Draft for Public Comment

U.S. Department of Justice
Office of Justice Programs
National Institute of Justice

National Institute of Justice

Law Enforcement and Corrections Standards and Testing Program

Draft NIJ Vehicular Digital Multimedia Evidence Recording System Standard for Law Enforcement

NIJ Standard–xxxx

July 2009
ABOUT THE LAW ENFORCEMENT AND CORRECTIONS

STANDARDS AND TESTING PROGRAM

The Standards and Testing Program is sponsored by the Office of Science and Technology of the National Institute of Justice (NIJ), Office of Justice Programs, U.S. Department of Justice. The program responds to the mandate of the Homeland Security Act of 2002, which directed the Office of Science and Technology to establish and maintain performance standards in accordance with the National Technology Transfer and Advancement Act of 1995 (Public Law 104-113) for, and test and evaluate law enforcement technologies that may be used by Federal, State, and local law enforcement agencies. The Homeland Security Act of 2002 also directed the Office of Science and Technology to establish and maintain a program to certify, validate, and mark or otherwise recognize law enforcement technology products that conform to the standards mentioned above.

The Standards and Testing Program is a basic and applied research effort that determines the technological needs of justice system agencies, sets minimum performance standards for specific devices, tests commercially available equipment against those standards, and disseminates the standards and the test results to criminal justice agencies nationally and internationally.

The Office of Law Enforcement Standards (OLES) at the National Institute of Standards and Technology develops voluntary national performance standards for compliance testing to ensure that individual items of equipment are suitable for use by criminal justice agencies. The standards are based upon laboratory testing and evaluation of representative samples of each item of equipment to determine the key attributes, develop test methods, and establish minimum performance requirements for each essential attribute. In addition to the technical standards, OLES also produces technical reports and user guidelines that explain in non-technical terms the capabilities of available equipment.

The National Law Enforcement and Corrections Technology Center (NLECTC), operated by a grantee, coordinates a national compliance testing program conducted by independent laboratories. The standards developed by OLES serve as performance benchmarks against which commercial equipment is measured.

Publications are available at no charge through NLECTC. Some documents are also available online at https://www.justnet.org/justnet.html. To request a document or additional information, call 800–248–2742 or 301–519–5060, or write:

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World Wide Web address: http://www.nlectc.org

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Draft NIJ Vehicular Digital Multimedia Evidence Recording System Standard for Law Enforcement

NIJ Standard–xxxx.00

Prepared for:
National Institute of Justice Office of Science and Technology
Washington, DC 20531

July 2009

NCJ xxxxxx
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International Association of Chiefs of Police Research Center Directorate
Foreword

The National Institute for Justice (NIJ) Vehicular Digital Multimedia Evidence Recording System Standard for Law Enforcement, NIJ Standard-xxxx.00, is a minimum performance standard for Vehicular Digital Multimedia Evidence Recording Systems used by law enforcement officers for recording events occurring in and around the vehicle. This standard contains minimum design and performance requirements that equipment must meet and the test methods used to verify performance.

Requirements for manufacturers to demonstrate conformity with NIJ Standard-xxxx.00 is provided in a separate document, the NIJ Vehicular Digital Multimedia Evidence Recording System Certification Program Requirements. Those seeking guidance concerning the selection and application of Vehicular Digital Multimedia Evidence Recording Systems should refer to the most recent revision of the NIJ Selection and Application Guide to Vehicular Digital Multimedia Evidence Recording Systems, which is published as a separate document and explains in nontechnical language how to select equipment that provides the level of performance required by a purchasing agency.

This standard is based in part on a performance specification produced by the International Association of Chiefs of Police. Portions of the document are used in this standard, and references to the document are cited using the letter symbol indicated below:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Cited Document</th>
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## Abbreviations, Symbols, Prefixes, and Conversions

### Standard Specific Abbreviations

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<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIE</td>
<td>Commission Internationale de L’Eclairage (International Commission on Illumination)</td>
</tr>
<tr>
<td>DUT</td>
<td>Device Under Test</td>
</tr>
<tr>
<td>DME</td>
<td>Digital Multimedia Evidence</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
</tr>
<tr>
<td>ESSID</td>
<td>Extended Service Set Identification</td>
</tr>
<tr>
<td>FCC</td>
<td>Federal Communications Commission</td>
</tr>
<tr>
<td>IACP</td>
<td>International Association of Chiefs of Police</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronic Engineers</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organization</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association</td>
</tr>
<tr>
<td>RC4</td>
<td>Rivest Cipher 4</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers</td>
</tr>
<tr>
<td>SI</td>
<td>System Internationale</td>
</tr>
<tr>
<td>SIA</td>
<td>Security Industry Association</td>
</tr>
<tr>
<td>SSID</td>
<td>Service Set Identification</td>
</tr>
<tr>
<td>UL</td>
<td>Underwriters Laboratories Inc.</td>
</tr>
</tbody>
</table>
Common Measures of Light: Luminous

Note: Light can be measured in radiant or luminous units. The former are for scientific purposes and do not restrict the wavelength spectrum and the latter are specific to visual and photographic applications and utilize the spectral sensitivity visible of humans.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>SI unit</th>
<th>Abbreviation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminous energy</td>
<td>lumen second</td>
<td>lm·s</td>
<td>The light energy flowing through a unit of space</td>
</tr>
<tr>
<td>Luminous flux</td>
<td>lumen (cd steradian)</td>
<td>lm</td>
<td>The power associated with light flowing through a unit of space</td>
</tr>
<tr>
<td>Luminous intensity</td>
<td>candela (lm/steradian)</td>
<td>cd</td>
<td>The intensity of light from a source in a given direction</td>
</tr>
<tr>
<td>Luminance</td>
<td>candela per square meter</td>
<td>cd/m²</td>
<td>The intensity of light emanating from a unit area on the source</td>
</tr>
<tr>
<td>Illuminance</td>
<td>lux (lm/m²)</td>
<td>lx</td>
<td>The power of light incident on a surface</td>
</tr>
<tr>
<td>Luminous emittance</td>
<td>lux (lm/m²)</td>
<td>lx</td>
<td>Used for light emitted from a surface after correction for the surface emissivity</td>
</tr>
<tr>
<td>Luminous efficacy</td>
<td>lumen per watt</td>
<td>lm/W</td>
<td>The ratio of luminous flux to radiant flux, used to relate certain luminous units to radiant units</td>
</tr>
<tr>
<td>Exposure</td>
<td>lux seconds</td>
<td>exp</td>
<td>Used to determine the input to a sensor chip or film</td>
</tr>
</tbody>
</table>
### Commonly Used Symbols and Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ampere</td>
<td>lbf</td>
<td>pound force</td>
</tr>
<tr>
<td>ac</td>
<td>alternating current</td>
<td>lbf-in</td>
<td>pound force inch</td>
</tr>
<tr>
<td>cd</td>
<td>candela</td>
<td>ln</td>
<td>lumen</td>
</tr>
<tr>
<td>cm</td>
<td>centimeter</td>
<td>ln</td>
<td>logarithm (base e)</td>
</tr>
<tr>
<td>dB</td>
<td>decibel</td>
<td>log</td>
<td>logarithm (base 10)</td>
</tr>
<tr>
<td>dc</td>
<td>direct current</td>
<td>m</td>
<td>meter</td>
</tr>
<tr>
<td>°C</td>
<td>degree Celsius</td>
<td>min</td>
<td>minute</td>
</tr>
<tr>
<td>°F</td>
<td>degree Fahrenheit</td>
<td>mm</td>
<td>millimeter</td>
</tr>
<tr>
<td>ft</td>
<td>foot</td>
<td>mph</td>
<td>miles per hour</td>
</tr>
<tr>
<td>ft/s</td>
<td>foot per second</td>
<td>m/s</td>
<td>meter per second</td>
</tr>
<tr>
<td>h</td>
<td>hour</td>
<td>V</td>
<td>volt</td>
</tr>
<tr>
<td>Hz</td>
<td>hertz</td>
<td>V</td>
<td>volt</td>
</tr>
<tr>
<td>in</td>
<td>inch</td>
<td>V</td>
<td>volt</td>
</tr>
<tr>
<td>Lb</td>
<td>pound</td>
<td>W</td>
<td>watt</td>
</tr>
</tbody>
</table>

area = unit² (e.g., ft², in², etc.); volume = unit³ (e.g., ft³, m³, etc.)

### PREFIXES

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>deci</td>
<td>d</td>
<td>10⁻¹</td>
</tr>
<tr>
<td>centi</td>
<td>c</td>
<td>10⁻²</td>
</tr>
<tr>
<td>milli</td>
<td>m</td>
<td>10⁻³</td>
</tr>
<tr>
<td>micro</td>
<td>µ</td>
<td>10⁻⁶</td>
</tr>
<tr>
<td>nano</td>
<td>n</td>
<td>10⁻⁹</td>
</tr>
<tr>
<td>pico</td>
<td>p</td>
<td>10⁻¹²</td>
</tr>
<tr>
<td>deka</td>
<td>da</td>
<td>10¹</td>
</tr>
<tr>
<td>deka</td>
<td>da</td>
<td>10¹</td>
</tr>
<tr>
<td>hecto</td>
<td>h</td>
<td>10²</td>
</tr>
<tr>
<td>kilo</td>
<td>k</td>
<td>10³</td>
</tr>
<tr>
<td>mega</td>
<td>M</td>
<td>10⁶</td>
</tr>
<tr>
<td>giga</td>
<td>G</td>
<td>10⁹</td>
</tr>
<tr>
<td>tera</td>
<td>T</td>
<td>10¹²</td>
</tr>
</tbody>
</table>

### COMMON CONVERSIONS

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30480 m = 1 ft</td>
<td>1 ft/0.30480 m</td>
</tr>
<tr>
<td>2.54 cm = 1 in</td>
<td>1 in/2.54 cm</td>
</tr>
<tr>
<td>0.4535924 kg = 1 lb</td>
<td>1 lb/0.4535924 kg</td>
</tr>
<tr>
<td>0.06479891 g = 1 gr</td>
<td>1 gr/0.06479891 g</td>
</tr>
<tr>
<td>0.9463529 L = 1 qt</td>
<td>1 qt/0.9463529 L</td>
</tr>
<tr>
<td>3600000 J = 1 kW·h</td>
<td>1 kW·h/3600000 J</td>
</tr>
<tr>
<td>1.609344 km/h = 1 mph</td>
<td>1 mph/1.609344 km/h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.448222 N = 1 lbf</td>
<td>1 lbf/4.448222 N</td>
</tr>
<tr>
<td>1.355818 J = 1 ft·lbf</td>
<td>1 ft·lbf/1.355818 J</td>
</tr>
<tr>
<td>0.1129848 N·m = 1 lbf·in</td>
<td>1 lbf·in/0.1129848 N·m</td>
</tr>
<tr>
<td>14.59390 N/m = 1 lbf/in</td>
<td>1 lbf/in/14.59390 N/m</td>
</tr>
<tr>
<td>6894.757 Pa = 1 lbf/in²</td>
<td>1 lbf/in²/6894.757 Pa</td>
</tr>
</tbody>
</table>
1. Scope, Purpose, and Application

1.1 Scope

1.1.1 This standard shall establish the minimum requirements for the design, performance, testing, documentation, and labeling of Vehicular Digital Multimedia Evidence (DME) Recording Systems used by law enforcement officers for recording events occurring in and around the vehicle. (Vehicular DME Recording Systems are hereinafter referred to as systems.)

1.1.2 This standard shall establish requirements for new, unused systems.

1.1.3 The design and performance requirements of this standard shall be met for a complete base unit with any possible combination of required accessories. Required accessories shall not hinder nor assist the performance of the vehicular digital recording system. If any of the components of the base unit are not dedicated exclusively to supporting the functionality of the system, the ability of the system to share resources is not addressed under the scope of this standard.

1.1.4 Any optional accessories shall not be required to meet the design and performance requirements of this standard, and the manufacturer shall provide written documentation identifying optional accessories.

1.1.5 This standard does not consider active or archival storage.

1.1.6 Compliance with this standard requires compliance with all requirements in the standard and not just portions of the standard.

1.1.7 This standard does not prohibit manufacturers from exceeding these minimum requirements.

1.2 Purpose

1.2.1 The purpose of this NIJ standard is to establish a minimum level of performance for systems to enhance officer safety and the effectiveness of audio/video evidence.

