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Current Status of Automobile Analysis in the USA

R. Neal Harvey

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R. Neal Harvey*

1. Federal Regulations

In 1990 the U.S. congress passed amendments to the Clean Air Act that require significant new reductions in vehicle emissions for compliance with air quality standards. The amendments established new, lower Tier 1 tailpipe emissions standards for certification of all light-duty vehicles and trucks. The amendments called upon the U.S. Environmental Protection Agency (EPA) to issue new standards and measurement techniques in three strategic areas—first, cleaner new vehicles; second, clean burning fuels; and third, an Inspection and Maintenance program for in-use vehicle emissions standards.

EPA has responded with many new revisions to existing regulations and is establishing new procedures and regulations to control vehicle emissions during periods of operation at low temperatures and to control evaporative emissions during idle periods of operation in cyclic environmental conditions. New regulations will require auto manufacturers to pass "Cold CO" carbon monoxide standards at 20°F(-6.7°C) test temperatures. The auto manufacturers are now busy installing refrigerated test cells with new 48-inch dynamometers, emissions instrumentation, and large "SOAK" areas to implement these procedures.

Meanwhile, other EPA regulations require a 1995 phase-in for cleaner burning, "reformulated" gasoline fuels. These new fuels should achieve a 15 percent reduction in hydrocarbons and toxic pollutants. By the year 2000 the "reformulated" fuels must achieve a 20% reduction in emissions.

The latest EPA action centers on reduction of emissions from the 50 million in-use vehicles operating in the smoggiest areas of the U.S. The new rules, published in November 1992, require the most polluted cities or states adopt either "basic" or "enhanced" Inspection and Maintenance Programs depending upon the severity of the ozone and carbon monoxide pollution of the area. EPA is establishing high-tech test requirements that will measure both tailpipe and evaporative emissions. The test equipment for "enhanced" areas will analyze exhaust emissions from a transient driving cycle operated on a chassis dynamometer simulating road load and vehicle inertia. The driving cycle, called IM-240 (**Fig.1**), is a 240 second, condensed version of the first 330 seconds of the Federal Test Procedure used for certification.

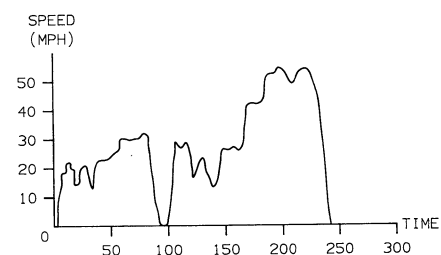


Fig.1 New driving schedule for EPA IM-240 vehicle inspection program

* Horiba Instruments Incorporated

Additional equipment in the test lane will perform two functional tests of the vehicle evaporative emissions control systems. This includes a simple pressure test to find leaks in the fuel system and a check of the ÅgpurgeÅhsystem that removes gasoline vapors stored in the charcoal canister and routes them to the engine where they can be burned. If a vehicle fails the new IM-240 test then the vehicle owner will be required to spend up to \$450 for emissions related repairs before the vehicle registration is renewed. IM-240 benefits include an estimated 28 percent reduction in Volatile Organic Carbon emissions plus 30 percent reduction in exhaust CO emissions and a 9 percent drop in exhaust NOx emissions.

2. California Regulations

The Los Angeles area of California has the most severe air pollution problem in the U.S. caused by the large population density of motor vehicles and the natural geography that traps emissions from all sources within the air basin. Consequently, California has received waivers from the EPA that permits the California Air Resources Board (CARB) to set lower exhaust emissions standards than the other 49 states.

In 1990 CARB adopted sweeping new regulations mandating clean burning fuels and low-emission vehicles. These new regulations take effect in 1994 for passenger cars and light-duty trucks sold in the state. The emissions regulations establish four new categories of low-emission vehicles; each successive category must meet lower standards than the previous category. Vehicle manufactures participating in the California market must produce a specified percentage of their production for each category. The categories are largely defined by differing levels of Volatile Organic Gases in the exhaust-a reactivity adjusted measurement termed NMOG (Non Methane Organic Gas). These four new categories of low-emission vehicles and the associated emissions requirements are summaries in **Table 1**.

