California Council on Diesel Education and Technology

CCDET III

Instructor Guide

Opacity Testing for Cargo Handling Equipment (CHE)

Instructor Guide
September 2018

TWI
Transportation Workforce Institute

California Council on Diesel Education and Technology

CCDET III

Course Outline

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Course Outline: CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

Table of Contents

Course Overview

This 4-hour course covers implementing the opacity testing for Cargo Handling Equipment (CHE). It includes the environmental and health impacts of particulate matter, smoke test regulations, requirements, and standards as they apply to CHE, SAE J1667 Snap-Acceleration Test procedures with specific variations for CHE, Opacity Test fail procedures, considerations for testing CHE with retrofitted DPFs, and an approved procedure for performing the Snap-Acceleration Test on RTG Cranes. The course includes both classroom and hands-on components.

I. Learning Outcomes and Objectives

Course Learning Outcomes

A. Workers, owners, and managers of cargo handling operations will be able to maintain their vehicles and cargo handling equipment in compliance with CARB regulations.

B. Class participants will be aware of specific regulatory requirements for cargo handling equipment and how they differ from other opacity-test procedures.

Learning Objectives

Upon completion of the course, participants will be able to:

1. Identify health and environmental effects of pollution and particulate matter.
2. Identify smoke test regulations, requirements, and standards as they apply to cargo handling equipment.
3. Correctly perform the SAE Snap-Acceleration Test using equipment provided.
4. Correctly calculate final Snap-Acceleration Test results for CHE when using an opacity meter that is not specifically calibrated for CHE.
5. Correctly perform opacity testing on CHE with OEM DPFs as well as those retrofitted with DPFs.
6. Follow the approved alternative procedure for performing opacity testing on RTG cranes.

II. Course Agenda

The following tables provide the agenda for this 4-hour course. There will be a short break after approximately two hours. There is no scheduled meal break because the course meets for only a half- day.

DAY 1	
15 Minutes	**Introduction** • Housekeeping tasks (sign-ins, etc.) • Course overview and objectives • Review of Course Agenda
10 Minutes	**Environmental Impacts of Particulate Matter** • Why these programs are needed • Detrimental effects of different pollutants • Specific health effect of particulate matter
30 Minutes	**Smoke Test Regulations, Requirements, and Standards** • CHE Regulations • Non-Yard Truck Equipment • CHE Opacity Testing Regulations • Certification Renewal
35 Minutes	**Snap-Acceleration Test Procedures** • Preparation and Safety • Equipment Setup • Test Overview • Performing the test • Validating and calculating results • Fail Procedures • Record Keeping Requirements • Considerations for DPF retrofits
15 Minutes	**Alternate Procedure for Opacity-testing RTG Cranes** • Procedure • Demonstration of RTG Crane controls
15 Minutes	**Break**
90 Minutes	**Hands-on Snap-Acceleration Test Procedures**
30 Minutes	**Assessment**

III. Course Information

COURSE NAME:	CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)
APPROVED:	TBD
CLASS TIME:	4 Hours
PREREQUISITES:	None
TRAINING LOCATION: **MAXIMUM CLASS SIZE:**	8-15 Participants
TARGET AUDIENCE:	Technicians, Owners, Managers, and other responsible for CHE
CERTIFICATE(S):	CCDET Course Completion Certificate

TRAINING AIDS AND EQUIPMENT:

- ☑ Smart Board and/or Projector
- ☑ Computer
- ☑ Whiteboard
- ☑ Personal safety equipment
- ☑ Maintenance reference documentation
- ☑ Vehicle Keys (Crew, operating, and maintenance keys)
- ☑ Set of maintenance tools
- ☑ PowerPoint Presentation
- ☑ Opacity Meter

HANDOUTS:

- ☑ Exercise Handouts
- ☑ Participant Handouts

PARTICIPANT EVALUATION METHODS:

- Written Final Assessment
  - Passing criterion: 70%

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CCDET III

Assessment

Opacity Testing for Cargo Handling Equipment (CHE)

Assessment
Answer Key & Printable Test

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Answer Key - Assessment: CCDET III: Opacity Testing for Cargo Handling Equipment (CHE) – Answer Key

1. The SAE J1667 procedure provides:
   - ***A. A description of how the snap-acceleration procedure is performed***
   - B. Diesel engine certification standards
   - C. Record keeping requirements
   - D. All of the above

2. The HDVIP / PSIP purpose is to?
   - A. Improve air quality
   - B. Address public concerns over smoking vehicles
   - C. To fulfill mandates of Senate Bill 1997
   - ***D. All of the above***

3. The merits of the SAE J-1667 Snap- acceleration test are:
   - A. Approval by the Engine Manufactures Association
   - B. Very effective at identifying possible tampered & poorly maintained vehicles
   - C. Reliable and repeatable results
   - **D. All of the above**

4. Some of the requirements to perform the Snap-acceleration test correctly include:
   - A. Performing the test on a fully warmed engine
   - B. Ensure all accessories are off
   - C. Instructions to the vehicle operator on proper testing procedures
   - ***D. All of the above***

5. CHE stands for:
   - A. Car Hulling Equipment
   - B. Car Handling Equipment
   - ***C. Cargo Handling Equipment***

6. CHE applies to what Equipment?
   - A. Mobile equipment
   - B. Compression-ignition engines
   - C. Used at the ports and intermodal rail yards
   - ***D. All of the above***

7. CHE regulations do not require annual reporting.
   - A. True
   - ***B. False***

8. CHE regulations do not require recordkeeping.
   - C. True
   - ***D. False***

9. Cargo handling Equipment Regulation started in what year?
   A. January 2004
   B. January 2005
   C. January 2006
   D. January 2007

10. Non-Yard Truck Equipment include CNG equipment?
   A. True
   B. False

11. Non-Yard Truck Equipment are a diverse group of vehicle types?
   A. True
   B. False

12. According to J1667 procedures, prior to testing, the opacity meter should be verified for:
   A. Zero reading
   B. Full Scale
   C. Mid-point reading
   D. A and B

13. When performing a smoke test always stand:
   A. To the side of the vehicle
   B. Between the wheels of the vehicle
   C. On top of the deck plate of the vehicle
   D. In front so the operator can see you

14. The snap-acceleration test results shall be considered invalid, when the post-test smoke meter zero shift check valves exceed:
   A. 10%
   B. 0's
   C. 0%
   D. 2%

15. When the engine has reached the maximum governed high idle speed, during any snap-acceleration, and the throttle has been depressed for the required time. The operator shall release the throttle and allow the engine to return to idle. Once the engine returns to the low idle speed, the engine should remain at idle for a minimum of _____ seconds and no longer than _____ seconds, before initiating the next snap-acceleration test cycle.
   A. 0 and 45 seconds
   B. 15 and 45 seconds
   C. 10 and 60 seconds
   D. 5 and 45 seconds

16. Under SAE J1667 smoke test procedure the maximum allowable Spread in opacity between the three snap acceleration tests is:
    A. 10%
    B. 15%
    C. 5%
    D. 2%

17. The snap-acceleration test cycle states that the operator shall move the throttle to the fully open position as rapidly as possible. Once the engine reaches its maximum governed high idle speed, the operator should hold the throttle depressed an additional:
    A. 15 to 45 seconds
    B. 1 to 4 seconds
    C. 5 to 60 seconds
    D. 0 to 45 seconds

18. The ARB Executive Order (EO) list both the PM certification level and the certification standard
    A. True
    B. False

19. Calculating final opacity value per CHE Regulation is done by?
    A. Average of the 3 readings
    B. Average of the 2 closest readings
    C. Average of the 2 lowest readings
    D. Average of the 6 readings

20. J1667 PSIP/ HDVP results are based on
    A. Average of the 3 readings
    B. Average of the 2 closest readings
    C. Average of the 2 lowest readings
    D. Average of the 6 readings

21. Opacity testing is required each year regardless of the previous year's results.
    A. True
    B. False

22. When opacity-testing cargo handling equipment with a retrofitted DPF, the opacity meter is placed upstream of the DPF.
    A. True
    B. False

23. When opacity-testing an RTG crane, the snap is performed by:
    A. Switching from the idle speed setting to the full speed setting and back again
    B. Lifting and lowering the hoist mechanism of the crane
    C. Switching the crane's engine from the off position to the run position and back off again
    D. There is no approved method for opacity testing an RTG crane

Assessment: CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

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   A. A description of how the snap-acceleration procedure is performed
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CCDET III

Handouts

Opacity Testing for Cargo Handling Equipment (CHE)

Handouts

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Applying the SAE J1667 Snap Acceleration Test Procedure to RTG Cranes

Target Audience

This procedure is designed specifically for RTG cranes that cannot be tested using the standard SAE J1667 procedure. Prior approval of the Executive Officer **is not** required for this modified procedure.

Other than when using this procedure, if performing the SAE J1667 Snap Acceleration Test is not feasible, the end-user must demonstrate that performing the test is not feasible, and use an alternative method of compliance that has been approved by the Executive Officer. The EO must determine whether the alternative procedure causes an increase in soot accumulation rates in the VDECS. This pre-approved procedure, allows end-users to avoid the case-by-case approval requirements for RTG cranes.

Overview

RTG cranes lack the throttle mechanisms commonly found in other vehicles. Therefore, it is impossible to perform the opacity test in the manner normally required.

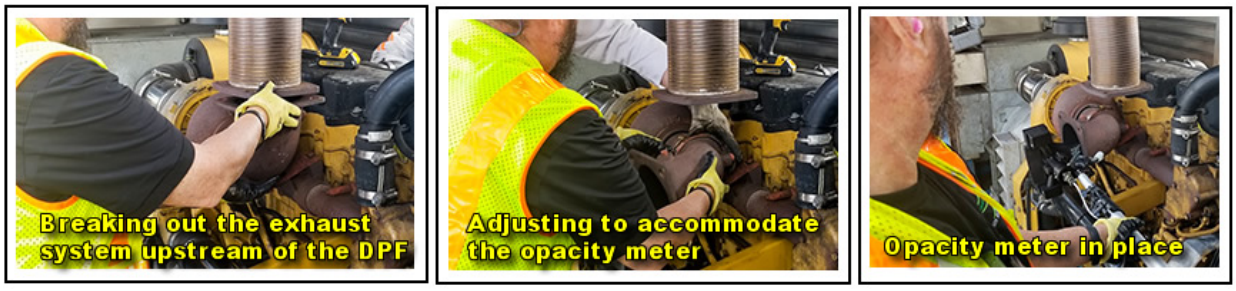
Most RTG cranes operate using a generator set. The diesel engine powers the generator. The engine is switched from *idle speed (650-750 rpm)* to *full speed (1800 rpm)* where it remains during normal operation. The system is designed to maintain 1800 rpm, which enables the generator to deliver consistent electrical frequency (60Hz) and voltage but makes the normal snap acceleration test impossible to administer. However, when the RTG crane begins to lift a load, the engine momentarily drops below 1800 RPM before returning to normal. This somewhat approximates the conditions found in an on-road vehicle during a typical snap acceleration test.

This procedure is performed by lifting the hoist mechanism of the RTG crane without a cargo container or other load attached. It was developed using Cummins and Caterpillar engines. Engines from other manufacturers should function similarly.

Where to Place the Opacity Meter

Cargo handling equipment (CHE), which has been retrofitted with a Diesel Particulate Filter (DPF), must be opacity-tested upstream of the DPF, while equipment that comes from the manufacturer with a DPF in place is tested at the stack or tailpipe as normal. This requirement exists because the retrofitted equipment was originally certified without a DPF in place; so subsequent testing is performed under similar conditions. A DPF greatly reduces but does not eliminate harmful emissions. The upstream testing requirement ensures that the DPF does not mask underlying engine problems.

Figure 1:
RTG Crane with a retrofitted DPF with the exhaust system broken-out at the turbo charger.



Applying the SAE J1667 Snap Acceleration Test Procedure to RTG Cranes

Procedure

This procedure modifies the J1667 opacity test to be used with RTG cranes. All other aspects of the existing J1667 procedure remain in place and should be followed.

