Visible Emission Management Community-Facility-Fire The Digital Opacity Compliance System Third Generation (DOCS3):

USEPA Alternative Method 082 Visible Emission Opacity, Particulate and Volatiles

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Evolution of DOCS II (2006-2020)

Booner's Compliance

Evolution of DOCSII...The Road to SaaS





Evolution of DOCS II



- 2000 to 2005 Several research projects contracted by DOD & Universities
 - EPA TTN, ETC Publishes PRE-008 Determination of Visible Emissions Opacity from Stationary Sources Using Computer-based Photographic Analysis Systems
- 2005 to 2009 Research continued by DOD
 - 2007 ASTM Workgroup formed due to EPA consensus standard direction
 - 2009 ASTM D7520-09 approved and published
- 2012 October ASTM D7520-13 Update Approved by ASTM
 - Allows use of any Digital Image Device: High-Definition Recorders (Digital Video), (Cell Phones), all Sony CCD based Cameras (98% of HDR, Surveillance market)
 - Allows certification of optical and digital zoom
- 2012 February EPA Office of Air Quality Planning and Standards published US EPA Alternate Method 082 (ALT 082), Broadly Applicable Standard:
 - Digital Camera Opacity Techniques (DCOTs) can be used "in lieu of Method 9", for all subparts of 40 CFR 60, 61 and 63
 - Federal Permit changes not required
 - Match ASTM D7520-09
 - Stationary, Mobile, Fugitive

US EPA ALT 082 Broadly Applicable Standard Prove in 2012-Most Credible Evidence Today



Evolution of DOCS II Continued



- 2012 to Present Fugitive Dust Applicability
 - Original research performed June 05'- June 11'
 - Full NIST Long Path Trans. certification completed January 2012
 - ASTM Research Report submitted to committee July 2012
 - Applicable to fugitives per 40 CFR 60 Subpart ooo October 2012
- 2013 301 Testing began to eliminate 7' ASTM stack exit limit
 - EPA desired "comparison with current compliance method"
 - Results ALT 082 is the same as Method 9 observers on stack exits greater than 7'.
- 2015- EPA opinion "Any Creditable Evidence" rule of Clean Air Act, DCOT Most Credible
 - Applicable to all Source types "a picture says a thousand words".
- 2015- FerroAlloy NESAP defines DCOT as BACT, and mandates for Process Fugitive Emis.
- 2016 ASTM D7520-16 Approved no limits on Applicability. Stationary, Mobile, Fugitive
- 2017 FerroAlloy NESHAP final reconsideration ruling DCOT is BACT for Opacity.
- 2018 DOCS II Flare Watch Development begins expanded background, auto detect
- 2019 DOCS II Heavy Diesel Inspection and Maintenance Full Speed Opacity Monitoring
- 2021 Auto-Detect released to production clients (COVID Delayed 8Mo.)
- 2021 Heavy Diesel Inspection and Maintenance Toll Integration (COVID Delayed 8Mo.)

DOCS II is the only ASTM D7520-16 & ALT 082 certified DCOT



DOCS II Global Acceptance





World Bank Requires,<20% Opacity Guarantee for Payment ASTM D7520-16, used for World Bank Opacity Measurement



Leading Organizations in Conservation, Compliance, Sustainability, Training Regulatory Policy and Enforcement, Local and International, all Agree **Digital Image Based Monitoring is the Way to GO**



FAMILIES FOR CLEAN AIR



Digital Image Based Analysis, The "Best" Solution



DOCS II Procedure

Capture







SAMSUNG

Transfer images automatically or manually



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Send for Analysis



Receive Validated Digital **Report**

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Wind Speed 9



Comparison of Compliance Methods



EPA Method 9

- (1) set of (25) White and (25) Black
 (50) readings
 - EPA Required Content Training
 - 50 plume certification
 - <u>+</u>7.5% overall and <= 15% within each set of 25.
- Cert. duration 6 months
- Operational conditions
 - Unlimited backgrounds
 - Unlimited weather conditions
- Paper Non-Validated Record

