

California Environmental Protection Agency

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**TEST PLAN FOR EVALUATION OF EVAPORATIVE AND EXHAUST  
EMISSIONS AND CONTROL TECHNOLOGY FOR OFF-HIGHWAY  
RECREATIONAL VEHICLES (OHRV)**

**Engineering Development and Testing Section  
Stationary Source Testing Branch  
Monitoring and Laboratory Division**

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# **Draft – TEST PLAN FOR EVALUATION OF EVAPORATIVE AND EXHAUST EMISSIONS CONTROL TECHNOLOGY FOR OFF-HIGHWAY RECREATIONAL VEHICLES (OHRVs)**

## **I. Background**

Evaporative emissions from OHRVs are a major source of hydrocarbon emissions in California. OHRVs include off-road motorcycles, all terrain vehicles (ATVs), snowmobiles, and other specialty vehicles. Evaporative emissions from these categories can be broken down into three distinct sources:

- Permeation emissions through the fuel tank and fuel hose
- Vented emissions from the fuel tank
- Emissions from the carburetor and leaking connections

In 2002 the U.S. EPA adopted an OHRV permeation standard that is set to be implemented in 2008. The reductions from the U.S. EPA regulation are limited because the regulation only controls a predicted 30 percent of diurnal emissions and has almost no effect on running loss emissions. The ARB is developing a rule that will control vented, carburetor, and running loss emissions as well as further control permeation emissions. Initial estimates predict that this ARB regulation can be up to 80 percent effective.

The current emissions inventory does not reflect actual emissions in California. ARB will re-evaluate the emissions factors, OHRVs usage, and OHRVs population to account for this discrepancy.

## **II. Plan Overview**

### **Inventory Development**

The current ARB emissions inventory is based on an old vehicle population and outdated emissions factors. The emissions inventory is calculated by combining usage, population, and emissions factors. The first step in developing a new emissions inventory is to develop new usage data for off-road motor cycles, ATVs, and snowmobiles. Usage data includes where, when, and how vehicles are being used and stored. ARB will develop new emissions factors by testing in-use and new OHRVs. A new population has already been developed.

### **Control Technology Testing**

To determine the efficiency of evaporative emissions controls, OHRVs will be progressively retrofitted and tested with emissions control technology. Emission factors that are generated with the retrofitted technology will be used to predict reductions. An important part of the emissions control technology evaluation is a safety and feasibility study. The OHRVs that are retrofitted with emissions control technology will be evaluated in an in-use safety and feasibility study.

### **Exhaust Emissions study**

Exhaust emissions will be measured to quantify potential advantages of improved fuel management systems. ARB is quantifying exhaust emissions reductions because high efficiency catalytic converters can easily be added to fuel injected OHRVs. Exhaust emissions will be measured from unmodified vehicles and then again from OHRVs with fuel injection and high efficiency catalysts. The feasibility and safety study will include evaluation of the exhaust emissions control technology.

## **III. Test Plan**

### ***Activity and Usage***

#### **Operation**

To determine OHRVs usage, information from available studies will be used. ARB will generate any additional data that is needed for the OHRV program. If required OHRVs usage data is required it will be generated by equipping representative in-use OHRVs with data loggers. The data loggers will record the number of times the OHRVs starts and stops, and the total hours of operated in a given period of time.

#### **Storage**

How OHRVs are stored has a large effect on evaporative emissions. If sufficient data is not available end users will be surveyed to determine:

- How long OHRVs are stored
- How OHRVs are prepared for storage
- Where OHRVs are stored
- What the fuel level is during storage
- What type of fuel is used in OHRVs
- On average how many times per riding day their off highway motorcycle is tipped over

#### **OHRVs Design**

OHRVs tested as in-use will represent popular models sold in a specific age group. Variations in design that will affect evaporative emissions will be considered.

## ***Inventory Development***

### **Preliminary Equipment testing**

Background, vented, and permeation emissions will be evaluated for both the Honda 450X dirt bike and the Polaris Sportsman 500 ATV. Diurnal emissions will be measured over a 65°F-105°F temperature profile using California Phase III RFG pump fuel unless specified otherwise. Background emissions will be measured on an OHRV as it is received from the dealer (without fuel in the fuel system). Vented emissions will be measured with the fuel tank half full but without allowing gas into the carburetor. Permeation emissions will be measured by allowing the fuel to soak in the fuel tank and lines for 30 days and re-tested. By evaluating each mode of evaporative emissions consecutively ARB will know where emissions are coming from.

### **Baseline Emissions**

Baseline emissions will include measuring the diurnal, hot soak, running loss, exhaust, and carburetor spillage emissions for in-use and new OHRVs. See Appendix A for a complete list of vehicles that will be used for inventory development and Appendix D for diurnal temperature profiles. The emissions data will be used to help develop the emissions inventory as well as serve as a baseline value for OHRVs control technology evaluation.

