Designation: F1405 – 08 (Reapproved 2013)

Standard Test Method for Determining the Dynamic Thermal Response of Direct Thermal Imaging Products—Atlantek Method[1]

This standard is issued under the fixed designation F1405; 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 measurement of thermal response of various direct thermal imaging papers or other thermal-coated substrates used for facsimile, labels, medical recorders, plotters, and printers.

1.2 The Atlantek Thermal Response Tester Model 200 described in this test method may be used for specification acceptance, product development, and research applications.

1.3 The values stated in inch-pound units are to be regarded as standard; values specific to the Atlantek Thermal Response Tester Model 200 are in SI units.

1.4 *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.* For specific precautionary statements, see Section 8.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D685 Practice for Conditioning Paper and Paper Products for Testing

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

F1623 Terminology Relating to Thermal Imaging Products

2.2 *ANSI Standards:*[3]

PH 2.17 Density Measurements—Geometric Conditions for Reflection Density

PH 2.18 Density Measurements—Spectral Conditions

2.3 *Operators Manual:*

Atlantek Operators Manual for Model 200 Thermal Response Test System[4]

3. Terminology

3.1 *Symbols:*

3.1.1 T_{cycle}—the time between printed lines. The larger the T_{cycle} value, the more time between printed lines. The result is slower print speeds. Smaller T_{cycle} values correspond to faster print speeds. Time between printed lines equals dot "on" time plus dot "off" time ($T_{cycle} = T_{on} + T_{off}$).

3.1.2 T_{on}—the amount of time that the heating elements (dots) on the printhead are energized. Typically, this value is in milliseconds. T_{on} is also called strobe time.

4. Summary of Test Method

4.1 This test method involves imaging direct thermal product using an Atlantek Model 200 Thermal Response Test System. The system is designed to provide thermal response measurements using printheads commonly used in facsimile units, label printers, medical recorders, plotters, and other printers. This system is based on a special purpose controller board which drives a standard thermal printhead and a programmable stepping drive controller. This system includes provisions for mounting standard performance printheads. A personal computer controls the system with parameter programming accomplished from menu-driven software designed specifically for thermal response and performance characterizations.

4.2 To determine thermal response, thermal product in roll or sheet form is fed into the printer. From the Main Menu, the test system is configured to the Test Mode. Again from the Main Menu, Execute a Test is chosen. A standard existing test file can then be loaded and the New Test can be given a file name or default standard test conditions can be used. The test thermal product (media) is identified, printhead voltage set, and the test executed. Densitometer measurements can then be entered into the test file (manually or automatically). Data in

[1] This test method is under the jurisdiction of ASTM Committee F05 on Business Imaging Products and is the direct responsibility of Subcommittee F05.06 on Carbonless and Thermal Imaging Products.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from Printrex, 276 East Gish Rd., San Jose, CA 95112, http://www.printrex.com/.

the test file created can then be used to graphically display the thermal response of the test thermal product.

5. Significance and Use

5.1 The Atlantek test system allows simulation of direct thermal printers in the marketplace. Thus, this system is useful in matching direct thermal product performance to various printer configurations.

5.2 This test system is useful for new product development. Direct thermal printer manufacturers can design print control algorithms to match particular thermal imaging products. Thermal imaging product manufacturers can formulate and design products (media) to provide a match with certain printer designs.

5.3 Manufacturing process control can make thermal response comparisons relative to process changes.

5.4 Customers for thermal products can use this test method to compare supplies from various manufacturers.

5.5 The test system can be used to evaluate thermal response of facsimile, label, medical recorder, plotter, and other direct thermal products (media).

5.6 Performance differences between printheads and media combinations can be measured and presented graphically.

6. Interferences

6.1 Testing under controlled environmental conditions is recommended. Wide variations in temperature and relative humidity can effect image density measurements.

6.2 Printhead loading and alignment is important to achieve reliable and reproducible results.

6.3 When testing new and experimental coatings, the printhead must be visually inspected for any residue or buildup and cleaned if required. Residue may prevent intimate printhead contact with the thermal imaging surface, resulting in lower image density and may cause printhead damage.

6.4 Thermal products are sensitive to prolonged exposure to light and should be protected from exposure prior to testing.

7. Apparatus

7.1 *Atlantek Thermal Response Test System,* Model 200.[4]

7.2 *IBM PC/AT,* or true compatible with the following configuration: 512K RAM minimum, 12 mhz clock, 20 megabyte hard disk, 1.2 M floppy disk, standard keyboard, monochrome or color system, parallel port (two required for plotting option) and serial port (two required for automatic densitometer readings).

7.3 *Densitometer,* Macbeth Model RD-914 (spectral response: black and white, visual) or equivalent. A serial interface is required for entering density measurements automatically to the test data file.

7.4 *Software,* Tech*Graph*Pad or equivalent (optional for plotting graphs).

7.5 *Plotter,* HP Colorpro with Centronics parallel printer or equivalent to prepare graphs.

8. Hazards

8.1 *Printhead Voltage*—Keep applied voltage at or below that specified for each printhead to avoid printhead damage. Before powering up the system and applying power, the voltage adjustment knob on the front panel should be turned fully counter-clockwise. This ensures that applied voltage will be below the maximum value recommended for the printhead.

8.2 The T_{cycle} value must be at least four times the T_{on} value when in full-width printing mode or two times the T_{on} value in reduced-width mode. The operating system software checks for this value.