EPA ALT 08 "Electronic Method 9"; allows separation of data "Capture" from "Analysis"

EPA ALT 082

System Certification Performed by Vendor

- (6) sets of (25) White and (25) Black against various backgrounds (300 images)
 - 4 independent Analyst use System to derive Opacity of each image (1200 results)
 - All (4) Analyst must pass all (6) sets, <u>+</u>7.5% overall and <= 15% within each set of 25
- Cert. duration 3 ½ years

Camera Operator Certification of Field user

- EPA Required Content Training
- DCOT-specific training
- Training for life (must submit 1 acceptable image for analysis quarterly; VTLLC company rule)
- Operational conditions
 - Unlimited backgrounds
 - Unlimited weather conditions
- Digital Validated Record



Problems & Solutions

Top 3 problems defending Method 9 Observations

- VEE record not technically correct, missing data, sun angle, point of view.....
- 2. VEE not performed by Certified Observer
- Smoke School Quality
 Assurance Protocol not
 meeting the requirements
 set forth by USEPA for VE
 certification programs

DOCS II solves top 3 problems

- 1. VEE record completely validated upon save
- Certified Analyst always available to perform analysis
- Certified Analyst history of opacity determination across hundreds of readings eliminating personnel bias

DOCS II SaaS, Complete & Validated, Certified, Reproducible Most Samples are sent to Labs Why not Opacity samples?





DOCS II Compared to Humans

- Less variation than Method 9 against NIST traceable transmissometer
 Average deviation count for students at CARB certification is 23
 Typical deviation count for DOCS II on same certification run is 15
 Over 95% of DOCS II readings were zero or 1 deviation count
- Average deviation under ideal conditions (high contrast)
 - •DOCS II <u>+</u>5%
 - •Method 9 <u>+</u>10%
- Average deviation under difficult conditions (low contrast)
 - •DOCS II <u>+</u>10%
 - •Method 9 <u>+</u>15%
- Flexible applicability
 - •Clouds, Rain, Snow, Trees, & Buildings
 - •Day or Night
 - •Close & Far (Limited only by camera zoom)

Simple, Fast, Reliable, Repeatable



How DOCS II Works

- An image or images of the emission source are captured by a certified Camera Operator using a certified camera
- The images are uploaded to the "Cloud" where they are acquired by a Certified Analyst who identifies the Regions of Interest (marked according to explicit rules and training)
- DOCS II then applies algorithms to the Regions of Interest and calculates the opacity of each image and the average, based on the selected rule, e.g. 6 min. avg., 3 min. avg.
- DOCS II generates a draft VEE report
- Source owner accepts and/or rejects the draft VEE report
- DOCS II generates final VEE report and archive record

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Simple, Fast, Reliable, Repeatable





Regulatory Compliance, Community Conservation





Flare Monitoring System with Opacity Event Reporting





Observation

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Marks observations JPG w opacity. Generates Monthly and Semi Annual report.



Gas & Oil OOOOa Fugitive Emission Survey Opacity Event Reporting



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COMPANY REP: SDD	DATE: 3/27/2018
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EMPERATURE: 63	WIND SPEED/DIR: 5 W
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FUGITIVE OR SMOKE EMISSION INSPECTION

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COMPANY: SENSORY
LOCATION: STARR PASS CONVENTION
COMPANY REP: SDD
SKY CONDITION: CLEAR
TEMPERATURE: 63
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OBSERVER: LINDA RAWSON AFFILIATION SENSORY DATE: 3/27/2018 PRECIPITATION: WIND SPEED/DIR: 5 W

SOURCE ID	SECONDS	IMAGE
AC1	65	
AC2	32	
AC3	0	

- User drags the emission points from facility onto map.
- Emission Points all start Blue

0 0 2

O Type here to search

- User touches each Emission point as they see emissions
- Emission points toggle color Green on Red off
- Clock displays survey time and remaining time
- End of Survey sum totals all on/off events by source and compares to limit
- Generates Survey report listing emission units, visible emission time
- User prompted to record picture of exceeding emission units.



