2-a	Maintenance Data Terminal (MDT) Software	All status and control functions available to install, configure, operate, and maintain the DME transponder, and update DME System software, shall be available from the Microsoft Windows-based MDT (GFE).	I, A, D, T			Roll-up req. Lead-in shall statement.
3.5.2-b		The MDT, running vendor provided software, shall:	A, D, T			
3.5.2-b.1		Display any changes to the DME System status;	D			
3.5.2-b.2		Display current values for all monitored parameters including environmental sensors (e.g., smoke, intrusion, temperature);	D			
3.5.2-b.3		Display the fault history (3.5.4);	D, T			
3.5.2-b.4		Display the results from fault diagnostics (3.5.5);	D, T			
3.5.2-b.5		Display the results from the most recent certification tests (3.4.5.4, 3.4.5.5, 3.4.5.6);	D			
3.5.2-b.6		Determine and report the logical, physical, and software configuration of the DME System to the extent practicable;	A, D			
3.5.2-b.7		Provide for a printable (to file) reference data display that includes selectable operational and certification parameters;	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.5.2-b.8		Determine and report system resource utilization (such as Central Processing Unit (CPU) utilization, and Random Access Memory (RAM), Programmable Read-Only Memory (PROM), and Non-Volatile RAM (NVRAM) memory usage and availability);	D			
3.5.2-b.9		Display all users logged onto the DME System; and	D			
3.5.2-b.10		Acknowledge and indicate either successful command execution or failure, including communication faults.	D, T			
3.5.3	Remote Control	Remote controls shall only be allowed when enabled from either the front panel or the MDT. See 3.6 for remote control function details.	D			
3.5.4-a	Fault History	At the MDT and RMLS interface, there shall be access to fault history data that provides a means to quickly display individual records associated with at least the 50 most recent alarms, pre-alarms, maintenance alerts, or other out-of-tolerance conditions that are brief or transient (i.e., less than alarm delay).	D, T	D, T		
3.5.4-b		Each record shall include the last normal parameter values and the post-fault (immediately prior to shutdown) parameter values.	D, T	D, T		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.5.5-a	Fault Diagnostics	Fault diagnostics shall provide diagnostics and system verification to facilitate fault isolation to the Line Replaceable Unit (LRU) level, including the remote maintenance monitoring subsystem(s).	D			
3.5.5-b		The diagnostic routine shall be able to localize 85% of all failures to a single faulty LRU, and 95% of all failure occurrences to no more than two candidate LRUs, one of which contains the fault.	D, T			
3.5.5-c		Fault diagnostics shall run per 3.5.7.e, and either continually or on command from the MDT.	D			
3.5.5-d		If fault diagnostics run upon command, then provisions shall be made to permit the operator to stop the test cycle at any time during the test sequence.	D, T			
3.5.5-e		All LRUs identified as failed by fault diagnostics shall be reported and listed in order of descending likelihood.	D			
3.5.5-f		Fault diagnostics that run continually shall not cause an out-of-tolerance condition of the radiated signals.	D, T			
3.5.5-g		Fault diagnostic data shall be stored in memory and accessible via the MDT or by RMLS request.	D	D		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.5.6-a	Trend Analysis Data Collection and Storage	The DME shall record and store, in non-volatile memory, system status, alarms, pre-alarms, maintenance alerts, all monitored parameter values, all results of fault diagnostics, results of certification tests, and any other system information or data that is required for corrective or preventative maintenance.	I, D			
3.5.6-b		The rate of data recording of these parameters shall be adjustable from once every 10 s to once every 10 000 s.	D, T			
3.5.6-c		Each individual record, which consists of one sample from all parameters recorded, shall be time and date stamped to the nearest second.	I			
3.5.6-d		The system memory shall be sufficient to store at least one year's worth of data, on a rolling basis (oldest data is replaced with new data, i.e., first in, first out), when set to sample and record at the fastest rate available.	A, D			
3.5.6-e		The data shall be available in American Standard Code for Information Interchange (ASCII), formatted as a comma-separated values (.csv) file from the MDT.	I			
3.5.7	Automatic Reset Function	The DME transponder automatic reset function shall:	D, T			Lead-in shall statement.
3.5.7-a		Return the DME transponder to normal operation when input power is restored after a power interruption;	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.5.7-b		Reinitialize all DME transponder software in the event of a restart/reboot (i.e., a momentary loss of power) such that it is fully functional with the latest loaded software version;	D			
3.5.7-c		Reset and restart the DME transponder at set intervals subsequent to a shutdown due to an alarm action, or protective actions in 3.2.8, 3.2.9, and 3.2.10;	T			
3.5.7-d		Be configurable to provide a minimum of three user-defined reset/restart time intervals; and	D			
3.5.7-e		Initiate fault diagnostics after the third or final restart and subsequent shutdown.	T			
3.6	Remote Maintenance Monitoring (RMM)	RMM consists of the various sensors, microprocessor(s), and software necessary to remotely monitor, control, record, and certify proper operation of the DME System to be furnished under this specification.				Header only, no IADT
3.6.1-a	Remote Monitoring Subsystem (RMS)	The RMS shall be independent from the DME monitor and shutdown control functions and circuits.	A			
3.6.1-b		RMS faults shall not affect the capability of the DME monitor and control functions to detect and respond to conditions that can cause HMI.	A			
3.6.1-c		Data monitored by the RMS shall be locally accessible at the MDT.	D			
3.6.1.1	RMS Functions	The DME RMS shall provide the following functions:	I, A, D			Lead-in shall statement.

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.1.1-a		Environmental monitoring as required in 3.6.6;	D			
3.6.1.1-b		Monitor each of the minimum set of performance parameters required to determine the operational status of the DME;	A, D			
3.6.1.1-c		Process the outputs of each of the monitoring devices as necessary to provide digital data in the appropriate engineering units for RMM;	D			
3.6.1.1-d		Process the outputs of each of the environmental (3.6.6) and spare (3.6.5) monitoring devices to determine alert and pre-alert status by comparing the monitored outputs to user-defined limits;	D			
3.6.1.1-e		Provide at least two limits for each monitored parameter in d. above, an alert (when the parameter reaches its established limit), and a pre-alert, which is typically 75% of the alert value;	I			
3.6.1.1-f		In response to a poll (data request message) received from the RMLS, transmit the current value of each parameter in the group or groups of parameters indicated by the content of the request message;	D	D		
3.6.1.1-g		Time stamping and local storage of the current status of alarms and alerts data values, alarm and alert limits, fault history (3.5.4) and trend analysis data (3.5.6);	I, D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.1.1-h		Capability to provide 100% additional memory storage capacity of that required to meet the requirements specified herein;	A, I			
3.6.1.1-i		The additional storage capacity required in h. above shall be provided in the initial design;				
3.6.1.1-j		Capability to process RMM reset commands; and	D	D		
3.6.1.1-k		Capability to process RMM restart commands to restore DME operation in the case of interrupted service.	D	D		
3.6.1.1-l		The RMS shall utilize Simple Asynchronous Interfacing (SAI) protocol messages contained within CMHP frames to communicate with RMLS using IP protocol.	D	D		
3.6.2	Alarm and Alert Messages	N/A Header only.				Header only, no IADT
3.6.2.1-a	Alarms	An alarm message shall be generated and transmitted to the RMLS when a failure occurs within the DME System that causes a loss of service to the user (shutdown).	T			
3.6.2.1-b		An alert message shall be generated and transmitted to the RMLS when a failure occurs within the DME System which does not cause a loss of service to the user.	T			
3.6.2.1-c		When the system is commanded off, or when the system is off as a normal state, alarm messages shall be inhibited.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.2.2-a	Maintenance Alerts	When the current value of a measured parameter exceeds the established alert limits, an indication of the maintenance alert condition shall be sent to the RMLS.	T	T		
3.6.2.2-b		The limits for maintenance alerts shall be adjustable locally from the MDT.	D			
3.6.3-a	Non-Volatile Data Storage	All control settings, operational parameters and limits, initialization data, data files and fault history shall be locally stored in the RMS.	I			
3.6.3-b		Local storage shall be supported with sufficient battery capacity that includes built-in charging, or other technique (i.e., flash memory), to ensure the non-volatility of stored data for a period of not less than 90 days.	I, A			
3.6.3-c		Means shall be provided to transfer stored data to another medium for permanent storage purposes.	I			
3.6.4	RMS Data Sampling Rate	The RMS shall sample each parameter within the RMS and DME monitor no less frequently than once every second.	D			
3.6.5-a	Spare Input /Output Capacity	The RMS shall provide at least three spare analog inputs, two spare digital inputs and two spare digital outputs.	I			
3.6.5-b		All spare analog inputs shall provide user-configurable alert and pre-alert limits.	I			
3.6.5-c		Data, alerts, and pre-alerts from the spare inputs shall be transmitted to the RMLS upon demand.	D	D		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.5-d		Specific requirements for the spare inputs and outputs shall be as follows:	I			Lead-in shall statement.
3.6.5-d.1		Analog inputs:				Lead-in statement – no IADT
3.6.5-d.1.i		Input range: Bipolar, -5.000 VDC to +5.000 VDC with respect to input ground.	I			
3.6.5-d.1.ii		Minimum accuracy: ±5% of reading, or ±0.01 V, whichever is numerically smaller.	T			
3.6.5-d.1.iii		Input impedance: 20 kΩ or greater.	T			
3.6.5-d.1.iv		Minimum A/D converter resolution: 1 part in 1000.	A			
3.6.5-d.2		Digital inputs:				Lead-in statement – no IADT
3.6.5-d.2.i		TTL, low = 0.0 V to +0.8 V, high = +2.0 V to +5.5 V.	A			
3.6.5-d.2.ii		Sense: Programmable such that either high or low represents alert, with the opposite sense representing normal.	D			
3.6.5-d.3		Digital outputs:				Lead-in statement – no IADT
3.6.5-d.3.i		TTL with the same voltage limits as the digital inputs.	A			
3.6.5-d.3.ii		Current sink capacity: 24 mA minimum.	A			
3.6.6-a	Environmental Monitoring	The following sensors shall be furnished with each DME System:				Lead-in shall statement.
3.6.6-a.1		Intrusion detector;	I			
3.6.6-a.2		Ionization-type smoke detector;	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.6-a.3		Obstruction light current sensor;	I			
3.6.6-a.4		AC power; and	I			
3.6.6-a.5		Temperature.	I			
3.6.6-b		Each sensor shall be provided with all necessary connectors, terminal boards, enclosures, mounting hardware, and installation instructions.	I			
3.6.6-c		Measurements from each environmental sensor shall be processed by the RMS for output locally via the MDT and transmission to the RMLS.	D	D		
3.6.6.1-a	Intrusion Detector	The intrusion detector shall detect the opening of the DME shelter door.	D			
3.6.6.1-b		The RMS building security timer shall start when the detector senses that the door has been open for 0.25 s.	D			
3.6.6.1-c		If an MDT is not connected within 5 minutes, the RMS shall indicate that the building security parameter is in alert.	T			
3.6.6.1-d		The RMS shall send an alert message to the RMLS when the building security parameter is in alert.	D	D		
3.6.6.1-e		If the MDT is connected within 5 minutes, the building security parameter shall return to normal.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.6.1-f		If after being connected, and the MDT is then disconnected, the RMS shall inhibit sensing a building security alert for a period of 5 minutes prior to resuming normal monitoring of the building security parameter.	T			
3.6.6.1-g		Capability shall be provided to arm and disarm (bypass) the intrusion detector locally via the MDT and through the RMLS.	D	D		
3.6.6.2-a	Smoke Detector	The ionization-type smoke detector shall be powered from the DME System.	I			
3.6.6.2-b		The smoke detector shall meet the requirements of Underwriters Laboratories (UL), Inc. Standard 268 and bearing the U.L. label showing compliance.	I			
3.6.6.2-c		The RMS shall send an alert message to the RMLS when the smoke detector is activated.	D	D		
3.6.6.3-a	Obstruction Light Sensor	The obstruction light (3.3.12) current sensor shall be capable of detecting an outage of one or more lamps.	T			
3.6.6.3-b		The sensor shall operate correctly when either incandescent or LED bulbs are used.	D			
3.6.6.3-c		The RMS shall send an alert message to the RMLS when one or more lamps fail.	D			
3.6.6.4-a	AC Power Sensor	The AC power sensor shall measure the AC power (voltage and current) applied to the DME equipment.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.6.4-b		The RMS shall transmit an AC power alert message to the RMLS when the DME System switches to the backup power source.	D	D		
3.6.6.5-a	Temperature Sensors	Two temperature sensors shall be provided for installation: one for inside the DME shelter and one for outside the DME shelter.	I			
3.6.6.5-b		The sensors shall measure temperature from -46°C to +70°C with an accuracy within ±4°C.	T			
3.6.6.5-c		The RMS shall be programmable with upper and lower temperature alert limits.	D			
3.6.6.5-d		Exceeding the temperature alert limits shall cause a temperature alert message to be transmitted to the RMLS.	T	T		
3.6.7	RMS Security	Log-on security shall be implemented to ensure that only authorized personnel can enter RMS commands.	D			
3.6.7.1	Security Implementation	The RMS security design shall:	D, T			Lead-in shall statement.
3.6.7.1-a		Include a standard initial log-on procedure for factory-delivered systems that provides security-level access for the purpose of assigning passwords and security access levels;	D			
3.6.7.1-b		Include a method to restore the factory log-on IDs and passwords;	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.7.1-c		Utilize assigned user IDs and passwords containing up to 16 alphanumeric characters with a minimum of 24 total ID/password combinations stored in the RMS non-volatile memory;	D			
3.6.7.1-d		Echo the user ID to the MDT as non-alphanumeric characters when logging in;	D			
3.6.7.1-e		Respond to entry of an invalid ID or password by displaying an error message to the MDT, terminating the log-in procedure (i.e., not prompt the user to try again), and returning to its idle (wait) state;	T			
3.6.7.1-f		Provide a message identifying the logged-in user to the RMLS for all validated access entries and send a log-off message when the user logs off;	D	D		
3.6.7.1-g		Inhibit the transmission of all alarm or alert messages to the RMLS after the initial log-in identification, during the time a second or third security-level user is logged in; and	D	D		
3.6.7.1-h		Automatically log off the user if the terminal has been idle for more than 15 minutes or if there is no terminal activity within 15 minutes following the completion of a user-initiated test.	D			
3.6.7.2	Security Level Definitions	Security levels for the RMS are defined as follows:				Lead-in statement – no IADT

