Appendix E2

State of California
Air Resources Board

Evaporative Emissions Test Methodology and Results for the Proposed Amendments

Date of Release: November 28, 2023

California Air Resources Board
1001 I Street
Sacramento, California 95814

Contents

Introduction

This report includes results and observations from evaporative testing of on-road motorcycles (ONMCs) that was conducted by the California Air Resources Board (CARB) in support of the Proposed Amendments to ONMC Emission Standards and Test Procedures rulemaking intended to go to the Board for consideration in 2023. This testing was performed at CARB's Haagen Smit Laboratory (HSL) located in El Monte, California in 2021.

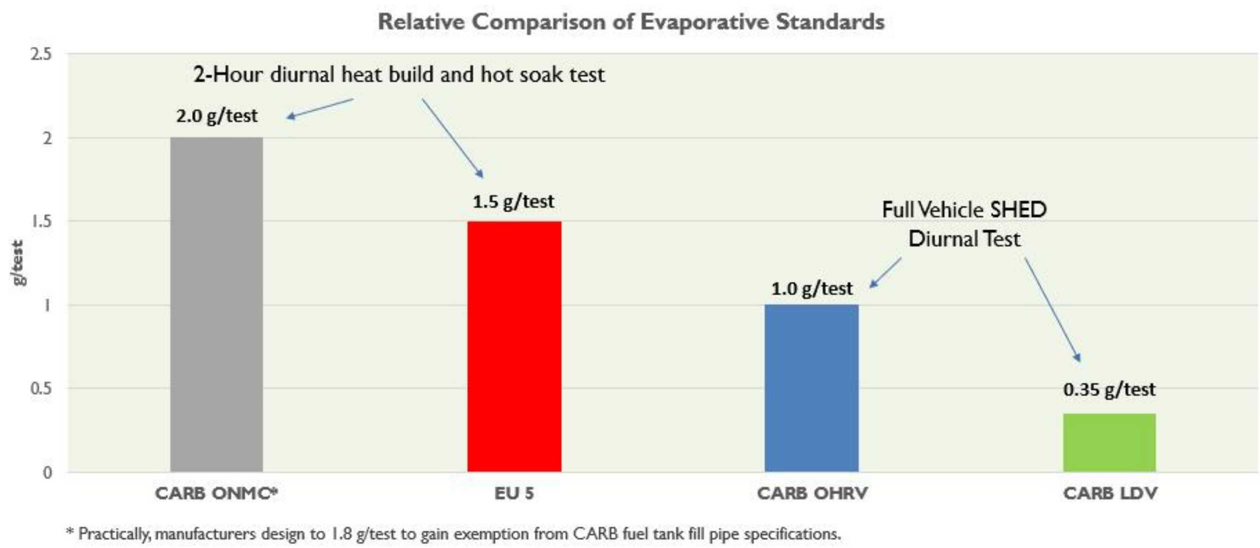
CARB has been regulating emissions from ONMCs since 1978. These regulations were last updated to the current emissions standards in 1998. Since then, other jurisdictions around the world have adopted additional stringent emissions standards, most notably in the European Union. These stringent standards have prompted industry to develop cleaner motorcycles than those currently certified in California. While current CARB ONMC evaporative standards are similar with most other jurisdictions around the world, other mobile source categories regulated by CARB are subject to much lower evaporative emissions limits. For example, in 2013 CARB adopted stringent evaporative emissions limits with more robust test methods for the Off Highway Recreational Vehicle (OHRV) category, which includes off-highway motorcycles with design characteristics that are closely related to some ONMCs. Because California has not enacted new ONMC emissions standards since 1998, allowable emissions rates for ONMCs are significantly higher than for other vehicle categories that are subject to more recent and stringent regulatory standards.

Therefore, CARB staff is developing a regulation to determine the feasibility of setting lower emissions limits for motorcycles and potentially harmonizing with lower European Union (EU) 5 motorcycle standards. The testing was conducted at the Haagen-Smit Laboratory (HSL) to compare emissions between EU 5 and CARB emissions certification procedures and evaluate the applicability of the current evaporative test procedure. This test plan details the testing requirements and procedures for the program that was performed at HSL based upon test vehicle availability.

In order to support a new regulation, it is necessary to collect emissions testing data from currently sold conventional ONMCs to better understand their emissions levels of regulated pollutants. It is also necessary to compare impacts of changes in current certification testing procedures to any proposed changes in certification testing procedures. The testing discussed in this paper addresses both of those needs.

The current evaporative standard is based off a 2-hour tank heating Sealed Housing for Evaporative Determination (SHED) test which consists of a one-hour diurnal and one-hour hot soak test. Manufacturers are required to meet a standard of 2 grams hydrocarbons (HC) for the complete 2-hour test. Additionally, if there is no fill pipe, the standard is reduced to 1.8 grams HC per test. The current ONMC evaporative emissions standard has been unchanged since its inception. During that time, all other light-duty categories have significantly reduced their evaporative emissions standards. A chart comparing the evaporative standards for different jurisdictions and programs is shown in Figure 1. All the data and calculations presented in the document, unless specified, are from CARB internal testing[1,2].

Figure 1: Comparison of Evaporative Emissions Standards for various jurisdictions



Technology can be transferred from the automotive sector to reduce evaporative emissions from ONMCs. CARB developed a test program to determine if more stringent standards are feasible and if the current test procedure is appropriate for measuring representative evaporative emissions.

The CARB test program focused on the following objectives:

- **Compare evaporative emissions results from multiple ONMCs and determine criteria to achieve low evaporative emissions out to vehicle useful life.**
    - Conduct testing on multiple ONMCs and compare emissions results and control technologies.
- **Evaluate correlation between butane working capacity (BWC) / fuel tank volume and 3-day diurnal emissions.**

---

[1] CARB. ONMC Inventory SHED Testing Spreadsheet to Support the Proposed Amendments to On-Road Motorcycle (ONMC) Emissions Standards, August 17, 2023.
[2] CARB. ONMC SHED Evaporative Emissions Spreadsheet to Support the Proposed Amendments to On-Road Motorcycle (ONMC) Emissions Standards, August 17, 2023.

    - Calculate BWC/Fuel Tank volume and compare ratios to diurnal emissions results to determine if canisters are sufficient to meet 1 g/day emissions.
- **Evaluate ONMC to quantify emissions from canisters, leaks, and other sources.**
- **Evaluate feasibility of emissions control over multiple days.**
    - Perform multiday diurnal testing on multiple ONMCs and compare emissions rates.
- **Evaluate comprehensive evaporative test procedure to control emissions.**

This report presents the rationale and results from the test program based on the program objectives.

Experimental Description

An objective of the CARB ONMC evaporative emissions test program was to conduct emissions testing from in-use vehicles for inventory testing and evaluate well performing ONMCs for design-based control technology criteria. As most ONMC fuel hoses are already low permeating and most ONMC fuel tanks are constructed of low permeation plastics or metal, staff considered design-based criteria and testing for controlling evaporative emissions with the focus of carbon canister specification. In addition, staff evaluated SHED testing over multiple days to determine the effects of emissions control over time.

The current on-road evaporative emissions test procedure is Part IV Evaporative Emissions Test Procedure for Motorcycles in "California Evaporative Emission Standards and Test Procedures for 2001 through 2025 Model Year Passenger Cars, Light-Duty Trucks, Medium-Duty Vehicles, and Heavy-Duty Vehicles and 2001 and Subsequent Model Year Motorcycles". The ONMC evaporative test procedure is a 2-hour evaporative SHED test that is preceded by preconditioning of the ONMC through an Urban Dynamometer Driving Schedule (UDDS) test cycle. The SHED test consists of a one-hour tank heating diurnal test and a one-hour hot soak test at 68-86°F (20-30°C). The heat build tank test is completed through the use of two temperature-controlled heat sources (e.g., heat strips, heat blanket, etc.). The fuel tank and vapor temperatures in the diurnal portion must go through an increase in temperature of 68°F (20°C) with a final temperature of 96°F (35.5°C) in 60 minutes. Immediately following the diurnal test, a hot soak evaporative emissions test is conducted between 68-86°F (20-30°C) for 60 minutes. The current test procedure does not measure evaporative emissions for more than 2 hours. Therefore, staff conducted evaporative emissions testing over multiple days to evaluate emissions during storage periods.

CARB testing was conducted on Class III ONMCs (greater than 279cc) over multiple days with various temperature profiles and fuels in a SHED. A 68-86°F (20-30°C) hot soak test was conducted prior to the diurnal. Regulatory testing was conducted on a representative class III ONMC. The goals of the testing program were to evaluate evaporative emissions over multiple days, determine the effects of ethanol over various test cycles, and evaluate feasibility of a one gram per day standard. All SHED results are presented in grams of total hydrocarbons (THC). In addition, purge testing was conducted to determine representative purge rates on ONMCs.

Diurnal testing was performed over multiple days on multiple ONMCS. Initial testing was performed to isolate well performing ONMCs and determine effectiveness of emissions controls. Staff also compared the change in emissions each day and evaluated performance criteria for lower emitting ONMCs. Emissions were compared between current ONMCs to develop a control strategy to reduce evaporative emissions. The focus of the test program was on optimizing the carbon canister and carbon quality and evaluate additional control technology if feasible. In addition, staff considered if a hot soak emissions strategy was practicable.

Drive Cycle Comparisons: Federal Test Procedure (FTP) and Worldwide Harmonized Motorcycle Testing Cycle (WMTC)

The FTP drive cycle represents the testing constraints of the current CARB certification testing, giving a good baseline from which to compare the impact of the WMTC drive cycle. The FTP drive cycle is composed of the UDDS followed by the first 505 seconds of the UDDS appended after the UDDS. It was designed to represent car driving but the WMTC was designed for the speeds, shift schedules, and driving patterns typical of motorcycle riding. LEV III test fuel was tested because it is the CARB certification test fuel for most other CARB vehicle categories using gasoline and is highly representative of California pump fuel.

Methods

SHED Testing Protocol

The SHED tests were done using the method below for diurnal testing.

<u>ONMC Preparation and Preconditioning</u>

1. Drive tire must be inflated to manufacturer specifications of +/- 2.2 psi.
2. Drain and re-fill tank with CaRFG3 summer fuel blend to 50% capacity.

