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Materiel Test Procedure 5-2-526
White Sands Missile Range

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

MISSILEBORNE OPTICAL RECEIVERS AND TRANSMITTERS

1. OBJECTIVE

The objective of this Materiel Test Procedure (MTP) is to determine the degree to which the test item conforms to the requirements document criteria (1) for receiver spectral response, frequency response, rise and fall time, optical power limits, and field of view; and (2) for transmitter wavelength, mode structure (lasers only), power, stability, modulation, losses, and field of broadcast.

2. BACKGROUND

Current and anticipated optical receivers used in missile systems fall into the category of photo-diodes and associated circuitry; optical transmitters fall into two major categories, coherent and non-coherent.

The simplest non-coherent sources are merely lamps, radiating over a broad area and with relatively broad spectra. The simplest form of a coherent source is a collimated non-coherent source. Lasers, however, are almost ideal coherent sources, and will be treated along with the other coherent and non-coherent sources in this MTP.

Engineering tests of developmental missile optical systems mentioned above are required to give an independent analysis to determine how well these systems meet requirements stated in applicable documents.

3. REQUIRED EQUIPMENT

- a. Vacuum-scanning spectrometer
- b. Assortment of optical filters
- c. Detectors (radiometers)
- d. Precision rotatable mount
- e. Laser Spectrum Analyzer
- f. Oscillograph recorder
- g. Precision rotatable bracket
- h. Cathode Ray Oscilloscope
- i. Appropriate light sources
- j. Magnetic Tape Recorder
- k. Assortment of Oscillators

4. REFERENCES

- A. Tippet, et. al., Optical and Electro-optical Information Processing, MIT Press, 1965.
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- F. Jenkins & White, Fundamentals of Optics, McGraw-Hill, 1957.
- G. Mace, A. E., Sample-Size Determination, Reinhold, N.Y., 1964.
- H. USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.
- I. TB MED 270, Control of Hazards to Health from Microwave Radiation.
- J. TB MED 279, Control of Hazards to Health from Laser Radiation.
- K. MTP 3-1-002, Confidence Intervals and Sample Size.
- L. MTP 6-2-507, Safety.

5. SCOPE

5.1 SUMMARY

The procedures outlined in this MTP describe the tests required to evaluate the performance parameters of missileborne optical receiver and transmitter systems. While it is desirable that these tests be performed on the receiver or transmitter subsystem divorced from the missile itself, such conditions are not completely necessary. Specific subtests include:

a. Receiver Tests

- 1) Spectral Response - The objective of this test is to determine the optical spectrum or wavelength response of the receiver.
- 2) Frequency Response - The objective of this test is to determine frequency response of the receiver.
- 3) Rise and Fall Time - The objective of this test is to determine the response of the receiver to pulsed optical data.
- 4) Optical Power Limits - The objective of this test is to determine at what power level the receiver is saturated and at what power level it fails to receive.
- 5) Field of View - The objective of this test is to determine the field of view of the receiver.

b. Transmitter Tests

- 1) Wavelength(s) - The objective of this test is to determine the operating wavelength(s) of the transmitter.
- 2) Mode Structure - The objective of this test is to determine the mode structure of the transmitter (for Laser sources only).
- 3) Peak Power - The objective of this test is to determine peak power output of pulsed transmitters.
- 4) Average Power - The objective of this test is to determine average power output of pulsed transmitters.
- 5) Steady-state Power - The objective of this test is to determine the power output of continuous sources.
- 6) Stability - The objective of this test is to determine output stability over long periods of time.
- 7) Modulation - The objective of this test is to determine the form, if any, of modulation of the transmitter output.

- 8) Losses - The objective of this test is to determine losses due to reflectors, lenses, and environment.
- 9) Spectrum - The objective of this test is to determine the spectrum of the source.
- 10) Power Distribution - The objective of this test is to determine spectral power distribution of the transmitter.
- 11) Field of Broadcast - The objective of this test is to determine the area and configuration of the broadcast radiation.

5.2 LIMITATIONS

This Materiel Test Procedure is applicable only to devices using visible or near visible radiation (.3 to 1.1 microns). While the tests are necessary also for infra-red or ultra-violet devices, changes in procedure and/or equipment would be required.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Prior to testing, study the test item as required to provide information on background and statistical considerations for use in testing and analysis of test results.