8.3 Maximum T_{on} varies with printhead resistance. See the table from the Atlantek Operators Manual for supplied printhead to ensure that the maximum value is not exceeded.

8.4 Prior to running a nonstandard test, consult documentation for each printhead with regard to maximum recommended T_{on}, energy, and printhead voltages.

8.5 *Changing Printheads—Never* attempt printhead replacement with the power on. The printhead should first be electrically disconnected from the printer by removing the printhead interface and printhead power connectors on the left side panel of the mechanism.

8.6 *Computer Connections*—Do not make or break any connections while the computer is powered up.

9. Test Specimen

9.1 The test specimen (media) shall be sheets or a roll of thermal product which has not been adulterated since it was manufactured.

9.2 Test specimens in sheet form should be cut into individual strips 8½ in. wide with a recommended length of 13 in. (minimum length is 11 in.).

9.2.1 If test specimens are less than 8½ in. in width with a minimum width of 4 in., they can be tested by enabling Reduced Width and Narrow Header. To initiate this change from the Test Menu, strike F8, Configure Output Image.

10. Calibration and Standardization

10.1 *Densitometer*—Calibrate the densitometer in accordance with the manufacturer's recommendations.

10.2 *Printhead Dot Line Alignment*—Adjust the printhead dot line alignment over the platen roller and set in accordance with the manufacturer's recommendations.

10.3 *Printhead Pressure*—Measure the printhead pressure with a force gage and set in the range from 7 to 8.5 lb (see Note 1). The pressure measurement is not precise. If the pressure is in this range, do not adjust.

11. Conditioning

11.1 Although no special conditioning of thermal product samples is required, it would be prudent to compare only tests run under the same environmental and aging conditions (see Method D685).

NOTE 1—Since the nominal printhead width is 8.5 in., the pressure should be 0.8 to 1.0 lb/linear in.

12. Establishment of Test Parameters

12.1 *ROHM KF2008-B1 and Kyocera KST-216-8MPD1 Thermal Printheads*—See the table from the Atlantek Operators Manual for recommended nominal printhead voltages for various resistances of the supplied printheads. Set T_{cycle} and T_{on} as specified for each printhead and set printhead temperature at 27.5°C (Head Heating–On).

NOTE 2—There is no provision for printhead cooling.

13. Procedure

13.1 With the computer powered up and the printer switched on, the Entry Screen will appear on the monitor. Select Thermal Response Test and strike the Enter key.

NOTE 3—Before striking the Enter key again, insert a formatted, high-density diskette into Drive A. This diskette is required for test and data storage.

13.2 The next screen message is to switch on the thermal response test system before striking the Enter key. Striking any other key will return the program to DOS.

13.3 Upon striking the Enter key, the computer will check for the presence of a formatted diskette in Drive A and present the Main System Menu. The monitor screen will appear as shown in Fig. 1.

13.4 *Configure Test System*—Choose Configure Test System by striking the F8 key. The screen will appear as shown in Fig. 2. From this menu, select Option F1, Enable Test System. Strike the F1 key and the screen will return to the Main System Menu.

13.5 *Test Specimen Loading*—The software test program refers to the thermal product test specimen as media.

13.5.1 *Roll Form*—See Fig. 3 for a side view of the test apparatus. Support the media roll on the spindle and thread the media under the metal bar (C) and between the printhead assembly and platen roller. The thermal imaging surface must be facing up. When roll media threading is complete, align the media under the printhead. Next, rotate the cam lever down to place the printhead in contact with the media imaging surface.

