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June 1975

Environmental Monitoring Series

GUIDELINES FOR QUALITY ASSURANCE PROGRAMS FOR MOBILE SOURCE EMISSIONS MEASUREMENT SYSTEMS:

PHASE IV, HEAVY-DUTY GASOLINE ENGINES - TEST PROCEDURES

U.S. Environmental Protection Agency
Office of Research and Development
Washington, D. C. 20460

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EPA-650/4-75-024-h "Guidelines for Quality Assurance Programs for Mobile Source Emissions Measurements Systems: Phase IV, Heavy-Duty Gasoline Engines - Test Procedures"

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GUIDELINES FOR QUALITY ASSURANCE PROGRAMS FOR MOBILE SOURCE EMISSIONS MEASUREMENT SYSTEMS:

PHASE IV, HEAVY-DUTY GASOLINE ENGINES - TEST PROCEDURES

by

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Mobile Source Air Pollution Control

and

Office of Research and Development
Washington, D. C. 20460

June 1975

EPA REVIEW NOTICE

This volume has been prepared by Olson Laboratories, Incorporated consistent with the Environmental Protection Agency Quality Assurance principles and concepts and with the Environmental Protection Agency Mobile Source Testing Practices at Ann Arbor, Michigan.

The guidelines and procedures are generally applicable to mobile source testing operations and are intended for use by those engaged in such measurement programs

It is requested that recipients and users of this document submit any comments and suggestions to the Project Officers.

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Publication No. EPA-650/4-75-024-h

INTRODUCTION

The test procedures contained in this volume are a documentation of the 1975 heavy-duty gasoline emission measurement test requirements presently in use at the Ann Arbor facility of the Environmental Protection Agency. These test procedures comply with Federal Regulations as stated in the Federal Register, (Subpart H). Refer to Section 3, of Volume I, for a listing of applicable Federal Register paragraphs.

Section 5, Volume I, outlines the development of an Operations manual which may be used as a guideline for a Quality Assurance program. A typical format of a test procedures manual is described and offers a guide for implementing and interpreting the test procedures contained in Volume II. A user may accept the manual in its presented form, or may modify the format to suit specific contractual obligations, or delete certain procedures which may not be performed at that facility. The user will be required to make revisions as needed to assure that the manual complies with Federal Regulations. Revisions may be implemented manually, by computer updates or by magnetic card storage.

For ease of use, the test procedures are separated into nine distinct sections, numbered 100-900. The table of contents shows the major heading of each section and the test procedures contained in each. To differentiate between the light-duty and heavy-duty testing which are both included in this contract, the test procedures are numbered to correspond to Light Duty, 101-149, 201-249, etc. and Heavy Duty, 150-199, 250-299, etc. Heavy-duty diesel procedures modified for use with heavy-duty gasoline engines are suffixed with a -G, e.g.TP-750-G. Certain procedures developed for Phase I and II (Light-Duty Gasoline Vehicle and Heavy-Duty Diesel Engine) are equally applicable to Phase IV (Heavy-Duty Gasoline Engines) and have been included in this volume, utilizing the original Test Procedure reference number allocated for Phase I and II.

To assist in defining the overall scope of the heavy-duty testing program, the tables from Section 3, Volume I, briefly outlining the test procedures, specifications, and quality provisions are included in the introduction to the test procedures manual.

This document details test procedures for heavy-duty gasoline engines. The test procedures for light-duty diesel (Phase III) appear as a supplement to the light-duty gasoline vehicle procedures detailed in Phase I, Volume II. Heavy-Duty Diesel Engine Test Procedures appear in Volume II of the Report for Phase II.