1.2.2 The standard identifies test methods for verifying the minimum performance requirements are met.

1.2.3 The test methods of this standard shall be used to demonstrate minimum performance and shall not be deemed as establishing performance levels for all situations in which systems may be used.

1.3 Application

1.3.1 This standard applies to systems that record video from at least one camera and audio from at least two microphones.
1.3.2 This standard does not address performance classifications or levels of systems.

1.4 Units

1.4.1 All measurement units used in this document are metric. Where useful, English units are indicated in parentheses immediately following the metric units, such as “2.54 cm (1 in)”. 
2. References

This standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence.

2.1 Federal Rules of Evidence


2.2 International Association of Chiefs of Police


2.3 International Organization for Standardization (ISO)


2.4 National Institute of Standards and Technology (NIST)


2.5 Society of Automotive Engineers (SAE)

SAE J1113-1, Electromagnetic Compatibility Procedures and Limits for Components of Vehicles, Boats (up to 15 m) and Machines, Except Aircraft, October 2006.


2.6 Underwriters Laboratories Inc. (UL)


2.7 Other Publications


3. Definitions

3.1 General

3.1.1 The standard-specific definitions in this chapter apply to the terms as used in this standard. Terms which are not specifically defined shall be used according to their generally accepted meaning within the context of the text, and the Merriam-Webster Collegiate Dictionary, 11th Edition may be consulted for the generally accepted meaning.

3.2 Standard-specific Definitions

3.2.1 Accessory: Any manufacturer-offered item or software that is not part of the base unit that may be used with the system but that is not required to meet the requirements of this standard.

3.2.1.1 Optional Accessories: Items available for use with the base unit but not necessary for meeting the requirements of this standard.

3.2.1.2 Required Accessories: Items provided with the base unit and necessary for meeting the requirements of this standard.

3.2.2 Accuracy: How close a measured value is to the true value or an established standard.

3.2.3 Active Storage: A storage location or device (i.e. server) to which Digital Multimedia Evidence (DME) is transferred from the in-vehicle recorder using any method. Active Storage shall provide ready access to recently recorded DME which has not been moved to Archival Storage due to elapsed time from the original recording creation date.

3.2.4 Ambient Interference: The conducted and/or radiated electromagnetic interference and/or mechanical motion interference, at a specific test location and time, which might be detrimental to the proper recording system or device performance.

3.2.5 Archival Storage: A storage location or device to which DME is moved after a designated amount of time and where it resides for an extended period of time. Access to DME contained within Archival Storage may be limited and may require administrator authorization to review or move back to Active Storage.

3.2.6 Authentication: The process of affirming that the data fairly and accurately represents what it purports to show. (FRE Rule 901)

3.2.7 Bit: The smallest amount of digital information. A bit is restricted to being either a one or a zero.

3.2.8 Byte: A basic unit of digital information. Most commonly comprised of 8 bits, but could contain 16, or 32, or 64, or 128, etc.

3.2.9 DME Audit Log: To be defined.
3.2.10 **Base unit:** The minimum set of hardware and software components that are defined by the manufacturer as necessary to meet the requirements of this standard.

3.2.11 **Capture:** (1) The process of producing or recording the DME from a natural event. (2) The transfer of data from one device to another.

3.2.12 **Capture Device:** A device used to record DME and associated metadata.

3.2.13 **CD/DVD (compact disc/digital versatile disc):** Optical disc formats designed to function as digital storage media.

3.2.14 **Circle of Blur:** A star-type test target is one with a series of thin triangles arranged in a circle, something like an asterisk. Each triangle is a dark color, usually black, and adjacent to each triangle there is a congruent triangle that is light, usually white. The dark and light triangles are arranged in a circle with the points all meeting in the center. Refer to Appendix A, Figure 1. When the chart is photographed, the area surrounding the points of the triangles will usually not be resolved while the broad ends (the bases) will be easily resolved. The center portion, where the details are not resolved will form a grayish circle where the image details are blurred together. This is the circle of blur or the blur circle.

3.2.15 **Codec:** A device/program capable of encoding and/or decoding digital data. Codecs encode a stream or signal for transmission, storage or encryption and decode it for viewing and listening.

3.2.16 **Compression:** The reduction of data used to represent DME.

3.2.17 **Consistency:** The degree of uniformity, standardization, and freedom from contradiction among the video/data or parts of a system or component.

3.2.18 **Correlated Color Temperature:** Characterization of a light source in terms of the temperature of a theoretical blackbody radiator that would have a color (spectral energy density) that most closely resembles that of the illuminating source.

3.2.19 **Data File:** A set of binary information representing DME.

3.2.20 **Date/Time Stamping:** A software feature that automatically inserts the current date/time into the data file.

3.2.21 **Default Settings:** Controls and settings established by the manufacturer prior to delivery.

3.2.22 **Digital Image:** A photographic image that is represented by discrete numerical values organized in a two-dimensional array or video stream. Each discrete block of the array is called a pixel. Black and white images have one byte per pixel, and color images usually have three bytes per pixel.
3.2.23 **Digital Multimedia Evidence (DME):** Data representing audio essence, video essence, metadata, and any other information attached to a digital file. A DME may be classified as follows:

3.2.23.1 **Compressed DME:** Data that has been transcoded from the original DME resulting in loss. Often referred to as proxy when describing motion video.

3.2.23.2 **Original DME:** Data recorded in the first instance, which is typically recorded in a compressed format.

3.2.23.3 **Uncompressed DME Copy:** A copy of the original DME where there is no loss of information or a transcoded copy into an industry standard file format where there is no loss of information.

3.2.24 **Digital Recorder:** Any device that is used to create a record of the DME.

3.2.25 **Digital Recording:** The storage of information as discrete numerical bytes. Digital recording converts information (text, graphics, sound, or pictures) to strings of bytes that can be physically represented on a storage medium.

3.2.26 **Display:** A viewing device.

3.2.27 **Download:** The process of receiving data from another digital source.

3.2.28 **Duplicate:** An acceptably accurate and complete reproduction of all data objects independent of the physical media.

3.2.29 **Encryption:** The process of coding data so that a specific code or key is required to restore the original data.

3.2.30 **Essence:** Sound and/or picture information, not including metadata.

3.2.31 **Export:** To move information from one system or program to another.

3.2.32 **Field of View (FOV):** The horizontal angular extent of a scene that is imaged by the video camera. The FOV depends on the focal length of the camera lens and the size of the camera’s imager chip.

3.2.33 **Format:** A specific structure for the data in a file.

3.2.34 **Hash function:** A mathematical formula that generates a unique number that is based on the data in a file and is used to verify the data’s integrity.

3.2.35 **Illuminance:** A photometric quantity that expresses the luminous flux (i.e. the light level in lumens) per unit area and that is measured in lumens per m², which is also called lux.
3.2.36 **Image Authentication**: The examination process used to verify that the information content of the analyzed material is a fair and accurate representation of what it purports to show.

3.2.37 **Industry Standard File Formats**: Formats that are viewable and playable without the need for proprietary codecs, players, or viewers available from only the system manufacturer.

3.2.38 **Import**: To bring information from one system or program into another.\(^A\)

3.2.39 **Integrity**: (1) The completeness of the DME throughout its lifecycle. (2) The degree to which a system or component prevents degradation, or unauthorized access to, or modification of DME.\(^A\)

3.2.40 **Intermediate Storage**: Any media or device on which data is temporarily stored for transfer to permanent or archival storage.\(^A\)

3.2.41 **Interoperability**: The sharing of uncompressed and compressed DME among law enforcement agencies in an industry standard file format.

3.2.42 **Internal Circuit Test**: A test function (whether manually or automatically initiated) that verifies that all device internal signal processing circuitry is working correctly.\(^A\)

3.2.43 **Metadata**: Data frequently embedded within a file that describes information about or related to the file or directory in which it is embedded. This may include but is not limited to the locations where the content is stored, dates, times, application specific information, and permissions.\(^A\) It is data about data.

3.2.44 **Modulation**: The ratio of the highest brightness portions of interest in a digital image to the lowest brightness portions of interest.

3.2.45 **Native File Format**: The original form of a file. This usually refers to a file format that is associated with, and unique to, a specific software application program.\(^A\)

3.2.46 **Network Topology**: Graphical representation of the arrangement of a network.\(^A\)

3.2.47 **Pixel**: A picture element.\(^A\)

3.2.48 **Primary Microphone**: Wireless microphone, transmitter, battery, and accessories such as cords, etc.

3.2.49 **Proprietary**: A quality of a technique, technology, or device in which it is owned and controlled by a company or other party, and is thereby only usable or adaptable as allowed by that party.\(^A\)
3.2.50 **Recording Media:**

3.2.50.1 **Non-Removable Recording Media:** Any data storage that is housed within a device and cannot be removed from that device without disassembly of the device.

3.2.50.2 **Removable Recording Media:** Any portable data storage device that contains data that is designed to be removed from the system without disassembly.

3.2.51 **Refresh Rate:** The number of images recorded or displayed per second.

3.2.52 **Reliability:** The extent to which a process can repeatedly produce the same effective output, with a central tendency and an acceptable dispersion, for consistent input settings. Information from such a system is said to be reliable.

3.2.53 **Risk of Electric Shock:** A risk of electric shock is determined to exist within a circuit unless the circuit meets one of the following criteria (UL 2075):

1. the circuit is supplied by an isolated source such that the maximum open-circuit voltage potential available to the circuit is not more than 30V ac rms, 42.4V dc, or 42.4V peak, or
2. the circuit is supplied by an isolated source such that the current available through a 1500-ohm resistor connected across any potential in the circuit (including to ground) does not exceed 5mA.

3.2.54 **Sensitometer:** A device to measure the response function of a photographic system.

3.2.55 **Step Tablet:** A test target comprised of a series of progressively darker areas on either a reflective or a transparent substrate.

3.2.56 **Storage Media:** Any object on which DME is preserved. 

3.2.57 **Transcoding:** The conversion of DME from one file format to another.

3.2.58 **Vehicular DME Recording System:** System for recording DME to document events in and around a vehicle. The system shall include at least one primary camera facing forward from the vehicle, at least one primary wireless microphone, at least one wired microphone, a digital recorder, a means for electronic data output, and a video/audio monitor. The system shall also incorporate the option for a secondary video camera and an additional wireless microphone. The system consists of the base unit and may or may not include accessories.

3.2.59 **Verification:** The process of confirming the accuracy of any copy of the DME compared to the original DME. This process normally includes the application of a type of hash function.

3.2.60 **Working Copy:** An accurate copy or duplicate of the original DME that can be used for subsequent processing and/or analysis.
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4. Design Requirements

4.1 System Requirements

4.1.1 The system shall consist of at least one primary camera, at least one primary wireless microphone, at least one wired microphone, a digital recorder, a video monitor, and an audio monitor. The video monitor and audio monitor may be combined into a single video/audio monitor. The system shall have the option to incorporate an additional wireless microphone, and such additional wireless microphones shall meet the requirements of the primary microphone.

4.1.2 The system shall have the option to incorporate a secondary video camera.

4.1.3 The system shall have the capability of recording DME in electronic file format to storage media and electronically transferring the DME to an external device.

4.1.4 The system shall be capable of recording a minimum of one video stream, a minimum of three synchronized audio streams, and the associated metadata.

4.1.5 The system shall be designed such that edges and corners have a minimum 1/8-in (3.2mm) radius or chamfer or be padded with an energy absorbing material to minimize the risk of injury.

4.1.6 The system components shall be capable of being illuminated for ready identification during periods of darkness. The illumination level shall be capable of being controlled over a range from bright to dark. The illumination level shall be set by either a discrete control within the unit itself or by linking to vehicle dash illumination control.

4.1.7 The system shall have an illuminated record indicator readily visible to persons outside the vehicle to the front and passenger side that indicates when the system is actively recording. This indicator light shall be capable of being disabled. A

4.1.8 The system shall have the ability to restrict access to the programming functions, including but not limited to date/time features. A

4.1.9 The system shall have the ability to prevent the user from erasing, altering, and/or recording over previously recorded information from either inside the vehicle or at the recording device controls. A

4.1.10 The system shall not present a risk of electric shock and shall not exceed Class 2 requirements as defined in NFPA 70.

4.2 Camera Requirements (primary and secondary cameras)

4.2.1 The Vehicular DME Recording System shall incorporate as the primary camera a front-facing camera and lens assembly. This assembly shall hereinafter be referred to as the primary camera. It shall conform to the image quality requirements set forth in Section 5.
4.2.2 The primary camera shall be equipped with autofocus, automatic exposure, and automatic white balance.

