Designation: E3235 – 21

An American National Standard

Standard Practice for Latent Print Evidence Imaging Resolution[1]

This standard is issued under the fixed designation E3235; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides recommendations on the resolving power that enables recording of Level 3 details of latent print evidence that are suitable for comparison purposes using a digital camera, a flatbed scanner, or other image capture device. These recommendations take into consideration the minimum resolution requirements for utilizing the photographs for comparison.

1.2 This practice describes procedures that can be used to verify the resolving power of such imaging systems and recommends equipment to be used.

1.3 Certain commercial equipment, instruments, or materials are used in this document as representative examples to more clearly explain the procedures. Such use does not imply a recommendation or endorsement.

1.4 *This standard is intended for use by competent forensic science practitioners with the requisite formal education, discipline-specific training (see Practice E2917), and demonstrated proficiency to perform forensic casework.*

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

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1732 Terminology Relating to Forensic Science

E2916 Terminology for Digital and Multimedia Evidence Examination

E2917 Practice for Forensic Science Practitioner Training, Continuing Education, and Professional Development Programs

2.2 *Other Documents:*

ISO-16067-1 Reflective Scanner Test Chart[3]

ISO/IEC 17020 Conformity assessment — Requirements for the operation of various types of bodies performing inspection[3]

ISO/IEC 17025 Testing and calibration laboratories[3]

T-90-N-CG Ultra High Resolution Target[4]

3. Terminology

3.1 *Definitions*—Refer to Terminologies E1732 and E2916 for terms not defined in this practice.

3.1.1 *achievable resolution, resolving power, n*—the measure of imaging system's practical limit to distinguish between separate adjacent elements, typically by imaging a known reference standard. **E2916**

3.1.2 *bit depth, n*—the number of bits (binary digits) used to specify the brightness or color range of each pixel in an image sensor.

Photo Review Magazine Digital Imaging Glossary (1)[5]

3.1.3 *Dmax, n*—an abbreviation for maximum density. The abbreviation is used in describing both the characteristics of an image and/or an imaging device such as a scanner.

Federal Agencies Digital Guidelines Initiative Glossary (2)

3.1.4 *dynamic range, n*—the difference between the brightest highlight and darkest value that a sensor can detect and record in a single image. **E2916**

3.1.5 *focal length, n*—the distance from the optical center of a lens to its point of focus at the sensor or image plane when focused at infinity. **E2916**

[1] This practice is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.12 on Digital and Multimedia Evidence.

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

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[4] Available from Applied Image, Inc., Rochester, NY, https://www.appliedimage.com.

[5] The boldface numbers in parentheses refer to a list of references at the end of this standard.

3.1.6 *lossless compression, n*—a data reduction process that is completely reversible, such that all of the original data can be retrieved in its original form. **E2916**

3.1.7 *lossy compression, n*—a data reduction process that is not completely reversible, and some original data is irretrievably lost. **E2916**

3.1.8 *machine resolution, optical resolution, n*—a nominal resolution specification for a flatbed scanner based on the actual number of pixels per inch in the sensor array and the number of individual steps per inch that the stepper motor can move the sensor array. This is to be distinguished from the maximum resolution specification that is based on resampling. This is also called optical resolution.

I Digital Photo Dictionary (3)

3.1.9 *nominal resolution, n*—the number of horizontal and vertical pixels an imaging system or sensor is capable of capturing. **E2916**

3.1.10 *normal lens, n*—a lens designed to approximate the field of view of the human eye without magnification or reduction. **E2916**

3.1.11 *quadripod, n*—a generic term for a four-legged camera support.

3.1.12 *resizing, n*—changing the size of an image by changing the number of pixels per unit of measurement without adding or subtracting any pixels from the image.

3.1.13 *resampling, n*—changing the size and/or resolution of the image by adding or subtracting pixels through interpolation.

Crime Scene Photography, 3rd ed. (4)

3.1.14 *resolution, n*—the act, process, or capability of distinguishing between two separate but adjacent parts or stimuli, such as elements of detail in an image, or similar colors.

Encyclopedia of Photography, 3rd Edition (5)

3.1.15 *resolving power, n*—see *achievable resolution*. **E2916**

3.1.16 *tri-linear array, n*—the sensor in a flatbed scanner, or digital scanning back, which is made up of three rows of pixels with a red filter covering one row, a green filter covering the second row and a blue filter covering the third row.