3. Cold soak ONMC between 68 to 86F for 12 to 36 hours if the ONMC is entering the lab for the first time.
4. Drive one J-prep cycle to precondition the ONMC. No emissions collection is necessary.
5. Within 1 hour of J prep completion, drain and re-fill tank with CaRFG3 summer blend fuel to 50% capacity.
6. Cold soak the ONMC between 68 to 86F for 12 to 36 hours. Remove key from the ignition during soaking.
7. During soak, purge and load canister to achieve 2-gram breakthrough per 40 CFR 86.132.96.

Test Procedure

1. Drive on dynamometer with the applicable test cycle.
2. Start 1-hour hot soak evaporative test no more than 7 minutes after the end of the FTP cycle. Once the engine is shut-off, the ONMC must be place in SHED within 2 minutes of key-off
3. Soak the ONMC at 65F for 6 to 36 hours.
    a. At the end of the soak period, connect the vent port of the vehicle's canister to a trap canister using appropriate tubing. Trap canister should be fully purged before using.
    b. Place trap canister on weight scale with a digital output to record mass over time and tare the scale after the canister is placed on it.
    c. Connect digital output to a data logger.
    d. Position the scale so the digital display can be clearly seen through a window from outside the SHED.
4. Perform 168-hour diurnal test, with SHED temperature cycling between 65 to 105F each day. If scale's digital display indicates 1.0 grams or more, terminate testing at the end of the full diurnal cycle (end of that day).
5. Any of the above evaporative test may be repeated at the discretion of the Project Engineer.

Carbon Canister Testing Protocol

OEM carbon canisters were used in this test procedure for their respective vehicles except for one prototype canister designed to evaluate the feasibility of more stringent standards. Staff followed the U.S. EPA light-duty test procedure from 40 CFR 86.132-96 to determine the carbon canister butane working capacity.

The protocols were as follows:

1. Purge canister

    a. Using fresh air volume equal to the equivalent of 300 times the canister carbon bed volume. Rate for purge is 22.7 L/min unless otherwise specified in the specific test described herein.

    b. Weigh canister and record.

2. Load canister

    a. BWC: 15 grams per hour butane with 50/50 butane/nitrogen mix until 2g breakthrough.

    b. Weigh canister and record.

3. Repeat steps 1-2 as necessary for repeat tests.

Test Program

ONMCs Tested

A total of ten class III ONMCs were selected by ECCD staff to be tested in this program as shown in Table 1. The test vehicles were anonymized as the goal of the testing was not to draw attention to specific manufacturers but rather to characterize emissions of representative Class III motorcycles. The motorcycles were tested at CARB's Haagen-Smit Laboratory in El Monte California.

The goal of this testing was to evaluate evaporative emissions over multiple regulatory diurnals and compare control technologies that are currently used for ONMCs. The test data will help determine potential effective strategies for future emissions control and establishing more stringent standards.

Ten Class III ONMCs with various engine displacements and model year ranges were chosen to evaluate emissions.

Table 1. Test Vehicle Descriptions

Description	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Model Year	2016	2018	2019	2014	2014	2015	2011	2015	2020	2019
Odometer (mi)	27,302	1,013	1,131	5,060	16,813	7,507	11,115	8,125	443	632
Cannister Capacity (g)	18	24	16	20	26	23.5	24	22	18	25
Cannister Volume (cc)	400	390	220	380	375	570	450	#8	260	#10

Test Fuels

The test fuel used for the evaporative regulatory program was:

- CARB LEV III test fuel
  - CARB's current certification test fuel for light duty vehicles.
  - CARB's proposed future certification test fuel for ONMCs.

The purpose of using CARB LEV III test fuel is that it generates results representing the evaporative emissions in California. For reference, CARB LEV III key parameters are listed in 2.

Table 2. Test Fuel Key Parameters

Test Fuel Key Parameters	CARB LEV III		
	Min	Max	Average
Ethanol Content (% Vol)	9.2	10	9.6
RVP (kPa)	48	50	49
RVP (psi)	6.9	7.2	7.1

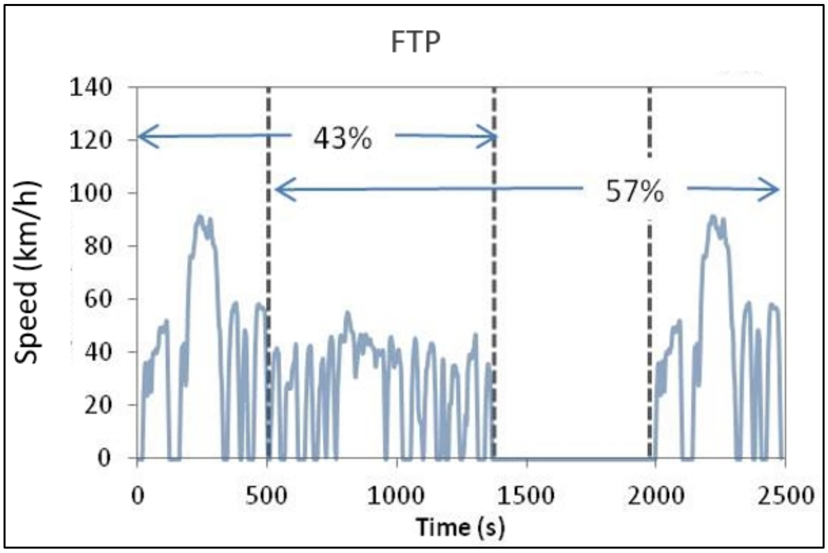
Drive Cycles

Drive Cycles in this testing included:

- FTP
  - CARB's current ONMC certification drive cycle.
  - Originally developed as representative of driving characteristics of passenger cars.
- WMTC
  - European type approval test cycle for motorcycles.
  - Originally developed as representative of driving characteristics of ONMCs.

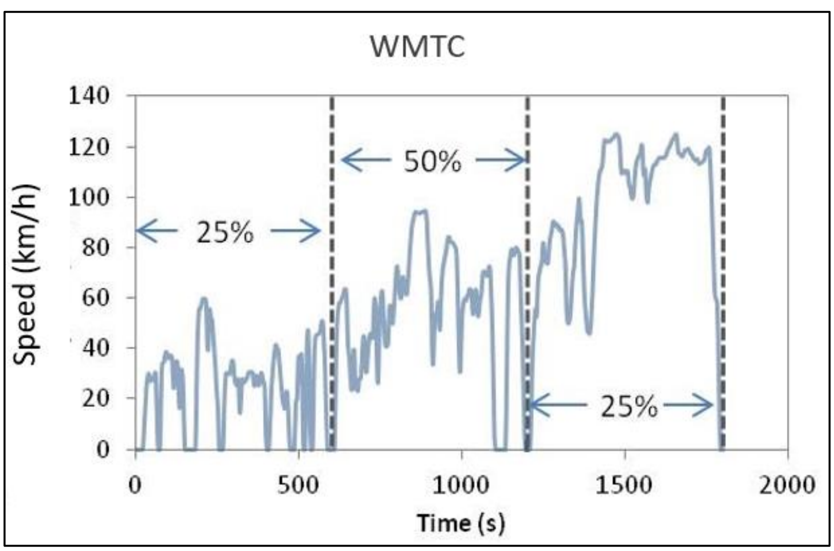
The FTP drive cycle (Figure 2) is the current ONMC certification drive cycle and includes a cold start followed by a hot start. Emissions are collected in 3 phases and weighted such that 43% is weighted on the combined results of bags 1 and 2 while the 57% is weighted on the combined results of bags 2 and 3. The maximum speed achieved is much lower than representative of typical ONMC recreational riding.

Figure 2. FTP Drive Cycle



The WMTC drive cycle (Figure 3) is the current European type-approval drive cycle and does not include a hot start. Emissions are collected in 3 phases and weighted such that 25% is weighted on the result of bag 1, 50% is weighted on the results of bag 2 and 25% is weighted on the results of bag 3. The maximum speed achieved is much more presentative of actual ONMC recreational riding.

Figure 3. WMTC Drive Cycle



A comparison of some key differences between the FTP and WMTC drive cycle is given in Table 3. Drive cycles are important for emissions control because they can affect how much a carbon canister is purged prior to diurnal emissions testing. The more a canister is purged, the more the carbon has sites to adsorb the vapors and therefore reduce evaporative emissions. So, choosing a more representative drive cycle can affect the emissions control necessary to meet California's emissions goals.

Table 3. Key Drive Cycle Differences

Key Drive Cycle Parameters	Max Speed (km/h)	Average Speed (km/h)	Distance (km)	Cold Start? (Y/N)	Hot Start? (Y/N)
FTP	91	34	18	Y	Y
WMTC	125	58	29	Y	N

Shift Schedules

How a rider shifts gears while riding an ONMC can make a difference in test results. This paper does not attempt to look into potential variations due to shifting. However, for the purpose of clarity it is important to note the strategy used. WMTC has a prescribed shift schedule that manufacturers must comply with. However, the FTP allows for either a prescribed shift schedule as given in the code of federal regulations, or the manufacturer may submit results obtained with their recommended schedule.

Carbon Canister Design Criteria Evaluation

Carbon canister designs vary by ONMC and manufacturer. They can come in any shape, size, and design as the ONMC can allow. ONMC canister configurations are mostly designed specifically for ONMCs as there is limited space on the ONMC. The basics of a carbon canister design include ports to purge the vapors, tank port, vent ports, and sometimes a drain port. The carbon canister includes a volume of activated carbon called the carbon bed. The canister also includes spacers or springs to hold the carbon bed in place for specific configurations with single and multiple chambers. Filters are also used to keep the carbon in place and keep dust from entering or exiting the canister. A diagram of two different types of carbon canisters is shown in Figure 4. Furthermore, activated carbon can come in many shapes and sizes which can affect emissions control performance (Figures 5,6, and 7).[3]

Figure 4: Cut-Out Diagrams of Carbon Canisters

[3] Manufacturers of Emission Controls Association (MECA), Evaluation of Motorcycle Evaporative Canisters. July 15, 2021.