- 1) Review design, operational, and instructional material for the test item.
- 2) Review previous reports of similar test items.
- 3) Prepare a test item sample plan to provide statistical confidence of final data. See MTP 3-1-002 and reference G.
- 4) Prepare record forms for systematic entry of data and chronology of test.
- 5) Review safety SOPs to insure safety of personnel and equipment.
- 6) Review security measures and SOPs to insure safeguarding classified materiel and data.

b. Select test equipment ideally having an accuracy of at least ten orders of magnitude greater than that afforded by the item under test.

c. Insure that test equipment is certified and calibrated according to pertinent Department of the Army Regulations.

d. Instruct test personnel as required to insure that they are familiar with the technical and operational characteristics of the test item.

e. Ascertain the availability of the safety statement for the test item as required per USATECOM Regulation 385-6.

f. Insure that the test item has successfully completed the examination prescribed in MTP 6-2-507.

g. Verify that the test item is in proper operational condition before any measurements are made. Correct discrepancies or misalignments as specified in pertinent operation and maintenance publications before testing.

h. Perform all tests, insofar as practical, in a dust-free laboratory

environment, to prevent dust build-up on optical components or dust interference with accurate data collection.

6.2 TEST CONDUCT

6.2.1 Receiver Subtests

6.2.1.1 Spectral Response

a. Set up the receiver on a fixed mount, with a white light source, also on a fixed mount, directly opposite the receiver, emitting directly into the receiver.

b. Connect an oscilloscope to the receiver.

c. Turn on and warm up the receiver, white light source and oscilloscope.

d. Insert a narrow bandpass optical filter between the source and the receiver.

e. Record the output of the receiver.

f. Repeat steps (d) and (e) above for the entire set of bandpass filters, covering the entire visible spectrum.

6.2.1.2 Frequency Response

a. Set the receiver on a stable fixed mount opposite a frequency variable light source of wavelength or spectrum equivalent to the design requirements of the receiver, with the emission of the source aimed at the receiver.

b. Connect an oscillator of the required frequency band to the source.

c. Connect the outputs of the oscillator and the receiver to an oscillograph or magnetic tape recorder.

d. Vary the frequency of the oscillator between minimum and maximum operating frequencies.

e. Remove the tape or oscillograph record and save for analysis.

6.2.1.3 Rise and Fall Time

a. Set up receiver opposite source or sources of varied rise and fall times.

b. Turn on and warm up receiver and source(s).

c. Monitor receiver output with an oscilloscope.

d. Decrease rise or fall time until receiver fails to detect source signal.

e. Record the minimum values of rise and fall time readable on the oscilloscope.

6.2.1.4 Optical Power Limits

a. Set the receiver on a fixed mount opposite a light source of variable output power at the wavelength (spectrum) designed to be received by the receiver.

b. Turn on and warm up the receiver and source.

c. Monitor the receiver output on an oscilloscope.

d. Starting at a median power level, decrease the power until the receiver output vanishes.

e. Record this figure as the lowest possible power level.

f. Increase the power of the source until the receiver output remains constant.

- g. Record this figure as the highest possible power level.

6.2.1.5 Field of View

- a. Mount the receiver on a precision turnable mount opposite a fixed source operating at the wavelength (spectrum) designed to be acceptable to the receiver.
- b. Connect an oscilloscope to the output of the receiver, for monitoring purposes.
- c. Turn on and warm up the receiver, source, and oscilloscope.
- d. Set the precision mount at zero degrees.
- e. Record the receiver output.
- f. Rotate the mount two degrees clockwise.
- g. Record the receiver output.
- h. Repeat steps (f) and (g) above, until receiver output vanishes.
- i. Repeat step (d) above.
- j. Rotate the mount two degrees counter-clockwise.
- k. Record the receiver output.
- l. Repeat steps (j) and (k) above, until the receiver output vanishes.
- m. Rotate the receiver around its central axis by 90°, until it lies on its side.
- n. Repeat steps (d) through (l) above.

6.2.2 Transmitter Subtests

6.2.2.1 Wavelength(s)

- a. Set up transmitter opposite a vacuum-scanning spectrometer, with transmitter radiation aimed at the input window of the spectrometer.
- b. Turn on and warm up transmitter and spectrometer.
- c. Scan the visible spectrum.
- d. Remove the strip chart record of the spectrometer and save for analysis.

6.2.2.2 Mode Structure

NOTE: This test is applicable to laser devices only.

- a. Set up transmitter opposite a Laser Spectrum Analyser.
- b. Turn on and warm up transmitter and Laser Spectrum Analyser.
- c. Record the general form of the displayed mode structure either in written form or by photographing the display.

6.2.2.3 Peak Power

- a. Set up transmitter opposite a suitable detector (radiometer).
- b. Connect the detector output to an oscillograph.
- c. Turn on and warm up transmitter, detector, and oscillograph.
- d. Transmit output and record it with oscillograph.
- e. Remove oscillograph record and save for analysis.

