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DEVELOPMENT OF SPECIFICATIONS FOR A MOTORCYCLE DYNAMOMETER AND MOTORCYCLE COOLING SYSTEM: VOLUME II- SPECIFICATIONS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

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by

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PREFACE

This volume contains the specifications for a motorcycle dynamometer system designed to meet the objectives and criteria set forth by the United States Environmental Protection Agency (EPA) in their Contract Number 68-03-2141 and Notice of Proposed Rulemaking dated October 22, 1975. This system will be utilized for research, emission certification and fuel economy applications.

The specifications are divided into three categories: performance, design, and procurement. The design specifications elaborate on the performance specifications including aspects necessary for interfacing with existing EPA equipment at the Mobile Vehicle Emissions Laboratory in Ann Arbor, Michigan. The procurement specifications describe requirements for product assurance, warranty, maintenance, and acceptance. The specifications do not require the incorporation of any components for which there is only a single manufacturer or distributor. Rather, they have been designed to enable dynamometers to be built by various manufacturers around the world while ensuring that the systems provide equivalent performances.

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Section 1

INTRODUCTION

This specification defines and establishes the required configuration, performance, and design characteristics for a motorcycle dynamometer and cooling system to be used during the measurement of exhaust emissions as specified in the Environmental Protection Agency's (EPA) Notice of Proposed Rulemaking (NPRM) dated October 22, 1975. The specified equipment is intended for use by the EPA for the purpose of conducting exhaust emissions certification tests and fuel economy tests. The equipment is used to provide an accurate in-place simulation of road operating loads and air-cooling velocities to enable measurement of exhaust pollutant emissions and fuel economy from motorcycles.

1.1 GENERAL DESCRIPTION

The pending regulations to control the exhaust emissions levels of carbon monoxide, hydrocarbons and oxides of nitrogen from new model motorcycles presents the need for the development of a dynamometer that will simulate typical dynamic road-load and environmental conditions for motorcycles. The regulations include all motorcycles of engine displacement of 50 cc or greater which are manufactured for operation on public streets and highways.

The problems of testing motorcycles are similar to those problems previously experienced with testing passenger vehicles. Since the motorcycles will have no forward velocity during indoor testing, the test device must provide a simulated dynamic road bed and proportional cooling for the test vehicle. The test device must accurately simulate all conditions normally encountered, such as vehicle frictional loss, vehicle rider mass, tire rolling resistance and wind resistance. These can be simulated indoors by roller-type dynamometers with the appropriate speed/power characteristics. If the vehicle's normal operating temperatures are substantially duplicated, the drive train and other parasitic losses for each individual vehicle will be inherently the same, both on the road and on the simulated test bed. An additional factor that affects indoor simulation of actual vehicle loading conditions is tire roll losses. These must be quantified and corrected for if accurate simulation is to be achieved.

Any dynamometer has an intrinsic power absorption as a result of frictional and aerodynamo losses in the system. These dynamometer losses must be ascertained and accounted for when establishing a calibration load curve, and these must be kept to a minimum because of the inherently small road loads produced by motorcycles with small displacement engines. Should these losses be of a significant magnitude, their power/speed characteristics would alter the vehicle loading to an undesirable degree, particularly during low-powered vehicle testing; These losses cannot vary with time; otherwise corrective compensation would be difficult.

The equivalent inertial mass of the motorcycle and rider also require simulation. The simulation must be controllable in small increments to provide accurate dynamic performance of the dynamometer.

If the motorcycle dynamometer system is to simulate accurate road operations, it must possess a means of duplicating engine temperatures. This is an important requirement since the majority of motorcycle engines are cooled via heat transfer resulting from the movement of air past the engine. This condition can be duplicated during operation of a motorcycle on a dynamometer by moving cooling air past the engine at the same velocity as the motorcycle's rear wheel is moving on the dynamometer roll.

This document defines the specification of a motorcycle dynamometer which accurately simulates road operational conditions. This system has been designed to meet the specific needs of the Environmental Protection Agency's Motor Vehicles Emission Laboratory in Ann Arbor. Additionally, its performance characteristics and major design features should serve as a model for others who wish to duplicate the EPA system.

1.2 TERMINOLOGY

For the purposes of this specification, wherever any of the following words, terms, or abbreviations are used herein, they shall have the meaning ascribed to them by the following definitions:

1.2.1 Words and Terms

Motorcycle - Any motor vehicle designed to operate on not more than three wheels (including any tricycle arrangement) in contact with the ground which is not a passenger car or passenger-car derivative.

Outlet Duct - The housing connected to the outlet of the air-moving unit through which cooling air is directed toward the motorcycle.