Heavy Duty Vehicle Emissions Enforcement

Enforcement Site



Convert to JPEG every 15 seconds During marked event times and display for observation cut down



Local copy of MP4 "video files" mirrored high capacity drives, Archived monthly Time marked by "Control Operators log" for events.

Local Mounted all

Weather IP Cam

Remote copy of MPEG "video files" Plate/Transponder number tag to images. MP4 into JPG at set interval (reduce storage) Opacity Analysis on high image (smoke > 5%) Creates Violation Record (Image, Opacity, Plate/Trans) Transmits Violation record to ??? For enforcement Automated Enforcement Close out Generates monthly follow up report





Complaint Management

People Complaint About What They

Log In or Create an Account

See with their Eyes, Smell with their Nose, Hear with their Ears



Navigate to SustainableSkys.Org

Take or Attach an Exiting







Touch the Screen to Indicate Where you are looking



Submit to create a Draft Report Submit Draft for Opacity Analysis **Receive Final Report**





2013-01-24 14-43-41



Ambient Temp (in F degrees): 45 Den Point (in F degrees): 31 Relative Hum (in %): 60 Wind Speed (in mph): 0 Wind Direction (in degrees): N Observer Lat Los: 41.19667,-112.10276 Source Lat Los: 41.19687-112.10311 Opacity (in %): TBD



CLICK HERE for review and opacity determination





Where are the Complaints? To Build Community Air Monitoring Infrastructure



Spot the Smoke 30,000 Downloaded on Android

- Spot the Smoke Released in March 2014 (7 Step)
 - Buggy and did not operate well on iPhone (Safari) platform
 - Revision 2, in June 2015 still has browser compatibility (5 Step)
 - works plug and play 70% of the time.
 - Revision 4, Released January 2017, (3 Step)
 - Revision 5, Released January 2020, (2 Step w/Autofill)
- Stationary Sources
 - Requiring Permits, require other compliance monitoring
 - Category people pay to expedite
- Mobile Sources
 - Smaller mobile sources, cars, trucks
 - Requiring frequent licensing
 - Larger mobile sources, planes, trains, ships
 - Reduced licensing frequency
- Fugitive Area Sources
 - Larger sources farms and agriculture
 - Fugitive emissions, largest category of undocumented air pollution
 - Includes Wood Smoke also category people pay to expedite
- Natural Area Sources (spikes during event)
 - Great Dust Storm and Forest Fire Pictures
 - Not predictable















Future Now: PM Speciation

• Measuring PM Concentration via: Light Scatter, Energy Emittance (Oscillation), Temperature variation,





Digital Images Contain The Building Blocks

DOCS II



Light Scatter is a well known Measurement Principle, As Particle size = Wave length = known Scatter (LiDAR)



Temperature change measurement is the baseline for all FTIR based Optical Gas Imaging

Each Pixel holds the values to measure scatter, temp change



Patented, Opacity/PM/VOC

Energy/Intensity Level,

humans can not feel



Cameras Document Light







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In Selected ROI's 30 % Opacity PM < 3m @ 20% PM 3-7m @ 35% PM > 7m @ 45%



Basic Research Reused from APTI 325



Mass Emissions/Opacity Relationship

background appearances under both conditions and not focus only on the appearance of the background through the emisNotes

sions. The observer should remember that the goal in determining opacity values is to judge how much the unobscured background is changed by the emissions.

Mass Emissions/Opacity Relationship

Generally, denser plumes have more particles and, consequently, higher mass emissions. When Method 9 was promulgated, the relationship between opacity and mass emissions was not well developed. Today, opacity can be predicted if sufficient information about the emissions is available. Factors that affect the mass emissions/opacity relationship include:

- · The number of particles
- The particle size distribution
- The pathlength through the plume
- The density of the particles
- The spectral characteristics of the light
 The index of refraction of the particle
- The index of refraction of the particle
 The opacity of the plume in terms of transmission

The relationship can be described by the following equation:

$C = \frac{K R \ln(T)}{P}$

- in which: C = mass concentration
 - K = particle size distribution
 - R = particle density
 - T = equivalent transmittance
 - P = pathlength through the plume

As the pathlength through the plume increases, the opacity increases because the number of particles between the source of light and the detector or observer has increased.