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.7.2-a		Level 1: Entry of a valid user ID and password shall allow READ ONLY access/display of system status, configuration, and monitored system parameters. The user has no control over the DME subsystem.	D			
3.6.7.2-b		Level 2: Entry of a valid user ID and password shall enable read and write access/display of all system functions and adjustable parameters except for user IDs and passwords.	D			
3.6.7.2-c		Level 3: Entry of a valid user ID and password shall enable Level 2 capabilities and also provide the ability to assign and/or modify user IDs and passwords.	D			
3.6.8-a	RMS Data and Control Filtering	All measurements and control functions available from the front panel or MDT shall be selectively available remotely.	D	D		
3.6.8-b		Capability to enable or disable any of these measurements and control functions shall be possible via software build procedures.	D	D		
3.6.8-c		The local system shall not execute remote commands or transmit measurements to the remote location for each disabled parameter.	D	D		
3.6.8-d		Enabling/disabling shall be implemented by a hard-coded configuration table listing each parameter monitored by the RMS.	I, D	D		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.6.8-e		Each parameter shall be selectable by software build procedures to send a pre-alert message, alert message, pre-alarm message, or an alarm message.	I, D	D		
3.6.8-f		A similar configuration table for each remote control function shall, by software build procedures, allow the enabling or disabling of remote control functions by the RMLS.	I, D	D		
3.6.9	RMS Failure Protection	The DME System design shall employ a failsafe mechanism such that failures in the RMS function cannot cause a loss or degradation of navigation service to the user.	A, D	D		
3.6.10-a	Interface with RMM Subsystems	The interface from RMS to RMLS shall be compliant with NAS-IC-51015108-01; FAA-E-3039; and selectively, either IPv4 or IPv6 protocols.	I, D	D		Lead-in shall statement.
3.6.10-b		The digital data provided at the RMLS interface shall be in the appropriate engineering units for the parameters monitored in the formats defined in NAS-IC-51015108-01, to include but not limited to:	I, D	D		
3.6.10-b.1		Executive parameters;	I, D	D		
3.6.10-b.2		System status;	I, D	D		
3.6.10-b.3		Environmental;	I, D	D		
3.6.10-b.4		Communication;	I, D	D		
3.6.10-b.5		Fault diagnostic results;	I, D	D		
3.6.10-b.6		Certification parameters/results; and	I, D	D		
3.6.10-b.7		Trend analysis data.	I, D	D		
3.7	Data Security	N/A Header only.				Header only, no IADT