Relative Humidity - The ratio of the quantity of water vapor present in the atmosphere to the quantity of water present in a saturated atmosphere at the existing temperature.

Road Load (RL) - The force which must be applied to move a vehicle over a level road at a constant speed.

Road Load Power (RLP) - The power which must be applied to move a vehicle over a level road at a constant speed.

Static Pressure Loss - Pressure differential associated with frictional and dynamic losses in ducting.

1.2.2 Abbreviations

Celsius. C
Degrees. . . . . .o
Fahrenheit . . . . .F
Hertz (cycles per second). . . . . .Hz
Hour . . . . .hr
Inches .in.
Kilograms. . . . . .kg
Kilometers . . . . .km
Kilometers per hour. . . . . .kph
Kilopascals. . . . . .kPa
Meter. .m
Miles per hour . . . . .mph
Milliamperes . . . . .ma
Millimeter . . . . .mm
Newtons. . . . . .nt
Newton-meter . . . . .nt-m
Phase. .Ø
Pounds per square inch . . . . .psi
Revolutions per minute . . . . .rpm
Second .sec
Volts alternating current. . . . . .VAC
Volts direct current . . . . .VDC
Water. . . . .H_2O

Section 2

PERFORMANCE REQUIREMENTS

This section of the specification defines the performance requirements of the dynamometer system. It has been divided into two subsections. The first details the performance characteristics of the dynamometer and inertia simulation system, and the second defines the performance specifications for the cooling system.

2.1 DYNAMOMETER

2.1.1 Functional Description

The motorcycle dynamometer specified herein is designed to permit the operation of a motorcycle within the confined spaces of a laboratory in a manner which simulates actual operating conditions. The dynamometer simulates all road conditions such as vehicle frictional loss, vehicle and rider inertia, tire rolling resistance, and aerodynamic resistance. Inertia simulation is achieved by utilizing a flywheel set, and road load conditions are duplicated by a power absorption unit (PAU) capable of adjustment to match the specific characteristics of the test vehicle.

2.1.2 Functional Speed Range

The motorcycle dynamometer shall be capable of simulating road load conditions for a motorcycle operating at speeds between 0 kph and 100 kph. The motorcycle will be operating on the dynamometer in both steady state and cyclic modes of operation. Typical driving cycles include the Federal Test Cycle, and the Highway Fuel Economy Cycle.

2.1.3 Functional Road Load Range and Accuracy

The road load (tractive force) characterisitics of a motorcycle can be described by an expression.

$$RL\ (nt) = F_0 + F_1 v + F_2 v^2 \qquad (2\text{-}1)$$

where "v" is the velocity of the motorcycle and F_0, F_1 and F_2 are characteristic constants. These constants are affected by the geometrical design and performance characteristics of the vehicle. Therefore, they can vary from one motorcycle model to another.

The control unit for the dynamometer power absorption unit (PAU) shall be designed to match the desired RL force of the test motorcycle as defined by equation 2-1 to within ±5 percent throughout the test speed range. The commands to the PAU shall have also been corrected to account for the inherent parasitic losses of the dynamometer assembly.

2.1.4 Functional Inertial Simulation Range and Accuracy

In order to duplicate road conditions during cyclic modes of operation, it is necessary to simulate equivalent vehicle mass. Flywheels which can be selectably engaged shall be used. A sufficient number of flywheels shall be provided to permit inertia simulation in the range between 100 kg and 700 kg in 10 kg increments. The accuracy of the simulation of equivalent mass shall be within ±1.5 kg of the required setting as defined in paragraph 85.478-15 of the NPRM.

2.1.5 Roller Characteristics

The roller assembly shall consist of a single, smooth, cylindrical roll having a diameter of 530.5 mm (20.9 inches).

2.1.6 Distance Measurement

The dynamometer roller shall be equipped with suitable instrumentation to determine the distance traveled by the rear tire of the motorcycle. The accuracy of this distance measurement shall be ±2m.

As a result of the requirements imposed by the test procedure, the distance measurement apparatus must be capable of displaying a previously measured distance while a second distance is being accumulated.

2.2 COOLING SYSTEM

2.2.1 Functional Requirements

The motorcycle dynamometer cooling system specified herein is designed to direct cooling air to the motorcycle operating on the dynamometer in a manner which simulates actual operating conditions. The simulation of road cooling conditions will result in motorcycle engine temperatures which duplicate those encountered during normal road operation. Cooling simulation shall be achieved by directing cooling past the motorcycle at a velocity equal to the simulated vehicle's velocity.

2.2.2 Functional Range

The motorcycle dynamometer cooling system shall be capable of simulating cooling conditions for a motorcycle operating up to 100 kph.

