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MILITARY SPECIFICATION

# FREQUENCY STANDARD, CESIUM BEAM TUBE

This specification is approved for use by the Space and Naval Warfare Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense

## 1 SCOPE

1.1 Scope This specification covers the performance requirements for a time and frequency standard, hereinafter referred to as the instrument, which uses a cesium beam tube resonator to stabilize the output frequency of a quartz crystal oscillator The instrument provides an extremely high order of frequency accuracy and is capable of serving as a primary frequency reference

## 2 APPLICABLE DOCUMENTS

2.1 Government documents

2.1.1 Specifications and standards Unless otherwise specified the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein

SPECIFICATIONS

MILITARY

| | |
|---|---|
| MIL-S-901 | Shock Test, H.I. (High-Impact), Shipboard Machinery, Equipment And Systems, Requirements For |
| MIL-P-15024 | Plate, Tags And Bands For Identification Of Equipment |
| MIL-E-15090 | Enamel, Equipment, Light-Gray (Formula No. 111) |
| MIL-E-16400 | Electronic Interior Communication And Navigation Equipment, Naval Ship And Shore General Specification For |
| MIL-E-17555 | Electronic And Electrical Equipment, Accessories, And Repair Parts, Packaging And Packing Of |
| MIL-C-39012/25 | Connector, Coaxial, Radio Frequency (Hardware For Radio Frequency Coaxial Connectors) |

STANDARDS

MILITARY

| | |
|---|---|
| MIL-STD-12 | Abbreviations For Use On Drawings, Specifications, Standards And In Technical Documents |
| MIL-STD-105 | Sampling Procedures And Tables For Inspection By Attributes |
| MIL-STD-109 | Quality Assurance Terms And Definitions |
| MIL-STD-167-1 | Mechanical Vibrations Of Shipboard Equipment (Type I - Environmental And Type II - Internally Excited) |
| MIL-STD-188 | Military Communication System Technical Standards |
| MIL-STD-415 | Test Provisions For Electronic Systems And Associated Equipment Design Criteria For |
| MIL-STD-461 | Electromagnetic Emission And Susceptibility Requirements For The Control Of Electromagnetic Interference |
| MIL-STD-462 | Electromagnetic Interference Characteristics, Measurement Of |
| MIL-STD-471 | Maintainability Verification/Demonstration/Evaluation |

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Commander, Space and Naval Warfare Systems Command (SPAWAR-8111), Washington, DC 20363-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter

| | |
|---|---|
| MIL-STD-781 | Reliability Design Qualification And Production Acceptance Tests Exponential Distribution |
| MIL-STD-810 | Environmental Test Methods And Engineering Guidelines |
| MIL-STD-965 | Parts Control Program |
| DoD-STD-1399, Section 300 | Interface Standard For Shipboard Systems, Electric Power, Alternating Current (Metric) |
| MIL-STD-1472 | Human Engineering Design Criteria For Military Systems Equipment And Facilities |
| MIL-STD-1631 | Procedure For Selection Of Electronic And Electrical Parts And Materials During Design Of Military Items |
| MS-3102 | Connector, Receptacle, Electric Box Mounting |
| MS-3122 | Connector Receptacle Electric, Series 1 Crimp-Type, Box Mounting, Flange, No 4 Holes |
| MS-3476 | Connector, Plug, Electric, Series 2, Crimp-Type, Bayonet Coupling, Classes A, L, S, And W |
| MS-25043 | Cover Electrical Connector, Receptacle, AN Type |

2 1 2 Other Government publications The following other Government publications form a part of this specification to the extent specified herein

PUBLICATIONS

NAVAL AIR SYSTEMS COMMAND (NAVAIR)

| | |
|---|---|
| WS-6536 | Process Specification Procedures And Requirements For Preparation And Soldering Of Electrical Connections |

NAVAL MATERIAL COMMAND (NAVMAT)

| | |
|---|---|
| NAVMAT P4855-1 | Navy Power Supply Reliability, Design And Manufacturing Guidelines |

(Copies of specifications, standards, and publications required by manufacturers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer )

2 2 Other publication(s) The following document forms a part of this specification to the extent specified herein The issue of the document which is indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

| | |
|---|---|
| EIA RS-310-C-77 | Racks Panels And Associated Equipment |

(Application for copies should be addressed to Electronic Industries Association 200, Eye Street, NW, Washington, DC 20006

(Industry association specifications and standards are generally available for reference from libraries They are also distributed among technical groups and using Federal agencies )

2 3 Order of precedence In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence

3 REQUIREMENTS

3 1 General The instrument shall be in accordance with MIL-E-16400 except as hereinafter specified

3 1 1 First article When specified, a sample shall be subjected to first article inspection (see 4 3 and 6 3)

3 2 Description The instrument shall contain a quartz crystal oscillator, a means of synthesizing a microwave frequency near the hyperfine transition frequency of cesium 133 (9,192,631,770 hertz (Hz)) from the quartz oscillator frequency, and a means of comparing the synthesized microwave frequency with the hyperfine transition frequency The result of the comparison shall be used to correct the frequency of the crystal oscillator to reduce to a minimum the difference between the synthesized microwave frequency and the hyperfine transition frequency Means shall be provided to operate the crystal oscillator at a frequency referenced to atomic time

3.3 Construction. The instrument shall consist of the items specified in a through i and other parts specified herein as required to make up a complete instrument.

a. Cesium beam tube
b. Power supply
c. Standby power supply (internal battery optional)
d. Quartz crystal oscillator
e. Dividers
f. Warning indicators for improper operation
g. Synthesizer
h. Clock
i. Accessories

3.4 Performance. Performance shall be as specified in 3.4.1 through 3.4.13.

3.4.1 Warmup. The instrument shall be fully operable and shall conform to all the requirements of this specification within 20 minutes from -28° Celsius (C) ambient temperature.

3.4.2 Accuracy. The instrument, without reference to or calibration with an external standard, shall be capable of producing a frequency that is within $\pm 3 \times 10^{-11}$ of that used for the International Definition of the Second (as referenced against the disseminated time scale of the U.S. Naval Observatory (USNO)). This accuracy shall be maintained during temperature exposure from -28°C to +65°C and magnetic flux densities as specified in 3.8.3.1, or any combination thereof.

3.4.3 Reproducibility. The instrument shall be capable of returning to the previous frequency within $\pm 1 \times 10^{-11}$ after having been turned off or having any one of its electronic modules (exclusive of beam tube) repaired or replaced and properly aligned and the instrument replaced in the same environment.

3.4.4 Settability. The instrument shall be capable of being calibrated to within $\pm(2) \times 10^{-12}$ of the USNO time scale during temperature exposure from -28°C to +65°C and magnetic flux densities as specified in 3.8.3.1, and any combination thereof. The total range of the calibration adjustment shall be at least 6.0 parts per (pp) $10^{11}$.

3.4.5 Long-term stability. The instrument shall display no systematic drift and shall not change from the original frequency more than $\pm 1 \times 10^{-11}$ for the life of the cesium beam tube. Frequency measurements made at different times shall be made in the same environment with the tolerances specified in a through c.

a. Temperature ±5°C
b. Magnetic field ±0.7 gauss
c. Humidity ±10 percent relative humidity

3.4.6 Short-term stability. The standard deviation of the short-term instabilities shall not exceed the limits specified in a through c.

a. $\leq 8 \times 10^{-c}$ for 100 microsecond (μs) sample interval
b. $\leq 7 \times 10^{-12}$ for 1 second sample intervals
c. $\leq 7 \times \frac{10^{-11}}{\tau}$ for sample intervals greater than 1 second and less than 1 day

3.4.7 Sinusoidal outputs. The instrument shall provide isolated sinusoidal outputs at both the front and rear panels as specified in TABLE I.

TABLE I. Sinusoidal outputs

| Frequency | Front | Rear |
|---|---|---|
| 5 MHz 1/ | 1 | 4 |
| 1 MHz | 1 | 1 |
| 100 kHz 2/ | 1 | 1 |

1/ Megahertz
2/ Kilohertz

The isolation between any sinusoidal output and any other sinusoidal output specified shall be a minimum of 40 decibels (dB) in the frequency range of 10 kHz to 10 MHz. The amplitude of the test signal used to verify the isolation shall be not greater than 0 dBm nor less than -10 dBm relative to the rated level of the sinusoidal output under test.

3 4 7 1 Amplitude Amplitude shall be not less than 1 volt root-mean-square (Vrms) nor more than 1 5 Vrms into 50 ohms

3 4 7 2 Harmonic distortion Harmonic distortion shall be 40 dB below rated output

3 4 7 3 Nonharmonic output At least 80 dB below rated output except under the extremes of vibration or magnetic field environments specified in 3 8, in which case the non-harmonic output shall be at least 60 dB below rated output

3 4 7 4 Signal-to-noise ratio (SNR) The phase noise in a 30-kHz bandwidth centered at the 5-MHz and 1-MHz outputs, but excluding a bandwidth of ±1 Hz from the output frequency, shall be at least 80 dB below the output level except under the extremes of vibration or magnetic field environments specified in 3 8 3, in which case the phase noise shall be at least 60 dB below the rated output

3 4 7 5 Short circuit protection All outputs shall be protected from damage due to short circuits at any of the terminals There shall be no degradation below the specified performance limits of any sinusoidal output by short circuit of any other sinusoidal output or combinations of outputs

3 4 8 Timing pulse and direct current (DC) outputs The instrument shall include a digital divider and clock that will provide the specified isolated timing pulse outputs at the front and rear panels

| Pulse repetition frequency (prf) | Front | Rear |
|---|---|---|
| 1 pulse per second (pps) | 1 | 1 |
| 1 pulse per minute (ppm) | | 4 |

In addition a minimum of 40 dB isolation shall be provided between any of the 1 ppm outputs in the frequency range of 10 kHz to 10 MHz For test purposes, the maximum interfering signal shall be 3 2 Vrms

3 4 8 1 Amplitude The pulse output shall have a high value of 10 volts (V) ±1 V, and the low value shall be 0 V, ±0 5 V, from ground reference into 50 ohms

3 4 8 2 Width The width shall be 20 µs, +50 percent, -20 percent, into a 50-ohm load

3 4 8 3 Rise time The rise time from the 10 percent to the 90 percent value of pulse amplitude shall be not greater than 50 nanoseconds (ns)

3 4 8 4 Fall time The pulse fall time from the 90 percent to the 10 percent value of pulse amplitude shall be not greater than 1 µs

3 4 8 5 Jitter The phase jitter on the leading edge of the pulse outputs shall be less than 5 ns root-mean-square (rms) referenced to the 5-MHz output averaged over 10,000 pulses