Step	Action
1	Start the diesel engine, and allow it to warm-up to normal operating temperature. • Typically, 10 to 15 minutes • Operating the crane often expedites reaching normal temperature
2	Once the engine is at normal operating temperature, lower the hoist mechanism to a low position. • During the test, you will lift the hoist mechanism ***without a cargo container or other weight attached***
3	Attach the opacity testing device as required by the SAE J1667 procedure. • **DPF Retrofit:** Attach opacity test equipment upstream of the DPF • **DPF OEM:** Attach opacity test equipment at the stack or exhaust pipe (downstream of the DPF)
4	On the opacity meter, press the **Start Button** or respond to the prompts to begin the test and to start each snap (varies by device).
5	**Perform the snap:** Lift the crane hoist mechanism for 1- 4 seconds at full speed. • This simulates fully depressing the throttle on an on-road vehicle
6	Stop lifting, and wait 5 to 45 seconds (target 8 to 10 seconds). • Engine should return to normal unloaded RPM (1800 RPM) • If the hoist mechanism is too high to complete the next lifting snap, lower it to a convenient position at a safe speed
7	Repeat steps 5 and 6 for a total of six cycles (three purge & three test). • The three test cycles must be completed within two minutes of the purge cycles
8	End the snap acceleration test.
9	Calculate results based on the nearest two of the three test readings, and retain the test results for your records. • As of this writing, only the *Wager 7500 Smoke Meter* performs CHE calculation automatically. All other opacity meters average all three test values; so the calculation for CHE equipment will need to be performed manually. *See the next page for test criteria and failure instructions.*

Applying the SAE J1667 Snap Acceleration Test Procedure to RTG Cranes

Test Criteria

PM Emission Standards Table

PM Emission Standard		Maximum Opacity
g/kw-hr	g/bhp-hr	
> 0.54	> 0.40	55%
0.42 to 0.54	0.31 to 0.40	45%
0.28 to 0.41	0.21 to 0.30	35%
0.15 to 0.27	0.11 to 0.20	25%
0.07 to 0.14	0.05 to 0.10	15%
< 0.07	< 0.05	5%

Opacity Limits

The ARB Executive Order (EO) lists both the PM certification level and certification standard. The EO for all engines can be found on the ARB website:

https://www.arb.ca.gov/msprog/offroad/cert/cert.php

Calculating Test Results for CHE

Average the closest two of the three snap test results. As of this writing, only the *Wager 7500 Smoke Meter* performs CHE calculation automatically. All other opacity meters average all three test values; so the calculation for CHE equipment will need to be performed manually.

Example: Given readings of 3%, 4%, and 6.5%, the closest two values of 3% and 4% would be averaged together for a final opacity test result of 3.5%.

Failure Instructions

If the equipment fails the opacity test:

- Take the equipment out of service and repair the engine as required
- After making the required repairs, test the equipment again using the same procedure and calculation method
- The opacity test results after repairs may not be more than five percentage points higher than the maximum defined in the CHE regulation, or the equipment may not be placed back into service
    - For example: If the maximum opacity is 35% the maximum opacity after repairs would be 40%; for a maximum opacity of 45%, the maximum opacity after repairs would be 50%

California Council on Diesel Education and Technology

CCDET III

Instructor Notes

Opacity Testing for Cargo Handling Equipment (CHE)

Instructor Notes

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CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

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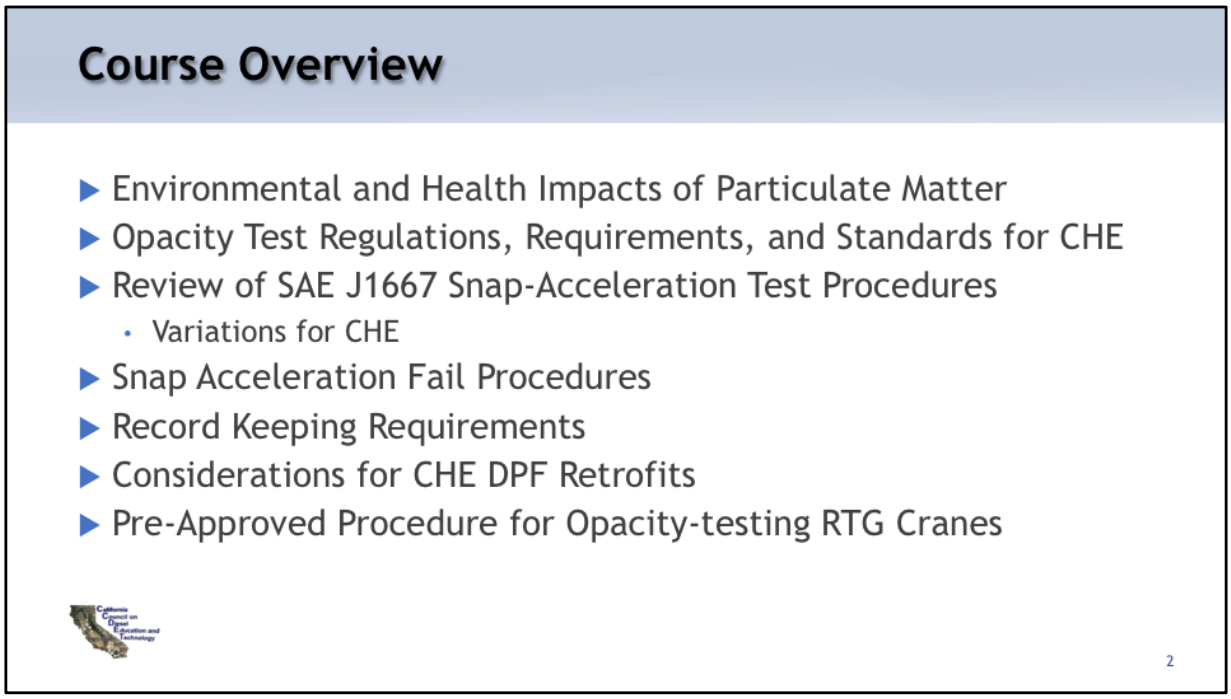
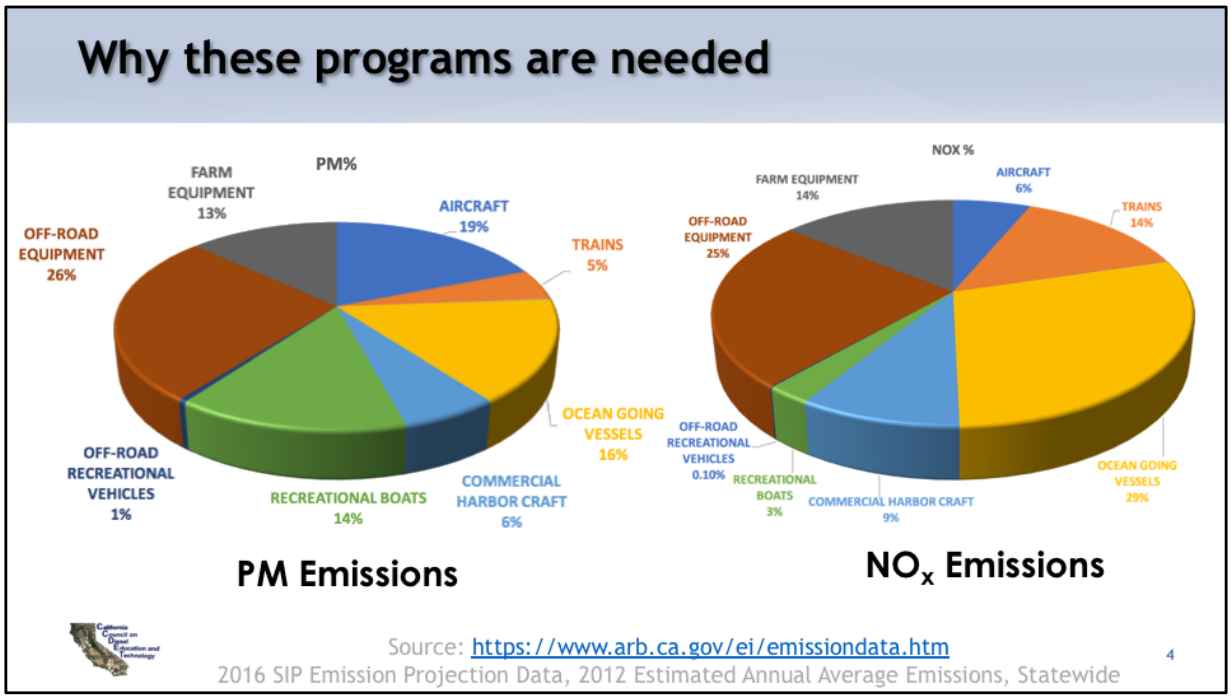


Go over the topics that will be covered in the course.
Refer students to the printed course outline for details and timing.

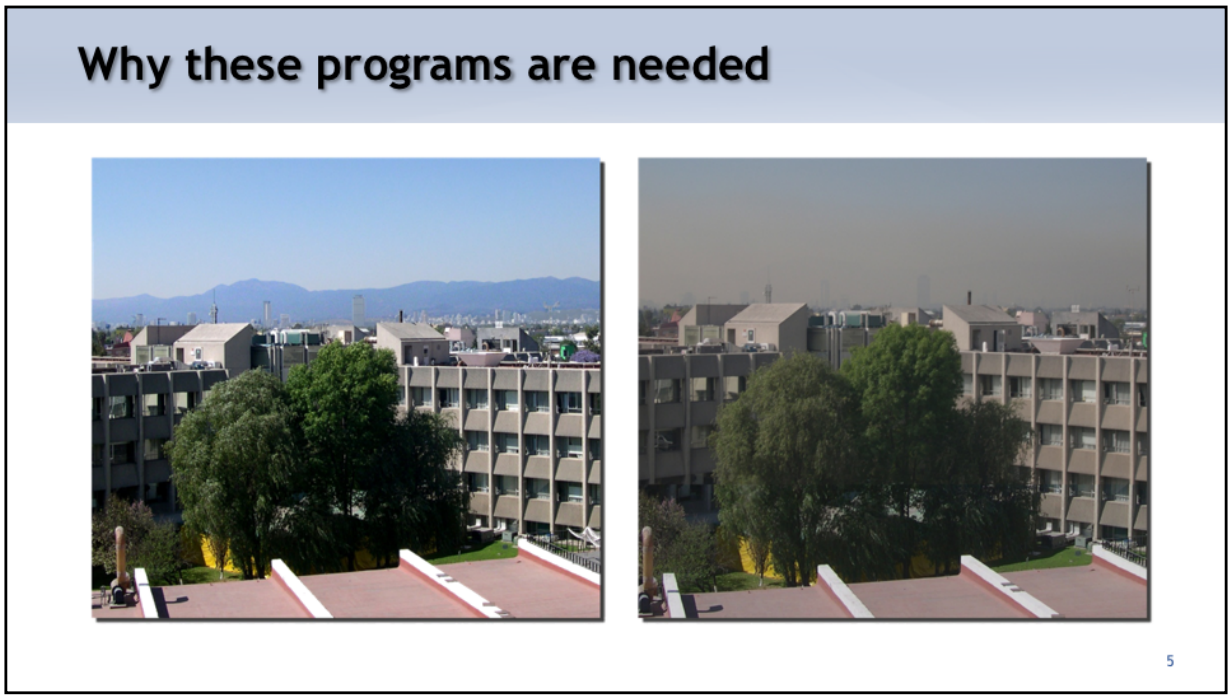

Environmental & Health Impacts of Particulate Matter
3

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)



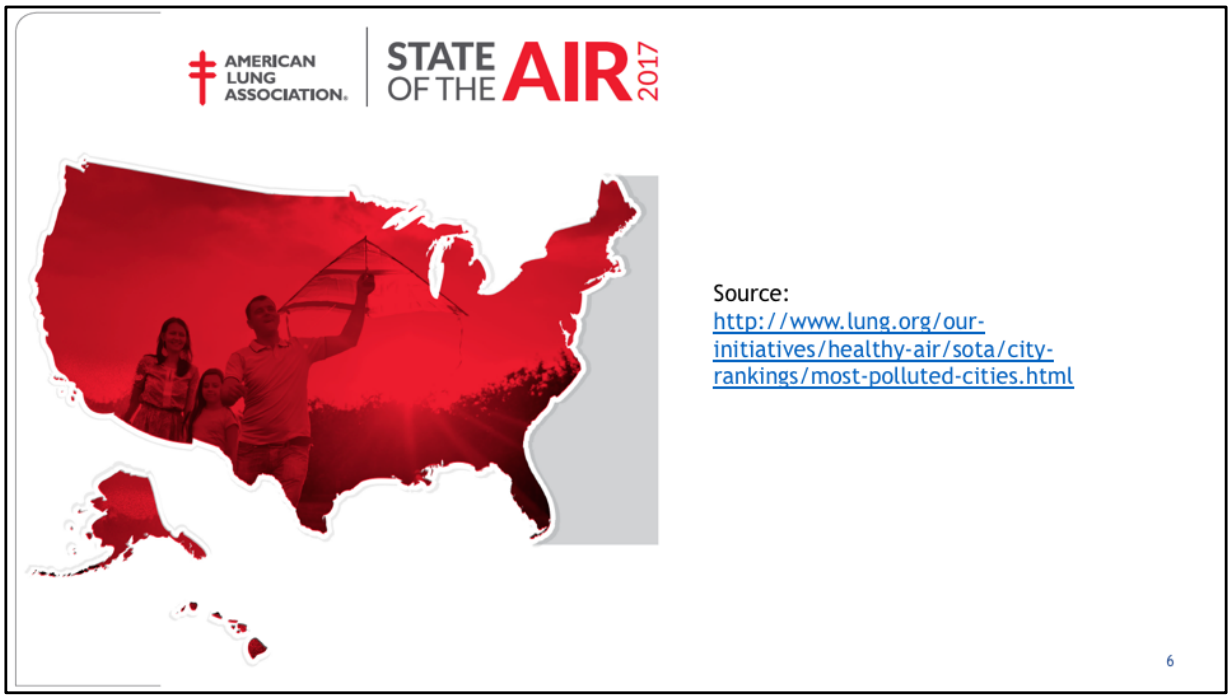
SOURCE:
2016 SIP EMISSION PROJECTION DATA, 2012 Estimated Annual Average Emissions, STATEWIDE
https://www.arb.ca.gov/ei/emissiondata.htm
Off-Road Sources

This chart shows “Other Mobile Sources” of pollution. Off-road equipment contributes to approximately 26% of PM Emissions and 25% of Nox emissions from other mobile sources.



