National Fire Protection Association

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M E M O R A N D U M

TO: NFPA Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment

FROM: David Trebisacci, Staff Liaison

DATE: November 4, 2011

SUBJECT: NFPA 1801 ROC **TCC** Letter Ballot (A2012)

In accordance with the NFPA Regulations Governing Committee Projects, attached is the Letter Ballot on the Report on Comments (ROC) for the 2013 Edition of NFPA 1801. Also attached is a copy of the Comments.

Please note the ballot has two parts:

Part 1 is a Letter Ballot on the Technical Correlating Committee Amendments to the ROC (TCC Notes), and not on the Comments themselves. Reasons must accompany "Negative" and "Abstaining" votes.

Part 2 is an Informational Letter Ballot Authorizing the Release of the ROC.

Negative votes are limited to subjects within the purview of the TCC. Opposition on a strictly technical basis is not sufficient grounds for substantiating a negative vote. If you have correlation issues please identify and describe your concerns in the area of the ballot form for identification of correlation issues.

Please complete and return your ballot as soon as possible but no later than **November 18, 2011**. As noted on the ballot form, please return the ballot to Yvonne Smith via e-mail to ysmith@nfpa.org or via fax to 617-984-7056. You may also mail your ballot to the attention of Yvonne Smith at NFPA, 1 Batterymarch Park, Quincy, MA 02169.

The return of ballots is required by the Regulations Governing Committee Projects. As usual, nonvoting members (for example, the nonvoting technical committee chairs) need not return ballots.

Attachments: Ballot Form
NFPA 1801 Comments

1801-1 Log #CC4 FAE-ELS Final Action: Accept
(Chapter 2 and Chapter 8)

Submitter: Technical Committee on Electronic Safety Equipment,
Comment on Proposal No: 1801-2
Recommendation:

****Insert Include 1801_LCC4_R Here****

Substantiation: In the revision of this document significant changes have been made to chapter 8. These changes are related to proposal CP 1.
As of the ROC meeting for NFPA 1801, one independent testing lab and three thermal imaging manufacturers have the capabilities to perform all of the testing required for a compliant product. Within the Thermal Imaging Task Group, six thermal imaging manufacturers, two thermal imaging core manufacturers, one independent testing laboratory, and one certification organization have actively participated in the development of the testing and pass/fail criteria presented to the Technical Committee on Electronic Safety Equipment.
The technical committee is in agreement that these changes are necessary, represent the intent of the committee and have been approved (via the NFPA process) by the committee.
Substantiations by paragraph:
2.3.4 Committee Comment 4 has a basis in NIST note 1630, so the technical committee is including it as a referenced document in Chapter 2.
8.1 The non-uniformity test was determined to be impractical and not a significant contributor to overall image quality. With the deletion of the NU test, only spatial resolution testing remains. The new Spatial Resolution test description will result in a better test to determine image quality and will greatly simplify the testing process.
8.6.3.5 As in the spatial resolution test, manufacturers should be permitted to refocus the cameras for optimal performance in this test. Most cameras are not in perfect focus at 1 meter and, if not refocused, will be unnecessarily handicapped in this test. Due to the size of the spatial resolution target, it is not practical to move the camera further away from the target.
8.6.5.8 The original intent of section 8.6 was to simulate a brief but extreme heat exposure to be sure that the TIC does no harm to the user (melt, drip, ignite) and that it is capable of displaying a usable thermal image. The 60 minute cool-down period followed by the very complex Image Recognition test does not require a usable image immediately after the exposure. Viewing the spatial recognition target immediately after the heat exposure to ensure that there is a usable image is a much more practical test and better meets the original spirit of the requirement.
8.6.5.9 Paragraph 8.6.5.9 is no longer needed with the re-write of paragraph 8.6.5.8. The original intent of section 8.6 was to simulate a brief but extreme heat exposure to be sure that the TIC does no harm to the user (melt, drip, ignite) and that it is capable of displaying a usable thermal image. The 60 minute cool-down period followed by the very complex Image Recognition test does not require a usable image immediately after the exposure. Viewing the spatial recognition target immediately after the heat exposure to ensure that there is a usable image is a much more practical test and better meets the original spirit of the requirement.
8.6.6.1 The original intent of section 8.6 was to simulate a brief but extreme heat exposure to be sure that the TIC does no harm to the user (melt, drip, ignite) and that it is capable of displaying a usable thermal image. The 60 minute cool-down period followed by the very complex Image Recognition test does not require a usable image immediately after the exposure. Viewing the spatial recognition target immediately after the heat exposure to ensure that there is a usable image is a much more practical test and better meets the original spirit of the requirement.
8.7.4.3 The technical committee decided to attach a tolerance to this requirement.

8.7.4.5 The technical committee decided to attach a tolerance to this requirement.
8.7.5.1 through 8.7.5.3 The technical committee believes these requirements are no longer best practices.
8.8.4.2 The technical committee decided to attach a tolerance to this requirement.
8.10 Image color testing was removed from section 8.10. The rest of section 8.10 was rewritten to simplify the effective temperature test to produce more repeatable and reproducible results. Removing color measurement requirements and placing them in the design requirements section allowed for more repeatable and reproducible test results.
8.12 The thermal sensitivity testing was revised to produce more repeatable and reproducible results.

Committee Meeting Action: Accept
Number Eligible to Vote: 22
Ballot Results: Affirmative: 19
Ballot Not Returned: 3 Morris, J., Roche, K., Townsend, S.

1801-2 Log #CC1 FAE-ELS Final Action: Accept
(Table 4.3.9, 4.3.11)

Submitter: Technical Committee on Electronic Safety Equipment,
Comment on Proposal No: 1801-2
Recommendation: Delete Table 4.3.9, and replace with updated table.

****Insert Table 4.3.9 Here****

Revise text to read as follows:
4.3.11 The certification organization shall not allow any modifications, pretreatment, conditioning, or other such special processes of the product or any product component prior to the product's submission for evaluation and testing by the certification organization. Manufacturers shall be permitted to refocus camera samples prior to conducting testing.
Substantiation: Providing an updated Table 4.3.9 makes this table consistent with Chapter 8.
Substantiation for 4.3.11 - Thermal imaging cameras are focused for optimal performance at a distance other than what is the distance required by NFPA 1801 and testing laboratory space/test equipment limitations; it is desirable to allow manufacturers the ability to refocus thermal imaging cameras prior to conducting the necessary testing within NFPA 1801.
Committee Meeting Action: Accept
Number Eligible to Vote: 22
Ballot Results: Affirmative: 19
Ballot Not Returned: 3 Morris, J., Roche, K., Townsend, S.

Revise text to read as follows:

2.3.4 Other Publications

NIST Technical Note 1630, Evaluation of Image Quality of Thermal Imagers Used by the Fire Service, National Institute of Standards and Technology, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, February 2009.

