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An American National Standard

Standard Test Method for Minimum Resolvable Temperature Difference for Thermal Imaging Systems[1]

This standard is issued under the fixed designation E 1213; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the minimum resolvable temperature difference (MRTD) capability of the compound observer-thermal imaging system as a function of spatial frequency.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 1316 Terminology for Nondestructive Examinations [2]

3. Terminology

3.1 *Definitions:*

3.1.1 *differential blackbody*—an apparatus for establishing two parallel isothermal planar zones of different temperatures, and with effective emissivities of 1.0.

3.1.2 See also Terminology E 1316.

4. Summary of Test Method

4.1 A standard four-bar target is used in conjunction with a differential blackbody that can establish one blackbody isothermal temperature for the set of bars and another blackbody isothermal temperature for the set of conjugate bars, which are formed by the regions between the bars (see Fig. 1). The target is imaged onto the monochrome video monitor of a thermal imaging system where the image is viewed by an observer. The temperature difference between the bars and their conjugates, initially zero, is increased incrementally only until the observer can distinguish the four bars. This critical temperature difference is the MRTD.

4.2 The spatial distribution of temperature of each target must be measured remotely at the critical temperature difference that determines the MRTD. The mean temperature of each bar must not differ from that of any other bar by more than the measured MRTD. A similar requirement applies to the temperature of each conjugate bar. Otherwise the MRTD value is unacceptable.

4.3 The background temperature and the spatial frequency of each target must be specified together with the measured value of MRTD.

4.4 The probability of resolution must be specified together with the reported value of MRTD.

5. Significance and Use

5.1 This test relates to a thermal imaging system's effectiveness for discerning details in a scene.

5.2 MRTD values provide estimates of resolution capability and may be used to compare one system with another. (Lower MRTD values indicate better resolution.)

NOTE 1—Test values obtained under idealized laboratory conditions may or may not correlate directly with service performance.

6. Apparatus

6.1 The apparatus consists of the following:

6.1.1 *Test Charts (Targets)*, comprised of four periodic bars of aspect ratio (width:height) 1:7, as shown in Fig. 1.

6.1.2 *Differential Blackbody*, temporally stable and controllable to within 0.1°C.

6.1.3 *Infrared Spot Radiometer*, calibrated with the aid of a blackbody source to an accuracy within 0.1°C.

NOTE 2—Test charts may be fabricated by cutting slots in metal and coating with black paint of emissivity greater than 0.95. In this case the slots would constitute the bars.

7. Procedure

7.1 Mount a test chart (target) onto the differential blackbody.

NOTE 3—Differential blackbodies may be used within an environmental isothermal temperature chamber. Then, at equilibrium the temperature of the conjugates approximately equals the temperature of the room, or ambient temperature.

7.2 Optimally focus the thermal imaging system directly on the target or on an optical projection of the target.

7.3 Adjust the thermal imaging system for quasi-linear operation.

7.4 Adjust the monochrome video monitor controls so that

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[2] *Annual Book of ASTM Standards*, Vol 03.03.

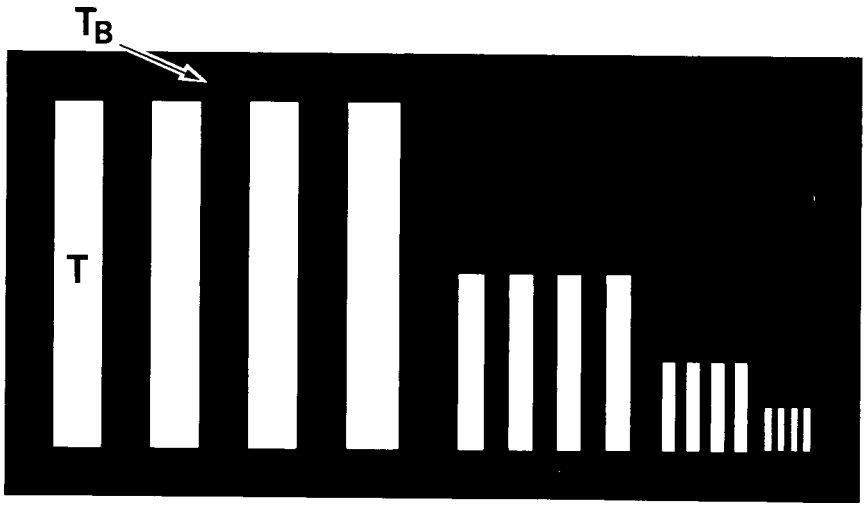

FIG. 1 Targets Used for MRTD Determinations

the presence of noise is barely perceivable by the observer.