TABLE OF CONTENTS

HEAVY DUTY GASOLINE ENGINE TEST PROCEDURE SUMMARY

PROCEDURE OR TASK	BRIEF DESCRIPTION	FR REF. EPA TP NO.	SPECIFICATION OR TOLERANCE-FED. REG.	SPECIFICATIONS SAE OR ENG. PRACT.	QUALITY PROVISIONS	TEST INVALID	CORRECTIVE ACTION	TRAINING OR SKILL LEVEL
1 Engine, Receiving Inspection	Engine shipped to the EPA from the manufacturer is inspected for damage and conformance to installation	FR. Vol. 40 2-27-75 85.774-29(a) TP 750-G		MSAPC Advisory Circular No. 22A Appendix A. 4-23-73	Receiving Inspection check list	Failure to comply with specifications/ shipping damage	Contact engine manufacture for disposition of the engine.	Knowledge of engine installation requirements/inspection procedures
2. Engine Installation	The engine and prealigned stand are installed in the test cell and attached to the dynamometer	85.774-11 85.774-16(a)(1) TP-750-G	Dynamometer capable of maintaining constant speed ±100 RPM from full throttle to closed throttle motoring	MSAPC No. 22A	Installation check list/inspection by mfr. rep.	Incomplete/Improper installation	Correct Discrepancy	Mechanical skill and knowledge of engine/ dyno.
3. Engine/Dyno Check out	The engine is operated at idle and load conditions to check for proper operation. Engine parameters are checked against manufacturer's specifications	85.774-16(2) TP-750-G	Adjustments on engine are limited to unscheduled maintenance listed in Ref. Para.	SAE J8166-Engine test code	Calibration of engine analyzer	Incorrect Engine parameters	Adjust to mfr. specifications	Knowledge of dyno engine analyzer operation
4. Engine preconditioning	Start engine and precondition with one or more cycles, service accumulation or test cycle. Allow to soak prior to test	85.774-7,11,16 TP-757	Engine must reach normal operating conditions, soak time 1-2 hours temp., 60-86°F	Water/oil at equilibrium temp	Speed/torque/temp. trace, soak time checked by Data Validation	Out of limit soak time/ Temp/Cycle	Repeat preconditioning	Knowledge of engine/ dyno operation
5. Engine Test Cycle	An initial 5 minute idle, two warmup cycles, and two hot cycles constitute a complete Dyno Run	85.774-11,12,16 TP-757	Amb. Temp. 68-86°F 2000± 100 RPM Idle - Mfr. spec.		Data validation Q.A. audit	Deviation of 2 sec. CT mode; 0.3 inc. Hg. cruise/PTD mode, 0.2 inc. Hg. PTA/FL Mode last 10 sec. of Mode. 200 RPM first 4 sec./100 RPM rest.	Repeat preconditioning and Test	As above
6. Sampling System	Comprised basically of 5 NDIR instruments, Sample pumps, refrigeration, flow controls and pressure and flow meters	85.775-13 TP-758	Instrument ranges LHC 0-1000 ppm Equiv. LHC 0-10,000 ppm Equiv. CO 0-10%, CO_2 0-16% NO 0-4000 ppm	Sampling System tubing/ hardware/accessories must be made of Teflon, stainless steel or glass only	Approval of system design and parts list, procurement control, inspection of system by Q.C. prior to on-line operation	System leak/component failure/incorrect sample flow or pressure/calibration overdue	Correct variance and repeat test	Trained for operation of analytical system.
7. Instrument Calibration	Calibration gases with concentrations varying across the instrument range are used to identify the instrument curve for data reduction	85.775-15 TP-203 TP-758	Calibrated once every 30 days, Flowrate HHC, LHC, NO 10CFH, CO, CO_2 5 CFH Concentration of gas should be known within ±2% of true value	Weekly checks, calibration standards traceable to NBS/known to ±1% of true value or better. Curve generated must be within ±2% of all points.	Curve defined mathematically by least squares method. Curve approved by Data validation/ Audit.	Overdue calibration, system leak during calibration.	Locate and correct problem, recalibrate.	As above
8. CO_2/H_2O Response check	The Hydrocarbon instruments are checked monthly for interference from water vapor and carbon dioxide	85.775-15 TP-304	CO_2 100% - Response not to exceed 0.5% Sat. N_2 75°F - LHC- 0.5% of full scale, HHC 0.5% of full scale.		Monthly check	Excessive interference from CO_2/H_2O	Recharge filter cell with CO_2 Replace detector.	As above
9. Sample Analysis	A portion of the exhaust gases are analyzed continuously from the first idle thru four nine-mode cycles ending with the engine at idle.	85.775-16, 17 TP-758	Chart Speed 6 in./min. Min. 4-nine mode cycles, 2 Idle modes-before and after test	Visually monitor inst. inlet pressure during sampling ±1 in. H_2O Tol.	Data validation, calibration check, Q.C. audit	Excessive hangup Instrument drift in excess of 2% or other malfunction	Clean sampling system, repair instrument, repeat test	As above. Corrective action may require basic knowledge of electronic instruments.
10. Data Reduction	Direct computer analysis of instruments' output is used to reduce the data to brake specific emissions (gms/hr.)	85.775-16 TP-758	Chart reading should be within 0.5% of full scale. Chart speed 3 in./ min. with marker to indicate computed segments.		Data validation, Computer program verification, random audit of test data.	Incorrect cycle segments used for computer analysis, recorder malfunction.	Manually reduce data/repeat test	

EPA TEST PROCEDURE	Number TP-750-G	Page 1 of 6

SUBJECT

RECEIPT, BUILD-UP AND INSTALLATION OF THE HEAVY-DUTY GASOLINE TEST ENGINE

Reference MSAPC ADVISORY CIRCULAR NO. 22A 4/3/73	Data Form No.
Responsible Organization HEAVY-DUTY TEST OPERATIONS	Computer Program NONE
Test Witness HD - TEST SUPERVISOR	Performance Interval EACH ENGINE
Type of Test Report CHECK LIST	Supersedes NEW
Report Distribution CERTIFICATION - TEST OPERATIONS - DATA FILE	Superseded by

REMARKS/COMMENTS

ORIGINAL RELEASE APPROVALS

Office	Section	Signature	Date
Lab. Oper.	Quality Assurance		
Test Oper.	Chief		
HD Testing	Supervisor		
Certification	Heavy Duty		

REVISIONS

Change Letter	Description of Change	Approval	Date

1.0 PURPOSE

Outlines the proper procedure for receiving inspection and proper installation of engines received for emission testing.

2.0 TEST ARTICLE DESCRIPTION

Heavy-duty gasoline engines are shipped to the EPA for certification or other emission tests. These engines are prepared for testing by the Manufacturer according to the prescribed procedure in MSAPC Advisory Circular No. 22A.

3.0 REFERENCES

3.1 MSAPC Advisory Circular No. 22A dated April 3, 1973.

3.2 Federal Register, paragraphs 85.744-12 and 85.974-12.

4.0 REQUIRED EQUIPMENT/CONDITIONS

4.1 Small tools and necessary plumbing, thermocouple connectors etc., necessary for installation. See Section 8.0 for more detail.

5.0 PRECAUTIONS

5.1 Care should be taken when unloading the engine to place the forks or other lifting device properly to prevent damage to engine or components.

5.2 Engine should not be lifted nor moved by any part of the engine except by those means provided by the manufacturer, such as bed plate pallet, engine mounts, etc.

5.3 Never start the engine without first checking all installation connections and alignment.

6.0 VISUAL INSPECTION

6.1 Receiving - Check engine for proper packaging and unloading requirements. After unloading, check for proper shipping documents and markings. Check for any signs of damage to shipping container and engine.

