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.

**Designation: E883 – 11 (Reapproved 2017)**

# Standard Guide for Reflected–Light Photomicrography[1]

This standard is issued under the fixed designation E883; 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.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope*

1.1 This guide outlines various methods which may be followed in the photography of metals and materials with the reflected-light microscope. Methods are included for preparation of prints and transparencies in black-and-white and in color, using both direct rapid and wet processes.

1.2 Guidelines are suggested to yield photomicrographs of typical subjects and, to the extent possible, of atypical subjects as well. Information is included concerning techniques for the enhanced display of specific material features. Descriptive material is provided where necessary to clarify procedures. References are cited where detailed descriptions may be helpful.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.* Specific precautionary statements are given in X1.7.

1.4 The sections appear in the following order:



1.5 *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]

E7 Terminology Relating to Metallography
E175 Terminology of Microscopy
E768 Guide for Preparing and Evaluating Specimens for Automatic Inclusion Assessment of Steel
E1951 Guide for Calibrating Reticles and Light Microscope Magnifications

2.2 *Other Standard:*[3]

MSDS Mercury-Material Safety Data Sheet

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, see Terminologies E7 and E175.

## 4. Significance and Use

4.1 This guide is useful for the photomicrography and photomacrography of metals and other materials.

4.2 The subsequent processing of the photographic materials is also treated.

## 5. Magnification

5.1 Photomicrographs shall be made at preferred magnifications, except in those special cases where details of the microstructure are best revealed by unique magnifications.

[1] This guide is under the jurisdiction of ASTM Committee E04 on Metallographyand is the direct responsibility of Subcommittee E04.03 on Light Microscopy.

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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 United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, http://www.epa.gov.

***A Summary of Changes section appears at the end of this standard**

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5.2 The preferred magnifications for photomicrographs, are: 25×, 50×, 75×, 100×, 200×, 250×, 400×, 500×, 750×, 800×, and 1000×.

5.3 Magnifications are normally calibrated using a stage micrometer. Calibration procedures in Guide E1951 should be followed.

## 6. Reproduction of Photomicrographs

6.1 Photomicrographs should be at one of the preferred magnifications. A milli- or micrometre marker shall be superimposed on the photomicrograph to indicate magnification, in a contrasting tone. The published magnification, if known, should be stated in the caption.

6.2 Photomicrograph captions should include basic background information (for example, material identification, etchant, mechanical or thermal treatment details) and should briefly describe what is illustrated so that the photomicrograph can stand independent of the text.

6.3 Arrows or other markings, in a contrasting tone, shall be used to designate specific features in a photomicrograph. Any marking used shall be referenced in the caption.

## 7. Optical Systems

7.1 Microscope objectives are available in increasing order of correction as achromats, semiapochromats (fluorites) and apochromats (see Terminologies E7 and E175). Plan objectives are recommended for photographic purposes because their correction provides a flatter image. The objective lens forms an image of the specimen in a specific plane behind the objective called the back focal plane. (This is one of several possible real image planes, called intermediary planes, where reticles may be inserted as optical overlays on the image.)

7.2 The eyepiece magnifies the back focal plane (or other) intermediary image for observation or photomicrography. Eyepieces are sometimes also used to accomplish the full correction of the objective's spherical aberration and to improve the flatness of field.

7.2.1 The pupil of the observer's eye must be brought to coincidence with the eyepoint of the visual eyepiece to view the entire microscopical image. High-eyepoint eyepieces are necessary for eyeglass users to see the entire image field.

7.2.2 Most microscopes have built-in photographic capabilities that use an alternate image path through the microscope leading to a camera attachment port or to a viewscreen. A projection eyepiece delivers the image to the camera port or screen.

7.3 Intermediate lenses (relay or tube lenses) are often required to transfer the specimen image from the intermediary plane of the objective to that of the eyepiece. They may also add their own magnification factor, either fixed or as a zoom system.