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.7.1	Access Control	The DME System shall contain features in its design and operation that prevent unauthorized and disruptive access to the system by implementing the following requirements as a minimum:	I, D, T			Lead-in shall statement.
3.7.1-a		Authorized user access verification;	D			
3.7.1-b		User password control;	D			
3.7.1-c		Restriction of access to system/operating system (OS) files/data;	D			
3.7.1-d		Denying access to direct OS functions/commands;	I, D			
3.7.1-e		Limited access to specific functions based on job category;	I, D			
3.7.1-f		While in the normal operating mode, prevent the loading of data from removable media or network connections; and	T			
3.7.1-g		Disable any unused ports during normal operation.	D			
3.7.2-a	Audit Logging	The DME System shall generate audit logs for both operating system-level and application-level events for local, non-local, and remote sessions on all devices capable of generating event logs.	I			
3.7.2-b		The following minimum events shall be captured, recorded, and reported through the Internet Protocol (IP) interface:	D			
3.7.2-b.1		Resource degradation alerts (e.g., 100% utilization, disk space full, volume full);	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.7.2-b.2		Login and logout, successful and unsuccessful;	D			
3.7.2-b.3		Unauthorized system access attempt;	D			
3.7.2-b.4		Account creation/modification and permissions or configuration changes;	D			
3.7.2-b.5		Administrator level activities;	D			
3.7.2-b.6		Startup/Shutdown of System/Services/processes;	D			
3.7.2-b.7		Access to privileged functions (e.g., setting auditable event and intrusion detection devices) including maintenance;	D			
3.7.2-b.8		Results from malicious code protection;	D			
3.7.2-b.9		Access control list denials; and	D			
3.7.2-b.10		Intrusion Detection System (IDS) signature based attacks.	D			
3.8	DME System Design Characteristics	N/A Header only.				Header only, no IADT
3.8.1-a	Maintainability	The system shall utilize LRUs.	I			
3.8.1-b		During routine servicing and maintenance, unsoldering of wires, removal of wire harnesses, parts, or assemblies, shall not be required.	I, D	D		
3.8.1-c		When it is necessary to displace a part in order to check or remove another part, the former part shall be wired and mounted so that it can be moved without being disconnected.	I, D	D		
3.8.1-d		Removal of any panels or LRUs for maintenance purposes shall be accomplished without unsoldering or soldering connections.	I, D	D		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.1-e		Replacement of air filters shall be accomplished without the shutdown of fans.	D			
3.8.1-f		All required connection caps, covers, or loads shall be securely affixed to the equipment.	I			
3.8.1.1-a	Real Time Clock/Calendar	The DME System shall incorporate a real time clock/calendar with date, hours, minutes, and seconds.	I			
3.8.1.1-b		The local system time shall be readable as a data point from the RMLS and the MDT.	D	D		
3.8.1.1-c		The local system time shall be adjustable locally from the MDT.	D			
3.8.1.1-d		The local system time drift shall be within 15 s a month.	A, D			
3.8.1.1-e		The local system time shall be supported by a battery independent of the subsystem backup power.	I			
3.8.1.1-f		The system shall include a clock battery with built-in charging that is capable of maintaining the local system time for at least 180 days.	A			
3.8.2	Reliability	The DME System shall have a mean time between failures (MTBF) of not less than 8760 hours as a serial reliability model.	A, D	D		
3.8.3-a	Modular Construction	Construction with plug-in or easily replaceable sub-assemblies (i.e., no special tools required) shall be used throughout the equipment in order to provide the specified level of maintainability.	I, D	D		
3.8.3-b		Modularization shall be based on logical functional block concepts.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.3-c		The design shall be such as to minimize the cost and number of different types of modules required for equipment support.	I			
3.8.3-d		Modules shall be printed circuit boards whenever practical from the standpoint of component size/weight and consistent with circuit performance requirements.	I			
3.8.3.1-a	Equipment Mounting	All electronic equipment shall be mounted within a standard EIA/ECA-310 rack.	I			
3.8.3.1-b		The outer dimensions of the equipment cabinet with doors closed shall not exceed 24 inches wide, 30 inches deep, and 76 inches in height.	I			
3.8.3.1-c		The rack or cabinet shall be steel or aluminum.	I			
3.8.3.1-d		The rack or cabinet shall be floor mounted, with easily accessible holes in the base for attaching the bottom of the rack to the shelter floor.	I	D		
3.8.3.1-e		The rack or cabinet shall allow the installation of as many as four conduits of up to 2-1/2 inch size for AC power, battery, ground, and signal cables.	I			
3.8.4-a	Test Points	Test points and controls for adjustment shall not be located in compartments with unprotected voltage points of 300 V or more.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.4-b		All test points and controls for adjustments shall be located to avoid accidental shock to personnel engaged in normal operating or maintenance activities.	I	D		
3.8.4-c		Protection shall be provided in the test point circuitry to prevent equipment damage caused by the external grounding of test points.	I	D		
3.8.4-d		Test points on plug-in circuit cards shall be easily accessible inside the electronic component cabinet.	I	D		
3.8.4-e		Each component of the ground station equipment shall contain test points and connectors, appropriately labeled and numbered as necessary, to provide for the examination of significant voltages, signal amplitudes, waveforms, and timing characteristics and to provide for the connection of test equipment for adjustment and maintenance operations.	I	D		
3.8.4-f		The type of test points and connectors provided shall be compatible with the applications (i.e., frequency range, voltage) for which the test points and connectors are needed.	I	D		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.4-g		Connection to test points and connectors utilized in either adjusting or testing the DME System for proper performance during prescribed periodic maintenance shall not require interruption of system operation.	D	D		
3.8.4-h		Test points on plug-in circuit cards required for periodic and field-level corrective maintenance shall be accessible without the use of extender boards, cables, or adapters.	D	D		
3.8.5-a	Interchangeability	Like LRUs shall be interchangeable in form, fit, and function without mechanical adjustment.	D	D		
3.8.5-b		LRU plug-in modules and assemblies shall be designed to prevent insertion into the incorrect location or orientation.	I, D	D		
3.8.6	Corrective Maintenance	The following time requirements assume the following: A single maintenance technician performs the repair; the technician has had adequate equipment-specific training; the repair work is performed under normal conditions in the equipment shelter; and a full set of spares and necessary tools are located at the shelter.				Lead-in statement of assumptions – no IADT
3.8.6-a		The mean time to isolate and replace a faulty LRU on the DME System shall be less than or equal to 30 minutes.	A, D	D		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.6-b		The maximum time to isolate and replace an LRU shall be less than or equal to 120 minutes.	D	D		
3.8.7-a	Preventative Maintenance	The period between preventative maintenance procedures shall be as long as practicable, but in no case less than every 3 months.	I			
3.8.7-b		The accomplishment of a set of periodically scheduled maintenance procedures shall require less than or equal to 2 hours to be completed.	D	D		
3.8.8-a	Software/Firmware Updates	Software and firmware for the DME System shall be field updatable, without adding or modifying existing hardware components.	D			
3.8.8-b		The software and firmware within the first article hardware shall use less than 50% of the available volatile memory, and less than 50% of the available non-volatile memory.	A, D			
3.8.9-a	Electrical Interfaces to DME Antenna	Cables and connectors used for the antenna, excluding the ground cable, shall be protected from exposure to the elements.	I			
3.8.9-b		Interconnecting power cables shall terminate at one or more connectors.	I			
3.8.10-a	RF Input/Output Connectors	The RF output connector shall be an N female type at the top of the equipment cabinet.	I			
3.8.10-b		The RF input connector from the antenna coupling probe shall be a Threaded Neill–Concelman (TNC) type female at the top of the equipment cabinet.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.10-c		The monitor interrogator RF output connection to the receiver shall be easily removable without damage.	D			
3.8.11-a	Grounding and Bonding	The ground reference for the equipment/system shall be in accordance with FAA-STD-019, FAA-C-1217, NFPA 70 Article 250, and chapters 8 and 9 of IEEE 1100.	I			
3.8.11-b		Shielding and bonding shall be per FAA-STD-019.	I			
3.8.11-c		Any removable rack-mounted unit, assembly, or subassembly whose rack provides multi-point grounding shall have a flexible grounding strap, using bonding connections per FAA-STD-019.	I			
3.8.11-d		Enclosure and rack doors shall have grounding straps across the hinges to ensure proper grounding per FAA-STD-019.	I			
3.8.11-e		For equipment connected to an AC supply line, the DC resistance to ground for each line input shall be at least 1 MΩ.	T			
3.8.12	Input Power	N/A Header only.				Header only, no IADT
3.8.12.1-a	AC Power	The system shall operate from 120 VAC, 60 Hz, single-phase power as the primary power source.	I			
3.8.12.1-b		The DME equipment shall be directly connected to line power.	I			
3.8.12.1-c		Line power shall enter through the top of the cabinet.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.12.1-d		In the event of the loss of the 120 VAC commercial power, the system shall operate utilizing backup power (3.8.12.10) without interruption.	D			
3.8.12.1-e		The DME System shall maintain all functionality while operating on backup power.	D			
3.8.12.1-f		The equipment shall interface to building wiring in accordance with FAA-C-1217, FAA-STD-032, and NFPA 70 in that order of precedence.	I			
3.8.12.1-g		Electrical enclosures, cabling, and wiring shall be approved by the Department of Labor Occupational Safety and Health Administration's (OSHA) Nationally Recognized Testing Laboratory Program (e.g., UL listed).	I			
3.8.12.2-a	Equipment Directly Connected To Line Power	Controls and indicators for the electrical line voltage of an equipment rack shall be located in accordance with NFPA 70.	I			
3.8.12.2-b		When switches or circuit breakers function as main power disconnecting means, operating either directly or through a contactor, they shall break the incoming line immediately before the line filter, terminal block or connector, fuses or other parts without compromising RFI, EMI shielding integrity.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.12.3	Power Plugs, Cords, and Outlets	The DME System shall include one 20 A, 125 VAC, NEMA WD 5 grounding duplex receptacle, installed and wired in accordance with the requirements of NFPA 70.	I			
3.8.12.3-a		The receptacle shall be located on the front of the cabinet at the bottom.	I			
3.8.12.3-b		The equipment design shall include the provisions required to provide power to this outlet from a source independent of the DME System power source.	I			
3.8.12.4	Leakage Currents	Leakage current shall be less than 5 mA.	D			
3.8.12.5	Power Factor	The power factor (PF) for the DME equipment shall be within 0.7 (lag) – 0.7 (lead) if the power draw of the equipment is less than 2000 W.	T		4.4.12	
3.8.12.6	Inrush Current	The ratio of peak inrush current to root mean square current for loads or devices up to 40 A, measured on the phase conductor with the highest current, shall be equal to or less than the ratio defined by Figure 3-3.	T		4.4.13	
3.8.12.7	Harmonic Distortion	The system shall meet the current harmonic distortion requirements stated in International Electrotechnical Commission (IEC) 61000-3-2:2018.	T			
3.8.12.8-a	Circuit Overload Protection	Current overload protection for the equipment shall be provided by fuses, circuit breakers, or other protective devices for primary circuits.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.12.8-b		Overcurrent devices used in any AC circuits with voltages exceeding 100 V shall have a minimum of 10 000 Ampere Interrupting Capacity (AIC) rating.	I			
3.8.12.8-c		Devices/components shall be protected from damage due to a loss of power.	I	D		
3.8.12.8-d		Series combination system overcurrent protection shall not be permitted.	I			
3.8.12.8-e		Transient protection shall be provided in accordance with IEEE C62.41.2-2002, IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000 V and Less) AC Power Circuits.	I			
3.8.12.9	Input Power Conditions	The system shall operate within tolerance when the AC input power varies according to the following:	T			Lead-in shall statement.
3.8.12.9-a		The input voltage from 102–132 VAC;	T			
3.8.12.9-b		Frequency is set to any value from 57–63 Hz (steady state);	T			
3.8.12.9-c		Steady state frequency by ± 0.5 Hz;	T			
3.8.12.9-d		Steady state frequency variation rate up to 1.5 Hz/s;	T			
3.8.12.9-e		Momentary deviation of frequency from 53–65 Hz, lasting 0.5 to 3 s; and	T			
3.8.12.9-f		Momentary changes in frequency at a 5 Hz/s rate, lasting 0.5 to 3 s.	T			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.12.10-a	Backup DC Power	The system shall be capable of operation from a facility backup power source (GFE) that provides 33–56 VDC.	D	D		
3.8.12.10-b		The system shall be capable of operation from a 48 V backup battery set provided with the DME System.	D	D		
3.8.12.10-b.1		The transponder equipment shall have a continuously engaged battery backup power supply that enables normal operation for a minimum of 4 hours, with fully charged batteries, and operating at a rate of 4,320 ppps subsequent to a failure of the primary power source.	D			
3.8.12.10-b.2		The system shall provide the capability to charge the backup battery set.	D			
3.8.12.10-b.3		Battery backup power supply charging shall be selectively enabled or disabled.	D			
3.8.12.11-a	Transformer Isolation of Non-Switching DC Power Supplies	All non-switching DC power supplies energized from the AC line power source shall be isolated from the AC line through a power transformer with separate primary and secondary windings.	I			
3.8.12.11-b		The DC resistance from each input line terminal (with fuses in place and AC line control contacts closed) to the signal or chassis ground shall be greater than 1 MΩ.	D			
3.8.13-a	Removable Parts and Mating Connectors	Electronic equipment shall be furnished with a complete set of installed fuses.	I	I		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.13-b		Parts that may be damaged by shipment in the operating sockets shall be packed in the normal part shipping container with information to identify their location in the system.	I	I		
3.8.13-c		Removable circuit cards shall include hardware to prevent inadvertent removal by shock and vibration.	I			
3.8.13-d		Mating connectors of equipment-mounted coaxial or cable connectors shall be provided.	I	I		
3.8.13-e		Mating connectors shall be provided when two or more pieces of equipment require interconnection.	I	I		
3.8.13-f		Circuit card guides shall support and retain the card in the guides during all phases of removal and insertion.	I	I		
3.8.14-a	Electronic Equipment Assembly Requirements	Equipment assemblies, subassemblies, printed circuit board assemblies, terminal board assemblies, and electronic modules shall be Class 2 or Class 3 as defined in IPC J-STD-001.	I			
3.8.14-b		Printed circuit boards exposed to uncontrolled environmental conditions shall have a conformal coating in accordance with IPC CC-830.	I			
3.8.14.1	Component Mounting	Component mounting shall be in accordance with IPC-CM-770 or IPC-SM-780, as applicable, except the term “not recommended” shall be interpreted as “reject.”	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.14.2	Printed Circuit Boards	Printed circuit boards shall be in accordance with IPC-A-600.	I			
3.8.14.3	Assembly	Assembly shall be in accordance with IPC-A-610 and IPC J-STD-001.	I			
3.8.14.4	Wire Wrap	Wire wrap shall not be used.	I			
3.8.15	Shelf Life	Materials, packaging, and processes shall ensure the equipment will meet performance requirements after a period of two years in a non-operational state after FAA acceptance.	I, A			
3.8.16	Accessibility	N/A Header only.				Header only, no IADT
3.8.16.1-a	General	All non-hinged shields or plates that are normally opened or removed in servicing equipment shall be secured with captive fasteners.	I			
3.8.16.1-b		Captive fasteners shall be spaced on centers not exceeding 10 inches and shall be located around the entire periphery of the shields or plates.	I			
3.8.16.2-a	Enclosures	No enclosure, or part thereof, shall support or sustain combustion in excess of the requirements of NEMA 250.	I			
3.8.16.2-b		Enclosures for equipment or systems, up to 1000 V, installed outside a building (outdoors) shall be either NEMA Type 4 or Type 4X.	I			
3.8.16.2-c		Enclosures for equipment or systems, up to 1000 V, installed inside a building where no dripping or splashing liquids or dust are normally expected shall be NEMA Type 1.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.16.2-d		Accessibility to chassis, assemblies, or parts contained within cabinets, consoles, or other enclosures shall be provided from outside the basic equipment.	I			
3.8.16.2-e		Mounting such items on withdrawal slides, swinging doors, through cable extenders and cable retractors, and provisions for circuit card extenders shall allow part or module operation in the open position.	I			
3.8.16.2-f		Locks shall be provided to lock the chassis in the servicing position.	I			
3.8.16.2-g		When withdrawal slides are used, they shall be of guided sectional construction.	I			
3.8.16.2-h		Complete removal and access for servicing of electronic equipment contained within cabinets, consoles, or other enclosures shall be provided from either the front or rear of the equipment.	I			
3.8.16.2-i		Guide pins (or locating pins), or the equivalent, shall be provided for mechanical alignment during mounting.	I			
3.8.16.3-a	Maintenance Access	The system shall be equipped with doors or panels for direct access to its essential parts.	I			
3.8.16.3-b		The removal of the doors or panels shall not compromise the structural integrity of support structures.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.17-a	Thermal Design	When air filters are required with forced air cooling, the air filters shall be in accordance with UL 900 and ASHRAE 52.2.	I			
3.8.17-b		The difference between the exhaust air temperature (measured inside the cabinet or console in front of the exhaust air vent) and input air temperature (measured outside the cabinet or console directly in front of the input air vent) shall be less than 15° C with the equipment operating under normal service conditions.	D	D		
3.8.17-c		Air exhaust shall be directed away from operating personnel.	I			
3.8.17-d		Cooling methods such as liquid, evaporative coolants, and vapor cycle refrigerants shall not be used.	I			
3.8.17-e		Failure of a cooling device shall cause a maintenance alert.	D			
3.8.18	Materials Processes and Parts	N/A Header only.				Header only, no IADT
3.8.18.1-a	Dissimilar Metals	The selection of metals for use in electronic equipment shall be made in accordance with the requirements of MIL-STD-889.	I			
3.8.18.1-b		Where electronic design requirements preclude the isolation from one another of incompatible metal combinations as identified in MIL-STD-889, the incompatible materials shall be isolated from exterior environments.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.18.2-a	Metals, Corrosion Resistance	Metals, including those used for door hinges/fasteners, shall be corrosion resistant or coated or metallurgically processed to resist corrosion.	I			
3.8.18.2-b		Non-corrosion resistant steel alloys, except where specifically required for electronic purposes, shall not be used.	I			
3.8.18.3-a	Corrosion-Resisting Ferrous Alloys	Austenitic corrosion-resisting steel shall be used for all exterior structural parts.	I			
3.8.18.3-b		Corrosion-resisting steels shall be given a passivation treatment.	I			
3.8.18.4	Flammable Materials	Materials used in the end item configuration shall be noncombustible, fire retardant, or self-extinguishing in the most hazardous conditions of the equipment environment.	I			
3.8.19	Equipment Manufacturing Processes	N/A Header only.				Header only, no IADT
3.8.19.1	Strain Relief	Each part lead terminating at a connection point shall allow for strain relief to minimize tensile or shear stress.	I			
3.8.19.2-a	Painted Finish	Metal surfaces not otherwise protected as described in this specification shall be painted.	I			
3.8.19.2-b		The painted surfaces shall withstand the environmental operating conditions defined in this specification without flaking, cracking, blistering, or allowing any corrosion of the underlying surface.	I, D	D		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.19.2-c		The painted finish shall be in accordance with FAA-STD-001. (Alternate colors will be allowed upon FAA approval.)	I			
3.8.19.2-d		Leaded paint shall not be used.	I			
3.8.20	Electrical Parts	N/A Header only.				Header only, no IADT
3.8.20.1-a	Batteries	Batteries shall be in accordance with NEMA C18.1M Part 1 and Part 2; NEMA C18.2M Part 1 and Part 2; NEMA C18.3M Part 1 and Part 2; and applicable recognized industry standards.	I			
3.8.20.1-b		Equipment containing batteries shall be able to operate and be maintained in accordance with their formally documented maintenance procedures for a minimum of 2 years before requiring replacement.	A, I			
3.8.20.1-c		Batteries shall not leak or generate toxic, corrosive, or combustible fumes.	I			
3.8.20.1-d		Except for equipment requiring permanent battery installation, battery-powered equipment shall be labeled externally as follows: “WARNING: REMOVE BATTERIES BEFORE SHIPMENT OR INACTIVE STORAGE OF 30 DAYS OR MORE.”	I			
3.8.20.1-e		Battery compartments shall be provided in accordance with the following:	I, D	D		
3.8.20.1-e.1		Contain devices to firmly secure the batteries.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.20.1-e.2		Provide access for battery installation, maintenance, testing, and removal without disassembly of equipment.	I, D	D		
3.8.20.1-e.3		Prevent the build-up of heat, gases, liquids, or chemicals released during battery operation, charging, deterioration, or rupture.	I			
3.8.20.1-e.4		Prevent build-up of heat, gases, liquids, or chemicals from entering the electronic compartment.	I			
3.8.20.1-e.5		Prevent accidental battery discharge during battery installation, maintenance, testing, and removal.	I			
3.8.20.1-f		Batteries used with or assembled to microelectronics that supply power to microelectronics shall not require a dedicated battery compartment.	I			
3.8.20.1-g		Connections, polarity, minimum acceptable voltage for equipment operation, nominal voltage, and type(s) of batteries required shall be marked as applicable in a prominent place on or adjacent to the battery compartment.	I			
3.8.20.2	Overcurrent Devices	N/A Header only.				Header only, no IADT
3.8.20.2.1-a	Circuit Breakers	Circuit breakers shall be in accordance with the requirements of UL 489, unless they are used in an Underwriters Laboratories approved equipment item or load.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.20.2.1-b		Each pole of all circuit breakers shall provide complete overcurrent protection by having inverse time and instantaneous tripping characteristics.	I			
3.8.20.2.1-c		Circuit breakers shall be operated by a toggle type handle and have a quick-make, quick-break, over-center switching mechanism, operating all poles, that is mechanically trip-free from the handle so that the contacts cannot be closed against short circuit currents.	I			
3.8.20.2.1-d		Circuit breakers shall be capable of manual operation to the open (off) and closed (on) conditions.	I			
3.8.20.2.1-e		Circuit breakers shall not be used as switches unless they are specifically approved and listed for switching duty.	I			
3.8.20.2.1-f		Circuit breakers operating handles shall indicate, by visual or tactile means, the open (off), closed (on), and tripped states of the breaker.	I			
3.8.20.2.1-g		Equipment or system circuit breakers shall be coordinated with the circuit breaker providing power to the equipment or system circuit breakers. The coordination shall be complete so that any overcurrent condition in the equipment or system will trip one or more equipment or system circuit breakers without tripping their power feed circuit breaker protecting the facility bus.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.20.2.1-h		Equipment and system circuit breakers shall provide complete continuous overcurrent protection for the load served and be unaffected by load harmonics and inrush current.	D			
3.8.20.2.1-i		Circuit breakers shall be full size units or multiples thereof, unless used in an Underwriters Laboratories-approved equipment item or load.	I			
3.8.20.2.1-j		Circuit breakers shall be permanently identified as to their continuous ampere rating.	I			
3.8.20.2.1-k		Standard trip curve circuit breakers shall be used to the limits possible, unless used in an Underwriters Laboratories-approved equipment item or load.	I			
3.8.20.2.1-l		Circuit breakers shall not perform the function of thermal overload relays.	I			
3.8.20.2.2-a	Fuses	Fusing shall be coordinated so that fuses in branch circuits will open before the fuses in the main circuit.	I			
3.8.20.2.2-b		Fuses shall not perform the function of thermal overload relay devices.	I			
3.8.20.2.2-c		Fuse ratings shall be compatible with both starting and operating currents.	I			
3.8.20.2.2-d		Connections to extractor post type fuse holders shall be such that the load is connected to the fuse terminal that terminates in the removable cap assembly.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.20.2.2-e		Fuses shall be readily accessible for replacement (i.e., not requiring removal of unrelated equipment for access).	I, D	D		
3.8.20.3-a	Connectors with Thermocouple Contacts	All connectors used in conjunction with thermocouples shall have their contact materials identified by one of the following methods:	I			Lead-in shall statement.
3.8.20.3-a.1		Nameplate securely attached to each connector half or mounted on the panel-mounted receptacles.	I			
3.8.20.3-a.2		Utilizing insulation sleeving or other markers designed for attachment around wire bundles.	I			
3.8.20.3-b		Markers shall be attached adjacent to the plug.	I			
3.8.20.3-c		Contact materials shall be identified using the standard abbreviations for the elements used.	I			
3.8.20.4-a	Electrical Power Connectors	All electrical power connectors shall be UL listed for their application and use.	I			
3.8.20.4-b		All power connectors shall be in accordance with NEMA WD 6 standards.	I			
3.8.20.4-c		Polarized connectors shall be used to ensure the safety of equipment and personnel.	I			
3.8.20.4.1-a	Protective Measures for Unmated Connectors	All unmated connectors shall be protected with metal or plastic caps or otherwise suitably protected during maintenance, storage, and shipment.	I	I		