4.2.3 The secondary camera, if included, shall be capable of automatically transitioning from the visible spectrum only to inclusion of the near-infrared in low light.

4.3 **Microphone Requirements**

4.3.1 The system shall incorporate as the primary microphone a remote wireless microphone and transmitter in a device worn by an officer. The remote wireless microphone and transmitter assembly shall hereinafter be referred to as the primary microphone.

4.3.2 The primary microphone shall contain an integrated antenna.

4.3.3 The primary microphone shall be able to activate audio and video recording from the remote transmitter.

4.3.4 The primary microphone shall transmit audio within FCC-approved frequency bands.

4.3.5 The primary microphone shall contain a memory-free rechargeable battery easily replaced by the user without special tooling.

4.3.6 The system shall incorporate as the secondary microphone a wired microphone mounted in the vehicle.

4.4 **Video and Audio Monitor Requirements**

4.4.1 The video monitor shall have a viewing screen with a diagonal of at least 3 in and shall be able to display color.

4.4.2 The video monitor shall be capable of displaying a live picture from the system camera(s) when the system is on (even if recording is not in progress).

4.4.3 The video monitor viewing screen light level shall be user adjustable and shall be capable of being turned off independently from the rest of the system.

4.4.4 The audio monitor shall provide monitoring of live audio from the microphones as well as recorded sounds during playback mode. The system shall contain a readily accessible control(s) to adjust the volume and enable and disable monitoring of live audio.

4.5 **Accessory Requirements**

4.5.1 Any required accessories shall not interfere with the function of the system. Where systems are provided with required accessories that are attached to or integrated with the system, the system with required accessories installed shall meet all of the design and performance requirements of this standard.
4.5.2 Any optional accessories shall not be required to meet the design and performance requirements of this standard, and the manufacturer shall provide written documentation identifying optional accessories.
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5. Performance Requirements

5.1 Performance Requirements

5.1.1 To declare conformity of a system against this standard, all performance requirements defined in the following sections shall be met for each of the categories listed below:

- Camera Features Requirements
- Microphone Requirements
- System Functional Requirements
- System Operational Requirements
- Security Requirements
- Electrical Safety Requirements
- Electromagnetic Compatibility Requirements
- Environmental Requirements

5.1.2 The system performance shall be evaluated by the test methods referenced within this section or as described in Section 6, and all tests identified in Section 6 shall include the requirements of Section 6.1.

5.1.3 No specific test sequence is required, but the sequence indicated in the requirements above is recommended.

5.2 Camera Feature Requirements

5.2.1 The system shall be tested as specified in Section 6.3 Camera Features Tests and shall meet the requirements below:

5.2.1.1 The cameras shall have a one-touch button to toggle between autofocus and manual focus and be tested according to 6.3. The cameras shall default to autofocus upon system startup and while the vehicle is in motion.

5.2.1.2 The primary camera shall be able to provide a focused image with a field of view of 40 degrees horizontally with the lens set at its normal zoom setting. If the lens is not a zoom lens, the imaging chip and focal length combination shall give a 40-degree horizontal view.

5.2.1.3 The primary camera shall be capable of being rotated 360 degrees on its mount in a horizontal plane or 180 degrees in either direction from its front-facing position without having to loosen any screws or knobs. The camera position shall not shift without intentional intervention from the operator.
5.2.1.4 The secondary camera shall be able to provide a focused image with a field of view of 50 in at an object distance of 30 in. If there is no secondary camera, the primary camera shall be able to provide a focused image with a field of view of 50 in at an object distance of 30 in.

5.2.1.5 The secondary camera shall be capable of automatically transitioning from the visible spectrum to include near-infrared in low light. If there is no secondary camera, then the primary camera shall be capable of being switched into and out of a mode where it can include near-Infrared in low light. When the camera is operating in the near-Infrared region, the requirements of Sections 5.2.3 and 5.3 shall not apply.

5.2.2 The cameras shall be tested for Autoexposure as part of Section 6.4, Dynamic Range Measurement Test, and shall function as specified by the manufacturer.

5.2.3 The cameras shall be tested for Automatic White Balance as part of Section 6.7, Color Fidelity Test, and shall function as specified by the manufacturer.

5.3 **System Functional Requirements**

5.3.1 The system shall demonstrate the following system functional requirements when tested as specified below. These system functional requirements shall not apply when the camera is operating in the visible to near-Infrared portion of the electromagnetic spectrum.

5.3.2 The system shall be tested as specified in Section 6.4, Dynamic Range Measurement Test, and shall have a range of 2.0 log exposure or more.  

5.3.3 The system shall be tested as specified in Section 6.5, Static Resolution Test, and shall be capable of resolving bars that represent one-half of a line pair per in (both lines of equal width, one black and one white) at a frame width of 24 ft.  

5.3.4 The system shall be tested as specified in Section 6.6, Aspect Ratio Test, and shall have an aspect ratio that is within 2% of 1:1.  

5.3.5 The system shall be tested as specified in Section 6.7, Color Fidelity Test, and shall have a mean squared error of less than 205.

5.3.6 The system shall be tested as specified in Section 6.8, Dynamic Modulation Test. The relative modulation shall be at least 50% at 15 miles per h equivalent (mphe) at both high and medium light levels. There shall be no dropped frames. The test shall capture the expected number of frames assuming 30 frames per second and as determined by target motion used in section 6.8.3.1. Each captured frame shall show the target progressing through the frame the expected number of pixels as determined by the target motion used in section 6.8.3.1.  

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5.4 **Microphone Requirements**

5.4.1 The system shall be tested as specified in Section 6.9, Wireless Microphone Test, and all wireless microphones shall meet the requirements below:

5.4.1.1 The wireless microphone shall transmit within FCC-approved frequency bands.

5.4.1.2 The wireless microphone shall be capable of transmitting intelligible audio to the vehicle-mounted recorder and monitor at a range of 1,000 feet, line of sight, under unobstructed and with no interference.\(^A\)

5.4.2 Each wireless microphone’s battery shall be tested as specified in Section 6.2, Battery Life and shall demonstrate a minimum battery-life of 15 h in the passive (standby) mode and 3.5 h in active mode.\(^A\)

5.4.3 All microphones shall be tested as specified in Section 6.10, Microphone Test and shall be capable of capturing sounds greater than or equal to 50 dB sound pressure level at a distance of 1 m within the frequency range of 300 to 3,000 Hz to the minus 6 dB points.

5.5 **System Operational Requirements**

5.5.1 The following system operational requirements shall be demonstrated when tested according to Sections 6.3, 6.4, 6.5, 6.6, 6.7, and 6.8.

5.5.1.1 The system shall have an illuminated record indicator for the purpose of indicating to the operator while outside the vehicle that the system is actively recording. This indicator light shall be able to be disabled by the operator.

5.5.1.2 Video and audio essence shall continue to be presented on the video and audio monitors during periods when the record function may not be initiated.

5.5.1.3 The system shall be capable of monitoring audio transmissions from the wireless microphone(s). The system shall also be capable of playing back previously recorded audio. The system shall contain a readily accessible control(s) to adjust the volume and enable and disable monitoring of audio.

5.5.1.4 The system shall have the ability to record and selectively display on the video monitor at least the following data: date/time, user identification information, emergency light indication, siren indication, braking indication, and system status indicators (video recording on/off, microphone(s) on/off). This data shall be captured for each video frame in the metadata and shall not overwrite image information.

5.5.1.5 The system shall demonstrate proper operation of the following controls\(^A\):

   a) Power on/off
   b) Play
c) Record start
d) Fast Forward
e) Rewind
f) Stop
g) Pause

5.5.1.6 The system shall provide the following indicators and displays:

a) System Power On
b) Microphone On
c) Media inserted and operational with remaining capacity/time available
d) Recording
e) Fast Forward
f) Rewind
g) Stop
h) Record Time Remaining Display
i) Diagnostic Display showing the results as specified in 5.7.1 through 5.7.1.3.

5.5.1.7 The system shall provide the following indicators to the user:

- Low record time remaining warning to activate when 1 h of recording time remains.
- Amount of recording time remaining on the media.

5.5.1.8 The system’s recording functions shall demonstrate activation by any of the following methods:

a) User pushes the “record” button.

b) Activation of the emergency lights and/or sirens.

c) User activates the “record” button on the primary microphone.

5.5.1.9 The system shall not incorporate any automatic triggers to stop recording but shall allow recording to be stopped only with operator intervention.

5.5.1.10 The system shall have a minimum image refresh rate of 30 frames per second per camera.

5.5.1.11 The system shall be capable of recording events uninterrupted for a minimum of 3.5 h at the highest bit rate of DME acquisition supported by the system.
5.5.1.12 The system shall have the ability to correctly reset the date/time either automatically or with user intervention following loss of power.

5.5.1.13 The system shall have the ability of pre-event and post-event DME recording for a minimum of 30 s.

5.5.1.14 The system shall allow the operator to enable or disable the pre-event and post-event audio capture capability while continuing to capture the remaining DME items.

5.5.1.15 The recording device shall indicate when media is not inserted into the recorder.

5.5.1.16 The system shall perform a continuous diagnostic to indicate complete functionality of the recorder, camera, displays, and microphones. The results of the diagnostic shall be documented in the DME Audit Log. Any malfunction should be indicated to the user immediately.

5.6 **Interoperability Requirements**

5.6.1 The following system interoperability requirements shall be demonstrated when tested according to Sections 6.3, 6.4, 6.5, 6.6, 6.7, and 6.8.

5.6.2 The Active Storage Server or the Archival Storage Server shall provide two interoperable formats for export of the DME: original DME export and compressed DME export.

5.6.3 **Original DME Export**

5.6.3.1 The DME (images, sounds, metadata, and DME Audit Log) shall be capable of being exported without compression into an industry-standard file format that is viewable and playable without the need for proprietary codecs, players, or viewers available from only the system manufacturer.

5.6.4 **Compressed DME (Proxy) Export**

5.6.4.1 The DME (images, sounds, metadata, and DME Audit Log) shall be capable of being exported as a compressed copy of the original in industry-standard file formats that are viewable and playable without the need for proprietary codecs, players, or viewers available from only the system manufacturer.

5.6.5 A DME verification check shall be performed to confirm the automatic verification mechanism of Section 5.7.4.1 prior to exporting the original DME.

5.6.6 A verification report shall be included with the original DME export stating the results of a DME verification check.

5.7 **Security Requirements**

5.7.1 The system shall have the capability to restrict unauthorized access to the programming functions including but not limited to time/date features.
5.7.2 The system shall prevent unauthorized erasing, altering, and/or recording over previously recorded information.

5.7.3 Consistency

5.7.3.1 The system shall provide a mechanism to capture the time and date of DME creation. A

5.7.3.2 Time stamping of DME elements (video essence, audio essence, and metadata) shall be consistent within all system components. A

5.7.3.3 The essence and metadata shall remain relatively synchronized.

5.7.3.4 The system recorder clock and active storage system clock shall either maintain synchronization to or be synchronized periodically with a known external reference (e.g. the U.S. Standard of Time). If synchronization is continually maintained to an external reference, it shall be maintained to within 33 milliseconds to that reference. If time clock synchronization is initiated periodically (such as via interface with an archival storage device), the system recorder clock and active storage system clock shall not demonstrate a drift from the external time reference in excess of 1 second over a 400 h time period. A

5.7.4 Transfer of DME

5.7.4.1 All electronic transfer of the DME shall have an automated verification mechanism. Information consisting of a minimum 512-bit hash value shall be attached to the DME when first recorded. The automated mechanism shall not introduce any visible or audible artifacts into the DME.

5.7.4.2 In-Vehicle Storage Media:

5.7.4.3 The storage media shall be secured using a mechanism that prevents unauthorized removal of the storage media from the recorder.

5.7.4.4 If non-removable storage media is being used, it shall be housed inside the recorder to prevent tampering with and/or destruction of the media.