7.4 The objective, the eyepiece, and the compound microscope (including any intermediate lenses) are designed as a single optical unit. It is recommended to use only objectives and eyepieces which are intended for the microscope in use.

7.5 The resolution of the microscope depends primarily on the numerical aperture of the objective in use (**1**)[4]. The term empty magnification is used to describe high magnifications (above approximately 1100 times the numerical aperture of an objective), which have been shown to offer no increase in image resolution. Nevertheless, some types of information, such as the distance between two constituents, may be more easily obtained from microstructures examined at moderate empty magnifications.

## 8. Illumination Sources

8.1 Metallographic photomicrography typically uses Köhler illumination. To obtain Köhler illumination, an image of the field diaphragm is focused in the specimen plane, and an image of the lamp filament or arc is focused in the plane of the aperture diaphragm. Specific steps to obtain Köhler illumination vary with the microscope used. The manufacturer's instructions should be followed closely.

8.2 For incandescent lamps, the applied voltage determines the unit brightness and the color temperature of the source. Evaporated tungsten blackens the envelope, resulting in diminished brightness and color temperature as the lamp ages. Tungsten-halogen lamps minimize envelope blackening, maintaining constant brightness and color temperature for most of their life. The high brightness and 3200 K color temperature of these lamps makes them especially suitable for color photomicrography.

8.3 With arc sources, brightness per unit area is substantially higher than that from any incandescent source. Their spectral output contains high energy spikes superimposed on a white-light continuum. They also contain significant ultraviolet (UV) and infrared (IR) emissions that should be removed for eye safety (and for photographic consistency, with UV); see 8.4, 11.3.1, and 11.5.2.

8.3.1 Xenon arcs produce a spectral quality close to daylight (5600K), with a strong spike at 462 nm. Strong emissions in the IR should be removed. Xenon arcs that do not produce ozone are recommended.

8.3.2 Carbon arcs have a continuous output in the visible portion of the spectrum, with a color temperature near 3800K and a strong emission line at 386 nm.

8.3.3 Mercury arcs have strong UV and near-UV output, and are particularly useful to obtain maximum resolution with a blue filter. The color quality is deficient in red; it cannot be balanced for color photomicrography. **Warning—**Mercury has been designated by EPA and many state agencies as a hazardous material that can cause central nervous system, kidney, and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury-containing products. See the applicable product Material Safety Data Sheet (MSDS) for details and EPA's website (http://www.epa.gov/mercury/faq.htm) for additional information. Users should be aware that selling mercury or mercury-containing products, or both, in your state may be prohibited by state law.

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

8.3.4 Zirconium arcs have strong spectral output lines in the near IR, requiring filtration. Within the visible region, they are rated at 3200K color temperature.

8.4 Arc lamps require heat protection for filters and other optical components, and certainly for eye safety. Infrared removal may be obtained by: "hot" mirrors in the illumination beam to reflect IR while transmitting visible light; heat-absorbing filters to transmit visible light while absorbing IR, for example, solid glass filters or liquid-filled cells.

8.5 A detailed discussion of illumination sources and the quality of illuminants is given by Loveland (**2**).

8.6 Some advice on using metallographic microscopes for visual observation has been compiled in Appendix X1.

## 9. Illumination of Specimens

9.1 Photomicrographs are made with a compound microscope comprised at least of an objective lens and an eyepiece with a vertical illuminator between them. Field and aperture diaphragms, with a lamp and lamp condenser lenses, are integral parts of the system. The microscope should allow sufficient adjustment to illuminate the field of view evenly and to completely fill the back aperture of the objective lens with light.

9.2 The vertical illuminator is a thin-film-coated plane glass reflector set at 45° to the optical axis behind the objective. It reflects the illumination beam into the objective and transmits the image beam from the objective to the eyepiece. In some microscopes prism systems are used to perform this function.