Delete Section 8.1, and replace with the following text:

8.1 Image Recognition Test.

8.1.1 Application. This test method shall apply to all thermal imagers.

8.1.2 Samples. Samples shall be complete thermal imagers.

8.1.3 Specimens.

8.1.3.1 Specimens for testing shall be complete thermal imagers.

8.1.3.2 A minimum of three specimens shall be tested.

8.1.3.3 Specimens shall be conditioned at a temperature of 22°C, ±3°C (72°F, ±5°F), and a relative humidity of 50 percent, ±25 percent, for at least 4 hours.

8.1.3.4 Specimens shall be tested within 5 minutes after removal from conditioning.

8.1.3.5 Specimens are permitted to be optimally focused to 1 meter by the manufacturer for this test.

8.1.4 Apparatus.

8.1.4.1 Testing shall be conducted in a room having an ambient temperature of 22°C, ±1°C (72°F, ±2°F).

8.1.4.2 The image recognition test apparatus shall consist of the following:

(1) A thermal imager positioning device

(2) A spatial resolution source target as specified in 8.1.4.3

(3) Ten thermocouples or equivalent temperature measurement devices as specified in 8.1.4.4

(4) Data acquisition software and hardware as specified in 8.1.4.5

(5) A visible spectrum camera and lens as specified in 8.1.4.7

(6) A visible spectrum camera mount as specified in 8.1.4.8

(7) Image capturing software and hardware as specified in 8.1.4.9

(8) A computer and image analysis software as specified in 8.1.4.10

(9) The computer image conversion software shall be ViewNX, version 2.

8.1.4.2.1 The thermal imager shall be set up at a distance of 1 m +/- 5mm from the outer-most optical element to the image recognition target.

8.1.4.2.2 The ambient lighting in the testing room shall be 1 lux or less.

8.1.4.2.3 The test operator shall have vision corrected to at least 20/20.

8.1.4.3 The spatial resolution source target shall consist of two thin, rigid, flat metal surfaces: the emitting surface and the stencil with the target and 15cm +/- 5mm x 15cm +/- 5mm square cutout. The metal shall be copper for the emitting surface and aluminum for the stencil as detailed in Figure 8.1.4.3. Each surface shall have dimensions of 3 mm, ±0.5mm. The front side of both surfaces shall be painted with flat black paint having a stated emissivity of 0.95, ±0.03.

8.1.4.3.1 The emitting surface shall be capable of being evenly heated to a surface temperature of 28°C +/- 0.5°C (82°F +/- 1°F). The mechanism by which the emitting surface is heated shall not be visible to the thermal imager under test. The heating mechanism shall be permitted to add thickness to the side of the surface that does not face the thermal imager during the test.

8.1.4.3.2 The stencil shall be maintained at ambient temperature and shall have a pattern cut cleanly through it as shown in black in Figure 8.1.4.3.

****Insert Figure 8.1.4.3 Spatial Resolution Source Target *****

8.1.4.3.3 Both surfaces shall be mounted such that their painted sides face the thermal imager under test, with the stencil placed directly between the emitting surface and the thermal imager at a distance of 102 mm, ±6mm (4 in., ±¼ in.), from the emitting surface.

8.1.4.4 Ten temperature measurement devices having a temperature measurement accuracy of at least 0.1°C and a response time of less than 1 second shall be secured to the surfaces of the source target facing the thermal imager under test as shown in Figure 8.1.4.3.

8.1.4.4.1 Five temperature measurement devices shall be secured to the emitting surface, and five temperature measurement devices shall be secured to the stencil. The temperature measurement devices and leads secured to the emitting surface shall not be visible to the thermal imager under test.

8.1.4.4.2 The temperature measurement device leads secured to the stencil surface shall be painted with flat black paint having a stated emissivity of 0.95, ±0.03, and shall not cross any of the open areas of the pattern cut into the stencil.

8.1.4.5 The data acquisition system, consisting of software and hardware, shall be capable of acquiring temperature measuring signals collected from the source target.

8.1.4.5.1 The data acquisition system shall average temperature measurements over a maximum of 10 seconds for each temperature measuring device.

8.1.4.5.2 The data acquisition system shall store the averaged temperature measurements in an electronic text file.

8.1.4.6 The thermal imager positioning device shall position the thermal imager facing the spatial resolution source target at a distance of 1 m +/- 5mm (40 in +/-0.2 in) from the outer-most optical element to the stencil.

8.1.4.6.1 The thermal imager shall not wobble, vibrate, or otherwise move out of position during the course of the test.

8.1.4.7 The visible spectrum camera shall be a Nikon D3 or D3S (which will be referred to as D3 in the following sections). The lens shall be a Nikkor 60 mm, f/2.8 macro lens. Other lenses of equivalent quality shall be permitted to be used in cases where the thermal imager display size or configuration is incompatible with the use of the Nikkor 60 mm, f/2.8.

8.1.4.7.1 The shutter shall be activated by a remote trigger release.

8.1.4.7.2 The Nikon D3 shall be calibrated for color and luminance every 12 months.

8.1.4.7.3 All Nikon D3 settings, other than those specified below, shall remain set at the factory default selections. The specific modifications to the Nikon D3 settings shall be as follows:

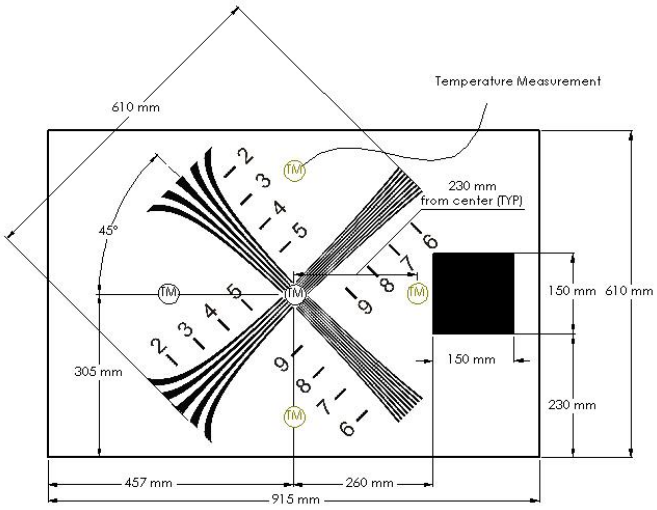
Exterior (Buttons and switches) Settings

(1) Release Mode “S”

(2) Focus Mode “M” (Manual)

(3) Right side of view finder – Metering Mode: 3-D Color Matrix II

NFPA 1801 ROC
Figure 8.1.4.3
Log CC 4



a. Stencil pattern and temperature measurement locations

NOTE: Temperature Measurements locations are denoted as TM in diagram. Temperature measurements are positioned in the same relative location on the emitting surface.