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.20.4.1-b		Unmated connectors with exposed contacts that may contain electrically hot circuits shall be covered with moisture-proof and vapor-proof caps.	I			
3.8.20.5	Switches	Switches shall maintain their indicated state, i.e., open or closed, when subjected to any accidental force on the switch or the switch mounting equivalent to a 10g acceleration of either switch or mounting.	T			
3.8.20.6	Wiring	The selection, application, and wiring practices for cable and wire shall be in accordance with the following subparagraphs.	I, D			Roll-up req.
3.8.20.6.1	Wiring – Electrical Clearance	Clearance between solder connections or bare conductors (such as terminal strips, stand-offs, or similar connections) shall not allow accidental contact between adjacent connections when subject to service conditions specified in this specification.	I, D	D		
3.8.20.6.2	Wiring – Marking	All signal, control, and power wiring shall be uniquely identified to and within the enclosure along the wire and at each termination by either permanent insulation markings or by heat shrink labels.	I			
3.8.20.6.3-a	Wiring – Protection	The wiring shall be secured and protected against chafing due to vibration or movement (such as slide out racks or drawers).	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.20.6.3-b		Wiring to pullout drawers shall employ cable retractors to protect the equipment.	I			
3.8.20.6.4	Wiring – Bend Radius	The bend radius of wire and cable shall be greater than or equal to five times the cable diameter to avoid establishing a permanent set in the cable.	I			
3.8.20.6.5-a	Wiring – Sleeving	Flexible plastic sleeving shall be used on cables subject to flexing, such as panel door cables.	I			
3.8.20.6.5-b		The sleeving shall be secured under cable clamps at each end.	I			
3.8.20.6.5-c		The cable shall be formed, secured, and protected so that no abrasion to the cable occurs when flexing in its normal motion.	I			
3.8.20.6.6	Wiring – Panel Door Cables	Wiring to parts on a hinged door shall be contained in a minimum number of cables, arranged to flex without becoming damaged when the door is opened and closed.	I			
3.8.20.6.7-a	Wiring – Through Hole Protection	Whenever wires are run through openings in metal partitions, shields, and the like, which are less than 0.125 inches in thickness, the holes shall be equipped with suitable mechanical protection (grommet) or insulation.	I			
3.8.20.6.7-b		Openings in panels 0.125 inches or more in thickness shall have either grommets or the edges of the openings rounded to a minimum radius of 0.0625 inches.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.20.6.7-c		Grommets for wires operating at RF potentials exceeding 500 V_{rms} shall be of ceramic or plastic material of suitable dielectric strength, except for coaxial cables with outside protection, where rubber or neoprene is acceptable.	I			
3.8.20.6.7-d		Insulating grommets are not required for wires or groups of wires passing through shields or other metallic partitions where clearance can be maintained sufficiently to preclude the possibility of accidental contact or damage by abrasion.	I			
3.8.20.6.8-a	Wiring – Arrangement	Signal, data, control, and other low power conductors shall not be placed adjacent to line power conductors.	I			
3.8.20.6.8-b		Materials used for lacing, binding, sleeving, and strapping shall be compatible with the conductor or cable insulation or jacket.	I			
3.8.20.6.8-c		Wiring shall be arranged to permit bundling or permanently mounted in cable ducts.	I			
3.8.20.6.9	Wiring – Slack	Discretely terminated wires and cables shall be as short as practicable and still allow for maintenance and operation without damage or crimping of the wires.	I, D	D		
3.8.20.6.10	Wiring – Entrance Cabling	Wiring from cable entrances to terminal boards, plugs, jacks, and similar devices shall be harnessed and clamped or supported in a cable duct.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.20.6.11-a	Wire	Stranded wire shall be preferred; however, solid wire may be used in the equipment, provided such wire is insulated and held in place so that it does not fail or show excessive motion likely to result in failure when the equipment is subjected to vibration and shock encountered under the specified service conditions.	I, D			
3.8.20.6.11-b		Wire shall be continuous from the point of origin, on a discrete device or terminal, to the point of destination, on a discrete device or terminal.	I			
3.8.20.6.11-c		Wire and cable shall be supported and secured to prevent stress on the conductors and terminals and change in position of the wire or cable during and after subjecting the equipment to specified service conditions, or after service or repair of the equipment in a normal manner.	I, D			
3.8.20.6.11-d		Twine or tape shall not be used for securing wire and cable.	I			
3.8.20.6.11-e		Insulation sleeving of conductors shall be UL listed for the application.	I			
3.8.20.6.12	Wiring - Fungus Protection	Materials that support fungus growth shall not be used for wiring or wiring insulation.	I			
3.8.20.6.13	Wiring - Aluminum Conductors	Aluminum conductors shall not be used for interconnections between LRUs.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.20.6.14	Wiring - Termination of Signal and Control Wiring	Except for terminations using terminal strips, all external signal and control wiring shall be terminated with a connector.	I			
3.8.20.6.15	Wiring - Fiber Optics	The use of fiber optics shall be in accordance with FAA-STD-049.	I			
3.8.21-a	Toxic Products	Toxic products and formulations shall be avoided to the maximum extent possible.	I			
3.8.21-b		Prior FAA approval shall be required on an individual case-by-case basis for any toxic materials usage.	I			
3.8.22	Nameplates and Markings	N/A Header only.				Header only, no IADT
3.8.22.1-a	Nameplates	Each subsystem shall have one or more nameplates determined by the equipment configuration.	I			
3.8.22.1-b		Each nameplate shall be in accordance with Figure 3-4.	I			
3.8.22.1-c		Nameplates shall be attached by a self-adhesive backing or removable 4-40 stainless steel pan-head screws.	I			
3.8.22.1.1-a	Equipment Titles	Unless specifically set forth in the equipment specification, the FAA shall approve titles and type designations.	I			
3.8.22.1.1-b		The titles of the equipment specifications shall not be assumed to be the correct equipment titles for use on the nameplates.	I			
3.8.22.1.2-a	Serial Numbers	Serial numbers shall start with one (1) for each equipment unit having an individual nameplate and continue consecutively up to the total number of such equipment units required.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.22.1.2-b		Serial numbers for a given part number shall not be duplicated or reassigned.	I			
3.8.22.2-a	Markings	Markings shall be permanent and legible during normal operation and maintenance usage.	I			
3.8.22.2-b		Markings shall be as specified in ASME Y14.44.	I			
3.8.22.2.1	Visibility of Parts Labels	All LRU parts that have labels or markings identifying data or ratings, shall be mounted so that the data is visible to maintenance personnel without the necessity for disassembly of parts or adjacent functional or structural parts.	I			
3.8.22.2.2	Fuse Position Markings	All fuse positions shall be marked with the rated current capacity of the fuse to be employed therein and approved by the FAA.	I			
3.8.22.2.3	Terminal Strips, Blocks, and Wafer Switches	All terminal strips, blocks, and wafer switches shall be identified.	I			
3.8.22.2.4-a	Controls and Indicating Devices	Markings shall be provided on the front of each exterior and interior panel and panel door, and also on control-mounting surfaces of each chassis, sub-panel, etc., to clearly designate the functions and operations of all controls, fuses, and indicating devices mounted thereon, protruding, or available through access holes therein.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.22.2.4-b		All markings shall be located on the panel or chassis in the correct relationship to the respective designated items.	I			
3.8.23	Workmanship	The following workmanship requirements were derived from MIL-HDBK-454.				Header statement, no IADT.
3.8.23.1	Cleaning	After fabrication, parts and assembled equipment shall be cleaned of smudges; loose, spattered, or excess solder; weld metal; metal chips and mold release agents; and any other foreign material that might detract from the intended operation, function, or appearance of the equipment.	I			
3.8.23.2	Threaded Parts or Devices	Screws, nuts, and bolts shall show no evidence of cross threading, mutilation, or detrimental or hazardous burrs, and should be firmly secured.	I			
3.8.23.3-a	Shielding	Shielding on wires and cables shall be secured in a manner that will prevent them from contacting or shorting exposed current-carrying parts.	I			
3.8.23.3-b		The ends of the shielding or braid shall be secured to prevent fraying.	I			
3.8.23.4-a	Containment	The harness and cable form containment means shall be neat in appearance, uniformly applied, and positioned to retain critical form factors and breakout locations.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.23.4-b		The containment means (lacing, ties, tiedown straps, clamps, etc.) shall not cause the wire or cable insulation to deform so that performance characteristics are adversely affected.	I			
3.8.23.5	Insulation	There shall be no evidence of burns, abrading, or pinch marks in the insulation that could cause short circuits or leakage.	I			
3.8.23.6	Clearance	The clearance between wires or cables and heat-generating parts shall be sufficient to minimize deterioration of the wires or cables.	I			
3.8.24-a	Employee Safety	Equipment design shall provide for personnel safety in accordance with IEEE C95.1-2019, Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz.	I			
3.8.24-b		Personnel shall be protected from injury by sharp edges of equipment or cabinets during maintenance.	I, D	D		
3.8.24-c		Personnel shall be protected from harm of moving parts when replacing filters.	I, D			
3.8.24-d		All equipment and enclosures shall be designed and installed so that the enclosure and the mounted LRU and/or components will remain upright and in place, and all access panels, doors, and drawers shall remain secured to the enclosure.	I, D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24-e		The equipment rack shall be bolted to the shelter floor to ensure positive attachment.	I	D		
3.8.24-f		The materials installed in the equipment shall not liberate gases that, when combined with the atmosphere, form an acid or corrosive alkali, nor shall they generate toxic or corrosive dust, mists, or fumes detrimental to the performance of the equipment or health of the equipment operators.	I			
3.8.24-g		Gases or fumes shall not be detrimental to plants, fish, or wildlife if vented to the outside.	I			
3.8.24-h		The materials shall not liberate gases that will produce a flammable or explosive atmosphere.	I			
3.8.24-i		Mercury and asbestos shall not be used.	I			
3.8.24.1-a	Electrical Safety	A means shall be provided to protect personnel from accidental contact with voltages in excess of 30 V_{rms} or DC during normal operations or maintenance of the equipment.	I			
3.8.24.1-b		After the power to the equipment is turned off, the system shall discharge all capacitors to 30 V or less within 2 s.	A, D			
3.8.24.1-c		Personnel shall be protected from circuits carrying currents greater than 21 mA at 10.5 VAC, and 80 mA at 40 VDC.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.1-d		The hot side of the incoming power line switch connections shall include physical protection against accidental contact.	I			
3.8.24.1-e		Site-specific Lockout/Tagout (LO/TO) Procedures shall be followed, including zero-energy verification, when de-energizing electrical sources in accordance with OSHA 29 CFR 1910.147 and FAA Order JO 3900.67. If equipment requires revisions to existing LO/TO procedures, written LO/TO procedures shall be updated and readily available at the work area, and personnel shall receive training.	I			
3.8.24.1-f		Equipment cables shall not cause tripping hazards in accordance with FAA Order 3900.19D and OSHA 29 CFR 1910 Subpart D.	I			
3.8.24.2-a	Ground Potential	The design and construction of the equipment shall ensure that all external parts, surfaces, and shields, exclusive of antenna and transmission line terminals, are at ground potential at all times during normal operation.	I			
3.8.24.2-b		Any external or interconnecting cable, excluding RF cables, where ground is part of the circuit, shall carry a ground wire in the cable terminated at both ends in the same manner as the other conductors.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.2-c		In no case, except with coaxial cables, shall the shield be depended upon for a current-carrying ground connection.	I			
3.8.24.2-d		Antenna and transmission line terminals shall be at ground potential, except for RF energy on their external surfaces.	I			
3.8.24.2-e		A point on the electrically conductive chassis or equipment frame shall serve as the common tie point for the static or power ground.	I			
3.8.24.3-a	Shielding	Except where a conflict with grounding requirements would be created, shielding on wire or cable shall be grounded to the chassis or frame.	I			
3.8.24.3-b		The shielding shall be at a sufficient distance from exposed conductors to prevent shorting or arcing between the conductor and the shielding under normal operating conditions and worst-case environmental conditions.	I			
3.8.24.4	Guarding of RF Voltages	Transmitter output terminals, antennas, and other devices that carry sufficient RF voltage that may burn or injure personnel shall be protected from accidental contact.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.5-a	Interlocks	Interlocks shall be used when voltages between 70–500 V are exposed when the access door, cover, or plate is opened. No interlocks are required when all potentials in excess of 70 V are completely protected with guards or barriers to prevent accidental contact under all operational conditions or any level of maintenance.	I			
3.8.24.5-b		Bypassable interlock switches shall be momentary action (spring-return) switches marked "INTERLOCK BYPASS" and are provided to allow interlocked access doors and covers to be opened with a manual latch for "on" position to be operated in the exposed interlock switch, without removing power from the equipment.	I			
3.8.24.5-c		The bypass switches shall be located so that one person can operate the switch, open the door or cover, and set the manual latch.	I, D	D		