Federal Agencies Digital Guidelines Initiative Glossary (2)

4. Summary of Practice

4.1 Select photographic equipment.

4.2 Create a photographic procedure manual.

4.3 Verify the resolving power of digital cameras used to photograph latent print evidence.

4.4 Verify the resolving power of scanners used to scan latent print evidence.

5. Significance and Use

5.1 The procedure described in this document is in accordance with current SWGFAST guidelines (**6**), as well as National Institute of Standards and Technology (NIST) standard (**7**), which specify 1000 pixels per inch (ppi) at 1:1 as the minimum scanning resolution for latent print evidence. This standard appears primarily to be historical and directed towards scanners, rather than cameras, though recent studies suggest that it is suitable for capturing Level 3 detail (**8**).

5.2 While the 1000 ppi resolution standard permits the capture of level three detail in latent prints, it does not mean that any image recorded at a lower resolution would necessarily be of no value for comparison purposes. Such an image could have captured level two details sufficiently for comparison. However, there are some latent print impressions that are so degraded or contain such limited quantity of information that at least 1000 ppi resolution is required to conduct an accurate examination. Some automated fingerprint identification systems require 1000 ppi for submission purposes. The relationship between machine (optical) resolution and achievable resolution (sometimes called *resolving power*) can vary greatly by manufacturer (**8**).

6. Recommended Photographic Equipment

6.1 A digital camera system with the following specifications:

6.1.1 A full frame, or larger, sensor is suggested because it will usually have less image noise as compared to smaller sensors.

6.1.2 *Interchangeable Lenses:*

6.1.2.1 A normal fixed focal length, or longer, macro lens is preferred. Listed below are two common examples of normal focal length lenses for different size camera sensors.

(1) For a full frame sensor, the normal focal lens is 40 mm to 60 mm.

(2) For an APS-C/H sensor, the normal focal lens is 35 mm to 45 mm.

6.1.2.2 A macro zoom lens set to approximately the normal focal length, or longer, based on the size of the camera sensor is acceptable.

6.1.2.3 *Optional*—A normal, or longer, focal length perspective control (PC) macro lens.

6.1.2.4 *Additional Lens Considerations:*

(1) When capturing images for comparative analysis, it is important to minimize distortion and obtain the correct perspective. In general, normal focal length prime lenses have less optical distortion as compared to zoom lenses.

(2) The photographs of the bottom of a shoe illustrate the problems of using a wide angle lens as compared to using a normal focal length lens and filling the frame. The photographs were taken with a 20 mm and 50 mm lens on a DSLR with a full frame sensor (see Figs. 1-4).

6.1.3 Manual and aperture priority exposure modes.

6.1.4 Automatic and manual focus.

6.1.5 Remote shutter release port or self-timer.

6.1.5.1 Choice of file format in order of preference

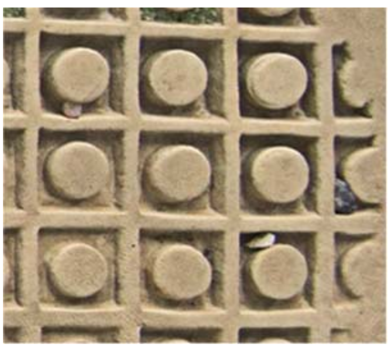
6.1.5.2 RAW file format at a maximum bit depth or RAW+JPEG.

6.1.5.3 Uncompressed or lossless compressed image file format such as TIFF.

6.1.5.4 If RAW and TIFF are not available, use the highest quality JPEG settings.

NOTE 1—The most obvious problem is the distortion that can be seen in the straight horizontal part of the ruler that is recorded as being curved.

FIG. 1 Photograph of the Bottom of a Shoe (Photographed with a 20 mm Wide Angle Lens on a Full Frame DSLR)



NOTE 1—If you look carefully you will see that the left sides of the cylinders are visible because the camera is too close to the shoe when filling the frame with a wide angle lens.

FIG. 2 Enlargement of the Heel of the Shoe

NOTE 1—Notice that with a 50 mm lens the straight edge of the ruler is straight in the photograph. With a 50 mm lens you will be farther away from the shoe when filling the frame as compared to a 20 mm wide-angle lens. Since the close-up range of most point and shoot cameras is in the wide-angle range of their zoom settings, this is one of many reasons why a point and shoot camera should not be used for this type of photography.