Black objects denote pattern cut into stencil, leaving an unobstructed line of sight from the thermal imager to the emitting surface.

Note: Ensure temperature devices do not interfere with stencil pattern (TYP).

*****NOTE: Insert (b) Source target and thermal imager position from Figure 8.1.4.5 in the 2010 edition of NFPA 1801 here*****

Figure 8.1.4.3 Spatial Resolution Source Target

(4) Bottom Right of the LCD – Focus Mode: Single-Point AF (Bottom of 3). Operator shall press the OK button to automatically center the focus point to the center of the Nikon camera display.

(5) Camera Needs to be turned on

(6) If the lens has Vibration Reduction control, it shall be turned off

Interior (Menu) Settings (Click menu button to left of LCD to enter menu)

A. Shooting Menu

1. Shooting Menu Bank - A
2. Reset Shooting Menu – No
3. Active Folder – [N/A]
4. File Naming – [N/A] (or DSC default)
5. Slot 2 – Overflow
6. Image Quality – NEF (RAW)
7. Image Area – Auto DX Crop – OFF
8. JPEG Compression – Size Priority
9. NEF RAW recording – Type – OFF; NEF (RAW) Bitdepth – 14 Bit
10. White Balance – Direct Sunlight – Center Color; A-B – 0; G-M – 0
11. Set Picture Control – Neutral
12. Manage Picture Control – [N/A]
13. Color space – sRGB
14. Active D-Lighting – OFF
15. Vignette Control – Normal
16. Long exp. NR – OFF
17. High ISO NR – OFF
18. ISO Sensitivity Settings – ISO Sensitivity – 200; ISO Sensitivity auto control – OFF
19. Live View – Live View Mode – Tripod; Release Mode – Single Frame
20. Multiple Exposure – OFF
21. Interval Timer Shooting – OFF

B. Custom Setting Menu

a. Autofocus

A1. AF-C priority selection – Release
A2. AF-S priority selection – Focus
A3. Dynamic AF Area – 9 Points
A4. Focus tracking with lock-on – OFF
A5. AF activation – Shutter/AF-ON
A6. Focus Point Illumination – Manual focus mode – ON; Continuous Mode – ON; Focus Point Brightness – 0 Normal
A7. Focus Point wrap-around – No Wrap
A8. AF point selection – AF51
A9. AF On Button – AF-ON
A10. Vertical AF On Button – AF-ON

b. Metering/Exposure

B1. ISO sensitivity step value – 1/3
B2. EV steps for exposure control – 1/3
B3. EV steps for exposure compensation – 1/3
B4. Easy exposure compensation – Off

B5. Center Weighted Area – Average
B6. Fine tune optimal exposure – No, don't continue
c. Timers/AE lock
C1. Shutter Release Botton/AE-L – OFF
C2. Auto meter-off delay – 6 s
C3. Self-timer delay – 10 s
C4. Monitor off delay – 10 s
d. Shooting/Display
D1. Beep – OFF
D2. Shooting Speed – Continuous High-speed – 9fps
D3. Max continuous release – 130
D4. File Number Sequence – ON
D5. Control panel/Viewfinder – Rear Control Panel – ISO Sensitivity; Viewfinder display – Frame Count
D6. Shooting Info display – Auto
D7. LCD Illumination – OFF
D8. Exposure Delay Mode – OFF
e. Bracketing/flash
E1. Flash Sync Speed – 1/250
E2. Flash Shutter Speed – 1/60
E3. Modeling Flash – ON
E4. Auto Bracketing Set – AE & Flash
E5. Auto Bracketing (Model M) – Flash/Speed
E6. Bracketing Order – MTR > under > over
f. f Controls
f1. Multi selector center button – Shooting Mode – OFF; Playback mode – Thumbnail on/off
f2. Multi selector – Do Nothing
f3. Photo info/playback – OFF
f4. Assign FUNC. Button – FUNC. Button Press – OFF; FUNC. Button + dials – Choose image area (FX/DX/5:4)
f5. Assign Preview Button – Preview Button Press – Preview; Preview + Command Dials – None
f6. Assign AE-L/AF-L button – AE-L/AF-L button press – AE/AF lock; AE-L/AF-L + command dials – None
f7. Customize Command Dials – Reverse Rotation – NO; Change Main/sub – OFF; Aperture Setting – Sub-Command Dial; Menus and Playback – OFF
f8. Release button to use dial – NO
f9. No memory card? – Release locked
f10. Reverse Indicators -- + ,,,,,|,,,,, - (Positive Left, Negative Right – For Exposure Compensation); This is the brightness sensor
C. Manual Mode Settings and Calibration Procedure
A. Turn Nikon On
B. Turn Thermal Imager On
C. Select 'Manual' for the camera exposure mode
D. Thermal Imager facing spatial resolution target as specified in 8.1.4.3
E. Aperture set with front scroll wheel to set as "22" on the LCD (this means f/22)

F. EV value set to the center (Hold down the +/- button next to the trigger release and adjust using the rear scroll wheel)

G. Adjust the shutter speed with the rear scroll wheel such that the brightness sensor is in the middle +/- 1 dot (1/3 of a tick) – this is one click with the scroll wheel

H. The refresh rate of the display of the thermal imager shall be provided by the manufacturer

I. The shutter speed must be at least twice the refresh rate of the thermal imager and less than 3 seconds. If this cannot be met with f/22 aperture, then the aperture should be adjusted to the closest value to f/22 that the conditions can be met.

J. Use ViewNX or ViewNX 2 to determine if there are areas within the regions of interest that either have lost highlights or lost shadows. Lost highlights represent areas of over exposure, and lost shadows represent areas of under exposure. In the event that areas within the region of interest are over exposed or under exposed, the EV button should be adjusted toward the negative or positive respectively to make the image darker or lighter. Once the EV value is changed, the shutter speed should then be changed accordingly to align the brightness sensor to center again. The EV compensation value shall be as close to 0 as possible.

Note: The camera focus can be determined by looking in the lower left hand side of the HUD within the viewfinder. If the camera is in focus, a small dot appears. If it is out of focus, an arrow pointing to the left or to the right appears. Arrows alternating back and forth means the camera is in focus. Arrows blinking simultaneously means the camera is unable to determine focus.

8.1.4.8 The visible spectrum camera shall be mounted such that the thermal imager display fills at least 90 percent of the FOV in the widest dimension.

8.1.4.8.1 The visible spectrum camera shall not wobble, vibrate, or otherwise move out of position during the course of the test.

8.1.4.8.2 A black shroud shall be placed around the visible spectrum camera and its view path to block out all light from the surrounding environment during all image capture.

8.1.4.9 The image capturing software and hardware shall permit 16-bit uncompressed color images to be downloaded from the visible spectrum camera to a computer or memory at a rate of one image every 3 seconds, ±0.1 second.