6.2.2.4 Average Power

- a. Set up transmitter opposite a suitable detector (radiometer).
- b. Turn on and warm up the detector and transmitter.
- c. Record average power reading from detector.

6.2.2.5 Steady-state Power

- a. Set up transmitter opposite a suitable detector (radiometer).
- b. Turn on and warm up transmitter and detector.
- c. Record reading of detector

6.2.2.6 Stability

- a. Set up transmitter opposite a suitable detector (radiometer).
- b. Connect detector output to a recording oscillograph.
- c. Turn on and warm up detector, oscillograph and transmitter.
- d. Record detector output for a pre-selected time interval.
- e. Remove oscillograph record and save for analysis.
- f. Repeat steps (c), (d), and (e) above periodically for a suitable interval.

6.2.2.7 Modulation

- a. Set up transmitter opposite a suitable detector (radiometer).
- b. Connect input of the transmitter's modulator to an oscillograph or magnetic tape recorder.
- c. Turn on and warm up transmitter, detector and recorder.
- d. Record modulation input and detector output on separate channels of the recorder.
- e. Remove record and save for analysis.

6.2.2.8 Losses

a. Non-coherent sources

- 1) Set up transmitter opposite an appropriate detector (radiometer).
- 2) Turn on and warm up transmitter and detector.
- 3) Run power checks described in sections 6.2.2.3 and 6.2.2.4 or 6.2.2.5 of this MTP, as appropriate.
- 4) Introduce lenses, mirrors, etc., used in conjunction with transmitter.
- 5) Repeat step (3) above.

b. Coherent (laser) sources

- 1) Repeat step (a) above.
- 2) Set up transmitter with beam to pass through a sealable tube, windowed at each end, with a suitable detector (radiometer) at the opposite end.
- 3) Run power checks described in sections 6.2.2.3 and 6.2.2.4 or 6.2.2.5 of this MTP, as appropriate.
- 4) Introduce suitable environmental test conditions into the sealed tube, e.g., humidity, pressure, etc.
- 5) Repeat step (3) above.

6.2.2.9 Spectrum

- a. Set up transmitter opposite a vacuum-scanning spectrometer.
- b. Turn on and warm up spectrometer and transmitter
- c. Scan the entire visible spectrum
- d. Remove the spectrometer record and save for analysis

6.2.2.10 Power Distribution

- a. Set up transmitter opposite a suitable detector (radiometer).
- b. Turn on and warm up the detector and transmitter.
- c. Insert lowest frequency bandpass filter (optical).
- d. Perform power checks as described in sections 6.2.2.4 or 6.2.2.5 of this MTP, as appropriate.
- e. Insert next-highest bandpass optical filter
- f. Repeat step (d) above.
- g. Repeat steps (e) and (f) above, until the entire visible spectrum has been checked.

6.2.2.11 Field of Broadcast

- a. Set up transmitter on a precision turnable mount opposite a suitable detector (radiometer).
- b. Align centers of transmitter and detector at zero degrees on the precision rotating mount.
- c. Perform power checks described in sections 6.2.2.4 or 6.2.2.5 of this MTP, as appropriate.
- d. Turn precision mount two degrees clockwise.
- e. Repeat step (c) above.
- f. Repeat steps (d) and (e) above until detector output vanishes.
- g. Repeat step (b) above.
- h. Rotate mount two degrees counter-clockwise.
- i. Perform power checks described in sections 6.2.2.4 or 6.2.2.5 of this MTP, as appropriate.
- j. Repeat step (h) and (i) until detector output vanishes.
- k. Rotate the transmitter within the mount 90°, until it lies in the mount on its side.
- l. Repeat steps (b) through (j) above.

6.3 TEST DATA

An engineering logbook of pertinent remarks and observations, which would aid in analysis of test data, shall be prepared to accompany test data.

6.3.1 Receiver Subtests

6.3.1.1 Spectral Response

Spectral Response data shall consist of power readings as taken from the oscilloscope.

6.3.1.2 Frequency Response

Frequency Response test data, to be preserved for analysis, shall consist of oscillograph or magnetic tape records.

6.3.1.3 Rise and Fall Time

Data for Rise and Fall Time tests shall consist of hand recorded values as found by section 6.2.1.3 of this MTP.

6.3.1.4 Optical Power Limits

Optical power limit data shall consist of hand recorded power readings.

6.3.1.5 Field of View

Field of View test data, to be preserved for analysis, shall consist of hand recorded power readings.

6.3.2 Transmitter Subtests

6.3.2.1 Wavelength(s)

Wavelength test data, to be preserved for analysis, shall consist of paper records from the spectrometer's strip-chart recorder.

