

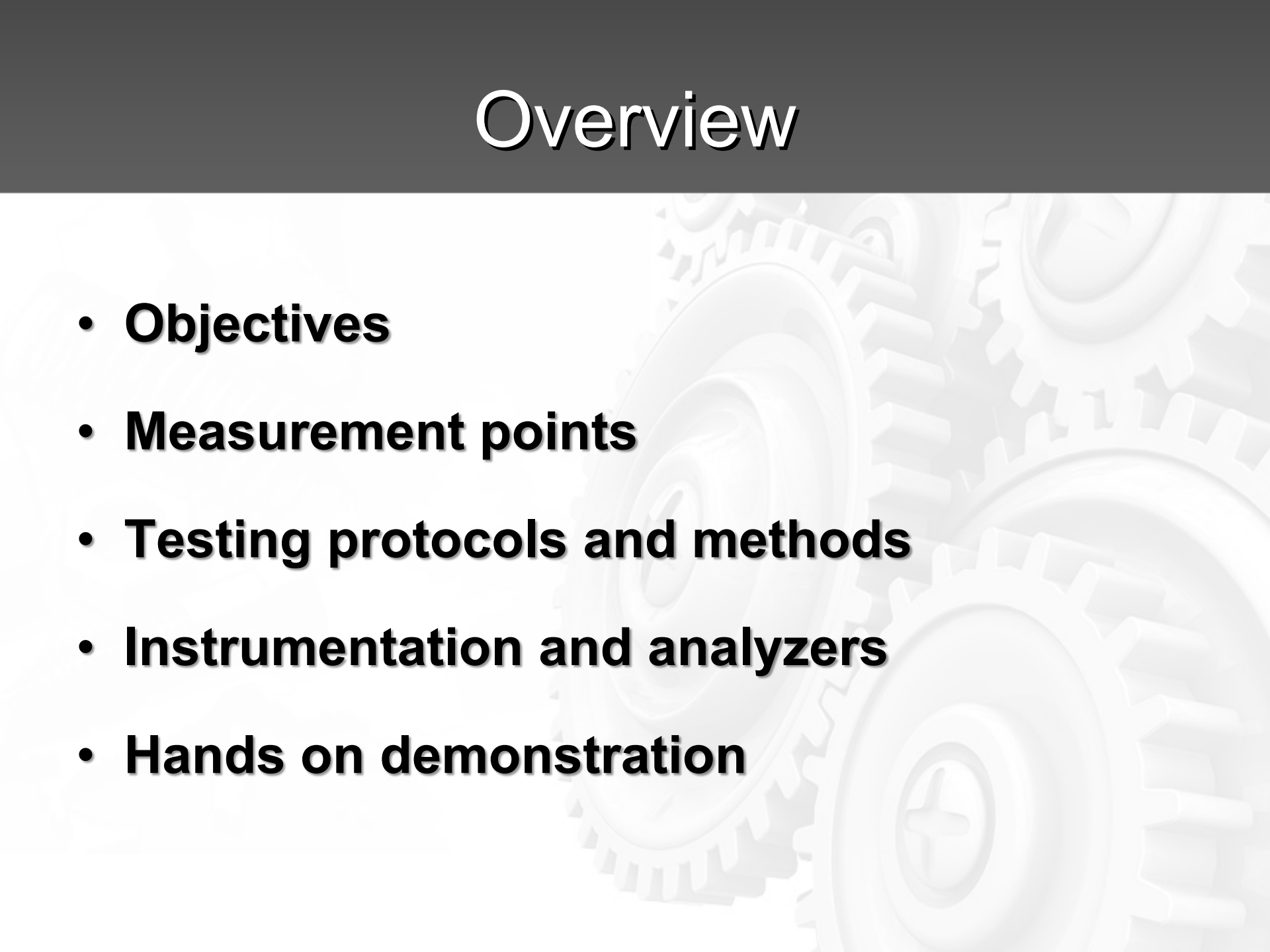
In-Use Emissions Field Testing

Sean McGinn



October 5th, 2023

Overview

- **Objectives**
 - **Measurement points**
 - **Testing protocols and methods**
 - **Instrumentation and analyzers**
 - **Hands on demonstration**
- 
- The background of the slide features a grayscale image of several interlocking gears of various sizes, creating a mechanical and industrial aesthetic.

Objectives

Why?

