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MEMORANDUM

To: Michael G. Dowd, Air Program Manager

From: R. David Hartshorn, Air Compliance Manager 
Bill Gillespie, Air Compliance Specialist

Through: Thomas Faha, Regional Director 

Subject: EPA Alternative Method 82
A Digital Camera Method for Determining Smoke Plume Opacity

Cc: James Golden, Deputy Director
Todd Alonzo, Office of Air Compliance Coordination
Jerome Brooks, Office of Water Compliance

Date: May 31, 2012

Summary and Results

The Northern Regional Office (NRO) has completed a field evaluation of the Digital Compliance Opacity System II (DOCS II), a digital camera system that can be used to measure smoke plume opacity. NRO does not recommend pursuing the use of DOCS II in air compliance determinations at this time. While the system performed reasonably well when used to measure the opacity of black smoke on a blue sky background, the system performed poorly when measuring the opacity of white smoke on a complex background of trees and shadows. NRO will continue to monitor developments in digital camera methods but will not engage in another field evaluation until Virtual Technology, LLC, the software vendor that sells DOCS II, or another vendor provides an improved product.

EPA Regional staff and state and local agencies have expressed an interest in digital camera methods for determining smoke plume opacity. Bill Gillespie and Peter Thaler are available to share their experience with DOCS II and Method 82 with air compliance staff in other DEQ Regions, other state and local agencies, and EPA.

The following pages provide background information on NRO's evaluation, a list of recommended improvements provided to Virtual Technology, and analytical results.

Background

On April 13, 2011, EPA approved Alternative Method 82 as an alternative means of determining smoke plume opacity in field observations. The long established method of making opacity measurements is a visual method, EPA Reference Method 9. Method 82 uses a digital camera, computer software, and a trained user to measure the opacity of a smoke plume. The digital camera method was developed by Committee D22.03 of the American Society for Testing and

Materials (ASTM), the Committee on Ambient Atmospheres and Source Emissions. Performing Alternative Method 82 requires the user to follow ASTM Method D7520-09 while meeting some additional EPA requirements.

At this time, Virtual Technology, LLC is the only company that provides a commercial product that uses digital camera methods to measure smoke plume opacity. This product, the DOCS II system, includes a Canon G11 digital camera, a laptop computer and software.

On September 22, 2011, NRO sponsored an afternoon seminar on digital camera methods and the development and capabilities of the DOCS II system. The seminar was attended by NRO air compliance staff; Todd Alonzo from the Office of Air Compliance Coordination; Jody Monk with Eastern Technical Associates, Inc., a smoke school provider; air compliance staff from the Commonwealth of Pennsylvania and Allegheny County, PA (Pittsburgh) and Steve Rasmussen from Hill Air Force Base, Utah. The U.S. Department of Defense has supported and contributed funding to the development of the DOCS II system.

On September 27-29, 2011, NRO, Virtual Technologies (VT) and Eastern Technical Associates, Inc. (ETA) hosted a training event that provided state and local air quality personnel with the opportunity to get certified as DOCS II users and to become certified to perform EPA Alternative Method 82. NRO and OACC staff attended along with air compliance staff from the Commonwealth of Pennsylvania and Allegheny County, PA (Pittsburgh) and the Bay Area Air Quality Management District in California. Of the eight attendees, five became certified to perform Alternative Method 82. Three DEQ employees, Todd Alonzo, Bill Gillespie, and Peter Thaler, were certified on version 2.0.41.0 of the DOCS II software.

NRO's Evaluation of DOCS II

To determine the accuracy of the DOCS II in practical trials, Bill Gillespie took photographs of smoke plumes of known opacity at two smoke schools run by ETA. Bill Gillespie and Peter Thaler analyzed the photographs using DOCS II software and found that the DOCS II system often performed fairly well when the background in the photographs was homogeneous, for example blue sky. With a homogeneous background, the accuracy of DOCS II was often, but not always, as good as the accuracy of a Method 9 smoke reader. "Stick placement" for background measurements in DOCS II, could produce opacity errors of as much as 15 percent in the measurement of opacities less than 50 percent. Background stick placement selects an area of the photograph to be used as the background for a particular opacity measurement. In many of the situations where DEQ used DOCS II to analyze black smoke on a blue sky background, DOCS II appeared to underestimate plume opacity by about 5 to 15 percent at opacities less than 30 percent. The attached scatter plots illustrate how DOCS II results compared with ETA's recorded opacities.

DOCS II did not perform well when the background in the photographs was heterogeneous, for example when the background was a mixture of trees and tree leaves. Technical experts at Virtual Technology, LLC believe the ability to analyze plumes with complex backgrounds would be improved if users ran DOCS II software on a large screen monitor. DEQ is currently using a small laptop, on loan from VT, to perform analyses. VT technical personnel are also working to

further improve their software to make complex analyses more accurate and easier to perform. The attached scatter plots show the poor performance of DOCS II when the system was used to analyze plumes with a heterogeneous background.

The Benefits of Digital Camera Methods

Objective Measurement: Method 9 is inherently subjective since it relies on the human eye as its sensor. Method 82 relies on the analysis of the pixels in digital images and is, for the most part, an objective measure of opacity.

Post-Observation Evidence: After estimating plume opacity using Method 9, an inspector has a series of visual observations written down every 15 seconds during the measurement period. Method 82 produces excellent post-observation evidence that can be used in enforcement cases. The evidence includes a series of high-quality digital photographs taken of the smoke plume every 15 seconds along with calculated plume opacities.

Less Frequent Training Requirements: Method 9 requires an 8-hour training class every three years and attendance at smoke school every six months. Method 82 requires an 8-hour training class and certification of their digital camera and software every three and a half years.

The Downside Aspects of DOCS II

Equipment Requirements: To perform Method 82 in the field, an inspector must have a certified camera with him/her. To perform Method 9, an inspector need only have a Method 9 run form and a pen or pencil with them. To perform a formal, "legally defensible" opacity determination, both methods require additional equipment (a compass, range finder, inclinometer, etc.)

Office Time: After taking pictures in the field, an inspector using Method 82 must download pictures to his/her computer and analyze the plume photographs they have taken. In simple analysis mode, the analysis of pictures on a homogeneous background, the time required to analyze the photographs is minimal, about a minute per picture. In complex analysis mode, the analysis of pictures with a heterogeneous background, the time required to analyze the photographs can be extensive (as much as about five minutes per picture). Shawn Dolan, the president of VT says his company is working to reduce the amount of time it takes to analyze images in complex mode. In the meantime, VT has offered to analyze photographs that require complex analysis for DEQ on a trial basis.

Costs

VT has provided DEQ with a complete DOCS II system, including camera, laptop and software, free of charge. DEQ is under no obligation to purchase the system.

Next Steps

NRO recommends that DEQ continue to explore the capabilities of digital camera methods because the DOCS II system produces accurate results in situations where opacity measurements are made on homogeneous backgrounds and because digital methods have improved in recent years and the technology is still evolving.