6.2 Build-up - Check engine for specified temperature, cooling, fuel, drive shaft, and pressure connections.

6.3 Installation - Check for proper coolant and oil level, distance from centerline of shaft to bed plate, engine lag down bolts.

7.0 TEST ARTICLE DESCRIPTION

See Sections 6.0 and 8.0 for preparation procedures.

8.0 TEST PROCEDURE

Test Sequence	Description	Data Output
101	Unload from truck using fork lift. Verify shipping weight does not exceed forklift capacity.	Check Sheet HD-750G-01
102	Fill out HD-receipt form. Explain all deficiencies. List all parts, number of shipping containers, shipping markings, other identifying marks and pertinent information.	Receiving Inspection Form No. HD-750G-02
103	Build-up and Install. o Thermocouple (s) o Water Hose (s) o Drive Shaft Check adapter plate bolts o Oil Pressure Line o Fuel Feed Line and Return Line o Fuel Pressure Line o Manifold Pressure Line	Check Sheet HD-750G-01
104	Check oil level (fill if required), distance from centerline of shaft to bed plate, engine lag down bolts.	Check Sheet HD-750G-01
105	Move engine to test cell and install on the test bed using the following sequence. o Prepare engine test bed to receive engine and pre-aligned stand o Lift engine onto bed with hoist and bolt it in place o Bolt coupling to dynamometer and engine shaft; connect fuel oil and coolant systems using hand tools (refer to appropriate manufacturer's requirements for specifications) o Check carburetor inlet air filter o Connect thermocouples pressure gauges, vacuum lines, ignition, accelerator activator o Check engine for completeness, engine mounting, and engine alignment, o Position engine cooling fan if required	Check Sheet HD-750G-01

8.0 TEST PROCEDURE (CONTINUED)

Test Sequence	Description	Data Output
105 (cont'd)	o Install exhaust system, making provisions for probe location o Verify compliance maintenance procedures.	
106	Engine - Dynamometer check out. After careful inspection of the installation, the engine is run to make adjustments.	
	o Using test cell dynamometer check list confirm that all the necessary connections have been made, instruments and equipment properly installed, and all controls are properly set prior to engine start up	Check List HD-750G-03
	o Check safety interlock system for proper installation	
	o Check throttle positioning	
	o Check oil and water for proper level	
	o Check operation of system safety interlocks	
	o Start engine and perform visual, audio, and functional inspection Listen for internal noises, such as piston slap, knocks, taps and gear noises that indicate irregularities in engine operation Check for fuel and lubricant leaks, check for exhaust and crankcase emission leaks	
	o Bring engine to rated load and speed in gradual steps	
	o Determine when engine conditions have stabilized and record BHP and fuel rate	Dyno Log
	o Lug engine to peak torque speed and record torque and fuel rate	
	o Check engine performance for compliance with manufacturer's specifications; if non-compliance is noted, contact supervisor	
	o Shut down engine and dynamometer systems and record time and ambient temperature	
	o Fill out request for repairs if necessary	
	o All pretest functions should be completed with a minimum amount of engine running time	
107	Preparation of test engine for return to Manufacturer	Check List HD-750G-04
	o Disconnect:	
	o Drive Shaft - Dyno End, only	

8.0 TEST PROCEDURE (CONTINUED)

Test Sequence	Description	Data Output

- o Engine Stand Lag Down Bolts
- o Accessory Stands
- o Exhaust System at exhaust manifold only
- o All temperature thermocouple wires from Control Room assembly
- o All sample probe lines from engine only
- o All fuel, oil, vacuum, manifold, pressure and feed lines from Control Room assembly only
- o Oil coolant hoses from Coolant package

- o Move Engine and Exhaust System
  - o Gasoline Engine (s) to Room 409
- o Disconnect

  Remove and put in proper place
  - o All thermocouples, wires and fitting (if installed by E.P.A.)
  - o Water Hoses
  - o Drive Shaft
  - o All fuel, oil, vacuum, manifold, pressure and feed lines and fittings
- o Drain
  - o Follow manufacturer's recommended procedure for draining coolant Drain oil if necessary
- o Re-Install
  - o Exhaust System and all other engine parts and accessories received

NOTE: Check HD Receiving form to assure shipment is complete as received

108 Complete Shipping Order No. HD-750G-05

9.0 DATA INPUT

9.1 Check sheets validated by supervisor and place into test file.

10.0 DATA ANALYSIS

None

11.0 DATA OUTPUT

None

12.0 ACCEPTANCE CRITERIA

12.1 Engine as received must conform to specifications outlined in MSAPC Advisory Circular No. 22A (4-3-73).

12.2 Engine must conform to manufacturer's specifications.

12.3 Engine must not exhibit any malfunctions such as oil leaks, engine noise, erratic running or overheating.

13.0 QUALITY PROVISIONS

13.1 Engine returned to manufacturer if all specifications not met.

13.2 Engine installation approved by supervisor and certification engineer.

13.3 Data validation inspects check lists for discrepancies and completeness.

13.4 Discrepancies noted during receiving inspection reported to supervisor and quality assurance.

Check List - Receipt, Build-Up And Installation Gasoline Test Engine

Description		Oper. Init.
Unload from truck		_____
Visual Inspection:	Fill out HD-receipt form	_____
	Explain all deficiencies	_____
	List all parts	_____
Build-up and Install:	Temperature Thermocouple (s)	_____
	Water Hose (s)	_____
	Drive Shaft (check adaptor plate bolts)	_____
	Oil Pressure Line	_____
	Fuel Feed Line	_____
	Vacuum Line(s)	_____
	Ignition Wiring	_____
	Fuel Pressure Line	_____
Check:	Oil Level (fill if required)	_____
	Distance C/L shaft to bed plate	_____
	Engine Lag Down Bolts	_____
Move to test cell:	Center engine stand on bed plate and lag down	_____
Connect:	Temperature Thermocouple (s)	_____
	Water Hoses	_____
	Drive Shaft	_____
	Oil Pressure Line	_____
	Fuel Feed Line	_____
	Fuel Pressure Line	_____
	Vacuum Line(s)	_____
	Ignition Line	_____
	Accelerator Actuator	_____
	Exhaust System	_____
	Exhaust Sample Probes	_____
	Cooling Fan (if required)	_____