9.3 The field diaphragm is an adjustable aperture which restricts the illuminated area of the specimen to that which is to be photographed. It eliminates contrast-reducing stray light. The field diaphragm is also a useful target when focusing a low-contrast specimen.

9.4 The aperture diaphragm establishes the optimum balance between contrast, resolution, and depth of field. It should be set to illuminate about 70 % of the objective's aperture diameter. This can be observed by removing the eyepiece and inspecting the back of the objective, either directly or with a pinhole eyepiece. The aperture diaphragm should never be used as a light intensity control.

9.5 See Fig. 1 for an illustration of a typical vertical illumination system.

## 10. Focusing

10.1 Sharp focus is necessary to obtain good photomicrographs.

10.2 There are two systems for obtaining sharp focus: ground-glass focusing and aerial image focusing.

10.2.1 For ground-glass focusing, relatively glare-free surroundings and a magnifier up to about 3× are required. To focus, the focusing knob is oscillated between underfocus and overfocus in succeedingly smaller increments until the image is sharp.

10.2.2 There are four possible variations for focusing an aerial image.

10.2.2.1 The simplest case is a transparent spot on a ground-glass containing a fiduciary mark in the film plane. The specimen image is focused to coincide with the fiduciary mark, using a magnifying loupe of about 3× to 5×. When the focus is correct, the specimen image and the fiduciary mark will not move with respect to each other when the operator's head is moved.

10.2.2.2 A second case uses a reticle fixed within the optical system at an intermediary plane. Focusing is a two-step process: focus the eyepiece on the reticle; bring the image into focus against the reticle figure.

10.2.2.3 In the third case, a reticle is inserted into a focusing eyepiece. Depending on equipment used, this can be either a two or three-step process: focus the reticle within the eyepiece; next, set the proper interpupiliary distance, if required (some equipment requires a specific interpupiliary distance for eyepiece focus to coincide with camera focus); then focus the image coincident with the reticle.

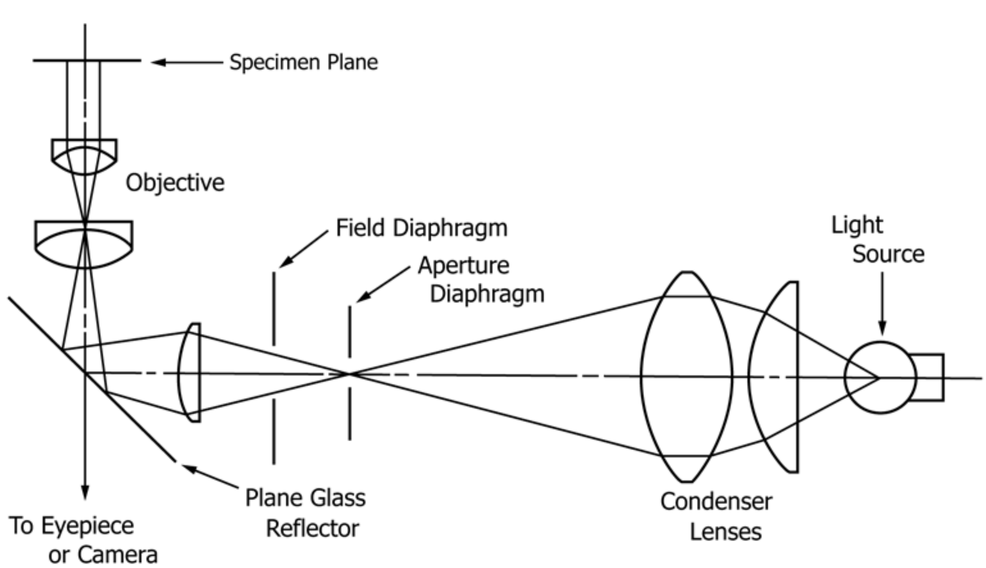


FIG. 1 Vertical Illuminating System for a Metallurgical Microscope