3.8.24.5-d		Non-bypassable interlocks shall be used for access doors, covers, and panels when the voltage accessible or exposed exceeds 500 V, and the current available exceeds 100 mA AC or 160 mA DC.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.6-a	High Voltage Protection	Assemblies operating at potentials in excess of 500 V shall be completely enclosed from the remainder of the assembly and interlocked in accordance with the requirements herein. Test probe holes may be provided in the barriers or guards where maintenance testing is required.	I			
3.8.24.6-b		When the operation or maintenance of equipment is employing potentials in excess of 300 V peak, the equipment shall be provided with test points so these voltages can be measured at a safe potential level.	I			
3.8.24.6-c		The voltage provided at the test points shall not exceed 300 V peak relative to ground.	I			
3.8.24.6-d		If a voltage divider is used, the voltage divider resistance between the test point and ground shall consist of at least two equally valued resistors in parallel.	I			
3.8.24.7	High Current Protection	All power buses supplying 25 A or over shall be protected against accidental short circuiting by tools, jewelry, or removable conductive assemblies.	I			
3.8.24.8-a	Electrical Connectors	The design of the connector shall be such that the operator is not exposed to electrical shock or burns when normal disconnection methods are used.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.8-b		Exposed pin contacts shall not be energized (hot) after being disconnected from the socket contacts.	I			
3.8.24.9-a	Mechanical Hazards	Suitable protection shall be provided to prevent contact with moving mechanical parts such as gears, fans, and belts when the equipment is operating.	I			
3.8.24.9-b		Cabinets, doors, and similar parts shall not have sharp projections.	I			
3.8.24.9-c		Equipment power switches shall be designed and located to prevent changing the equipment state due to accidental contact by personnel.	I			
3.8.24.9-d		Equipment with sharp or pointed edges shall be properly guarded (e.g., foam "head-banger"/bumper guards for monitor corners, antennas, shelves/racks, pipes, I-beams, cable trays).	I			
3.8.24.10	Mechanical Interconnection	The design shall provide positive means to prevent the inadvertent reversing or mismatching of fittings, couplings, instrument leads, and electrical connections.	I			
3.8.24.11-a	Glass Fibers	Glass fibrous materials shall not be used as the outer covering on cables, wire, or other items where they may cause skin irritation to operating or maintenance personnel.	I			
3.8.24.11-b		All glass used in the equipment shall be of the shatterproof type.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.12	Safety Markings, Signs, Tags, and Symbols	N/A Header only.				Header only, no IADT
3.8.24.12.1-a	Markings	Guards, barriers, and access doors, covers, or plates shall be marked to indicate the hazard that may be reached upon removal of such devices.	I			
3.8.24.12.1-b		A hazard marking shall be located on the equipment such that it is not removed when the barrier or access door is removed.	I			
3.8.24.12.1-c		Warnings of hazards internal to a unit shall be marked adjacent to hazards if they are significantly different from those of surrounding items.	I			
3.8.24.12.1-d		Physical hazards shall be marked with color codes in accordance with ANSI Z535.1, where applicable to electronic equipment.	I			
3.8.24.12.1-e		LRUs weighing more than 30 pounds shall have caution labels indicating the weight, center of gravity, and number of people recommended for lifting and carrying in accordance with FAA Standard HF-STD-001B, Human Factors Design Standard, Chapter 5.10, Personnel Safety	I			
3.8.24.12.2-a	Accident Prevention Signs and Labels	Accident prevention signs and labels shall be provided whenever equipment has characteristics or operating conditions that present a hazard to operators and maintenance or other personnel.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.12.2-b		Signs and labels shall have the same life expectancy, or greater, as the equipment on which they are affixed.	I			
3.8.24.12.3	Sign Design	Signs shall consist of three panels as shown on Figure 3-5.	I			
3.8.24.12.3-a		The ratio of width to height of the upper panel (a:b) shall fall within 2:1 to 5:1 inclusive.	I			
3.8.24.12.3-b		The lower panel shall be equal to the upper panel width (both equal to a).	I			
3.8.24.12.3-c		The lower panel height shall be equal to or greater than the upper panel height, but less than twice the width of the sign ($b \leq c < 2a$).	I			
3.8.24.12.3-d		The optional symbol panel shall be square with each edge equal to the sum of the upper and lower panel (b + c) and placed to the right.	I			
3.8.24.12.3-e		The upper panel shall contain the signal or key word.	I			
3.8.24.12.3-f		The lower panel shall contain additional direction or explanation.	I			
3.8.24.12.3-g		The wording of this panel shall be brief, provide positive direction, and be limited to a single hazard.	I			
3.8.24.12.4	Sign Classifications and Detailed Design	N/A Header only.				Header only, no IADT
3.8.24.12.4.1-a	Class I (Danger)	These signs indicate immediate and grave danger, peril, or hazard capable of producing irreversible damage or injury, and prohibitions against harmful activities.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.12.4.1-b		These signs shall have the word “DANGER” in white within a red oval outline with a white on black rectangle in the upper panel.	I			
3.8.24.12.4.1-c		The lower panel, for additional wording, shall be in black or red on a white background.	I			
3.8.24.12.4.2-a	Class II (Caution)	These signs are used to call attention to potentially dangerous hazards capable of or resulting in severe, but not irreversible, injury or damage.	I			
3.8.24.12.4.2-b		These signs shall have the signal word “CAUTION” in yellow on a black rectangle in the upper panel. The lower panel, for additional wording, shall be in black on a yellow background.	I			
3.8.24.12.4.3-a	Class III (General Safety)	These signs include notice of general practice and rules relating to health, first aid, housekeeping, and general safety other than the two cases above.	I			
3.8.24.12.4.3-b		These signs shall have the appropriate keyword in white on a green rectangle in the upper panel.	I			
3.8.24.12.4.3-c		The lower panel, for additional wording, shall be in black or green on a white background.	I			
3.8.24.12.4.4-a	Class IV (Fire and Emergency)	These signs shall be used only to label or point the way to fire extinguishing equipment, shutoffs, emergency switches, and emergency procedures.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.12.4.4-b		These signs shall have the keyword in white on a red rectangle in the upper panel.	I			
3.8.24.12.4.4-c		The lower panel, for additional wording, shall be in red on a white background.	I			
3.8.24.12.4.5-a	Sign Placement	Signs shall be placed to alert and inform personnel to avoid the hazard or to take appropriate action.	I			
3.8.24.12.4.5-b		Signs shall be readable from a distance commensurate with a. above, create no additional distractions, and not be hazards themselves.	I			
3.8.24.12.5	Symbols	The following symbols shall be used as applicable:	I			Lead-in shall statement.
3.8.24.12.5-a		Ionizing radiation hazard – ANSI/HPS N2.1.	I			
3.8.24.12.5-b		Microwave and radio-frequency radiation – ANSI Z535.2 and IEEE C95.2.	I			
3.8.24.13-a	Display Warnings	Video display warnings shall be provided on equipment with associated video displays to warn operators of impending danger, to alert operators to critical system changes or equipment status, or to remind operators of a critical action that must be taken.	I			
3.8.24.13-b		Display alert/warnings shall be designed to incorporate clearly discriminative features that distinguish the warning (color, blink, size, etc.) from other display information.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.14		Battery systems may pose electrical safety hazards (electrical shock and arc flash) or chemical hazards if containing electrolytes/acid. An emergency eyewash/shower station shall be located immediately adjacent to strong caustics (e.g., batteries with electrolytes/acid, cleaners) and identified with a highly visible sign in accordance with ANSI Z358.1 and FAA Order 3900.19D.	I			
3.8.24.15	Fire Life Safety	Equipment shall not block egress routes (3’ clearance), sprinklers, or fire extinguishers, and installation/removal activities shall not impact fire barriers/firestop systems (e.g., drilling through fire rated walls or floor penetrations) in accordance with FAA Order JO 6930.1B and OSHA 29 CFR 1910, Subpart E.	I			
3.8.24.16		Equipment with the potential of falling shall meet the anchoring requirements for seismic activity in accordance with FAA-G-2100J and FEMA E-74.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.24.17		PPE Hazard Assessments shall be conducted by a Safety and Health Specialist to determine whether hazards are present for selecting PPE (e.g., high voltage, hearing protection devices, eye protection) that will protect affected employee(s) from identified hazards and ensure employees are trained in the proper use, maintenance, and storage in accordance with FAA Order JO 3900.79, ATO Personal Protective Equipment, and FAA Order 3900.19D, Chapter 9, Personal Protective Equipment and Respiratory Protection.	I			
3.8.25	Mechanical Parts	N/A Header only.				Header only, no IADT
3.8.25.1	Controls and Switches	N/A Header only.				Header only, no IADT
3.8.25.1.1-a	Direction of Movement	Controls shall be connected in the circuit, so the controlled characteristics (e.g., sensitivity, volume, or voltage) increase with clockwise rotation of the control as seen from the operating position.	D			
3.8.25.1.1-b		Movement of a control forward, clockwise, right, or up, shall turn the equipment on, or cause the quantity to increase, the equipment to move forward, clockwise, to the right, or up.	D			
3.8.25.1.2	Operating Controls	Controls necessary for the operation of the equipment shall be located on the front panel of the unit.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.25.1.3-a	Adjustment Controls	Adjustment controls that are required for periodic alignment or calibration shall be mounted behind covered openings (such as access doors), and on the faces of the equipment most accessible when installed.	I			
3.8.25.1.3-b		When not adjustable by hand, controls shall be designed to accept a common screwdriver blade tip.	I			
3.8.25.1.3-c		Controls that are infrequently adjusted need not be accessible from the operating panel, but shall be readily accessible for servicing without the use of an extender card when the equipment is opened for maintenance purposes.	I			
3.8.25.1.3-d		The adjustment range shall not be large enough to cause equipment damage.	I			
3.8.25.1.4-a	Operation	Play and backlash in controls shall be held to a minimum commensurate with intended operational functions, maintaining electrical contact and accurate settings.	D			
3.8.25.1.4-b		Controls shall operate freely and smoothly without binding, scraping, or cutting.	D			
3.8.25.1.4-c		Normal settings of all continuously variable controls shall not fall in the first tenth or last tenth of angular rotation.	I			
3.8.25.1.5-a	Stops	Mechanical stops shall be provided for all adjustable controls, except controls designed for unlimited rotation.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.25.1.5-b		Stops shall be provided on the driving end of the shaft where flexible control shafts are employed or where stops that are integral to the adjustable control or the mechanism could be damaged by excessive torque.	I			
3.8.25.1.6-a	Locking Devices	Control locking devices shall retain the controls in any given setting within the range of control.	D			
3.8.25.1.6-b		The locking and unlocking action shall not affect the setting of the control.	D			
3.8.25.1.6-c		Where vernier controls are used, the locking devices shall operate on both main and vernier controls, if necessary, to prevent damage.	D			
3.8.25.1.7	Non-Turn Devices	All non-turning controls and bodies or cases of turning controls shall be equipped with a positive device to prevent their turning in the panel or in the assembly on which they are mounted.	D			
3.8.25.2-a	Fastener Hardware	Fasteners shall be able to be removed and installed without damage to hardware.	D			
3.8.25.2-b		Fasteners shall remain secure when exposed to equipment operational and environmental stresses.	D			
3.8.25.2-c		Except for those items designed to be affixed with one fastener, parts shall be secured so the failure of a single fastener will not free the part completely.	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.25.2-d		Friction between mating surfaces shall not be employed as the sole means of preventing fixed parts from rotating or shifting.	I			
3.8.25.2-e		Fasteners shall be selected to minimize the number of standard tools used during maintenance.	I			
3.8.25.3	Ventilating Fan Motors	All ventilating fan motors (commonly called pancake type) shall:	I			Lead-in shall statement.
3.8.25.3-a		Be ball bearing type;	I			
3.8.25.3-b		Not be required to have overload protection if they are of inherently safe construction (i.e., can be continuously energized with their rotation blocked); and	I			
3.8.25.3-c		Be of frame construction type.	I			
3.8.25.4	Bearings	Any bearings used shall not require maintenance.	I			
3.8.26	Human Engineering	N/A Header only.				Header only, no IADT
3.8.26.1	Noise Criteria	Equipment located in general work areas (areas requiring occasional telephone use or occasional direct oral communications at distances up to 1.5 m (approximately 5 ft)) shall not exceed 65 dB(A).	D			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.26.2-a	Identification of Noise Hazard Areas and Equipment	Noise levels greater than 85 dBA or impulse/impact noise above 140 dB peak sound pressure level, regardless of exposure time, shall require hearing protection devices (HPDs) and compliant caution signage posted prior to entering areas with equipment exceeding these noise levels according to OSHA 1910.95 and FAA Order 3900.19. Only Safety and Health Specialists can assign HPDs.	I			
3.8.26.2-b		Noise caution signs shall be clearly visible and legible to all personnel exposed to the hazard.	I			
3.8.26.3-a	Display Information	The information generated by the equipment shall be capable of selection by and display to an operator.	D			
3.8.26.3-b		Information shall be limited to that which is necessary to perform specific actions or to make decisions.	I			
3.8.26.3-c		Numeric digital displays shall not be used as the only display of information when perception of pattern or variation is important to correct comprehension of the information.	I			
3.8.26.3-d		Numeric digital displays shall not be used when rapid or slow digital display rates inhibit proper understanding.	I			