Form HD-750G-01

Date_____ Manufacturer_____

Engine C.I.D._____ Engine I.D.#_____

Test Type Cert.[ ] Dura.[ ] Correl.[ ] Other [ ]

Pieces_____

Description_____

_____

Condition_____

_____

Received by_____

_____

Test Date_____ Test #_____

EPA EPA

HC_____ Accel._____

CO_____ Lug_____

NO_x_____

Manufacturer's Rep. Signature_____

Certification Rep. Signature_____

Returned Date_____

Form HD-750G-02 - Receiving Inspection Report

Check List Test Cell 3 and 4
Gasoline Engine Dynamometer Operation

Check: **Water Cooler Package:** — Oper. Init.

- Water ON _____
- Expansion Tank - 2/3 to 3/4 full _____
- Booster Pump ON _____
- Air Pressure - ON _____

Control Boom Assembly:

- Vacuum Line - Installed _____
- Fuel Line - Installed _____
- Fuel Pressure Line - Installed _____
- Oil Pressure Line - Installed _____
- Temperature Thermocouple (s) - Installed _____
- Ignition Wire - Connected _____
- Throttle Control - Connected _____

Dynamometers:

- Drive Shaft - Connected _____
- Drive Shaft Guard - Connected _____

Engine

- Water Hoses - Connected _____
- Exhaust Muffler etc: - Connected _____
- Exhaust Sample Probes - Connected _____
- Fuel Regulator - Correct Setting _____
- Cooler Fan (if used) - ON _____

Console

- All Potentiometers in OFF position _____
- M. G. set - ON- 10 min. warm-up min. _____
- Vacuum Manometer at zero _____
- Rotation - CW - front side _____
  CCW - rear side _____
- Inertia - Pos. position _____
- Mode - Manual _____
- Strip chart recorder - ON _____

Power ON in M.G. Room _____
Primary Power - ON _____
Ignition - ON _____
Temp. Recorder - ON _____

Wet Bulb thermo-filled and power ON _____

Form HD-750G-03

Check List - Preparation of Test Engine for Return to Mfr.

Description		Oper. Init.
Disconnect:	Drive Shaft - Dyno End, only.	
	Engine Stand Lag Down Bolts.	
	Accessory Stands.	
	Water Hoses from Coolant package.	
	Exhaust System at Exhaust manifold only.	
	All Temp. thermocouple wires from Control Boom Assembly.	
	All sample probe lines from engine only.	
	All fuel, oil, vacuum, manifold, pressure, and feed lines from Control Boom Assembly only.	
	Oil coolant hoses from Coolant package.	
Move Engine and Exhaust System	Heavy-Duty Gasoline Engine(s) to Room 409.	
Disconnect,	Remove and put in proper place: All Thermocouples, wires and fittings (if installed by E.P.A.)	
	Water Hoses	
	Drive Shaft	
	All fuel, oil, vacuum, manifold, pressure and feed lines and fittings.	
Drain:	Coolant complete; oil (if required).	
Re-Install:	All pipe plugs, cap plugs and other fittings removed by E.P.A.	
Disassemble: Pack in Box: Strap to Skid:	Exhaust System and all other engine parts and accessories received.	

Note: Check HD Rec. form to assure shipment is complete as received.

Form HD-750G-04

Environmental Protection Agency
Office of Air & Water Programs
2565 Plymouth Road
Ann Arbor, Michigan 48105

SHIPPING ORDER

No._____

Date_____

Ship To :

Address :

Attention:

Charge To:

Address :

Attention:

The following listed material/equipment/engine(s) now on consigment/loan to this facility is herewith returned per signature of your carrier (or, common carrier, if applicable.)

Quantity	Description	Ser. No.

The above items were received by_____
(Signature)

on_____
(Date)

Form HD-750G-05

EPA TEST PROCEDURE	Number TP-757	Page 1 of 6

SUBJECT

HEAVY-DUTY GASOLINE ENGINE DYNAMOMETER TEST CYCLE

Reference FEDERAL REGISTER VOL. 40 NO. 40 FEBRUARY 27, 1975	**Data Form No.**
Responsible Organization TEST OPERATIONS	**Computer Program**
Test Witness SUPERVISOR - HEAVY-DUTY TESTING	**Performance Interval** EACH TEST
Type of Test Report COMPUTER OUTPUT	**Supersedes** NEW
Report Distribution CSD/LAB. CHIEF/MFR. REP./DATA FILE	**Superseded by**

REMARKS/COMMENTS

ORIGINAL RELEASE APPROVALS

Office	Section	Signature	Date
PROGRAM MGMT.	QUALITY ASSURANCE		
LAB. BRANCH	CHIEF		
LAB. BRANCH	TEST OPERATIONS CHIEF		

REVISIONS

Change Letter	Description of Change	Approval	Date

1.0 PURPOSE

A prescribed sequence of engine operating conditions are conducted on an engine dynamometer to determine conformity with the standards stated in the Federal Register.