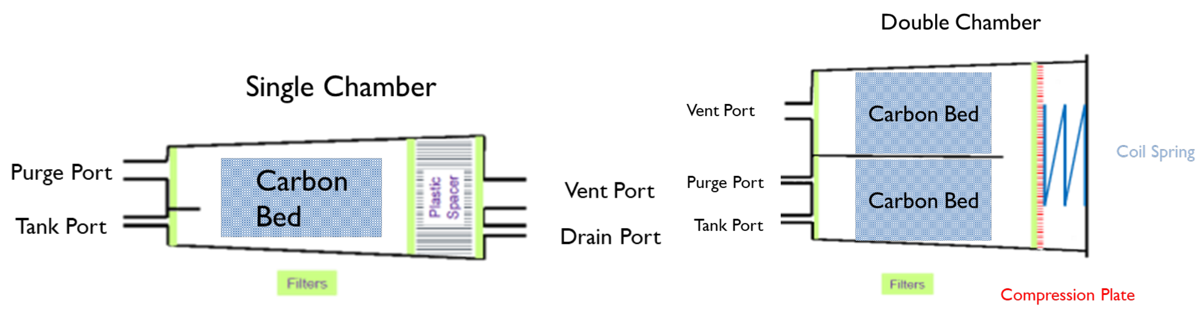


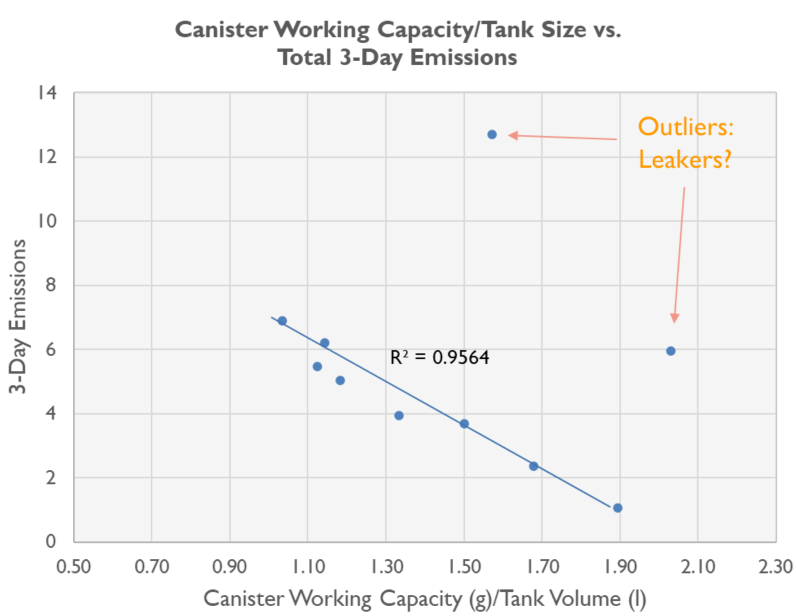
Figure 5: Different Shapes and Sizes of Carbon Canisters

Figure 6: Carbon Canister Components

Figure 7: Various Activated Carbon Shapes

CARB testing shows that 3-day evaporative emissions may be correlated to the ratio of canister working capacity to fuel tank size. Based on this data, staff can extrapolate a theoretical ratio to determine the working capacity to fuel tank size and emissions over three days. Staff evaluated this as a potential proposal for a carbon canister design-based standard.

Figure 8: Carbon Canister Butane Working Capacity Comparison to Fuel Tank Size and the Relationship to 3-Day Total HC Emissions



Based on the data, it was shown that increasing the ratio of butane working capacity to fuel tank volume reduced emissions over multiple days, there are additional factors that can attribute to reducing emissions from ONMCs. With the exception of two outliers that are likely the result of leakage, the correlation between canister working capacity and fuel tank volume was more than 95%. Of all the design specifications, it was determined that there were 3 primary factors that controlled evaporative emissions from ONMCs.

Increasing carbon capacity

Carbon canisters are designed with a defined volume that is usually filled with carbon granules. MECA found that of the 8 canisters they analyzed, the carbon volume to canister size ratio ranged from 34% to 55% of carbon in the canister[4] (MECA, 2021). This means that current ONMCs are using carbon canisters that are not fully utilized to the maximum efficiency for reducing evaporative emissions vapors. This is important because the carbon canisters on current ONMCs have additional room in their installed carbon canisters to increase the carbon volume and improve emissions performance.

Improving carbon quality

The amount of gasoline molecules that can be adsorbed by the carbon can be affected by the way the carbon is processed. Not all carbon is created equal and using a carbon with a higher BWC with better durability reduces emissions over the useful life of the ONMC. Additionally, a carbon that is not as durable can lose BWC over time and not be as effective adsorbing vapors. A more robust carbon with higher BWC would be recommended for reducing evaporative emissions.

Increasing Length/Diameter (L/D) ratio

Carbon canisters can come in many different shapes and sizes. They can be rectangular or cylindrical or any configuration that will fit in any allowable engine space. MECA analyzed the pathway of the butane flow to determine how shape and size can affect the BWC of the canister. By increasing the length of the canister and/or reducing the diameter of the canister, the carbon canister can adsorb more vapors. By adjusting these design factors, ONMC emissions could be reduced significantly. For one particular ONMC, improved canister design reduced diurnal BETP emissions 62% from the current US canister design.

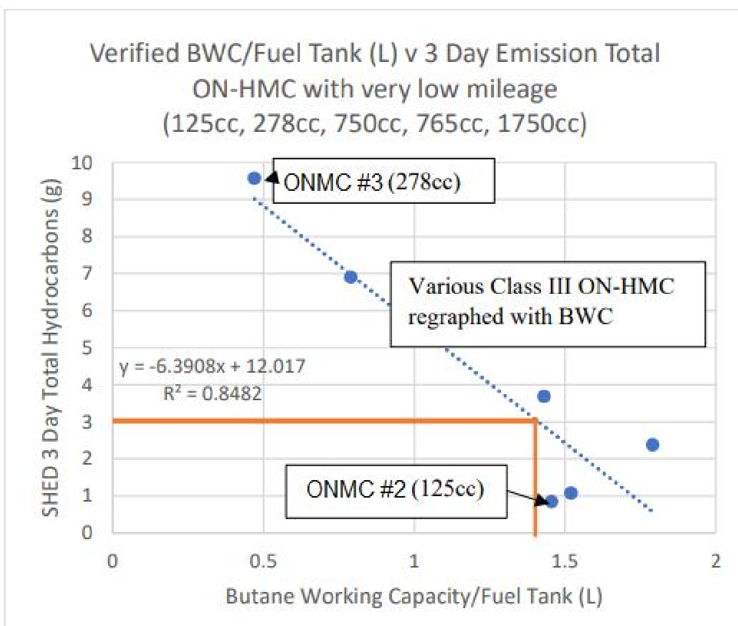
It should be noted that increasing the L/D ratio may be limited for certain ONMCs as they have minimal available space. Additionally, in both test programs it was noted that ONMCs had issues with vapor leaks, especially from the fuel cap. Leak emissions were significant and can emit more than the complete evaporative emissions control system, so leak tests were needed to ensure that fuel caps are sealed. In some cases, it was not noticed until after the test was conducted. It was recommended that if a

[4] MECA, Evaluation of Motorcycle Evaporative Canisters, 2021.

design criteria requirement was to be proposed, then a leak measurement strategy/test is necessary to control emissions from all evaporative emission sources.

The U.S. EPA[5] (U.S. EPA, 2021) conducted evaporative emissions testing at the National Vehicle and Fuel Emissions Laboratory to evaluate the effectiveness of evaporative emissions control based on application to carbon canister design criteria. Specifically, the U.S. EPA conducted 3-day SHED diurnal tests and measured hydrocarbon emissions over all three days. If ONMC emissions were greater than 3 grams over 3 days, then the canister would be replaced with another canister with a higher BWC until it was less than 3 grams over 3 days. Once a canister was less than 3 grams over 3 days, then the butane working capacity to fuel tank size ratio was noted and an additional test was conducted to compare test cycles. U.S. EPA staff applied the BWC/Fuel Tank size ratio design criteria to their internal tests. The results of the U.S. EPA data are shown on Figure 9.

Figure 9. Comparison between BWC to fuel tank volume ratio compared to three-day hydrocarbon emissions total



U.S.EPA, Evaporative Strategy[6] (U.S. EPA, 2021)

Although the design criteria for canister emissions followed a linear relationship, it was determined that the design criteria alone were not sufficient to encapsulate all

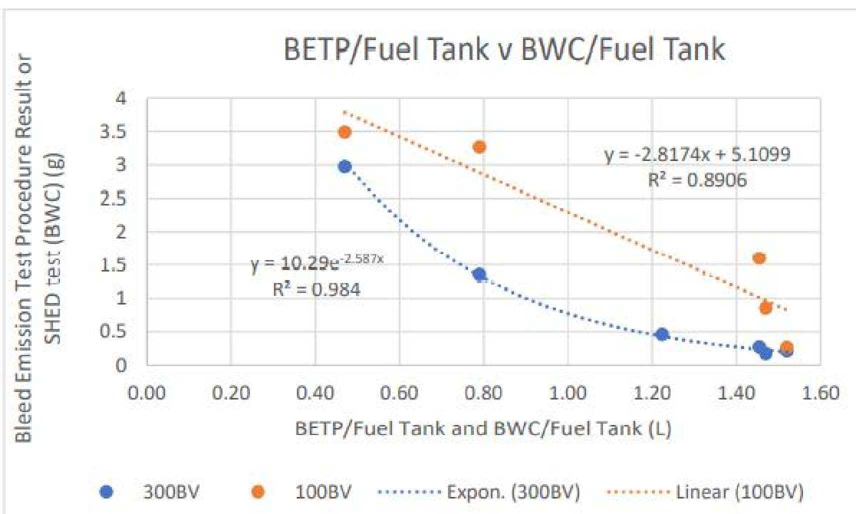
[5] U.S. Environmental Protection Agency (U.S. EPA). Evaluation and Development of an On-Highway Motorcycle Evaporative Emission Reduction Strategy. August 2021.

[6] Ibid U.S. EPA, 2021. 2021.

the emission sources. Evaporative emissions still exceeded more than 3 grams over 3 days in some cases.

U.S. EPA test engineers also compared the bleed emissions to the fuel tank and determined it is a better metric for design criteria. The bleed emission results compared to the BWC/Fuel Tank ratio are presented in Figure 10.