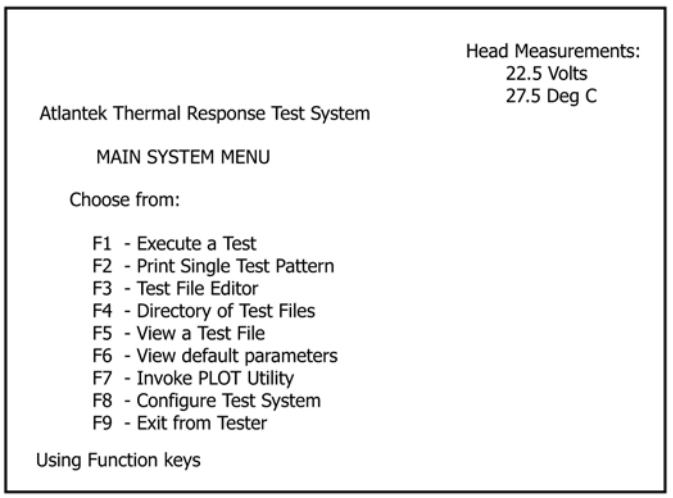

FIG. 1 Main System Menu

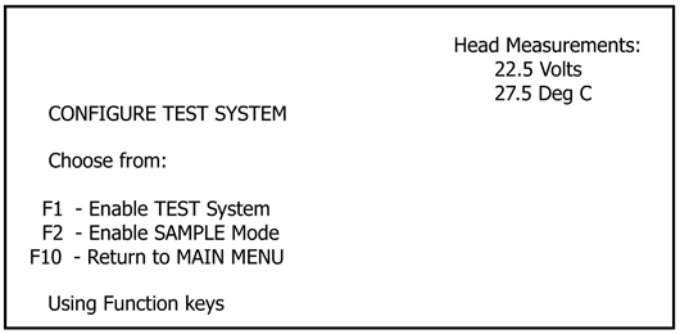

FIG. 2 Configure Test System

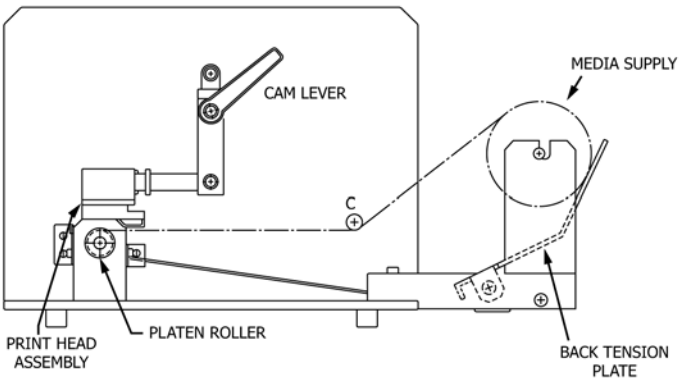

FIG. 3 Atlantek Model 200 (Side View) Test Specimen (Media) Loading—Roll Form

13.5.2 *Sheet Form*—Loading the media is similar to the procedure described in 13.5.1. Again the thermal imaging surface must be facing up and a little more care is needed to properly align the media between the printhead assembly and platen roller. When sheet threading is complete, rotate the cam lever down to place the printhead in contact with the media imaging surface.

13.6 *Execute a Test*—Choose Execute a Test by striking the F1 key. The following prompt will appear:

You may now load an existing file or define a new file by typing in a File Name of up to 8 alphanumeric characters:

13.6.1 Name a new test file and enter test parameters established in Section 12 or recall an existing test file with established test parameters.

13.6.2 If the file name is not found on the diskette, the screen will go directly to the Test Menu which will display the standard default settings for the installed printhead.

13.6.3 If the file name is found on the diskette, the following screen prompt will appear:

The parameters have been loaded from the existing file, please type the name of the file into which you wish to save this test (up to 8 alphanumeric characters):
Type New File Name: _____

Upon entering the new file name, the Test Menu will appear on the screen.

13.7 *Test Menu*—Screen appears as shown in Fig. 4.

13.7.1 *Test Parameters*—A wide variety of test parameters are available with this test unit. For example, test parameters might be selected as given in Table 1.

13.7.2 *Changing and Defining Test Parameters*—If the test parameters as defined in the Test Menu are correct, proceed to 13.7.3.

13.7.2.1 *Pattern Type*—Choose the pattern type option by striking the F2 key and the following prompt will appear:

Do you wish to change Test Pattern type? (Y/N): _____

If Yes, the menu appears as shown in Fig. 5. Choose the checkerboard pattern by striking the F1 key and the new menu will appear as shown in Fig. 6. Choose 10 % pattern by striking the F1 key and the screen will return to the Test Menu.

13.7.2.2 *Dot Pulse Duration (T_{on})*—Choose the dot pulse duration (T_{on}) option by striking the F3 key. The following prompt will appear:

Do you wish to sequence this parameter? (Y/N): _____

Select Yes and the following prompt appears:

You have chosen to sequence the Dot Pulse Duration
Please type the maximum value of this parameter in milliseconds (0.01 to 2.0):? _____

Enter the desired value and the following message appears:

This parameter will be sequenced from 10 % value to 100 % (100 % representing the value just typed in) in steps of 10 %. This will appear as a single 8 by 11 sheet with 10 fields of output appearing as horizontal stripes for each value in the sequence and with increasing values appearing along the paper direction.

Strike any key to continue ....

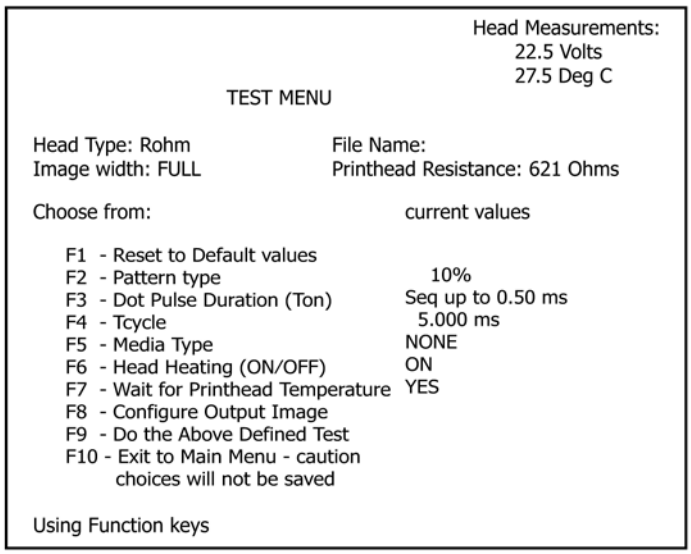

FIG. 4 Test Menu

TABLE 1 Example Test Parameters

Parameters	ROHM KF2008-B1	Kyocera KST-216-8MPD1
Pattern type:	10 %	
Dot pulse duration (T_{on})	Sequence up to 0.50 or 1.00 ms	
T_{cycle}	5.000 ms	
Head heating (on/off)	On	
Waiting for printhead temperature	Yes	
Printhead voltage	See 12.1	