- Regulatory compliance
- HSE compliance (corporate / operation)
- Machine performance
- Maintenance and reliability performance
- Fault detection and scanning
- Field diesel ventilation assessment - FDVA

Measurement Points

Two Levels

1. Engine Systems
2. Exhaust System



Measurement Points

Two Levels

1. **Engine Systems**
2. Exhaust System



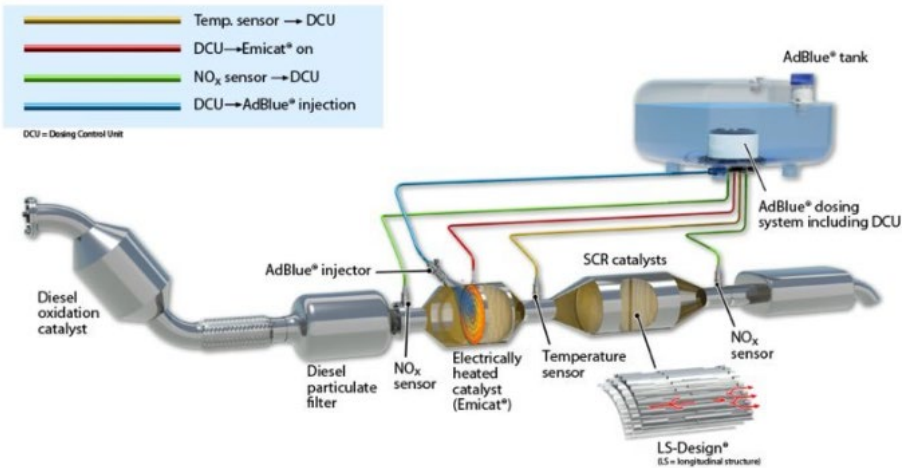
- **Intake**
- **Exhaust**
- **Fuel Injection**
- **Cooling**
- **Lube**
- **Electronic Control**

- ✓ **Pressures**
- ✓ **Temperatures**
- ✓ **Speeds**
- ✓ **OBD diagnostics**

Measurement Points

Two Levels

1. Engine Systems
2. Exhaust System



- O₂
 - CO
 - NO
 - NO₂
 - NO_x
 - Temp
 - Backpressure
 - CO₂
 - SO₂
 - DPM
 - HC
 - Mass Fuel
 - Mass Flow
- Level 1
Level 2
Level 3

Measurement Points

Engine Certification CAN/CSA M424.2

$$EQI = \frac{CO}{50} + \frac{NO}{25} + \frac{DPM}{2} + 1.5 \left[\frac{SO_2}{3} + \frac{DPM}{2} \right] + 1.2 \left[\frac{NO_2}{3} + \frac{DPM}{2} \right]$$

Dilution Ratio (DR)