5.7.4.5 Removable media shall contain the following items and markings:

- Tamper detection process;
- Damage protection; and
- The media must be marked on the exterior with an identifying number (or markings) that identifies each media and makes that media unique.
5.7.4.6 If the system uses removable storage media, an integrity check shall be used to validate that the DME on the Active Storage is an exact duplicate of any data on the removable storage media prior to the clearing of the data on the removable storage media.\(^A\)

5.7.4.7 The DME Audit Log shall contain the following items when the DME on a removable media device is transferred to Active Storage\(^A\):

   a) Name or ID (badge number or employee number) of officer or person submitting digital asset for transfer;

   b) A verification check per section 5.7.4.1 shall be performed and logged to validate that the DME transferred to the Active Storage is an exact duplicate prior to any clearing of data on the removable media device.\(^A\)

5.7.4.8 Wired or Wireless Transfer Network Topology

5.7.4.9 A wireless network used to transfer the DME from the recorder to Active Storage shall, at a minimum, use 128-bit encryption to create a secure connection for the DME to be transferred. IEEE standards-based wireless networking equipment shall support the following security standards: customized network name, Disabled SSID/ESSID (Network Name) broadcast, and 128-bit RC4 link encryption. If non-IEEE standards-based wireless networking equipment is used, it should be configured to at least meet the equivalent minimums defined in this section.\(^A\)

5.7.4.10 A wired network used to transfer the DME from the recorder to Active Storage shall be equipped with encrypted line data transmission security, and encryption algorithms of a minimum of 128 bits shall be used to provide protection against a compromise attempt.\(^A\)

5.7.4.11 For systems incorporating encrypted line security, evidence of a certificate of compliance for the validation of encryption algorithms [for example, Federal Information Processing Standards (FIPS) 197 or 46-3] or validation of security requirements for cryptographic modules (for example, FIPS 140-2) shall be provided.

5.8 Electrical Safety Requirements

5.8.1 The system shall comply with safety requirements as specified in IEC 60065-7:2001, Audio, Video, and Similar Electronic Apparatus – Safety Requirements.

5.8.2 The system shall comply with safety requirements as specified in IEC 60950-1, 2nd Edition, including revisions through March 27, 2007, Information Technology Equipment – Safety – Part 1: General Requirements.

5.8.3 Each system primary and secondary battery shall be tested in accordance with UL 1642, Lithium Batteries and/or UL 2054, Household and Commercial Batteries.
5.8.4 The system shall be tested as specified in Section 6.11, Electrical System Safety Tests and shall meet the requirements identified within the test method.

5.9 Electromagnetic Compatibility Requirements

5.9.1 The systems shall be tested as specified in Section 6.12, EMC Tests, and shall meet the requirements of SAE J1113-1:2006, Electromagnetic Compatibility Procedures and Limits for Components of Vehicles, Boats (up to 15 m) and Machines, Except Aircraft.

5.10 Environmental Requirements

5.10.1 The system shall be tested as specified in Section 6.13, Environmental Tests, and shall meet the requirements below.

5.10.1.1 When subjected to the high and low temperature exposures, the system’s video monitor shall function properly, there shall be no missing DME data capture, and there shall be no external system damage.

5.10.1.2 When subjected to the humidity exposure, the system’s video monitor shall function properly, and there shall be no missing DME data capture.

5.10.1.3 When subjected to the mechanical vibration exposure, the system’s video monitor shall function properly, there shall be no missing DME data capture, and there shall be no change in frame width greater than 10%.

5.10.1.4 When subjected to the mechanical shock exposure, the system’s video monitor shall function properly, and there shall be no missing DME data capture.

5.10.2 The system shall comply with environmental requirements as specified in SAE J1455, Recommended Environmental Practices for Electronic Equipment Designed in Heavy Duty Vehicle Applications, June 2006.
6. Test Methods

6.1 General

6.1.1 Typically the performance requirement pass/fail criteria shall be as stated in Chapter 5 Performance Requirements; however, in some cases, the pass/fail criteria is stated within the test method.

6.1.2 Samples

6.1.2.1 Each test shall be performed on one sample representative of the production model unless otherwise specified within the individual test procedure.

6.1.2.2 A complete system shall be furnished as the sample for evaluation. A complete system consists of all components required for evaluation.

6.1.3 Unless the performance requirement is specifically stated as an average result, any individual sample result not meeting the performance requirement shall constitute failing performance.

6.1.4 All test data and observations shall be recorded and reported, including make, model, special settings and accessories tested.

6.1.5 All tests related to image quality shall be performed on uncompressed DME.

6.1.6 The system shall be setup and operated according to the manufacturer’s instructions.

6.1.7 In order to declare conformity for a particular model, all of the following tests must be successfully completed.

6.2 Primary Microphone Battery Life Test

6.2.1.1 Install in the primary microphone new or fully charged batteries of the type specified by the manufacturer. Turn the primary microphone on in the passive mode and allow it to remain on for a continuous 15 h ± 10 min period at a temperature between 19 °C and 23 °C (66 °F and 73 °F). Within 1 h from the end of this period and without changing the batteries, test the primary microphone by performing the Microphone Test specified in Section 6.10.

6.2.1.2 Install in the primary microphone new or fully charged batteries of the type specified by the manufacturer. Turn the primary microphone on in the active mode and allow it to remain on for a continuous 3.5 h ± 10 min period at a temperature between 19 °C and 23 °C (66 °F and 73 °F). Within 1 h from the end of this period and without changing the batteries, test the primary microphone by performing the Microphone Test specified in Section 6.10.
6.2.2 Report

6.2.2.1 Each trial result shall be recorded and reported.

6.2.3 Interpretation

6.2.3.1 This task is evaluated on a pass/fail basis. Each sample shall pass in order for the final result to be considered a pass.

6.3 Camera Features Tests

6.3.1 Samples

6.3.1.1 A complete system consists of all components required for evaluation. This will include the following: primary camera in its housing, secondary camera if part of the system, recorder in its housing, monitor with controls in its housing, speaker in its housing, microphones, cabling, and any software needed to connect to a standard video analysis workstation. A technical representative from the manufacturer shall be available during testing to assure proper set up and use of the equipment.

6.3.1.2 All system controls and adjustment settings shall be recorded and considered as part of the model designation.

6.3.1.3 Testing shall be conducted at ambient conditions that are within the temperature range of 16 °C to 27 °C (60 °F to 80 °F) and 20% to 60% rh.

6.3.2 Initial Conditions

6.3.2.1 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image, or as specified in the specific test. The nominal operating power as described in the system manual shall be applied to the system, and the system shall be turned on.

6.3.3 Procedure

6.3.3.1 Auto/Manual focus: The camera shall be tested to assure that both the automatic and manual focus adjustments perform their respective functions. The camera shall be affixed to a stable mount, such as a tripod. The camera shall be verified to be operating properly by noting a video image on the display. The focus shall be set to autofocus. A star-type test target shall be placed approximately 6 m (20 ft) from the camera. Refer to Appendix A, Figure 1 for a figure representing the star-type test target. The test target shall be illuminated with 200 to 500 lux at a correlated color temperature of 2,800 to 3,200 K. Recording shall be initiated for 5 to 10 s and then stopped. The focus shall be set to manual focus. Recording shall be performed while the focus is manually adjusted slowly, and then recording shall be stopped. This process shall be repeated at a distance of 2 m (6.6 ft). When the recorded video is played back, the circle of blur around the center of the test pattern shall be nominally...
the same for both the autofocus setting and the best setting of the manual focus adjustment series, and during the manual focus testing, the size of the blur circle should change as the focus is changed. Best focus corresponds to the smallest blur circle. The circle of blur will not be the same for both distance settings. Record the results.

6.3.3.2 Field of view: The camera shall be tested to assure that the field of view and the focus ranges are capable of both proper operation at (1) object distance of 10.7 m (35 ft) and frame width of 7.3 m (24 ft) and (2) object distance of 76 cm (30 in) and frame width of 127 cm (50 in). Affix the camera to a stable mount, such as a tripod. Ensure the camera is operating properly by noting a video image on the display. Place a test target, the primary test target, at approximately 10.7 m (35 ft) from the camera such that the optical axis of the camera is nominally perpendicular to the surface of the primary test target. Place two additional test targets, one on either side of the primary test target and each separated from the primary target by approximately 7.3 m (24 ft), parallel to and in the plane of the primary test target. Acquire a video image. Evaluate the image to determine if all three test targets are visible in the video and record the results. Repeat this process except with the primary test target at a distance of approximately 76 cm (30 in) from the camera and with the additional test targets separated from the primary test target by approximately 127 cm (50 in). Record the results.

6.3.3.3 Test for Primary Camera Rotation. The camera on its mount shall be tested to assure that it can turn at least 180 degrees to both the left and the right sides of forward. Use a test platform that emulates the mounting location and procedures for the appropriate vehicle. Attach the camera to the test platform so that when the camera rotation angle is nominally at 0°, the camera is facing forward. Rotate the camera approximately -180° from this position and record any restrictions to this motion. Rotate the camera 360° from this last position and record any restrictions to this motion.

6.3.4 Report

6.3.4.1 Each trial result shall be recorded and reported, and the report shall document the camera make and model and record all system settings at the time of testing.

6.3.4.2 The average of the three trials for each model shall be recorded and reported.

6.3.5 Interpretation

6.3.5.1 This task is evaluated on a pass/fail basis. Each sample shall pass in order for the final result to be considered a pass.

6.4 Dynamic Range Measurement Test

6.4.1 The purpose of this test is to determine the degree to which the system under test will be able to record both light and dark contents in the scenes.
6.4.2 Initial Conditions

6.4.2.1 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image. The nominal operating power as described in the system manual shall be applied to the system, and the system shall be turned on.

6.4.3 Procedure

6.4.3.1 Record several seconds of video of a step tablet, illuminated in a sensitometer, with a brightness range of 10,000 to 1. Use a step tablet approximately 7 cm (2.8 in) by 20 cm (7.9 in) with at least 41 steps approximately 1 cm (0.4 in) wide and of increasingly darker increments of 0.1 transmission optical density per step starting at transmission optical density of nominally 0.05. Allow the camera to use its internal auto brightness and color balance functions.

6.4.3.2 The correlated color temperature of the light should be nominally 2800 K to 3200 K.

6.4.3.3 Select any three frames from the recorded video from Section 6.4.3.1 as per the process provided by the system vendor and open them in a software program such as Adobe Photoshop™.

6.4.3.4 Using a sampling tool that can provide a brightness value for at least five contiguous pixels, measure the red, green, and blue brightness values of each of the steps in each of the three randomly selected frames. Compute the average for each step across the frames.

6.4.3.5 Using the data for the sensitometer, plot the brightness values for each color band for each optical density step of the step tablet as a function of its log (base 10) exposure value, where exposure is in lux·s on the camera sensor but measured in cd/m² as seen by the camera lens and the camera shutter controls the number of seconds. Absolute values are less important than relative values since the camera will use its auto exposure function.

6.4.3.6 Determine the point on the log exposure axis at which the response curve becomes nominally flat with increasing exposure (decreased transmission optical density values on the step tablet). The curve becomes nominally flat at this point due to saturation of the camera and is called the saturation point.

6.4.3.7 Determine the point on the log exposure axis of the response curve where the brightness value is approximately twice that of the noise. This is the threshold point. The noise value is determined by the nominally flat region of the response curve for small exposure (large transmission optical density values on the step tablet).

6.4.3.8 Subtract the threshold point value from the saturation point value. This is the dynamic range in terms of log exposure. (See figure in Appendix A, Figure 2.)
6.5  Static Resolution Test

6.5.1 The purpose of this test is to determine if the system is able to capture images of small items of importance in the typical scenes it is likely to encounter in practice.\textsuperscript{A}

6.5.2 Initial Conditions

6.5.2.1 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image. The nominal operating power as described in the system manual shall be applied to the system, and the system shall be turned on.

6.5.3 Procedure

6.5.3.1 Work at an illuminance in the range from 500 lux to 2000 lux, and record 30 to 60 frames of video of a high-contrast, bar-type resolution test target\textsuperscript{A} at each of four frame width settings:

- Close setting, 3.05 m ± 0.3m (10 ft ± 12 in)
- Normal setting, 7.3 m ± 0.3m (24 ft ± 12 in)
- Moderately long setting, 9.1m ± 0.3m (30 ft ± 12 in)
- Long setting, 10.7 m ± 0.3m (36 ft ± 12 in)

6.5.3.2 The settings can be accomplished by either moving the camera or by using optical zoom. The target shall have several bars of black interspersed with white. The white and black bars shall be of equal width, and the width of each line pair shall be such that it appears to represent 0.5 line pairs/in [that is, the width of the white and black lines are each 2.5 cm (1 in)] at a horizontal field of view of 7.3 m (24 ft). The white bars shall be no darker than 0.1 in reflectivity density, and the black bars shall be at least 1.9 in reflectivity density.\textsuperscript{A} The test target shall also contain an additional set of bars, only these bars will be twice the width of the main set just described. The space surrounding the sets of bars should be medium gray, between 15% and 25% reflectance. In addition, there should be squares of black (optical density greater than 1.9) and white (optical density less than 0.1). These squares should be at least 5 cm (2 in) on a side.