- Particulate matter (PM) that is 10µ in size and smaller is inhalable PM. Inhaled PM aggravates & irritates lung tissue causing it to become inflamed affecting breathing
    - PM from diesel exhaust has toxics such as benzene, nickel, arsenic, formaldehyde, & polycyclic aromatic hydrocarbons. These chemicals are toxic, carcinogenic, mutagenic & teratogenic.
- Oxides of nitrogen (NOx) are/is created when the temperature of combustion meets & exceeds approximately 2500° F.
    - NOx is a precursor to photochemical smog & ozone.
    - Smog & ozone irritates mucus membranes (eyes, throat, lungs), exacerbates heart & lung diseases, increases hospital visits, stunts plant growth & reduces crop yields (CA's #1 industry is ag), affects tourism
- Both PM & smog reduces visibility

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)



CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

Ranking of People at Risk in Most Polluted Cities - 2017			
Rank	Year-Round Particle Pollution	Oxone Pollution	Short-Term Particle Pollution
1	Visalia-Porterville-Hanford, CA	Los Angeles-Long Beach, CA	Kern, CA
2	Bakersfield, CA	Bakersfield CA	Fresno, CA
3	Fresno-Madera, CA	Fresno-Madera, CA	Kings, CA
4	San Jose-San Francisco-Oakland, CA	Visalia-Porterville-Hanford, CA	Stanislaus, CA
5	Los Angeles-Long Beach, CA	Phoenix-Mesa-ScottAZ	Fairbanks North Star Borough, AK
6	Modesto-Merced, CA	Modesto-Merced, CA	Madera, CA
7	El Centro, CA	San Diego-Carlsbad, CA	San Joaquin, CA
8	Pittsburgh-New Castle-Weirton, PA-OH-WV	Sacramento-Roseville, CA	Salt Lake, UT
9	Cleveland-Akron-Canton, OH	New York-Newark, NY-NJ-CT-PA	Cache, UT
10	San Luis Obispo-Paso Robles- Arroyo Grande, CA	Las Vegas-Henderson, NV-AZ	Merced, CA
11	Medford-Grants Pass, OR	Denver-Aurora, CO	Shoshone, ID
12	Philadelphia-Reading-Camden, PA-NJ-DE-MD	Houston-The Woodlands, TX	Utah, UT
13	Indianapolis-Carmel-Muncie, IN	Dallas-Fort Worth, TX-OK	Lemhi, ID
14	Louisville/Jefferson County– Elizabethtown–Madison, KY-IN	El Centro, CA	Riverside, CA
15	Johnstown-Somerset, PA	Fort Collins, CO	Douglas, NV
16	Houston-The Woodlands, TX	El Paso-Las Cruces, TX-NM	Franklin, ID
17	Fairbanks, AK	Redding-Red Bluff, CA	Tulare, CA
18	Detroit-Warren-Ann Arbor, MI	San Jose-San Francisco-Oakland, CA	Ravalli, MT
19	Altoona, PA	San Antonio-New Braunfels, TX	Plumas, CA
20	Lancaster, PA	Salt Lake City-Provo-Orem, UT	Weber, UT
21	Cincinnati Wilmington-Maysville, OH-KY-IN	Hartford-West Hartford, CT	Santa Cruz, CA
22	Birmingham-Hoover-Talladega, AL	Baton Rouge, LA	Los Angeles, CA
23	Harrisburg-York-Lebanon, PA	Philadelphia-Reading-Camden, PA-NJ-DE-MD	Inyo, CA
24	New York-Newark, NY-NJ-CT-PA	Sheboygan, WI	Lincoln, MT
25	Erie-Meadville, PA	Chico, CA	Washoe, NV

Source: http://www.lung.org/our-initiatives/healthy-air/sota/city-rankings/most-polluted-cities.html

- State of the Air report shows why these programs are so important in CA
    - All cities in red are in California

Health and Environmental Impacts

Constituent	Detrimental Effect
Particulate Matter (PM)	(PM10/PM2.5) Carcinogenic/Mutagenic Respiratory Disease
HC & Nox (Smog Precursors)	Ozone (smog) Respiratory Disease Crop Losses
NOx & Sox	Acid Deposition Visibility Degradation
Toxic Air Contaminants	Cancer & Other Ill Effects

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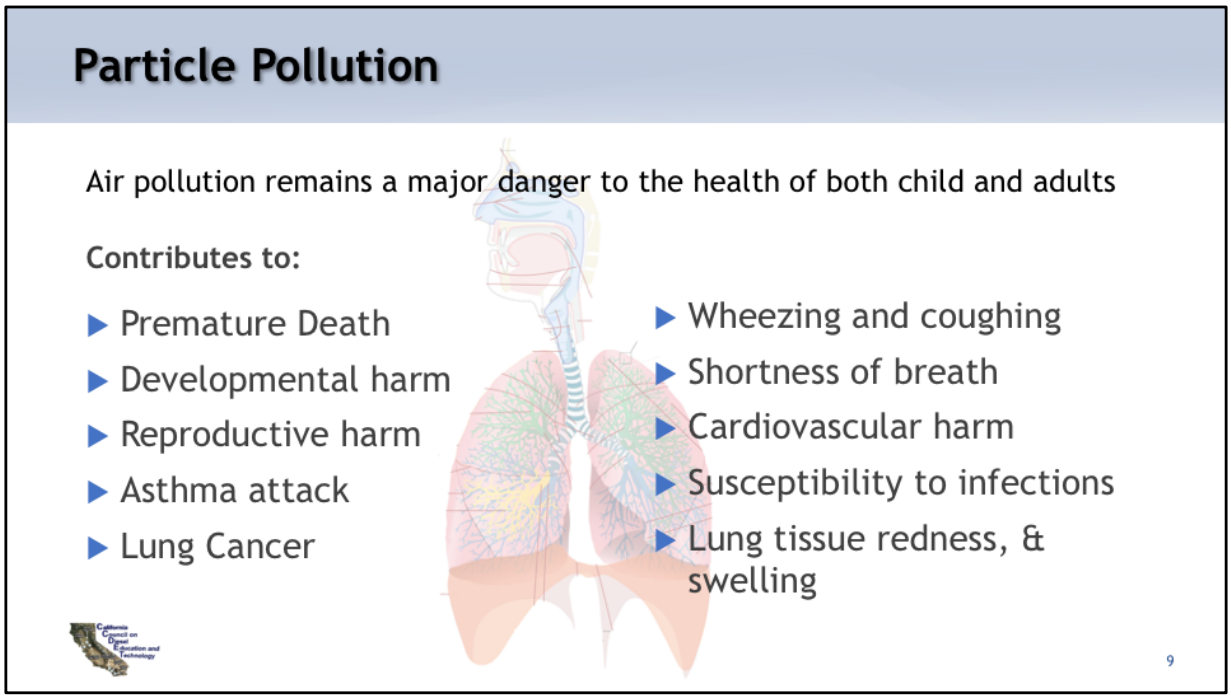
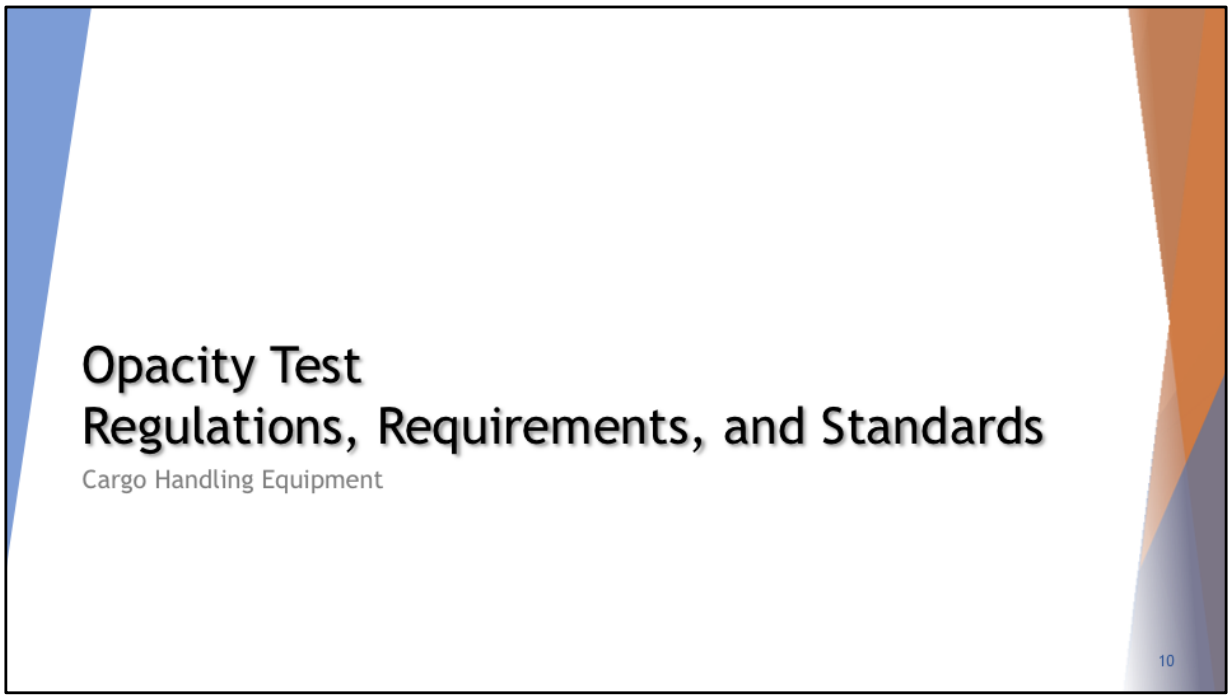
Summarize the health and environmental effects according to the chart.

Hazardous air pollutants (source: Natural Resources Defense Council https://www.nrdc.org/stories/air-pollution-everything-you-need-know#sec3)
These are either deadly or have severe health risks even in small amounts. Almost 200 are regulated by law; some of the most common are mercury, lead, dioxins, and benzene. “These are also most often emitted during gas or coal combustion, incinerating, or in the case of benzene, found in gasoline,” Walke says. Benzene, classified as a carcinogen by the EPA, can cause eye, skin, and lung irritation in the short term and blood disorders in the long term.

Polycyclic aromatic hydrocarbons, or PAHs, are toxic components of traffic exhaust and wildfire smoke. In large amounts, they have been linked to eye and lung irritation, blood and liver issues, and even cancer. In one recent study, the children of mothers who’d had higher PAH exposure during pregnancy had slower brain processing speeds and worse symptoms of ADHD.



Go over the health impacts of particle pollution as outlined in the slide.


Opacity Test
Regulations, Requirements, and Standards
Cargo Handling Equipment
10

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

Cargo Handling Equipment (CHE) Regulations

- Implementation of CHE Regulation began Jan. 1, 2007
- Regulation applies to:
  - Mobile equipment with compression-ignition engines
  - Used at ports & intermodal rail yards
- Applies to new and in-use engines
- Annual reporting and recordkeeping requirements

11

Discuss CARB regulations as they pertain to CHE

- The Cargo Handling Equipment Regulation began in January 2007
- The Regulation applies to mobile equipment with compression-ignition engines that are used at ports and intermodal rail yards.
- The Regulation does not apply to portable compression-ignition engines or equipment, equipment used for fuel delivery or to transport personnel, and equipment brought on site temporarily for construction projects or special jobs/repairs that were not planned or due to maintenance activities.
- Applies to both new and in-use engines
- Recordkeeping is Required. Reporting is voluntary but is encouraged

- "In-use" equipment is defined by the CHE Regulation as equipment that was on a port or intermodal rail yard before January 1, 2007. All in-use non-yard truck equipment had to be fully compliant with the regulation by December 31, 2013, and yard truck equipment had to bet be fully compliant with the CHE Regulation by December 31, 2017.
- All equipment that is subject to the CHE Regulation must participate in annual opacity testing. Newly purchased equipment must be tested annually started on January 1st of the calendar year four years later than the MY of the engine.

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

- MY is defined as the engine family name date. DCEXL06.7AAH is a 2013 engine. This engine must be tested on Jan 1, 2017, even if it was manufactured in 2014.

Non-Yard Truck Equipment

- Top picks, side picks, rubber-tired gantry cranes, forklifts, manlifts, pickup trucks, etc.
- Used to load, unload, stack, and store cargo containers, maintenance and repair activities

- Dozers, loaders, excavators, etc.
- Used to handle bulk and dry cargo

Discuss the CHE affected by the regulations

- The non-yard truck equipment are a diverse group of vehicle types.
- For our regulation, they include equipment that
    - Handle cargo containers such as top picks, side picks, rubber-tired gantry cranes, and forklifts.
    - They also include dozers, loaders, and excavators that handle bulk and dry cargo
- The non-yard truck equipment account for almost a third of the cargo handling equipment population and emissions.