Figure 10: Comparison of Canister Bleed Emissions and Fuel Tank Volume to Butane Working Capacity and Fuel Tank Volume for Total Emissions



U.S.EPA, Evaporative Strategy[7] (U.S. EPA, 2021)

U.S. EPA staff concluded that BWC to fuel tank volume ratio is not sufficient to ensure reduced evaporative emissions from ONMCs. Additional steps must be taken to ensure that emissions are controlled from other sources than the canister optimization. One step is to ensure the gasket material is durable enough to withstand wetting and cracking. Also, carbon must be more durable to maintain working capacity over the lifetime of the vehicle. The most important facet of the

[7] Ibid U.S. EPA, 2021. 2021.

reducing evaporative emissions is controlling leaks and the U.S. EPA recommends implementing a leak test procedure in addition to setting design criteria for an emissions control strategy.

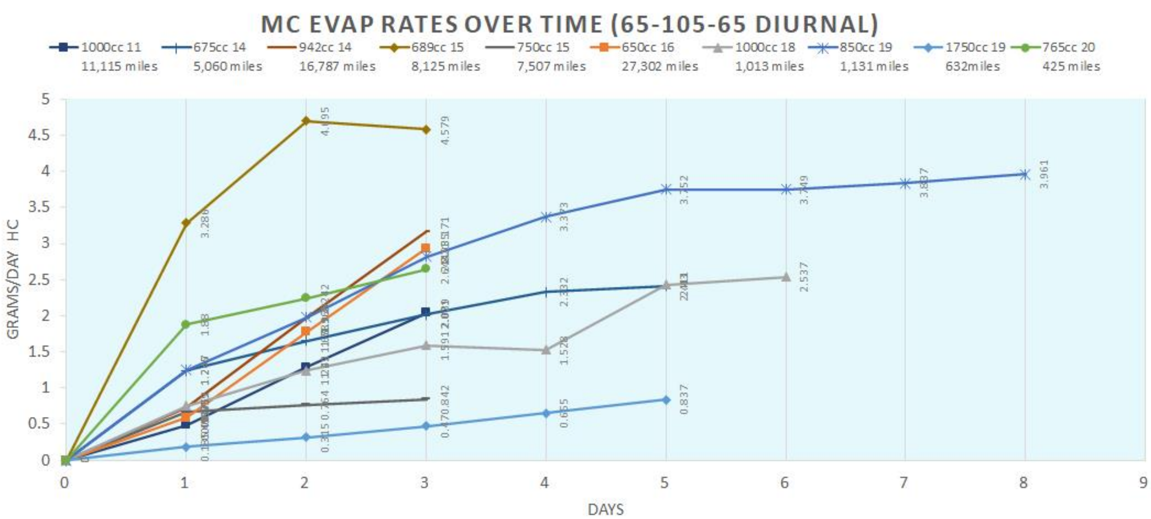
Results

Diurnal Emissions

The THC results for daily evaporative emissions from in-use ONMCs over multiple days of SHED testing are presented in Figure 11. This testing showed an increase in evaporative emissions over multiple days for all vehicles. It is noted that Day 1 THC emissions did not indicate behavior of THC emissions for the following days. THC emissions for the first day were similar for multiple ONMCs but varied substantially for the following days. For example, the 650cc 2016 ONMC had similar emissions to the 750cc 2016 ONMC on the first day at about 0.5 grams HC. However, on the third day, THC emissions results varied greatly with the 650cc 2016 ONMC at 3 grams and the 750cc 2016 at 1 gram.

Staff intended to measure emissions over 7 days for all vehicles, however there were issues with the SHED when conducting testing over multiple days. Generally, lab limitations affected the longer test conditions, but the SHED did not run properly when concentrations were too high, especially with high emitters. Further, the lab staff ran into trouble where they needed to cut short a test for technical problems. One of the vehicles had mechanical issues and was discontinued after a day. So, CARB only considered data from vehicles that could test for 3 or more days without testing issues.

Figure 11: Daily THC Emissions (g/day) Between ONMCs for Inventory SHED Testing



The results for the THC emissions from multiple ONMC are presented in Figure 12 for the FTP cycle over 3-days testing in the SHED. Figure 12 presents the daily emissions rate over the FTP drive cycle which shows an increase in diurnal emissions for each following day. It is noted that most vehicles had relatively low emissions on the first day (around 1 gram per day as indicated by the red line) and then varied dramatically after the first day. Fuel tank volumes ranged from 12.8 to 18 liters and BWC ranged from 16 to 26 grams. Combinations of BWC to fuel tank volume ratio is shown in Figure 13. The gradient between the first and following days varied between not only the ONMC but manufacturer as well. For some ONMCs, diurnal emissions rates remained below 1 gram per day with current emission control technology. Although for the most part, ONMCs exceeded more than 1 gram per day following the initial day. It is important to note also that the emissions after the first day do not indicate what the emissions will be on the following days. SHED testing for a single day is not sufficient to determine the emissions for more than one day of storage. A multiday test would be needed to evaluate the storage emissions from ONMCs.

Depending on the carbon canister sizing, the carbon will adsorb the vapors during the heating part of the diurnal until it reaches maximum adsorption. When the temperature cools down, vapors are pulled back into the fuel tank. A larger canister would provide sufficient vapor adsorption and durable carbon would retain and adsorb vapors more efficiently. Also, the age of the canister could have a negative effect on the durability of the carbon. Carbon can degrade over time and become less effective for the butane working capacity.

Figure 12: CARB Multiday Diurnal Test Results for ONMCs

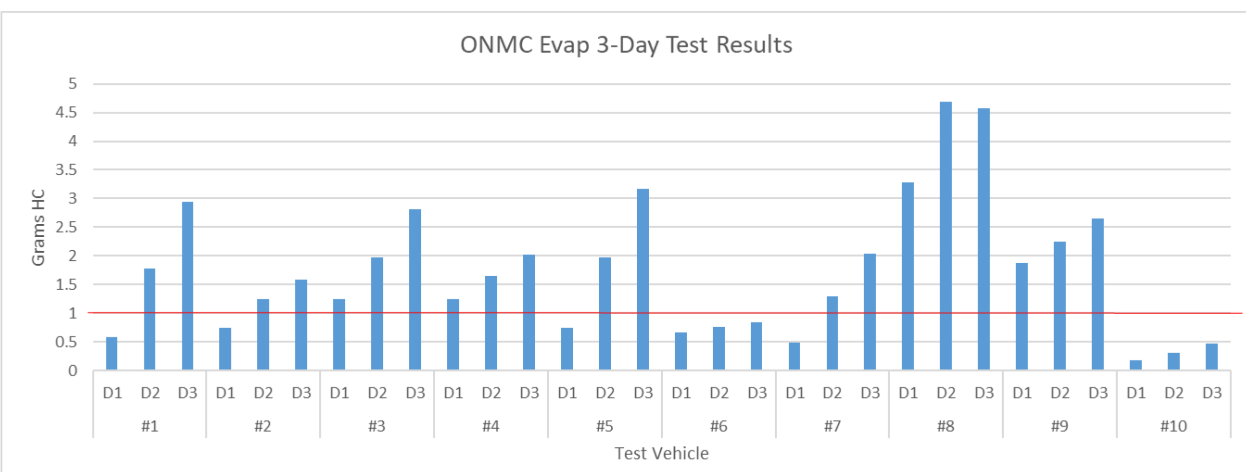


Table 4 shows the average emissions values for the daily emissions rates for the different ONMCs. The average THC emissions from ONMCs showed an increase in emissions from Day 1 and continued to increase each day. It should be noted that the current certification test procedure only requires a one-hour heat blanket diurnal test and does not account for evaporative emissions for additional days. The certification test also does not account for the degradation of non-durable carbon in the canister which would affect the BWC over time and use.

Table 4: Average Daily Emissions from ONMC 3-Day Emissions Testing

Day	Average	STD
1	1.108	0.857
2	1.793	1.118
3	2.311	1.134

It should also be noted that the standard deviation is increased over the daily emissions testing. The variability in emissions test data is greater over multiple days. This implies that emissions from ONMCs may differ between each other and/or carbon canisters are not equally efficient. This indicates that first day emissions are not indicative of emissions on the third day. Staff was unable to extrapolate any information that could be used to anticipate emissions on the third day with only the first day emissions data. As ONMCs come in many shapes and sizes, and with different emissions control configurations, it is difficult to predict the emissions control over multiple days. A longer test duration would be able to confirm whether the emissions are controlled over multiple days. Therefore, staff is proposing that evaporative emissions testing be conducted for more than one day.

Carbon Canister BWC/Fuel Tank Ratio vs 3-Day Total Emissions

Staff examined the carbon canister to fuel tank volume ratios for the 10 ONMCs that were tested for inventory. The results of the 3-day emissions SHED testing compared to the BWC/fuel tank volume ratios are shown in Table 5.