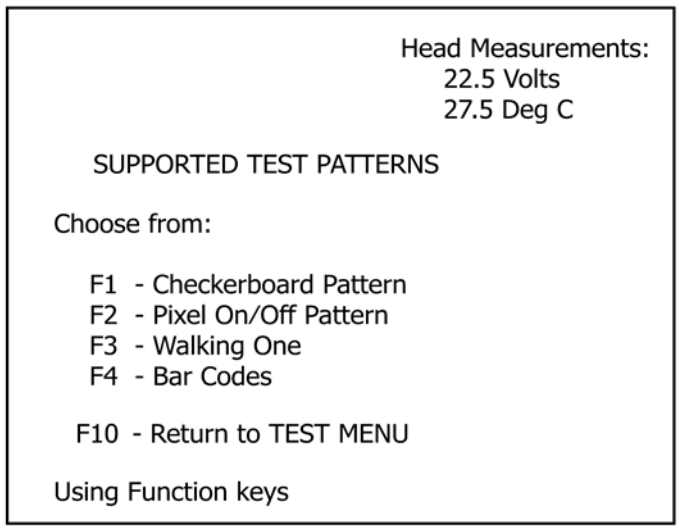

FIG. 5 Pattern Type

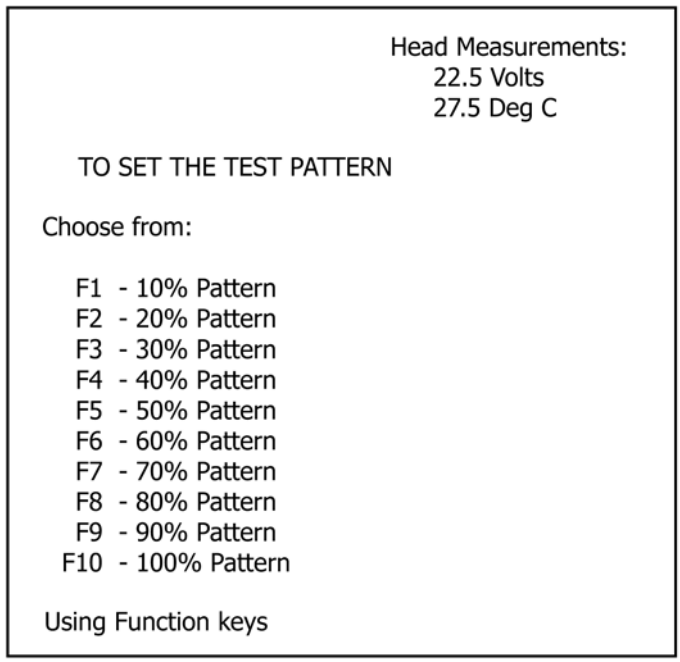

FIG. 6 Setting the Test Pattern

Striking any key returns the screen to the Test Menu.

13.7.2.3 T_{cycle}—Choose the T_{cycle} option by striking the F4 key and the following prompt appears:

Do you wish to sequence this parameter? (Y/N): _____
Select No and the screen appears as shown in Fig. 7. Choose the desired option and the screen returns to the Test Menu.

13.7.2.4 *Printhead Temperature*—A printhead set temperature above that of room temperature should be established to control this variable. The Head Heating and Waiting for Printhead Temperature options should be toggled On (F6 and F7 keys, respectively).

13.7.3 *Printhead Voltage*—Check head measurement value and adjust printhead voltage to desired value.

NOTE 4—If the adjusted value is greater than 10 % above the nominal voltage, the operating system issues a warning.

13.7.4 *Do the Above Defined Test*—If the test parameters as defined in the Test Menu are correct, strike the F5 key to enter Media Type (identification of thermal test product) and then choose the Do the Above Defined Test option by striking the F9 key.

13.7.4.1 *Choose Pattern Size*—Upon striking the F9 key, the screen will appear as shown in Fig. 8. Select F4 to generate 80 by 80 dot blocks for densitometer measurements. Upon striking F4, the printer will start or the screen message will indicate the following:

Waiting for temperature ....

NOTE 5—The printhead described in this test method has 8 dots/mm.

13.7.4.2 *Enter File Comments*—As soon as the printer starts operating, the screen will change, allowing the operator to enter comments into the test file (See Fig. 9).

13.7.4.3 A test printout example is shown in Fig. 10.

13.7.5 *Input Densitometer Readings*—After entering comments, the operator will be queried regarding densitometer readings with the screen shown in Fig. 11.