Specification			Test Allocation		Verification Paragraph	Remarks
Paragraph	Title	Requirement	Development Test (DT)	Operational Test (OT)		
3.8.26.3-e		The absence of an indication on status displays shall not be used to indicate critical occurrences (i.e., indicates that the valve has actually closed and not that the button has been pushed or voltage applied).	I			
3.8.26.4-a	Virtual Displays - Flash	The flash rate shall be two flashes per second.	D			
3.8.26.4-b		The flash on time shall be 0.25 ± 0.025 s.	D			
3.8.26.4-c		The flash off time shall be 0.25 ± 0.025 s.	D			
3.9	Installation	The equipment shall be designed for installation, removal, and reinstallation without special tools unless approved by the FAA.	D	D		

5. PACKAGING

This section is not applicable to this specification.

6. NOTES

6.1 Definitions

6.1.1 Automatic Gain Reduction (AGR)

A transponder feature that automatically reduces the sensitivity of the receiver to limit the number of replies to interrogations to a specified maximum.

6.1.2 Continuous Wave (CW)

A continuous wave or continuous waveform is an electromagnetic wave of constant amplitude and frequency; and in mathematical analysis, of infinite duration.

6.1.3 Control

A “control” can be either a physical switch or a function controlled by a connected computer.

6.1.4 Echo Suppression

A transponder feature intended to prevent multiple replies as the result of echoes in the interrogation (air-to-ground) path.

6.1.5 Electromagnetic Interference (EMI)

Any emitted, radiated, conducted, or induced voltage that degrades, obstructs, or interrupts the desired performance of electronic equipment.

6.1.6 Equivalent Isotropically Radiated Power (EIRP)

The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain).

6.1.7 Executive Monitoring

A device which continuously examines key parameters of the output signals of the facility/equipment and which provides for shutdown of equipment when these signal characteristics are found to be outside of pre-established tolerances and which simultaneously initiates local and remote alarm indication. In normal unattended operation of the facility these actions are automatic and not subject to human actions.

6.1.8 Interrogation Signal

The term interrogation signal denotes a signal having the characteristics identified in the subparagraphs below.

6.1.8.1 Radio Frequency Pulse Spectrum

The RF spectrum of the interrogation signal is such that not less than 90% of the energy in each pulse is within a 0.5 MHz band centered on the channel interrogation signal frequency and in which each additional lobe of the spectrum is of lesser amplitude than the adjacent lobe nearer the channel frequency.

6.1.8.2 RF Pulse Shape

The RF envelope of each pulse, as detected by a linear detector, has a shape falling within the limits set forth in the subparagraphs hereto.

6.1.8.2.1 Pulse Rise Time

The pulse rise time from the 10% point to the 90% point of the maximum voltage amplitude on the leading edge of the pulse.

6.1.8.2.2 Pulse Top

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

6.1.8.2.3 Pulse Width

The pulse width, from the 50% point of the maximum voltage amplitude on the leading edge of the pulse to the 50% point of the maximum voltage amplitude on the trailing edge of the pulse.

6.1.8.2.4 Pulse Decay Time

The pulse decay time, from the 90% point to the 10% point of the maximum voltage amplitude on the trailing edge of the pulse.

6.1.8.3 Pulse Coding

Pulses are coded in pairs with a spacing as measured between the 50 % maximum voltage amplitude point on the leading edge of the first RF pulse to the corresponding point on the leading edge of the second RF pulse.

6.1.8.4 Interrogation Rate

The pulse pair rate for each interrogation signal is not less than 10 nor more than 150 ppps.

6.1.9 Line Replaceable Unit (LRU)

An LRU is the lowest possible unit to be replaced within the system component during site-level maintenance activities. It is a separate, installable physical package performing a single function or group of closely related functions.

6.1.10 Mean Time Between Failures (MTBF)

MTBF is the average time between failures of system components and is calculated by dividing the total operating time by the number of failures that have occurred. This does not include the time in which the system is in a non-operational state.