2.2.3 Functional Accuracy

The intent of the motorcycle cooling system is to maintain, during the dynamometer operation, motorcycle engine temperatures within the range of temperatures observed during similar road operations. In order to insure this, the linear air velocity of the cooling air, as measured at the center of the cooling air outlet duct, shall be within ±10 percent of the simulated motorcycle velocity when this speed is between 10 and 100 kph. For speeds less than 10 kph, the air speed shall be within ±1 kph of the simulated road speed. Additionally, the cooling air outlet flow shall be uniform to within ±20 percent across the outlet area, as measured at the center of the outlet duct, as compared to the center of each quarter area.

2.2.4 Outlet Duct Design

The exit of the outlet duct shall be positioned squarely in line with the motorcycle frame no further than 0.45m (1.48 feet) in front of the vehicle's front wheel. The cross-section of the exit shall have an outlet area of at least $0.5m^2$ ($5.4\ feet^2$). The exit cross-section shall be square or other geometric shape appropriate for cooling diverse motorcycles. The exit can be squarely positioned before the front wheel of the vehicle or can envelope the front wheel. The bottom of the duct exit shall be between 0.15m (0.49 feet) and 0.2m (0.66 feet) above floor level.

Section 3

DESIGN SPECIFICATIONS - DYNAMOMETER

In Section 2.1 the performance requirements which this system must satisfy have been detailed. In this section some of these performance requirements are expanded and design characteristics delineated. These specifications combine to describe the characteristics of a motorcycle dynamometer capable of simulating road load conditions for a motorcycle operating at speeds between 0 kph and 100 kph in both steady state and cyclic modes of operation. Typical driving cycles will include the Federal Test Cycle, and the Highway Fuel Economy Cycle.

The design specifications for the dynamometer have been divided into five sections; each section details the specification for a major subassembly of the dynamometer. These subassemblies are:

- Main Frame Assembly
- Roll Assembly
- Inertia Simulation Assembly
- Motorcycle Restraint Assembly
- Power Absorption Unit and Dynamometer Control Assembly
- Driver information display and driver controls.

3.1 MAIN FRAME ASSEMBLY

The main frame assembly which supports the roll, inertia simulation assembly and power absorption unit shall be designed to be installed in a pit. The main frame assembly shall be of sufficient rigidity such that four mounting points provide adequate support for the entire unit including a motorcycle having a mass of 700 kg.

3.2 ROLL ASSEMBLY

Type: Single Roller
Diameter: 530.5 mm (20.9 in)
Width: 300 mm (11.8 in) minimum
Material: low carbon steel
Surface: cylindrical (uncrowned)
Surface Texture: Smooth
Maximum Rotational Speed: 1500 rpm
Maximum Weight Resting on Roller: 350 kg

3.3 INERTIA SIMULATION ASSEMBLY

In order to duplicate road conditions during cyclic modes of operation, it is necessary to simulate equivalent vehicle mass. Flywheels which can be selectably engaged shall be used. A sufficient number of flywheels shall be provided to permit inertia simulation in the range between 100 kg and 700 kg in 10 kg increments.

The inertia simulation assembly will consist of the following components:

- Fixed flywheel simulating minimum vehicle weight

- Flywheels and engagement control system
- Drive components
- Protective covers

Inertia system specifications are delineated below.

Inertia Simulation Range: 100 kg to 700 kg equivalent vehicle mass in 10 kg increments

Inertia Simulation Accuracy: ±1.5 kg for the total simulated inertia

Maximum Acceleration/Deceleration Rate: 16 kph/sec (10 mph/sec)

Flywheel Construction: Symmetric, fully machined and dynamically balanced

Inertia assembly/Roller assembly coupling: Positive drive

Inertia Selection Method: Inertia shall be selected by activating a thumbwheel, rotary or pushbutton switch located on the dynamometer control panel, which in turn activates the inertia engagement system. A method of positively sensing proper flywheel engagement shall supply a signal which is compared to the inertia selector signal. A light on the dynamometer control panel shall indicate when the selected flywheels have engaged. An adjustable signal from each flywheel shall be supplied to the interface panel. Nominal values will be 18 VDC at 60 ma for an engaged flywheel, - 18 VDC at 15 ma for a disengaged flywheel

Flywheel and drive line bearings: Average bearing life shall be in excess of 50,000 hours

Safety Interlocks: System shall be failsafe in case of loss of electric power or air pressure. There shall also be an interlock to prevent the engagement or disengagement of flywheels during the operation of the dynamometer

Fixed Trim Flywheel: A flywheel if necessary shall be attached to the roller shaft. The inertia of this flywheel shall be such that the vehicle mass equivalence of the inertia of the basic dynamometer system is 100 kg.

