

An Update on Measuring Smoke Plume Opacity Using Digital Camera Methods

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Bill Gillespie
Virginia Department of Environmental Quality
Northern Regional Office

William.Gillespie@deq.virginia.gov

(703) 583-3828

Presentation Topics

- EPA's approval of ASTM D7520-09
- How the new ASTM method works
- Some "pros and cons" of the new method
- Practical problems associated with the new method
- Areas where EPA, state and local agencies, and others can support and improve the method

EPA's Approval of a New Method for Determining Plume Opacity

- On April 13, 2011, EPA issued “broad approval” of ASTM D7520-09
- ASTM is the American Society for Testing and Materials
- ASTM D7520-09 is a Standard Test Method for Determining the Opacity of a Plume in the Outdoor Ambient Atmosphere
- The ASTM method is available (for \$55) at: <http://www.astm.org/Standards/D7520.htm>

Quick Summary of the New Method

- The new ASTM method is: “Method 9 with a digital camera as the sensor.”
- The method requires:
 - A digital camera
 - Analysis software
 - A trained operator
- The EPA approval letter places some additional requirements on the method. See:
<http://www.epa.gov/ttn/emc/approalt/ALT082.pdf>

Some Implications of EPA's Approval of the New Method

- Broad approval means the ASTM method can be used in lieu of Method 9 when opacity determinations are performed under any subpart to 40 CFR 60, 61, and 63 for ducted emission sources.
- EPA and state and local agencies may begin receiving opacity determinations based on the new method.
- EPA and state and local agencies have a new way to evaluate smoke plume opacity.

EPA Staff Involved in the Approval of ASTM D7520-09

OAQPS Measurement Technology Group Staff

- Jason M DeWees USEPA/OAQPS/AQAD/MTG;
Research Triangle Park, NC; (919) 541-9724
E-mail: dewees.jason@epa.gov
- Robin Segall, USEPA/OAQPS/AQAD/MTG;
Research Triangle Park, NC; (919) 541-0893
E-mail: Segall.Robin@epamail.epa.gov

How the new ASTM method works

The Camera

- The method does not specify any particular camera or camera type.
- The camera must be capable of operating in:
 - Default auto focus mode
 - Default auto-exposure mode
- The camera must be able to generate EXIF 2.1 JPG (or higher) formatted output files.
- Optical zoom is allowed.
- Digital zoom is not allowed.

Photographing the Plume

- Position yourself as you would for Method 9.
- Position yourself to maximize the contrast between the plume and its background.
- Turn off digital camera features such as: flash, optical filters, digital zoom, image stabilization.
- Do not photograph steam....
- Center pictures on the plume observation point.
- Take JPEG images every 15 seconds.