Table 5: BWC/Fuel Tank volume ratios and 3-day total emissions for ten ONMCS

Description	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
BWC/Fuel Tank	1.13	1.50	1.14	1.14	2.03	1.68	1.33	1.57	1.03	1.89
Total Emissions	5.30	3.59	6.05	4.92	5.88	2.27	3.82	4.70	2.67	0.97

Figure 13: BWC to fuel tank volume ratios to the 3-day SHED emissions for the ten ONMCs

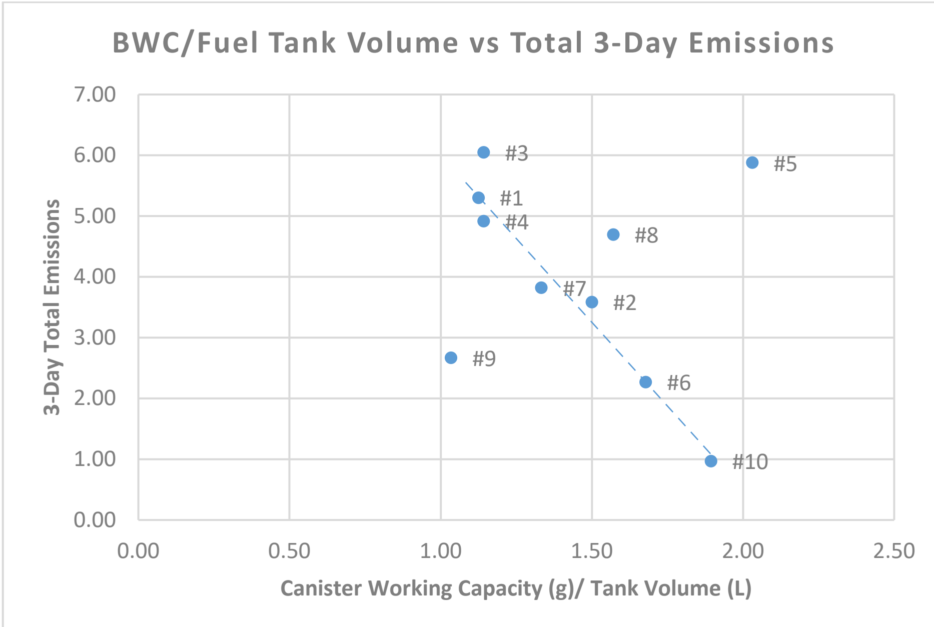


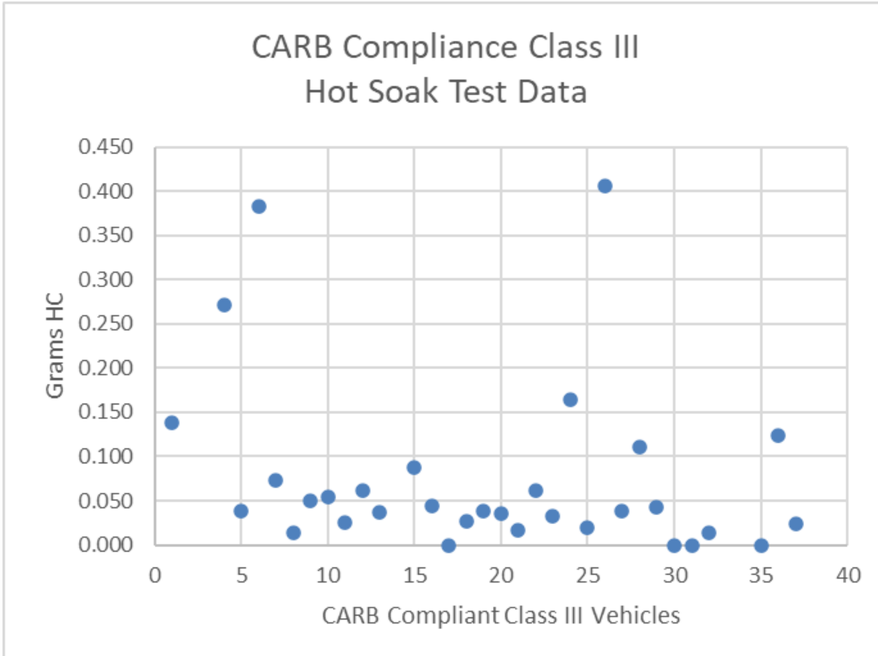
Figure 13 indicates that emissions tend to decrease as the BWC increases for a given tank volume. Excluding the ONMCs #5, #8, and #9, the correlation coefficient is 94.87%. The results are similar to the analysis and previous results as presented earlier in this report. Adjusting the carbon canister sizing is one-way manufacturers can reduce evaporative emissions from ONMCs if leak emissions are controlled.

Hot Soak Testing Results

In addition to the diurnal emissions standards, staff is proposing a hot soak standard be required so that high emitting ONMCs are controlled throughout the various conditions exposed to the vehicle. Staff conducted a review of the current CARB hot soak compliance data to evaluate the feasibility of current hot soak standards. Data was evaluated from fuel injected ONMCs that were tested to current ONMC hot soak compliance procedures. The hot soak tests were conducted at 68 – 86°F.

Figure 14 shows CARB compliance hot soak data from ONMCs that were tested from 2010 through 2019.

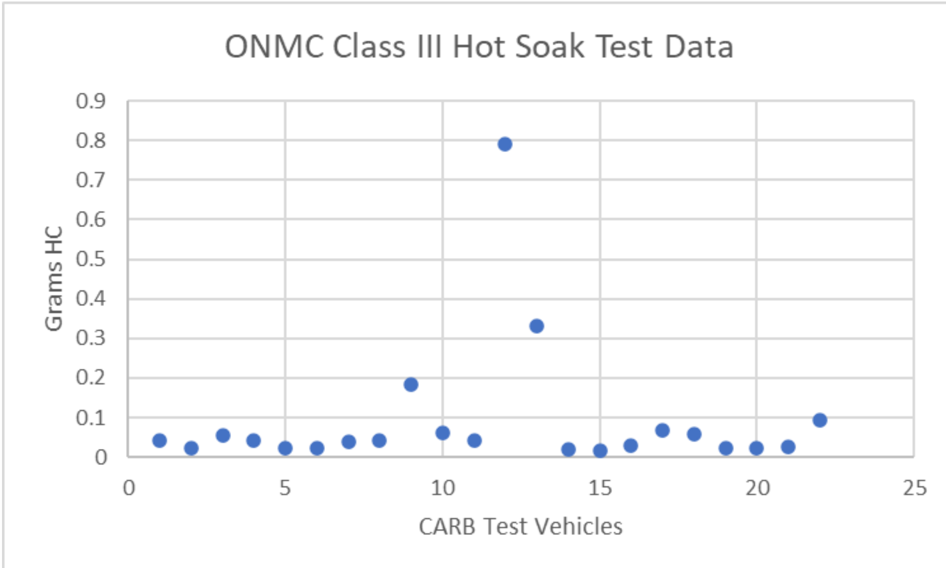
Figure 14: CARB Internal Compliance 2010-2019 Hot Soak Data



The data from Figure 14 represents data from CARB compliant Class III ONMCs that meet the current ONMC standard according to the ONMC test procedure. Figure 14 shows that most of the CARB compliant ONMCs are below 0.2 grams HC. However, there are a few outliers that are more than 3 times the standard deviation of the sample set. With emissions much higher than the average, it is likely that the source is from leaks. These high emitters are complying with the current CARB evaporative emissions standards as tested using the current CARB certification procedures while being an outsized contributor to the State's emissions problems.

In addition to the CARB hot soak compliance data, staff conducted hot soak emissions testing for the ONMC inventory test program. The test results from the internal CARB testing are shown in Figure 15 below.

Figure 15: 2021 Hot Soak Test Data



The recent hot soak data shows similar results from the CARB compliance hot soak data in that high emitters continued to be prominent from CARB certified vehicles.

Leak Emissions

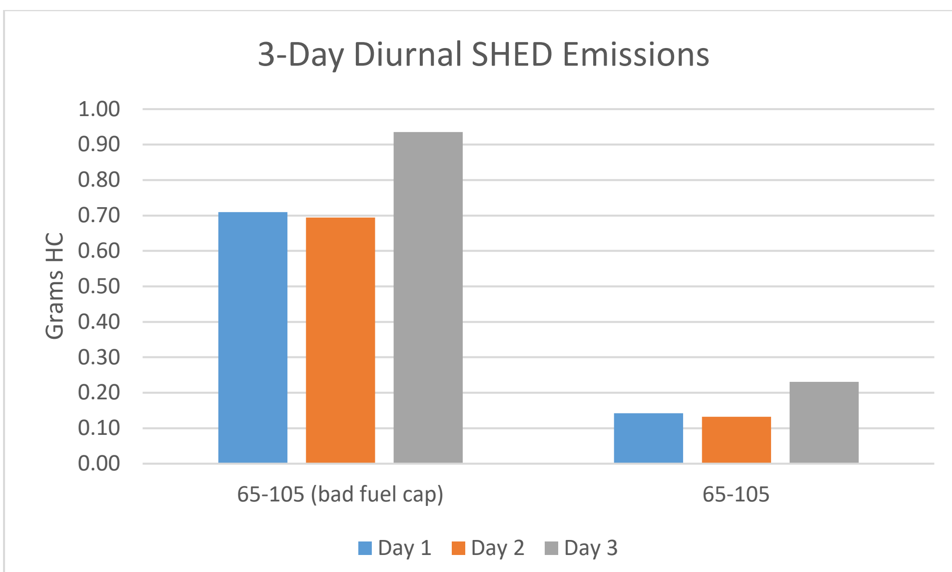
During the inventory testing, test engineers noted that some of the ONMCs were leaking emissions through the fuel cap. Staff was aware of common leakage from ONMCs from MECA[8] (MECA, 2021) and U.S. EPA[9] (U.S. EPA, 2021) in through their internal testing. Before testing, test engineers conducted preliminary leak checks by using a smoke machine ad a smog check exhaust probe. If detected, staff would use a sniffer probe connected to the Horiba gas analyzer to get a better reading of the leak emissions. It was noted that often times, when the vehicle was warmed up, leaks would be observed around the gas cap and confirmed with the smoke machine.

[8] MECA, Evaluation of Motorcycle Evaporative Canisters, 2021.
[9] Ibid U.S. EPA, 2021. 2021.

Figure 16: Degraded seal from leaking ONMC fuel cap

If a leak was found, staff would seal the cap and measure the emissions. In one case, staff replaced a fuel cap with a new one and measured the emissions difference between the leaking fuel cap and the new one. The difference in emissions between an ONMC that was leaking emissions from the fuel cap and a sealed cap is presented in Figure 17.

Figure 17: Comparison of ONMC Diurnal Leak Emissions



The testing showed that leak emissions are significant compared to controlled emissions. On average, the emissions were more than 300% lower when the fuel cap was not leaking emissions.

Staff considered the inclusion of a leak test as a design-based option for meeting testing requirements. However, leaks can come from multiple sources on the ONMC and would require significant resources to monitor each component. A test procedure that includes all sources of evaporative emissions including leak emissions would ensure emissions are controlled from all sources.

