

## ASTM D7520-09 Summary

ASTM D7520-09 is available from [www.ASTM.org](http://www.ASTM.org) to follow is a summarized version.

### Scope:

The test method describes the procedures to determine the opacity of a plume, in the outdoor ambient environment using digital imagery and associated software and hardware. The opacity of emissions is determined by the application of a Digital Camera Opacity Technique (DCOT) that consists of a Digital Still Camera, Analysis Software, and the Output Function's content to obtain and interpret digital images to determine and report plume opacity ranging from 0-100% opacity.

### References:

DCOT software maintained in accordance with IEEE 12207

DCOT cameras must produce EXIF 2.1 or higher JPG images.

Images acquired in accordance with EPA Method 9, visible emission evaluation procedure e.g. sun in 140 degree cone to back, shortest path-length through plume, best color contrast available (densest part of plume).

### Terminology:

*opacity*—measurement of the degree to which particulate emissions reduce the intensity of transmitted photopic light and obscure the view of an object through an effluent gas stream of a given path length in ambient air.

*opacity source*—any source that produces emissions that are visible to the human eye.

### Summary of Test Method:

A Digital Camera is used to capture a set of digital images of a plume against a contrasting background. Each image is analyzed with software that determines plume opacity by comparing a user defined portion of the plume image where opacity is being measured in comparison to the background providing the contrasting values. The Analysis Software is used to average the opacities from the series of digital images taken of the plume over a fixed period of time. The software is also used to archive the image set utilized for each opacity determination including the portion of each image selected by the operator.

1. The image must be captured in a JPEG format that adheres to the EXIF 2.1 (or higher) standard.
2. The image must be captured with the sun within a 140° sector directly behind the Image capture device.
3. The image must be captured perpendicular to the direction of plume travel.
4. Digital enhancement capabilities of the Image Capture Device (that is, flash, optical filters, digital zoom, and image stabilization) shall not be used. However, the optical zoom may be used when capturing the JPG image.
5. The ambient light must be sufficient to show a clear contrast between the plume and its background.
6. The portion of the plume selected for opacity determination shall not contain condensed water vapor.
7. The selected portions of each image representing the visible plume and the uniform background must contrast sufficiently for the software to differentiate between the plume and its background.
8. The portion of the plume selected for opacity determination shall represent the part of the plume with the highest apparent opacity, excluding water vapor, as determined by the DCOT operator.
9. Each DCOT vendor shall provide training for operators of their DCOT system. The training shall include the content of the "Principles of Visual Emissions Measurements and Procedures

to Evaluate those Emissions” aka “EPA Method 9” and a description of how to operate that specific DCOT system that certified to the D7520-09.

Significance and Use: Same as EPA Method 9

Air permits from regulatory agencies often require measurements of opacity from air pollution sources in the outdoor ambient environment. Opacity has been visually measured by certified smoke readers in accordance with USEPA (USEPA Method 9). DCOT is also a method to determine plume opacity in the outdoor ambient environment. This standard sets a minimum level of performance for products that use DCOT to determine plume opacity in outdoor ambient environments.

Interferences: Same as EPA Method 9 “Visual Emission Evaluation Procedures”

System Description:

The DCOT system is formulated into three distinct and severable components: (1) Digital Still Camera, (2) Analysis Software and its associated computing platform, and (3) the Output Function. The DCOT must be maintained in accordance with IEEE 12207. Image capture devices must generate JPG EXIF 2.1 or higher images, software certified in a kit, computer platform, operating system, camera model, version of DCOT application, tied to the camera model for each certification, one version of a DCOT can be certified to multiple camera models.

Procedures:

The DCOT operator must follow the procedures of EPA Method 9 “Visual Emission Evaluation Procedure”

8.1 The DCOT operator must be knowledgeable about observing plumes to determine their opacity in accordance with “Principles of Visual Emissions Measurements and Procedures to Evaluate those Emissions Using Digital Camera Optical Technique (DCOT)”. The DCOT operator shall use the following procedures for determining the opacity of emissions in the ambient environment. All equipment shall be maintained in accordance with the manufacturer’s specifications.

The DCOT shall generate at a minimum the data content of a Visible Emission Measurement form per EPA Method 9, e.g. VE Form, with the addition of the image capture device serial number and the DCOT version number.

Certification of DCOT and DCOT Operator

9.1 *Certification Requirements of DCOT*—To be certified to this standard as a qualified DCOT, the specified DCOT must be tested and demonstrate the ability to assign opacity readings in 5 % increments to 25 different black plumes and 25 different white plumes, with an error not to exceed 15 % opacity on any one reading and average error not to exceed 7.5 % opacity in each category. Specified DCOT configurations shall be tested in accordance with the procedures described in 9.2. Valid certification for that DCOT will last for 3.5 years for the documented DCOT configuration as described by the manufacturer, model name, and model number of the Digital Still Camera the version of the Analysis Software, and the Output Function. Re-certification to this standard is required if the documented configuration of the original DCOT is revised. Each DCOT shall provide a self-test facility upon startup. The Self test shall utilize existing certification data to ensure that no impacts to the configured DCOT have occurred due to operating system updates. The procedure shall utilize the same comparison methodology as the certification. For instance, if the DCOT identifies an area in the plume as compared to an area outside the plume (background) to derive opacity, the exact same areas/dimensions must be used for the self-test. If a different result on any reading is returned, a re-certification is required.

9.2 *DCOT Certification Procedure*—The specific DCOT shall be certified to determine the opacity of plumes once it passes six individual complete runs of 50 plumes within a six month period as described in 9.1. The DCOT operator must include in the certification documentation the results of all smoke school tests. Those results shall include whether the DCOT passed or failed the tests and for the time periods

between and during the six successful smoke school tests. Each individual run consists of collecting images of a complete run of 50 plumes: 25 black plumes and 25 white plumes-generated by a calibrated smoke generator. Plumes within each set of 25 black and 25 white runs shall be presented in random order and distributed over the entire range of opacities (that is, 0 to 100 % opacity values for black and white plumes). The DCOT operator shall use the Digital Still Camera's default auto-focus settings, default auto-exposure settings and may use optical zoom when recording the digital images of the plumes. The DCOT operator shall not use digital image control such as the flash, optical filters, digital zoom, and image stabilization of the Digital Still Camera when recording the digital images of the plumes. The Analysis Software shall verify that such conditions were used when obtaining the digital images. The Analysis Software shall define the areas to determine plume opacity and the acceptable size of areas used to determine plume opacity. The entire digital image shall remain in its native state. The DCOT must capture the image of the measured plume and assign an opacity value to each along with the required environment information listed in Section 8 of this standard. At the completion of each run of 50 readings, the score of the DCOT is determined. If a DCOT fails to qualify, the complete run of 50 readings must be repeated in any retest. The smoke test shall be administered as part of a smoke school or training program and shall be preceded by training or familiarization runs of the smoke generator during which candidates are shown black and white plumes of known opacity.

**9.3 Certification of DCOT Operator**—The DCOT operator shall be certified to acquire digital images from the Digital Still Camera to determine plume opacity by meeting the requirements specified by the training course for the specified DCOT system. The operator will use and shall be knowledgeable of the content described in "Principles of Visual Emissions"

Precision and Bias: Same as EPA Method 9