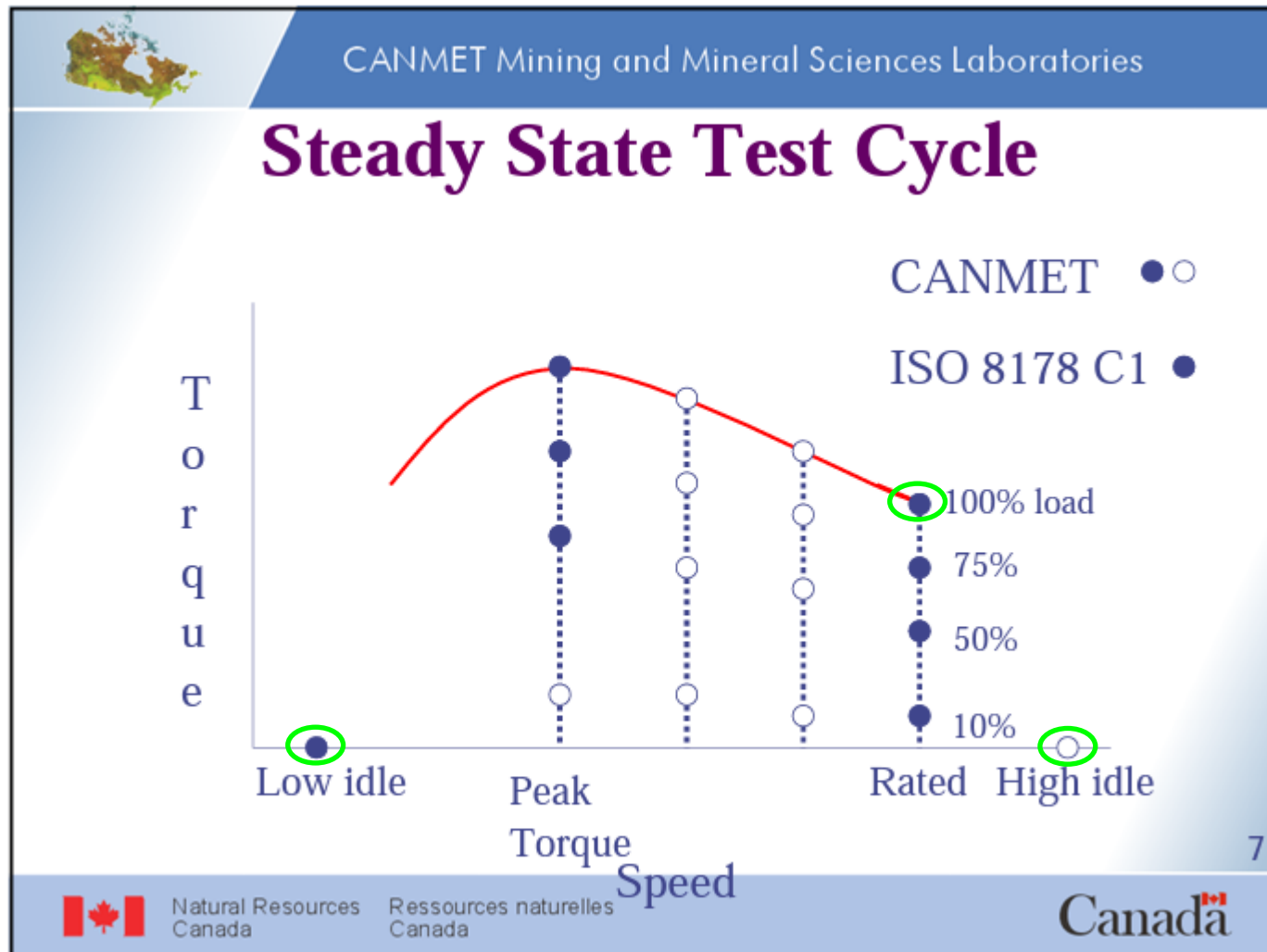
CO / 50
NO / 25
NO₂ / 3
CO₂ / 5000
SO₂ / 3
DPM / 2

Pass / Fail

CO 650 ppm
NO 650 ppm
NO₂ 75 ppm
DPM 15 mg/m³

- O₂
- ✓ CO
- ✓ NO
- ✓ NO₂
- NOx
- Temp
- Backpressure
- ✓ CO₂
- ✓ SO₂
- ✓ DPM
- HC
- Mass Fuel
- ✓ Mass Flow