8.1.4.10 The image analysis software shall open 16-bit uncompressed color image files, convert the image files to 16-bit uncompressed grayscale images, determine the pixel intensities of selected pixels, calculate the contrast transfer function of the selected pixels, and write the results to an electronic text file.

8.1.5 Spatial Resolution Procedure.

8.1.5.1 The thermal imager lens and display and the visible spectrum camera lens shall be cleaned in accordance with the manufacturer's specifications. If they exist, condensation and frost shall be removed.

8.1.5.2 The thermal imager shall be activated at least 3 minutes, + 1/-0 minute, prior to the beginning of the test. Specimens shall operate in the TI BASIC mode.

8.1.5.3 The spatial resolution source target emitting surface temperature shall be stabilized at 28°C, ±0.5°C (82°F, ±1°F).

8.1.5.4 The thermal imager shall be oriented such that it is vertically centered and maximizes the visible area of the warm region of interest. A similarly sized space on the opposite side for a room temperature region of interest shall be included. The thermal imager should be normal to the spatial resolution target.

8.1.5.5 The visible spectrum camera shall be placed at the optimum viewing position with respect to the thermal imager display such that the thermal imager display fills at least 90 percent of the FOV in the widest dimension and is in focus.

8.1.5.6 A minimum of 10 uncompressed color images at a minimum bit depth of 16 bits shall be captured from the visible spectrum camera at a rate of one image every 3 seconds, ±0.1 second. The image having the lowest contrast shall be excluded.

8.1.5.7 The images captured from the visible spectrum camera shall be converted to uncompressed grayscale images having a minimum bit depth of 16 bits using Equation 8.1.5.7

Grayscale = 0.30 x red + 0.59 x green + 0.11 x blue (8.1.5.7)

8.1.5.8 A region of interest shall be selected within the warm square on the right side of the spatial resolution target that encapsulates at least 70% of the available square area excluding any text, symbols and boundary regions and shall not interfere with the spatial frequency patterns. This region of interest shall be labeled W. The image processing software shall apply these regions of interest to all images.

8.1.5.9 A region of interest shall be selected equal in size to the warm region of interest. This second region of interest should be on the opposite side of the spatial resolution target from the warm region of interest. This second region of interest contains ambient temperature pixels only and shall not interfere with the spatial resolution patterns and shall be labeled A. The image processing software shall apply these regions of interest to all images.

8.1.5.10 Two separate pixel smoothing filters shall be applied to the regions of interest. A moving average in two dimensions shall be applied to the region of interest, with the average having a period equal to the width and height of he thermal imager display pixels observed in the captured images. It shall be labeled the 1X filter. A second filter shall be applied in the same manner as the 1X filter but with a period four times greater and shall be labeled the 4X filter. Both filters shall be applied to the original image and the resulting images shall be labeled W_{1X}, W_{4X}, A_{1X} and A_{4X} and shall be stored independently for further calculation.

8.1.5.11 W_{1X} is the 1X filter warm region of interest, W_{4X} is the 4X filter warm region of interest, A_{1X} is the 1X ambient region of interest and A_{4X} is the 4X ambient region of interest.

8.1.5.12 The image processing software shall scan each of the four regions of interest for the lightest pixel intensity (I_{max}) and the darkest pixel intensity (I_{min}). The software shall then find the contrast of each of the four regions of interest using Equation 8.1.5.12.

*****Insert Equation E1801-1 Here**** (Equation 8.1.5.12)

8.1.5.13 Noise Warm (N_W) and Noise Ambient (N_A) shall be calculated. N_W is the contrast of W_{4x} subtracted from the contrast of W_{1x} . and N_A is the contrast of A_{4x} subtracted from the contrast of A_{1x}.

8.1.5.14 N_W and N_A shall then be averaged and the resulting value is the noise of the image, N.

8.1.5.15 Noise shall be calculated for all images of the spatial resolution test.

8.1.5.16 The average pixel intensity, μ, of the W_{1x} region of interest shall be calculated using Equation 8.1.5.16 and labeled μW_0.

$$C = (I_{max} - I_{min})/(I_{max} + I_{min})$$

*****Insert E1801-2 Here****

$$\mu = \frac{1}{N}\sum_{i=1}^{N} X_i$$

8.1.5.17 The average pixel intensity, μ, of the A_{1x} region of interest shall be calculated using Equation 8.1.5.16 and labeled μA_0.

8.1.5.18 The contrast shall be calculated using Equation 8.1.5.12 where $I_{max} = \mu W_0$ and $I_{min} = \mu A_0$. N shall be subtracted from this value and the resulting value shall be labeled C_0.

8.1.5.19 Each of the four sets of converging lines shall be rotated such that the center line is vertical before selecting a region of interest and performing calculations. The region of interest shall be selected from index 1 to 5 on the low frequency bars, and from index 5 to 9 on the high frequency bars. The region of interest shall be drawn along the lines as specified in Figure 8.1.5.19. No symbology shall be included in the ROI. In the case where symbology interferes with the target, the ROI shall be drawn around the interference such that horizontal lines are perpendicular to the center line and such that equal portions of white and dark areas are included.

****Insert FIGURE 8.1.5.19 Region of interest selection - Here****

Figure 8.1.5.19 Region of Interest Selection

8.1.5.20 The data processing software shall analyze each row in the regions of interest of the converging lines. For each row, the maximum pixel intensity shall be recorded and the minimum pixel intensity shall be recorded. They shall be labeled I_{max} and I_{min} respectively. For each row, the contrast C_i shall be found using Equation 8.1.5.12.

8.1.5.20.1 After all of the regions' rows have been analyzed, the C_i values from the sets of converging lines in quadrant 1 and quadrant 3 shall be concatenated from lowest frequency to highest frequency. Likewise, the C_i values from the sets of converging lines in quadrants 2 and 4 shall be concatenated from lowest frequency to highest frequency. All of the C_i values shall be paired with their respective frequencies.

8.1.5.20.2 The noise value, N, shall be subtracted from each of the C_i values and then normalized to C_0 as shown in Equation 8.1.5.20.2.