3 4 8 6 Noise immunity The timing of the output pulses and the circuits that generate the output pulses shall not be harmed or degraded below specified performance by application of external pulses 1 µs wide up to 200 V peak from a 50-ohm source

3 4 8 7 Short-circuit protection The outputs specified in 3 4 8 shall be protected from damage due to short circuits at any of the terminals There shall be no degradation below the specified performance limits of any pulse output by short circuit of any other pulse output

3 4 8 8 Temperature stability The phase change of the pulse outputs, per degree C, shall be less than 5 ns referenced to the 5-MHz output

3 4 8 9 Pulse advance The time of the 1 pps and 1 ppm output shall be adjustable from the front panel over a range of 1 second in discrete steps of 100 milliseconds (ms) 10 ms, and 1 ms, and 100 µs, 10 µs, 1 µs, and 0 1 µs

3 4.8 10 Automatic synchronization The 1-ppm and 1-pps output shall synchronize automatically, with a preset advance (see 3 4 8 9), to the leading edge of an external pulse The synchronization error shall be not greater than ±0 5 µs An external synchronization input jack shall be provided on the front panel The external synchronization pulse shall have an amplitude of not less than +5 V rise time of not more than 50 ns from 0 5 V to 5 V and a pulsewidth of not less than 500 ns into 50-ohms nominal impedance A front panel control shall be provided to initiate synchronization

3 4 8 11 One-ppm reset The 1-ppm output shall be settable from the front panel to coincidence with any selected 1-pps output pulse of the 1-minute period With the occurrence of the next 1-pps pulse after the reset switch is depressed, the time display shall change to the next minute and 00-second, and the 1-ppm pulses thereafter occur at each 00-second event and within 100 ns of the corresponding 1-pps output pulses

3 4 8 12 Timing fault output The instrument shall provide a timing fault output at the rear panel when any interruption occurs that prevents the instrument from operating as a frequency standard, as specified in a through c

a Normal operation - not less than 3 volts direct current (VDC), not more than 5 5 VDC

b Fault indication - not less than 0 VDC not more than 0 5 VDC

c When loaded with 500 ohms connected to +5 VDC (standard transistor logic load)

3 4 9 Open loop quartz crystal oscillator performance Provision shall be made for operating stress compensated (SC)-cut quartz crystal oscillator independently of the cesium reference When so operated, the 5-MHz output signal of the instrument shall conform to the requirements of 3 4 9 1 through 3 4 9 6 and 3 6 5

3 4 9 1 Short-term stability The standard deviation of fractional frequency deviation, measured for averaging times of 1 0 second and 10 0 seconds, shall not exceed $\pm 1 \times 10^{-11}$ for 100 measurements of sample size 2 and 0 dead time

3 4 9 2 Orientation stability The average frequency change observed when the instrument is placed successively with each of its six surfaces down shall not exceed 1 0 pp $10^{9}$

3 4 9 3 Frequency adjustment The magnitude and linearity of fractional frequency shift shall be observable when the frequency control is adjusted through the range (see 3 4 11 3)

3 4 9 4 Frequency stability as a function of supply voltage The fractional frequency shift observed for a 10 percent variation in line voltage when operated from alternating current (AC) power, or for ±4 % variation from 26 V when operated from DC power, shall not exceed $\pm 2 \times 10^{-10}$ for AC variations and $\pm 4 \times 10^{-10}$ for DC voltage variations

3 4 9 5 Frequency stability as a function of temperature The fractional frequency shift observed when the ambient temperature is varied from -28°C to +65°C shall not exceed $\pm 5 0 \times 10^{-9}$ from the frequency at 25°C

3 4 9 6 Frequency stability as a function of load The fractional frequency shift from open circuit to short circuit, or from open circuit to a 50-ohm resistive or reactive load, shall not exceed $\pm 2 \times 10^{-11}$

3 4 9 7 SNP The level of phase noise components in the 5-MHz output signal, measured in a 30-kHz bandwidth excluding a band of 1 Hz around the carrier, shall be less than -87 dB referenced to the level of the 5-MHz signal Under the extremes of the vibration or magnetic field environments specified in 3 8, the phase noise when measured as specified herein shall be at least -60 dB referenced to the level of the 5-MHz signal

3 4.9 8 Aging rate Provided the crystal off time has not exceeded 24 hours after 4 hours of continuous operation, the shift in the frequency of the oscillator output shall not exceed 5 parts in $10^{10}$ per 24 hours

3 4 10 Beam tube characteristics Substitution of the requirements specified in 3 4 10 1 through 3 4 10 4 by other methods and approaches is permissible provided the instrument conforms to the accuracy and stability requirements of this specification and the substitute methods and approaches are approved by the procuring activity

3 4 10 1 Beam tube line width Beam tube line width shall be less than 1500 Hz (see 6 4 1).

3 4 10 2 Beam tube signal-to-background ratio The ratio of the beam tube signal current to the background current, as measured with no microwave power applied, shall be greater than 0 5 (see 6 4 2)

3 4 10 3 Beam tube SNR The beam tube SNR shall be the ratio of the beam tube signal current (see 3 4 10 2 and 6 4 2) to the rms beam tube noise current in a 0 25-Hz noise bandwidth This ratio shall be not less than 800

3 4 10 4 Beam tube figure-of-merit ($F_m$) The beam tube $F_m$ shall be computed from the beam tube line width, signal-to-background ratio, and SNR as specified in 3 4 10 1 through 3 4 10 3 according to the following formula

$$F_m = \frac{\text{beam tube SNR}}{\text{beam tube line width}} \times \left[ \frac{\text{signal-to-background ratio} + 1}{\text{signal-to-background ratio} + 2} \right]^{1/2}$$

The beam tube $F_m$ shall be not less than

3 4 11 Controls indicators, and panel layouts The design of controls and indicators and their arrangement on operator and maintainer panels shall conform to the criteria of MIL-STD-1472 The color coding and marking of pin jacks and other test points shall be in accordance with MIL-STD-415 Abbreviations used on panels shall be in accordance with MIL-STD-12 All controls shall be protected from accidental movement by a front panel access door

3 4 11 1 Alarm indicator An alarm indicator shall be mounted on the front panel of the instrument to indicate that adjustable parameters critical to the operation of the instrument are near tolerance or dynamic limits

3 4 11 2 Continuous operation indicator A continuous operation indicator shall be mounted on the front panel of the instrument The indicator shall indicate that all circuits are functioning properly and that the instrument is operating as a frequency standard

3 4 11 3 Oscillator frequency controls Oscillator frequency controls shall be accessible from the front panel of the instrument The frequency control shall provide quartz crystal oscillator frequency adjustment not less than ±5 parts in $10^7$ The resolution shall be at least $\pm 1 \times 10^{-9}$

3 4 11 4 C-field control The calibration adjustment should be a calibrated control mounted on the front panel and visible from the front of the instrument The adjustment shall be calibrated in fractional frequency units not greater than $\pm 1 \times 10^{-9}$ Resolution shall be $\pm(2) \times 10^{-12}$, or better, and accuracy for difference shall be better than ±10 percent

3 4 11 5 Modulation switch A MOD-ON-OFF switch shall be provided on the instrument The switch shall control the low frequency modulation of the microwave energy applied to the cesium beam tube

3 4 11 6 Loop gain control A loop gain control shall be provided on the instrument The control shall adjust the gain of an amplifier forming a part of the quartz crystal oscillator stabilization loop This control shall be accessible by removal of the top cover

3 4 11 7 Logic reset switch A switch shall be provided to reset the instrument alarm logic circuits subsequent to any disturbance in the operation of the instrument that causes an alarm indication

3 4 11 8 Pulse advance The pulse advance switches shall be mounted on the front panel and shall give direct indication of the amount of advance applied to the pulse outputs (see 3 4 8 9)

3 4 11 9 Automatic synchronization A switch shall be provided to initiate the automatic synchronization requirements of 3 4 8 10

3 4 11 10 Manual clock controls Manual clock controls shall be mounted on the front panel to accomplish the functions of 3 4 12 1

3 4 11 11 Time scale step control Time scale step control shall provide means of approximating Universal Time (UT) from Atomic by stepping 1 second at appropriate intervals, according to USNO revised procedures beginning 1 January 1972 The 1-second step shall be reflected in the time of occurrences of the 1-pps output pulse and the clock on the front of the instrument

3 4 11 12 Mode switch A mode switch shall be mounted on the front panel of the instrument to select the instrument mode of operation The positions specified in a and b shall be provided

a OPERATE The normal mode with the quartz crystal oscillator locked to the atomic frequency

b LOOP OPEN All circuits are energized but the atomic control loop is open

3 4 11 13 Circuit check switch and meter A switch and meter shall be mounted on the front panel of the instrument The switch and meter shall provide facilities to monitor and check the preselected functions listed in TABLE II

TABLE II Circuit monitor functions

| Switch position | Description |
|---|---|
| Supply | Indicates unregulated input voltage |
| +18 V | Indicates +18 V regulator output |
| +5 V | Indicates +5 V regulator output |
| Int Batt I | Indicates internal battery charge or discharge current |
| Ion Pump | Indicates vacuum in cesium beam is at an acceptable level |
| 5 MHz | Indicates output level of 5-MHz oscillator |
| OSC | Indicates power to oscillator oven heater |
| CS Oven | Indicates power to oven in cesium beam tube |
| Synth | Indicates proper lock condition of synthesizer |
| Beam I | Indicates DC beam current from cesium beam tube |
| Second harmonic | Indicates second harmonic amplitude |
| Control | Indicates DC control voltage to quartz crystal oscillator |

3 4 11 14 Power requirements Power requirements shall be as specified in 3 4 11 14 1

3 4 11 14 1 Indicators Front panel indicators shall show whether AC power, external DC power, or internal battery is being used The indicators shall also show whether DC backup power (either internal or external) is available during the normal AC mode of operation

3 4 12 Clock requirements A 24-hour clock that is driven from the internally generated timing pulses shall be mounted on the front panel of the instrument to display hours, minutes, and seconds The clock shall be easily readable over a wide angle and a reasonable distance from the front panel The instrument shall generate a time code word specifying the displayed time for transmission to a remote location Manual means shall be provided to set the clock

3 4 12 1 Manual clock controls Operationally simple controls shall be provided to control the clock in either of the modes specified in a and b

a SET mode The hours, minutes, and seconds shall be independently settable The clock shall stop with the initiation of the SET mode and start under operator control This operation shall not affect the time position of the 1-pps output pulses

b ADD or SUBTRACT mode The hours, minutes, and seconds shall be capable of being increased or decreased over the ranges of 0 to 24, 0 to 59, and 0 to 59, respectively The clock shall continue to run in the ADD or SUBTRACT mode with the corrections applied to current time between two successive 1-second pulses This operation shall not affect the time positions of the 1-pps output pulses

3.4.12.2 Time code. The instrument shall produce a time code word output to define the current time displayed by the clock. The signal format shall be that of the time code word specified in 3.4.12.2.1. The time code output shall be capable of driving a standard (low-level) receive interface as specified in MIL-STD-188.