The natural log, In, of the equivalent transmittance, which is referred to as optical density, is also directly proportional to particle concentration. All other factors being equal, opacity is a function of the number of particles in a specified size distribution per unit volume of gas. Particle density is used to convert particle concentration to mass concentration.

Principles of Visual Emissions Measurement • 2-11

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<u> </u>	Р

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- T = equivalent transmittance
- P = pathlength through the plume

As the pathlength through the plume increases, the opacity increases because the number of particles between the source of light and the detector or observer has increased.

The natural log, ln, of the equivalent transmittance, which is referred to as optical density, is also directly proportional to particle concentration. All other factors being equal, opacity is a function of the number of particles in a specified size distribution per unit volume of gas. Particle density is used to convert particle concentration to mass concentration.



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Applied to Wildfires Southern Arizona 2022



>10 VOC

DOCS II



VISIBLE EMISSION	N OBSERVA	TION FORM	Form Nur	nber	Π	Т	Page	of			
Method Used			Continued on VEO Form Number								
Equipment Owner Start			Observat	ion Date	Tr	me Zone	8	Start Time Frei Time			
Shawn Facility Name			1/2/200	00	U	SMST		12:23:43 12:5			
Virtual Technology LLC								Comments			
561 Camino Ramanote			1	45	55	80	65				
EO City Rio Rico	EO Region US-AZ	EO Zip 85648	2	65	65	65	65				
Process	3	50	55	65	60	Avg Opacity = 74.62					
N/A	A N/A N/A				100	65	50				
Control Equipment N/A	5	65	95	75	95						
Describe Emission Point			6	90	40	45	65				
N/A			7	55	50	50	30				
Height of Emiss. Pt Read, 1582-06 East, Same	Height of Emiss.	Pt. Rel. to Observer	8	45	50	45	60				
Distance to Emiss. Pt	Direction to Emiss	a. Pt (Degrees)	9	95	90	70	90				
Start 45218.41 End Same	Start 225.51	End Same	10	85	85	70	90	L			
Vertical Angle to Obs, PL	Direction to Obs.	Pt	11	50	90	65	65				
Distance and Direction to Observa	tion Point from Emissio	n Point	12	65	60	60	90				
Start 956.36 / 150.86 Describe Emissions	End Same		13	55	70	85	60				
Start Other	End Same		14	70	70	50	60				
Emission Color	Water Droplet Plu Attached: () Deta	me iched:()NA:(X)	15	70	60	60	55				
San write End Same		()	16	45	60	60	70				
Stert mountains	End Same		17	60	90	70	55				
Background Color	Sky Conditions		18	50	85	55	65				
Start Dust End Same Wind Speed	Start Overcast Wind Direction	End Same	19	40	90	50	90				
Start 2.8 End Same	Start 298	End Same	20	45	55	40	55				
Ambient Temp. Wet Bu Start 82.99 End Same Start 6	63.5 End Same Sta	Percent rt 52 End Same	21	50	90	95	85				
			22	65	65	60	70				
A THE PART	The second	AL	23	60	100	90	65				
an said a		State of the second	24	70	70	90	60				
Industry Pro		Se vin	25	55	85	95	85				
and the second second	1		26	70	90	65	90				
Carles Process	and and the	Sec. 1	27	40	60	65	70				
100 - 100 - 27		1000	28	45	60	65	85				
THE ADDRESS OF	· · · · · · · · · · · · · · · · · · ·	- Patter	29	65							
THE LE	201 125 9		30								
	m Th	- 3 TE	31								
and the second second	1445	And	32								
14 Mar 1953	A State		Observer	s Name (P	rint)						
A DE TRANS	S. 1 1 28		Shawn	Dolan			0				
Constant State	and the second s	CU.	Shaw	n Dola	n		1/2	/2000			
Longitude Latitud 111.03.03.924.W 31.26	20.474.N	lination	Virtual	Technol	ogy LL	C 05					
Notes			Certified Shawn	By Dolan			D#	4/2022			
							_				