FIG. 3 Photograph of the Bottom of a Shoe (Photographed with a 50 mm Normal Focal Length Lens on a Full Frame DSLR)

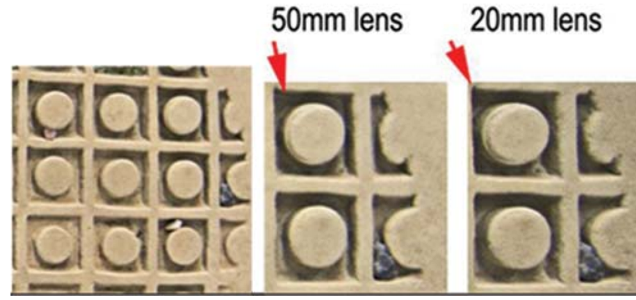
6.2 Point and shoot and cell phone cameras are not recommended for taking photographs intended for comparative analysis purposes for several reasons, some of which include, but are not limited to:

6.2.1 The lenses are usually not as well corrected for distortion.

6.2.2 The macro range is usually in the wide-angle zoom range.

6.3 Spare batteries for any camera using removable batteries.

6.4 Appropriate light sources (for example, floodlights, flashlights, LASER, alternate light sources (ALS), or a combination thereof).



NOTE 1—On the left and center are enlargements of the photograph taken with a 50 mm lens of the heel of the shoe. If you look carefully you will see that the sides of the cylinders (center enlargement) are not visible because the camera is far enough from the shoe when filling the frame with a normal focal length lens to have the flat perspective that is more accurate for comparison purposes. Compare the center enlargement with the right enlargement and observe that when the camera was moved closer to the shoe to fill the frame with a 20 mm lens that part of the side of the cylinder is visible.

FIG. 4 Enlargements of the Photograph Taken

6.5 Photographic filters.

6.6 Remote shutter release.

6.7 Sturdy copy stand, tripod or other study camera support.

6.8 Flat rulers using standard units of measure which are traceable to a NIST or other national metrological institute standard (see ISO/IEC 17025 and ISO/IEC 17020, policy for measurement of uncertainty).

6.9 Level.

6.10 Spare camera memory cards and card storage cases for empty and used camera cards, unless tethered to a computer.

6.11 Lens cleaner and lens cleaning tissue.

6.12 Photographic log/notes.

6.13 Photo labels/tags

6.14 Computer with appropriate software.

6.15 Camera card reader.

6.16 Archival storage device.

6.17 A magnifier.

6.18 For camera resolution testing, an opaque or a transparent, or both, resolution test target with resolution bars within the range of 9.8 to 13 cycles per millimetre (c/mm), which is also, called line pairs per millimetre (lp/mm). Resolution targets are calibrated by an accredited calibration provider traceable to NIST or equivalent metrology institute.

6.19 A flatbed scanner either from the FBI Certified Biometric Products List (9)or with the following specifications:

6.19.1 A preferred machine resolution of 2400 ppi 1200 minimum.

6.19.2 A reflected document size of at least 8.5×11 in.

6.19.3 A minimum Dmax rating of 4.0.

6.19.4 A transmitted light (transparency) adapter of at least 4×5 in. 8×10 in. is preferred.

6.20 For the flatbed scanner higher resolution targets should be needed to determine at what point increasing the nominal resolution setting only increases the file size, without any increase in achievable resolution. Targets with resolution bars up to 100 lp/mm should be adequate for this task. These higher resolution targets should require the use of a low power microscope to visually verify the line pairs. Resolution targets shall be certified traceable to NIST or equivalent metrology institute.

7. Recommended Protocol for Verifying the Resolving Power of Digital Cameras Used to Photograph Latent Print Evidence

7.1 As with scanners, camera systems also rarely achieve nominal resolution in practice. One recent study showed that high-resolution black-and-white TMAX film with a nominal resolution of 34.56 megapixels using a stabilized professional camera under studio conditions was able to achieve a pixel-equivalent resolution of 13.75 megapixels (**10**).

7.2 There is a dearth of peer reviewed literature comparing optical and achieved resolution, but the achieved resolution can be approximated. Jain (**11**) has demonstrated that sampling at a nominal 1000 ppi can provide level three details. Zhang, et al., (**12**) has similar results. By application of the Nyquist theorem, a 1000 ppi nominal resolution can theoretically achieve a maximum resolution of 500 line pairs. In practice, as noted elsewhere, Nyquist sampling is inadequate; and three to four samples are required instead of two, resulting in resolution between 250 to 330 line pairs per inch, or 9.8 to 13 cycles per millimetre.