3.4 MOTORCYCLE RESTRAINT ASSEMBLY

The restraint assembly is designed to position and hold the motorcycle on the dynamometer. It shall lock the motorcycle front wheel in place so that its rear axle is positioned directly above the roller axis. The restraint assembly shall be sized to accomodate two-wheeled motorcycles of all sizes and standard tire configurations without damage to the motorcycle.

Safety interlocks shall be provided to prevent the disengagement or engagement of the restraint while the dynamometer roller is in motion. Additionally when the restraint is in an unlocked position, the roller shall be locked in position. Actuators for the restraint shall be located alongside the restraint. This actuator shall be a foot-actuated switch located at least 10 cm (3.9 inches) above the floor.

The restraint and positioning assembly shall be designed so that not more than two technicians are required to position and restrain the motorcycle within a 5-minute period.

3.5 POWER ABSORPTION UNIT (PAU) AND DYNAMOMETER CONTROL UNIT

PAU type: Water-cooled eddy-current absorption unit or DC regenerative motor

Maximum absorption load at 1000 rpm: 14.7 kw (20 Hp)

Maximum rotational speed: 1500 rpm

Speed Measurement: Tachometer or tachometer generator; 50 m sec response time; 0-10 vdc output; ±0.5 km/hr accuracy.

Distance Measurement: Two independently actuated roller revolution counters shall be provided to determine distance traveled. Accuracy of distance measurement shall be ±2 m. Controls and readouts for distance measurement shall be mounted on the drivers control panel. Two signals from each counter shall be supplied to the interface panel. These signals shall be a square-wave digital of 0 to 30 VDC at 20 may not to exceed 100 Hz.

Torque Measurement: Strain gauge load cell or nonslip ring shaft torquemeter with appropriate signal conditioners; less than 50 m sec. response time excluding adjustable dampening; ±1 percent accuracy, ±0.3 percent repeatability

Load Curve. The PAU shall be able to simulate the motorcycle's tractive force curve which will be defined by the polynomial expression

$$R.L\ (nt.) = F_0 + F_1 v + F_2 v^2 \qquad (3\text{-}1)$$

Where:

F_1 and F_2 are each 4-digit constants; F_0 and F_2 are positive numbers and F_1 can be either positive or negative. V is roller surface velocity expressed as m/sec.

The three constants are set on 4-digit thumbwheel or pushbutton switches located on the dynamometer control panel.

Accuracy of road-load simulations shall be ±5 percent at all load conditions. The accuracy constraint shall apply to the total simulated road load and shall include any calibration techniques or systems to treat parasitic losses in the PAU, roller assembly, or inertia system.

Two types of parasitic loss compensation systems are feasible. In the first system, the dynamometer controller could be adjusted by a calibration system or by a memory device to compensate automatically for the parasitic losses. With this system the operator-inputed constants reflect the desired road load. In the second, but less desirable approach, the parasitic losses, which have been previously determined, are expressed as function of speed in a form similar to equation 3-1. The constants inputed into the road-load simulator may then be modified to compensate for these losses.

Automated Coast-Down Equipment: The dynamometer shall be equipped with sufficient motoring capacity and instrumentation to perform dynamometer calibration tests as described in paragraph 85.478-15 and Appendix II of EPA's NPRM without using a motorcycle to drive the rollers up to speed

Computer Interface Panel: An interface panel shall be provided to allow connection of cabling from a real-time computer. The signals to be provided at the interface are:

Velocity - 0 to 10 VDC analog
Torque - 0 to 10 VDC analog
Roll Counter - Square wave digital signal, +30 VDC 20 ma, not to exceed 100 HZ
Flywheel Signals (6) +18 VDC @ 60 ma
-18 VDC @ 15 ma

Load Algorithm coefficients F_0, F_1, F_2	-10 VDC to +10 VDC with a voltage resolution between consecutive coefficient values of at least 0.1 volt.

3.6 DRIVERS'S DISPLAY AND CONTROLS

Driver's Display: The driver's display shall consist of an analog and digital display of velocity; an analog and digital display of power, which may be switched by interlocked illuminated pushbuttons to display torque; and two distance counters for measuring the distances traveled during the cold transient and cold stabilized segments of the FTP as defined by paragraph 85.478-15 of the NPRM. The appropriate counter is selected by an interlocked illuminated pushbutton. A reset button for each counter shall be labeled and located with respect to other controls so as to minimize accidental clearing of the display. The approximate ranges for the displays are:

Velocity - analog	0 to 150 kph
Velocity - digital	XXX.XX
Power, torque - analog	0 to 20 kw, torque, as required
Power, torque - digital	XXX.XX
Distance counters	XX.XXX in kilometers

A button to activate a light and buzzer in the control room shall be located within easy reach of the driver. Emergency stop and reset buttons shall also be located within easy reach of the driver. The driver's display shall be isolated from motorcycle and/or dynamometer vibrations. It must be located within easy reach of the motorcycle driver so that the distance counters may be reset.