3.4.12.2.1 Code format. The code word shall be a 24-bit serial binary-coded decimal (BCD) word. The first bit shall be the most significant bit of the most significant digit of the hours. The twenty-fourth bit shall be the least significant bit of the least significant digit of the seconds. At the termination of the twenty-fourth bit, the signal shall hold at a mark until the beginning of the next code word. The BCD code shall be the 8421 code.

3.4.12.2.2 Timing. The leading edge of the first bit shall be coincident (within 100 µs) with the leading edge of each 1-pps output of the instrument. The signaling rate shall be 50 bits per second.

3.4.12.2.3 Digital sense. A digital one state (mark) shall be denoted by a positive voltage and a digital 0 state (space) by a negative voltage. The voltage shall be 6 V, ±1 V.

3.4.12.3 Clock indication relative to 1-ppm output pulse. The clock shall indicate 00 second with the occurrence of the 1-ppm output pulse. Changes to the clock time as specified in 3.4.12.1 shall be reflected in the time of occurrence of the 1-ppm output pulse. Use of the automatic synchronization feature (see 3.4.6.10), shall cause a 00 second clock indication coincident with the external sync pulse.

3.4.12.4 Time scale adjustment. The time scale step of 1 second provided to facilitate approximation of UT according to USNO revised procedures beginning 1 January 1972 shall be applied to the clock as well as the time of occurrence of the 1 ppm.

3.4.13 Accessories. The accessories to be provided with each instrument shall include, but shall not be limited to, the items specified in a through f.

a. AC power cable, detachable, three-wire ground type, 1.83-meter (m) 6-foot (ft) minimum length with standard three prong ground plug on one end and mating connector to frequency standard or other end (see TABLE III).

b. Rack mount kit to provide for rack-mounting the instrument, including drawer slides.

c. Connectors as specified in TABLE III and mating connector for observation of cesium beam current (see 3.7.4).

d. Board extender.

e. Special tools (see 6.4.4), connectors, and cables for troubleshooting, adjustment, and alignment.

f. Operating and service manual, including theory of operation, installation, and maintenance information.

3.5 Electrical requirements. Electrical requirements shall be as specified in 3.5.1 through 3.5.1.6.

3.5.1 Power sources. The instrument shall conform to all applicable performance requirements when operated from 115 V ±10 percent or 230 V ±10 percent, single-phase, at frequencies of 47 Hz to 63 Hz and 360 Hz to 460 Hz, and from 22 VDC to 30 VDC. When both the AC and DC voltages are applied simultaneously, the DC source shall provide power only if the AC source fails.

3.5.1.1 Voltage transients. The instrument shall be capable of withstanding, with no permanent damage, a voltage transient of at least ±20 percent from any point within the ±10 percent steady-state voltage tolerance band of 3.5.1, recoverable to this point within 2 seconds.

3.5.1.2 Frequency transients. The instrument shall be capable of operating during frequency transients of ±5 percent, of which not more than 1 percent is outside the steady-state tolerance band of frequency as specified in 3.5.1. The transient shall recover to the steady-state frequency in this band within 2 seconds.

3.5.1.3 Standby battery. Provision shall be made for an internal standby battery to permit uninterrupted operation in the event of failure of both the external AC and external DC power sources (battery optional).

TABLE III Connector requirements

| Location | Quantity (each) | Function | Connector type | Mating connectors and covers (contractor supplied) |
|---|---|---|---|---|
| Front panel | 1 | 5 MHz output | Bendix Microwave 33062-1 7/ | CW-123A/U 8/ 9/ |
| | 1 | 1 MHz output | Bendix Microwave 33062-1 7/ | CW-123A/U 8/ 9/ |
| | 1 | 1 pps output | Bendix Microwave 33062-1 7/ | CW-123A/U 8/ 9/ |
| | 1 | Sync 1/ output | Bendix Microwave 33062-1 7/ | CW-123A/U 8/ 9 |
| | 1 | 100 kHz output | Bendix Microwave 33062-1 7/ | CW-123/AL 8/ 9/ |
| | 1 | Cesium beam tube current monitor | To be determined by contractor | To be determined by contractor |
| Rear panel | 1 | 1 MHz output | Amphenol 31-357-1022 7/ | CW-123A/U 8/ 9/ |
| | 1 | 100 kHz output | Amphenol 31-357-1022 7/ | CW-123A/U 8/ 9/ |
| | 2 | 5 MHz outputs 2/ | MS3102R10SL-3P | MS25043-10C, MS3106R10SL-3S 9/ |
| | 4 | 1 ppm outputs 3/ | MS3102R10SL-4P | MS25043-10C, MS3106R10SL-4S 9/ |
| | 1 | AC power input 4/ | MS3122E14-12P | MS3126F14-12S |
| | 1 | DC power input 5/ | MS3102R14S-6P | MS3106R14S-6S |
| | 1 | 5 MHz and timing fault output 6/ | MS1511/21EB02SL | MS1511/18-10, MS1511/26EB02P 9/ |
| | 1 | Time code output | MS3102R10SL-4P | MS25043-10C MS3106R10SL-4S 9/ |
| | | | Bendix Microwave 33062-1 7/ | CW-123A/U 9/ |

1/ Synchronized

2/ MS3102 connector wiring for 5 MHz outputs
Pin A - Signal
Pin C - Signal return
Pin B - Unused
7-each Cable Clamps MS3057-4A

3/ MS3102 connector wiring for 1 ppm outputs
Pin A - Signal
Pin B - Signal return
7-each Bushings MS3420-4

4/ MS3122 connector wiring for AC power input
Pin H - Neutral (system ground)
Pin M - Safety ground
Pin N - 117 volts alternating current (VAC)
2-each Adapters MS1511/14-014

5/ MS3102 connector wiring for DC power i
Pins A and B - (connected internally
Pin C - Ground, DC return
Pin D - +22 VDC to +30 VDC power input
Pin E - +22 VDC to +50 VDC for pump input
Pin F - Ground-ion pump return
2-each Adapters G1760N10SL2A1 s (Glenair

6/ MS1511 connector wiring for 5 MHz and timing fault outputs
Pin 1 - 5-MHz signal
Pin 2 - 5-MHz return
Pin 3 - Timing fault
Pin 4 - Timing fault ground
Pin 5 - Unused

7/ Each cable clamp, see MS3057A, each bushing see MS3420-4
8/ In accordance with MIL-C-39012/25
9/ To be furnished by contractor

CAUTION Connector adapter incompatibility will exist if manufacturer of MS connector is not specified when using Glenair adapters

3 5 1 3 1 Capacity The instrument shall have the capacity for not less than 1 hour normal operation at 25°C after full charge In addition to the specified 1-hour operation at 25°C, the required capacity of the standby battery shall be 0 5 hour at 55°C and not less than 0 5 hour at -28°C

3 5 1 3 2 Charging rate The internal battery shall reach specified capacity in 16 hours after complete discharge

3 5 1 3 3 Switchover Switchover to the internal battery shall be automatic without interruption of operation, upon loss of both AC and DC external power sources

3 5 1 4 Maximum power consumption Maximum power consumption shall be as specified in a through d

| | | 115 VAC | or | 24 VDC |
|---|---|---|---|---|
| a | Frequency and time standard only (25°C) | 60 watts (W) | | 45 W |
| b | Standby battery only, trickle charge | 6 W | | 3 W |
| c | Standby battery only, normal charge | 50 W | | 3 W |
| d | Additional requirements during warmup | 75 W | | 30 W |

Warmup testing (see 3 4 ) shall not be performed when operation is from the standby power sources (see 3 5 1 3 Maximum power drain is the sum of items a, c, and d

3 5 1 5 Power supply requirements Power supply requirements shall be as specified in a through j

a The power density shall be output power divided by power supply envelope volume, including electromagnetic interference (EMI) filtering where required Power density exceeding 2 W per cubic inch shall require the approval of the procuring activity

b Junction temperature of semiconductor devices (diodes transistors, hybrid and monolithic integrated circuits and so forth) shall not exceed +110°C under worst-case conditions

c Case/hot spot temperatures shall not exceed 40°C rise above external device ambient with a maximum absolute temperature of +110°C for devices less than or equal to 2 W of dissipation 55°C rise above external device ambient with a maximum absolute temperature of +125°C for devices greater than 2 W of dissipation, 30°C rise above external device ambient with a maximum absolute temperature of +100°C for transformers, and 10°C rise above external device ambient, due to self-heating, with an absolute maximum temperature of 85°C for capacitors

d The use of nonstandard parts shall not be prohibited provided there are at least two independent sources

e Power supplies shall be designed to be maintainable at either intermediate or depot level power supplies shall not be limited by design to repair by the manufacturer

f Power supplies shall not be encapsulated or embedded (potted) unless it can be shown by analysis and test to be necessary for heat removal or dissipation This requirement shall not exclude conformal coating

g Power supply manufacturing shall include random vibration and temperature cycling of every unit, under full electrical load this may be done in the end item but shall be performed on a unit basis for spares

h EMI requirements shall be tailored for the power supply which will enable the end equipments to conform to MIL-STD-461, Class A4 EMI shall be developed for the power supply which will permit the power supply to be purchased separately from the end equipment

i The mean-time-between-failures (MTBF shall not be less than 40 000 hours for Naval sheltered equipment, at 55°C with 110°C maximum junction temperature

j Guidance for design and manufacturing of power supplies is contained in NAVMAT P4855-1

3 5 1 6 Shipboard power When operating from an AC source the instrument shall be capable of withstanding without permanent damage a 2500-V spike and other anomalies specified in DoD-STD-1399, Section 300

3 6 Magnetic characteristics The instrument shall conform to the magnetic characteristics requirements of MIL-E-16400, including magnetic signature, magnetic materials, and any current magnetism, except as hereinafter specified

3 7 Mechanical requirements Mechanical requirements shall be as specified in 3 7 1 through 3 7 4

3.7.1 Dimensions and weight. Dimensions and weight shall be as specified in 3.7.1.1 and 3.7.1.2.

3.7.1.1 Dimensions. The dimensions of the instrument, including the covers, fasteners, louvers, rear connectors, and guards, shall be 17 inches (in.) wide and not more than 5.25 in. high or 21 in. deep behind the front panel. The front panel shall be 19 in. wide by 5.25 in. high with mounting holes. Detachable drawer slides (Zero Manufacturing Company slide MT-2RT-24-24.50, or equal) shall be provided with provisions for mounting the slides on the instrument for installation in a 19-in. rack. Mounting holes for the equipment slides shall be in accordance with EIA RS-310-C-77.