### **Carburetor Spillage Emissions for Off Highway Motorcycles**

At extreme angles such as when an Off Highway Motorcycle (OHMC) is tipped over, the carburetor can leak. Leaks from the carburetor do not fall into any of the existing emissions categories; therefore this will be considered a new source of emissions. The emissions inventory for this category will be calculated by multiplying the following values:

Mass of emissions per tip X tips per trip X trips per year X population

ARB will quantify the emissions factors using the following procedure.

- The OHMC will be tilted until the carburetor begins to leak, this angle will be recorded.
- The vent lines from the carburetor will be connected to a reservoir.
- The carburetor spillage emissions from setting the OHMC on each side will be evaluated separately.
- The OHMC will be set on its side for 60 +/-10 seconds and then lifted backup.
- The actual time the OHMC is tipped past the angle where spillage begins will be recorded.
- The hydrocarbon emissions will be measured as weight gain from the reservoir.

### ***Predictive Model Testing***

An ethanol fuel study will be conducted to determine the effect of ethanol on evaporative emissions. For a complete list of tests and equipment included in the ethanol fuel study see Appendix B.

## ***Control Technology Testing***

Only one piece of equipment from each category will be tested with control technology because of the cost and complexity of retrofitting and testing. Of the new OHRVs the Honda CRF 450X off road motorcycle, the Polaris Sportsman 500 ATVs, and a snowmobile (still to be determined) will be evaluated with control technologies. See Appendix C table 8 for a list of testing to be conducted for control technology evaluation. Snowmobiles are not operated during ozone non-attainment days; therefore, snowmobiles will not be evaluated with running loss control technology (e.g. fuel injection, passively purged carbon canisters, or catalytic converters).

Each type of control technology will be tested by progressively adding more control technology, and quantifying the emissions reductions as the technology is added.

Technology will be added in the following order:

1. Low permeation fuel tank and fuel line
2. Passively purged carbon canister
3. Fuel injection and an actively purged carbon canister – off-road motorcycle and ATVs only
4. Catalytic converter – off-road motorcycle and ATVs only

The evaporative emissions data generated will be used to help develop an inventory as well as to set evaporative standards for the current regulatory initiative. The exhaust emissions data will be used to support a separate exhaust emissions rulemaking at an undetermined time.

## **Engine Loading for Running Loss Emissions**

OHRV running loss tests will be performed using a load profile based on the load profile used for exhaust testing. Both ATVs and Off road motorcycles will be tested based on the Urban Dynamometer Driving Schedule found in 40 CFR part 86, Appendix I.

## ***In-use Durability Testing***

An in-use durability study will be conducted on the off road motorcycle and ATV after all the emissions control technology has been implemented and tested. The durability testing will help define customer acceptance, real world durability, and ride ability. OHRVs durability will be evaluated over 100 hours of operation. The first 70 hours of operation will be conducted on a dynamometer. During the last 30 hours of durability testing the OHRVs will be operated in the field. During the dynamometer and field durability testing, control technology safety will be evaluated.

## ***Safety Study***

During the safety evaluation, industry representatives from Consumer Products Safety Commissions (CPSC) (pending), California State Fire Marshal, and

American Motorcycle Association (AMA) will evaluate the safety of the OHRVs as a whole and specifically the catalytic converter and the carbon canister. The following is a list of safety concerns and how they will be evaluated:

*Issue:* Exhaust gas and component temperature increases from catalytic converters.

*Evaluation:* Exhaust gas and component temperatures will be measured while the OHRVs is on the dynamometer before and after the OHRVs is retrofitted.

*Issue:* Exothermic reaction during carbon canister loading.

*Evaluation:* Virgin carbon will be loaded at the fastest reasonable loading rate while the internal temperature is monitored.

*Benefit:* Reduction of hydrocarbons being emitted into confined spaces.

*Evaluation:* During SHED testing the reduction of hydrocarbons being released into a confined space during storage will be quantified.

These laboratory tests should quantify the safety concerns. To evaluate the safety of OHRVs in a real world setting industry representatives will be invited to evaluate the OHRVs in the field during the 30 hour field testing. Industry representatives will have access to the laboratory safety results.

### ***Quality Assurance/Quality Control***

Testing will be conducted in compliance with the procedures documented in Chapter 40, Part 86, Section 86.107-90 and 96 of the Code of Federal Regulations, and the California Evaporative Emission Standards and Test Procedures for 1978-2000 Model Motor Vehicles. The engineer conducting the testing will validate quality assurance/quality control data for background, recovery and retention checks to ensure that it meets the requirements of 40 CFR Part 86. In addition all fuels used for testing will be evaluated by ARB's Southern Laboratory Branch to ensure they meet CAR and SAE specifications.