- All in-use non-yard truck engines must have a Verified Diesel Emission Control Strategy (VDECS) installed. All Tier 3 and older engines that were compliant at time of purchase were required to have a Level 3 VDECS installed one year after purchase.
    - Tier 0-Tier 3 engines need to have a retrofit DPF installed to be in compliance with the CHE regulation. These need to be tested upstream of the DPF.

- All newly purchased yard truck and non-yard truck equipment brought onto a port

or intermodal rail yard must have either a Tier 4 Final off-road engine or a model year (MY) 2010 or newer on-road engine.

* Tier 4i or Tier 4 final engines come with an OEM DPF and should be tested at the tailpipe.
* A yard truck with an on-road engine cannot have a retrofit DPF installed - this is illegal under the verification regulations.
* There are no DPFs verified for off-road engines with EGR.

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

Examples of Yard Trucks

Source: Exit2DOS2000
https://commons.wikimedia.org/w/index.php?curid=7265374

Source: © Superbass / CC-BY-SA-4.0
https://commons.wikimedia.org/wiki/File:2016-07-29-Terminal_tractor-6213.jpg

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- A yard truck is defined as an off-road mobile utility vehicle used to carry cargo containers with or without chassis. They are also known as utility tractor rigs (UTRs), yard tractors, yard goats, yard hostlers, yard hustlers, or prime movers. Non-yard truck equipment refers to all other types of CHE except yard trucks. This includes, but is not limited to equipment categories such as container handling equipment, forklifts, construction equipment, or gantry cranes

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

CHE Regulation & Opacity Testing

- Opacity testing included as part of 2011 amendments
- U.S. EPA authorized enforcement of 2011 amendments to CHE regulation in 2015
- Requires opacity testing similar to the **SAE J1667** procedure used for HDVIP
- Enforcement began October 26 2015
  - Compliance phase-in at 100% since July, 2016
- Regulation requires that all testers must be **CCDET certified**

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Discuss these additional regulations as they apply to CHE.
Enforcement began October 26, 2015,

ARB had a compliance phase-in schedule listed below.
Percentage of Fleet Opacity Tested Compliance
Date
25% October 26, 2015
50% January 24, 2016
75% April 28, 2016
100% July 27, 2016

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

Opacity Monitoring Requirements

- New CHE exempt for first four (4) years
  - Example: MY 2015 engine exempt until Jan. 1, 2019
- If not feasible due to engine configuration, end-user must use alternative methods of compliance:
  - Must be approved by ARB
  - Must demonstrate opacity test not feasible
  - Must detect increased soot
  - Pre-approved alternate procedure for RTG cranes
- Testing required on 100% of fleet since July 27, 2016

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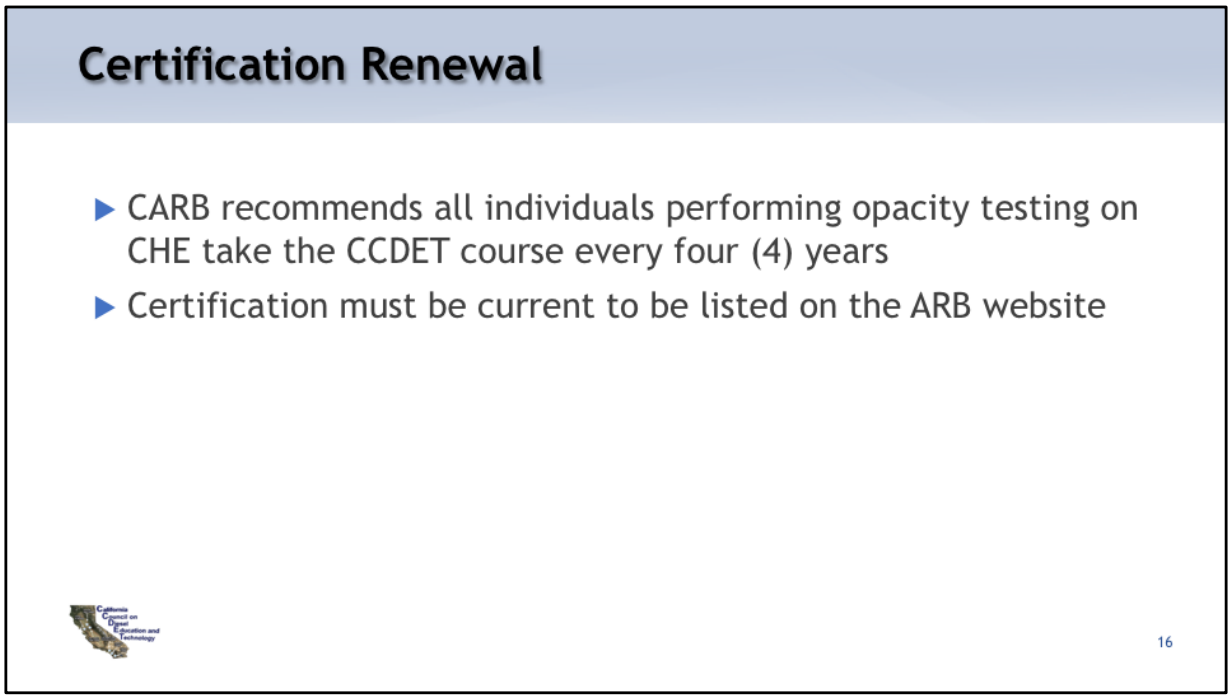
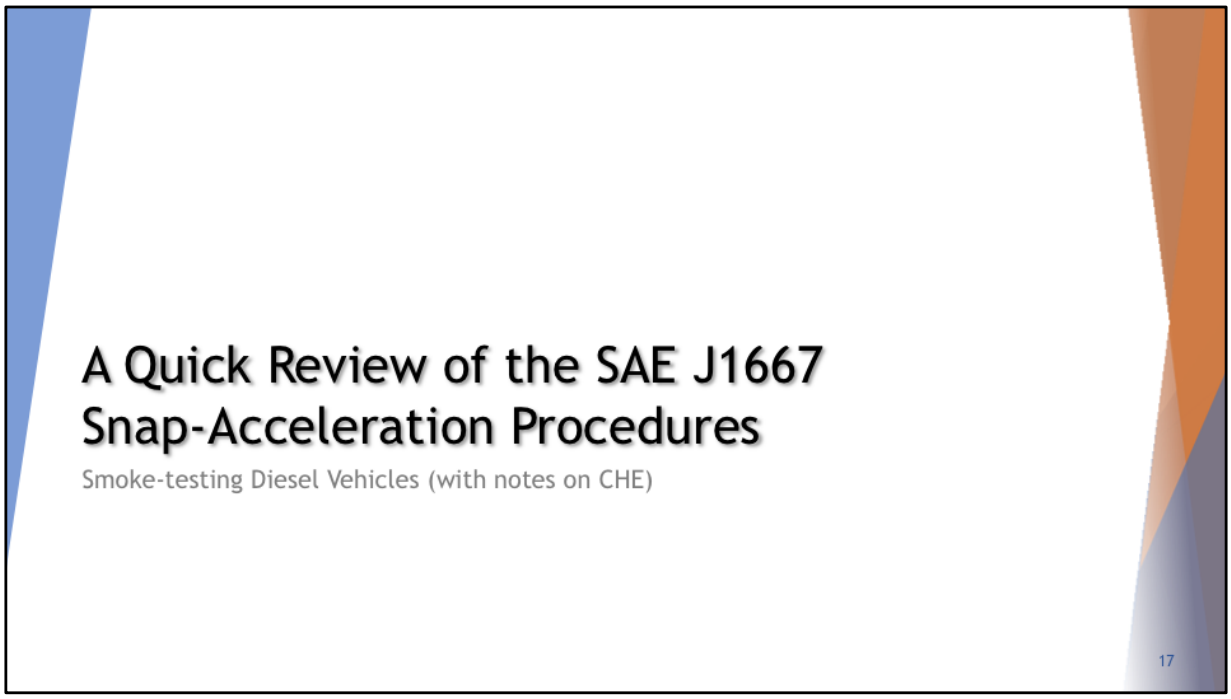
- New CHE are exempt from the opacity monitoring requirements until four years old (for example – 2015 MY engine is subject January 1, 2019)
  - That is 4 years after the model year/family name of the engine. (MY = family name year) The engine could be a 2012 installed in a new 2013 crane, or a 2013 manufactured in 2014. Date is based on engine family name
- If it can be demonstrated that complying with the opacity testing requirements is not feasible due to the engine/equipment configuration, then an alternative method of compliance may be used if approved by the ARB Executive Officer.
- The alternative compliance method must be submitted to ARB staff for review and approval, the equipment owner/operator must demonstrate that the required opacity test is not feasible, and the alternative test method must be able to detect increased soot accumulation rates in the after treatment control device and the need for maintenance and repair.
- Engines that operate at constant speed and variable load (such as rubber-tired gantry crane engines) are one type of engine that could require an alternative compliance method.
- Pre-approved alternative method for testing RTG Cranes
- The CHE regulation allowed a compliance phase-in schedule for opacity

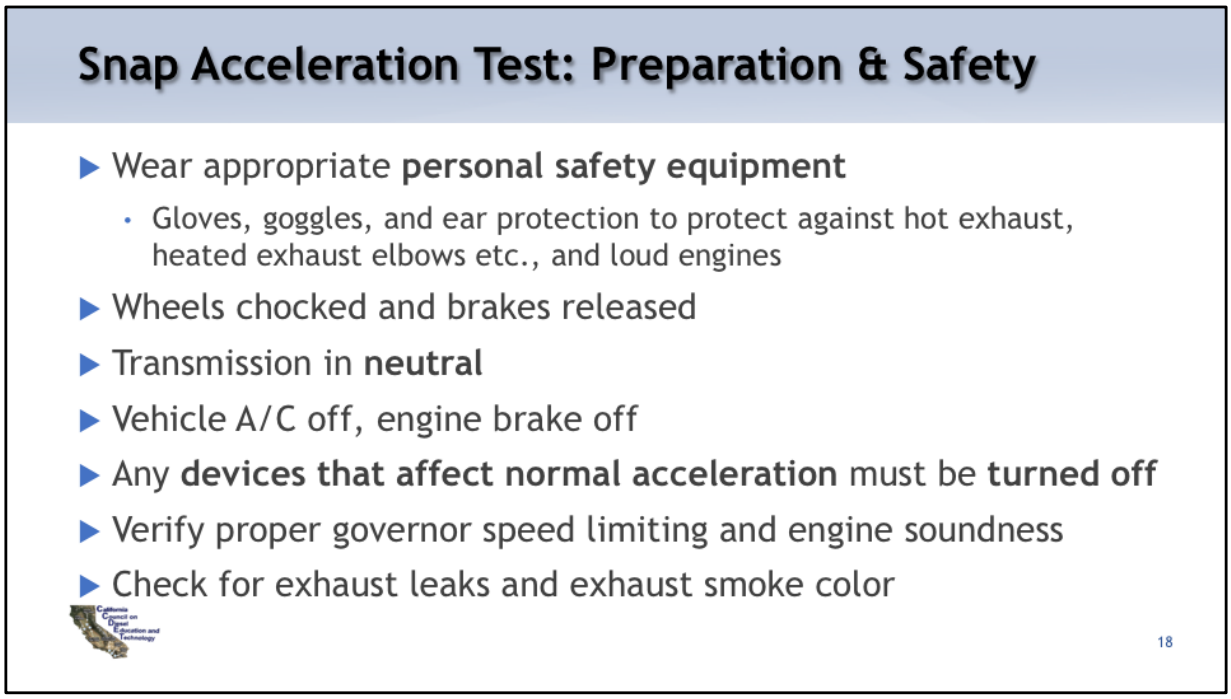
monitoring. Those dates have all now passed. All diesel engines at the ports and intermodal rail yards must be tested annually for opacity.

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)



Discuss certification renewal requirements and how to sign-up for classes.


A Quick Review of the SAE J1667
Snap-Acceleration Procedures
Smoke-testing Diesel Vehicles (with notes on CHE)
17



Discuss preparation and safety procedures.

Add something about personal safety regarding the hot exhaust and loud engines requiring gloves to handle the hot exhaust elbows and use ear protection.