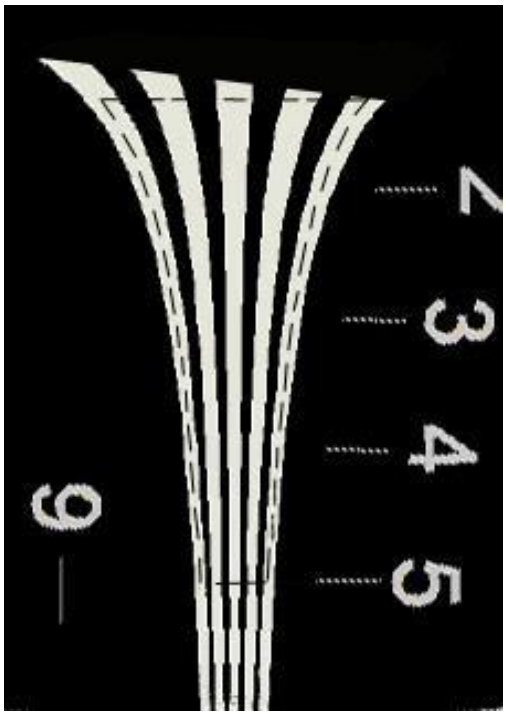
$CTF_i = (C_i - N)/C_0$ (Equation 8.1.5.20.2)

8.1.5.20.3 The two resulting CTF_i curves shall be multiplied by $\pi/4$ in order to approximate the MTF of each ROI. The resulting curves are $MTF_{i(up)}$ and $MTF_{i(down)}$. Each MTF_i curve shall be integrated resulting in SR_{up} and SR_{down}. Negative values shall be set to zero before the integration. The SR_{up} and SR_{down} values shall be averaged, resulting in the respective spatial resolution value for each image SR.

8.1.6 Report. The N and SR values shall be reported after the spatial resolution test.

NFPA 1801 Log CC 4

Figure 8.1.5.19 Region of Interest Selection



8.1.7 Interpretation. Any one specimen failing the test shall constitute failing performance.

8.2.4.3 The large compartments shall encase the complete thermal imager that is larger than 5161~~.0~~ mm^2 (8 in^2).

8.2.4.4 The small compartments shall encase the complete thermal imager that is smaller than 5161~~.0~~ mm^2 (8 in^2).

8.6.3.5 Manufacturers shall be permitted to optimally focus specimens to a distance of 1 meter for this test.

Delete paragraph 8.6.5.8.

8.6.5.8 After the specified exposure, the specimen shall be removed from the oven and immediately aimed perpendicularly at the spatial resolution target at a distance of 1 +0.01/-0 meters. The highest resolvable index number on the spatial resolution target shall be recorded.

Delete paragraph 8.6.5.9.

Delete Paragraph 8.6.6.1.

8.6.6.1 The highest resolvable index number on the spatial resolution target shall be recorded and reported.

8.7.4.3 The specimens shall be mounted on the test fixture to simulate the intended-use position as specified in the manufacturer's instructions, ensuring that the orientation of the center axis of the thermal imager lens is perpendicular to the burner array, horizontally centered, and located 610 mm (24 in.) ± 25 mm above the base of the lift-cart subassembly.

8.7.4.5 The test oven shall be a horizontal forced circulating air oven with an internal velocity of 61 m/min (200 ft/min) ± 15 m/min. The test oven shall have minimum dimensions of 915 mm depth × 915 mm width × 1220 mm (36 in × 36 in × 48 in) height.

Delete paragraphs 8.7.5.1, 8.7.5.2, and 8.7.5.3, and renumber the remaining paragraphs.

8.8.4.2 After each test, the specimen product labels shall be examined at a distance of 305 mm (12 in.) +25/-0 mm by the unaided eye with 20/20 vision or vision corrected to 20/20.

Delete Sections 8.10 and 8.12 and replace with the following text:

8.10 Effective Temperature Range Test.

8.10.1 Application. This test method shall apply to all thermal imagers.

8.10.2 Samples. Samples shall be complete thermal imagers.

8.10.3 Specimens.

8.10.3.1 Specimens for testing shall be complete thermal imagers.

8.10.3.2 A minimum of three specimens shall be tested.

8.10.3.3 Specimens shall be conditioned at a temperature of 22°C, ±3°C (72°F, ±5°F), and a relative humidity of 50 percent, ±25 percent, for at least 4 hours.

8.10.3.4 Specimens shall be tested within 5 minutes after removal from conditioning.

8.10.4 Apparatus.

8.10.4.1 Testing shall be conducted in a room having an ambient temperature (T_{amb}) of 22°C, ±3°C (72°F, ±5°F).

8.10.4.2 The test apparatus shall consist of the following:

(1) A source target as specified in 8.10.4.3

(2) A thermal imager positioning device as specified in 8.10.4.4

(3) A visible spectrum camera and lens as specified in 8.10.4.5

(4) A visible spectrum camera fixture as specified in 8.10.4.6

(5) Image capturing software and hardware as specified in 8.10.4.7

(6) A computer

(7) Image analysis software as specified in 8.10.4.8

(8) A mirror with the dimensions of height of 8 +/-0.25 in, width of 10+/-0.25 in and a thickness of 0.25+/-0.125

8.10.4.3 The source target shall consist of surfaces arranged as shown in Figure 8.10.4.3. All surfaces shall have an emissivity of 0.95, ±0.03. The use of a collimated source target shall be permitted.

****Insert FIGURE 8.10.4.3 Test Image for Effective Temperature Range Test****

Figure 8.10.4.3 Test Image for Effective Temperature Range Test

8.10.4.3.1 The surface labeled T_{hot} shall range in temperature from 50°C to 550°C (1022°F) and shall fill at least 25% +/- 5% of the FOV. The radiation source producing the T_{hot} surface shall be a blackbody and shall have an emissivity of 0.95, ±0.03. The source target shall be calibrated at least every 6 months. The nonuniformity of the blackbody shall not exceed 0.02. The blackbody temperature accuracy shall be ±0.5°C (±1°F). The stability of the emitting surface temperatures shall be 0.15°C. The mirror specified in 8.10.4.2 (8) shall be used to reflect the hot surface into the camera's FOV, if necessary, to meet the 25% +/-5% requirement.

8.10.4.3.2 The bars in the right region of the source target and the conjugate spaces between the bars shall be 13 mm, ±0.1 mm (1⁄2 in., ±0.003 in.), wide. The bars shall maintain a constant temperature (T_{bar}) of 8°C +/- 0.5°C above the surfaces in the FOV, excluding the T_{hot} surface.

8.10.4.3.3 All surfaces in the FOV, excluding the T_{hot} and T_{bar} surfaces, shall be held constant at T_{amb}, 22°C, ±3°C (72°F, ±5°F).

8.10.4.4 The thermal imager shall be positioned so that the image center points to the surface labeled T_{hot} and the bars are in focus and are viewed at a frequency of 0.04 cyc/mrad. The thermal imager shall not wobble, vibrate, or otherwise move out of position during the course of the test. When placed or replaced in the positioning device, the thermal imager shall always be positioned at the same distance, angle, and attitude relative to the source target.

8.10.4.5 The visible spectrum camera shall be a Nikon D3 as specified in section 8.1.4.7

8.10.4.6 The visible spectrum camera shall be mounted as specified in section 8.1.4.8 such that the thermal imager display fills 90 percent of the FOV in the vertical dimension and is in focus.