6.1.11 Monitor Delay Time

The time delay between the occurrence of an out-of-tolerance condition at the monitor input(s) and the resulting control actions that result in the cessation of service. This delay includes, at a minimum, the following:

1. Time to measure the parameter(s)
2. Averaging of the result
3. Check of the parameter against the alarm limit(s)
4. Algorithms to reduce nuisance alarms
5. Event logging of alarms
6. Generation of indication at the monitor of the fault condition
7. Required programmable timer to delay control action
8. Generation of an indication to the system that controls the transmitter on/off state
9. Delay within the control system
10. Delay in the transmitter to cease reply pulses

6.1.12 Positive Attachment

An attachment that resists a reasonable amount of force in any direction.

6.1.13 Receiver Dead Time

A period of time (nominally 60 µs) following the decoding of an interrogation pulse pair (and encompassing the time occupied by the transmittal of a reply pulse pair) during which the receiver is prevented from decoding a following interrogation pulse pair.

6.1.14 Receiver Sensitivity

That level of interrogation signal as measured at the antenna input terminals of the ground station transponder which results in 70% replies to the interrogation signal. The terms “receiver sensitivity” and “receiver threshold triggering level” are often used interchangeably.

6.1.15 Receiver Threshold Triggering Level

As used herein refers to the receiver sensitivity in the absence of traffic loading resulting in AGR or reduction in reply efficiency due to echo suppression blanking.

6.1.16 Remote Monitoring and Logging System

RMLS provides automated information support to Technical Operations personnel in the performance of operations and maintenance in the NAS. It provides a unified, automated technical and administrative support tool to facilitate logging, certification, periodic maintenance and scheduling, report generation, facility service and equipment profiles, maintenance operations, administrative functions, and remote maintenance monitoring functions. RMLS consists of four applications to automate and standardize the collection, retrieval, and reporting of maintenance data in order to streamline and standardize maintenance operations record keeping throughout the organization. The four applications that make up RMLS are Event Manager (OCC/SOC and NOCC Event Manager (EM) versions), Simplified Automated Logging (SAL), Peabody, and

Maintenance Automation System Software (MASS). The RMLS National Logging Network (NLN) is the primary tool used by the Federal Aviation Administration (FAA) to log maintenance activities and manage RMLS user authentication and authorization.

6.1.17 Remote Maintenance Monitoring

RMM consists of the various sensors, microprocessor(s), and software necessary to remotely monitor, control, record, and certify proper operation of the DME System to be furnished under this specification and to be in compliance with RMMC Order 6000.53D.

6.1.18 Reply Efficiency

The percentage of replies provided by the transponder to an interrogation signal of a given level. The maximum reply efficiency is limited by the number of receiver output pulses (squitter plus replies) and the receiver dead time.

6.1.19 Special Tools

Tools that are of a specialized nature that are required to perform measurements, installations, maintenance, or repairs. Their unique nature is limited to use with a particular system.

6.1.20 Squitter

Randomly occurring pulse pairs generated within the transponder as required to maintain a minimum output pulse count of 750 ppps. As the number of replies to aircraft interrogations increases, the number of squitter pulses is automatically reduced to maintain the minimum output pulse count at the specified level.

6.1.21 Transponder Reply Delay Time

Reply delay time is defined as the time in microseconds of all delay introduced by circuitry of the transponder equipment in transmitting a pair of reply pulses in response to an interrogation signal. The reply delay time is measured from the 50% maximum voltage amplitude point on the leading edge of the first constituent RF pulse of the interrogation pulse pair to the corresponding point on the first constituent RF pulse of the reply pulse pair. (Note that first pulse timing is involved which will require retention of the time of the 50% amplitude point of the leading edge of the first pulse pending decode or pulse spacing validation. The nominal values of reply delays are 50 us for X channel and 56 us for Y channel.)

6.1.22 Transistor-Transistor Logic (TTL)

A digital logic convention in which bipolar transistors act on direct-current pulses. The minimum input voltage level regarded as a HIGH signal is 2.0 V. The maximum input voltage level regarded as a LOW signal is 0.8 V.

6.2 Acronyms, Abbreviations, and Initializations

A	Ampere
A	Analysis
AC	Alternating Current

AIC	Ampere Interrupting Capacity
AGR	Automatic Gain Reduction
ANSI	American National Standards Institute
AWG	American Wire Gauge
BNC	Bayonet Neill–Concelman
C	Celsius
CW	Continuous Wave
D	Demonstration
dB	Decibel
dB(A)	Decibel (Acoustic)
dBi	Decibel Isotropic
dBm	Decibel Milliwatt
DC	Direct Current
DME	Distance Measuring Equipment
DT	Developmental Test
EIRP	Equivalent Isotropically Radiated Power
EMC	Electromagnetic Compatibility
EMI	Electromagnetic interference
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FCC	Federal Communications Commission
g	Gravitational Acceleration
GHz	Gigahertz
HMI	Hazardously Misleading Information
HPD	Hearing Protection Device
Hz	Hertz
I	Inspection
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
kHz	Kilohertz
kPa	Kilopascal
kV	Kilovolt
LED	Light Emitting Diode
LO/TO	Lockout/Tagout
LRU	Line Replaceable Unit
m	Meter
MHz	Megahertz
mA	Milliampere
mbar	Millibar
mJ	Millijoule
mm	Millimeter
MTBF	Mean Time Between Failures
mW	Milliwatt

NAS	National Airspace System
NEC	National Electric Code
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
OOT	Out of Tolerance
OS	Operating System
OSHA	Occupational Safety and Health Administration
OT	Operational Test
pF	Picofarad
PF	Power Factor
PPE	Personal Protective Equipment
ppps	Pulse Pairs Per Second
psia	Pounds Per Square Inch Absolute
RF	Radio Frequency
RFI	Radio Frequency Interference
RMLS	Remote Monitoring and Logging System
RMM	Remote Maintenance Monitoring
RMS	Remote Monitoring Subsystem
rms	Root Mean Square
T	Test
THD	Total Harmonic Distortion
TNC	Threaded Neill–Concelman
TTL	Transistor-Transistor Logic
VAC	Volts, Alternating Current
V	Volt
V_{rms}	Volts Root Mean Square
VHF	Very High Frequency
VRTM	Verification Requirements Traceability Matrix
VSWR	Voltage Standing Wave Ratio
W	Watt

6.3 International Civil Aviation Organization (ICAO) Requirements Traceability

Table 6-1 ICAO Annex 10 Compliance Matrix

ICAO Annex 10 Para No.	Paragraph Title	DME Spec Para No.	Comments
3.5.2	General	3.1.1	
3.5.2.1	---	3.1.1	
3.5.2.2	---	3.1.1	
3.5.2.3	---	3.1.1	
3.5.2.4	---	N/A	DME/P only
3.5.2.5	---	3.1.1, 3.2.4	
3.5.2.6	---	N/A	Siting limitations
3.5.3	System Characteristics		Header only
3.5.3.1	Performance		Header only
3.5.3.1.1	Range	3.1.1	
3.5.3.1.2	Coverage	3.2.5.3, 3.3	
3.5.3.1.3	Accuracy		Header only
3.5.3.1.3.1	System Accuracy	3.2.5.6	
3.5.3.1.4	DME/P Accuracy	N/A	DME/P only
3.5.3.2	Radio Frequencies and Polarization	3.2.1, 3.3.2 3.3.3	
3.5.3.3	Channeling		Header only
3.5.3.3.1	---	3.2.1	
3.5.3.3.2	Pulse Coding	N/A	DME/P only
3.5.3.3.3	---	3.2.1	
3.5.3.3.4	Channel Pairing	3.2.1	
3.5.3.4	Interrogation Pulse Repetition Frequency	N/A	Interrogator requirements
3.5.3.5	Aircraft Handling Capacity of the System	3.2.3.6	
3.5.3.6	Transponder Identification		Header only
3.5.3.6.1	---	3.2.4	
3.5.3.6.2	---	3.2.4	
3.5.3.6.2.1	---	3.2.4.3	
3.5.3.6.2.2	---	N/A	Recommendation only
3.5.3.6.2.3	---	N/A	DME/P only
3.5.3.6.2.4	---	N/A	DME/P only
3.5.3.6.2.5	---	N/A	DME/P only
3.5.3.6.3	Independent Identification Signal Characteristics	3.2.4.3	
3.5.3.6.4	Associated Identification Signal Characteristics	3.2.4.4	
3.5.3.6.5	Identification Implementation		Header only
3.5.3.6.5.1	---	3.2.4	
3.5.3.6.5.2	---	3.2.4	
3.5.3.6.5.3	---	3.2.4	
3.5.3.7	DME/P mode transition	N/A	DME/P only
3.5.3.8	System efficiency	N/A	DME/P only
3.5.4	Detailed technical characteristics of transponder and associated monitor		Header only
3.5.4.1	Transmitter		Header only
3.5.4.1.1	Frequency of operation.	3.2.1	

ICAO Annex 10 Para No.	Paragraph Title	DME Spec Para No.	Comments
3.5.4.1.2	Frequency Stability	3.2.1.3	0.001% in spec and 0.002 % in Annex 10
3.5.4.1.3	Pulse Shape and Spectrum	3.2.6.1, 3.2.6.5	
3.5.4.1.4	Pulse Spacing		Header only
3.5.4.1.4.1	---	3.2.6.2	
3.5.4.1.4.2	---	3.2.6.2	
3.5.4.1.4.3	---	N/A	Recommendation only
3.5.4.1.4.4	---	N/A	DME/P only
3.5.4.1.4.5	---	4.3.2.1	
3.5.4.1.5	Peak Power Output		Header only
3.5.4.1.5.1	---	N/A	Recommendation only
3.5.4.1.5.2	---	3.2.5.3, 3.3	
3.5.4.1.5.3	---	N/A	DME/P only
3.5.4.1.5.4	---	3.2.6.4	
3.5.4.1.5.5	---	3.2.5.1	
3.5.4.1.5.6	---	3.2.3.8.4	
3.5.4.1.6	Spurious Radiation	3.2.6.7	
3.5.4.1.6.1	DME/N	3.2.6.7	
3.5.4.1.6.2	DME/P	N/A	DME/P only
3.5.4.1.6.3	Out-of-Band Spurious Radiation	3.2.6.6	
3.5.4.1.6.4	CW EIRP	3.2.6.6	
3.5.4.2	Receiver		Header only
3.5.4.2.1	Frequency of Operation	3.4.1	
3.5.4.2.2	Frequency Stability	3.4.1.3	
3.5.4.2.3	Transponder Sensitivity		Header only
3.5.4.2.3.1	---	3.2.3.6	
3.5.4.2.3.2	---	3.2.3.6	
3.5.4.2.3.3	DME/N Dynamic Range	3.2.3.6.3	
3.5.4.2.3.4	DME/P Dynamic Range	N/A	DME/P only
3.5.4.2.3.5	---	3.2.3.6.1.1	
3.5.4.2.3.6	DME/N	3.2.3.2.2	
3.5.4.2.3.7	DME/P	N/A	DME/P only
3.5.4.2.4	Load Limiting		Header only
3.5.4.2.4.1	DME/N	3.2.3.9.1	
3.5.4.2.4.2	DME/P	N/A	DME/P only
3.5.4.2.5	Noise	3.2.3.6.4	
3.5.4.2.6	Bandwidth		Header only
3.5.4.2.6.1	---	3.2.3.1	
3.5.4.2.6.2	DME/N	3.2.3.1.1	
3.5.4.2.6.3	DME/P	N/A	DME/P only
3.5.4.2.6.4	DME/P	N/A	DME/P only
3.5.4.2.6.5	---	3.2.3.6.2, 3.2.3.7	
3.5.4.2.7	Recovery Time	3.2.3.4	
3.5.4.2.8	Spurious Radiations	3.2.6.6	
3.5.4.2.9	CW and Echo Suppression	3.2.3.5	
3.5.4.2.10	Protection Against Interference	N/A	Recommendation only
3.5.4.3	Decoding		Header only
3.5.4.3.1	---	3.2.3.2	