Snap Acceleration Test: Equipment Setup

- Altitude above 1500 feet reading correction
- Air **temperature** above or below 36 to 86 degrees F.
- Excessively **windy conditions should be avoided**
- **Dry air density** may affect the exhaust smoke opacity
- Humidity no visible fog, rain, or snow in the area were the smoke plume is measured
- Opacity meter type may adjust readings or may not
- Choose your type of meter depending on, cost, test location, and ambient conditions encountered

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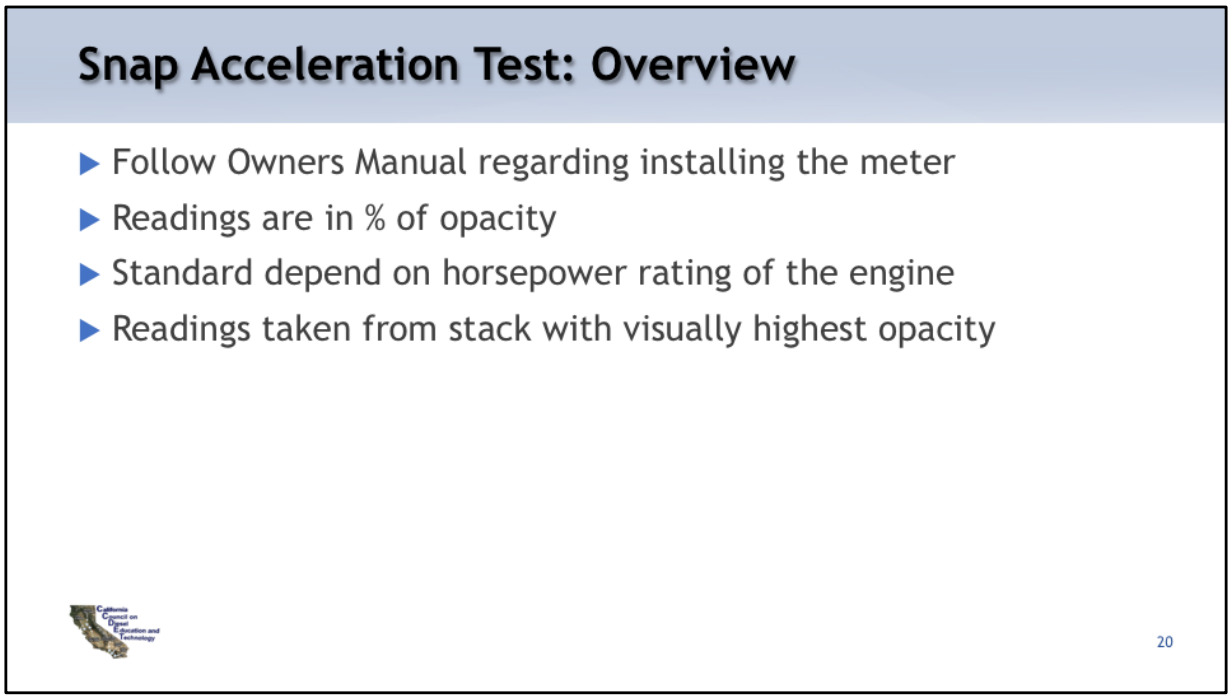
Discuss the factors that might affect the test.



Provide an overview of the test including following the manual for the particular opacity meter used, how results are reported, looking up standards based on horse power, and choosing which stack to test.

Snap Acceleration Test: Performing the Test

- Engine should be at normal operating temperature
  - Operate for at least 15 minutes

1. Perform the Snap:
   a. Driver depresses throttle to full open as rapidly as possible
   b. When engine reaches max RPM, hold throttle at max governed speed for 1 to 4 seconds, and then release the throttle
2. Let engine reach low idle RPM, wait 5-45 secs. (target 8-10 secs)
3. Repeat six times (3 cleanout/purge snaps; 3 test snaps)
   - Test snaps must be completed within 2 minutes of the purge snaps

Note: At the beginning of each snap, the tester indicates a new snap in the test meter according the the Owners Manual the opacity meter being used.

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- Operating temperature- vehicle will not reach operating temperature by idling. It must be driven in order to reach the proper temperature. An alternative is that fleet operator can schedule PSIP inspections when vehicles return from their daily routes.
- Ensure to emphasize the throttle application procedures listed above.

Snap Acceleration Test: Are the Test Results Valid?

Test Validity Check:

- Post-test smoke meter zero shift check - Not to exceed 2% opacity
- The differences between test snaps must not exceed 5% opacity

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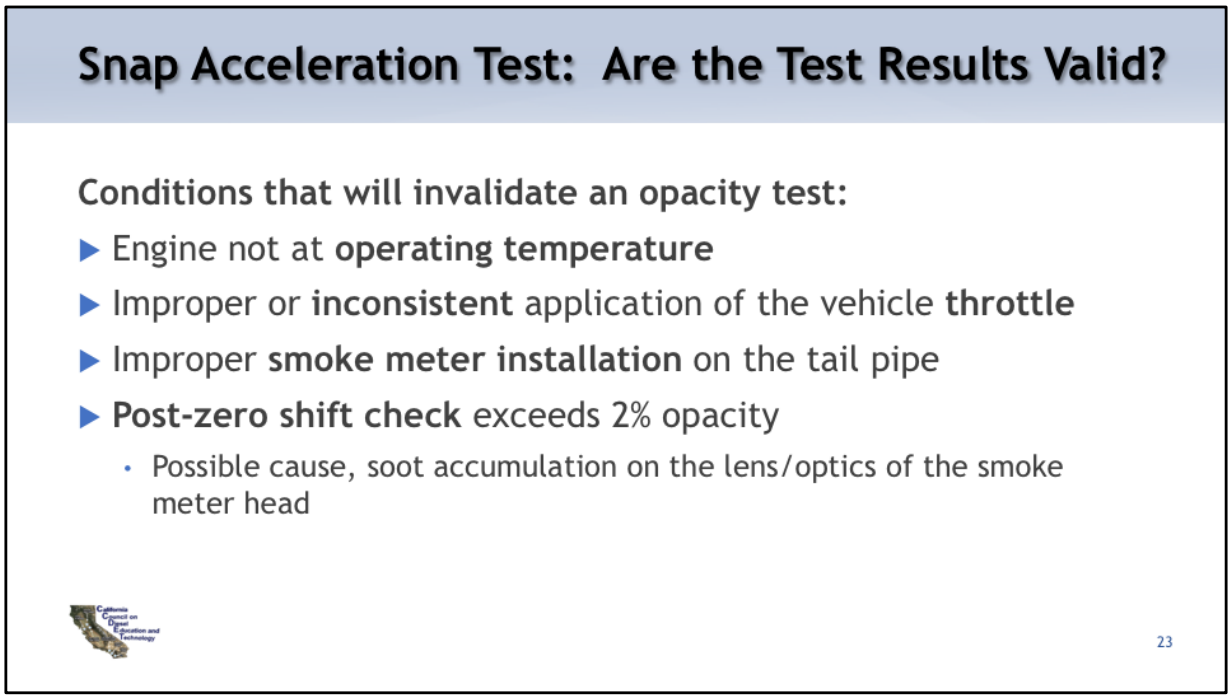
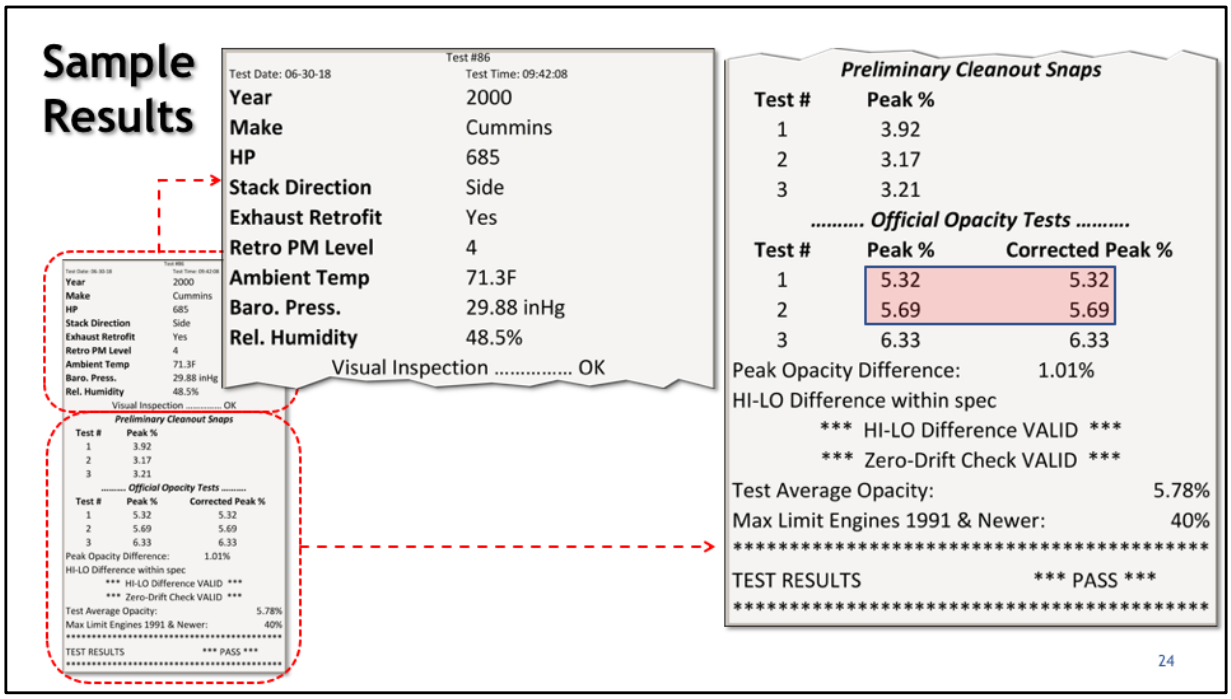
- Second column shows a corrected reading due to ambient conditions
- If tests exceed 5% opacity difference, this is likely caused by inconsistent or improper application of throttle by the technician performing the test.



- Discuss these factors that might render a test invalid.

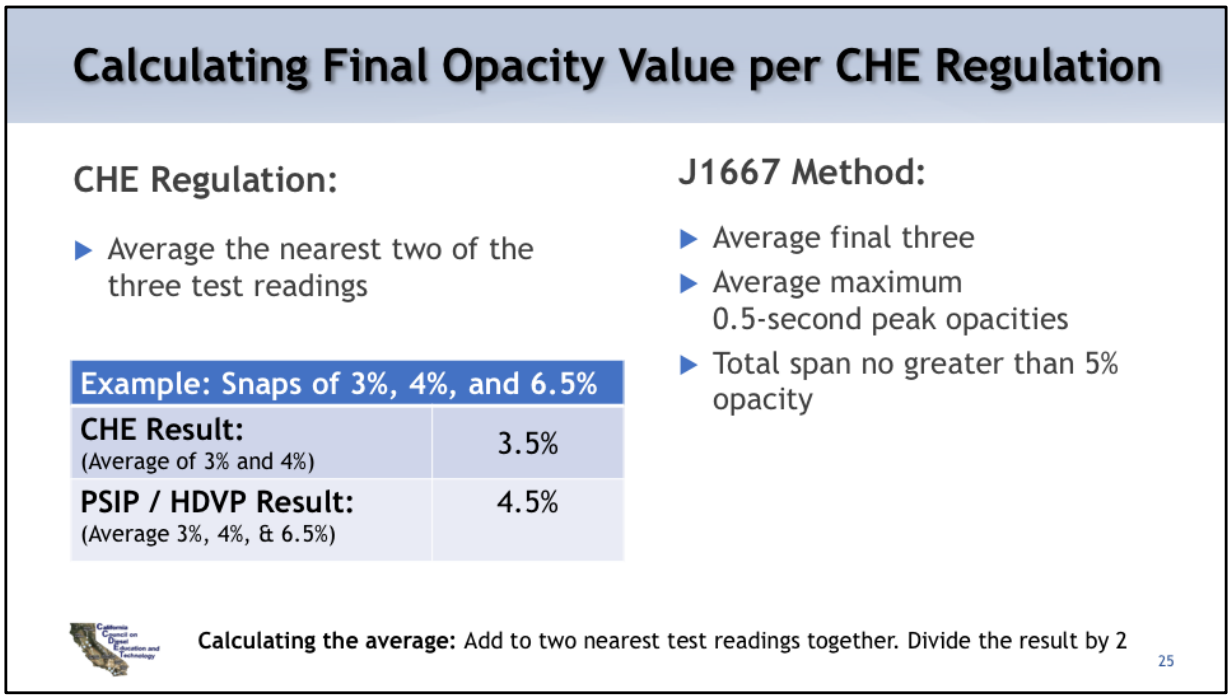
CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)



- Second column show a corrected reading due to ambient condition
- If tests exceed 5% opacity difference, this is likely caused by inconsistent or improper application of throttle by the technician performing the test.

- Highlighted section indicates nearest two snaps. Note the test page on the right indicates that all three results are identical; so any two may be selected.