Dynamometer Control Panel: As a minimum, the dynamometer control panel shall contain the the following:

Three, four-digit thumbwheel or pushbutton switches for selecting the load coefficients, plus a selector for the sign (+ or -) of the coefficient of the term linear with velocity.

A thumbwheel or pushbutton switch for selection of inertia

A positive indicator that the correct inertia flywheels have engaged

Dynamometer voltmeter and ammeter analog displays

On-off buttons and indicating lights for main power supply. Reset and emergency stop pushbuttons for dynamometer.

Dynamometer Controls and Functions: In addition to the controls and functions defined above, the system shall have the following controls, features and functions (*regenerative dc PAU only; **eddy current PAU only). These controls and functions shall be installed on the dynamometer control panel or control box.

* 1. Forward motor rotation only
2. Solid state excitation for dynamometer field
3. Speed regulation
4. Adjustable overspeed protection
* 5. Dynamometer field loss protection
** 6. Dynamometer field overcurrent protection
* 7. Current limit adjustment
* 8. Instantaneous overcurrent protection
9. Short circuit protection at AC power circuit
10. Low voltage protection at AC power circuit
**11. Cooling water low pressure protection
**12. Inlet cooling water high temperature protection
13. Emergency stop
14. Coast stop
*15. Auxiliary and Control power disconnect
16. Dynamometer armature ammeter - analog display
*17. Dynamometer voltmeter - analog display
18. Dynamometer field ammeter - analog display
19. Dynamometer speedometer readout - digital and analog display
20. Dynamometer power readout - digital display
21. On-off pushbuttons and indicating lights for main power supply
22. Reset and emergency stop pushbuttons for dynamometer
23. Recorder outputs, 0-100 mv, for speed, power and torque

Section 4

DESIGN SPECIFICATIONS - COOLING SYSTEM

4.1 OUTLET DUCT DESIGN

The exit of the outlet duct shall be positioned squarely in line with the motorcycle frame no further than 0.45m (1.48 feet) in front of the vehicle's front wheel. The cross-section of the exit shall have an outlet area of at least $0.5m^2$ ($5.4\ feet^2$). The exit can be squarely positioned before the front wheel of the vehicle or can envelope the front wheel. The bottom of the duct exit shall be between 0.15m (0.49 feet) and 0.2m (0.66 feet) above floor level.

The outlet duct shall be designed to connect to the exit of the vaneaxial blower defined in Section 4.2. It shall be so designed that the static pressure loss of air flowing through it at maximum conditions does not exceed 0.750 kpa (3 inches H_2O).

4.2 BLOWER/FAN DESIGN

A vaneaxial-style fan shall be used to provide the motorcycle cooling air. It shall be capable of generating air velocities at the exit of the outlet duct (as described in Section 4.1) of 100 kph.

The fan shall be configured for operation by a direct-drive motor, foot-mounted, or "C" flanged and foot-mounted.

The fan shall be equipped with vanes which shall be foil-shaped and fabricated from high-strength cast aluminum. The rotational speed of the fan wheel at maximum flow condition shall be less than 1,750 rpm.

The fan shall be equipped with a curved inlet orifice which has been designed to minimize entrance losses. A safety guard shall be installed on the inlet orifice to prevent entrance of foreign objects.

A wheel inspection door shall be installed to facilitate the inspection and cleaning of the wheel. Support legs, which bolt to the inlet and discharge flange-rings shall also be provided. This support shall be capable of supporting the blower and motor.

4.3 MOTOR AND CONTROL SYSTEM DESIGN

The motor and control system shall utilize either a regenerative DC motor or an eddy current motor equipped with an electromagnetic brake.

The motor/control system shall be able to deliver sufficient power to drive the fan at the maximum requirement of 1,750 rpm and 100 kph air velocities through a duct having a cross-sectional area of at least $0.5m^2$. The motor shall be rated at least 15 percent higher than needed to achieve the maximum air flow.

The motor/control system shall be equipped with tachometer or shaft follower circuitry with manual override which will allow the fan to be accelerated at a rate equivalent to maximum exit air velocity changes of 16km/hr/sec. The motor shall have sufficient torque capacity to achieve the maximum acceleration rate at 1/30 maximum motor speed. The control system shall be capable of slowing the fan to follow motorcycle decelerations as high as 10 km/hr/sec. Accuracy requirements have been defined in Section 2.3.2 of this specification.