Conclusion

During inventory testing, CARB test engineers noticed that fuel caps that passed leak tests began to leak when heated to higher temperatures. Since the CARB compliance procedure differs from the certification procedure in that the hot soak is preceded by a drive cycle as opposed to a diurnal, this provides another metric for detecting leakage from an ONMC. The heating of the fuel system has an effect on the leakage emissions and can be determined through additional testing. Therefore, staff is proposing a hot soak procedure be conducted before the diurnal test and following the drive cycle preconditioning. Manufacturers will be required to meet a 0.2-gram HC standard following the hot soak. The concept of testing and meeting a hot soak standard is important so that leakage emissions can be monitored when the evaporative fuel system is exposed to higher temperatures immediately following a drive cycle. To ensure controlled emissions through the lifetime of the ONMC, it appears that durability procedures are necessary as well. So, staff is also proposing more stringent durability procedures to address the leakage emissions from high emitters.

Staff considered the inclusion of a leak test as a design-based option for meeting testing requirements. However, leaks can come from multiple sources on the ONMC and would require significant resources to monitor each component. Staff has therefore developed a test procedure that can measure for all sources of evaporative emissions including leak emissions.

CARB staff considered a carbon canister design standard as a requirement for meeting the CARB certification. However, leakage emissions are significant and emissions from the venting line is not only the factor in evaporative emissions. It is possible that a design-based standard for carbon canisters is possible but would only be allowed if an extensive leakage test be conducted. Therefore, staff evaluated a comprehensive test procedure that would encompass all the aspects of evaporative emissions.

Diurnal testing of ONMCs showed that multiple diurnals are necessary to characterize the evaporative emissions of storage vehicles. ONMC diurnal emissions for the first day is not indicative of the following days. Many examples showed that two ONMCs can have the similar first day emissions but diverge drastically the following days. Staff is proposing a 3-day diurnal to encapsulate the storage emissions of ONMCs. The current test procedure is not sufficient to represent real-world emissions and a single day diurnal does not accurately depict the emissions over the following days. A multiday diurnal is necessary to characterize real-world evaporative emissions and will account for any leakage emissions regardless of the type of vehicle and the location of the leak. CARB testing showed that a 1 gram per day standard is feasible with the current technology and minor adjustments to the fuel cap and evaporative system.

Appendix 1

Test Plan

Gavin Newsom, Governor
Jared Blumenfeld, CalEPA Secretary
Mary D. Nichols, Chair

TO: Mark Fuentes, Division Chief
Mobile Source Laboratory Division

Allen Lyons, Division Chief
Emissions Certification and Compliance Division

THROUGH: Sharon Lemieux, Chief
In-Use Programs Branch

Thomas Valencia, Chief
Haagen-Smit Laboratory Engineering & Testing Branch

Mang Zhang, Chief
Chemical Analysis & Emissions Research Branch

FROM: Scott Bacon, Manager
Engineering and Regulatory Development Section
Emissions Certification and Compliance Division

DATE:

SUBJECT: ON-ROAD MOTORCYCLE REGULATORY DEVELOPMENT TESTING

PROJECT NUMBER: 2R1904
PROJECT START DATE: September 1, 2019

REFERENCED TEST PROCEDURES

The purpose of this testing is to quantify emissions differences between exhaust certification test procedures and the certification fuels used. These tests are as follows:

1. EU 134/2014, Annex II (Test type I requirements: tailpipe emissions after cold start). This will be referred to throughout simply as the WMTC. https://eur-lex.europa.eu/eli/reg_del/2014/134/oj/eng
2. Federal Test Procedure (FTP), Subparts E and F, Part 86, Title 40, Code of Federal Regulations, as they existed on July 7, 1986. This will simply be referred to throughout as the FTP.

TESTING FACILITY

This testing program will be conducted in HSL's Test Cell 3. The major equipment components for Cell 3 are as follows.

Test Cell Dynamometer
Test Cell 3 is equipped with a 20 inches single roll portable motorcycle dynamometer capable of testing motorcycle up to 1,000 kg.

Test Cell Sampling System
Test Cell 3 is equipped with a 10-inches full-flow dilution tunnel constant volume sampler (CVS) with a nominal flow between 150 and 1,000 standard cubic feet per minute.

Test Cell PM Filter-based Sampling System
Test Cell 3 has three AVL SPC-472 Samplers. Teflon filters can be used to collect PM samples for PM mass analysis.

Test Cell Analytical System
Test Cell 3 is equipped with an analytical bench for measuring Total Hydrocarbon (THC), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitric Oxide/Oxides of Nitrogen (NO/NO_x) and methane (CH_4) for each test phase. Cell 3 has the ability to measure real-time modal emission data for THC, CO, CO_2, and NO/NO_x.

Real-time PM Instruments
Multiple real-time PM instruments will be used to measure the diluted exhaust from the CVS dilution tunnel:

1. Particle number: a PMP-compliant SPC system with cut-point of 23 nm for solid particle count measurement will be used.
2. Particle size spectrum: an EEPS (Model 3090, TSI) will be used for real-time PM size distribution measurement.
3. Black carbon (BC): an MSS (Model 483, AVL) will be used to measure real-time BC emissions.

MOTORCYCLES

A total of four class III motorcycles have been selected by ECCD staff to be tested in this program as shown in the Table 1, Appendix A. Three motorcycles have been purchased by ECCD and one EU 5 compliant motorcycle is being loaned from a manufacturer. Note that these motorcycles will also be used in other ongoing test plans as well so some coordination may be needed between these programs.

TEST CYCLE REQUIREMENTS

Gaseous (THC, NMHC, CH_4, CO, NO_X, and CO_2) and PM emissions will be collected for all FTP and WMTC drive cycles performed in the test cell. Weekly tunnel blank

(TB) PM will be collected using the FTP (EC1B) test cycle with the 3-filter method. Project engineer will decide which FTP and WMTC tests will conduct modal measurements.

TEST FUELS

This program will use three fuels throughout the testing that will be specified during each procedure. The test fuels used will be:

1. Indolene certification fuel Tier 2 (E0) with the CARB fuel code IC21.
2. LEV III certification fuel (E10) will be used that is available in drums at HSL with the CARB fuel code EC09-1-1.
3. EU 5 (E5) reference fuel as specified in EU 134/2014. CARB fuel code will be assigned and updated after fuel analysis is completed.

MOTORCYCLE DELIVERY AND CHECK-IN

The motorcycles 1 and 3 from Appendix A are currently available for testing. Motorcycle 2 and 4 are expected to be acquired by ECCD staff by August 2019. ECCD staff will ensure these motorcycles have reached 1000 miles. Upon mileage being accumulated, ECCD staff will notify the test engineer, then deliver the motorcycles to HSL laboratory for testing.

EXHAUST TESTING PROCEDURE

All applicable test cell Standard Operation Procedure (SOPs) should be followed and weekly quality assurance (QA) should be performed, verified, and documented prior to conducting motorcycle emission testing. A chain of custody sheet shall be filled out for each motorcycle as it goes through testing. These sheets can be found in Appendix C.

<u>General Test Preparation</u>

1. Verify tire pressures to manufacturer specifications ± 2.2 psi;
2. Conduct a 3-filter FTP (EC1B) TB test weekly in Test Cell 3.

<u>Motorcycle Preparation and Preconditioning for FTP (EC1B):</u>

1. Verify and record motorcycle has minimum mileage accumulation of 3,500 km (2,175 mi) prior to testing.
2. Verify and record driver mass 80 ± 10 kg (176 ± 22 lb).
3. Drain and re-fill tank with Indolene test fuel to 50% capacity.
4. Confirm dynamometer coefficients based on EIM with 40 CFR §86.529.98 and follow shift schedule as specified in 40 CFR §86.528.78.

5. Drive one UDDS cycle to precondition the motorcycle as specified in 40 CFR §86.515.78(a). No emissions collection is necessary.
6. Cold soak the motorcycle 12-36 hours at standard temperature 68°F to 86°F for next day's testing. Remove key from the ignition during soaking.

<u>Testing Sequence for FTP (EC1B):</u>

1. Push the motorcycle to dynamometer.
2. Ensure the connections between the motorcycle tailpipe and sampling equipment are leak-tight.
3. Conduct an FTP (EC1B) test cycle to measure bag emissions and real time PM measurements, and collect PM samples. The filters will be sent to chemistry lab for PM mass analysis.
4. Follow shift schedule as specified in 40 CFR §86.528.78.
5. If three tests have not been completed, cold soak the motorcycle at standard temperature 68°F to 86°F overnight to prepare for next day's testing. Remove key from the ignition during soaking.
6. Repeat steps 1 to 4 until three valid EC1B tests have been conducted.

<u>Motorcycle Preparation and Preconditioning for Type I Test (WMTC):</u>

1. Verify and record motorcycle has minimum mileage accumulation prior to testing of 1,000 km (621 mi).
2. Verify and record driver mass 75 ± 5 kg (165 ± 11 lb). If we do not have a driver meeting these qualifications, contact Project engineer for instructions.
3. Drain and re-fill tank with Indolene test fuel to 50% capacity;
4. Decide sub-classification under L-category for the motorcycle to be tested:
   - EU Class 1: Engine capacity <150 cm3 and Vmax < 100 km/h
   - EU Class 2-1: Engine capacity <150 cm3 and 100 km/h< Vmax < 115 km/h
   - EU Class 2-2: Engine capacity >150 cm3 and Vmax < 115 km/h
   - EU Class 3-1: 130 km/h < Vmax < 140 km/h
   - EU Class 3-2: Engine capacity >1500 cm3 or Vmax > 140 km/h
5. Select WMTC Stage 3 test cycles parts based on the motorcycle sub-classification under L-category:
   - Class 1: Part 1 (reduced speed) + Part 1 (reduced speed)
   - Class 2-1: Part 1 (reduced speed) + Part 2 (reduced speed)
   - Class 2-2: Part 1 + Part 2
   - Class 3-1: Part 1 + Part 2 +Part 3 (reduced speed)
   - Class 3-2: Part 1 + Part 2 +Part 3
7. Set dynamometer coefficients based on EIM (Refer to Appendix 5, Commission Delegated Regulation No 134/2014).
8. The blower outlet shall be at least 0.40 m^2 (4.31 ft^2). Locate the blower bottom outlet 5-20 cm above floor level and blower outlet 30-45 cm in front of motorcycle front wheel.