Analyzing the Photographs

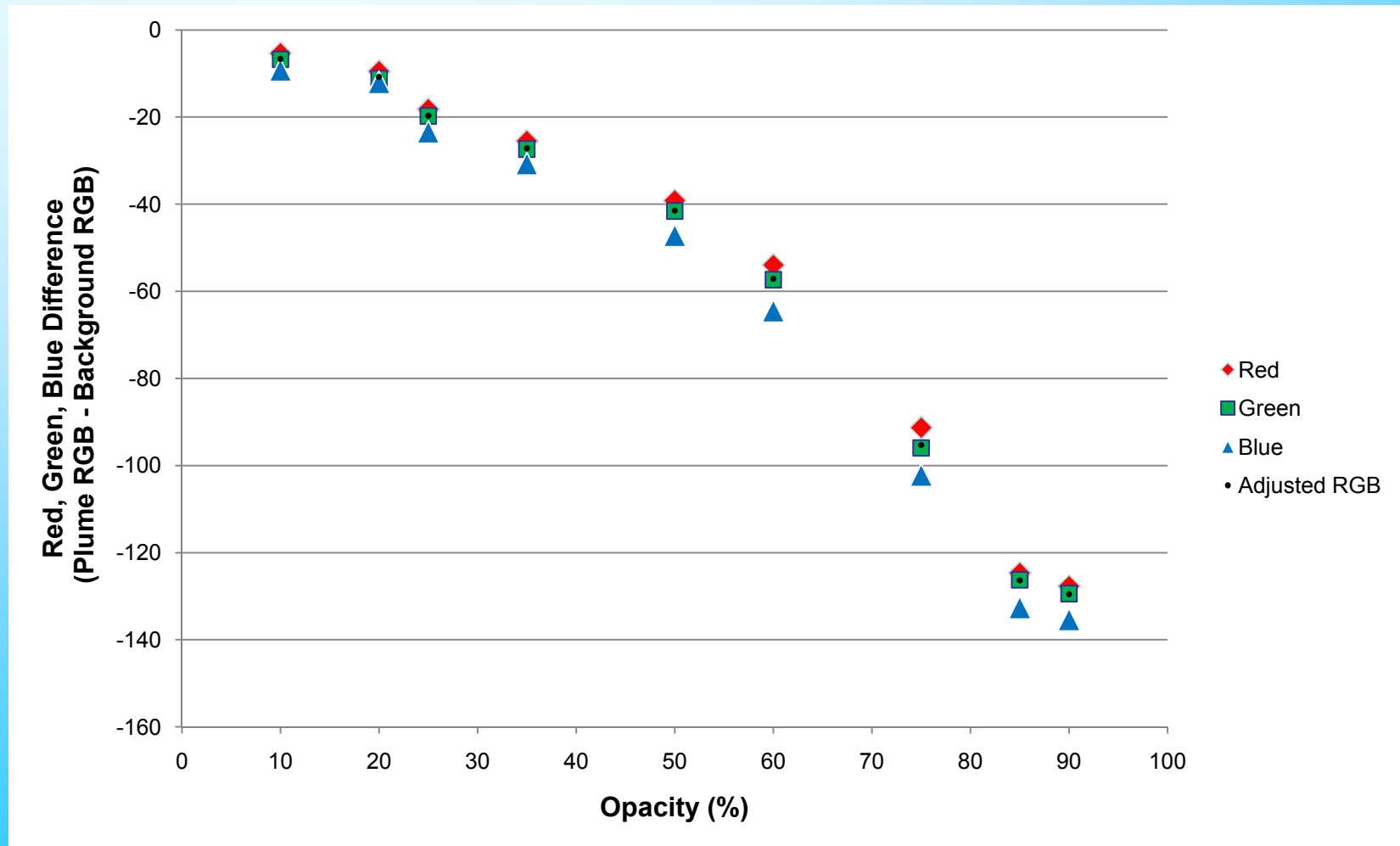
- Download the photographs to a PC.
- Analyze the photographs with software.
 - Compare “in the plume” areas to “background areas” adjacent to the plume.
 - The difference between “in the plume” values and “out of the plume” values is correlated to opacity.

Analyzing a Photograph



Photograph Courtesy of Eastern Technical Associates, Inc.