Category	Emission Levels(g/mil)			Year
	NMOG	CO	NOx	
TLEV: Transitional Low Emission Vehicle	0.125	3.4	0.4	1994
LEV : Low Emission Vehicle	0.075	3.4	0.2	1997
ULEV: Ultra Low Emission Vehicle	0.040	1.7	0.2	1997
ZEV : Zero Emission Vehicle	0	0	0	1998

Table1 Four new categories of low-emission vehicles and the associated emissions requirements

A ZEV is a non-combustion powered vehicle such an electric car. The ZEV requirement will start at 2 percent of sales in 1998 and rise to 10 percent in 2003.

These new CARB regulations change the way in which motor vehicle emissions are measured. Today's California standards measure organic emissions as total hydrocarbons (measured by a Flame Ionization Detector) less methane, commonly known as Non-Methane Hydrocarbon (NMHC). The new rules address the ozone-forming potential of exhaust by going beyond the NMHC measurement to a reactivity adjusted mass emissions measurement previously referred to an NMOG. NMOG includes NMHC plus aldehydes, ketones, alcohols, and ethers as measured via gas and liquid chromatography.

The resultant NMOG mass value is then multiplied by a Reactivity Adjustment Factor (RAF) determined by CARB for every motor fuel in each emission category TLEV, LEV and ULEV. CARB will determine the RAF for each fuel based upon the individual ozone forming reactivity for each of about 150 organic compounds identified in exhaust gas. The RAF rewards the use of cleaner burning fuels such as reformulated gasoline, alcohol and compressed natural gas (CNG) when compared to today's average gasoline. The first clean fuels are man-

dated for distribution in California beginning in 1994.

Evaporative emissions from motor vehicles comprise a significant percentage of the total organic emissions released in the California air basins. Therefore, CARB is adopting new evaporative emission test procedures to replace current test procedures that do not accurately represent real environmental conditions. The new California Evaporative Emissions Test Procedures Comprise a three-phase test consisting of a Running Loss Test, a Hot Soak Test and a Diurnal Breathing Loss Test.

The Running Loss Test measures evaporative emissions from the vehicle during operation on a chassis dynamometer at elevated temperatures (105°F or 40.6°C). The test is conducted in a sealed enclosure (SHED). Atmospheric sampling within the SHED for total hydrocarbons before and after the dynamometer driving procedure determines the HC mass emissions.

Phase 2, the Hot Soak Test, measures evaporative emissions from a warm, idle vehicle sealed in a SHED at 105°F(40.6°C). Again, atmospheric sampling within the SHED for THC before and after the 60-minute test determines the HC mass emissions.

The Phase 3 evaporative emissions test is termed the Diurnal Breathing Loss Test (DBL)—a procedure designed to simulate evaporative emissions measurement from a vehicle parked outdoors for 72 hours. The SHED is special, it is equipped with sophisticated temperature and pressure controls that simulate a 24-hour ambient temperature cycle between 65°F and 105°F. The pressure control system must accommodate thermal expansion of the SHED atmosphere during the full 72-hour procedure. Hydrocarbon sampling after each 24-hour cycle establishes the HC mass emissions.

3. Instrumentation for New Regulations

Auto manufacturers, oil companies, and regulatory agencies have increased capital spending for facilities and equipment to satisfy these new Federal and California emissions regulations. Currently U.S. manufacturers are installing and starting-up new Cold Room facilities to meet the Federal Cold CO test requirements. In addition, the manufacturers and oil companies are installing multiple Variable Temperature/Variable Volume SHEDs for Federal and California Diurnal Breathing Loss and Hot Soak procedures. Industry concerns about health and safety issues have stalled some American installations of Running loss SHEDs. A Point Source sampling technique which does not require a sealed enclosure has been proposed as a viable alternative to the Running Loss SHED.