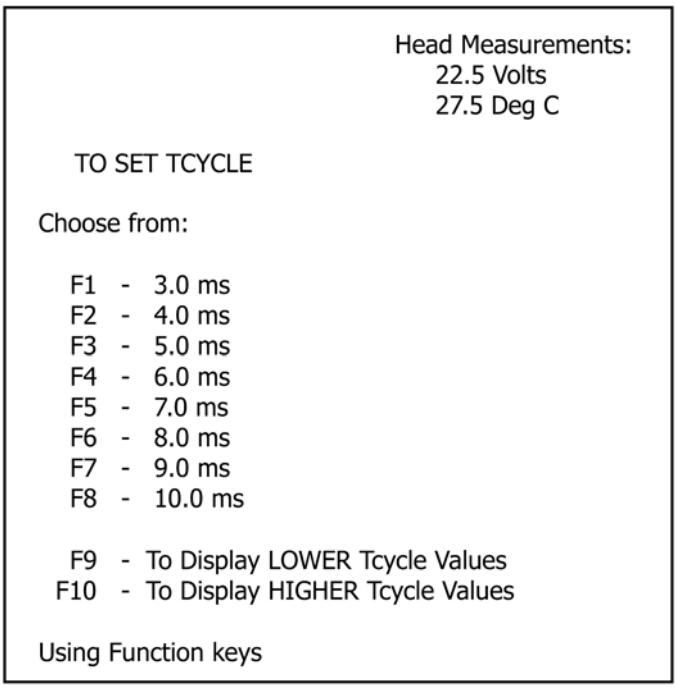

FIG. 7 T_{cycle} Option

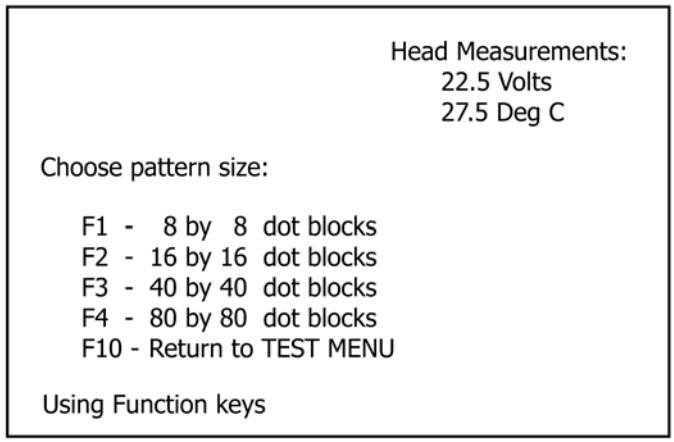

FIG. 8 Pattern Size

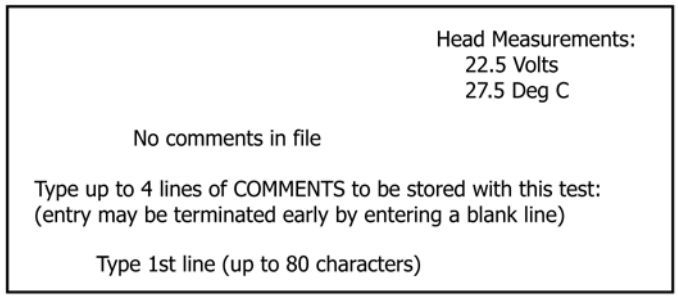

FIG. 9 File Comments

13.7.5.1 *F1*—Choosing F1 will enter the readings at a later date, and will return the program to the Main System Menu.

13.7.5.2 *F2*—Choosing F2 will add the following message to the screen:

You may enter up to 10 densitometer readings
Terminate by entering no reading:
press any key when ready

13.7.5.3 *F3*—Choosing F3 will add the following message to the screen:

You may enter up to 10 densitometer readings
press any key when ready

13.7.6 *Densitometer Entries*—If F2 or F3 were selected in 13.7.4, the screen given in Fig. 12 will next appear after any key is pressed.

13.7.7 *Plot Variable Entry*—After selecting the number of densitometer entries, the operator will be asked to select the plot variable entry (*x*-axis) by the screen shown in Fig. 13.

13.7.7.1 If F1 is chosen the screen message will change to:

Transmit Densitometer reading 1a
Press any key to Exit

13.7.7.2 *Plot Type for T_{on} Sequences*—If F2 is chosen, the screen will appear as shown in Fig. 14. If F1 is chosen, go to 13.7.7. If F2 is chosen, the program will prompt the operator to

Test: TON SEQUENCE
Pattern: 10 %
Head Voltage = 22.5
File: ASTM3
Width:FULL

Head Type: Rohm2
Ton: Seq up tc 0.50 ms
Head Temp = 27.5 Deg. C
Date: 04-23-1991
Head Res.= 621 Ohms