Before Field Work, the Camera, Software & Operator Must Be Certified

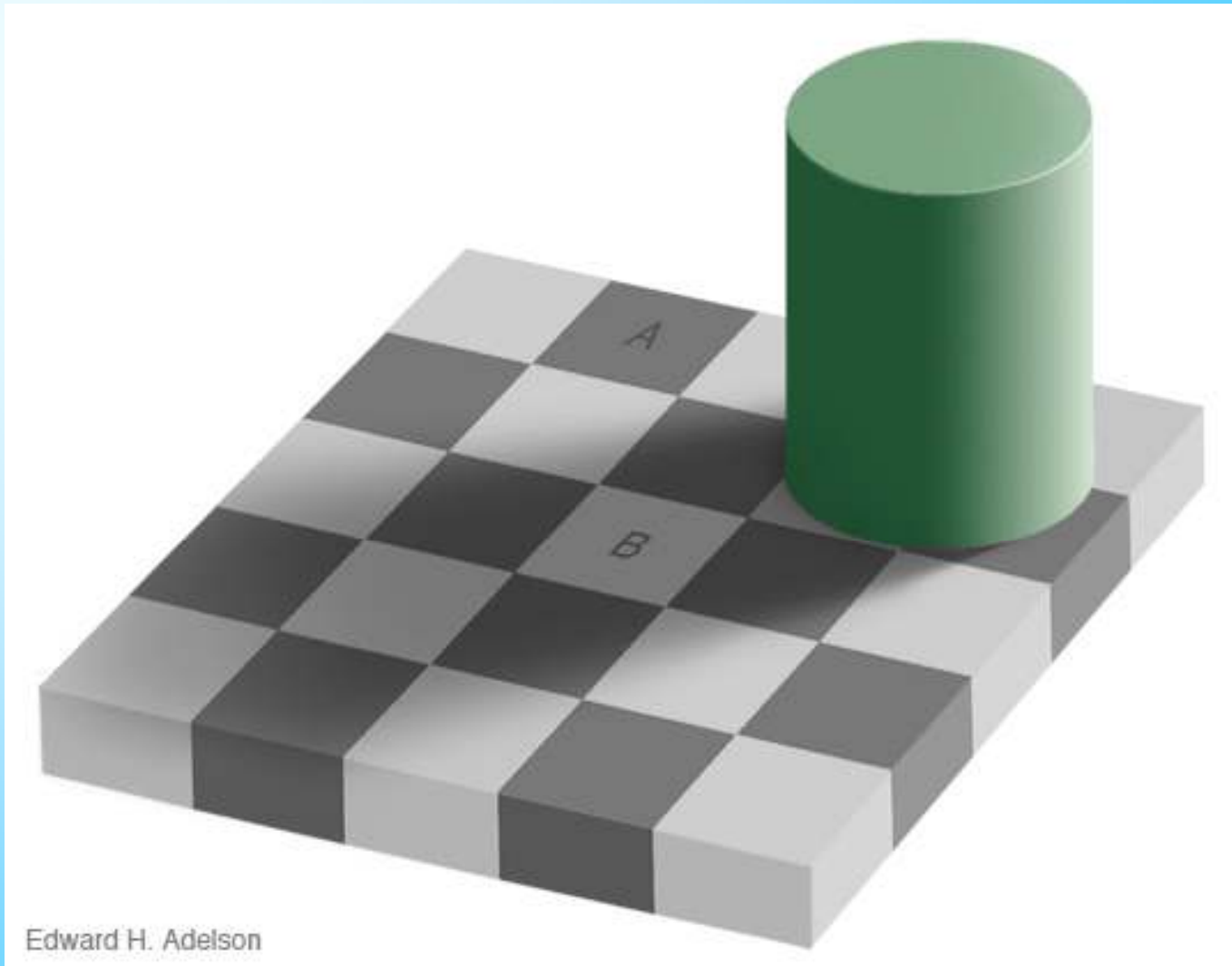


Some “Pros and Cons” of Method 9 and the new ASTM method

Some “Pros and Cons” of Method 9 and the New ASTM Method

Method 9	ASTM D7520-09
A well established method. State & local inspectors are familiar with the method.	Method is new and relatively unknown. Method is very similar to Method 9, however.
Tested in the courts.	Not tested in the courts.
Requires an initial one day of training & certification testing every 6 months thereafter.	Requires 3 to 5 days of training & camera certification every 3.5 years.
Requires minimal equipment.	Requires a camera, software & PC.
Relies on the human eye for opacity measurement.	Relies on a camera and analytical software for opacity measurement.
Provides little post-observation data or evidence.	Provides excellent post-observation data and evidence. A picture is worth...
Appropriate for any size stack.	Not applicable to stacks greater than 7 feet inside diameter, but this may soon change.
Some staff strongly dislike Method 9 certification training.	Staff have expressed an interest in this method.