Testing Protocols and Methods



Source:
Dr. Mahe Gangal
MDEC 2012

Testing Protocols and Methods

$$\text{bhp} = \text{Torque (lb-ft)} \times \text{RPM} / 5252$$

$$\text{kW} = \text{Torque (N.m)} \times \text{RPM} / 9.5488$$

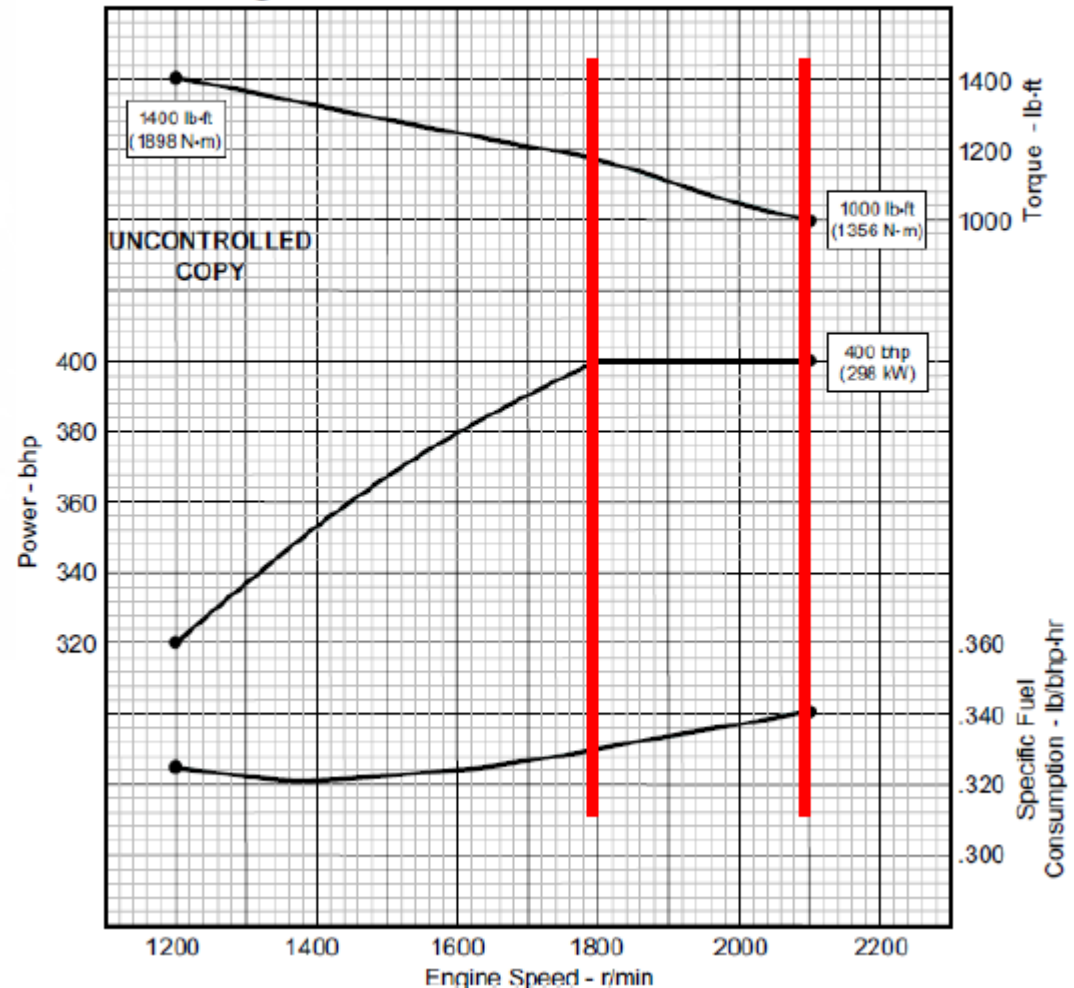
Test @ full power – steady state

Model: Series 60®

Rating: 400 bhp @ 2100 r/min

1400 lb-ft @ 1200 r/min

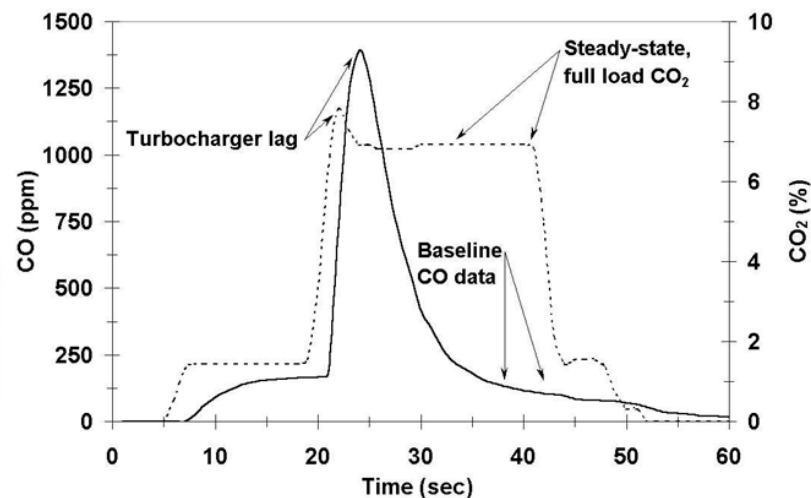
Certification: MSHA



Testing Protocols and Methods

Field Testing – Heavy Duty

- Rated speed – Full Load (Stall)
- **Steady state** for minimum 60 seconds – min/max/avg
- Hysteresis both mechanical and instrument – filter 30 seconds
- **Requirement: Baseline values all measured variables and pass / fail**



Source:
Brent Rubeli

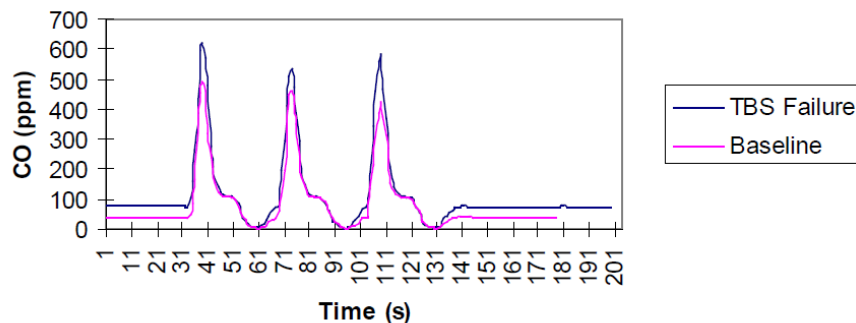
Testing Protocols and Methods

Field Testing – Light Duty

- Toyotas , Kubota RTVs, etc
- **Transient** snap x3 - idle > full throttle @ 10 seconds each (SAE J1667)
- Min / Max / Avg
- Hysteresis for instrument – filter 30 seconds
- **Requirement: Baseline values all measured variables and pass / fail**