ICAO Annex 10 Para No.	Paragraph Title	DME Spec Para No.	Comments
3.5.4.3.2	---	3.2.3.2.1	
3.5.4.3.3	DME/N	3.2.3.2.2	
3.5.4.3.4	DME/P	N/A	DME/P only
3.5.4.4	Time Delay		Header only
3.5.4.4.1	---	3.2.5.5	
3.5.4.4.2	---	N/A	Colocated with MLS only
3.5.4.4.2.1	---	N/A	DME/P only
3.5.4.4.3	---	3.2.5.5	Recommendation only
3.5.4.4.3.1	DME/N	6.1.21	
3.5.4.4.3.2	DME/P	N/A	DME/P only
3.5.4.4.3.3	DME/P	N/A	DME/P only
3.5.4.4.4	DME/N	N/A	Recommendation only
3.5.4.5	Accuracy		Header only
3.5.4.5.1	DME/N	3.2.5.6, 3.2.6.3	
3.5.4.5.1.1	DME/N	N/A	Recommendation only
3.5.4.5.1.2	DME/N	3.2.5.6, 3.2.6.3	Exclusive of outside effects
3.5.4.5.2	DME/N	3.2.5.6, 3.2.6.3	
3.5.4.5.3	DME/P – FA Mode	N/A	DME/P only
3.5.4.5.4	DME/P	N/A	DME/P only
3.5.4.5.5	---	N/A	Recommendation only
3.5.4.6	Efficiency		Header only
3.5.4.6.1	---	3.2.3.6	
3.5.4.6.2	Transponder Dead Time	3.2.3.3	
3.5.4.6.2.1	---	N/A	DME/P only
3.5.4.7	Monitoring and Control		Header only
3.5.4.7.1	---	3.4.5	
3.5.4.7.2	DME/N Monitoring Action		Header only
3.5.4.7.2.1	---	3.4.5.1	
3.5.4.7.2.2	---	3.4.5.2.3	
3.5.4.7.2.3	---	3.4.5.2.4	
3.5.4.7.2.4	---	3.4.5.2.4, 3.4.5.2.6, 3.4.5.2.7, 3.4.5.2.10	
3.5.4.7.2.5	---	3.4.5.1.5	
3.5.4.7.2.6	---	3.4.5.3	
3.5.4.7.3	DME/P Monitoring Action	N/A	DME/P only
3.5.5	Technical Characteristics of Interrogator	N/A	Interrogator only

Note: --- Denotes a paragraph with no title.

APPENDIX A - DME FREQUENCY CHANNELIZATION

Channel	Interrogation Frequency MHz	Interrogation Pulse Spacing µsec	Reply Frequency MHz	Reply Pulse Spacing µsec
1X	1025	12	962	12
1Y	1025	36	1088	30
2X	1026	12	963	12
2Y	1026	36	1089	30
3X	1027	12	964	12
3Y	1027	36	1090	30
4X	1028	12	965	12
4Y	1028	36	1091	30
5X	1029	12	966	12
5Y	1029	36	1092	30
6X	1030	12	967	12
6Y	1030	36	1093	30
7X	1031	12	968	12
7Y	1031	36	1094	30
8X	1032	12	969	12
8Y	1032	36	1095	30
9X	1033	12	970	12
9Y	1033	36	1096	30
10X	1034	12	971	12
10Y	1034	36	1097	30
11X	1035	12	972	12
11Y	1035	36	1098	30
12X	1036	12	973	12
12Y	1036	36	1099	30
13X	1037	12	974	12
13Y	1037	36	1100	30
14X	1038	12	975	12
14Y	1038	36	1101	30
15X	1039	12	976	12
15Y	1039	36	1102	30
16X	1040	12	977	12
16Y	1040	36	1103	30
17X	1041	12	978	12
17Y	1041	36	1104	30

Channel	Interrogation Frequency MHz	Interrogation Pulse Spacing µsec	Reply Frequency MHz	Reply Pulse Spacing µsec
18X	1042	12	979	12
18Y	1042	36	1105	30
19X	1043	12	980	12
19Y	1043	36	1106	30
20X	1044	12	981	12
20Y	1044	36	1107	30
21X	1045	12	982	12
21Y	1045	36	1108	30
22X	1046	12	983	12
22Y	1046	36	1109	30
23X	1047	12	984	12
23Y	1047	36	1110	30
24X	1048	12	985	12
24Y	1048	36	1111	30
25X	1049	12	986	12
25Y	1049	36	1112	30
26X	1050	12	987	12
26Y	1050	36	1113	30
27X	1051	12	988	12
27Y	1051	36	1114	30
28X	1052	12	989	12
28Y	1052	36	1115	30
29X	1053	12	990	12
29Y	1053	36	1116	30
30X	1054	12	991	12
30Y	1054	36	1117	30
31X	1055	12	992	12
31Y	1055	36	1118	30
32X	1056	12	993	12
32Y	1056	36	1119	30
33X	1057	12	994	12
33Y	1057	36	1120	30
34X	1058	12	995	12
34Y	1058	36	1121	30
35X	1059	12	996	12

Channel	Interrogation Frequency MHz	Interrogation Pulse Spacing µsec	Reply Frequency MHz	Reply Pulse Spacing µsec
35Y	1059	36	1122	30
36X	1060	12	997	12
36Y	1060	36	1123	30
37X	1061	12	998	12
37Y	1061	36	1124	30
38X	1062	12	999	12
38Y	1062	36	1125	30
39X	1063	12	1000	12
39Y	1063	36	1126	30
40X	1064	12	1001	12
40Y	1064	36	1127	30
41X	1065	12	1002	12
41Y	1065	36	1128	30
42X	1066	12	1003	12
42Y	1066	36	1129	30
43X	1067	12	1004	12
43Y	1067	36	1130	30
44X	1068	12	1005	12
44Y	1068	36	1131	30
45X	1069	12	1006	12
45Y	1069	36	1132	30
46X	1070	12	1007	12
46Y	1070	36	1133	30
47X	1071	12	1008	12
47Y	1071	36	1134	30
48X	1072	12	1009	12
48Y	1072	36	1135	30
49X	1073	12	1010	12
49Y	1073	36	1136	30
50X	1074	12	1011	12
50Y	1074	36	1137	30
51X	1075	12	1012	12
51Y	1075	36	1138	30
52X	1076	12	1013	12
52Y	1076	36	1139	30

Channel	Interrogation Frequency MHz	Interrogation Pulse Spacing µsec	Reply Frequency MHz	Reply Pulse Spacing µsec
53X	1077	12	1014	12
53Y	1077	36	1140	30
54X	1078	12	1015	12
54Y	1078	36	1141	30
55X	1079	12	1016	12
55Y	1079	36	1142	30
56X	1080	12	1017	12
56Y	1080	36	1143	30
57X	1081	12	1018	12
57Y	1081	36	1144	30
58X	1082	12	1019	12
58Y	1082	36	1145	30
59X	1083	12	1020	12
59Y	1083	36	1146	30
60X	1084	12	1021	12
60Y	1084	36	1147	30
61X	1085	12	1022	12
61Y	1085	36	1148	30
62X	1086	12	1023	12
62Y	1086	36	1149	30
63X	1087	12	1024	12
63Y	1087	36	1150	30
64X	1088	12	1151	12
64Y	1088	36	1025	30
65X	1089	12	1152	12
65Y	1089	36	1026	30
66X	1090	12	1153	12
66Y	1090	36	1027	30
67X	1091	12	1154	12
67Y	1091	36	1028	30
68X	1092	12	1155	12
68Y	1092	36	1029	30
69X	1093	12	1156	12
69Y	1093	36	1030	30
70X	1094	12	1157	12

Channel	Interrogation Frequency MHz	Interrogation Pulse Spacing µsec	Reply Frequency MHz	Reply Pulse Spacing µsec
70Y	1094	36	1031	30
71X	1095	12	1158	12
71Y	1095	36	1032	30
72X	1096	12	1159	12
72Y	1096	36	1033	30
73X	1097	12	1160	12
73Y	1097	36	1034	30
74X	1098	12	1161	12
74Y	1098	36	1035	30
75X	1099	12	1162	12
75Y	1099	36	1036	30
76X	1100	12	1163	12
76Y	1100	36	1037	30
77X	1101	12	1164	12
77Y	1101	36	1038	30
78X	1102	12	1165	12
78Y	1102	36	1039	30
79X	1103	12	1166	12
79Y	1103	36	1040	30
80X	1104	12	1167	12
80Y	1104	36	1041	30
81X	1105	12	1168	12
81Y	1105	36	1042	30
82X	1106	12	1169	12
82Y	1106	36	1043	30
83X	1107	12	1170	12
83Y	1107	36	1044	30
84X	1108	12	1171	12
84Y	1108	36	1045	30
85X	1109	12	1172	12
85Y	1109	36	1046	30
86X	1110	12	1173	12
86Y	1110	36	1047	30
87X	1111	12	1174	12
87Y	1111	36	1048	30

Channel	Interrogation Frequency MHz	Interrogation Pulse Spacing µsec	Reply Frequency MHz	Reply Pulse Spacing µsec
88X	1112	12	1175	12
88Y	1112	36	1049	30
89X	1113	12	1176	12
89Y	1113	36	1050	30
90X	1114	12	1177	12
90Y	1114	36	1051	30
91X	1115	12	1178	12
91Y	1115	36	1052	30
92X	1116	12	1179	12
92Y	1116	36	1053	30
93X	1117	12	1180	12
93Y	1117	36	1054	30
94X	1118	12	1181	12
94Y	1118	36	1055	30
95X	1119	12	1182	12
95Y	1119	36	1056	30
96X	1120	12	1183	12
96Y	1120	36	1057	30
97X	1121	12	1184	12
97Y	1121	36	1058	30
98X	1122	12	1185	12
98Y	1122	36	1059	30
99X	1123	12	1186	12
99Y	1123	36	1060	30
100X	1124	12	1187	12
100Y	1124	36	1061	30
101X	1125	12	1188	12
101Y	1125	36	1062	30
102X	1126	12	1189	12
102Y	1126	36	1063	30
103X	1127	12	1190	12
103Y	1127	36	1064	30
104X	1128	12	1191	12
104Y	1128	36	1065	30
105X	1129	12	1192	12

Channel	Interrogation Frequency MHz	Interrogation Pulse Spacing µsec	Reply Frequency MHz	Reply Pulse Spacing µsec
105Y	1129	36	1066	30
106X	1130	12	1193	12
106Y	1130	36	1067	30
107X	1131	12	1194	12
107Y	1131	36	1068	30
108X	1132	12	1195	12
108Y	1132	36	1069	30
109X	1133	12	1196	12
109Y	1133	36	1070	30
110X	1134	12	1197	12
110Y	1134	36	1071	30
111X	1135	12	1198	12
111Y	1135	36	1072	30
112X	1136	12	1199	12
112Y	1136	36	1073	30
113X	1137	12	1200	12
113Y	1137	36	1074	30
114X	1138	12	1201	12
114Y	1138	36	1075	30
115X	1139	12	1202	12
115Y	1139	36	1076	30
116X	1140	12	1203	12
116Y	1140	36	1077	30
117X	1141	12	1204	12
117Y	1141	36	1078	30
118X	1142	12	1205	12
118Y	1142	36	1079	30
119X	1143	12	1206	12
119Y	1143	36	1080	30
120X	1144	12	1207	12
120Y	1144	36	1081	30
121X	1145	12	1208	30
121Y	1145	36	1082	12
122X	1146	12	1209	12
122Y	1146	36	1083	30

Channel	Interrogation Frequency MHz	Interrogation Pulse Spacing µsec	Reply Frequency MHz	Reply Pulse Spacing µsec
123X	1147	12	1210	12
123Y	1147	36	1084	30
124X	1148	12	1211	12
124Y	1148	36	1085	30
125X	1149	12	1212	12
125Y	1149	36	1086	30
126X	1150	12	1213	12
126Y	1150	36	1087	30