The motor design can be either drip-proof or totally enclosed, but it must be compatible with the fan selected. It must be smaller than the fan hub and must not interfere with the flow of air through the fan.

Motor leads shall be sufficiently long to extend through the fan housing. At least 8 meters of cabling shall be provided between the motor and controller.

An isolation transformer or comparable components shall be provided to minimize effects of voltage fluctuations and RF and electromagnetic interferences.

The motor and controller shall not require the use of water or external compressed air.

4.4 FAN MOUNTING DESIGN

The fan and motor system shall be mounted on wheels or rails so that the fan can be positioned with respect to the motorcycle. Repositioning shall be accomplished by no more than one technician in less than a 5-minute period. A safety interlock shall be provided so that the fan and dynamometer cannot be operated until the fan assembly is securely locked to the floor or track.

Section 5

DESIGN SPECIFICATIONS - GENERAL

5.1 APPLICABLE DOCUMENTS

The following documents form part of the equipment specification to the extent defined herein. In the event of conflict between the documents referenced herein and the content of this specification, the order of procedures shall be: first, the content of this specification; second, all other documents in the order of listing below.

(a) Scope of Work, EPA contract No. 68-03-2141, Development of Specifications for Motorcycle Dynamometer and Motorcycle Cooling System - Established minimum requirements and design criteria.

(b) Regulations for New Motorcycles, Notice of Proposed Rulemaking October 22, 1975 defines motorcycles, identifies emissions test equipment, and describes procedures for certification and durability testing.

(c) Municipal and State Building Codes and Regulations applicable to Ann Arbor, Micigan.

(d) Regulations of the Occupational Health and Safety Administration - Establishes minimum health and safety-related design and performance requirements.

(e) National Electrical Code - Defines uniformity and safety requirements for design and construction of electrical power circuits and electrical installation of equipment.

(f) Joint Industry Conference (JIC) Electrical Standards for Industrial Equipment - Defines uniformity and safety requirements for design and construction of electrical equipment.

(g) Air Moving and Conditioning Association, Inc., (AMCA) - Standard Test Code for air moving devices. Performance standards for air moving equipment.

5.2 ENVIRONMENTAL AND UTILITY REQUIREMENTS

5.2.1 Test Cell Environment

The dynamometer and cooling system specified herein are integral parts of a dynamometer system which will be installed in a test cell which will house the cooling system, a dynamometer, the motorcycle being tested, a vehicle driver, and auxiliary instrumentation for the measurement of exhaust emissions.

The environment of the test cell will be controlled. Test cell temperatures will be maintained between 20^{o} and $30^{o}C$ (68^{o} and $86^{o}F$). Relative humidity of the test cell will be less than 80 percent.

The altitude of the test cell will be less than 1,000m.

Noise emissions from the system shall comply with applicable noise regulations as promulgated by the Department of Labor Occupational Noise Exposure Standards detailed in the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910, subpart G, 36 FR 10466, May 29, 1971.

5.2.2 Test Cell Dimensions

The system will be installed in existing laboratory cells located at the Environmental Protection Agency's Vehicle Test Laboratory in Ann Arbor, Michigan.

The dimensions of the test cell are 3.5 m (11.5 ft) wide by 7.5 m (24.6 ft) long by 3 m (9.8 ft) high. Maximum pit depth is 76 cm (30 inches).

The dynamometer shall be designed for installation in this test cell. Sufficient access shall be provided for maintenance, accessibility and movement within the test cell.

5.2.3 Utility Requirements

5.2.3.1 Air

A compressed air supply having a minimum pressure of 620 kpa (90 psi) will be available for use with this system.

5.2.3.2 Water

A supply of city water will be available for use in this system. Water supply pressure is 340 kpa (50 psi).

5.2.3.3 Electric Power

All components requiring electric power shall use either 115 VAC, 1Ø, 60 Hz and 230 VAC, 3Ø, 60 Hz; 208 VAC, 3Ø, 60 Hz, or 460 VAC, 3Ø, 60 Hz power.

5.3 PERSONNEL AND EQUIPMENT SAFETY

The motorcycle dynamometer system shall be designed and constructed so as to comply with OSHA regulations (Code of Federal Regulations, Title 28, Chapter XVII, Part 1910. Specific features shall be in accordance with the following paragraphs from these regulations:

(a) <u>Mechanical Safety</u>: Mechanical features which could cause injury to operating personnel during operation or maintenance shall be avoided. The projection of overhanging edges and corners shall be minimized and any projections shall be rounded. The radius of corners shall be a 3 mm (0.18-inch) minimum.