8.1. Throughout the test, a variable-speed cooling blower (fan) shall be positioned in front of the motorcycle so as to direct the cooling air onto it in a manner that simulates actual operating conditions. The blower speed shall be such that for motorcycle speeds of:
   - < 10 km/h, the linear velocity of the air at the blower outlet ranges from 0 km/h to a maximum of 5 km/h above the corresponding roller speed;
   - 10 to 50 km/h, the linear velocity of the air at the blower outlet is within ±5 km/h of the corresponding roller speed;
   - > 50 km/h, the linear velocity of the air shall be within ± 10 percent.

8.2. If fan is not capable of conforming to these standards, run the fan as close as possible and note how the fan constraints differed from the testing constraints of 8.1 above.

9. Shift schedule must be determined for each motorcycle and follow the equations as given per Annex II, Section 4.5.5.2 Test Motorcycles with Manual Transmission, Commission Delegated Regulation No 134/2014.
   9.1. An example calculation can be found in Appendix 9 to Annex II.
10. Drive or push the motorcycle to dynamometer.
11. Drive one WMTC cycle as determined in step 3 above with the shift schedule derived in step 6 above to precondition the motorcycle. No emissions collection is necessary.
12. Cold soak the motorcycle at standard temperature 68°F to 86°F for next day's testing for 12-36 hours. Remove key from the ignition during soaking.

<u>Testing Sequence for Type I Test (WMTC):</u>

1. Push the motorcycle to dynamometer.
2. Ensure the connections between the motorcycle tailpipe and sampling equipment are leak-tight.
3. Conduct a WMTC cycle as determined in preconditioning steps above to measure bag emissions and real time PM measurements, and collect PM samples. The filters will be sent to chemistry lab for PM mass analysis.
4. Follow shift schedule as determined during preconditioning steps above.
5. Put transmission in gear 15 s after the engine is started.
6. No simultaneous use of brake and throttle shall be permitted.
7. Turn off cooling fan immediately after the end of sample period.
8. If three tests have not been completed, cold soak the motorcycle at standard temperature 68°F to 86°F overnight to prepare for next day's testing. Remove key from the ignition during soaking.
9. Repeat steps 1 to 7 until three valid WMTC tests have been conducted on the specified test fuel.
10. Upon completing three valid tests on the Indolene test fuel, repeat the entire WMTC preconditioning and testing process again but for both EU 5 and CARB

LEV III test fuels until three tests have been completed successfully on each of those fuels.

PM FILTER REQUIREMENT

Filter-based PM samples will be collected to determine PM gravimetric mass. Monthly trip blank Teflon filters will be collected in this program. Weekly FTP tunnel blank tests will be sampled for PM mass with the 3-filter method. It is estimated that a total of 170 Teflon filters will be needed for this project including for samples, tunnel blanks, and trip blanks.

The Project Manager/Engineer and Test Engineer will determine the PM filter numbers required for each week and notify the Aerosol Analysis and Method Evaluation Section (AAMES) staff, two weeks prior to motorcycle testing, about the filter requirement.

The tentative schedule for PM filter collection for motorcycles selected to be tested are shown in Appendix D.

VERIFIABLE DATA

All test cycles including the FTP and WMTC shall strictly meet all regulatory requirements to be considered a valid test. Any specially designed screening test cycles will be considered valid as long as the test equipment meets its normal acceptance procedures. Additionally, motorcycles tested under these special cycles without utilizing a HFID analyzer will also be considered valid. In general, the only special cycles that will be invalidated are those tests where the cycle was not completed in its entirety or when the filter sampler is left on during non-cycle testing. In case of doubt, the Project Manager/Engineer will make the final decision on the validity of the data.

DATA HANDLING AND MANAGEMENT

The Test Engineer will review all test results for completeness and verify that all tests meet applicable EU, CFR and CARB applicable requirements, and that all documentation is complete. In case of test aborts or invalidation of data, the test will be repeated and the reasons for test aborts/invalidation will be documented. After reviewing and approving the data, the Test Engineer will notify the Project Engineer of the status of the test data.

The Project Engineer will have access to all test data and documentation of the test motorcycles at any time during this project. All data will be reviewed by the Project Engineer for completeness and accuracy.

At the end of the project, the Project Manager/Engineer will notify the Laboratory Data Support Branch (LDSB) staff the completion of the project, coordinate with the LDSB staff to complete the final data verification and transfer data into the Motorcycle Emission Database System.

QUALITY CONTROL

Only tests meeting all weekly QA criteria will be used for data analysis. This includes but is not limited to dynamometer speed and load accuracy checks, CVS propane recovery tests, analyzer responses to gas standards, and tests of the accuracy of environmental measurements (barometric pressure, dew point, and temperature).

DATA ANALYSIS/REPORT

The Project Engineer will analyze the data collected in this program and present the final report to upper management within 8 weeks of test completion.

MOTORCYCLE RELEASE

The Test Engineer will notify the Project Manager/Engineer after all scheduled testing has been completed and emissions as well as repair data have been reviewed.

TEST PROJECT PERIOD

The duration of this project is about 4 months and is planned to start in July 2019. However, some of these motorcycles will be tested under other parallel test plans which could cause delay with some of this testing.

PROJECT REPORT AND CONTACTS

Project Engineer: Jason McPhee, Engineering and Regulation Development Section (ERDS), at (916) 323-1104 or jason.mcphee@arb.ca.gov

Backup Project Engineer: Shishan Hu, Project Planning and Data Analysis Section (PPDAS), at (626) 450-6105 or shishan.hu@arb.ca.gov

Test Engineer: Tuyen Dinh, In-Use Inventory Testing Section (IUITS), at (626) 450-6180 or tuyen.dinh@arb.ca.gov. mailto:

Backup Test Engineer: Thomas Desimone, IUITS, at (626) 350-6580 or tdesimon@arb.ca.gov
Chemistry Staff: Ying You, Aerosol Analysis and Methods Evaluation Section, at (626) 459-4391 or ying.you@arb.ca.gov.

Appendices

A. Motorcycle List and Testing Summary
B. Motorcycle Description Sheet
C. Chain of Custody
D. PM Sample Matrix
E. Project Information Sheet

Appendix A

Motorcycle List and Testing Summary

Table 1 Motorcycles List

MC#	Brand	Models	Model Year
1	Redacted	Redacted	2018-Current
2	Redacted	Redacted	2017-Current
3	Redacted	Redacted	2018-Current
4	Redacted	Redacted	2020

* The EU 5 compliant motorcycle has not yet been identified as it is expected to be on the market in late 2019.

Table 2 of this appendix lists the specific tests and total number of tests that each motorcycle must be run through.

Table 2. Test Matrix Summary

MC#	Tests				
	TYPE I (WMTC)			FTP	Total
	LEV III	Indolene	E5	Indolene	
1	3	3	3	3	12
2	3	3	3	3	12
3	3	3	3	3	12
4	3	3	3	3	12
Total	**12**	**12**	**12**	**12**	48

Appendix B

Motorcycle Description Sheet

Highway Motorcycle and Off-Road Recreational Vehicle Description

Project: ☐☐☐☐☐☐☐☐ **Vehicle No.** ☐☐☐ **VIN :** ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐
Model Year: ☐☐ **Engine Family:** ☐☐☐☐☐☐☐☐☐☐☐☐
Manufacturer: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐ **Evap. Family:** ☐☐☐☐☐☐☐☐☐☐☐☐
Division: ☐ **Model Code:** ____________
Model : ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Fuel Tanks
Size (gal) : ☐☐.☐☐ ☐ Aux. Tank
50% Cap. (gal): ☐☐.☐☐

Veh. Class: ________
MC1A = HMC Class I-A <50 cc
MC1B = HMC Class I-B 50 cc - 169 cc
MC2 = HMC Class II 170 cc - 279 cc
MC3 = HMC Class III 280 cc and over
OFMC = Off-Road Motorcycle
ATV = All Terrain Vehicle
OFUV = Off-Road Utility Vehicle
OFSV = Off-Road Sport Vehicle
SC = Sand Car

Equivalent Inertia Mass (kg): ☐☐☐☐
Road Load Force (N): ☐☐☐☐.☐
Dyno.Coeff's (SI units): A ____________ B ____________ C _
Drive Wheels : __________
1F = One Wheel Drive, Front
2F = Two Wheel Drive, Front
2R = Two Wheel Drive, Rear
1R = One Wheel Drive, Rear
4M = Four Wheel Drive, Mandatory
4O = Four Wheel Drive, Optional

Received date : ____/____/________
License Number : ☐☐☐☐☐☐☐
Country : ☐☐☐☐☐☐☐☐☐
State : __________
Source Project : ________________
Gross Veh. Wt. (kg) : ☐☐☐☐☐
Tire Size : ______________ **Drive Tire Pressure (Psi):** ______
Miles / Hrs ☐☐☐☐☐☐ ___MI ___KM ___NA
Project Engineer : ________________________
Zip Code : ☐☐☐☐☐

Codes

Thermodynamic Cycle: ________
B = Spark Ignited, 4 Stroke
C = Spark Ignited, 2 Stroke
D = Comp Ignited, 4 Stroke
E = Comp. Ignited, 2 Stroke
F = Sterling
G = Spark ignited, 5 Stroke
H = Other

Specifications

Num. Cylinders : ☐☐
Num. Caburetors : ☐
Barrels/Carb. : ☐
Eng. Disp. Vol. (cc) : ☐☐☐☐
Rated Power (kW) ________
Rated Speed (rpm) ________
Peak Torque (N-m) ________
Peak Torque Speed (rpm) ______

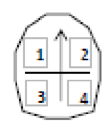
EGR System : ___Yes ___No
Engine Cooling: Air Cooled _____ Water Cooled _____

O2 Sensor Code : ________
N = No O2S
1 = Oxygen Sensor
2 = Dual O2S
3 = Heated O2S
4 = Heated O2S (two)
5 = Heated O2S (three)
6 = Dual Heated O2S
7 = Heated O2S, O2S
8 = Air-Fuel Ratio Sensor
9 = Heated AFS
D = Dual Heated AFS
E = OTHER

Turbo Type : _____ N = None S = Supercharger T = Turbocharger
Air Inject Type : _____ N = Neither A = Air Injection Pump P = Pulse Air

Pre-Catalyst Type : __________
N = Neither Cat. Nor Thermal Reactor
1 = Oxidation Catalytic Converter
2 = OC (two)
3 = Dual OC
4 = Dual OC (two)
5 = Warm-Up OC
6 = Dual Warm-Up OC
7 = Three-Way Catalytic Converter