2.0 TEST ARTICLE DESCRIPTION

Applicable to new gasoline heavy-duty engines beginning with the 1974 model year. A heavy-duty engine is defined as any engine which the engine manufacturer could reasonably expect to be used for motive power in a heavy-duty vehicle.

3.0 REFERENCES

3.1 Federal Register, Volume 40, Number 40, February 27, 1975. pp 8482 - 8495

4.0 REQUIRED EQUIPMENT/CONDITIONS

4.1 An engine dynamometer capable of maintaining constant speed ± 100 RPM from full throttle to closed throttle motoring.

4.2 A chassis-type exhaust system or equivalent.

4.3 A radiator typical of that used with the engine in a vehicle or equivalent.

4.4 Auxiliary fixed speed cooling fan (if required.)

4.5 Tape recorder with prerecorded instructions for dynamometer operator.

4.6 Fuel shall be Indolene clear or Indolene HO if catalyst equipped.

5.0 PRECAUTIONS

5.1 Maintain ambient temperature of test cell between 60°F to 68°F during engine soak period and between 68°F to 86°F during test cycle.

5.2 Tolerances for time, speed and manifold vacuum must be followed during cycle in order to perform valid test.

5.3 Visual and audible observation of engine-dyno operation should be performed during test. Shut down engine-dyno if abnormalities are detected.

6.0 VISUAL INSPECTION

6.1 Perform visual inspection of engine-dyno systems prior to start up.

6.2 Inspect fuel system for leaks before and after test.

7.0 TEST ARTICLE PREPARATION

Refer to TP-750-G.

8.0 TEST PROCEDURE

An initial 5-minute idle, two warm-up cycles and two hot cycles constitute a complete dynamometer run. Idle modes may be run at the beginning and end of each test only, thus eliminating the need to change speed between cycles.

Test Sequence	Test Description	Data Output
100	PRECONDITIONING	
101	Start cooling system.	
102	Start the engine and precondition it by operation over one or more cycles prescribed for service accumulation or dynamometer operation until the engine has reached normal operating conditions.	Dyno Log Book Water Temp. ^{o}F
103	Shut down engine and cooling system and allow to stand for at least 1 hour but not more than 2 hours.	Record Soak Time
200	TEST CYCLE	
201	Start cooling system.	
202	Start engine and operate within the manufacturer's RPM specifications for off-idle operation for 5 minutes.	
203	Return the engine throttle control to the normal idle position.	
204	Turn on prerecorded tape and run four nine mode cycles according to the following time, speed, load requirements.	Continuous Record Of RPM, Manifold Vacuum vs. Time

Test Sequence	Test Description	Data Output

SEQUENCE NO.	MODE	MANIFOLD VACUUM	TIME IN MODE-SECS.	CUMULATIVE TIME-SECS.	WEIGHTING FACTORS
1	Idle		70	70	0.232
2	Cruise	16" Hg	23	93	.077
3	PTA	10" Hg	44	137	.147
4	Cruise	16" Hg	23	160	.077
5	PTD	19" Hg	17	177	.057
6	Cruise	16" Hg	23	200	.077
7	FL	3" Hg	34	234	.113
8	Cruise	16" Hg	23	257	.077
9	CT		43	300	.143

- The engine dynamometer shall be operated at a constant speed of 2,000 r.p.m. ±100 r.p.m. (Speed deviations, not to exceed 200 r.p.m., will be allowed during the first four seconds of each mode.)

- The idle operating mode shall be carried out at the manufacturer's recommended engine speed. The CT operating mode shall be carried out at the same engine speed as above.

- If the specified manifold vacuum can not be reached during the PTD mode, the engine shall be operated at closed throttle during that mode. If the specified manifold vacuum can not be reached during the FL mode, the engine shall be operated at wide open throttle during that mode.

205 Record fuel flow and brake horsepower during each mode. — Lbs/Hr Torque

206 Shut down engine and cooling system after last idle period. — Record Engine Running Time

9.0 DATA INPUT

9.1 Test number/system tested/inst. oper./dyno oper./engine make/I.D. #/ mfr. data.

9.2 Engine date of manufacture/engine hours/CID/family/idle RPM/carb/BBl.

9.3 Date and time of day for each part of the test schedule.

9.4 Intake manifold vacuum and engine RPM continuously recorded on the same chart.

10.0 DATA ANALYSIS

10.1 Determine whether the cycle was run in accordance with Acceptance Criteria (12.0) by observing chart peaks, speed trace and manifold vacuum traces.

11.0 DATA OUTPUT

11.1 All data entries and chart records maintained in HD Test File.

12.0 ACCEPTANCE CRITERIA

12.1 The test will be invalidated if there is a deviation by more than:

(a) two seconds from the specified time for the CT mode, or
(b) 0.3 inch Hg during the cruise and PTD modes, or more than 0.2 inch Hg during the PTA and FL modes from the specified mode vacuums during the last ten seconds of a mode, or
(c) 200 r.p.m. during the first four seconds of each mode, or 100 r.p.m. during the remainder of each mode.