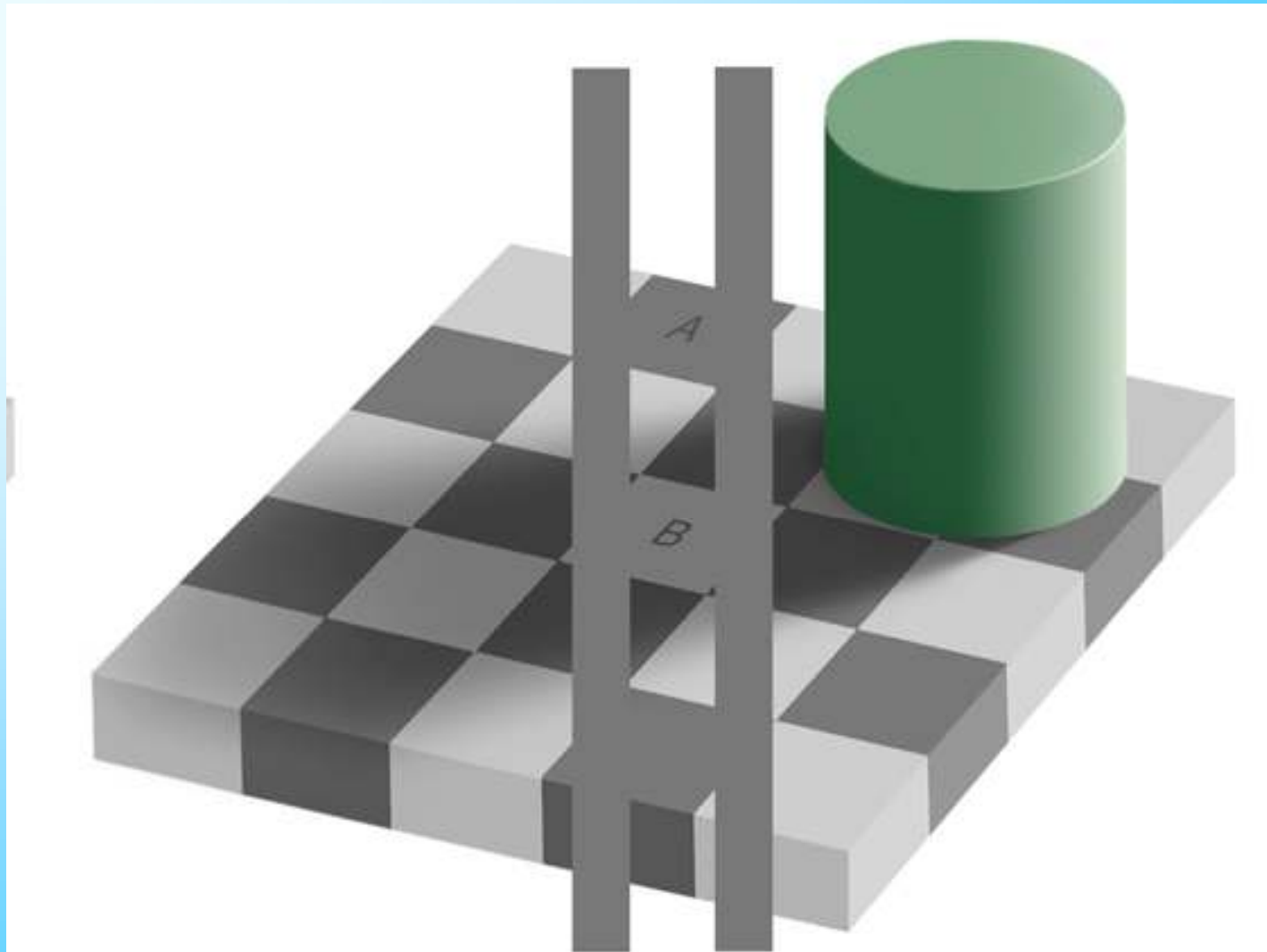
Visual Methods Can Yield Poor Results...



Edward H. Adelson

The squares marked A and B are the same shade of gray.

Courtesy of Edward H. Adelson, MIT



http://web.mit.edu/persci/people/adelson/checkersshadow_proof.html

Digital camera methods hold promise
as good, objective analytical methods
for evaluating smoke opacity....

Some Practical Problems Associated with the New Method

Some Practical Problems Associated with the New Method (1 of 2)

- The only commercially available software to analyze photos for the ASTM method is: DOCS II from Virtual Technology, LLC
<http://www.virtuallc.com/virtuallc/index.asp>
- DOCS II is sold as a package for \$5,995 and includes: camera, PC, software & the usual Method 9 equipment.
- Many states and local agencies just want good, reasonably priced software. (They already have cameras, PCs and Method 9 gear....)

Some Practical Problems Associated with the New Method (2 of 2)

- Commercial interests appear to be strongly influencing/controlling method development...
- Sean Nolan, President of Virtual Technology, LLC leads the Work Group developing the ASTM method.
- Virtual Technology LLC and Eastern Technical Associates, Inc. (a smoke school company) are marketing DOCS II.

Free Software May Allow State and Local Agencies to Analyze Photos

- ImageJ software from the National Institute of Mental Health is a tool state and local agencies might be able to use to analyze digital photographs.
- DEQ is exploring whether ImageJ software can be used calibrate & certify digital cameras for the ASTM method.
- ImageJ software is available at:
<http://imagej.nih.gov/ij/download.html>
- Software specifically designed to analyze smoke plumes would be a better solution....

Areas where EPA, state and local agencies, and others can support and improve the method

What EPA & State & Local Agencies Can Do to Support the New Method

- Get involved with the ASTM Workgroup.
- Try the new method.
- Fund the development of software that:
 - Is easy to use.
 - Runs well in the Windows environment.
 - Provides intermediate results for user QA.
 - Has good documentation so agencies know exactly how the software arrived at its answer.
- Funding could come from EPA, S&Ls, SEPs,...

References

- EPA Method 9
<http://www.epa.gov/ttn/emc/promgate.html>
- ASTM's Digital Camera Opacity Technique (DCOT)
<http://www.astm.org/Standards/D7520.htm>
- DOCS II by Virtual Technology LLC
<http://www.virtuallc.com/virtuallc/index.asp>
- ImageJ software is available at:
<http://imagej.nih.gov/ij/docs/intro.html>

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