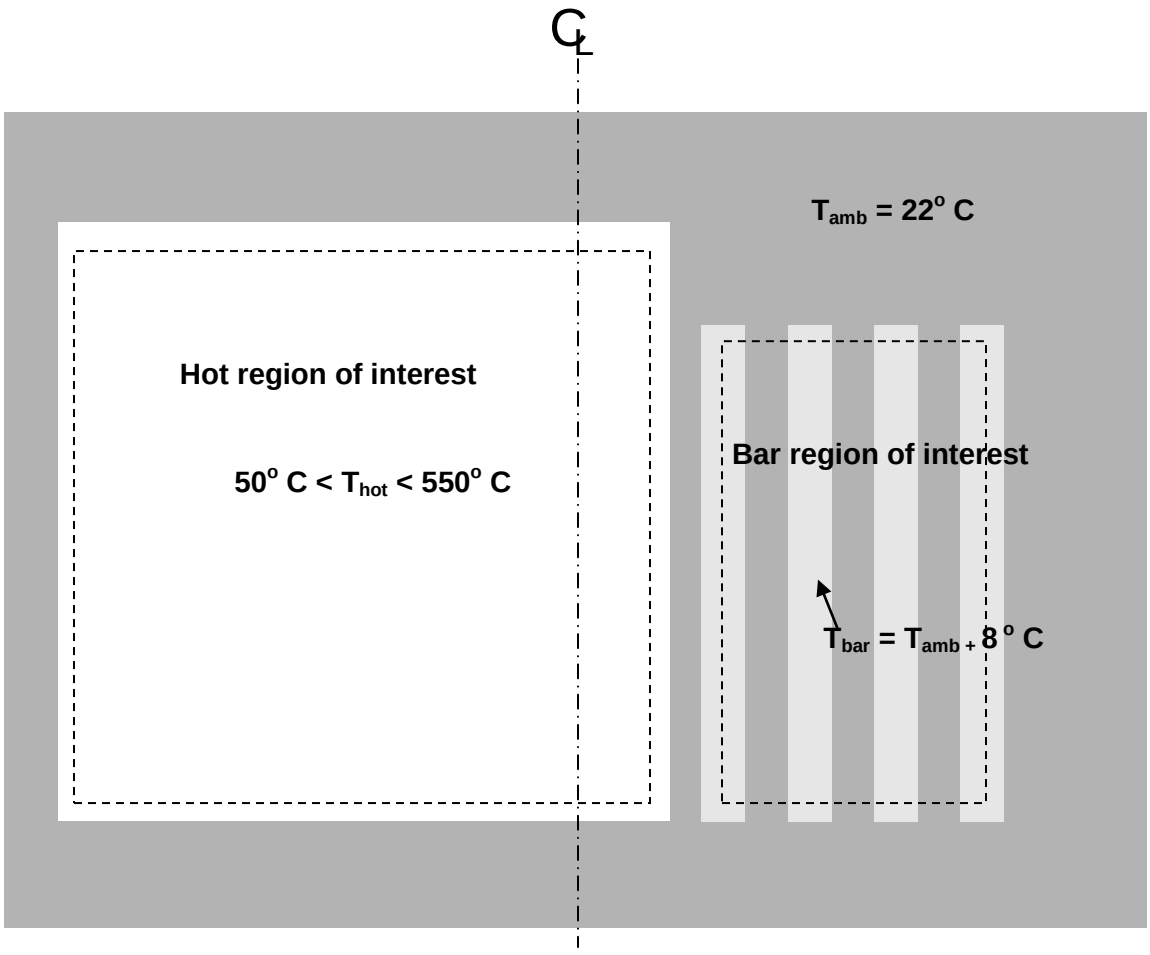
8.10.4.7 The image capturing software and hardware shall permit 16-bit uncompressed color images to be downloaded from the visible spectrum camera to a computer or memory at a rate of one image every 3 seconds, ±0.1 second.

8.10.4.8 The image analysis software shall open 16-bit uncompressed color image files, convert the image files to 16-bit uncompressed grayscale images using a lossless conversion, select a group of pixels within an image, determine pixel intensities within the selected group, and write the results to a text file.

8.10.4.9 The high-frequency noise created by over-sampling the thermal imager's display shall be removed from the captured images. A moving average in two dimensions shall be applied to

NFPA 1801 Log CC 4

Figure 8.10.4.3, Test Image for Effective Temperature Range Test



the region of interest, with the average having a period equal to the width and height of the thermal imager display pixels observed in the captured images.

8.10.5 General Procedure.

8.10.5.1 The thermal imager lens and display and the visible spectrum camera lens shall be cleaned in accordance with the manufacturer's specifications.

8.10.5.2 The thermal imager shall be equipped with a fully charged power source.

8.10.5.3 The thermal imager shall be activated 3 minutes, ±1 minute, prior to the beginning of the test.

8.10.5.4 All surface temperatures in the FOV shall be adjusted to the assigned temperatures and shall be allowed to come to steady-state prior to starting the test.

8.10.5.5 The visible spectrum camera shall be placed at the optimum viewing position with respect to the thermal imager display such that the thermal imager display fills 90 percent of the FOV in the vertical dimension and is in focus.

8.10.5.6 A black shroud shall be placed around the visible spectrum camera and its view path to block out all light from the surrounding environment during all image capture.

8.10.5.7 The image capturing software and hardware shall permit 16-bit uncompressed color images to be downloaded from the visible spectrum camera to a computer or memory at a rate of one image every 2^{o} C + 0.1^{o} C (3.6^{o} F + 0.2^{o} F), as T_{hot} increases from 50°C to 550°C (1022°F) at a rate not greater than 15°C (27°F) per minute.

8.10.5.8 Pixels that represent symbols, icons, and text shall be excluded from the analysis.

8.10.6 Effective Temperature Range Procedure.

8.10.6.1 The high frequency noise created by over-sampling the thermal imager's display shall be removed from the captured images. A moving average in two dimensions shall be applied to the region of interest, with the average having a period equal to the width and height of the thermal imager display pixels observed in the captured images.

8.10.6.2 The images shall be converted to uncompressed grayscale images having a minimum bit depth of 16 bits using Equation 8.1.5.7.

8.10.6.3 The bar pixel intensity differential, ΔI, as shown in the bar region of interest in Figure 8.10.4.3 shall be calculated for each row in each image as specified in Equation 8.10.6.3. All of the ΔI values for each image shall be averaged and recorded as ΔI for that image.

*****Insert Equation E1801- Here****

$\Delta I = I_{max} - I_{min}$ (Equation 8.10.6.3)

8.10.7 Report. ΔI shall be reported and recorded.

8.10.8 Interpretation. Any one specimen failing the test shall constitute failing performance.

8.12 Thermal Sensitivity Test.

8.12.1 Application. This test method shall apply to all thermal imagers.

8.12.2 Samples. Samples shall be complete thermal imagers.

8.12.3 Specimens.

8.12.3.1 Specimens for testing shall be complete thermal imagers.

8.12.3.2 A minimum of three specimens shall be tested.

8.12.3.3 Specimens shall be conditioned at a temperature of 22°C, ±3°C (72°F, ±5°F), and a relative humidity of 50 percent, ±25 percent, for at least 4 hours.