13.0 QUALITY PROVISIONS

13.1 Dynamometer calibrated monthly according to TP-250. Weekly single point torque check.

13.2 Fuel flow meter calibrated using dead weight tester.

13.3 RPM/torque recorder output checked prior to each test. Recorder serviced and calibrated at 3 month intervals.

13.4 Driving tape checked monthly for proper timing and wear.

EPA TEST PROCEDURE	Number TP-758	Page 1 of 7

SUBJECT

HEAVY-DUTY GASOLINE ENGINE EXHAUST ANALYSIS PROCEDURE, CO, CO_2, HC AND NO_x

Reference FEDERAL REGISTER VOL. 40 NO. 40 FEBRUARY 27, 1975	**Data Form No.**
Responsible Organization TEST OPERATIONS	**Computer Program** SAQP: GAS
Test Witness SUPERVISOR - HEAVY-DUTY TESTING	**Performance Interval** EACH TEST
Type of Test Report COMPUTER OUTPUT	**Supersedes** NEW
Report Distribution CSD/LAB. CHIEF/MFR. REP./DATA FILE	**Superseded by**

REMARKS/COMMENTS

ORIGINAL RELEASE APPROVALS

Office	Section	Signature	Date
PROGRAM MGNT	QUALITY ASSURANCE		
LAB. BRANCH	CHIEF		
LAB. BRANCH	TEST OPERATIONS CHIEF		

REVISIONS

Change Letter	Description of Change	Approval	Date

1.0 PURPOSE

Exhaust gases are analyzed continuously during a prescribed sequence of engine operating conditions to determine conformity with the standards specified in the Federal Register.

2.0 TEST ARTICLE DESCRIPTION

Applicable to new heavy-duty engines beginning with the 1974 model year. A heavy-duty engine is defined as any engine which the engine manufacturer could reasonably expect to be used for motive power in a heavy-duty vehicle.

3.0 REFERENCES

3.1 Federal Register, Volume 40 Number 40 February 27, 1975. pp 8482-8495

4.0 REQUIRED EQUIPMENT/CONDITIONS

4.1 Exhaust gas sampling and analytical system conforming to schematic H774-1 (Attachment No. 1) with the following instruments:

A. Nitric oxide NDIR analyzer, range 0-4000 PPM

B. Carbon monoxide NDIR analyzer, range 0-10 percent

C. Carbon dioxide NDIR analyzer, range 0-16 percent

D. High-range hydrocarbon NDIR analyzer, range 0-10,000 PPM hexane equivalent (propane conc. x 0.52)

E. Low-range hydrocarbon NDIR analyzer, range 0-1,000 PPM hexane equivalent.

Sample lines, filter, valves, pumps, flowmeters and other components which are in contact with exhaust sample must be of stainless steel, teflon, viton or glass construction.

4.2 Zero grade air or nitrogen meeting the following maximum requirements of contamination level

Carbon Response	= 10 ppm
CO Response	= 10 ppm
NO Response	= 1 ppm
CO_2 Response	= 400 ppm

4.3 Calibration gases with concentrations known to be within ±2 percent of true value as follows (N_2 diluent):

Low range HC analyzer-Hexane equivalent[1]	High range HC analyzer-Hexane equivalent	NO analyzer-NO	CO and CO_2 analyzers-Blend of CO and CO_2 containing	
			CO plus CO_2	
			Mole percent	Mole percent
p.p.m	p.p.m	p.p.m		
100.....	600.....	250....	0.5	16.0
200.....	1,000.....	500....	1.0	15.0
300.....	1,500.....	750....	2.0	14.0
400.....	2,500.....	1,000....	3.0	13.0
600.....	4,000.....	1,500....	4.0	12.0
800.....	6,000.....	2,000....	6.0	10.0
1,000.....	8,000.....	2,500....	8.0	8.0
	10,000.....	3,000....	10.0	6.0
		3,500.....		
		4,000.....		

[1] The hexane equivalent of propane when used as the normalizing gas for calibrating nondispersive infrared analyzer is prescribed to be 0.52 (propane concentration x 0.52 = hexane equivalent concentration). Minimum storage temperature of the cylinders shall be 60°F; minimum use temperature shall be 68°F.

NOTE: Concentration values should be traceable to EPA gravimetric standards.

4.4 Daily working gases (span gases) equivalent to 80 to 100 percent full scale response for each range.

4.5 Recorders (4 channels) for continuous record of analyzer output and calibration.

5.0 PRECAUTIONS

5.1 Safety precautions should be followed when handling compressed gases. NO and CO are toxic gases.

5.2 Insure gas cylingers have adequate pressure for testing (>200 psig.)

5.3 When calibrating/spanning/sampling the identical instrument inlet pressure must be used. Adjust flows to pressure reading rather than flowmeter.

5.4 Insure that flowrates are adequate to minimize response time.

5.5 Check the condition of the drier in the nitric oxide analyzer sampling line. Replace the drying agent if necessary.

5.6 Insure that the sample probe(s) is properly inserted 2 feet into tailpipe.

6.0 VISUAL INSPECTION

6.1 Inspect recorder connections and other electrical connections to insure they are secure.

6.2 Inspect pressure gauges and flowmeters for proper operation, stuck floats, pointers, etc.

6.3 Inspect system vent for proper connection.

7.0 TEST ARTICLE PREPARATION

7.1 Leak check exhaust gas sampling system by closing off valve at sample probe. All pressure gauges should drop to zero reading.

7.2 Calibrate exhaust emission analyzer system using zero and span gases. Adjust instrument gain and zero as required. Analyzers require a minimum of 2 hours warm-up, therefore they are usually never turned off, except for chopper motors, while they are in service.

7.3 The following inter-service checks are performed monthly.

(5) Check response of hydrocarbon analyzer to 100 percent CO. If response is greater than 0.5 percent full scale, refill filter cells with 100 percent CO, and recheck. Note any remaining response on chart. If response still exceeds 0.5 percent, replace detector.