3.7.1.2 Weight. The weight of the instrument shall be held to a minimum consistent with the other requirements of this specification and shall not exceed 60 pounds (lbs) without the standby battery, or 70 lbs including the standby battery.

3.7.2 Construction. The instrument shall include miniature unitized construction where possible. Optimum use of replaceable subassemblies shall be made.

3.7.2.1 Accessibility. Construction shall allow maximum accessibility to replaceable assemblies.

3.7.2.2 Rough usage. The instrument shall be designed to preclude damage to the instrument when handled by relatively unskilled personnel.

3.7.2.3 Printed circuit boards (PCBs). Heat-producing or heat-sensitive parts shall have sinking or other cooling to limit heat concentrations properly and to preclude discoloration of PCBs.

3.7.2.4 Finish. A front panel finish shall be light-gray enamel, Type III, Class 2 of MIL-E-15090. Finish of all surfaces shall be in accordance with MIL-E-16400.

3.7.2.5 Nonstandard parts. Prescreening of nonstandard parts approval requests shall be accomplished in accordance with MIL-STD-1521.

3.7.3 Controls. All controls necessary to operate the instrument shall be placed on the front panel. If internal-external concentric controls are used, the internal knobs shall be designed so that it will be possible to turn them without turning the external knobs.

3.7.4 Connectors. Connectors shall be as specified in TABLE II, for all input and output functions. An external connector for monitoring the cesium beam tube current shall be provided and specified by the contractor prior to first article testing.

3.7.5 Interchangeability. Unless otherwise approved by the procuring activity, mechanical and electrical interchangeability shall exist between similar assemblies, subassemblies, and replaceable parts furnished by the contractor. In the design of the instrument, provisions shall be made for design tolerance sufficient to accommodate variations in parts, such as tubes, resistors, and other parts having the limiting dimensions and characteristics specified for the particular parts involved without departure from the required performance.

3.7.5.1 Interchangeability with existing frequency standards. The instrument shall operate as a form-fit, and function replacement for the Frequency Standard, Cesium Beam, O-1695A/U and the Master Reading Clock, O-1624/U. The instrument shall be equipped with pin connectors and power receptacles that are interchangeable with O-1695A/U and O-1624/U equipment signal and electrical interconnectors.

3.7.5.1.1 Cesium beam tube interchangeability. The instrument shall operate with the built-in cesium beam tube provided by the contractor. The instrument shall also be designed to accept and operate with the Hewlett-Packard cesium beam tube part number 05062-60500 (Assembly A15), or equal, currently used in the J-1695A/B and with the Frequency Electronics Incorporated, cesium beam tube, part number ICD 42701-9201-1, or equal.

3 7 6 Storage The instrument shall not be adversely affected and shall perform as specified in 3 4 after storage in the nonoperating condition for a period not greater than 4 months at temperatures specified in 3 8 2.1, except that when stored at a temperature of 35°C or higher, the ion pump shall be energized in accordance with the contractor's recommended maintenance procedures The instrument shall not be adversely affected by storage for a period greater than 4 months, provided the contractor's recommended procedures for maintenance during storage are followed A low temperature (-40°C) storage limitation shall apply to the internal battery and to the clock display to avoid permanent damage High temperature battery storage limits shall not exceed 65°C

3 8 Environmental requirements Environmental requirements shall be as specified in 3 8 1 through 3 8 5

3 8 1 Shock and vibration The instrument shall conform to the requirements for Grade A, Class 1, Type A equipment of MIL-S-901 and Type 1 vibration testing of MIL-STD-167-1 in accordance with MIL-E-16400 Fractional frequency shift shall recover to less than $2 \times 10^{-11}$ from a reference as a result of shock testing and shall exhibit less than $2 \times 10^{-11}$ frequency shift during vibration testing

3 8 2 Temperature and humidity The instrument shall operate within the accuracies specified herein over the entire temperature range from -28°C to +65°C, with a relative humidity of 95 percent, and shall conform to MIL-E-16400, Range 2

3 8 2 1 Nonoperating temperature Temperatures from -62°C to +71°C shall not damage the instrument when it is not operating

3 8 2 2 Operating temperature The instrument shall operate as specified in 3 4 when exposed to ambient temperatures from -28°C to +65°C The fractional frequency shift exhibited over that temperature range shall not exceed $2 \times 10^{-11}$ from the frequency at 25°C

3 8 2 3 Humidity The instrument shall operate as specified herein, except that the maximum temperature during the test shall be 50°C and the accuracy of the instrument shall be determined as the fractional frequency shift referred to the frequency established at 25°C and 50 percent relative humidity The fractional frequency shift exhibited during the humidity test shall not exceed $\pm 1 \times 10^{-11}$

3 8 3 Magnetic field environment The instrument shall not be damaged while operating within the requirements of this specification when in the environments specified in a and b

a An ambient steady-state magnetic field intensity of 0 oersteds to 25 oersteds
b A magnetic field intensity varying approximately sinusoidally from 0 oersteds to 25 oersteds at the rate of 1 Hz

3 8 3 1 External magnetic fields When subjected to a magnetic flux density of 2 gauss DC of any orientation or 1 gauss peak 50 Hz, 60 Hz, and 400 Hz AC flux density, the fractional frequency shift shall not exceed $\pm 2 \times 10^{-12}$

3 8 4 Altitude The instrument shall operate within the accuracies specified herein for all altitudes up to 15,250 m (50,000 ft)

3 8 5 Inclination The average frequency change of the instrument shall not exceed $\pm(3 \times 10^{(10}$ when subjected to the inclination test of MIL-E-16400 Inclination angle shall be 45 degrees for the standard

3.9 Parts control. The parts to be incorporated in the equipment shall be controlled in accordance with MIL-STD-965, Procedure I

3 9 1 Encapsulation and embedment Encapsulated and embedded (potted) parts or assemblies shall not be used in construction of the instrument, except as required for maintaining operational performance at high altitudes and for thermal considerations.

3.10 EMI The instrument shall conform to the requirements of MIL-STD-461 for Class A4 equipment, except that the acceptable level of radiation for RE01 is modified to be 20 decibels per pico Tesla (dB/pT) above that specified The frequency range for RE01 is extended to cover 30 kHz through 110 kHz at a constant 40 dB/pT level

3.11 Electromagnetic pulse (EMP) All equipment and interfaces including terminal pins for control signal leads, grounds, and neutrals which are not grounded internally to the equipment or subsystem shall not exhibit any permanent malfunction, degradation of performance, or deviation from specified indications. After being subjected to a test signal having either the waveform and common mode current level or the waveform and common mode voltage level shown in FIGURE 1, whichever occurs first, at the specific test frequency

3.12 Identification and marking Nomenclature assignment and identification plate approval for equipment identification shall be in accordance with MIL-F-15024

3.13 Safety Instrument design shall promote maximum safety of both operational and maintenance personnel and equipments during all phases of operational life

3.13.1 ON-OFF switch An ON-OFF switch to remove all power from the internal circuits shall be incorporated to facilitate repair, to prevent equipment damage, and to protect personnel during maintenance and repair actions The switch shall be designed so that a deliberate unlocking action is required for operation to prevent inadvertent switching action

3.13.2 Control positions Positions of controls in any possible combination shall not damage the equipment

3.13.3 Overload protection Overload protection shall be provided for all power source circuits

3.14 Reliability Reliability shall be as specified in 3.14.1 and 3.14.2

3.14.1 Quantitative reliability requirements The instrument shall have an upper test MTBF ($\theta_0$ as defined in MIL-STD-781) of 10,000 hours The lower test MTBF ($\theta_1$ as defined in MIL-STD-781 shall be 3333 hours

3.14.2 Operating life The instrument shall have a total operating service life expectancy of 20 years with reasonable maintenance and replacement of parts The cesium beam tube furnished as a component of the instrument, shall have an operating service life expectancy of not less than 5 years Parts needing scheduled replacement shall require the approval of the procuring activity

3.15 Maintainability The instrument shall have a mean-time-to-repair (MTTR) not exceeding 0.5 hour and a maximum-corrective-maintenance-time ($M_{maxct}$) (95th percentile), not exceeding 1.0 hour when repair is accomplished at the intermediate level of maintenance by replacement of the lowest subassemblies (PCBs, plug-in modules, and so forth)

3.15.1 Test points Test points and test facilities shall be provided within the instrument for quickly and accurately checking the operation of the equipment Special tools (see 6.4.4) connectors, or adapters required in the testing of the instrument shall be supplied with the unit The use of test points for fault isolation shall be adequately covered in the technical manual

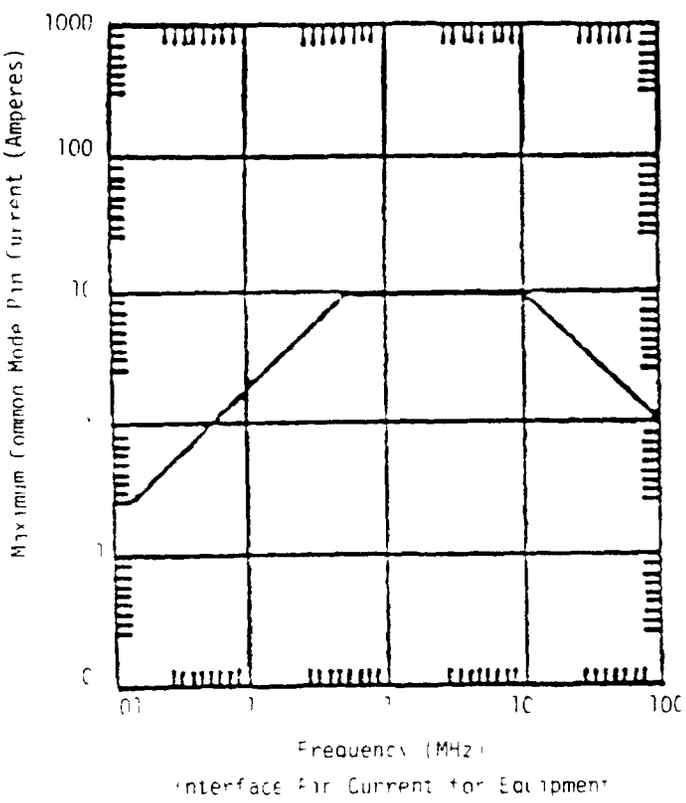
3.16 Workmanship Workmanship shall be as specified in 3.16.1 and 3.16.2