SHED temperature data is collected on a minute by minute basis. The engineer conducting the testing will watch the temperature in order to identify temperature data that is operating outside of the given parameters. This temperature data will be flagged by the engineer. The engineer must then determine if the flagged data should be accepted or rejected.

**Grand Total Number of Tests in this Test Plan: 95 +18 =113**

## Appendix A – Inventory Testing

All inventory tests will be conducted with California Summertime Pump Fuel (RFG 3).

**Table 1**

### ATVs Inventory testing

All Terrain Vehicles (ATVs)		Baseline and Inventory Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New ATVs 1	0-15	1	x	x	x	
New ATVs 2	15-25	1	x	x	x	x
Polaris Sportsman 500	25-50	See Table 6	See Table 6	See Table 6	See Table 6	See Table 6
Used ATVs 1	0-15	1	X	x	x	
Used ATVs 2		1	X	x	x	
Used ATVs 3	15-25	1	X	x	x	
Used ATVs 4		2	X	x	x	
Used ATVs 5	25-50	1	X	x	x	
Used ATVs 6		1	X	x	x	

Number of tests: 9

**Table 2**

**Off Highway Motorcycle Inventory Emissions Testing**

Off Highway Motor Cycle (OHMC)		Baseline and Inventory Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New OHMC 1	0-15	1	X	x	x	
New OHMC 2	15-25	1	X	x	x	
New OHMC 3	25-50	1	X	x	x	x
Honda CRF 450X	50-120	See Table 6	See Table 6	See Table 6	See Table 6	See Table 6
Used OHMC 1	0-15	1	X	x	x	
Used OHMC 2		1	X	x	x	
Used OHMC 3	15-25	1	X	x	x	
Used OHMC 4		2	X	x	x	
Used OHMC 5	25-50	1	X	x	x	
Used OHMC 6		1	X	x	x	
Used OHMC 7	50-120	1	X	x	x	
Used OHMC 8		1	X	x	x	

Number of tests: 12

**Table 3**

**Snowmobile Emissions Inventory Testing**

Snowmobiles		Baseline and Inventory Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New Snowmobile #1	NA	1	X	x	X	
New Snowmobile #2	NA	1	X	x	X	

Number of Tests: 2

**Table 4**

**Deterioration Rate Emissions Testing – Inventory**

Deterioration Rate		Deterioration rate Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New ATVs 2 after 1 year	15-25	1	X	x	X	x
New OHMC 3 after 1 year	25-50	1	X	x	X	x

Number of tests: 2

## Appendix B – Ethanol Testing for the Predictive Model

**Table 5 Ethanol Testing for Predictive Model - Off Highway Motor Cycles**

Off Highway Motor Cycles				Ethanol Testing for Predictive Model		
Equipment	HP Range	Temp Profile	Ethanol content	Fuel	Hot soak + Diurnal	Running Loss
New Yamaha 250 Dirt Bike	15-25	65-105 summer	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1
Used Off Highway Motor Cycle	25-50	65-105 summer	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1
		47-66 winter	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1

Number of tests: 9

**Table 6 Ethanol Testing for Predictive Model - ATVs**

ATVs				Ethanol Testing for Predictive Model		
Equipment	HP Range	Temp Profile	Ethanol content	Fuel	Hot soak + Diurnal	Running Loss
Honda ATV	15-25	65-105 summer	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1
Used ATV	15-25	65-105 summer	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1
		47-66 winter	E0	California Phase II Cert.	1	1
			E6	California Summertime Pump Fuel	1	1
			E10	CE10	1	1

Number of tests: 9

# Appendix C – Emissions Control Technology Testing

Table 7

## Snowmobile Emissions control Technology Emissions Testing Matrix

	Number of Tests	Diurnal and Hot Soak With Low Permeation Fuel Hose And Tank	Hot Soak and Diurnal With A Passively Purged Carbon Canister
Snowmobile Model X	3	X	X