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)



J1667 method specifies averaging of final three opacity test results (with total span no greater than 5% opacity)

CHE regulation final result calculated not from the average of three, but from the nearest two maximum averages permitting J1667 validity criteria are achieved

Example: average of three snaps 3%, 4%, and 6.5%

CHE result: 3.5% (average of 3% and 4%)

PSIP/HDVIP result: 4.5% (average of 3%, 4%, and 6.5%)

To calculate an average, add the numbers and divide the result by the number of numbers. In this case there will always be two numbers (the nearest two test results). Add those together and divide by two

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

CHE Opacity Limits Table

PM Standard or Emissions Limit g/kw-hr	PM Standard or Emissions Limit g/bhp-hr	Maximum Opacity Limit
> 0.54 or uncertified	Greater than 0.40	55%
0.42 to 0.54	0.31 to 0.40	45%
0.28 to 0.40	0.21 to 0.30	35%
0.15 to 0.27	0.11 to 0.20	25%
0.07 to 0.13	0.05 to 0.10	15%
Less than 0.07	Less than 0.05	5%

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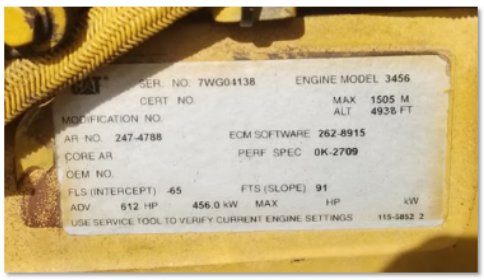
- Here are the designated maximum allowable opacity limits set forth by the CHE regulation. The two column(s) on the left provide the U.S. EPA PM emissions standard levels in two different sets of units and the column on the right provides the maximum allowable opacity limit.
- The left column is the g/kW-hr.
- The middle column is g/bhp-hr. These are the units we generally talk about when we discuss emissions from the CHE engines.
- To convert from g/kW-hr to g/bhp-hr, we multiple the g/kW-hr by 0.746

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

Opacity Limits

- Opacity limit is a function of the engine's PM Certification Standard
- The ARB Executive Order (EO) lists both the PM certification level and the certification standard
- The certification standard (STD) is the emissions standard/limit, and is used to determine the opacity limit per the mobile CHE regulation

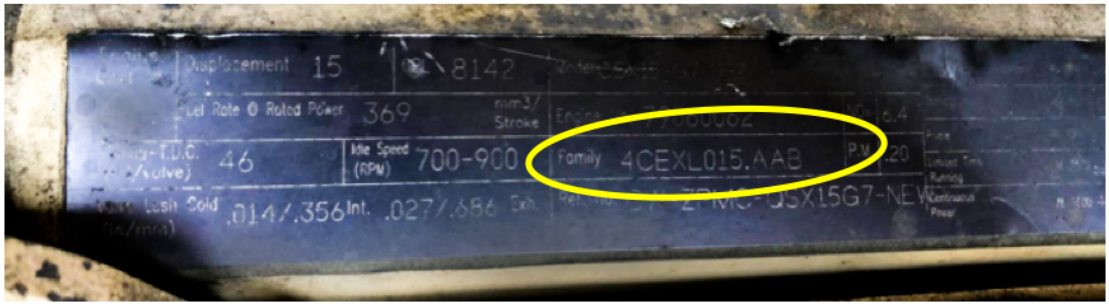


- Must know engine family name in order to locate EO for engine

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

Opacity Limits: Finding Limits Demonstration

- The EO for all engines can be found on the ARB web site: http://www.arb.ca.gov/msprog/offroad/cert/cert.php



Shown here: Cummins Engine on a RTG Crane

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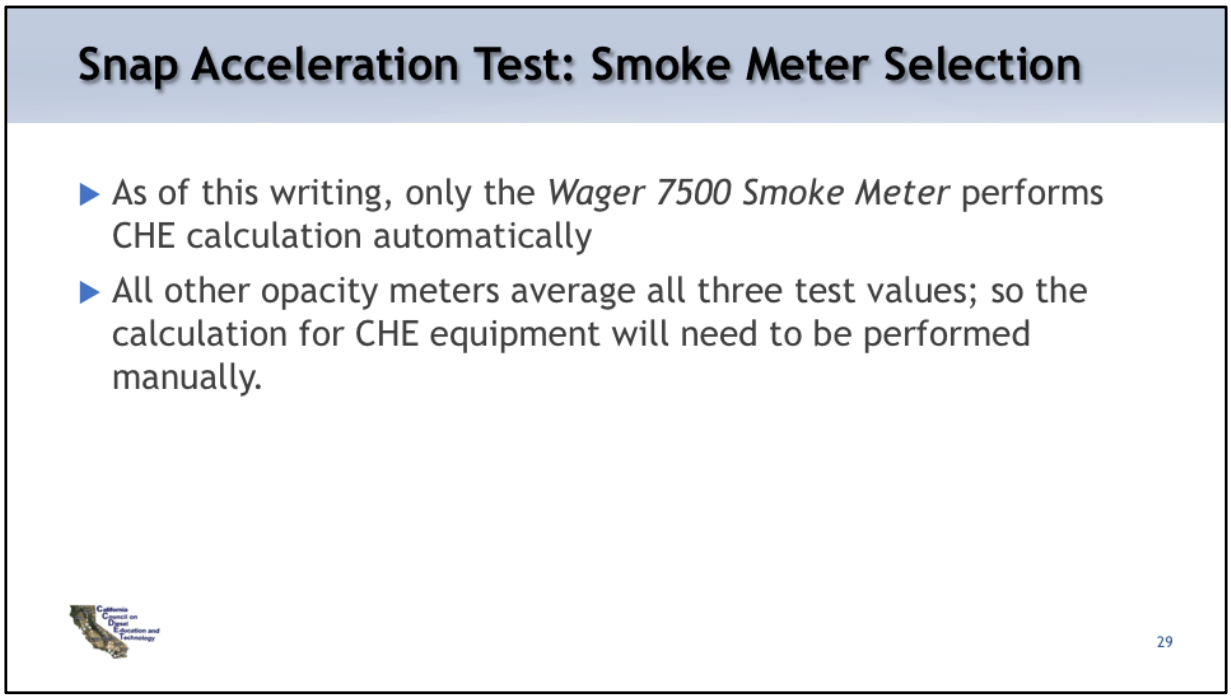
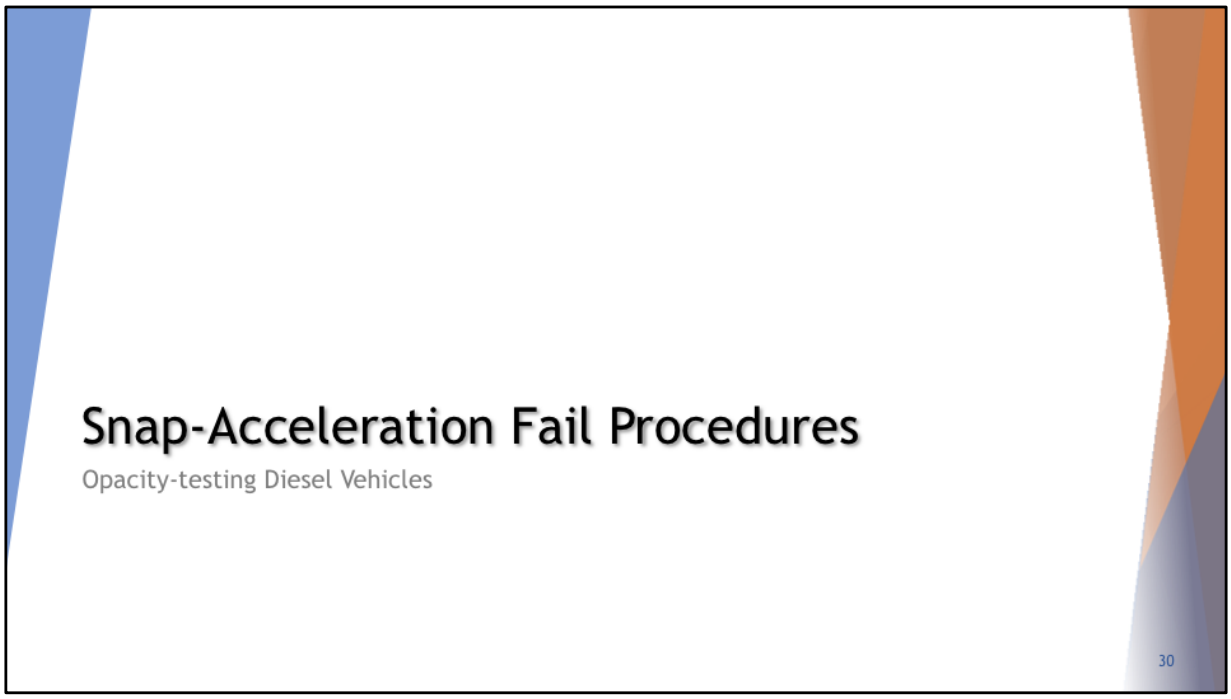
- Must know engine family name in order to locate EO for engine
- Sometimes engine plates are missing. In these cases you might need to look up engine specifications online based on purchase or previous maintenance records
- Show an example, how to find the engine family name, the EO on the web, and where to find the certification standard



Discuss these issues with selecting an opacity meter, and remind participants to perform the manual calculation if not using a meter specifically calibrated to test CHE.


Snap-Acceleration Fail Procedures
Opacity-testing Diesel Vehicles
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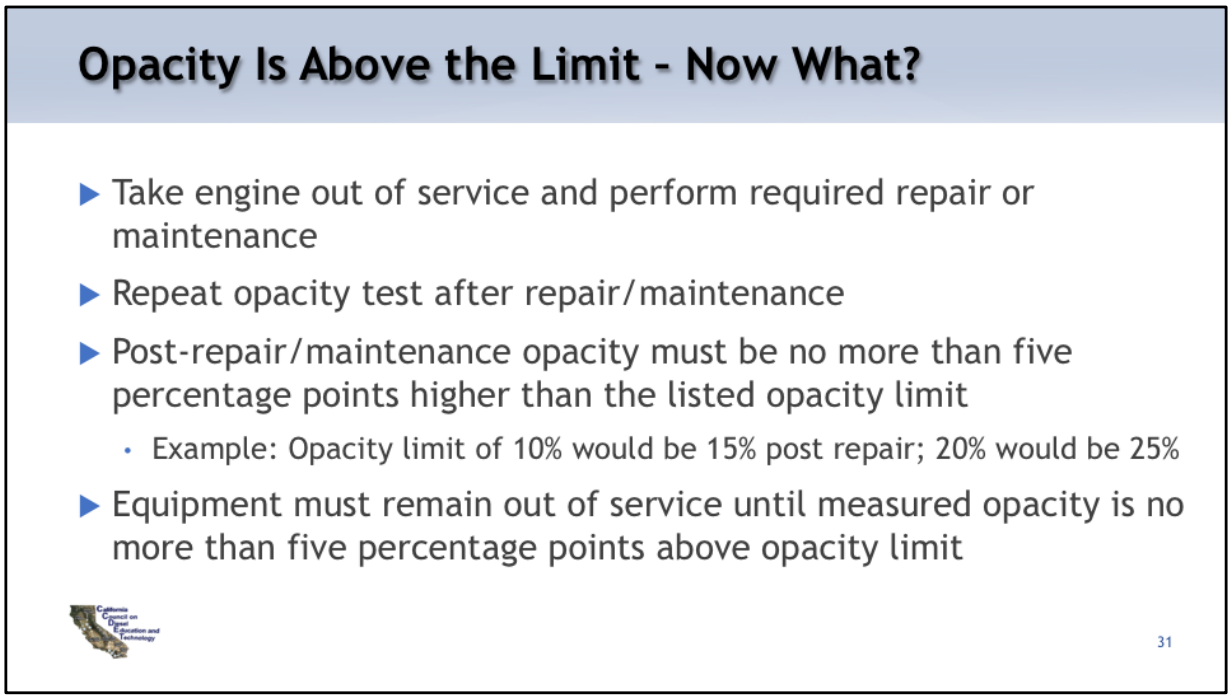

- So, what must you do if an engine's opacity measures higher than the allowable limit?
- First, the engine must be removed from service, evaluated for operational issues, and repaired or maintenance done to address the problem.
- Then a post-repair/maintenance opacity test must be run.
- Post-repair/maintenance opacity must be no more than five percentage points higher than the listed opacity limit
    - Example: Opacity limit of 10% would be 15% post repair; 20% would be 25%
- Equipment must remain out of service until measured opacity is no more than five percentage points above opacity limit

CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)

Examples of Initial and Post-Repair Opacity Tests

Opacity Limit	Initial Result	Action Needed	Retest Result	Retest Pass or Fail?
45%	49% - Fail	Reparative maintenance	47%	**Pass**, within 5% of post-repair limit (50%)
45%	48% - Fail	Reparative maintenance	35%	**Pass**, below opacity limit (45%)
35%	13% - Pass	None	N/A	**No retest required**
45%	54% - Fail	Reparative maintenance	52%	**Fail**, must stay out of service until retested at an opacity below 50%

Note: Opacity testing to be repeated each year regardless of the results of the previous year's test.

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Discuss these initial vs. post-repair results. Explain the pass criteria.


Record Keeping Requirements
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2479(i)(1)(D) Record Keeping Requirements

Vehicle owner requirements, record the following Information:

(D) Records of opacity testing results

1. Brand name and model of the opacity meter
2. Dates of last calibration of the opacity meter and chart recorder
3. Name of the smoke meter operator who conducted the test
4. Name and address of the contracted smoke test facility or vehicle repair facility that conducted the test (if applicable)
5. Applicability of smoke opacity standard for the tested vehicle
6. Vehicle identification number, vehicle's engine model, engine make, engine model year, and test date
7. Initial smoke test opacity levels (for three successive test readings)

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This is the same information that should be provided to CARB to clear a citation.