3.16.1 General workmanship Workmanship shall conform to the Workmanship paragraph of MIL-E-16400 Soldering shall conform to the requirements of WS-6536

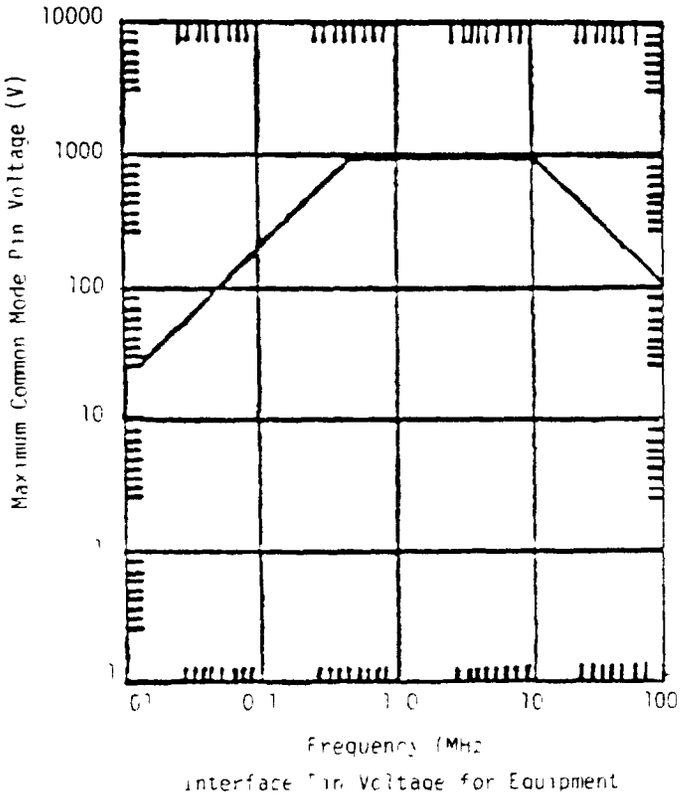
3.16.2 Workmanship screen All instruments shall withstand a defect detection vibration screen of random type vibration at 0.04$g^2$/Hz ±3 dB from 80 Hz to 350 Hz and temperature cycling with operation at the maximum and minimum operating temperatures and dwell time at the nonoperating temperature extremes

## 4 QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements




Interface Pin Current for Equipment




Interface Pin Voltage for Equipment

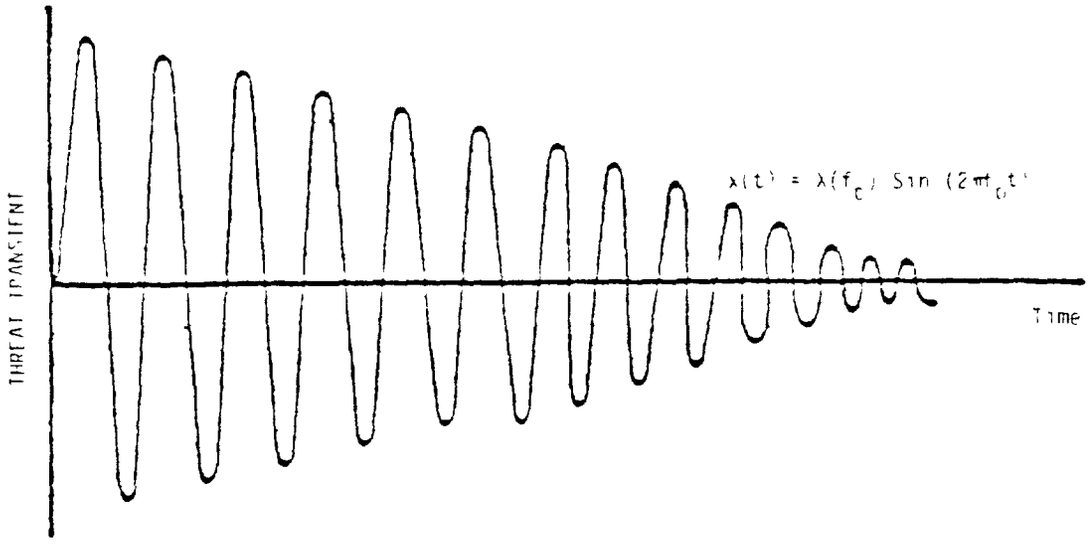



FIGURE 1 Interface pin current and voltage for equipment

4 1 1 Government verification All quality assurance operations performed by the contractor will be subject to Government verification at any time Verification will consist of, but is not limited to, a) surveillance of the operations to determine that practices, methods, and procedures of the written quality program are being properly applied, b) Government product inspection to measure quality of the product to be offered for acceptance, and c) Government inspection of delivered products to assure compliance with all inspection requirements of this specification Failure of the contractor to promptly correct deficiencies discovered by him or of which he is notified shall be cause for suspension of acceptance until corrective action has been taken or until conformance of the product to prescribed criteria has been demonstrated

4 1 2 Quality assurance terms and definitions Quality assurance terms used in this specification shall be as defined in MIL-STD-109

4 2 Classification of inspections The inspection requirements specified herein are classified as specified in a through c

a First article inspection (see 4 3)
b Quality conformance inspection (see 4 4)
1 Production inspection (Group A) (see 4 4 1)
2 Production control inspection (Group B) (see 4 4 2)
3 Environmental inspection (Group C) (see 4 4 3)
c Inspection of preparation for delivery (see 4 10)

4 3 First article inspection Unless otherwise specified (see 6 2), two units shall be required for first article inspection First article inspection shall consist of all examination and testing necessary to determine compliance with the requirements of this specification First article inspection shall include the tests specified in TABLE IV

4 4 Quality conformance inspection Quality conformance inspection shall be as specified in 4 4 1 through 4 4 3 3

4 4 1 Production inspection (Group A) Production inspection shall be conducted on every instrument offered for delivery Production inspection shall comprise examination and testing which will prove the workmanship and reveal the omissions and errors of the production process, such as functional and performance tests at a limited number of points, tests which detect deviations from design, tests of controls and adjustments, and tests which detect hidden defects of materials Production inspection shall include the examinations and tests shown in Group A of TABLE IV

4 4 2 Production control inspection (Group B) Production control inspection shall be conducted on a sampling basis as specified in 4 4.2 1 Production control inspection shall consist of the examinations and tests which encompass functional and performance tests throughout the entire range of operation, tests which will detect any deterioration of the design by wear of such items as dies, molds, and jigs, and by substitution of different parts, tests to determine temperature rise produced in operation and ability of the instrument to withstand this heat, and tests of efficiency Production control inspection shall be performed on the complete instrument as offered for delivery Production control inspection shall include the examinations and tests shown in Group B of TABLE IV

4 4 2 1 Sampling for production control inspection Instruments submitted for production control inspection shall be selected by the contractor under the supervision of the Government quality assurance representative (QAR) and shall be representative of current production Production control inspection, including sampling, shall conform to the procedures for small-sample inspection of MIL-STD-105, using the special inspection levels Production control inspection shall be performed on inspection lots that have passed production inspection The acceptable quality level shall be a 6 5 percent defective for each of the examinations and tests shown in Group B of TABLE IV and the inspection level shall be S-3 for normal, tightened, and reduced inspection

TABLE IV Examinations and tests

| Examination or test | Requirement paragraph | Test paragraph | First article inspection | Quality conformance inspection | | |
|---|---|---|---|---|---|---|
| | | | | Group A | Group B | Group C |
| Surface examination | | | | | | |
| Weight | 3.7.1.2 | 4.6.1 | X | X | | |
| Dimensions | 3.7.1.1 | 4.6.1 | X | X | | |
| Parts, materials, and processes | 3.7.2.5, 3.9 | 4.6.1 | X | X | | |
| Finish | 3.7.2.4 | 4.6.1 | X | X | | |
| Identification and marking | 3.12 | 4.6.1 | X | X | | |
| Safety | 3.13 | 4.6.1 | X | X | | |
| General workmanship | 3.16.1 | 4.9.1 | X | X | | |
| Pre-performance | 3.4 | 4.6.1 | X | X | | |
| Performance | 3.4 | 4.6.2 | X | X | | |
| Accessories | 3.4.13 | 4.6 | X | | | |
| Low temperature | 3.8.2 | 4.6.1 | X | | | X |
| High temperature | 3.8.2 | 4.6.1 | X | | | X |
| Humidity | 3.8.2.3 | 4.6.1 | X | | | X |
| Workmanship screen | 3.16 | 4.9.2 | | X | | |
| Fungus | 3.1 | 4.6.1 | X | | | |
| EMP | 3.11 | 4.6.5.1, 4.6.5.2 | X | | | X |
| Shock | 3.8.1 | 4.6.1 | X | | | X |
| Vibration | 3.8.1 | 4.6.1 | X | | | X |
| Inclination | 3.8.5 | 4.6.1 | X | | | X |
| Magnetic field environment | 3.8.3 | 4.6.1 | X | | | X |
| Interchangeability | | | | | | |
| Frequency standards | 3.7.5.1 | 4.6.3.1 | X | | | |
| Cesium beam tube | 3.7.5.1.1 | 4.6.3.2 | X | | | X |
| Altitude | 3.8.4 | 4.6.4 | X | | X | |
| Steady-state voltage and frequency | 3.5.1 | 4.6.1 | X | | X | |
| Transient voltage | 3.5.1.1 | 4.6.1 | X | | | |
| Transient frequency | 3.5.1.2 | 4.6.1 | X | | | |
| Spike voltage | 3.5.1.6 | 4.6.1 | X | | | |
| Power interruption | 3.5.1.6 | 4.6.1 | X | | X | |
| Power and power factor | 3.5.1.6 | 4.6.1 | X | | X | |
| Leakage current | 3.1 | 4.6.6 | X | | | X |
| EMI | 3.10 | 4.6.5 | X | | | X |
| Thermal design | 3.1 | 4.6.1 | X | | | |
| Reliability demonstration | 3.14 | 4.7 | X | | | |
| Maintainability demonstration | 3.15 | 4.8 | X | | | |

4.4.2.2 Rejected lots If an inspection lot is rejected, the contractor may withdraw the lot from further inspection. The contractor may also rework a rejected lot to correct the defective instruments and reinspect the lot using tightened inspection. Rejected lots shall be kept separate from new lots and shall not lose their identity.

4.4.3 Environmental inspection (Group C). Environmental inspection shall be accomplished on a sampling basis as specified in 4.4.3.1. Environmental inspection shall encompass environmental tests to prove the durability of the materials, parts, units, and the instrument as a whole, tests of the effects of changes of environment (such as extremes of temperature and humidity), and tests of the effects of shock and vibration. Environmental inspection shall include the examinations and tests shown in Group C of TABLE IV. Environmental inspection shall be performed on instruments that have passed production inspection.