Main-Catalyst Type : _________
8 = TWC (two)
9 = Dual TWC
W = Dual TWC (two)
X = TWC Plus OC
Y = Warm-Up TWC
Z = OTHER



Engine Configuration : _____
L = In Line H = Horizontally opposed R = Rotary C = Single Cylinder
V = V Type S = Stratified Charge T = Transverse P = Other

Certification Code : _____
A = 50 States B = 49 States C = CA Only
D = Other

Evap. Canisters
Canister Type : _____
1 = No Canister on Vehicle
2 = Canister Inaccessible
3 = Closed Bottom Canister
4 = Open Bottom Canister

Canister Location : ____
N = Not Applicable
1 = Vehicle Quadrant Location
2 = Vehicle Quadrant Location
3 = Vehicle Quadrant Location
4 = Vehicle Quadrant Location
M = Multiple Locations

Transmission Type : ______
A = Automatic
A2 = Auto, 2Sp
A3 = Auto, 3Sp
A4 = Auto, 4Sp
A5 = Auto, 5Sp
M = Manual
M3 = Manual, 3Sp
M4 = Manual, 4Sp
M5 = Manual, 5Sp
M6 = Manual, 6Sp
M8 = Manual, 8Sp
AV = Auto, Variable Sp
C4 = Creeper, 4Sp
L3 = Lock Up Auto, 3Sp
L4 = Lock Up Auto, 4Sp
L5 = Lock Up Auto, 5Sp
SM = Semi-manual
SA = Semi-Auto
S2 = Semi-Auto, 2Sp
S3 = Semi-Auto, 3Sp
S4 = Semi-Auto, 4Sp
S5 = Semi-Auto, 5Sp
NA = N/A or Unidentified
OT = Other

Comments
____
____
____
____
____

Extra parts? Yes No
ABS: Yes No
Stability Control: Yes No
Traction Control: Yes No

Fuel Injection Type :
1 = None
4 = Sequential MFI
7 = Direct Diesel Injection
2 = Throttle Body Fuel Injection
5 = Direct Gasoline Injection
3 = Multi-port Fuel Injection
6 = Indirect Diesel Injection

Exhaust: **Single** **Dual**

OBD Type : ________
A = No OBD B = Yes, Non-mandated C = Yes OBD I D = Yes, OBD II

Multi-Fuel Capability : ________
S = Dedicated B = Bi-Fuel F = Flexible Fuel K = Dual X = Hybrid Electric

Date : Check out ______________
Mi/Hrs Check out ______________

ARB Signature: Check-in ____________ **ARB Signature:** Check-Out ____________

Driver Signature: Check-in ____________ **Driver Signature:** Check-Out ____________

Appendix C

Chain of Custody

Project Engineer: Jason McPhee   Backups: Shishan Hu

Test Engineer: Tuyen Dinh   Backup: Thomas Desimone

Persons performing task shall sign, date, and fill-in time when task is completed.

Certification Exhaust Test (WMTC, LEV III Fuel)				
Motorcycle #:				
	Initial	**Date**	**Completed Time**	**Odometer**
Weekly 3-filter (EC1) Tunnel Blank				
Accumulate miles to 621 mi if necessary using commercial fuel				
Drain and re-fill tank with CARB LEV III fuel to 50% capacity				
Adjust Tire Pressure to Mfr.'s ± 2.2 psi				
Record driver mass Target is 75 ± 5 kg (165 ± 11 lb).				
Perform one WMTC cycle as preconditioning				
Drain and re-fill tank with CARB LEV III fuel to 50% capacity				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test 1				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test 2				
Add 1 gallon CARB LEV III fuel				

Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test 3				
Repeat WMTC Test if Necessary (3 valid tests)				
Perform one WMTC cycle as preconditioning (Skip this if a WMTC test is conducted on the same day)				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test (makeup)				

Chain of Custody

Engineer: Jason McPhee **Backups: Shishan Hu**

Test Engineer: Tuyen Dinh **Backup: Thomas Desimone**

<u>Persons performing task shall sign, date, and fill-in time when task is completed.</u>

Certification Exhaust Test (WMTC, E5 Fuel)				
Motorcycle #:				
Drain and re-fill tank with E5 fuel to 50% capacity				
Adjust Tire Pressure to Mfr.'s ± 2.2 psi				
Record driver mass Target is 75 ± 5 kg (165 ± 11 lb).				
Perform one WMTC cycle as preconditioning				
Drain and re-fill tank with E5 fuel to 50% capacity				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test 1				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test 2				
Add 1 gallon E5 fuel				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test 3				

Repeat WMTC Test if Necessary (3 valid tests)				
Perform one WMTC cycle as preconditioning (Skip this if a WMTC test is conducted on the same day)				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test (makeup)				

Chain of Custody

Project Engineer: Jason McPhee   Backups: Shishan Hu

Test Engineer: Tuyen Dinh   Backup: Thomas Desimone

<u>Persons performing task shall sign, date, and fill-in time when task is completed.</u>

Certification Exhaust Test (WMTC, Indolene Fuel)				
Motorcycle #:				
Weekly 3-filter (EC1) Tunnel Blank				
Drain and re-fill tank with Indolene fuel to 50% capacity				
Adjust Tire Pressure to Mfr.'s ± 2.2 psi				
Record driver mass Target is 75 ± 5 kg (165 ± 11 lb).				
Perform one WMTC cycle as preconditioning				
Drain and re-fill tank with Indolene fuel to 50% capacity				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test 1				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test 2				
Add 1 gallon Indolene fuel				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test 3				

Repeat WMTC Test if Necessary (3 valid tests)				
Perform one WMTC cycle as preconditioning (Skip this if a WMTC test is conducted on the same day)				
Cold Soak 68°F to 86°F for 12-36 hours				
Conduct WMTC test (makeup)				

Chain of Custody

Project Engineer: Jason McPhee   Backups: Shishan Hu

Test Engineer: Tuyen Dinh   Backup: Thomas Desimone

<u>Persons performing task shall sign, date, and fill-in time when task is completed.</u>

Certification Exhaust Test (FTP, Indolene Fuel)				
Motorcycle #:				
Weekly 3-filter (EC1) Tunnel Blank				
Adjust Tire Pressure to Mfr.'s ± 2.2 psi				
Drain and re-fill tank with Indolene fuel to 50% capacity				
Record driver mass Target is 80 ± 10 kg (176 ± 22 lb).				
Perform one UDDS cycle as preconditioning (J-prep)				
Cold Soak 68°F to 86°F 12-36 hours				
Conduct EC1B test 1				
Cold Soak 68°F to 86°F (6-36 hours for MC1 8-36 hours for MC2 12-36 hours for MC3)				
Conduct EC1B test 2				
Add 1 gallon Indolene fuel				
Cold Soak 68°F to 86°F 12-36 hours				
Conduct EC1B test 3				
Repeat EC1B Test if Necessary (3 valid tests)				
Cold Soak 68°F to 86°F 12-36 hours				
Conduct EC1B test (makeup)				

Appendix D

PM Sample Matrix

Weekly Estimate		PM Sample (Teflon Filter)
Monday	Tunnel Blank (weekly)	3
Tuesday	Motorcycle 1 (FTP or WMTC)	3
	Motorcycle 2 (FTP or WMTC)	3
Wednesday	Motorcycle 1 (FTP or WMTC)	3
	Motorcycle 2 (FTP or WMTC)	3
Thursday	Motorcycle 1 (FTP or WMTC)	3
	Motorcycle 2 (FTP or WMTC)	3
Friday	Motorcycle 3 (FTP or WMTC)	3
	Motorcycle 4 (FTP or WMTC)	3
	Trip Blank (monthly)	1
	(Makeup Tests)	(6)
	Total =	**34**

Note:

(1) It is planned to conduct two cold start tests for two motorcycles per day. If more motorcycles are available to be tested at the same week, test engineer will coordinate with AAMES for filter preparing.

Appendix E

Project Information Sheet

PROJECT INFORMATION FORM	
INITIAL PROJECT INFORMATION (must be filled out when project ID is issued)	
PROJECT ID: **(No more than 8 characters)**	(to be assigned by LTSS)
PROJECT ABSTRACT: **(Short paragraph describing the objective of this project)**	To draw exhaust emissions comparisons between EU and CARB motorcycle certification test procedures and quantify certification fuel type impact on motorcycle emissions.
Project Engineer:	Jason McPhee
Test Engineer:	Tuyen Dinh
Project Estimated Start Date:	29-Jul-19
Project Estimated End Date:	6-Mar-20
Estimated Number of Vehicles at End of Project:	4
Primary Test Cell Used for Testing:	3
Estimated Total # of Tests for Project:	48
Estimated # of Tests per Vehicle:	12
Is Final Report Planned: (Y/N):	Y
Estimated Test Time per Vehicle (days):	16
More than one manufacturer? Y/N	Y
Type of Testing	☐ Engine ☐ Vehicle ☑ Motorcycle ☐ Other : ____________
Type of Project	☑ Research ☐ Surveillance ☐ Crosscheck ☐ Screening ☐ Title 13 ☐ Confirmatory ☐ Compliance/In-Use ☐ After Market Part Evaluation ☐ Other: ____________

Appendix 2

Test Plan Amendment 1

TEST PLAN AMENDMENT SUMMARY

On-Road Motorcycle Regulatory Development Testing

Project No. 2R1904 – Amendment #1

Prepared by the

Engineering and Regulatory Development Section

September 4th, 2019

This is the first amendment to Project No. 2R1904. The test plan section changes were made in Exhaust Testing Procedure. The purpose of this amendment is to add canister loading during motorcycle soaking to reduce emission testing variance.

In the section EXHAUST TESTING PROCEDURE, under Motorcycle Preparation and Preconditioning for FTP (EC1B), add:

7. "During soaking, load the motorcycle's canister at 15 grams of butane per hour until 2 grams breakthrough is achieved".

In the section EXHAUST TESTING PROCEDURE, under Motorcycle Preparation and Preconditioning for Type I Test (WMTC): add:

13. "During soaking, load the motorcycle's canister at 15 grams of 50% butane per hour until 2 grams breakthrough is achieved".