P/H Set Temperature: 27.5
Tcycle = 5.000 ms
Media Type: SAMPLE 1
Time: 11:20:14

1 2 3 4 5 6 7 8 9

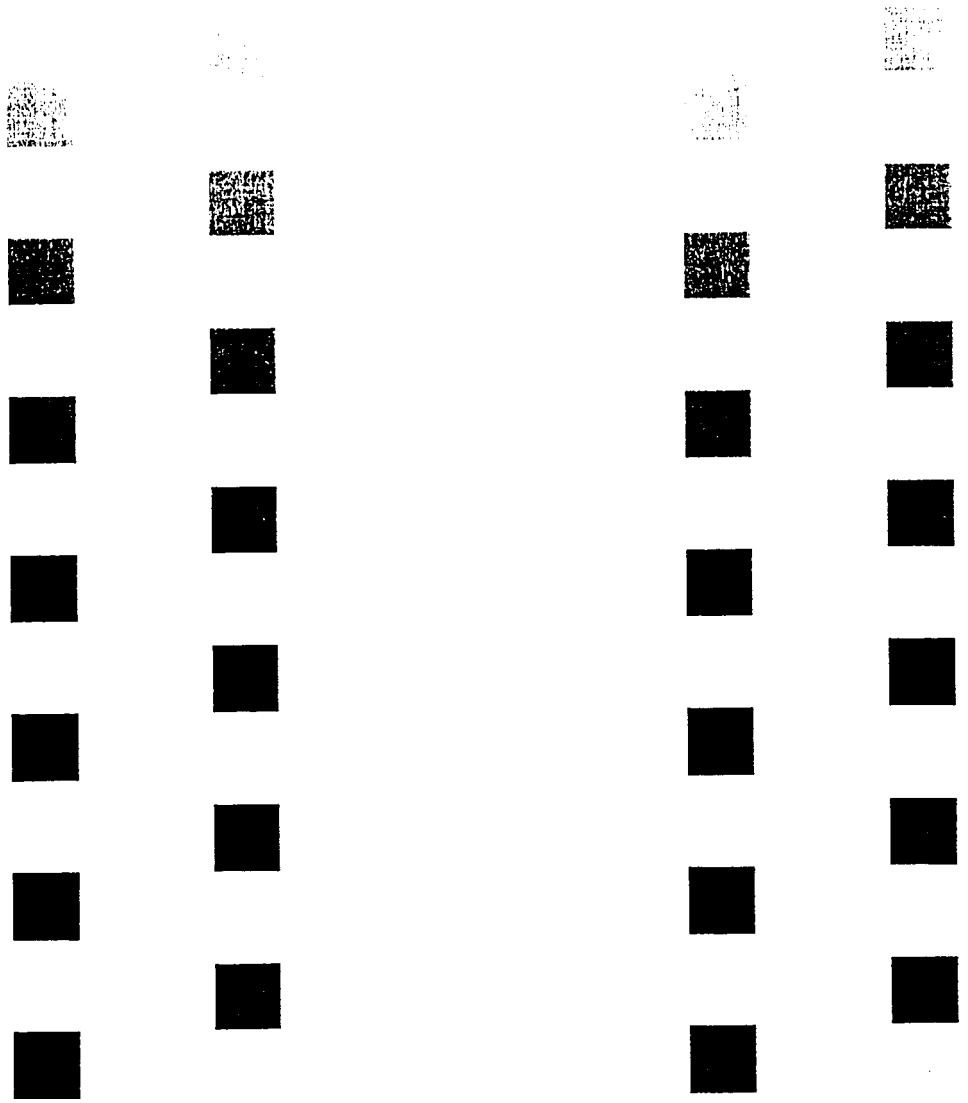

FIG. 10 Test Printout Example

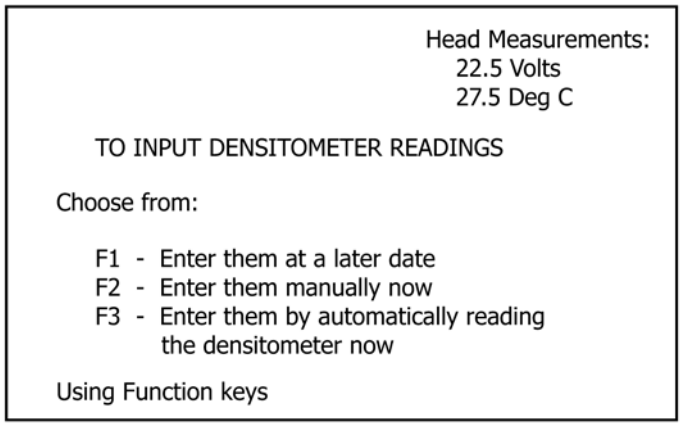

FIG. 11 Input Densitometer Readings

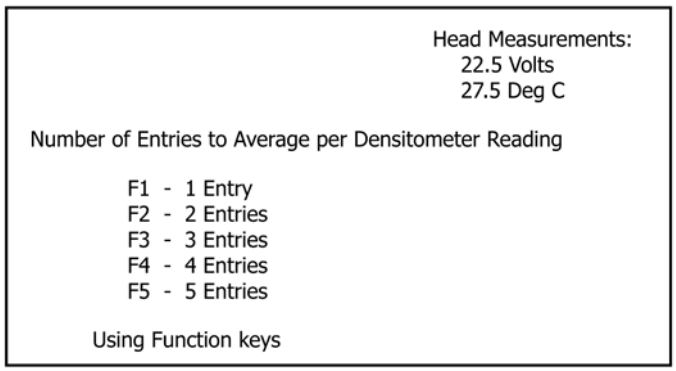

FIG. 12 Densitometer Entries

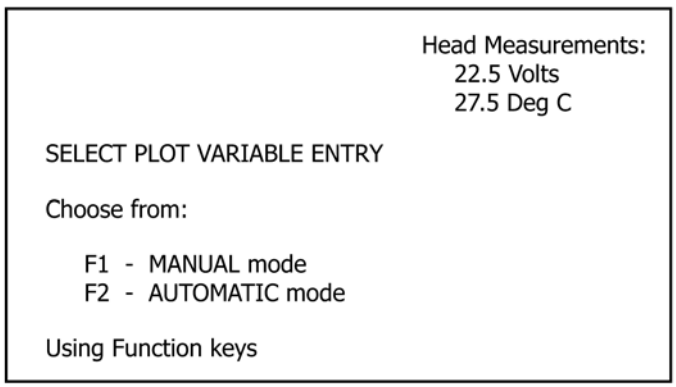

FIG. 13 Plot Variable Entry

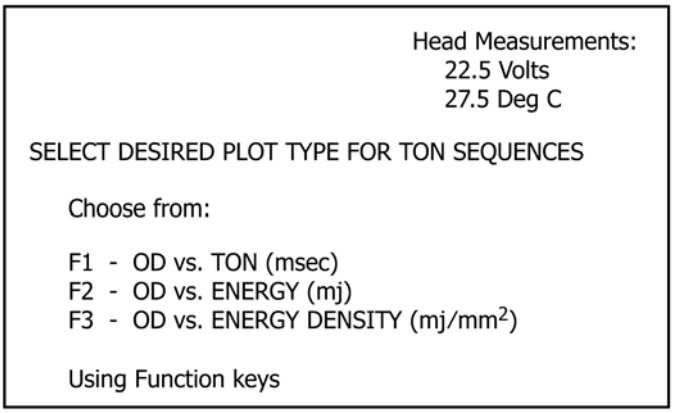

FIG. 14 Plot Type for T_{on} Sequences

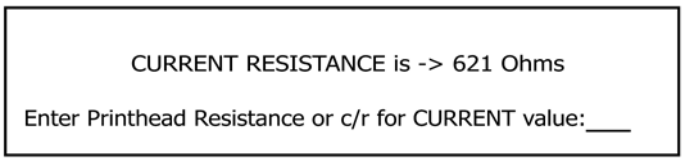

FIG. 15 Current Resistance

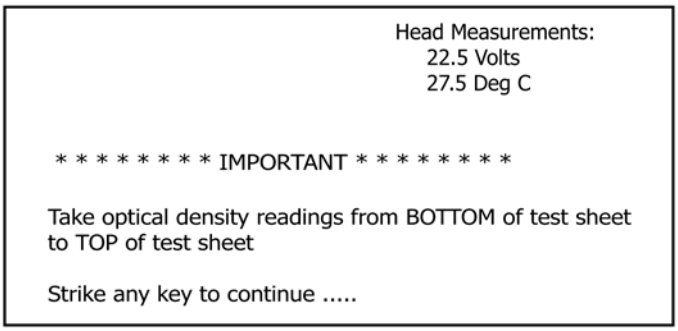

FIG. 16 Density Measurements

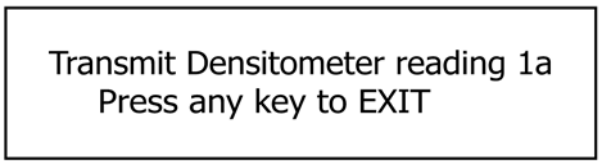

FIG. 17 Exiting the Program

confirm the printhead resistance (ohms) value to make the energy calculations. The prompt will appear as shown in Fig. 15.

13.7.8 *Density Measurements*—The last screen prompt before asking for densitometer measurements is shown in Fig. 16. Striking any key will then initiate the prompt for densitometer readings shown in Fig. 17. After all the densitometer readings have been entered and the test is complete, pressing any key will save the data files to the "A:" disk drive, Exit the program, and return to the Main System Menu.

14. Interpretation of Results

14.1 *Data Plot*—The data plot will be in the form of the "S" curve shown in Fig. 18.