(i) Recordkeeping Requirements

Beginning December 31, 2006, an owner or operator of mobile cargo handling equipment shall maintain the following records or copies of records at port and intermodal rail yard facilities where applicable. The owner or operator shall provide the following records for inspection to an agent or employee of ARB upon request, including copies of these records at the department's expense, for all mobile cargo handling equipment subject to compliance with the regulation:

(1) Records Kept at Terminal. The owner or operator shall keep the following records accessible either in hard copy format or computer records at the terminal where the mobile cargo handling equipment normally resides:

(A) Owner or Operator Contact Information

1. Company name
2. Contact name, phone number, address, e-mail address
3. Address of equipment

(B) Equipment and Engine Information

1. Make of equipment and engine
2. Model of equipment and engine

3. Engine family (if applicable)
4. Engine serial number
5. Year of manufacture of equipment and engine (if unable to determine, approximate age)
6. Rated brake horsepower
7. Control equipment (if applicable)
a. Type of diesel emission control strategy
b. Serial number of installed diesel emission control strategy
c. Manufacturer of installed diesel emission control strategy
d. Model of installed diesel emission control strategy
e. Installation date of installed diesel emission control strategy
f. Level of control (1, 2, or 3); if using a Level 1 or 2, include the reason for the choice
g. Documentation for Minimum Use Requirement Compliance Extension pursuant to paragraph (f)(5)
(C) Records of maintenance for each installed diesel emission control strategy

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8. Indication of whether the vehicle passed or failed the initial smoke test
9. For vehicles that failed the smoke test and that were repaired, the following information:
a. Name of the mechanic
b. Date of the repair
c. A statement identifying the nature of the repairs made
d. An itemized list of parts used in the repair
e. Post-repair test date
f. Post-repair smoke test opacity levels (for three successive test readings)
g. Indication of whether the vehicle passed or failed the post-repair smoke test

2479(i)(1)(D) Record Keeping Requirements

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2479(i)(1)(D) Record Keeping Requirements

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36

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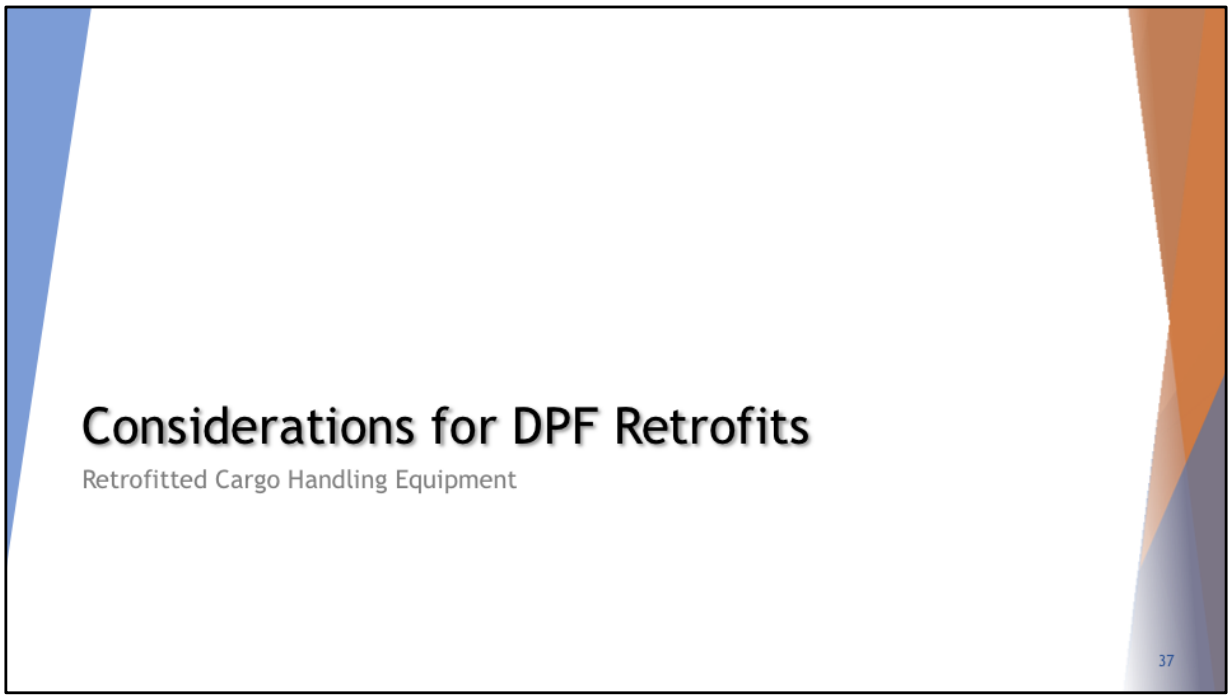
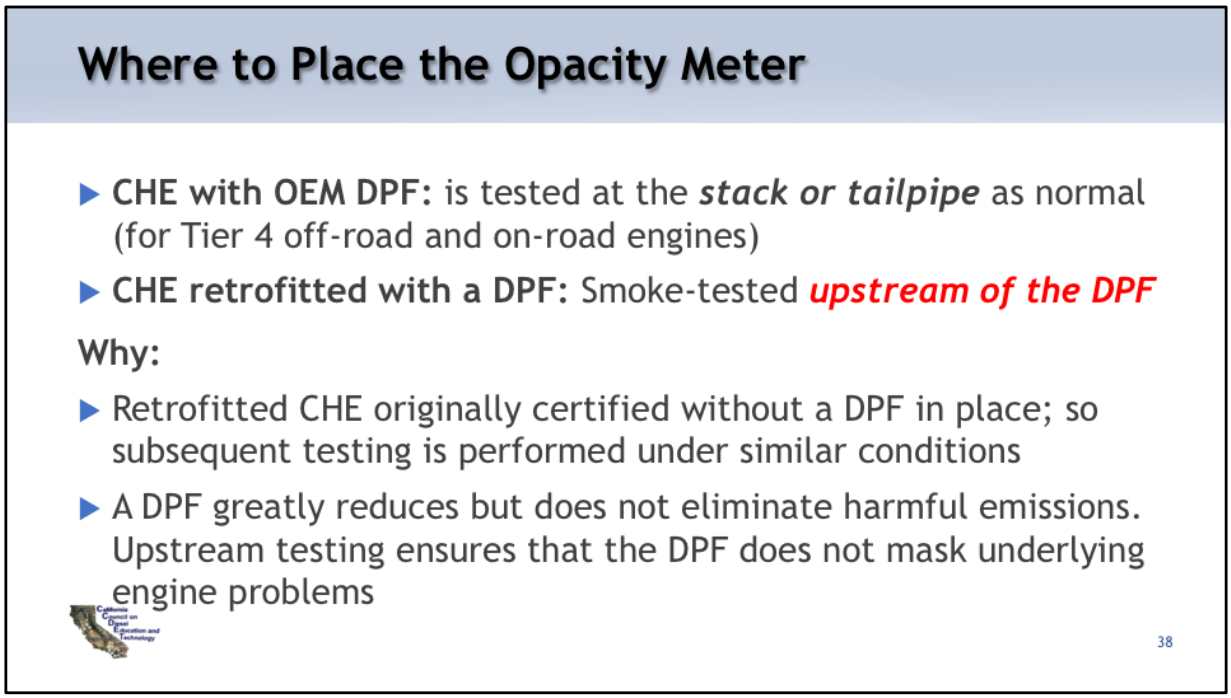

Considerations for DPF Retrofits
Retrofitted Cargo Handling Equipment
37

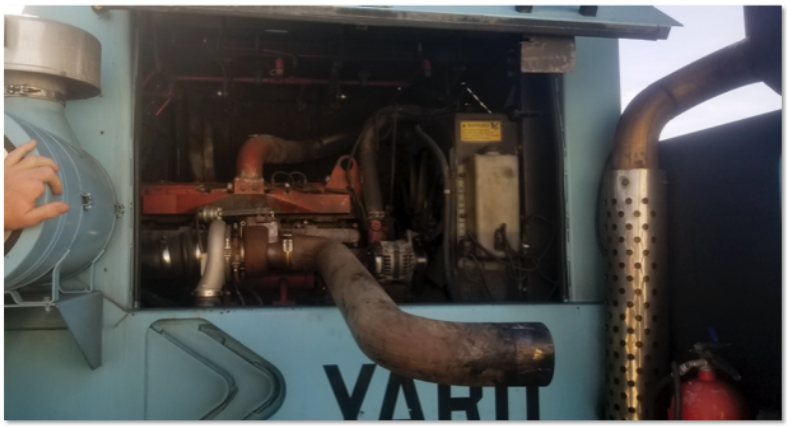
CCDET III: Opacity Testing for Cargo Handling Equipment (CHE)



- Cargo handling equipment (CHE), which has been retrofitted with a DPF, must be smoke-tested upstream of the DPF, while equipment that comes from the manufacturer with a DPF in place is tested at the stack or tailpipe as normal.
    - Off-road engines tier 0 - tier 3 have a retrofit DPF
    - It is illegal to have a retrofits on CHE with on-road engines
    - There are no verified DPFs for off-road engines with EGR

- This requirement exists because the retrofitted equipment was originally certified without a DPF in place; so subsequent testing is performed under similar conditions. A DPF greatly reduces but does not eliminate harmful emissions. The upstream testing requirement ensures that the DPF does not mask underlying engine problems.

Top Pick with Temporary Attached Elbow



Note: *The elbow pipe, shown above, is attached to enable the opacity test. It is removed at the conclusion of the test, and the equipment is reassembled. CARB does not permit permanent installation of an elbow pipe, bypass line, or other sampling port on CHE that is retrofit with a DPF* 39

- Cargo handling equipment (CHE), which has been retrofitted with a DPF, must be smoke-tested upstream of the DPF, while equipment that comes from the manufacturer with a DPF in place is tested at the stack or tailpipe as normal. This requirement exists because the retrofitted equipment was originally certified without a DPF in place; so subsequent testing is performed under similar conditions. A DPF greatly reduces but does not eliminate harmful emissions. The upstream testing requirement ensures that the DPF does not mask underlying engine problems.
- ***Note:*** *The elbow pipe, shown above, is attached to enable the opacity test. It is removed at the conclusion of the test, and the equipment is reassembled. CARB does not permit permanent installation of an elbow pipe, bypass line, or other sampling port on CHE that is retrofit with a DPF*

Shown on this slide:

- Top pick with a retrofitted DPF
- A temporary elbow pipe is attached to the diesel engine to make smoke testing upstream of the DPF possible

Placement of Smoke Test Device

- Retrofitted engines
  - Might require modified placement of the opacity testing device to avoid excessive heat
  - May damage or even melt equipment

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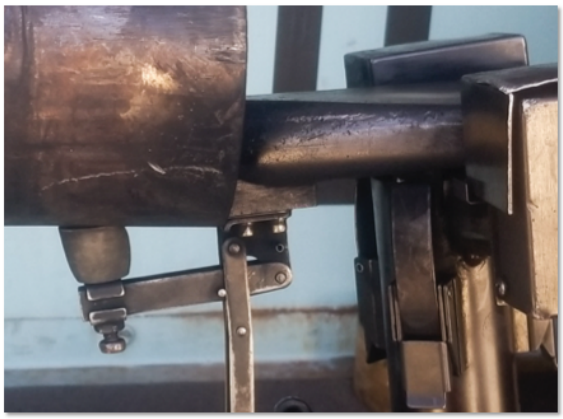
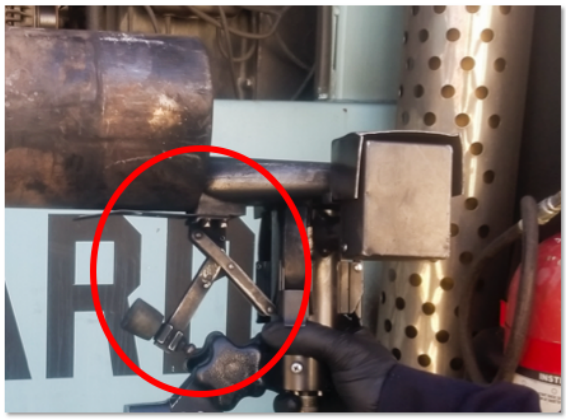
- This slide shows the placement of the opacity testing device on a retrofitted top pick
- Because the attached elbow pipe is so close to the turbo, the heat can be excessive
- It may be necessary to adjust the placement of the smoke test device to avoid heat damage or melting