6.5.3.3 Evaluation of the images should be done after the images are converted to gray scale. Select any three video frames at random from each of the four frame width settings and examine them to determine that the bars are separated clearly enough to be counted correctly and that there are the correct number of them. If there are only one or two very dark or very light bars on an almost grayish background, and there are not the right number of bars, there is an aliasing problem. If there is aliasing, those bars
are not resolved. This should be done for both wider and thinner bar sets and all four settings. Visually, the wide bars at the close frame width must be unequivocally clear. That is, there must be dark bars separated by distinct white bars. If this is not the case, the system fails the test.

To confirm the interpretation, adjust the blacks to a zero brightness level and the whites to 255 brightness level for the full image using the brightness of the central areas of black and white squares respectively. This can easily be done using the levels tool of a software package such as Adobe® Photoshop®. Now select the area containing the bars and using the histogram tool, read the standard deviation of the distribution of pixel brightness’s. Do this for all eight sets of bars (wide and narrow bars at four different frame width settings). The standard deviation read for the wide bars at the close frame width setting should be scaled to be 100%, and the scale factor should be applied to all of the other readings. A plot of the scaled standard deviations for each bar set at the four frame width settings will result in two descending curves. Put a quadratic regression line through the two curves and note the percent scaled standard deviation for the normal line set at the main frame width setting of 7.3 m (24 ft). That standard deviation shall be greater than 65%.

6.5.3.4 The target shall have bars that are within 5 degrees of parallel, perpendicular, and 45 degrees with respect to either the rows or columns of the imaging array in the camera.

6.5.3.5 Equivalent geometry may be used.\textsuperscript{A}

6.6 Aspect Ratio Test

6.6.1 The purpose of this test is to determine if the system presents images to the user that have the correct aspect ratio (width to height) so that valid measurements can be made from recorded video.\textsuperscript{A}

6.6.2 Initial Conditions

6.6.2.1 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image. The nominal operating power as described in the system manual shall be applied to the system, and the system shall be turned on.

6.6.3 Procedure

6.6.3.1 Record between 30 and 60 frames of video of a test target with a circle completely inside of a square and an ellipse completely inside of a rectangle. The rectangle shall have a width that is 1.1 times its height. The diameter of the circle shall equal the width of the square. The minor axis of the ellipse shall equal half the height of the rectangle and the major axis of the ellipse shall equal half the width of the rectangle.
6.6.3.2 Select any three frames of the recorded video for capture. Measure the height and width of the circles, squares, rectangles, and ellipses in these frames. Compute the frame average of the heights and widths for the circle, square, rectangle, and ellipse. Compute the ratio of width to height for the circle and square and record these ratios. Compute the ratio of width to height for the rectangle and ellipse, divide these ratios by 1.1, and record the results.

6.7 **Color Fidelity Test**

6.7.1 The purpose of this test is to determine the degree to which the system under test can capture colors accurately so that color can be reliably used to track activity of objects and persons during analyses of recorded video.\(^A\)

6.7.2 **Initial Conditions**

6.7.2.1 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image. The nominal operating power as described in the system manual shall be applied to the system, and the system shall be turned on.

6.7.3 **Procedure**

6.7.3.1 Record 30 to 60 frames of video of a Macbeth Corporation Color Checker\(^TM\). The light should be illuminated by a source with a correlated color temperature of 5000 to 6000 K and between 300 and 400 lux illuminance.\(^A\)

6.7.3.2 Among its many uniform patches, the target (MacBeth Corpt. Color Checker\(^TM\)) has patches of the primary colors (red, green, blue, cyan, magenta, and yellow) and six shades of gray.\(^A\)

6.7.3.3 Determine the three CIE/L*a*b* (Refer to CIE No. 15.2) dimensions for each patch in the test target\(^A\) and record for later comparison to values taken from captured video.

6.7.3.4 Select three frames at random from the video acquired in 6.10.2.1 and open them using an image editing software such as Adobe Photoshop\(^TM\). Measure the three CIELAB dimensions for each patch using a sampling tool with a sampling size of at least 5 x 5 average.\(^A\)

6.7.3.5 Subtract the measured image CIELAB values from the respective target patch CIELAB values (see 6.10.2.2) for all 12 patches.\(^A\)

6.7.3.6 Square the individual differences of the CIELAB values and sum them.\(^A\)

6.7.3.7 Divide the previous result by 36 (the number of values), which gives the CIELAB mean squared error.\(^A\)
6.7.4 Clarification

6.7.4.1 The Commission Internationale d’Eclairage (CIE) is an organization that in 1931 published a color space definition that was supposed to represent how humans see color. This was revised in 1976 to provide a more accurate representation. The new space is referred to as CIE 1976 \((L^*, a^*, b^*)\) color space, or more briefly as CIE/L*a*b*, or CIELAB. The \(L\) dimension gives the lightness of a color and runs from black, through shades of gray to white. The \(a\) and \(b\) dimensions are mathematical constructions and give the hue and saturation of a particular color. All three dimensions are mathematically independent of each other.

6.8 Dynamic Modulation Test

6.8.1 The purpose of this test is to determine the ability of the system under test to reproduce moving portions of the scene that are moving as a function of their size, velocity, and scene brightness. It invokes the system’s shutter function, compression function, and image capture process.\(^A\)

6.8.2 Initial Conditions

6.8.2.1 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image. The nominal operating power as described in the system manual shall be applied to the system, and the system shall be turned on.

6.8.3 Procedure

6.8.3.1 The system shall be turned on. Move a test target across the field of view in a horizontal direction relative to the camera. If the target is accelerating as it moves, it will capture a series of frames in which the target is moving at increasing velocities. The range of velocities should vary from 0 mphe to at least 40 mphe. The equivalency is the actual target rate as it would be seen if it were at that velocity at an object distance of 10.7 m (35 ft) with a horizontal field of view of 7.3 m (24 ft). Record DME as the target moves from standstill to maximum velocity. Allow the camera to use its internal auto brightness and white balance functions. (See Appendix A, Figure 3.)

6.8.3.2 The test target should move across the video frame and it should cover at least 40% of the frame (vertical) height.\(^A\)

6.8.3.3 The test target should have two series of white and black bars that are the equivalent of two and four in wide each respectively.\(^A\) The white bars should have optical reflection density of no more than 0.1 and the black bars should have optical reflection density of at least 1.9. The white and black bars should be equally wide.
6.8.3.4 The test target will be illuminated at two illuminance levels: one level between 1,800 lux and 2,200 lux incident and the other level between 9,000 and 10,000 lux incident at a correlated color temperature between 2,800 and 5,600 K. A

6.8.3.5 Capture the frames from both the high and low light level runs and open them in an editing software package such as Adobe Photoshop™. A

6.8.3.6 Render the images as grayscale images from 0 to 255 brightness values. A

6.8.3.7 Measure the brightness levels of the dark and light bars at their nominal centers using a sampling tool. A

6.8.3.8 Subtract the dark bar values from the light bar values for each frame to determine the modulation for that frame. A Calculate the equivalent velocity of the test target for each frame. The equivalent velocity is computed by considering the size of the frame and the distance to the test target. The formula for equivalent velocity (velocity of a free-falling body as a function of distance) is provided in Equation 1.

Equation 1
\[ v = \sqrt{2 \times g \times d} \]

Where:  
\( v \) = velocity  
\( g \) is the acceleration due to gravity  
\( d \) = distance

Since this test is done at \( \frac{1}{4} \) scale, the equivalent velocity will be \( \frac{1}{4} \) times the value calculated in this equation. To calibrate the device, \( g = 32.17 \) feet per second per second. The distance fallen, \( d \), is given in feet, and the resulting velocity will be in feet per second. This can be converted to mph using 5,280 feet per mile.

6.8.3.9 Normalize the modulation for each velocity by dividing it by the modulation of the stationary test target (see Section 6.6).

6.8.3.10 Plot the relative modulation for each frame as a function of the velocity of the target for that frame. A Connect the points and smooth the curve near its mid-point. Record the equivalent velocity at which the curve crosses the 50% modulation level. Do this for both the high and low light runs.

6.9 Wireless Microphone Test

6.9.1 This test is designed to determine if the audio system delivers intelligible audio when the microphone is transmitting to the receiver at a distance of 1,000 feet. A
6.9.2 Initial Conditions

6.9.2.1 The system shall have an empty DME storage device prior to the beginning of this test. The nominal operating power as described in the system manual shall be applied to the system, and the system shall be turned on.

6.9.3 Test Equipment

6.9.3.1 The following equipment is required for this test: CD of Modified Rhyme Test with Babble (Cosmos Dist. Inc. or equivalent), audio CD player, 2 matched microphones, audio oscillator, oscilloscope, frequency independent delay line, audio signal inverter, signal mixer, true RMS voltmeter, and headphones.

6.9.4 Procedure

6.9.4.1 Connect the equipment as shown in the Microphone to Receiver Test Schematic provided in Appendix A, Figure 6. Items specified below are indicated in the figure.

6.9.4.2 Fix the relative locations of items 1, 2, and 3 so that they can be moved without changing their positioning.

6.9.4.3 Place the sound source equipment (items 1, 2, 3, and 11) at least 50 feet from the receiver, item 4. Drape the 1,000 feet of microphone cable sinuously as opposed to leaving it on a coil to minimize any inductance effects.

6.9.4.4 Send a sine wave from item 11 to item 1 at approximately 440 Hertz (A above middle C) and set the volume controls to assure that there is no clipping visible on the oscilloscope, item 9 when sent via the reference track, 3, 7, 6, and 12.

6.9.4.5 Check the device under test (DUT) track, 2, 4, 5, and 6 and readjust volume levels to assure strong signal with minimal clipping.

6.9.4.6 Adjust the delay line, item 12, and the mixer gain on the reference track such that the oscilloscope indicates that the DUT track and the reference track signals are in phase.

6.9.4.7 Adjust the mixer gains for both tracks so that they are close to the same level. Invert the reference track polarity, item 7, and further adjust the gain controls to minimize the now bucked-out signals. Using the meter, item 8, check to see that the polarity reversal reduces the signal by a factor of at least 10:1 (linear voltage).

6.9.4.8 Record the settings and do not change them.
6.9.4.9 Play the Intelligibility CD speech plus babble rhyming words tracks and record at least 50 words, starting at some random point on the answer sheets. Record the signal on the computer as this is done. Repeat and record the reference signal track.

6.9.4.10 Move the sound source equipment (items 1, 2, 3, and 11) one thousand feet from the receiver, item 4. The remote site and the receiver site should be connected by 1,000 feet of nominally clear, line-of-sight pathway. There should be no large metallic structures (bridges, large overhead signs, marquees, etc.).

6.9.4.11 Using the A above C frequency and the polarity switch, note the degree of cancellation. It should be at least 8:1.

6.9.4.12 Adjust the speech and babble track volume levels such that the combination is 3 db (sound pressure level) above the babble alone. Play the Intelligibility CD speech plus babble rhyming words tracks and record at least 50 words on the answer sheets. Record the signal on the computer as this is done. Repeat and record the reference track.

6.9.4.13 The system should produce at least 45 out of 50 words intelligibly.

6.9.5 Report

6.9.5.1 Each trial result shall be recorded and reported.

6.9.6 Interpretation

6.9.6.1 This task is evaluated on a pass/fail basis. Each sample shall pass in order for the final result to be considered a pass.

6.10 Microphone Test

6.10.1 Initial Conditions

6.10.1.1 The system shall have an empty DME storage device prior to the beginning of this test. The nominal operating power as described in the system manual shall be applied to the system, and the system shall be turned on.

6.10.2 Test Equipment

6.10.2.1 The following test equipment is required for this test: CD of Modified Rhyme Test with Babble (Cosmos Dist. Inc. or equivalent), audio CD player, 2 matched microphones, audio oscillator, oscilloscope, frequency independent delay line, audio signal inverter, signal mixer, true RMS voltmeter, headphones, and computer for data collection.
6.10.3 Procedure

6.10.3.1 Place the microphone being tested a distance of one meter from the sound source.

6.10.3.2 Adjust the babble track to produce a sound pressure level of 50 db and adjust the balance control to give a combined speech and babble sound pressure level of 53 db.