8.12.3.4 Specimens shall be tested within 5 minutes after removal from conditioning.

8.12.4 Apparatus.

8.12.4.1 Testing shall be conducted in a room having an ambient temperature (T_{amb}) of 22°C, ±3°C (72°F, ±5°F).

8.12.4.2 The thermal sensitivity test apparatus shall consist of the following:

(1) Two source targets as specified in 8.12.4.3 through 8.12.4.6

(2) Thermal imager positioning device as specified in 8.12.4.7 through 8.12.4.10

(3) Visible spectrum camera and lens as specified in 8.1.4.7

(4) Visible spectrum camera fixture as specified in 8.1.4.8

(5) Image capturing software and hardware as specified in 8.12.4.14

(6) Computer and image analysis software as specified in 8.12.4.15

8.12.4.3 The source targets shall both be flat-surface extended-area blackbodies arranged as shown in Figure 8.12.4.3, where the emitting surfaces are indicated as T_1 and T_2. The source targets shall be calibrated every 6 months.

****INSERT EXISTING FIGURE 8.12.4.3 FROM 2010 EDITION****

Figure 8.12.4.3 Thermal Sensitivity Test Apparatus Configuration.

8.12.4.4 The emitting surfaces shall have dimensions of at least 102 mm × 102 mm and shall have an emissivity of 0.95, ±0.03.

8.12.4.5 The temperature accuracy of the emitting surfaces shall be 0.02°C or better. The stability of the emitting surface temperatures shall be 0.01°C or better.

8.12.4.6 The emitting surface of the source targets shall be equal in size, ±10 percent, as viewed on the thermal imager's display.

8.12.4.7 The thermal imager positioning device shall position the thermal imager in front of the source targets such that the source targets fill at least 40 percent of the thermal imager's FOV. The thermal imager shall not be required to be in focus.

8.12.4.8 The thermal imager shall be centered on the space between the source targets with the line of sight perpendicular to the plane of the source targets.

8.12.4.9 The thermal imager shall not wobble, vibrate, or otherwise move out of position during the course of the test.

8.12.4.10 The visible spectrum camera shall not wobble, vibrate, or otherwise move out of position during the course of the test.

8.12.4.11 A black shroud shall be placed around the visible spectrum camera and its view path to block out all light from the surrounding environment during all image capture.

8.12.4.12 The image capturing software and hardware shall permit 16-bit uncompressed color images to be downloaded from the visible spectrum camera to a computer at a rate of one image every 3 seconds, ±0.1 second.

8.12.4.13 The image analysis software shall be capable of opening 16-bit uncompressed color image files, converting them to 16-bit uncompressed grayscale images using a lossless conversion, selecting a group of pixels within an image, determining the mean pixel intensity and

standard deviation of pixel intensities within the selected group, and writing the results to a text file.

8.12.5 Procedure.

8.12.5.1 The thermal imager lens and display and the visible spectrum camera lens shall be cleaned in accordance with the manufacturer's specifications.

8.12.5.2 The thermal imager shall be equipped with a fully charged power source.

8.12.5.3 The thermal imager shall be activated 3 minutes, ±1 minute, prior to the beginning of the test.

8.12.5.4 Both source targets shall be stabilized to within ±0.02°C of their initial set-point temperatures. The temperature setting of the T_1 source target shall remain constant throughout the test.

8.12.5.5 The thermal imager shall be positioned such that the source targets fill at least 40 percent of the FOV and the axis of the thermal imager's outermost lens is perpendicular with the source target surface. The thermal imager shall not be required to be in focus.

8.12.5.6 The visible spectrum camera shall be placed at the optimum viewing position with respect to the thermal imager display, such that the thermal imager display fills 90 percent of the FOV in the vertical dimension and is in focus.

8.12.5.7 Each thermal imager shall be tested with the source target T_1 at a set-point temperature of 30°C (86°F).

8.12.5.7.1 The T_2 source target shall be set at $T_2 = T_{amb} - 5°C$, and the T_2 source target shall then be increased at a rate of 0.5°C per minute until $T_2 = T_{amb} + 5°C$. Uncompressed color images at a minimum bit depth of 16 bits shall be captured from the visible spectrum camera at a rate of one image every 15 seconds, ±0.1 second, while the T_2 temperature is increasing.

8.12.5.8 The images captured from the visible spectrum camera shall be converted to uncompressed grayscale images using a lossless conversion. The images shall have a minimum bit depth of 16 bits using Equation 8.1.5.7.

8.12.5.9 Two regions of interest shall be used to select pixels for analysis in each image. Pixels representing the T_2 source target shall make up one of the regions of interest, shall encompass at least 90 percent of the T_2 source target, and shall not include pixels located along the edge of the T_2 emitting surface. Pixels representing ambient conditions shall make up the other region of interest, which shall include the same number of pixels as the T_2 region of interest. The same regions of interest shall be used on all images captured throughout the test. Pixels that represent symbols, icons, and text shall be excluded from the analysis.

8.12.5.10 The high frequency noise created by over-sampling the thermal imager display shall be removed from the captured images. A moving average in two dimensions shall be applied to the region of interest with the average having a period equal to the width and height of the thermal imager display pixels observed in the captured images.

8.12.5.11* The mean pixel intensity of each region of interest in each image shall be calculated using Equation 8.1.5.16. The mean pixel intensities shall then be divided by 65536. For each image, the resulting normalized pixel intensities for the T_{amb} region of interest shall be subtracted from the T_2 region of interest, and the difference shall be plotted with respect to the T_2 source target temperature. A linear trend line shall be fit to the plotted data using a least squares fit method. The slope of the trend line shall be the response slope. The goodness of fit of the data to the trend line shall be the correlation coefficient.

In Annex, Change A.8.12.5.13 to A.8.12.5.11.