Close-Up: Adjusted Smoke Test Device





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- This slide shows the placement of the opacity testing device on a retrofitted top pick
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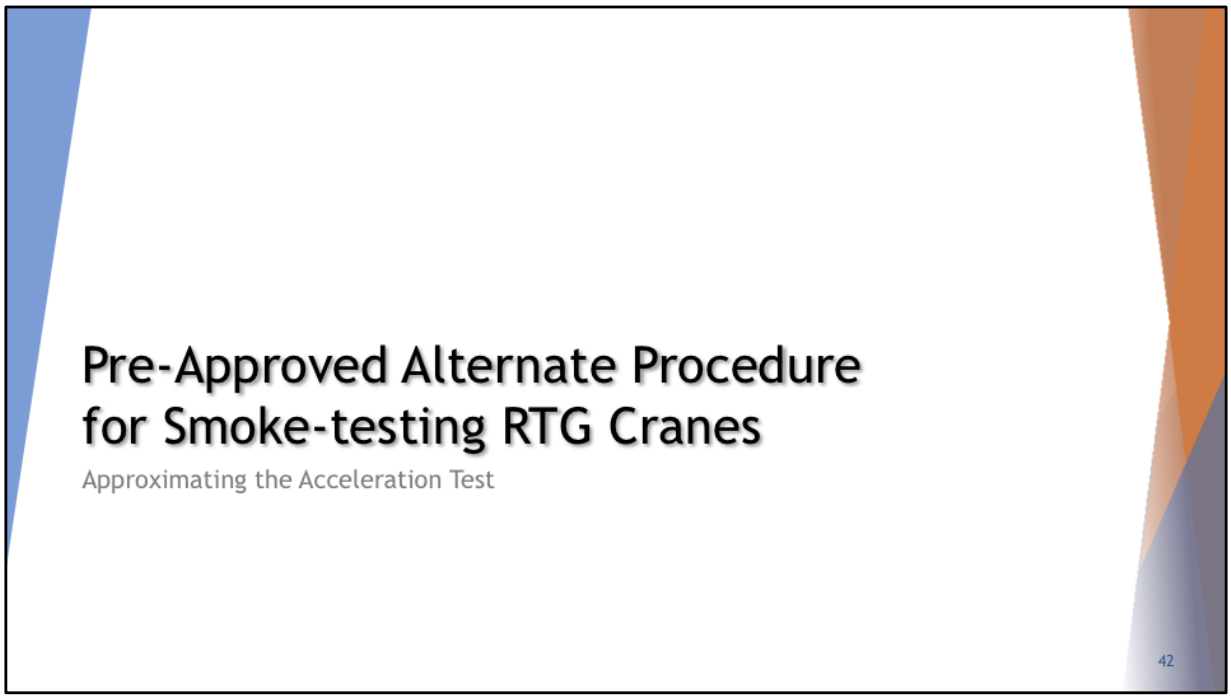
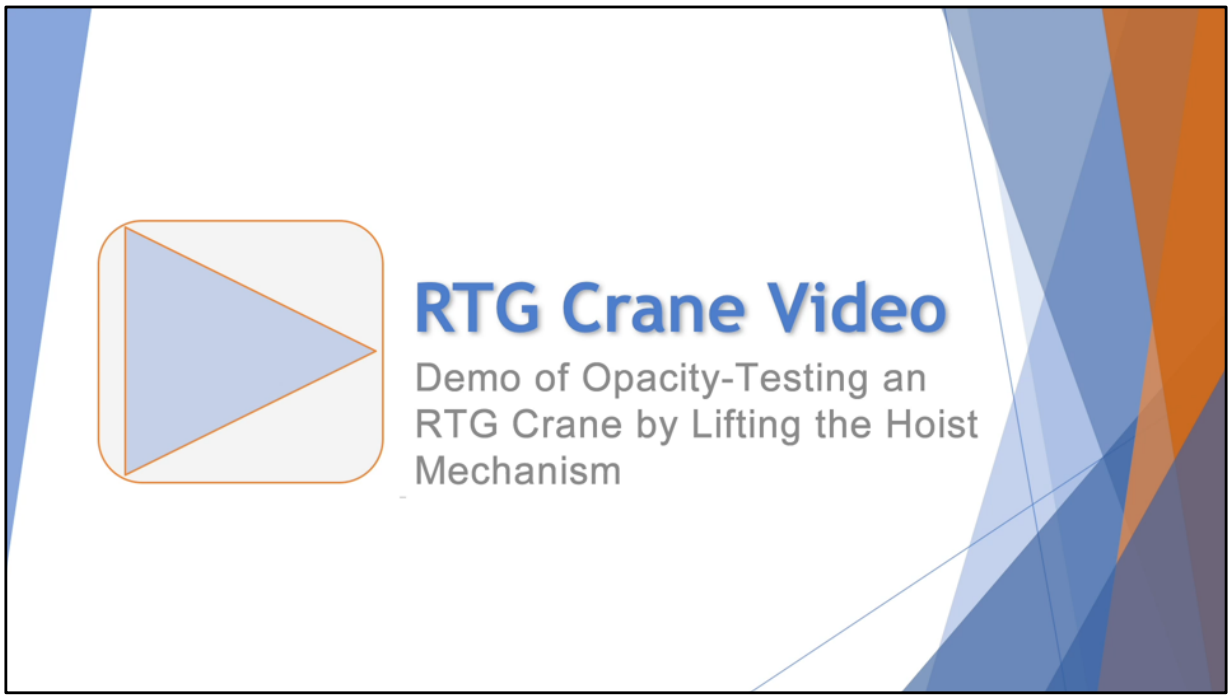

Pre-Approved Alternate Procedure
for Smoke-testing RTG Cranes
Approximating the Acceleration Test
42

RTG cranes lack the throttle mechanisms commonly found in other vehicles. Therefore, it is impossible to perform the opacity test in the manner normally required.

Most RTG cranes operate using a generator set. The diesel engine powers the generator. The engine is switched from *idle speed (650-750 rpm)* to *full speed (1800 rpm)* where it remains during normal operation. The system is designed to maintain 1800 rpm, which enables the generator to deliver consistent electrical frequency (60Hz) and voltage but makes the normal snap acceleration test impossible to administer. However, when the RTG crane begins to lift a load, the engine momentarily drops below 1800 RPM before returning to normal. This somewhat approximates the conditions found in an on-road vehicle during a typical snap acceleration test.

This procedure is performed by lifting the hoist mechanism of the RTG crane without a cargo container or other load attached. It was developed using Cummins and Caterpillar engines. Engines from other manufacturers should function similarly.



This slide shows the thumbnail for an embedded video of switching an RTG crane from idle to full and back again.
Click the slide to start the video.

The the embedded version does not work, access the video directly from Vimeo at:
https://vimeo.com/258321414

Opacity Test Procedure for RTG Cranes

Step	Action
1	Start the diesel engine, and allow it to warm-up to normal operating temperature. • Typically 10 to 15 minutes • Operating the crane often expedites reaching normal temperature
2	Lower the hoist mechanism to a low position.
3	Attach the opacity testing device as required by the SAE J1667 procedure. • **DPF Retrofit:** Attach opacity test equipment upstream of the DPF • **DPF OEM**: Attach opacity test equipment at the stack or exhaust pipe (downstream of DPF)
4	Begin the snap idle test (Press the **Start Button** or whatever is required by your meter).
5	**Perform the snap:** List the hoist mechanism for 1 - 4 seconds at full speed.
6	Stop lifting, and wait 5-45 seconds (target 8 -10 seconds). • Lower the hoist if too high to complete the next snap
7	Repeat steps 5 and 6 for a total of six cycles (3 purge & 3 test).
8	End the snap idle test, and retain the test results for your records.
9	Calculate average using nearest two of the three test readings. Service the engine as required.

- Refer students to the handout containing this procedure.
- This procedure is designed specifically for RTG cranes that cannot be tested using the standard SAE J1667 procedure. Prior approval of the Executive Officer **is not** required for this modified procedure.
- Other than when using this procedure, if performing the SAE J1667 Snap Acceleration Test is not feasible, the end-user must demonstrate that performing the test is not feasible, and use an alternative method of compliance that has been approved by the Executive Officer. The EO must determine whether the alternative procedure causes an increase in soot accumulation rates in the VDECS. This pre-approved procedure, allows end-users to avoid the case-by-case approval requirements.
- This procedure modifies the J1667 opacity test to be used with RTG cranes. All other aspects of the existing J1667 procedure remain in place and should be followed.


ARB Contacts
Cargo Handling Equipment Information
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CHE Contacts at ARB

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  - phone: (916) 327-7213

Web Site: http://www.arb.ca.gov/cargo

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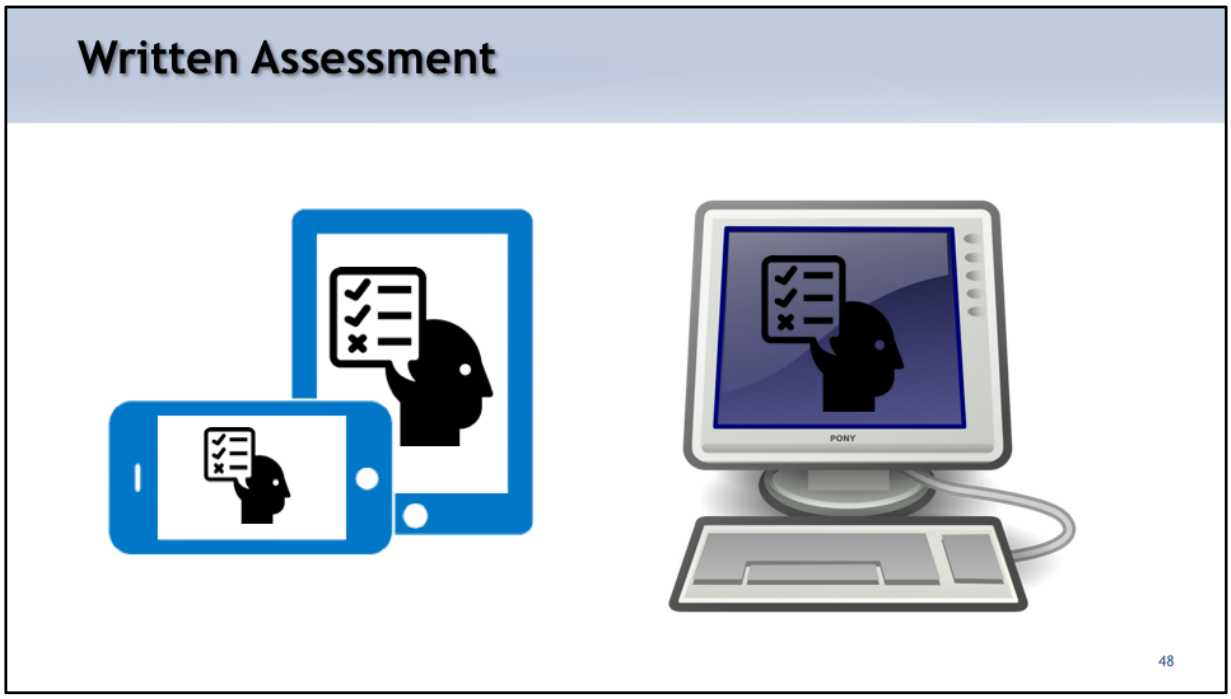
Written Assessment
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Hands-on with Opacity Meter

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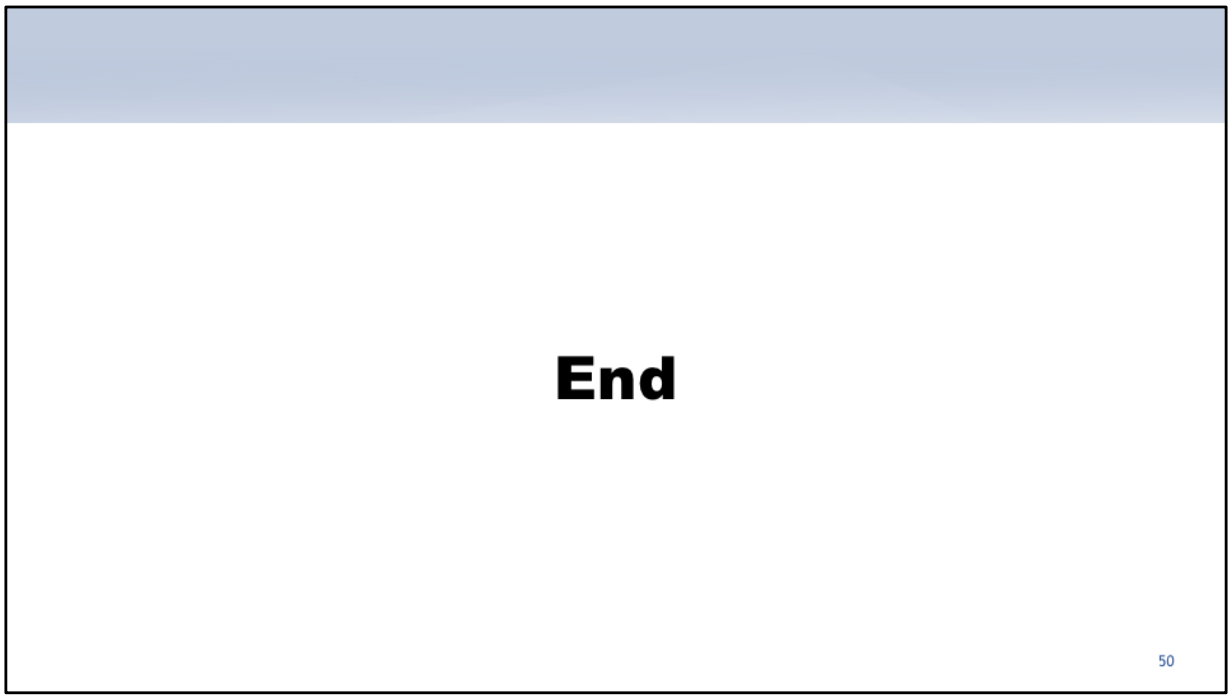
End
50