6.3.2.2 Mode Structure

Mode structure test data, to be preserved for analysis, shall consist of hand recorded descriptions of waveforms, or oscilloscope photographs.

6.3.2.3 Peak Power

Peak Power test data, to be preserved for analysis, shall consist of oscillograph records.

6.3.2.4 Average Power

Average Power test data, to be preserved for analysis, shall consist of hand recorded power readings.

6.3.2.5 Steady-state Power

Steady-state Power test data, to be preserved for evaluation, shall consist of hand recorded power readings.

6.3.2.6 Stability

Stability test data, to be preserved for analysis, shall consist of oscillograph records.

6.3.2.7 Modulation

Modulation test data, to be preserved for analysis, shall consist of oscillograph or magnetic tape records.

6.3.2.8 Losses

Losses test data, to be preserved for analysis, shall consist of hand recorded power readings and oscillograph records.

6.3.2.9 Spectrum

Spectral test data, to be preserved for analysis, shall consist of spectrometer strip chart records.

6.3.2.10 Power Distribution

Power Distribution test data, to be preserved for analysis shall consist of hand recorded power readings, and oscillograph records.

6.3.2.11 Field of Broadcast

Field of Broadcast test data, to be preserved for analysis, shall consist of hand recorded power readings and/or oscillograph records.

6.4 DATA REDUCTION AND PRESENTATION

a. Processing of raw test data will, in general, consist of the following:

- 1) Converting units of measured parameters to units of measure as expressed in applicable test criteria.
- 2) Constructing suitable graphical presentations.
- 3) Determining test item performance relative to test criteria.

b. Test data shall be properly marked and grouped according to subtest title. Specific instructions for the reduction and presentation of individual subtest data are outlined in the following paragraphs.

6.4.1 Receiver Subtests

6.4.1.1 Spectral Response

Spectral Response test data shall be presented in graphical form, with power output plotted versus optical frequency.

6.4.1.2 Frequency Response

Frequency Response test data shall be presented graphically with frequency plotted versus $20 \log$ (input voltage of source/output voltage of receiver).

6.4.1.3 Rise and Fall Time

Rise and Fall Time data as obtained in paragraph 6.2.1.3 of this MTP shall be used as a comparison against test criteria.

6.4.1.4 Optical Power Limits

Optical Power Limits test data as obtained in paragraph 6.2.1.4 of this MTP shall be used as a comparison against test criteria.

6.4.1.5 Field of View

Field of View test data shall be plotted as two graphs, one for the vertical plane, another for the horizontal. The angle of rotation (plus for clockwise, minus for counter-clockwise) shall be plotted versus the power output of the receiver.

6.4.2 Transmitter Subtests

6.4.2.1 Wavelength(s)

Wavelength test data shall be presented graphically, with wavelength being plotted versus relative magnitude of power.

6.4.2.2 Mode Structure

Mode Structure test data shall be presented as a picture of waveform or thorough description of waveform for comparison to standard mode waveforms.

6.4.2.3 Peak Power

Peak Power test data shall be determined by averaging peak power figures taken from the oscillograph record, and compared to test criteria.

6.4.2.4 Average Power

Average Power test data shall be obtained as specified in paragraph 6.2.2.4 of this MTP, and compared to test criteria.

6.4.2.5 Steady-state Power

Steady-state power test data shall be obtained as specified in paragraph 6.2.2.5 of this MTP, and compared to test criteria.

6.4.2.6 Stability

Stability test data shall be presented graphically with time, as a varying scale, plotted versus output power, as found from the oscillograph records; stability data shall then be compared to test criteria.

6.4.2.7 Modulation

If in paper record form, Modulation test data on the two channels

shall be reviewed for loss of data and errors, and the data loss and error rates compared to test criteria. If in magnetic tape form, Modulation test data shall be compared by use of an appropriate digital computer system programmed to determine data loss and error rates to be compared with test criteria.

6.4.2.8 Losses

Losses test data shall be determined by calculating the percentage of power lost and comparing these percentages to the test criteria.

6.4.2.9 Spectrum

Spectral test data shall be presented in graphical form, plotting wavelength versus relative power, for comparison with test criteria.

6.4.2.10 Power Distribution

Power Distribution test data shall be presented in graphical form with power plotted versus wavelength for comparison with test criteria.

6.4.2.11 Field of Broadcast

Broadcast Field test data shall be presented as two graphs, one in the horizontal plane, the other in the vertical plane. Angle of rotation shall be plotted (plus for clockwise, minus for counter-clockwise) versus power level for comparison with test criteria.

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1 NOV 65

(PAGE 1)

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1 NOV 63

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