Some of the standards set by new regulations will be easy for the auto manufacturers to achieve via re-calibration of fuel systems and implementation of known technology. However, high emissions from other new test procedures may be difficult to reduce and could lead to significant emission development programs to meet the regulatory deadlines. New emissions equipment and instrumentation being requested by the automotive industry include:

(1) Cold CO

Cold Rooms equipped with 48-inch chassis dynamometers, complete analytical systems with modal emissions capability.

(2) Evaporative Emissions

- ① Variable Temperature/Variable Volume SHEDs for Diurnal Breathing Loss and Hot Soak tests, equipped with temperature and pressure control systems and total hydrocarbon analytical systems.
- ② Point Source Dilution Systems or Running Loss SHEDs equipped with total hydrocarbon analytical systems.

(3) Emissions Analysis

- ① Non-Methane Hydrocarbon (NMHC) FIA's for transient analysis of NMHC during the Federal Test Procedure and CVS bag analysis.
- ② Variable Flow Rate Venturi Samplers for LEV tests.
- ③ Impinger Sampling Systems for alcohol and aldehyde sampling.
- ④ New analyzer techniques to measure alcohols and aldehydes to replace labor intensive Impinger Systems.
- ⑤ Fast analyzer techniques such as Gas Chromatograph-Mass Spectrometers (GC/MS) for measuring organic gas species on a routine basis.
- ⑥ Fast Response Analyzers capable of tracking quick changes in exhaust gas concentration that reflect operational characteristics of emission control devices.

Responding to EPA's new IM-240 Inspection and Maintenance rules, cities and states are now incorporating EPA's analytical specifications into contract requirements for centralized testing programs. Low cost, mass produced systems with analytical performance equivalent to today's certification test systems are required. Unique requirements dictate operation in such diverse ambient environmental conditions as from freezing to desert conditions.

4. Horiba Instruments, Inc., Product Strategy

The last decade has seen a steady increase in the auto manufacturers dependence upon the engineering expertise of their emissions equipment suppliers to meet the regulatory requirements for sophisticated analytical equipment. Horiba Instruments, Inc. and its parent company, Horiba, Ltd., have responded to these new market demands with many new products and services. Today, Horiba Instruments supplies a full compliment of custom designed systems, computer software and engineering design services that satisfy market needs from simple analyzers to "turn-key" facilities.

Recent product developments by Horiba Instruments expand the list of equipment available to satisfy the new regulations.

In 1991 EPA awarded Horiba Instruments a contract to supply up to 20 new 48-inch AC electric dynamometers (**Fig.2**) for EPA's facilities in Ann Arbor, Virginia, and Colorado. These dynamometers will replace the 8.65-inch twin-roll hydrokinetic dynamometers used by EPA since the 1960's. EPA rated Horiba's design superior in all seven technical areas. Through November, 1992, EPA has released orders for 11 units to be installed in two EPA Cold Test Rooms, a certification cell and R&D cells; all located in Ann Arbor, Michigan. Auto manufacturers have ordered an additional 35 units since the EPA contract was

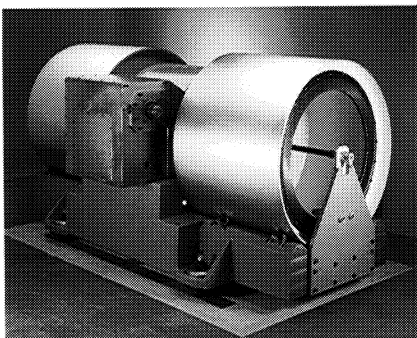


Fig.2 Horiba 48-inch chassis dynamometer built for EPA contract

awarded.

For the new Evaporative Emissions procedures, Horiba Instruments supplies VT/VV Diurnal Breathing Loss SHEDs complete with control system, HC analytical system and PC based Data Acquisition for complete documentation and reporting.