Number of Tests 6

**Table 8 Testing with the Honda 450X dirt bike and Polaris Sportsman 500 ATV**

			Test Type			
Fuel Used		Configuration (all fuel levels at 1/2 full)	Running loss	Hot soak	Diurnal	Exhaust
Background Emissions	No Fuel	No fuel, new tank and lines			1	
	CE 10	no fuel in carb.			1	
		no soak			1	
Varying temp/fuel emissions testing	CE10	soaked 30 days, Annual average temp		1	1	
		Refill, Summertime 65-105	3	3	3	
		Refill, Wintertime temp		1	1	
	PH II cert	soaked 30 days, Annual average temp		1	1	
		Refill, Summertime 65-105	1	1	1	3
		Refill, wintertime temp		1	1	
	Summertime pump fuel  Wintertime Pump Fuel (ATV)	soaked 30 days, Annual average temp		1	1	
		Refill, Summertime 65-105	1	1	1	1
		Refill, wintertime temp		1	1	
		Soak 30 Days, wintertime temp		1	1	
Control Technology testing	CE 10	Low Perm Fuel line/tank, soaked 140 days, summertime 65-105	3	3	3	
		Refill, Low Perm Fuel line/tank + passive CC, summertime 65-105	3	3	3	
		Refill, Low Perm Fuel line/tank + Active CC+ FI, summertime 65-105	3	3	3	
Varying temp/fuel control technology testing	CE 10	Refill, All Perm Control, Annual average temp		1	1	
		Refill, all perm control wintertime temp		1	1	
	PH II cert	soaked 30 days, all perm control, Annual average temp		1	1	
		Refill, All Perm control, Summertime 65-105	1	1	1	3
		Refill, All Perm control, Wintertime temp		1	1	
	Summertime pump fuel	all perm control, soaked 30 days, Annual average temp		1	1	
		Refill, all perm control Summertime 65-105	1	1	1	
	Wintertime pump fuel (ATV)	all perm control, soaked 30 days, Wintertime temp		1	1	

Number of Tests: 39 (32 evap. (each for the MC and ATV (70 total) and 4 additional Exhaust)

# Appendix D

**Table 9**  
**Test Temperature Profiles**

<u>Hour</u>	65-105	Off-road	<u>Annual</u>
	<u>Temp</u>	<u>Winter</u>	<u>Average</u>
		<u>Temp</u>	<u>Temp</u>
0	65	47.1	55.3
1	66.6	46.2	54.6
2	72.6	45.6	54
3	80.3	45.2	53.6
4	86.1	44.7	53.2
5	90.6	44.4	53.2
6	94.6	44.1	54.3
7	98.1	44.8	56.8
8	101.2	48.3	60.4
9	103.4	53.5	63.8
10	104.9	58.0	66.5
11	105	61.5	68.6
12	104.2	63.8	70
13	101.1	65.2	70.8
14	95.3	65.8	71.1
15	88.8	65.2	70.6
16	84.4	63.0	68.9
17	80.8	59.3	66.2
18	77.8	55.7	63.2
19	75.3	53.2	60.7
20	72	51.5	59
21	70	50.2	57.8
22	68.2	49.0	56.8
23	66.5	48.4	56

## Appendix E

### Test Procedure: Running Loss/Exhaust, Hot Soak, and Diurnal

#### Preconditioning

- Fill fuel system with fuel.
- Operate OHRVs at an idle for 15 minutes.
- OHRVs equipped with low permeation fuel system components will be pre-soaked with fuel in the fuel system for 20 weeks at 30° +/- 10°C\*
- OHRVs *not* equipped with low permeation fuel system components will be pre-soaked with fuel in the fuel system for 4 weeks at 30° +/- 10°C\*
- After initial soak and for in-use OHRVs the fuel system will be soaked for 4 weeks at 30° +/- 10°C

#### Testing

##### ***Running Loss/Exhaust Emissions***

- Drain the fuel system and fill the fuel tank to 50% with CE10 (phase 2 cert.)
- Start and idle the OHRVs for at least 15 minutes
- Place the OHRVs on the dynamometer in a SHED preheated to 95°F and connect plumbing to allow ambient air directly into the engine and exhaust gasses to exit the SHED
- Allow the OHRVs to acclimate in the SHED at 95°F for at least 6 hours\*
- Operate the OHRV on a load profile based on the “off-road driving cycle” while measuring the emissions from the exhaust and HC from the shed once a minute
  - NOTE: Exhaust testing may not be possible in the running loss shed, if not exhaust testing will be conducted separately between 68°-86°F

##### ***Hot Soak/Diurnal Option 1 (continuous testing)***

- Turn off engine and immediately begin measuring hot soak HC emissions at 95°F for 90 minutes.
- Measure HC emissions in the SHED every minute
- Cool chamber to 65°F and allow the equipment to acclimate for at least 6 hours
- Begin 65° to 105° to 65°F 24 hour diurnal test
- Record HC results for the entire profile

##### ***Hot Soak/Diurnal Option 2 (non-continuous testing)***

- ***Remove the OHRVs from the running loss SHED***
- Refill fuel tank to 50%
- If continuous testing is not possible equipment loading will be conducted outside the SHED and the equipment will be placed in the SHED not more than 7 minutes after finishing the dynamometer loading. After the equipment is shut off the test must begin within 2 minutes.
- ***Move the OHRVs into a variable temperature SHED set to 65°F***
- Allow the OHRVs to acclimate for at least 6 hours
- Begin 65° to 105° to 65°F 24 hour diurnal.
- Record HC results for the entire profile

\*These times may be re-evaluated after preliminary testing.