SAE J1667 CO Emissions -
Simulated Turbo Boost Sensor Failure



Source:
Brent Rubeli

Instrumentation and Analyzers

Tier I

Basic CO testing
EC gas cells
Small sample pump
Basic sample conditioner
Save – Print
No data stream
Basic maintenance

Tier II

Multi gas O₂-CO-NO-NO₂
Exhaust temp
Pressure and ΔP
EC gas cells
Better sample pump
Sample conditioner
Condensate cooling
Save – Print
Data stream
USB – Bluetooth – Wifi
Software interface
Advanced maintenance

Tier III

Multi gas O₂-CO-NO-NO₂
CO₂ – CH₄
Exhaust temp
Pressure and ΔP
EC + NDIR gas cells
Larger sample pump
Sample conditioner
Condensate cooling
Save – Print
Data stream
USB – Bluetooth – Wifi
Software interface
Advanced maintenance +

Tier IV

PEMS
Multi gas CO-CO₂-NO-NO₂
HC with FID
Fuel economy
Exhaust mass flow
NDUV - NDIR gas cells
DPM module
Sample conditioning
Real time data processing
Zero-span-calibration
EPA 40CFR – Euro 7
In-use verification

Instrumentation and Analyzers

Tier I



Tier II



Tier III

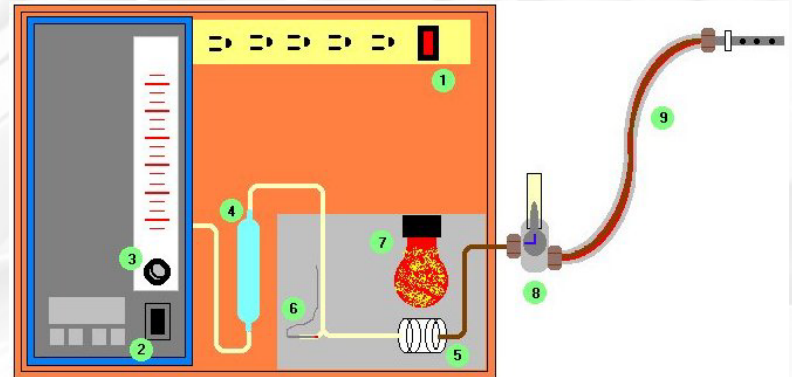


Tier IV

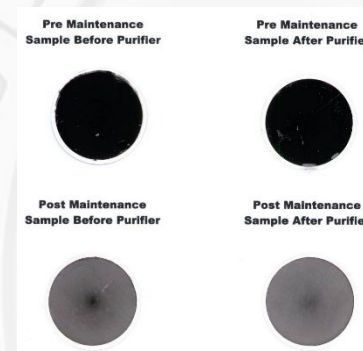


Instrumentation and Analyzers

DPM Sampling and Analysis



- 1 MAIN POWER SWITCH
- 2 PUMP SWITCH
- 3 PUMP FLOW ADJUSTMENT
- 4 DESSICANT DRIER
- 5 DPM FILTER CASSETTE
- 6 TEMPERATURE THERMOCOUPLE
- 7 CASSETTE HEATER
- 8 DIVERTER VALVE
- 9 HEATED SAMPLE LINE & PROBE ASSY



Objective Discussion

- **Regulatory compliance**
- **HSE compliance (corporate / operation)**
- **Machine performance**
- **Maintenance and reliability performance**
- **Fault detection and scanning**
- **Field diesel ventilation assessment - FDVA**

Date / Time: 2021-08-24 1:35:42 PM

User Name: SM CGINN

Test Location: Outlet DPF

Sample Duration: 0.5

Comment: Full Throttle Stall / Power

Vehicle:

Fuel: Diesel

RPM: 1800

		Sample Value	Target Value
SMOKE		1	7
O2	%	9.2	12
CO	PPM	16.9	100
NO	PPM	649.6	500
NO2	PPM	154.3	50
CO2	%	8.7	6
T.GAS	C	350.8	350
MEQI		78.1	50
NOx	PPM	803.8	550