Low Level Emissions instrumentation and systems have been delivered by Horiba Instruments for numerous projects. One popular item is an Impinger System (Fig.3) for collecting alcohol and aldehyde samples from alternate fuels test programs. A second item, currently being evaluated by EPA, CARB, and the manufacturers, is a variable flowrate conversion kit for existing critical-flow-venturi CVS's. This variable flow conversion facilitates adjusting CVS flow to maximize CVS bag concentrations yet avoid moisture condensation within the sampling system.

Horiba Instruments' IM-240 System(Fig.4) has been selected by more than 80 percent of the major contractors involved with the state Inspection and Maintenance programs. Horiba offers a turn-key system for modal CVS analysis, micro-processor based data acquisition and reporting. MEXA 9000 type analyzers, critical flow venturis and proven software generate mass flow data for each pollutant at 1.0 Hz from 10 Hz sampling.



R.Neal Harvey
Horiba Instruments Incorporated
Executive Vice President

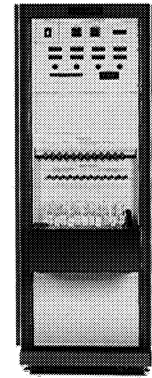


Fig.3 Horiba impinger system for speciation of exhaust emission hydrocarbons

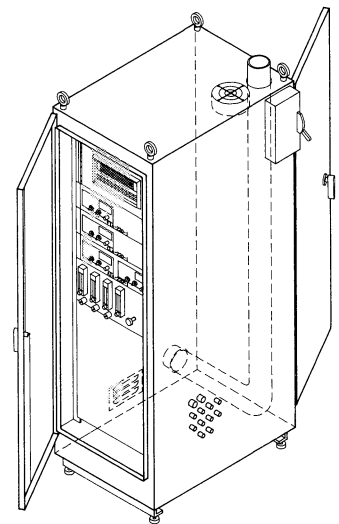


Fig.4 Horiba emissions system for new EPA IM-240 vehicle inspection program

米国における自動車排出ガス分析の現状

米国の新しい規制に対応するために必要となる自動車排出ガス分析の概要を解説し、排出ガス分析の総合メーカとして積極的に計測・評価用機器の開発・製品化に取り組んでいるホリバインストルメンツ社(Horiba Instruments Incorporated : HII)の戦略を紹介した。

(1) 連邦規制

1990年連邦議会は大気清浄化法の大幅な改正案を可決した。EPAではこれを受け、あらたに低温作動時の排出ガスやアイドリング時の蒸散量の規制と、試験・評価方法を策定中である。より厳しい地域では、IM-240とよばれる走行サイクルで試験される。

(2) カルフォルニア規制

カルフォルニア大気汚染対策局(CARB)は、TLEV, LEV, ULEV, ZEVと段階的に低公害車を実現するために規制を刷新した。新しい規制では、従来の炭化水素に加えアルデヒドやケトンなど非メタン系有機性ガス(NMOG)をも対象とするもので、また、蒸散ガスの試験方法はランニング・ロス、ホットソーク、ダイアナル・ブリージング・ロスの3段階の試験から構成されている。

(3) 新規の規制に対応する排出ガス計測装置

新しい規制に対応するために自動車業界からは次のような排出ガス計測装置が求められている。

- ① 48インチシャシダイナモメータを備えたコールドCO分析システム
- ② R/L, HS, DBL&PS-CVSの各試験設備
- ③ NMOG, NMHCを高精度かつ高速に分析できる分析装置 およびサンプリング装置

(4) HII の製品戦略

新たな規制に対応するために、次のような計測機器を開発し好評を得ている。

- ① EPA4へ納入し高い評価を受けている48インチシャシダイナモメータ
- ② HCガス分析計、制御装置、データ処理装置を含めたDBL SHEDシステム
- ③ アルコール、アルデヒド用インピンジャ・サンプリング装置
- ④ バッグ内部で水分の凝縮を防ぐCVS用流量可変装置
- ⑤ IM-240サイクル試験を総合的に行う自動車排出ガス計測システム