7.3 *Camera Resolution Testing:*

7.3.1 This step defines the largest area that can be photographed and still meet the 1000 ppi resolution standard at an achievable resolution that is adequate to record 3rd level details in a latent print. If the area covered by the latent print evidence and a ruler is smaller than the determined value, the photograph should be taken filling the frame with the latent print evidence and ruler (see Figs. 5-7).

7.3.2 Determine the maximum field of view in which a minimum nominal resolution of 1000 ppi should be achieved for each camera and lens combination to be used to photograph latent print evidence.

7.3.2.1 Determine the effective pixel dimensions of the camera's sensor as stated by the manufacturer. This can usually be found in an image size setting in the camera menu. For this example a DSLR camera using a full frame lens (FX or 35 mm film camera lens) and the full sensor this would be 7360×4912 pixels. However with some full frame sensor cameras such as Nikon,[6] you should have to also determine the smaller pixel dimensions that the camera should default to whenever a lens designed for a smaller sensor (DX lens) is attached to the camera. For a Nikon D810 using a DX lens, this would be 4800×3200 pixels. This additional resolving power testing also applies only if the camera is to be set to a lower resolution setting.

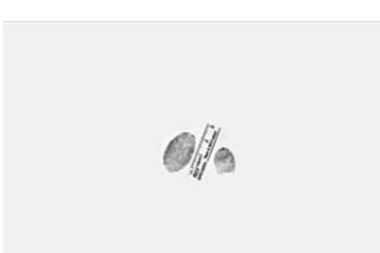


FIG. 5 This Is Not Filling the Frame.

FIG. 6 Many Persons Mistake Filling the Short Dimension of the Viewfinder with the Long Dimension of the Latent Print and Ruler

FIG. 7 Filling the Long Dimension of the Viewfinder with the Long Dimension of the Latent Print and Ruler

7.3.2.2 To determine the largest area that can be photographed at a nominal resolution of 1000 ppi, divide each pixel dimension of the digital camera's sensor by 1000 ppi. Using the full sensor in a Nikon D810, this would equal 7.36×4.912 in. This makes the maximum field of view approximately 7.35×4.9 in. If you are using a metric scale, multiply inches by 25.4 to convert inches to millimetres (approximately 187 mm×124 mm, see Fig. 8).

7.3.2.3 Not all camera optical viewfinders cover 100 % of the capture area. Take a test image of a template drawn on a sheet of graph paper lined in tenths of an inch to determine coverage of the optical viewfinder. If the camera has a live view capability, compare the optical viewfinder field of view with both the live view field of view and the captured image.

7.3.2.4 Make a template on precision graph paper to outline the maximum area that can be photographed at the 1000 ppi nominal resolution standard (see Fig. 9).

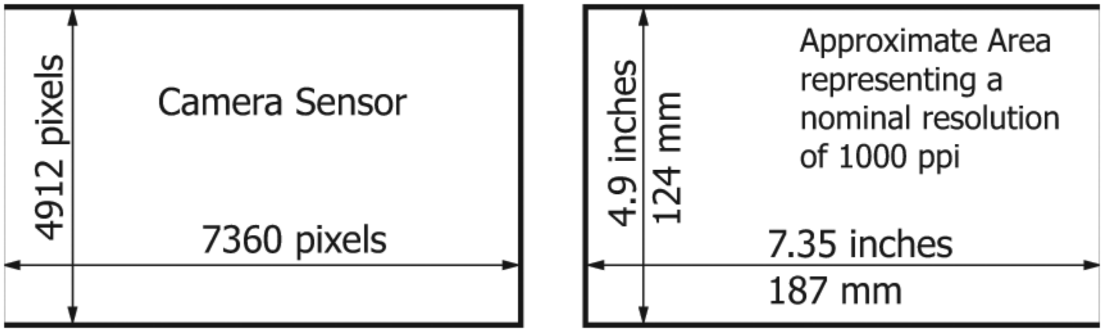
7.3.2.5 Place the template on a flat surface.

7.3.2.6 Mount the camera on a tripod or copy stand above the flat surface on which the template rests. Ensure the camera focal plane is parallel with the template.