8.12.6 The response slope and the correlation coefficient shall be calculated, recorded, and reported.

8.12.7 Interpretation. Any one specimen failing the test shall constitute failing performance.

Table 4.3.9 Test Matrix for Thermal Imagers

Test Order	Specimens 1–3	Specimens 4–6	Specimens 7–9	Specimens 10–12	Specimens 13–15	Specimens 16–18
1	Field of View Measurement Section 8.11 Specimens 1–3	Cable Pullout Test Section 8.9 Specimens 4–6	Corrosion Test Section 8.4 Specimens 7–9	Heat Resistance Test Section 8.6 Specimen 10-12	Vibration Test Section 8.2 Specimen 13-15	Durability Test Section 8.13 Specimens 16–18
2	Image Recognition Test Section 8.1 Specimens 1–3	Impact Acceleration Resistance Test — Ambient Section 8.3 Specimen 4	Product Label Durability Test Section 8.8 Specimens 7–9	Product Label Durability Test Section 8.8 Specimens 10–12	Image Recognition Test Section 8.1 Specimens 13-15	Image Recognition Test Section 8.1 Specimens 16-18
3	Effective Temperature Range Test Section 8.10 Specimens 1–3	Impact Acceleration Resistance Test — Cold Section 8.3 Specimen 5	----	---	---	Product Label Durability Test Section 8.8 Specimens 16–18
4	Thermal Sensitivity Test Section 8.12 Specimens 1–3	Impact Acceleration Resistance Test — Elevated Temperature Section 8.3 Specimen 6	—	---	—	—
5	Heat and Flame Test Section 8.7 Specimen 1–3	Image Recognition Test Section 8.1 Specimens 4-6	—	—	—	—

1801-3 Log #CC2 FAE-ELS Final Action: Accept
(6.6.4.8.2 and 6.6.4.8.3)

Submitter: Technical Committee on Electronic Safety Equipment,
Comment on Proposal No: 1801-2
Recommendation: Revise text as to read follows:
6.6.4.8.2 Each TI BASIC PLUS option indicator shall consist of an indicator distinctly different from other ~~icons~~ indicators.
6.6.4.8.3 Each TI BASIC PLUS option ~~icon~~ indicator shall be displayed in the center of the left (additional information area) vertical section of the viewing area.
Substantiation: The technical committee is recommending this change for consistency in terminology in this section.

Committee Meeting Action: Accept
Number Eligible to Vote: 22
Ballot Results: Affirmative: 19
Ballot Not Returned: 3 Morris, J., Roche, K., Townsend, S.

1801-4 Log #CC3 FAE-ELS Final Action: Accept
(Chapter 7)

Submitter: Technical Committee on Electronic Safety Equipment,
Comment on Proposal No: 1801-2
Recommendation: Revise text to read as follows:
7.1.1 Thermal imagers shall be tested for ~~image recognition~~ spatial resolution as specified in Section 8.1, ~~Image Recognition Spatial Resolution Test,~~ and shall have ~~an image recognition test P(IQ) value of at least 0.80~~ a minimum SR value of 0.06.
Delete paragraphs 7.1.2 and 7.1.3 and renumber remaining paragraphs.
7.1.4 Thermal Imagers shall be tested for effective temperature range as specified in Section 8.10, ~~Image Color and~~ Effective Temperature Range Test and shall have ~~all P(IQ) values be greater than or equal to 0.80~~ all ΔI values greater than or equal to 5000.
7.1.10 Thermal imagers shall be tested for resistance to vibration as specified in Section 8.2, Vibration Test, and shall have a minimum ~~image recognition test P(IQ) value of 0.80.~~ SR value of 0.06.
7.1.11 Thermal imagers shall be tested for resistance to impact as specified in Section 8.3, Impact-Acceleration Resistance Test, and shall have a minimum ~~image recognition test P(IQ) value of 0.80~~ SR value of 0.06 and shall have nothing fall off the thermal imager, and the thermal imager shall have no observable damage to any external component that would compromise the case integrity.
7.1.14 Thermal imagers shall be tested for resistance to heat as specified in Section 8.6, Heat Resistance Test, and shall ~~have a minimum image recognition test P(IQ) value of 0.80~~ be able to resolve frequencies to the index number 4 of the spatial resolution target and shall not have any part of the thermal imager melt, drip, or ignite.
7.1.18 Thermal imagers shall be tested for durability as specified in Section 8.13, Durability Test, and shall have the thermal imager remain functional, shall have a minimum ~~image recognition test P(IQ) value of 0.80~~ SR value of 0.06, shall have no water inside the electronics compartment(s), and shall have no water inside the power source compartment(s).
Substantiation: Substantiations are provided by paragraph as follows:
7.1.1 The P_{iq} is no longer valid. The image recognition test has been replaced with the spatial resolution test per the recommendation of the Image Quality task group. The image recognition value P_{iq} test did not produce consistent, reliable values. The spatial resolution (SR) value was selected as being representative of the ability to resolve fingers on a hand (1/2 inch) at a distance of approximately 15 feet.
7.1.2 Due to the size of the target (black body) required to perform this test, natural convection currents were being captured by the thermal imager, resulting in non-uniformity values that are not accurate. In addition, it was determined that non-uniformity is not a significant factor in determining the overall performance of a thermal imaging camera. The Image Quality task group recommends elimination of this test for these reasons.
7.1.3 The standard is no longer testing for the temperatures at which colorization occurs.
7.1.4 The standard is no longer testing for the temperatures at which colorization occurs. The ΔI value is a more consistent indicator of the contrast and the ability to resolve differences in temperature.
7.1.10 The image recognition test has been replaced with the spatial resolution test per the recommendation of the Image Quality task group. The image recognition value (P_{iq}) test did not produce consistent, reliable values. The spatial resolution (SR) value was selected as being representative of the ability to resolve fingers on a hand (1/2 inch) at a distance of approximately 15 feet.
7.1.11 The image recognition test has been replaced with the spatial resolution test per the recommendation of the Image Quality task group. The image recognition value (P_{iq}) test did not produce consistent, reliable values. The spatial resolution (SR) value was selected as being representative of the ability to resolve fingers on a hand (1/2 inch) at a distance of approximately 15 feet.
7.1.14 The image recognition test has been replaced with the spatial resolution test per the recommendation of the Image Quality task group. The image recognition value (P_{iq}) test did not produce consistent, reliable values. The intent of this test was to quickly verify camera functionality immediately following removal from the oven.
7.1.18 The image recognition test has been replaced with the spatial resolution test per the recommendation of the Image Quality task group. The image recognition value (P_{iq}) test did not produce consistent, reliable values. The spatial resolution (SR) value was selected as being representative of the ability to resolve fingers on a hand (1/2 inch) at a distance of approximately 15 feet.

Committee Meeting Action: Accept
Number Eligible to Vote: 22
Ballot Results: Affirmative: 19
Ballot Not Returned: 3 Morris, J., Roche, K., Townsend, S.

1801-5 Log #1 FAE-ELS Final Action: Accept
(B.1.2.3)

Submitter: John F. Bender, Underwriters Laboratories Inc.
Comment on Proposal No: 1801-14
Recommendation: Revise text to read as follows:

B.1.2.3 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096

UL 1642, Standard for Lithium Batteries, 2005, Revised 2009.

UL 2054, Standard for Household and Commercial Batteries, 2004, Revised 2009.

Substantiation: Update referenced standards to add the dates indicated that were in the ROP but apparently omitted from the 2012 Edition Preprint.
Committee Meeting Action: Accept
Number Eligible to Vote: 22
Ballot Results: Affirmative: 19
Ballot Not Returned: 3 Morris, J., Roche, K., Townsend, S.