(6) Check response of hydrocarbon analyzers to nitrogen saturated with water at ambient temperature. Record ambient temperature. If the low-range instrument response exceeds 5 percent of full scale with saturated nitrogen at 75°F., replace the detector. If the high-range response exceeds 0.5 percent of full scale, check detector on low-range instrument, then reject if response exceed 5 percent of full scale at 75°F.

7.4 Change filter papers and back flush water traps and sample line.

7.5 Turn-on sample pumps.

8.0 TEST PROCEDURE

The exhaust sample is analyzed continuously during 4 nine-mode cycles.

Test Sequence	Test Description	Data Output
101	Check zero, span, flow and pressure immediately prior to start of cycle.	Recorder Defl.
102	Start sample flow and recorders when engine throttle control is returned to normal idle position from the initial off-idle position. Chart speed should be 6 inch per minute.	Recorder Defl.
103	Sample and analyze exhaust gases for 4 nine-mode cycles (TP-757) including the final idle mode.	Continuous Trace, Computer Input
104	Purge sample line with nitrogen to establish a a constant hydrocarbon "hangup".	HC Defl. vs. Time
105	Recheck zero, span, flowmeter, pressure gauge readings.	

9.0 DATA INPUT

9.1 The following steps are performed by direct computer analysis.

(a) Time correlate the hydrocarbon, carbon monoxide, carbon dioxide, and nitric oxide charts. Determine the location on the chart of analyzer response corresponding to each mode. Determine and compensate for trace abnormalities.

(b) Locate the last 3 seconds of the HC, CO, CO_2, and NO traces obtained from the 3 inch, 10 inch, 16 inch, 19 inch and idle modes. Divide this portion of each trace into a minimum of three segments of equal length. Determine the chart reading at the end of each segment to within 0.5 percent of full scale. Convert these readings into concentration values. Determine the average of these values.

(c) The values recorded for the initial idle mode are used for both warm-up cycles 1 and 2. The final idle mode values are applied to hot cycles 3 and 4.

(d) Locate the HC, CO, CO_2, and NO closed throttle mode traces. Divide each trace into a minimum of 43 segments of equal length. Determine the chart reading at the end of each segmentss within 0.5 percent of full scale. Convert these reading into concentration values. Determine the average of these values.

9.2 Fuel consumption in lbs. per hour are determined for each mode including idle.

9.3 Record test number, instrument operators, all pertinent instrument information such as tuning-gain-serial numbers-detector number-range, barometric pressure, intake air temperature and humidity.

10.0 DATA ANALYSIS

10.1 Analysis of all recorded data performed by Data Validation for completeness, accuracy and conformance to specified procedure.

11.0 DATA OUTPUT

11.1 Concentration values are reduced by computer to brake specific values (gms/hr) for CO, HC and NO_x using specified weighting and humidity correction factors.

12.0 ACCEPTANCE CRITERIA

12.1 Upon completion of the test, the hydrocarbon concentration (hangup) shall drop to 5 percent or less of full scale within 10 seconds and 3 percent or less of full scale within 3 minutes, while being purged with nitrogen at the specified flow rate, or the test is invalid.

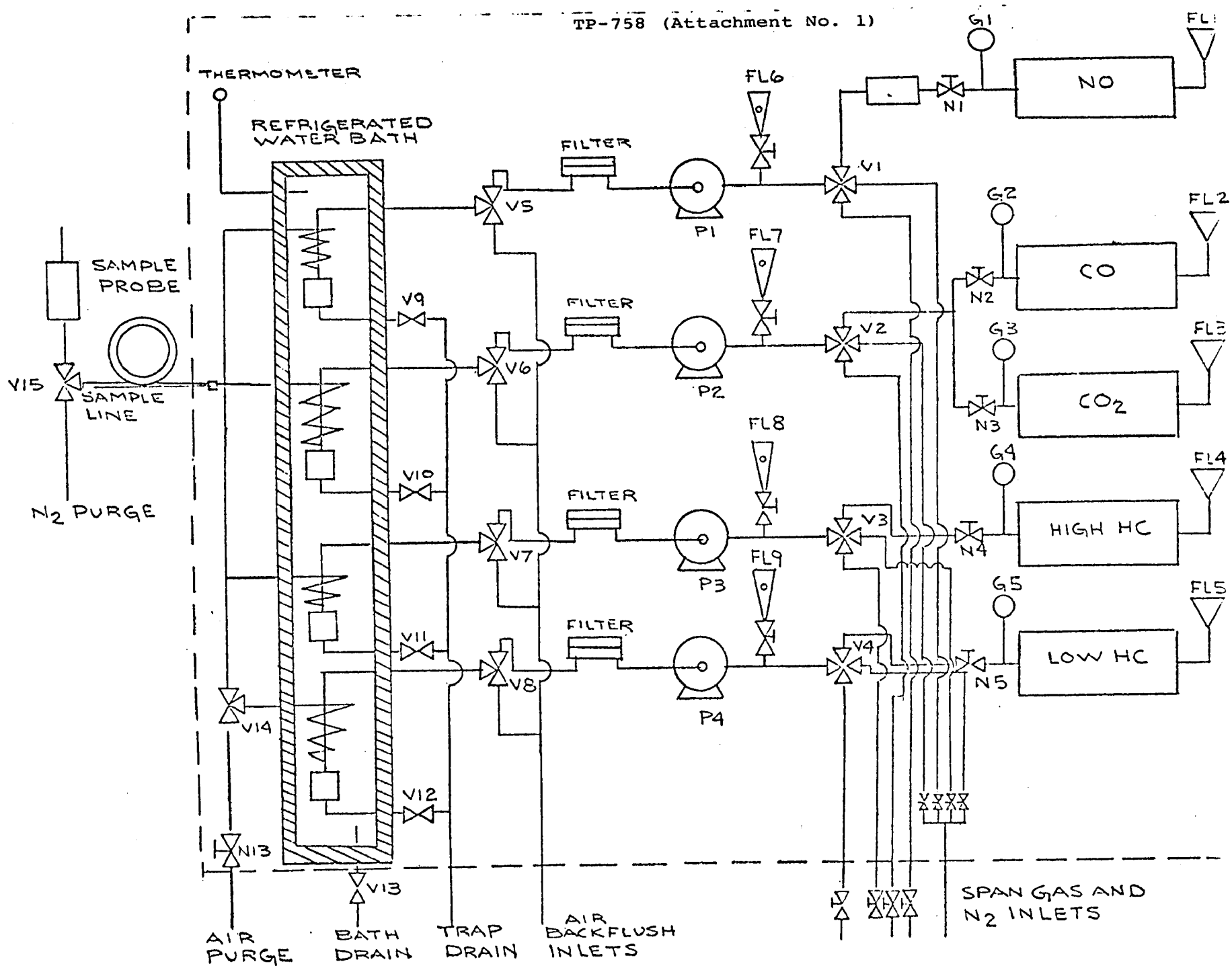
12.2 A drift in excess of 2 percent of full scale in the calibration of any one or the exhaust emission analyzers invalidates the test.