Image	Opacity	Coordinates	Date Taken	Camera Information
Image025.jpg	65	Foreground Coordinates T L B R 742 1001 769 1033 Background Coordinates T L B R 696 313 723 345	Date Taken: 2000-01-0 Camera Mfg/Model: VIVOTEK Temperature: 82.99 Rel Humidity: 52	2 12-29-43.000 (SD9362 Wind Speed/Dir: 2.8 NW Wet Bulb Temp: 63.5
Image026.jpg	55	Foreground Coordinates T L B R 742 1001 769 1033 Background Coordinates T L B R 096 313 723 345	Date Taken: 2000-01-0 Camera Mfg/Model: VIVOTEK Temperature: 82.99 Rei Humidity: 52	2 12:29:58.000 (SD9362 Wind Speed/Dir: 2.8 NW Wet Bulb Temp: 63.5
Image082.jpg	50	Foreground Coordinates T L B R 742 1001 769 1033 Background Coordinates T L B R 696 313 723 345	Date Taken: 2000-01-0 Camera Mfg/Model: VIVOTEK Temperature: 82.99 Rei Humidity: 52	2 12:43:58.000 (SD9362 Wind Speed/Dir: 2.8 NW Wet Bulb Temp: 63.5
Image083.jpg	90	Foreground Coordinates T L B R 742 1001 769 1033 Background Coordinates T L B R 696 313 723 345	Date Taken: 2000-01-0 Camera Mfg/Model: VIVOTEK Temperature: 82-99 Rel Humidity: 52	2 12:44:13.000 SD9362 Wind Speed/Dir: 2.8 NW Wet Bulb Temp: 63.5
Image084.jpg	95	Foreground Coordinates T L B R 742 1001 769 1033 Background Coordinates T L B R 696 313 723 345	Date Taken: 2000-01-0 Camera Mfg/Model: VIVOTEK Temperature: 82.99 Rel Humidity: 52	2 12:44:28.000 (SD9362 Wind Speed/Dir: 2.8 NW Wet Bulb Temp: 63.5
Image085.jpg	85	Foreground Coordinates T L B R 742 1001 769 1033 Background Coordinates T L B R 696 313 723 345	Date Taken: 2000-01-0 Camera Mfg/Model: VIVOTEK Temperature: 82.99 Rel Humidity: 52	2 12:44:43.000 (SD9362 Wind Speed/Dir: 2.8 NW Wet Bulb Temp: 63.5
Image086.jpg	65	Foreground Coordinates T L B R 742 1001 769 1033 Background Coordinates T L B R 696 313 723 345	Date Taken: 2000-01-0 Camera Mfg/Model: VIVOTEK Temperature: 82.99 Rei Humidity: 52	2 12:44:58.000 (SD9362 Wind Speed/Dir: 2.8 NW Wet Bulb Temp: 63.5
Image087.jpg	65	Foreground Coordinates T L B R 742 1001 769 1033 Background Coordinates T L B R 696 313 723 345	Date Taken: 2000-01-0 Camera Mfg/Model: VIVOTEK Temperature: 82.99 Rel Humidity: 52	2 12:45:13.000 SD9362 Wind Speed/Dir: 2.8 NW Wet Bulb Temp: 63.5

DOCS II



Virtual Technology LLC **Automated Electronic** Visible Emissions Observations Visible Emission Surveys (Method 22) **Opacity Observations** (Method 9) Stack/Flare Watch (custom) Heavy Duty Vehicle Emissions (custom) **Opacity to Speciated Particulate Concentration**

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