6.10.3.3 Play the Intelligibility CD speech plus babble rhyming words tracks and record at least 50 words on the answer sheets. Record the signal on the computer as this is done.

6.10.3.4 The system should produce at least 45 out of 50 words intelligibly.

6.10.3.5 Connect an audio oscillator to an amplifier and speaker in order to produce a sound pressure level of 60 db.

6.10.3.6 Place the microphone under test four feet from the source.

6.10.3.7 Systematically adjust the oscillator to 300, 350, 440, 600, 1,200, 2,000, 2,500, and 3,000 Hz.

6.10.3.8 Place a sound pressure meter within 6 in of the system output speaker. Set it to measure a-filtration and at least one second integration time sound levels.

6.10.3.9 Record the measured sound levels as a function of input frequency. Average the values between 350 Hz and 2,500 Hz. This is the average output value. The values at 300 Hz and at 3,000 Hz can be no more than 6 db below the average output value.

6.10.4 Report

6.10.4.1 Each trial result shall be recorded and reported.

6.10.4.2 The average of the three trials for each model shall be recorded and reported.

6.10.5 Interpretation

6.10.5.1 This task is evaluated on a pass/fail basis. Each sample shall pass in order for the final result to be considered a pass.
6.11  Electrical System Safety Tests

6.11.1  Test Conditions

6.11.1.1  Unless otherwise specified within a given test method, the following conditions shall be established within the test environment and maintained throughout the test:
   a)  Ambient temperature at 23 ± 3°C (73.4 ± 5°F)
   b)  Relative humidity at 50 ±20%,
   c)  Supply voltage, if applicable, adjusted to 100% of rated input voltage.

6.11.2  Electrical Supervision Test

6.11.2.1  This test is based on UL 983, Standard for Surveillance Camera Units, Section 28 with modifications added from UL 2075, Standard for Safety Gas and Vapor Detectors and Sensors.

6.11.2.2  Power shall be applied to the system.

6.11.2.3  Malfunctioning of an electronic component, such as opening or shorting of a capacitor, shall either not impair the intended operation or shall be indicated by a trouble signal, or the product shall be provided with a test feature as described in Section 6.11.2.5 below.

6.11.2.4  A surveillance camera unit shall be electrically supervised so that a malfunction of the power supply or loss of primary power shall result in the extinguishing of a visual “power on” indicator.

6.11.2.5  A manual test method provided as a part of the operation of the system which effectively tests the capability of the critical components may be used in lieu of electrical supervision.

6.11.2.6  A critical component is one whose failure impairs the operation of the product, or results in risk of fire or electric shock.

6.11.2.7  If failure of a critical, limited life electronic component, such as opening or shorting of an electrolytic capacitor, is not indicated by a trouble signal, then a reliable component shall be used. The reliable component shall fall within the reliability prediction described below:
   •  Component, Limited-life: A component that is expected to fail and be periodically replaced and the failure of which is supervised, when failure of the component affects the intended operation. Typical examples of such components include incandescent lamps, electronic tube heaters, and functional heating elements.
• Component, Reliable: A component that is not expected to fail or be periodically replaced and is not supervised. A reliable component shall have a predicted failure rate of 2.5 or less failures per million h as determined for “Ground Fixed” (GF) environment by MIL-HDBK 217F, or equivalent.

6.11.2.8 All results shall be recorded and reported.

6.11.3 Field Connection Leads Test

6.11.3.1 This test is based on UL 983, Standard for Surveillance Camera Units, Section 42.2.

6.11.3.2 Each lead used for field connections, including a battery clip lead assembly, shall withstand for 1 minute a pull of 10 lbf (44.5 N) without any evidence of damage or of transmittal of stress to internal connections. The means of affording strain relief does not meet the requirement when, at the point of connection of the conductors, there is movement of the wire indicating stress has been transmitted to the connections.

6.11.3.3 When the strain relief is dependent upon a polymeric material, the requirement above is to be completed after the Mold Stress-Relief Distortion Test specified in UL 746C, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, is conducted.

6.11.3.4 All results shall be recorded and reported.

6.11.4 Current Protection Test

6.11.4.1 This test is based on UL 983, Standard for Surveillance Camera Units, Section 26.

6.11.4.2 Internal damage to circuitry shall not result when field wiring terminals are accidently shorted or jumped to power supply terminals. See also below.

6.11.4.3 A power source of rated voltage shall be connected between the terminal under test and ground.

6.11.4.4 All connections to power terminals and input and output lines shall be reversed as pairs, individually or connected to any terminal adjacent to the correct one.

6.11.4.5 When damage results from the incorrect connection specified above, then markings clearly visible to the installer during installation shall warn of consequences of unintended connection. When correct polarity is required, then polarity markings shall appear immediately adjacent to wiring terminals.
6.11.4.6 All results shall be recorded and reported.

6.11.5 Current Input Test

6.11.5.1 This test is based on UL 983, *Standard for Surveillance Camera Units*, Section 27.

6.11.5.2 The input current of the system shall not exceed 110% of the unit’s marked input current, power, or V-A rating while connected to a source of supply in accordance with the requirements below.

6.11.5.3 The test voltage for this test is to be the maximum rated voltage for the product. For a product having a single voltage rating, such as 115 V, maximum rated voltage is to be that single voltage. When the voltage is given in terms of a range of voltages, such as 110 – 120 V, the maximum rated voltage is the highest value of the range.

6.11.5.4 Power shall be applied to the system as specified above, and the input current shall be measured.

6.11.5.5 All results shall be recorded and reported.

6.11.6 Overvoltage Test

6.11.6.1 This test is based on UL 983, *Standard for Surveillance Camera Units*, Section 29 with modifications as indicated.

6.11.6.2 Three units shall be subjected to this test.

6.11.6.3 The system shall operate as fully intended when connected to a supply source of 110% of the rated value. When the rated value is a voltage range, the overvoltage level shall be 110% of the higher limit of the range.

6.11.6.4 The system shall be tested for its intended operation with the minimum number of cameras and/or microphones connected, as specified by the installation instructions.

6.11.6.5 The system shall be energized in standby condition at the overvoltage level for a minimum of 16 h and then tested as specified in Section 6.5 Static Resolution Test.

6.11.6.6 The results for each unit shall be recorded and reported.
6.11.7 Undervoltage Test

6.11.7.1 This test is based on UL 983, *Standard for Surveillance Camera Units*, Section 29 with modifications as indicated.

6.11.7.2 Three units shall be subjected to this test.

6.11.7.3 The system shall operate as fully intended when energized from a supply source of 85% of the test voltage specified by the manufacturer. The system shall be tested for intended operation with the minimum number of cameras and/or microphones connected, as specified by the installation instructions.

6.11.7.4 For devices provided with a standby battery, the test is to be conducted at 85% of the charged battery voltage. When the standby battery provides a trouble signal requiring replacement at higher than 85% of the charged battery voltage, the test is to be conducted at the battery trouble signal voltage level.

6.11.7.5 The system shall be energized at the rated voltage. After that, the voltage is to be reduced to 85% of this level, and battery operated devices are to be operated at the trouble level voltage. The systems shall then be tested for proper operation.

6.11.7.6 The results for each unit shall be recorded and reported.

6.11.8 Static Discharge Test

6.11.8.1 This test is based on UL 2075, *Standard for Gas and Vapor Detectors and Sensors*, with modifications as indicated.

6.11.8.2 Two units shall be subjected to this test.

6.11.8.3 The test shall be conducted in an ambient temperature of $23 \pm 3 \, ^\circ C (73.4 \pm 5 \, ^\circ F)$, at a relative humidity of $10 \pm 5 \%$ and a barometric pressure of not less than 700 mm of mercury (93 kPa).

6.11.8.4 The system shall be mounted in its intended mounting position and connected to a source of supply at the rated level. If the system is intended to be installed on a metal junction box, the device is to be connected to earth ground. A 250-picofarad, low-leakage capacitor, rated 10,000 V dc, is to be connected to two 3-foot (0.9-m) leads which are rated for more than 30 V. A 1500-ohm resistor is to be inserted in series with one lead. The end of each lead is to be attached to a 1/2-in (12.7-mm) diameter metal test probe with a spherical end and mounted on an insulating rod. The capacitors are to be charged by touching the ends of the test leads to a source of
10,000 V dc for a minimum of 2 seconds for each discharge. One probe shall be touched to the system, and the other probe shall then be touched to earth ground.

6.11.8.5 Ten discharges shall be applied to different points on the exposed surface of the device. The capacitors shall be recharged for each discharge. Five discharges of positive polarity shall be made with one lead connected to earth ground and the other lead probed on the system surface followed by five discharges with the polarity reversed.

6.11.8.6 For a VDMERS intended to be serviced by the user, ten additional discharges shall be applied as described above, except each lead shall be probed, in turn, on all internal parts capable of being contacted by the user.

6.11.8.7 Following all discharges, the system shall be tested for normal operation when tested as specified in Section 6.5 Static Resolution Test.

6.11.8.8 The results for each unit shall be recorded and reported.

6.11.9 Dielectric Voltage-withstand Test

6.11.9.1 This test is based on UL 983, *Standard for Surveillance Camera Units*, Section 38 with modifications as indicated.

6.11.9.2 Power shall not be applied to the system during this test.

6.11.9.3 A product shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 to 75 hertz, or a DC potential, between live parts and the enclosure, between live parts and exposed dead metal parts, and between live parts of circuits operating at different potential or frequencies. The test potential is to be as follows (see also section 6.11.9.4 below):

(a) For a unit rated 30 V ac rms (42.4 V dc or ac peak) or less: 500 V ac (707 V, when a dc potential is used).

(b) For a unit rated between 31 and 150 V ac rms: 1000 V ac (1414 V, when a dc potential is used).

6.11.9.4 Exposed dead metal parts are noncurrent-carrying metal parts that are capable of becoming energized and are accessible from outside of the enclosure during operation with the door of the enclosure closed.

6.11.9.5 For the application of a potential between live parts of circuits operating at different potentials or frequencies, the voltage is to be the applicable value specified in section
6.11.9.3 (a) or (b) based on the highest voltage of the circuits under test instead of the rated voltage of the unit. Electrical connections between the circuits are to be disconnected before the test potential is applied.

6.11.9.6 When the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is sufficient to prevent maintenance of the specified AC test potential, the capacitor or filter is to be tested using a DC test potential in accordance with 6.11.9.3.

6.11.9.7 The test potential shall be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. The method of applying the test voltage is to be such that there are no transient voltages that result in the instantaneous voltage applied to the appliance or circuit exceeding 105% of the peak value of the specified test voltage. The applied potential is to be:

(a) Increased from 0 at a uniform rate so as to arrive at the specified test potential in approximately 5 seconds, then

(b) Maintained at the test potential for 1 minute without an indication of a breakdown or leakage of greater than 0.5 mA. Control of the rate of rise shall be either manual or automatic.

6.11.9.8 A printed wiring assembly or other electric circuit component that would be damaged by, or would short-circuit, the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly is then to be tested instead of an entire unit. Where applicable, rectifier diodes in the power supply are to be individually shunted before the test to avoid destroying them in the case of a malfunction elsewhere in the secondary circuits.

6.11.9.9 The system shall be powered and tested as specified in Section 6.5 Static Resolution Test.

6.11.9.10 All results shall be recorded and reported.

6.11.10 Temperature Test

6.11.10.1 This test is based on UL 983, Standard for Surveillance Camera Units, Section 39 with modifications as indicated.

6.11.10.2 Power shall be applied to the system during this test.

6.11.10.3 The values for temperatures in the table in Appendix B are based on an assumed ambient temperature of 25 ± 15°C (77 ± 27°F), and tests are to be conducted at an ambient temperature within that range. A temperature is determined to be constant...
when there is no change in three successive readings taken at intervals of 10% of the previously elapsed duration of the test but not less than 5 minute intervals.

6.11.10.4 All values for temperature rises apply to equipment intended for use with ambient temperatures normally prevailing in occupiable spaces which usually are not higher than 25°C (77°F). When equipment is intended specifically for use with a prevailing ambient temperature constantly more than 25°C (77°F), the test of the equipment is made with the higher ambient temperature, and the allowable temperature rises specified in Table 38.1 are to be reduced by the amount of the difference between the higher ambient temperature and 25°C (77°F). A temperature is considered to be constant when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5 minute intervals, indicate no change.