14.1.1 The bottom portion of the plot (A in Fig. 18) shows background measurement if the densitometer readings were taken to the extreme lowest energy levels where no visible image was formed. Generally, whiter surfaces have lower background readings.

14.1.2 The top portion of the plot (C in Fig. 18) indicates the maximum image density capability of the thermal product.

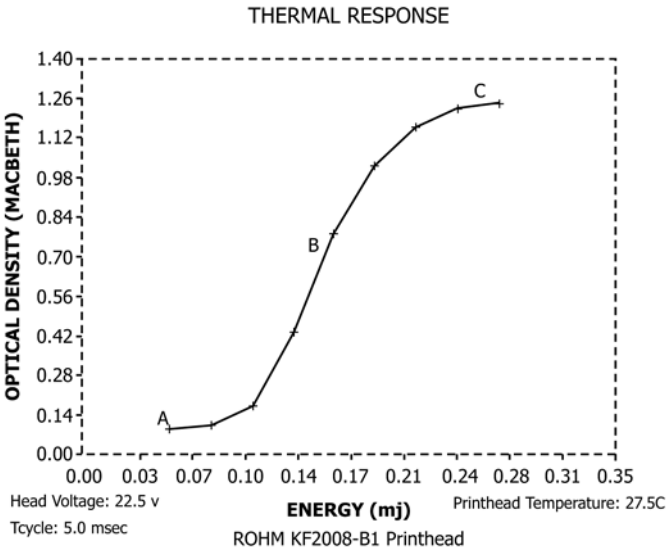

FIG. 18 Thermal Response

14.1.3 The steep sloped portion of the plot (B in Fig. 18) indicates how quickly the thermal image develops density at a given energy level.

14.2 When comparing more than one thermal product, the more thermally responsive product will be the "S" plot furthest to the left. Fig. 19 shows three sample test plots. Sample 1 is more thermally responsive than Samples 2 and 3. Sample 3 is the least thermally responsive.

14.3 If Sample 1 (Fig. 19) yields an image density of 1.0 in a certain facsimile printer, Samples 2 and 3 will yield lower and lowest respective image densities.

14.4 Visual observation of the test image plots may reveal causes of lower thermal response.

14.4.1 If the image areas show voids and nonuniform image fill, the thermal imaging surface has not fully contacted the printhead elements. This is generally due to the thermal imaging surface not being sufficiently smooth and level to match the particular printhead characteristics. In actual thermal printing, the image print quality will be negatively affected by this condition.