(b) <u>Vertical Stability</u>: The vertical stability of free-standing equipment shall be such that the height of the center of gravity shall be no greater than two times the least base dimension.

(c) <u>Guards, Barriers and Enclosures</u>: Guards and barriers shall be provided to protect personnel from accidentally contacting rotating or moving parts, exposed electrical contacts, or terminals in circuits operating at more than 40V rms.

(d) <u>Circuit Protection</u>: Failure of the system equipments, or any portion thereof, shall not result in a hazardous condition in externally-located circuits or other equipments.

5.4 GENERAL DESIGN AND CONSTRUCTION

5.4.1 Enclosures

The controller enclosures shall provide dust-protective housing. Ventilating air-flow shall be filtered. The enclosures shall provide complete dust-protecting and drip-proof housing of equipment.

5.4.2 Exterior Finish

The equipment shall be finished with durable, low-luster paint applied over a compatible primer coating. Unpainted exterior surfaces shall be stainless steel or anodized aluminum. Exposed fasteners shall be plated (cadmium, chromium, nickel, or galvanized) for corrosion resistance. All joining metals shall be electrochemically compatible to prevent corrosion.

5.5 WIRING DESIGN AND CONSTRUCTION

Wiring shall be designed and constructed using first-quality commercial grade materials and installation techniques so as to insure reliable, functional electrical circuits and shall conform to standards listed in Section 5.1.

5.5.1 Electromagnetic Interference

Electronic equipment will be designed and shielded to prevent erroneous readings due to conducted or radiated interference, such as from ignition systems, fluorescent lights, motors and switching transients, nor shall electronic equipment within the dynamometer affect the operation or performance of other electronic components located in the test and adjacent control room.

5.5.2 Cabling Construction

System cables shall be designed of material resistant to gasoline, oil, water, and engine exhaust components. They will be of heavy construction so as to survive abuse.

5.5.3 Cable Terminations/Equipment Interfaces

Cable terminations and the corresponding equipment interfaces shall employ plug and socket connectors where necessary to implement ready replacement. Interfaces to nonfunctional units (e.g., cabling to a junction box), or interfaces to functional units involving less than twelve terminations, may be made by terminal blocks.

All terminations shall be identified by at least one of the following means: letter, number, or color code.

If edge connectors are used, cables shall be strain-relieved and no exposed conductors shall be permitted.

Section 6

PROCUREMENT SPECIFICATIONS - PROCUCT ASSURANCE

This section of the specification details maintenance, warranty, pre-delivery checkout and installation requirements. Prospective bidders must address these areas of concern in their response to this specification.

6.1 MAINTAINABILITY

All routine maintenance operations, including inspection, lubrication, adjustments, and calibration, shall be enabled by provision for access by ports, doors, and/or quick-release panels to all critical areas. All field-replaceable components and adjustment points shall be accessible without removal or displacement of other components.

Circuit boards, relays, and similar electrical assemblies and components shall be modularly replaceable without necessity for soldering or unsoldering.

Any part subject to wear must be capable of rapid replacement by normally skilled mechanics without need for machining, fitting and alignment operations.

6.2 RELIABILITY

The equipment, when maintained per manufacturer's specifications, shall provide a minimum service life of 10 years with an operating duty of 2,000 hours per year. Where necessary, the expected time of replacement of any component which will not meet the service life shall be defined.

Reliability (MTBF) estimates shall be provided to substantiate the projected equipment life. The estimates shall be based on accepted reliability modeling methods, if these are available. In addition to, or in lieu of, the calculated MTBF, field experience data shall be provided in support of the project equipment life.

6.3 PRODUCT SUPPORT

The supplier shall provide the following information to substantiate adequate product support:

(a) Initial system calibration service and procedures.

(b) Capability and location of service and repair parts stations, including number and qualifications of personnel in the area of Ann Arbor; Michigan, where the equipment will be installed.

(c) Product support activity planned for field personnel in support of this equipment installation, and list of charges for additional support that may be required.

6.4 RECOMMENDED SPARE PARTS

A list of recommended spare parts to be held in inventory by the user shall be supplied with the bidder's proposal. This list shall identify those items that are necessary to ensure that the equipment can be maintained by local area personnel with local area equipment and supplies without need for emergency direct factory support.

6.5 INSTALLATION DATA

Installation drawings shall be furnished within 45 days after contract award. All details shall be final and shall cover the excavation and foundation requirements, air, electrical requirements, water supply and disposal, and complete installation procedures.