6.11.10.5 Temperature measurements on equipment intended for recessed mounting shall be made with the unit installed in an enclosure of 3/4-in (19.1-mm) wood having clearances of 2 in (50.8 mm) on the top, sides and rear, and the front extended to be flush with the unit’s cover.

6.11.10.6 Except at coils, temperatures are to be measured by thermocouples consisting of wire not larger than 24 AWG (0.21 mm2) or by the change-in-resistance method. The thermocouple method is not to be employed for a temperature measurement at any point where supplementary thermal insulation is employed.

6.11.10.7 Thermocouples consisting of 30 AWG (0.06 mm) iron and constantan wires and a potentiometer-type indicating instrument are to be used whenever referee temperature measurements by thermocouples are necessary.

6.11.10.8 The temperature of a coil winding may be determined by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature by means of the formula:

$$\Delta t = R / r (k + t_1) - (k + t_2)$$

In which:
- \(\Delta t\) is the temperature rise to be determined in degrees C,
- \(R\) is the resistance in ohms at end of test,
- \(r\) is the resistance in ohms at the start of test,
- \(k\) is 234.5 for copper or 225.0 for electrical conductor grade aluminum,
- \(t_1\) is the room temperature at start of test in degrees C, and
- \(t_2\) is the room temperature at end of test in degrees C.
6.11.10.9 To determine compliance with the requirements of above, the product is to be connected to a supply circuit of rated voltage and frequency and operated continuously under representative service conditions that will produce the highest temperature.

6.11.10.10 The duration of the test operating condition is to not be less than:
(a) Operation until constant temperatures are attained during the standby condition.
(b) Operation for 1 h of recording operation of a unit designed to operate continuously until it is restored to the standby condition.

6.11.10.11 All results shall be recorded and reported.

6.11.11 Polymetric Materials Tests

6.11.11.1 Polymeric materials used as an enclosure, or for the support of current-carrying parts, shall comply with the applicable portion of UL 746C, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations.

6.12 EMC Tests

6.12.1 Initial Conditions

6.12.1.1 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image. The nominal operating power as described in the system manual shall be applied to the system, and the system shall be turned on.

6.12.2 Procedure Conducted Emissions

6.12.2.1 This section details the procedure for measuring the electrical emissions applied back into the input power system.

6.12.2.2 The SAE J1113/41 details the method and limits for this test. The class 3 limits defined in paragraph 6.2 table 4 shall be applied.

6.12.3 Procedure Conducted Immunity

6.12.3.1 This section details the procedure for evaluating the ability of the system to reject signals that might be present on the input power system.

6.12.3.2 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image. The SAE J1113/11 details the method and limits for this test.
6.12.4 Procedure Radiated Susceptability

6.12.4.1 This section details the procedure for evaluating the ability of the system to be operated while being exposed to radiated electrical signals.

6.12.4.2 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image. The SAE J1113/21 details the method and limits for this test. The level 3 limits defined table B1 shall be applied.

6.12.5 Procedure Radiated Emissions

6.12.5.1 This section details the procedure for evaluating the amount of radiated electrical emissions that is generated by system.

6.12.5.2 The system shall have an empty DME storage device prior to the beginning of this test. There shall be sufficient light for the system to capture an image. The SAE J1113/21 details the method and limits for this test. The level 3 limits defined table B1 shall be applied.

6.13 Environmental Tests

6.13.1 Samples

6.13.1.1 For each model being considered, one sample shall be submitted for testing.

6.13.1.2 Complete systems shall be furnished for evaluation. A complete system consists of all components required for evaluation.

6.13.2 Test Targets and Equipment

6.13.2.1 The high temperature, low temperature, and humidity chamber test target shall be an analog clock with a diameter chosen in combination with the camera lens focal length and the distance to the clock such that the clock face fills at least 33% of the video frame’s area.

6.13.2.2 The mechanical vibration and mechanical shock test target shall be created as follows: Place numbered vertical black lines on a sheet that is as wide as indicated in Table 1, or a linear interpolation of the chart. The sheet should be ¾ the width in height. The lines should be centered vertically and on a white background. From two inches above and two inches below the lines the background of the sheet should be gray with a reflectance between 15% and 25%.
Table 1. Dimensions for Test Target.

<table>
<thead>
<tr>
<th>Distance from camera (ft)</th>
<th>Width of sheet (ft)</th>
<th>Separation of lines (ft)</th>
<th>Width of lines (in)</th>
<th>Height of lines (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.0</td>
<td>15.0</td>
<td>3.0</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>17.5</td>
<td>7.50</td>
<td>1.5</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>8.75</td>
<td>3.75</td>
<td>0.75</td>
<td>0.5</td>
<td>4</td>
</tr>
</tbody>
</table>

6.13.3 High Temperature Exposure Procedure

6.13.3.1 The system shall have an empty DME storage device and a fully charged battery for the primary microphone prior to the beginning of this test. The system shall be placed inside a chamber such that the camera is viewing through a clear window at the test target. The system’s video monitor shall either be visible through the window or shall be recorded via video camera during this test. The test target shall have sufficient illumination to allow the system to capture an image. Power shall be applied to the system, and the system shall be placed in the record mode.

6.13.3.2 The chamber temperature shall be increased to from room temperature to 120 ºF over a 1-h period. The chamber will stay at the 120 ºF +/- 5 ºF for a period of 1 h. During this period, the system shall continue to record. The functionality of the video monitor shall be observed and recorded at the end of the 1-h period.

6.13.3.3 After 30 min, obscure the window for 1 min. The chamber temperature shall then be decreased to room temperature over a 1-h period. During this period, the system shall continue to record.

6.13.3.4 The stored data shall be examined for any missing DME data capture by performing the DME Verification Test specified in Section 6.13.10. The exterior of the system shall be inspected for any damage. The functionality of the video monitor shall be observed.

6.13.3.5 All results and observations shall be recorded and reported.

6.13.4 Low Temperature Exposure Procedure

6.13.4.1 The system shall have an empty DME storage device and a fully charged battery for the primary microphone prior to the beginning of this test. The system shall be placed inside a chamber such that the camera is viewing through a clear window at the test target. The system’s video monitor shall either be visible through the window or shall be recorded via video camera during this test. The test target shall have
sufficient illumination to allow the system to capture an image. Power shall be applied to the system, and the system shall be placed in the record mode.

6.13.4.2 The chamber temperature shall be decreased from room temperature to 30 °F over a 1-h period. The chamber will stay at the 30 °F +/- 5 °F for a period of 1 h. During this period, the system shall continue to record. The functionality of the video monitor shall be observed and recorded at the end of the 1-h period.

6.13.4.3 After 30 min, obscure the window for 1 min. The chamber temperature shall then be increased to room temperature over a 1-h period. During this period, the system shall continue to record.

6.13.4.4 The stored data shall be examined for any missing DME data capture via performing the DME Verification Test specified in Section 6.13.10. The exterior of the system shall be inspected for any damage. The functionality of the video monitor shall be observed.

6.13.4.5 All results and observations shall be recorded and reported.

6.13.5 Humidity Exposure Procedure

6.13.5.1 The system shall have an empty DME storage device and a fully charged battery for the primary microphone prior to the beginning of this test. The system shall be placed inside a chamber such that the camera is viewing through a clear window at the test target. The system’s video monitor shall either be visible through the window or shall be recorded via video camera during this test. The test target shall have sufficient illumination to allow the system to capture an image. Power shall be applied to the system, and the system shall be placed in the record mode.

6.13.5.2 The chamber temperature shall be increased from room temperature to 100 °F over a 1-h period, and the chamber humidity shall be increased to 90% rh over that 1-h period. The chamber will stay at these conditions for a period of 1 h. During this period, the system shall continue to record. The functionality of the video monitor shall be observed and recorded at the end of the 1-h period.

6.13.5.3 The chamber temperature shall then be decreased to the initial temperature and humidity conditions over a 1-h period. During this period, the system shall continue to record.

6.13.5.4 The stored data shall be examined for any missing DME data capture by performing the DME Verification Test specified in Section 6.13.10. The functionality of the video monitor shall be observed.
6.13.5.5 All results and observations shall be recorded and reported.

6.13.6 Mechanical Vibration Exposure Procedure

6.13.6.1 The system shall have an empty DME storage device and a fully charged battery for the primary microphone prior to the beginning of this test. The system shall be mounted on a vibration plate utilizing the system’s provided mounting hardware, and the camera shall be aimed at the test target. If multiple mounting kits are provided with the unit, the test shall be performed with each mounting kit. The test target shall have sufficient illumination to allow the system to capture an image. Power shall be applied to the system, and the system shall be placed in the record mode.

6.13.6.2 Prior to running the test, set the camera zoom to its longest focal length, but be sure there are at least three lines in the frame. Focus on the test target. Make sure that at least three vertical lines are in the frame. The system under test should be running at least a few seconds prior to, during the test, and a few seconds after the vibration is applied. Extract a frame from before the application of vibration (before frame).

6.13.6.3 The system shall be subjected to a random vibration tests detailed in SAEJ1445 as outlined in paragraph 4.10. The vibration profiles depicted in figures 6, 7 and 8 of SAEJ1445 will be used. The system shall be exposed to these levels for a period of 15 minutes for each of the profiles for a total exposure time of 45 minutes. During the exposure to the random vibration, the system shall continue to capture DME data. Following each profile, the position of the camera shall be examined. A change of >10% of the frame width shall constitute a failure.

6.13.6.4 At the conclusion, the stored data shall be examined for any missing DME data capture by performing the DME Verification Test specified in Section 6.13.10. The functionality of the video monitor shall be observed.

6.13.6.5 Extract a frame from after the vibration is turned off (after frame). Measure the number of pixels across the displayed frames for the system under test. Measure the number of pixels between lines from both the before and after frames. Any change over 3% indicates an unacceptable change in the zoom setting due to vibration. Compare the edges of the lines on both the before and after frames. Visually different sharpness indicates an unacceptable change in focus. Measure the number of pixels from the left hand edge of the before frame to the closest (to the left edge) vertical line and note the line’s number. Repeat this measurement for the after frame. Subtract the pixel count for the after frame from that of the before frame and divide this by the number of pixels across the frame to get the percent frame movement. The percent frame movement should be less than 10% in either direction (in magnitude).
6.13.7 Mechanical Shock Exposure Procedure

6.13.7.1 The system shall have an empty DME storage device and a fully charged battery for the primary microphone prior to the beginning of this test. The system shall be mounted on a vibration plate utilizing the system’s provided mounting hardware, and the camera shall be aimed at the test target. If multiple mounting kits are provided with the unit, the test shall be performed with each mounting kit. The test target shall have sufficient illumination to allow the system to capture an image. Power shall be applied to the system, and the system shall be placed in the record mode.

6.13.7.2 Prior to running the test, set the camera zoom to its longest focal length, but be sure there are at least three lines in the frame. Focus on the test target. Make sure that at least three vertical lines are in the frame. The system under test should be running at least a few second prior to, during the test, and a few seconds after the mechanical shock is applied. Extract a frame from before the application of vibration (before frame) and one from after the vibration is turned off (after frame).

6.13.7.3 The system shall be subjected to random tests detailed in SAEJ1445 as outlined in paragraph 4.11.3.4. The mechanical shock profile is depicted in figure 12. The mechanical shock shall be applied to each of the three mutually perpendicular axes. Each axis will subjected to three mechanical shock pulses. During the exposure to the mechanical shock pulses, the system shall continue to capture DME data. Following each of the exposures, the stored data shall be examined for any missing DME data capture by performing the DME Verification Test specified in Section 6.13.10. The functionality of the video monitor shall be observed.

6.13.7.4 Extract a frame from after the exposure to shock (after frame). Measure the number of pixels across the displayed frames for the system under test. Measure the number of pixels between lines from both the before and after frames. Any change over 3% indicates an unacceptable change in the zoom setting due to vibration. Compare the edges of the lines on both the before and after frames. Visually different sharpness indicates an unacceptable change in focus. Measure the number of pixels from the left hand edge of the before frame to the closest (to the left edge) vertical line and note the line’s number. Repeat this measurement for the after frame. Subtract the pixel count for the after frame from that of the before frame and divide this by the number of pixels across the frame to get the percent frame movement. The percent frame movement should be less than 10% in either direction (in magnitude).