13.0 QUALITY PROVISIONS

13.1 Analyzer calibrations and interference checks performed monthly while in service.

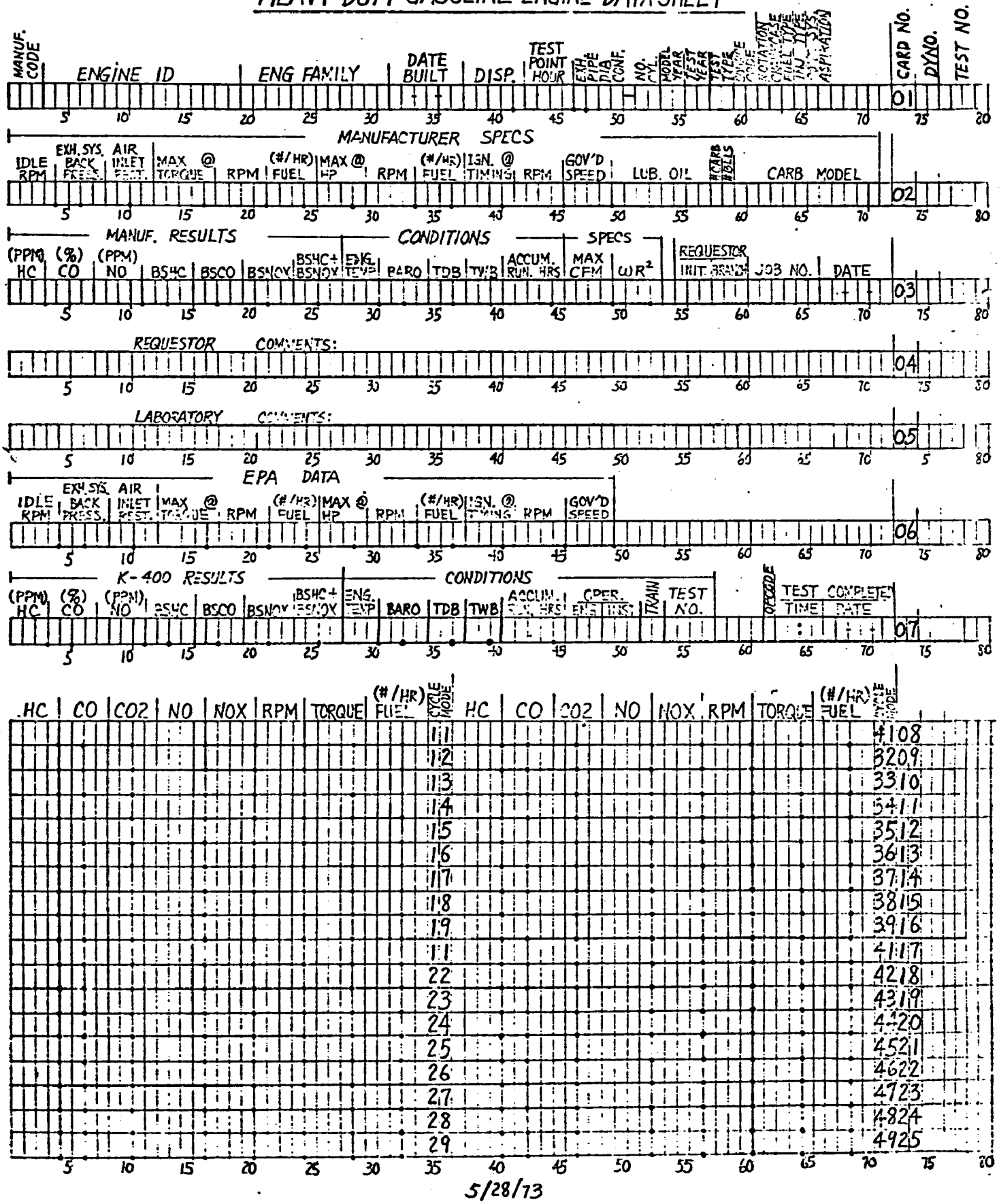
13.2 Calibration checks performed before and after each test.

13.3 Quality Assurance performs audit of procedure and test cell equipment on non-routine basis.



FLOW SCHEMATIC OF EXHAUST GAS ANALYSIS SYSTEM EMPLOYED BY EPA

HEAVY DUTY GASOLINE ENGINE DATA SHEET



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