7.3.2.7 If using a fixed focal length lens, proceed to step 7.3.2.8. If using a zoom lens, proceed to step 7.3.2.9.

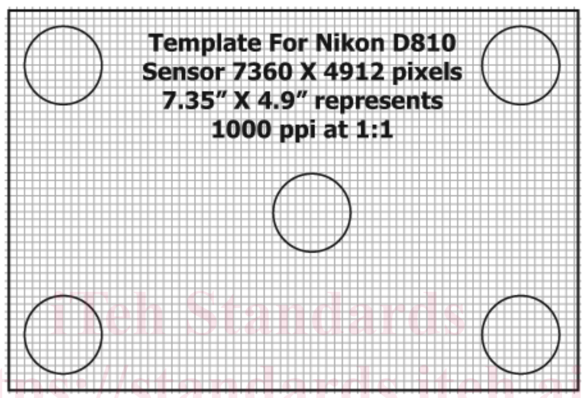
7.3.2.8 While looking through the viewfinder, adjust the height of the camera to fill the frame with the template, while keeping the image in sharp focus with the camera set to manual

[6] Nikon is a trademark of Nikon Corporation in Tokyo, Japan.



NOTE 1—The diagram on the left shows the pixel dimensions of the full frame sensor of a DSLR camera that was used as an example. The diagram on the right shows the approximate area that represents a nominal resolution of 1000 ppi with the camera set to an image size of 4912×7360 pixels.

FIG. 8 Converting Inches to Millimetres



NOTE 1—The graph paper was photographed with the black lines at the edge of the optical viewfinder. The area approximately 0.05 in. outside of the optical viewfinder was included in the image but not visible in the viewfinder. However, this area was visible in live view. For the resolving power samples used in this document, the resolution test target was photographed at this magnification. Using precision graph paper also makes it easier to determine if the lens has excessive barrel or pincushion distortion and if the distortion can be corrected in software. The five circles were added to demonstrate how well curved details are reproduced.

FIG. 9 Make a Template on Precision Graph Paper

focus and manual exposure. If focus cannot be accomplished for this lens, then the 1000 ppi standard cannot be met and a different lens shall be used. Otherwise, go to step 7.3.2.10.

7.3.2.9 When using a zoom lens, repeat step 7.3.2.8 for each of the zoom settings that will be used for photographing latent prints. This will result in different camera heights for different zoom settings. If focus cannot be accomplished for some zoom settings, then the 1000 ppi standard cannot be met for those settings. If focus cannot be accomplished for this lens at all, then the 1000 ppi standard cannot be met and a different lens shall be used. Otherwise, go to step 7.3.2.10.

7.3.2.10 Using a fixed reference point on the camera body, record the height determined in step 7.3.2.8 or 7.3.2.9. This height is the maximum camera-to-subject distance to provide 1000 ppi resolution. In this example, when the macro zoom lens was set to 50 mm, the distance from the top of the camera body strap eyelet was 12.75 in. When the macro zoom lens was set to 105 mm, the distance from the top of the camera body strap eyelet was 19.5 in.

7.3.2.11 The camera setup is ready to replace the template with the resolution test target that is calibrated to a NIST or equivalent metrology institute standard. For the example in this practice, an ultra-high resolution test target (T-90-N-CG) was used that has one set of the Group 2 resolution bars certified traceable to a NIST standard (see Figs. 6 and 7). This test target has line pairs printed in only one direction. Any standard resolution test target that has printed line pairs in the 9.8–13 cycles per millimetre range can be used for this resolution test. The test target shall initially include a certificate from the manufacturer or a 3rd party what the accuracy of at least one of the relevant resolution bars and that this certification was traceable to a NIST or other relevant national standard. Examples of test targets that are known to meet these requirements, in addition to the T-90 test target, include but are not limited to: NBS 1963A Resolution Target (NSM 1010A) (**13**), 1951 USAF Resolution Test Chart (**14**), and the FBI Mitre Scanner Image Quality Test (SIQT) Chart (**15**).

NOTE 1—That although all the F-stops were tested for this example, only the F-stop settings that you use for photographing latent prints need to be tested.

7.3.2.12 Visually verify that you can clearly see the 15 lines and 14 spaces on the 12.5 c/mm section of the T-90 test target (see Figs. 10 and 11) before using the test target.