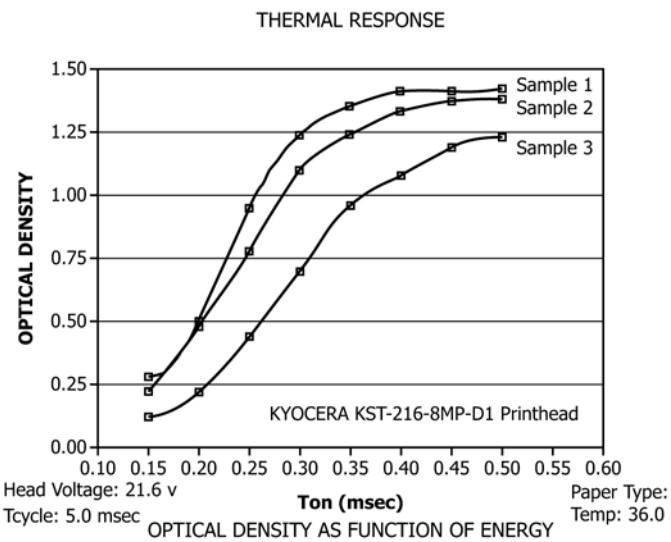

FIG. 19 Thermal Response Comparison

14.5 *Visual Ranking*—The imaged test samples can be ranked from lowest to highest thermal response.

14.5.1 Highest thermal response products will show greater image density at the lowest printhead energy levels.

14.5.2 In addition to thermal response, maximum image density comparisons can be made by comparing images printed at the highest printhead energy level.

15. Report

15.1 *Data Plot*—To analyze results and make comparisons, prepare an *x-y* plot. Optical density is on the *y*-axis and printhead energy in terms of millijoules (mJ) or pulse width (T_{on}) is on the *x*-axis.

15.1.1 *Plot Utility*—If the program package includes Tech*Graph*Pad or similar software, invoke the program and prepare the data plot. An example is shown in Fig. 18.

15.1.2 *Manual Plot*—To prepare the plot manually, press F5 to View a Test File Plot and retrieve the test file data. Prepare the data plot and connect the data point to define the relationship.

15.2 *Visual Ranking*—If a densitometer is not available, it is possible to make visual comparisons and rank the test samples in order of lowest to highest thermal response.

16. Precision and Bias[5]

16.1 *Precision*—An interlaboratory study of this test method was conducted in 1992 by operators in six laboratories with three different thermal facsimile products. Since each laboratory utilized different densitometers, part of the study involved measurement of pre-imaged samples to correlate the densitometers. Sample A was known to have the highest thermal response while Samples B and C (different thermal chemistries) were expected to yield similar thermal response. A reproducible ranking order was repeatable between the laboratories. All of the laboratories found the highest thermal response sample to have the highest densities in the printhead energy range used to generate thermal images. All of the laboratories found the other two samples to be similar and generally ranked them the same. For samples with average density values ranging from 1.0 to 1.4, the within-laboratory standard deviation varied between 0.036 and 0.009; the between laboratories standard deviation varied between 0.126 and 0.061. With densitometers correlated, the within-laboratory standard deviation varied between 0.026 and 0.008; the between laboratory standard deviation varied between 0.057 and 0.016. The design of the experiment and summary of the analysis of the data employing Practice E691 are given in ASTM Research Report RR:F05-1006. Based on statistical analysis of the results, the following criteria should be used for judging the acceptability of results at the 95 % confidence level:

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: F05-1006.

16.1.1 *Repeatability*—Given an average of three test runs with the Atlantek Model 200 operated at the same test conditions by the same operator with an average of four optical density measurements per energy level. Optical density measurements should be suspect if they differ by the amount shown as follows:

Optical Density	Maximum Variation
1.30 to 1.39	±0.03
1.20 to 1.29	±0.04
1.10 to 1.19	±0.05
1.00 to 1.09	±0.06

16.1.2 *Reproducibility*— Given an average of three test runs with the Atlantek Model 200 operated at the same test conditions by the same operator in different laboratories with an average of four optical density measurements per energy level. Optical density measurements should be suspect if they differ by the percent relative amount shown as follows:

Optical Density	Maximum Variation	Densitometers Correlated Maximum Variation
1.30 to 1.39	±0.17	±0.04
1.20 to 1.29	±0.19	±0.06
1.10 to 1.19	±0.25	±0.11
1.00 to 1.09	±0.30	±0.18

16.2 *Bias*—Bias cannot be determined, as there are no standard materials.

17. Keywords

17.1 direct thermal; dynamic thermal response; thermal imaging

APPENDIX

(Nonmandatory Information)

X1. PRINTHEAD ALIGNMENT ADJUSTMENT

X1.1 To verify the alignment of the printhead dot line along the platen roll, press the test button on the front panel of the test unit. A consistent, uniform image density should be observed across the width of the sample media. To correct for nonuniformity, mechanical adjustment of the printhead is required.

X1.2 Adjustment Procedure

X1.2.1 To correct printhead dot alignment across the platen roll, the thumbwheel located at the rear of the printhead mounting is used. This adjustment moves the entire printhead forward or backward with respect to the platen roll.

X1.2.2 To correct for nonuniform image density across the platen where the center may have greater density than the edges, the platen roll may require alignment with the printhead. Loosen the platen yoke locking nuts and move that end of the platen forward or backward until uniform image density is achieved.

X1.2.3 The entire trial and error adjustment process is complete when visual observations indicate image uniformity has been optimized. Once adjustments are complete, the thumbwheel or nuts, or both, should be secured.