6.6 INSTRUCTION MANUALS

The supplier shall furnish three copies of instruction/maintenance manuals for each piece of equipment supplied under these specifications. The manual shall contain complete instructions for the proper installation, operation, calibration and maintenance of equipment, including detailed drawings and schematics, directions and charts for lubricating, wiring and piping diagrams, necessary drawings, parts list, and any special notes which are required.

6.7 PRE-DELIVERY CHECKOUT

Prior to delivery to EPA, the hardware supplier shall perform an engineering evaluation of the motorcycle dynamometer and/or cooling system. The contractor shall compare actual equipment specifications, as represented by suppliers' engineering data, to the original specification. Variance to the purchase specification will not be allowed.

The engineering evaluation shall include testing of the dynamometer power absorber to demonstrate the ability of the dynamometer to simulate empirical road-load force versus speed curves to within the limits specified in the Specifications. The testing shall also include verification of the accuracy of the cooling air speed with respect to the simulated roll speed to within the limits specified in the Specifications. The inertia simulation of the dynamometer shall also be subject to test verification. This acceptance testing shall be observed by personnel from Olson Laboratories and EPA.

Upon the successful completion of the pre-delivery checkout, the hardward supplier will be authorized to ship the equipment to EPA's facility in Ann Arbor. Final acceptance of the hardware will be made after the final system is installed and operating satisfactorily in EPA's facility.

6.8 INSTALLATION SUPERVISION AND TRAINING

The services of a field engineer shall be furnished to supervise the installation of equipment, the start-up equipment, and the training of customer's personnel in the proper calibration use and maintenance of the equipment. The system will be installed in the EPA's Motor Vehicle Emissions Laboratory in Ann Arbor, Michigan.

6.9 WARRANTY

The supplier shall warrant equipment delivered under this specification to be free of defects in materials and workmanship for the supplier's standard period of warranty or for at least a year's period following first use (start of checkout at EPA's facility), whichever is greater.

Should a defect occur within the warranty period, the defective material or workmanship will be repaired or replaced without cost to the Environmental Protection Agency or Olson Laboratories.

Section 7

DELIVERY

The completed dynamometer system shall be delivered to EPA Motor Vehicle Emissions Laboratory, Ann Arbor, Michigan within 5 months after the purchase order is issued. Prior to delivery, the manufacturer of the dynamometer and/or cooling system shall perform preliminary acceptance tests in the presence of Olson Laboratories or EPA staff engineers at the site of manufacturer. The minimum acceptance tests have been outlined in Section 6.7.

Section 8

EVALUATION CRITERIA

Table 8-1 details the evaluation criteria established by Olson Laboratories. These criteria require examination of the performance, operational, maintenance, and cost characteristics of the proposed designs. Dynamometer manufacturers responding to this specification should provide sufficient details in their proposals so that an accurate evaluation can be made utilizing the factors listed in Table 8-1.

Table 8-1. EVALUATION CRITERIA

FACTORS	WT. FACTOR	DYNAMOMETER CONFIGURATION RATING					
		System 1		System 2		System 3	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
I. Performance							
1. Ability to Simulate Road Conditions	1.0						
2. Ability to Simulate Vehicle Inertia	1.0						
3. Ability to Accommodate Various Motorcycles	1.0						
4. Ability to Simulate Cooling Conditions							
5. Fail-Safe Provisions	1.0						
6. System Repeatability	1.0						
II. Operation							
1. Operating Personnel Training	0.5						
2. Pre-Test, Set-Up Procedures	0.6						
3. Supporting Utilities Required	0.6						
4. Test Data Acquisition	0.4						
5. Facility Spatial Requirements	0.5						
III. Maintenance							
1. System Complexity	0.6						
2. Maintainability of System	0.8						
3. Reliability of Components	0.8						
4. Preventative Maintenance	0.6						
IV. Costs							
1. Purchase Price	0.8						
2. Installation Costs	0.5						
3. Annual Operating Costs	0.6						
V. Delivery Schedule	1.0						
Cumulative Ratings							
Ranking							

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

This project developed the specifications for a motorcycle dynamometer and motorcycle cooling system to be used in motorcycle exhaust emission certification programs. In the development of dynamometer specifications, various power absorbers, roll assemblies, and inertia assemblies were evaluated and their performance related to road data. Variable-flow blower systems were examined as a technique to simulate on-road engine cooling. Specific cooling system parameters studied included blower style, ducting requirements, noise levels, efficiency, power requirements, flow control methods, cost, and delivery.

This volume, the specifications, define and establish the required configuration, performance, and design characteristics of a motorcycle dynamometer and cooling system to be used by the U.S. Environmental Protection Agency for the purpose of conducting exhaust emissions certification tests and fuel economy measurements.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

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