6.13.7.5 All results and observations shall be recorded and reported.

6.13.8 Report

6.13.8.1 Each trial result shall be recorded and reported.
6.13.9 Interpretation

6.13.9.1 This task is evaluated on a pass/fail basis. Each sample shall pass in order for the final result to be considered a pass.

6.13.10 DME Verification Test

6.13.10.1 To be defined.
7. Labeling and Information

7.1 General Product Label Requirements

7.1.1 The system shall have a product label permanently and visibly attached to, stamped on, or printed on each component of the system.

7.1.2 All text on the required product label shall be at least in English.

7.1.3 Symbols and other graphical information shall be permitted to be used to supplement text on the product label(s) and shall be explained in the user information.

7.1.4 Each component of the system shall have at least the following information printed legibly on the label(s) in letters at least 2 mm (1/16 in) high:

- Manufacturer’s name, identification, or designation.
- Manufacturer’s address.
- Date of manufacture.
- Model number
- Serial number.
- Optional components and accessories tested with the system.

7.2 User Information

7.2.1 The manufacturer shall provide user information including, but not limited to, warnings, information, and instructions with each complete system or component, if sold separately.

7.2.2 The manufacturer shall include the required user information to the system in such a manner that it is not possible to use the system without being aware of the information.

7.2.3 The manufacturer shall provide at least the following instructions and information with each system:

- Instructions for proper use as intended by the manufacturer, including safety considerations.

- Warranty information.

- Proper care instructions, including maintenance, cleaning, inspection guidelines and frequency, recommended operating temperature range, recommended storage practices and storage life, and cautions.
• If any of the components of the base unit are not dedicated exclusively to supporting the functionality of the system, it shall be noted that the ability of the system to share resources is not addressed under the scope of this standard, and it is recommended that a risk analysis be conducted by the end user to ensure that the system is interoperable with other equipment.

• Guidelines on the storage media life-cycle.

• Accessories tested with the system.

7.3 Technical Documentation

7.3.1 Upon request of the purchaser, the manufacturer shall furnish technical documentation for the system, including all documentation required by this standard.

7.3.2 The technical documentation shall include the manufacturer trade name, model number, manufacturer-replaceable components, available options, and accessories.

7.3.3 The technical documentation shall address accessories provided for use with the system. Any manufacturer-recommended accessories shall be considered to be tested as part of the system.
Appendix A. Figures

Figure 1. Star-type Test Target.
Figure 2. Schematic for Capturing Video for Measurement of Dynamic Range

Schematic for Capturing Video for Measurement of Dynamic Range
(not to scale)

Step tablet on platen

Light source

Sensitometer schematic

Camera from device under test
Figure 3. Device for Capturing Dynamic Modulation Video

Device for Capturing Dynamic Modulation Video
(not to scale)

- The test target is allowed to drop
- The drop distance is marked off on frame
- The field of view is ¼ of 24 feet
- The camera is placed ¼ of 35 feet away

Side view of drop frame with camera from the device under test mounted in portrait mode on a tripod

Front view of drop frame with test target
Figure 4. Brightness Values for Analog vs. Digital Video

Sample Cameras

Vertical axis is brightness value, 0 – 255
Horizontal axis is test target brightness in relative $\log_{10}(\text{Lux} - \text{seconds})$
Figure 5. Actual In-car System Example

DR of 2.1 Log E
Figure 6. Microphone to Receiver Test Schematic.

1. CD player
2. DUT microphone
3. Reference microphone
4. DUT Receiver
5. Pick up microphone
6. Mixer

7. Polarity switch
8. True RMS voltmeter
9. Oscilloscope
10. Computer
11. Oscillator
12. Delay line
Appendix B. UL 983, *Standard for Surveillance Camera Units*, Table 39.1

The table provided in this annex is taken from UL 983:2006.

### Table 39.1
Maximum temperature rises

<table>
<thead>
<tr>
<th>Materials and components</th>
<th>Standby, °C</th>
<th>Operation under holdup condition, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(°F)</td>
<td></td>
</tr>
<tr>
<td><strong>A. MOTORS</strong>&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Class A insulation systems on coil windings of alternating-current motors 7 inches (178 mm) or less in diameter (not including universal motors):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) In open motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermocouple or resistance method</td>
<td>75</td>
<td>135</td>
</tr>
<tr>
<td>b) In totally enclosed motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermocouple or resistance method</td>
<td>80</td>
<td>144</td>
</tr>
<tr>
<td>2. Class A insulation systems on coil windings of alternating-current motors more than 7 inches (178 mm) in diameter and of direct-current and universal motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) In open motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermocouple method</td>
<td>65</td>
<td>117</td>
</tr>
<tr>
<td>Resistance method</td>
<td>75</td>
<td>135</td>
</tr>
<tr>
<td>b) In totally enclosed motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermocouple method</td>
<td>70</td>
<td>126</td>
</tr>
<tr>
<td>Resistance method</td>
<td>80</td>
<td>144</td>
</tr>
<tr>
<td>3. Class B insulation systems on coil windings of alternating-current motors 7 inches (178 mm) or less in diameter (not including universal motors):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) In open motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermocouple or resistance method</td>
<td>95</td>
<td>171</td>
</tr>
<tr>
<td>b) In totally enclosed motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermocouple or resistance method</td>
<td>100</td>
<td>180</td>
</tr>
<tr>
<td>Materials and components</td>
<td>Standy, °C</td>
<td>Operation under holdup condition, °C</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td></td>
<td>℃</td>
<td>℉</td>
</tr>
<tr>
<td></td>
<td>℉</td>
<td>℉</td>
</tr>
<tr>
<td>4. Class B insulation systems on coil windings of alternating-current motors more than 7 inches (178 mm) in diameter and of direct-current and universal motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) in open motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermocouple method</td>
<td>85</td>
<td>153</td>
</tr>
<tr>
<td>Resistance method</td>
<td>95</td>
<td>171</td>
</tr>
<tr>
<td>b) in totally enclosed motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermocouple method</td>
<td>90</td>
<td>162</td>
</tr>
<tr>
<td>Resistance method</td>
<td>100</td>
<td>180</td>
</tr>
</tbody>
</table>

B. COMPONENTS

1. Capacitors<sup>a-d</sup>
   a) Electrolytic types
   b) Other types
   |
| 25        | 45        | 40        | 72 |
| 25        | 45        | 65        | 117 |

2. Rectifiers – at any point:
   a) Germanium
   b) Selenium
   c) Silicon:
      1) Maximum 60 percent of rated volts
      2) 61 percent or more of rated volts
      3. Relay, solenoid, transformer and other coils with:
         a) Class 105 insulation system:
            Thermocouple method
            Resistance method
         b) Class 130 insulation system:
            Thermocouple method
            Resistance method
         c) Class 155 insulation system:
            1) Class 2 transformers:
               Thermocouple method
               Resistance method
            2) Power transformers:
               Thermocouple method
               Resistance method
         d) Class 180 insulation system:
            1) Class 2 transformers:
               Thermocouple method
               Resistance method
            2) Power transformers:
               Thermocouple method
               Resistance method
   |
| 25        | 45        | 50        | 90 |
| 25        | 45        | 50        | 90 |
| 50        | 90        | 75        | 135 |
| 25        | 45        | 75        | 135 |

3. Relay, solenoid, transformer and other coils with:
   a) Class 105 insulation system:
      Thermocouple method
      Resistance method
   b) Class 130 insulation system:
      Thermocouple method
      Resistance method
   c) Class 155 insulation system:
      1) Class 2 transformers:
         Thermocouple method
         Resistance method
      2) Power transformers:
         Thermocouple method
         Resistance method
   d) Class 180 insulation system:
      1) Class 2 transformers:
         Thermocouple method
         Resistance method
      2) Power transformers:
         Thermocouple method
         Resistance method
   |
| 25        | 45        | 50        | 90 |
| 50        | 90        | 125       | 225 |
| 25        | 45        | 50        | 90 |

4. Resistors<sup>a</sup>
   a) Carbon
   b) Wire wound
   c) Other
   |
| 25        | 45        | 50        | 90 |
| 50        | 90        | 125       | 225 |
| 25        | 45        | 50        | 90 |

5. Solid state devices

6. Other components and materials:
   a) Fiber used as electrical insulation or cord bushings
   |
| 25        | 45        | 65        | 117 |
Table 39.1 Continued

<table>
<thead>
<tr>
<th>Materials and components</th>
<th>Standby, °C</th>
<th>Standby, °F</th>
<th>Operation under holdup condition. °C</th>
<th>Operation under holdup condition. °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Varnished cloth insulation</td>
<td>25</td>
<td>45</td>
<td>60</td>
<td>108</td>
</tr>
<tr>
<td>c) Thermoplastic materials</td>
<td>rise based on temperature limits of the material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Phenolic composition used as electrical insulation or as parts where deterioration results in a risk of fire or electric shock</td>
<td>25</td>
<td>45</td>
<td>125</td>
<td>225</td>
</tr>
<tr>
<td>e) Wood or other combustibles</td>
<td>25</td>
<td>45</td>
<td>65</td>
<td>117</td>
</tr>
<tr>
<td>f) Sealing compound</td>
<td>15°C (27°F) less than the melting point</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g) Fuses</td>
<td>25</td>
<td>45</td>
<td>65</td>
<td>117</td>
</tr>
</tbody>
</table>

C. CONDUCTORS
1. Appliance wiring material[^a]
25°C (45°F) less than the temperature limit of the wire

2. Flexible cord (for example, SJT, SJU)

3. Conductors of field-wired circuits to be permanently connected to the product

D. GENERAL
1. All surfaces of the product and surfaces adjacent to or upon which the product may be mounted
2. Surfaces intended to be contacted by the user in operating the unit (control knobs, push buttons, levers, and the like):
   a) Metal
   35 | 63 | 35 | 63 |
   b) Nonmetallic
   60 | 108 | 60 | 108 |
3. Surfaces subjected to casual contact by the user (enclosure, grille, and the like):
   a) Metal
   45 | 81 | 45 | 81 |
   b) Nonmetallic
   65 | 117 | 65 | 117 |

[^a]: The motor diameter is to be measured in the plane of the laminations of the core circumscribing the stator frame, excluding lugs, boxes, and the like, used solely for motor cooling, mounting, assembly, or connection.

[^b]: Coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices (for example, a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation such as more than two layers, 1/32 inch (0.8 mm) maximum, of cotton, paper, rayon, or the like. For a thermocouple measured temperature of a coil of an alternating-current motor having a diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation on the conductor. At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may exceed the indicated maximum, if the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

1) 5°C (49°F) for Class A insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.
2) 10°C (18°F) for Class B insulation on coil windings of alternating-current motors having a diameter of 7 inches or less, open type.
3) 15°C (27°F) for Class A insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm), open type.
4) 20°C (36°F) for Class B insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm), open type.

[^c]: For an electrolytic capacitor which is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure shall not be more than 65°C (117°F).

[^d]: A capacitor that operates at a temperature higher than a 65°C (117°F) rise may be judged on the basis of its marked temperature rating.

[^e]: The temperature rise of a resistor may exceed the values shown when the power dissipation is 50 percent or less of the manufacturer's rating.
<table>
<thead>
<tr>
<th>Materials and components</th>
<th>Standby, °C (°F)</th>
<th>Operation under holdup condition, °C (°F)</th>
</tr>
</thead>
</table>

1 The temperature of a solid state device (for example, transistor, SCR, integrated circuits) shall not exceed 50 percent of its rating during the Normal Standby Condition. The temperature of a solid state device shall not exceed 75 percent of its rated temperature under the Holdup Condition or any other condition of operation that produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) shall be 0 percent. For integrated circuits, the loading factor shall not exceed 50 percent of its rating under the Normal Standby Condition and 75 percent under any other condition of operation. Both solid state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:

   1) The component complies with the requirements of MIL-STD-883E.
   2) A quality control program is established by the manufacturer consisting of an inspection stress test followed by operation of 100 percent of all components, either on an individual basis, as part of a subassembly, or equivalent.
   3) Each assembled production unit is subjected to a burn-in test, under the condition that results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F).

a The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and rated for higher temperatures than those specified in Table 39.1.

b For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code, ANSI/NFPA 70. The maximum temperature rise in any case is 25°C (77°F) less than the temperature limit of the wire in question.