4 4 3.1 Sampling for environmental inspection. One instrument from each 100 shall be selected. For production quantities of less than 100 units, an environmental inspection shall be accomplished if required by the contract (see 6 2).

4.4.3 2 Nonconforming environmental sample units. If a sample unit fails the tests specified in 4 4.3, the contractor shall immediately investigate the cause of failure and shall report to the QAR the results thereof and details of the corrective action taken to correct units of products which were manufactured under the same conditions, with the same materials, processes, and so forth If the QAR does not consider that the corrective action will enable the product to conform to specified requirements, or if the contractor cannot determine the cause of failure, the matter shall be referred to the contracting officer

4 4 3 3 Reinspection of conforming environmental sample units Unless otherwise specified (see 6.2), units which have been subjected to, and have passed, environmental inspection may be accepted on the contract, provided they are resubjected to, and pass, production inspection after repair of all visible damage.

4.5 Testing criteria Unless otherwise specified in 4 6, examinations and testing shall be in accordance with the quality assurance provisions of MIL-E-16400 specified in a through c

a Test facilities, chambers, and apparatus
b Standard test conditions
c Performance of test

4 6 Test methods Test methods shall be as specified in 4 6 1 through 4 6 6 2

4.6 1 Examinations and tests The examinations and tests specified in TABLE IV shall be conducted in accordance with the applicable test methods of MIL-E-16400, except as specified in 4 6 2 through 4.6 6.2

4 6 2 Performance tests The instrument shall be subjected to performance tests, including all operating controls, to determine compliance with the performance parameters and safety requirements specified in 3 4 and 3 12 The performance tests for the first article inspection units, the production inspection units, and the sample units selected for production control inspection shall consist of the tests specified in TABLE V

4.6 3 Interchangeability demonstration The instrument shall be examined and tested to verify compliance with 3 7 5 by utilizing at least two instruments and interchanging each interchangeable assembly, subassembly, module, and so forth, between the two instruments Satisfactory instrument performance shall be demonstrated prior to, and after, the interchange of the interchangeable assemblies, subassemblies, modules, and so forth Interchangeability of piece parts shall be verified by examination

4 6 3 1 Interchangeability with existing frequency standards Interchangeability with existing frequency standards specified in 3 7 5 1 shall be verified by examination

4 6 3 2 Cesium beam tube interchangeability Cesium beam tube interchangeability requirements shall be verified by demonstrating satisfactory operation of the instruments with the tubes specified in 3 7.5 1 1 installed in place of the built-in cesium beam tube provided by the contractor

4 6 4 Altitude The instrument shall be subjected to the altitude test of MIL-STD-810, Method 500 2, Procedure II to demonstrate compliance with 3 8 4

4 6 5 Electromagnetic compatibility (EMC) test Conformance to the requirements of 3 10 shall be verified by tests performed in accordance with MIL-STD-462

4.6.5 1 EMP hardness validation Conformance to the requirements of 3.11 shall be validated by test and analysis to verify that the instrument is intrinsically EMP hard or has been hardened.

4 6 5.2 EMP test. Conformance to the requirements of 3 11 shall be verified by the test methods specified in 4.6.5 2.1 through 4 6 5 2.3.2.

4.6 5 2 1 Applicable test frequencies The tests shall be performed for the injection frequencies of 0 0 MHz, 0 1 MHz, 0 5 MHz, 1 MHz, 2 MHz, 5 MHz, 10 MHz, 20 MHz, and 50 MHz and critical frequencies, such as local oscillator, power switching frequencies and harmonics, radio frequencies, clock frequencies, bandpass frequencies, and so forth, as specified in the EMI test plan

TABLE V Performance tests

| Examination or test | Requirement paragraph | First article inspection | Quality conformance inspection | |
|---|---|---|---|---|
| | | | Group A | Group B |
| Warmup | 3.4.1 | X | | |
| Accuracy | 3.4.2 | X | X | |
| Reproducibility | 3.4.3 | X | | X |
| Settability | 3.4.4 | X | | X |
| Long-term stability | 3.4.5 | X | | X |
| Short-term stability | 3.4.6 | X | X | |
| Sinusoidal outputs | | | | |
| Isolation | 3.4.7 | X | X | |
| Amplitude | 3.4.7.1 | X | X | |
| Harmonic distortion | 3.4.7.2 | X | | |
| Nonharmonic output | 3.4.7.3 | X | | |
| SNR | 3.4.7.4 | X | | X |
| Short-circuit protection | 3.4.7.5 | X | | |
| Timing pulse outputs | | | | |
| Isolation | 3.4.8 | X | X | |
| Amplitude | 3.4.8.1 | X | X | |
| Width | 3.4.8.2 | X | X | |
| Rise time | 3.4.8.3 | X | X | |
| Fall time | 3.4.8.4 | X | X | |
| Jitter (1 pps only) | 3.4.8.5 | X | | X |
| Noise immunity | 3.4.8.6 | X | | |
| Short-circuit protection | 3.4.8.7 | X | | |
| Temperature stability | 3.4.8.8 | X | | |
| Pulse advance | 3.4.8.9 | X | | X |
| Synchronization | 3.4.8.10 | X | X | |
| One ppm reset | 3.4.8.11 | X | | X |
| Timing fault output | 3.4.8.12 | X | X | |
| Quartz crystal | 3.4.9 through 3.4.9.8 | X | | X |
| Cesium beam tube | 3.4.10 through 3.4.10.4 | X | | X |
| Manual clock controls | 3.4.12.1 | X | | X |
| Time code | 3.4.12.2 through 3.4.12.2.3 | X | | X |
| Clock indication relative to 1-ppm output pulse | 3.4.12.3 | X | X | |
| Controls and circuits | 3.4.11 through 3.4.11.14.1 | X | | |
| Time scale adjustment | 3.4.12.4 | X | | |
| Battery life test | 3.5.1.3.1 | X | | |
| Automatic switchover | 3.5.1.3.2 | X | | X |
| Power test | 3.5.1.4 | X | | |

4 6 5 2 2 Apparatus Test apparatus shall consist of the equipment specified in a through d

a Source injection pulse generator with the capabilities specified in 1 through 4

1 Damped sinusoidal transient as shown in the applicable limit and as specified by the equations in A and B

A $I_{pin}(t) = 1.05\ I(f)\ e^{-0.2\ ft}\ SIN\ (2\pi\ ft)$

B $V_{pin}(t) = 1.05\ V(f)\ e^{-0.2\ ft}\ SIN\ (2\pi\ ft)$

where

$I_{pin}(t)$ = Pin to case current, in amperes at time, t

$V_{pin}(t)$ = Pin to case voltage, in V at time, t

f = Specific test frequency, in MHz

t = Time in seconds

I(f) = Current determined from applicable limit curve of FIGURE 1

V(f) = Voltage determined from applicable limit curve of FIGURE 1

2 Variable amplitude so the injected transient can be increased from a minimum to a maximum specified level (that is, at least 10 percent, 50 percent, and 100 percent of the amplitude shall be tested at each specified test frequency)

3 Frequency range capable of generating the required test frequencies

4 Current output level of at least 10 amperes into a 100-ohm load

b Current probe

c Oscilloscope with a minimum bandwidth capability of 100 MHz

d Interconnecting test cable

4 6 5 2 3 Test setup and procedure The test setup and procedure shall be as specified in 4 6 5 2 3 1 and 4 6 5 2 3 2. A functional analysis shall be performed before the certification testing to identify the items in a through c

a The interface pin connectors

b The test sample functions which shall be monitored to determine system failure or transient upset

c The additional test frequencies (that is, interface cable resonant frequency, clock frequencies, data rates, and so forth)

4 6 5 2 3 1 Test setup The test setup shall be as shown in FIGURE 2

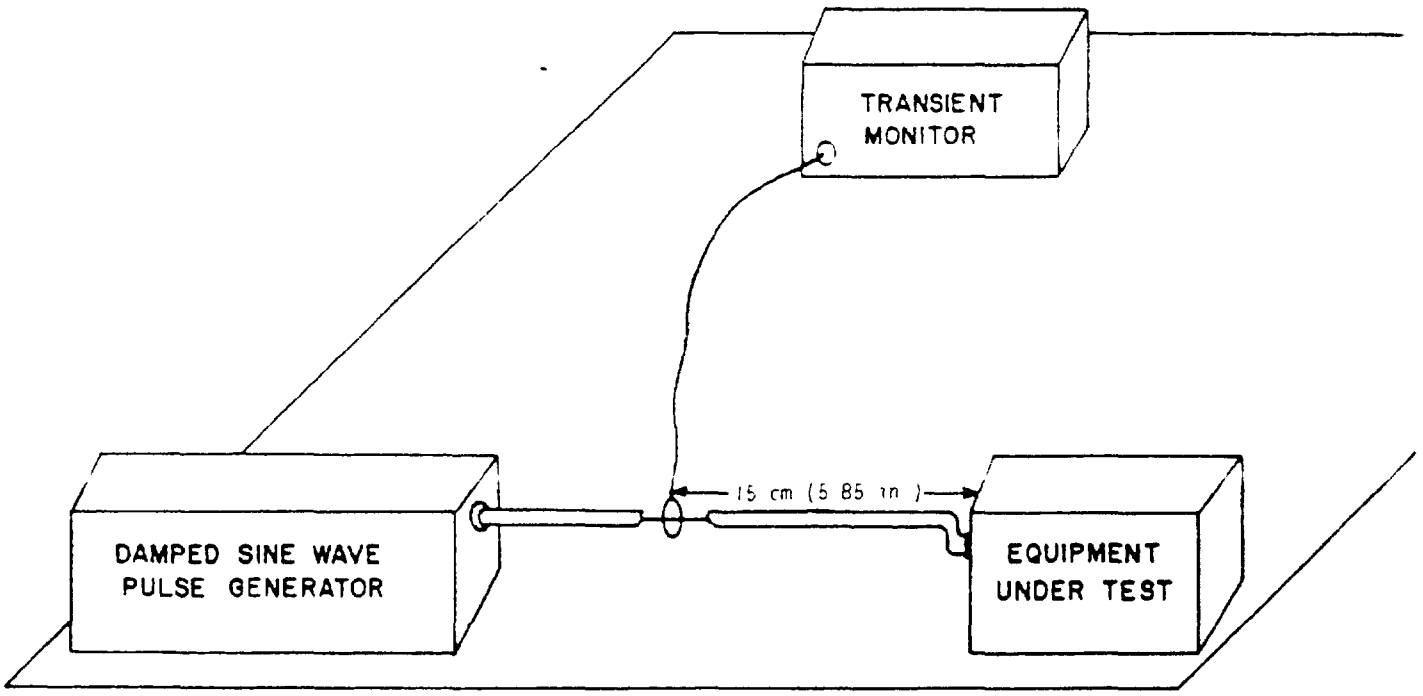



FIGURE 2 EMP test setup

4 6.5 2 3 2 Test procedure. The test procedure shall be as specified in a through g

a Apply the test signal to each interface pin of the test sample, at each test frequency

b Monitor the test sample functions in all modes of operation to determine whether there is a failure or transient upset

c Inject one transient pulse on each interface pin and at each test frequency

d The test sample shall be tested with power off and on

e Determine test frequency and level at which a failure or upset occurs

f The test sample shall be tested on a ground plane There shall be no insulated materials between the test setup and the ground plane

g The test cable running between the test sample and the damped sinusoidal generator shall be kept 4 centimeters (cm) (approximately 1 6 in ) to 6 cm (approximately 2 3 in ) above the ground plane