7.5 Make the display luminance and the laboratory ambient luminance mutually suitable for visual acuity and viewing comfort.

7.6 Instruct the observer to signal when he can perceive the appearance of four distinct bars on the monitor. Refrain from further conversation during the test which could conceivably influence or bias the observer.

7.7 Record the distances that determine spatial frequency (see 8.1), and set the nominal ΔT (the nominal temperature of the bars minus the nominal temperature of the conjugate bars, zero or a positive number) equal to zero.

7.8 Gradually increase the nominal ΔT in increments not exceeding 0.1°C until the observer signals.

7.9 Measure the spatial distribution of temperature of the targets with an infrared spot radiometer of accuracy better than 0.1°C. Each bar and each conjugate must be measured in at least three locations that include the ends and centerpoint. If additional locations are measured, all must be at regular intervals. The field of view must be confined to the bar or conjugate being measured.

7.10 Calculate the mean temperature of each bar and intercompare the values, and calculate the mean temperature of each conjugate bar and intercompare the values.

7.11 Calculate the actual ΔT (the average temperature of the bars minus the average temperature of the conjugate bars). Provisionally, this is the MRTD.

7.12 Compare the largest difference in the mean temperatures of any two bars, or any two conjugate bars, with the MRTD. If this difference exceeds the MRTD, the test results are unacceptable for this particular spatial frequency.

7.13 Replace the test chart with another of different spatial frequency and repeat the test (7.2-7.12).

7.14 Repeat 7.13 one or more times.

7.15 Repeat the entire test (7.1-7.14) with a different observer.

7.16 Repeat 7.15 one or more times.

NOTE 4—Observers must be free of eye disease, have good eyesight, and be familiar with viewing thermal imagery.

NOTE 5—Only one observer at a time shall be present during the testing.

8. Calculation

8.1 Calculate the spatial frequency, F, of the test charts as follows:

$$F = \frac{10^{-3} D}{s} \left[\frac{\text{cycles}}{\text{mrad}} \right] \quad (1)$$

where:

F = spatial frequency,
D = distance from target to thermal imaging system, m,
s = center line to center line separation of bars, m, and D >> s.

8.2 Calculate the probability of resolution as shown by the following illustration: For a given test chart, the MRTD results obtained with three different observers are 0.5°C, 0.6°C, and 1.0°C. The observer who resolved 0.5°C would also be capable of resolving 0.6°C and 1.0°C; similarly the observer who resolved 0.6°C would also be capable of resolving 1.0°C. Therefore, the respective probabilities of resolution are: for 0.5°C, ⅓ = 33 %; for 0.6°C, ⅔ = 67 %; for 1.0°C, ⅗ = 100 %.

9. Report

9.1 Report the following information:

9.1.1 Spatial frequency,

9.1.2 MRTD,

9.1.3 Probability of resolution, and

9.1.4 Background temperature.

9.2 MRTD values must relate to a probability of resolution of at least 50 %.

9.3 Only a single probability of resolution must be used throughout.

NOTE 6—A graph of MRTD versus spatial frequency is a convenient form of reporting the data.

10. Precision and Bias

10.1 Insufficient data are available on which to base a precision and bias statement. Notwithstanding, owing to the

partially subjective nature of the test, repeatability and reproducibility are apt to be poor and MRTD differences less than 0.2°C are considered to be insignificant.

11. Keywords

11.1 infrared imaging systems; minimum resolvable temperature difference; nondestructive testing; thermal imaging systems; thermography; infrared