4 6 6 Leakage current test Leakage current shall be measured on one instrument of the first month's production Thereafter leakage current shall be measured on one instrument per 100 successive instruments produced Leakage current shall be measured at 230 V, 50 Hz

WARNING

THIS TEST MAY BE HAZARDOUS DUE TO THE UNGROUNDED CONDITION OF THE INSTRUMENT DURING THE TEST DO NOT TOUCH EXPOSED METAL SURFACES WITHOUT ADEQUATE ELECTRIC SHOCK PROTECTION

THE UNITED STATES GOVERNMENT NEITHER ASSUMES NOR ACCEPTS RESPONSIBILITY FOR ANY INJURY OR DAMAGE THAT MAY OCCUR DURING OR AS A RESULT OF THIS TEST

4 6 6 1 Instrument test connections After power removal, each instrument directly connected to an external power source and units deriving power from the instrument shall be placed on an insulated surface All safety ground conductors between the instrument and the units deriving power from the instrument shall be intact The safety ground conductor between the instruments under test and the source power shall be opened during the test OBSERVE WARNING STATEMENT The instrument shall be connected as shown in FIGURE 3 for single-phase source power

4 6 6 2 Measurement Leakage current shall be measured on the instrument in its normal operating configuration Instrument controls in each operating mode shall be such that maximum power will be utilized during leakage current measurements The leakage current shall be determined by the voltage-drop method A true rms voltmeter shall be used The voltage measured across the 1500-ohm resistor, when equal to 7 5 V, represents 5 milliamperes of leakage current The overall measurement error shall not exceed 5 percent The probe shall be used on all external conducting parts such as case, connector housings, recessed calibration or adjustment controls, and control shafts with knobs removed The voltage shall be measured from each part to ground for every combination of switch positions available in FIGURE . The oper safety ground conductor shall be reconnected immediately after the test is completed

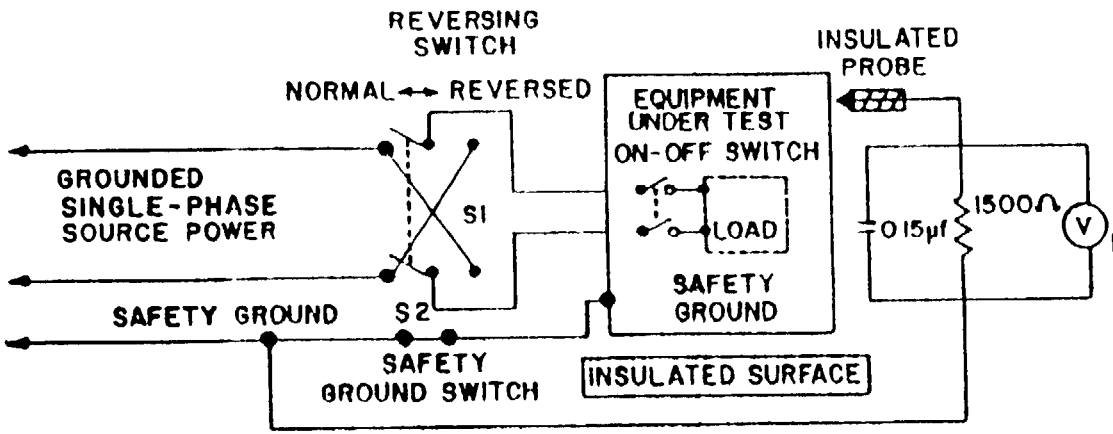
4 7 Reliability verification test A reliability verification test shall be performed on four units as part of the first article inspection The reliability verification test shall be performed in accordance with Test Plan XVIIC of MIL-STD-781

4 7 1 Reliability test conditions and procedures The test conditions and procedures shall be as specified in 4 7 1 1 through 4 7 1 8

4 7 1 1 Burn-in Debugging and burn-in of instruments assemblies, or parts prior to performance of the reliability testing shall be limited to the debugging and burn-in to be performed on all production equipment

4 7 1 2 Preventive maintenance. Except for normal battery replacement in instruments powered by self-contained batteries, no preventive maintenance shall be performed during the reliability tests

4 7.1 3 Temperature cycling During each 48-hour period of reliability testing, there shall be five complete cycles of temperature alternation, with each cycle consisting of approximately equal periods of time at the lower test temperature (-28°C ±2°C) and the upper test temperature (+65°C ±2°C) The rate of change between upper and lower temperatures shall not exceed 25°C per half hour Temperature cycling shall be continued for the duration of the reliability test




GENERAL ORDER OF TEST:

1. Source power OFF. Connect equipment per diagram
2. ON-OFF SW OFF S1 SW normal. S2 SW closed. Connect source power.
3. OBSERVE WARNING S2 SW OPEN. ON-OFF SW ON.
4. For each probe point, record voltmeter reading (CASE, CONNECTORS, CONTROLS, SHAFTS).
5. ON-OFF SW OFF. Repeat Step 4.
6. S1 SW REVERSED ON-OFF SW ON Repeat Step 4.
7. ON-OFF SW OFF. Repeat Step 4.
8. S2 SW CLOSED. S1 SW normal.
9. Repeat Step 3 THRU 8 for each mode of operation
10. Remove source power. Disconnect equipment. Sign record sheet.

**WARNING**

**DO NOT TOUCH EXPOSED METAL SURFACES**

**THIS TEST MAY BE HAZARDOUS DUE TO THE UNGROUNDED CONDITION OF THE EQUIPMENT DURING THE TEST. THE UNITED STATES GOVERNMENT NEITHER ASSUMES NOR ACCEPTS RESPONSIBILITY FOR ANY INJURY OR DAMAGE THAT MAY OCCUR FROM THE USE OF THIS DIAGRAM FOR LEAKAGE CURRENT MEASUREMENT.**

FIGURE 3. Single-phase test diagram for leakage current measurement

4 7 1 4 Humidity The humidity need not be rigorously controlled during the reliability tests, but the test chamber should have a relative humidity of approximately 35 percent at 25°C

4 7 1 5 Vibration Each instrument shall be subjected to continuous sine sweep vibration at an amplitude of 0 508 millimeters (mm) (0 020 in ) (double amplitude (DA)) ±0 102 mm (±0 004 in ) DA The sweep frequency range shall be 4 Hz to 33 Hz to 4 Hz The time to sweep up and down shall be 10 minutes ±2 minutes

4 7 1 6 Instrument ON-OFF cycling All external power shall be turned off and the instrument shall be powered by the internal standby batteries for 30 minutes during the phase of one temperature cycle in each 24-hour period The instrument shall be turned on continuously during the reliability test

4 7 1 7 Operating tests The performance tests of 4 6 2 (see TABLE V) shall be performed during the latter part of one low-temperature alternation and during the latter part of one high-temperature alternation each week During the remainder of the ON time (including the vibration periods), the instrument shall conform to the 5-MHz accuracy requirements and the output amplitudes for the sinusoidal outputs The amplitude of sinusoidal and pulse outputs shall be measured twice daily and the 5-MHz accuracy shall be continuously monitored for the duration of the tests

4 7 1 8 Power input voltage cycling Instruments powered by other than self-contained batteries shall have the input voltage sequentially cycled during each power-on period (see 4 7 1 6) The power input voltage shall be maintained at the nominal voltage specified in 3 5 1 during the first power-on period, at the high voltage during the second power-on period, and at the low voltage during the third power-on period This sequence shall be repeated throughout the reliability test The power supply voltages and frequencies specified in 3 5 1 shall be employed for approximately equal periods during the reliability test

4 7 2 Failure In the event of a failure (see 6 4 3) failure action shall be taken as required by MIL-STD-781 The final decision as to the relevancy or nonrelevancy of a failure shall be made by the procuring activity using the Failure categories paragraph of MIL-STD-781 as a guide

4 7 3 Reject decision If a reliability test results in a reject decision, the requirements of the Reject in reliability qualification phase or the Reject in reliability production acceptance phase paragraphs of MIL-STD-781 shall apply as applicable Any corrective action taken as a result of a reject decision shall be included in all instruments delivered under the contract The contractor shall retrofit all instruments which may have been delivered to the procuring activity prior to approval of the corrective action

4 7 4 Disposition of tested instruments Upon successful completion of reliability testing, tested instruments shall be reconditioned as required and subjected to the production tests of 4 4 to ensure that the instruments conform to the requirements of this specification After successfully passing the production tests the instruments may be delivered as specified in the contract

4 8 Maintainability demonstration Unless otherwise specified (see 6 2), the contractor shall perform a detailed maintainability demonstration in accordance with MIL-STD-471 The maintainability demonstration at the intermediate level shall be performed by technicians with experience equivalent to that of a third class petty officer The demonstration shall include provisions to demonstrate the MTTR for equipment at the intermediate level of maintenance

4 8 1 Maintainability demonstration conditions The maintainability requirements shall be demonstrated by replacement of subassemblies at the intermediate level The contractor shall determine 50 faults for the maintainability demonstration in accordance with Appendix A of MIL-STD-471 The procuring activity, or its author zed representative, shall select a sample of 20 faults to be used in this part of the maintainability demonstration For fault simulation, a number shall be assigned to each component or part within a subassembly Fault simulation for subassemblies shall be accomplished by introduction of faulty parts corresponding to the number selected or by fault simulation

4 8 2 Accept or reject criteria The accept or reject criteria for the demonstration of the MTTR and $M_{maxct}$ for intermediate demonstration shall be as specified in TABLE VI Acceptance shall occur when the number of observed corrective maintenance task times which exceed the required value of each specified index (MTTR, $M_{maxct}$) is less than, or equal to, that shown in TABLE VI corresponding to each index for the specified confidence level The duration of each task shall be compared to the required value(s) and determined as greater than or lesser than each index The actual value shall also be determined An accept decision can only be made when an accept decision is made for both MTTR and $M_{maxct}$

TABLE VI. Acceptance criteria

| | MTTR | $M_{maxct}$ |
|---|---|---|
| Confidence level | 90 percent | 90 percent |
| Acceptance level | 8 | 0 |
| Sample size | 20 | 20 |

4 8 2 1 Rejection If a reject decision is reached, the procuring activity shall be immediately notified

4 9 Workmanship Workmanship shall be as specified in 4 9 1 through 4 9 2 2

4 9 1 General workmanship The instruments, including subassemblies and assemblies, shall be examined for workmanship and soldering during the fabrication and assembly process and at the end item level for conformance to the requirements of 3 16 1 Each solder connection and associated wiring or leads shall be visually examined

4 9 2 Workmanship screen Vibration and temperature cycling shall be performed on each instrument Vibration shall be performed before temperature cycling The vibration may be performed at the module, drawer, or end item level All the hardware, including cables and connectors, shall be exposed to vibration

4 9 2 1 Vibration The vibration shall be random or subject to procuring activity approval pseudo-random or complex waveform vibration, for an accumulated time of 10 minutes in the axis deemed most susceptible to vibration excitation All items shall be hard-mounted (without shock isolators and subjected to the vibration conditions of FIGURE 4 Input vibration levels shall be measured at the mounting points of the item under vibration If variations are found at these points, the level used for control purposes shall be the average of the levels at the mounting points Control equipment having a bandwidth no greater than 10 Hz for vibration frequencies up to 500 Hz and 100 Hz for vibration frequencies above 500 Hz shall be used for the control and analysis of the acceleration spectral density (ASD The instantaneous acceleration peaks may be limited to three times the rms acceleration level The instrument shall be energized during vibration, and appropriate input signals shall be applied to observe any abnormal conditions of the output functional characteristics All failures occurring during screening shall be corrected, and the vibration resumed

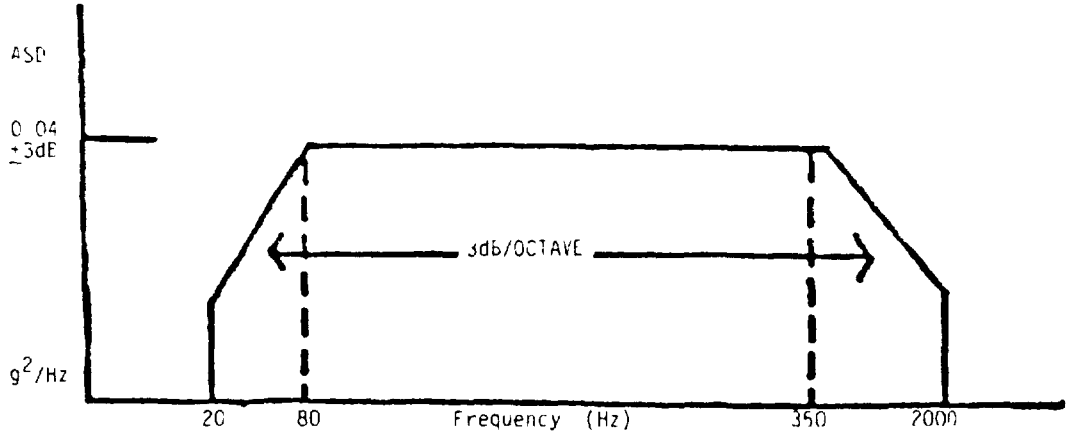



FIGURE 4. Random vibration curve

4.9.2.2 Temperature cycling Each instrument shall be subjected to 10 cycles of the temperature curve shown in FIGURE 5 The temperature rate of change shall be not less than 5°C per minute Instrument power shall be turned on and off at the indicated times The instrument shall be positioned for maximum exposure to the changing temperature Where performance measurements are called for, a minimal functional operating test shall be performed The dwell time shall be maintained until the largest electrical or electronic part in the instrument reaches 80 percent of the chamber temperature When failures occur the instrument shall be reworked, and the cycling continued for a cumulative total of 10 cycles

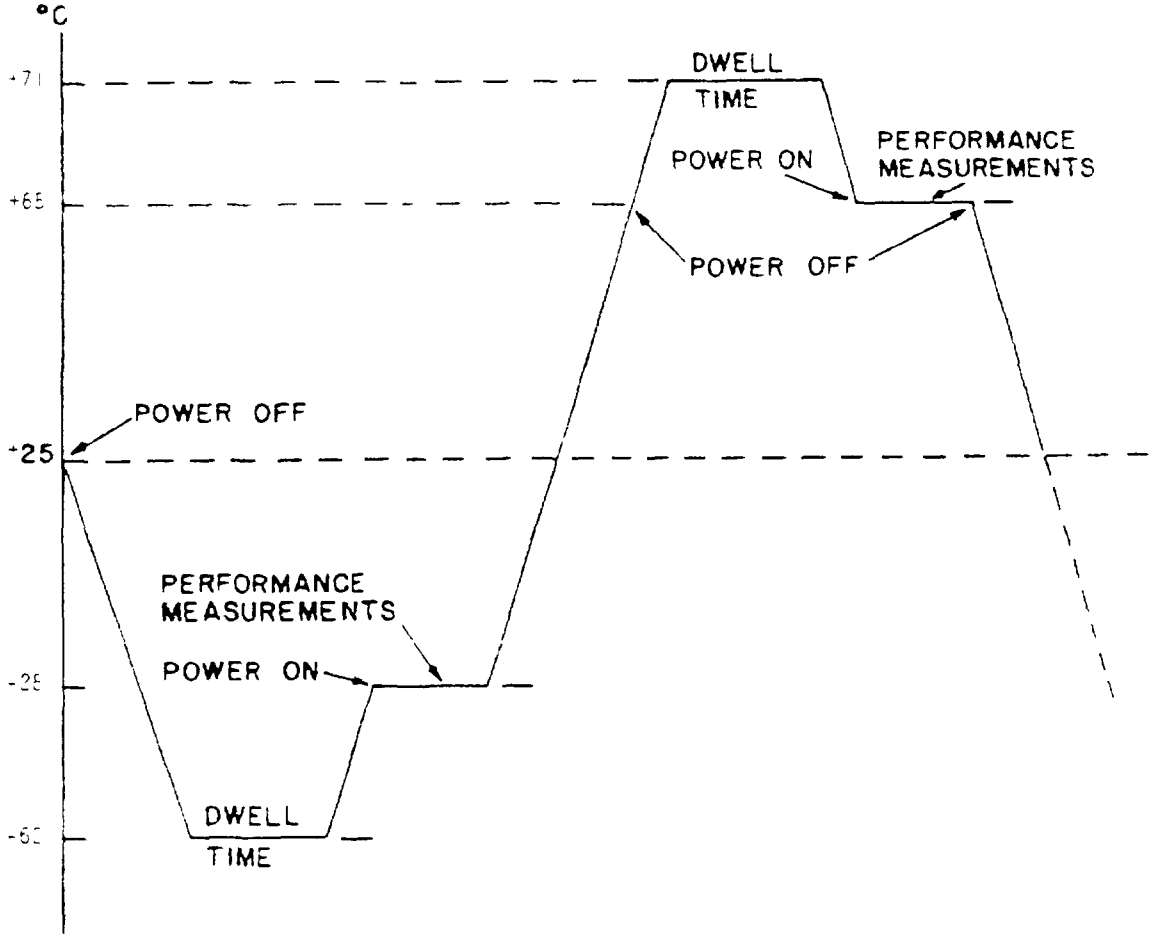



FIGURE 5 One cycle of temperature curve (not to scale)

4.10 Inspection of preparation for delivery Inspection shall be conducted to ensure conformance with the requirements of Section 5

5 PACKAGING

(The preparation for delivery requirements specified herein apply only for direct Government procurements Preparation for delivery requirements of referenced documents listed in Section 2 do not apply unless specifically stated in the contract Preparation for delivery requirements for products procured by contractors shall be specified in the individual order )

5 1 Preservation, packaging, packing, and marking Unless otherwise specified herein, preparation for delivery shall be in accordance with the applicable levels of preservation, packaging, packing, and marking specified in M..-E-.7555 (see 6 2)

6 NOTES

6 1 Intended use The instrument covered by this specification is intended for use on land and sea (surface ships and submarines), mobile platforms, and at fixed shore stations

6 2 Ordering data Procurement documents should specify

a Title, number, and date of this specification
b Internal standby battery to be supplied (see 3 5 1 3)
c Number of first article samples to be submitted if other than specified in 4 3
d Environmental inspection for production quantities less than 100 units (see 4 4 3 1)
e When reinspected conforming environmental sample units may not be accepted (see 4 4 3 3)
f Maintainability demonstration (see 4 8)
g Levels of preservation, packaging, packing, and marking (see 5 1)

6.3 First article Wher a first article is required it should be tested and approved under the appropriate provisions of 52 209-3 of the Federal Acquisition Regulations The first article should be a first production item The first article should consist of two units The contracting officer should include specific instructions in all procurement instruments, regarding arrangements for examinations, tests, and approval of the first article

6 4 Definitions Definitions of terms used in this specification are given in 6 4 1 through 6 4 4

6 4 1 Beam tube line width The width of the central peak of the beam tube resonance (measured halfway between central peak and adjacent minima,

6 4 2 Beam tube signal-to-background ratio The difference between the current at the central peak of the beam tube resonance and the current at an adjacent minimum with unmodulated microwave power applied

6 4 3 Failure Any malfunction or parameter deviation that prevents the instrument from performing within the operational requirements

6 4 4 Special tools Special tools are defined as those tools not listed in the National Supply Catalog (copies of this catalog may be consulted in the office of the Defense Contract Administration Service)

Preparing activity
NAVY-EC

(Project No 6625-N828

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| 1 DOCUMENT NUMBER | 2 DOCUMENT TITLE |
|---|---|
| MIL-F-28811A | |

| 3a. NAME OF SUBMITTING ORGANIZATION | 4 TYPE OF ORGANIZATION *(Mark one)* |
|---|---|
| | ☐ VENDOR |
| b. ADDRESS *(Street, City, State, ZIP Code)* | ☐ USER |
| | ☐ MANUFACTURER |
| | ☐ OTHER *(Specify)* _____ |

5 PROBLEM AREAS

a. Paragraph Number and Wording

b. Recommended Wording

c. Reason/Rationale for Recommendation

6 REMARKS

| 7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional | b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional |
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