Ministry of Environment, Notification No. 2010-

Regarding matters about concerning the average fuel efficiency standard for automobiles, the allowable automobile emission standard of greenhouse gases (GHGs) for automobiles and application and management of the standards under Article 47-2 of □Framework Act on Low Carbon, Green Growth□ and Article 37 of Enforcement Ordinance of the Act, the followings are notified.

2010. . .

Minister of Environment

Notification (proposal) about average fuel efficiency standard for automobiles, allowable emission standard of GHGs for automobiles and their application and management

Chapter 1. General Provisions

Article 1 (Purpose) The purpose of this Notification is to define the average fuel efficiency standard and the allowable emission standard of GHGs for automobiles that automobile manufacturers (including importers, considered same hereinafter) should follow under Article 47 of □Framework Act on Low Carbon, Green Growth□ and Article 37 of Enforcement Ordinance of the Act and to stipulate matters necessary to apply and manage the standards.

Article 2 (Terminology) The terms used in this rule are defined as follows:

1. “Fuel efficiency” is a mileage (km/ℓ) per fuel used in automobile.
2. “Average fuel efficiency” is an average (km/ℓ) calculated by dividing the sum of fuel efficiency of all automobiles sold by auto manufacturers by the number of automobiles sold.
3. “Average fuel efficiency standard” is a standard (km/ℓ) about the average fuel efficiency that auto manufacturers should follow.
4. “Greenhouse gas (GHG) emissions” are the sum (g/km) of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emitted from an automobile per mileage.
5. “Average GHG emissions” are the average (g/km) of the sum of GHGs emitted from all vehicles sold by auto manufacturers by the number of automobiles sold.
6. “Allowable emission standard of GHGs for automobiles” is the standard (g/km) about the average GHG emissions that auto manufacturers should follow.
7. “Same vehicle type” is the group of automobiles whose fuel efficiency and GHG emissions are expected to be similar according to their structure and characteristics, and they are not considered as same vehicle type when the followings are changed:

    A. Vehicle type

    B. Displacement, supercharger, intake-cooling method, etc.

    C. Fuel supply system

    D. Transmission type (automatic, manual), gear mode, and drive methods

(front-wheel drive, rear wheel drive, four-wheel drive, etc.)

E. More than 5% of change in complete vehicle curb weight

F. Other cases recognized for their necessity of being separately categorized

8. “Complete vehicle curb weight” is a total weight of an automobile with a full tank of fuel, motor oil and coolant, spare tires, standard parts and options installed on mores than 50% o the vehicles including air conditioner and power steering wheel that use the power of motor.

Article 3 (Applicable Vehicle) This Notification is applied only to cars and a van for 10 or fewer passengers sold in Korea, manufactured in Korea or imported under Article 3 of Automobile Management Act and Table 1 in Article 2 of Enforcement Regulations of the Act and whose total weight is less than 3.5t, provided that vehicles with the following special purposes are considered as exception:

1. Vehicles manufactured for the medical purposes such as treatment and patient transportation.
2. Military vehicles
3. Vehicles manufactured for the purposes of broadcasting, telecommunication and others
4. Vehicles categorized as special-purpose one considering such purposes as public interest

Chapter 2. Average fuel efficiency standard and allowable emission

standard of GHGs

Article 4 (Average fuel efficiency standard, allowable emission standard of GHGs, etc.) □ The average fuel efficiency standard for automobiles set by the Minister of Knowledge Economy and the allowable emission standard of GHGs for automobiles set by the Minister of Knowledge Economy are described in Table 1.

□For automobiles to which the average fuel efficiency standard or the allowable emission standard of GHGs is applied, the rules shall be applied in a phase-in manner, based upon the sales volume of each auto manufacturer: 30% in 2012; 60% in 2013; 80% in 2014; and 100% in 2015. [

Article 5 (Selection of Standards) □ Auto manufacturers should select and follow either an average fuel efficiency standard or an allowable emission standard of GHGs every year.

□ According to the above □, auto manufacturers should select a standard to follow for the year and report it to Minister of Environment by end of March. In this case, if an auto manufacturer wants to change a standard that was selected for the previous year, it should attach a reason for the standard change. Unless a car manufacturer additionally submits a standard by end of March, the manufacturer shall be deemed to keep using the standard selected in the previous year.

□ The Minister of Environment should provide information about standards selected by auto manufacturers under the above □ and □ to the Minister of

Knowledge Economy.

□ An auto manufacturer, in principle, may not change standards selected for the year, but unavoidable changes of standard for reasons such as corporate M&A shall be allowed if the Minister of Environment and the Minister of Knowledge Economy permit so in consultation

Article 6 (Standard for Manufacturer with Small Sales Volume) In consultation with the Minister of Knowledge Economy, the Minister of Environment may define separate rules about standards and application for an auto manufacturer whose sales volume is small in Korea.

Chapter 3. Measurement of automobile fuel efficiency and GHG emissions

Article 7 (Fuel efficiency and GHG emissions measurement, data submission, etc.)

□ Before putting automobiles on the market, an auto manufacture should categorize them into a group of the same vehicle type and obtain certification about fuel efficiency and GHG emissions from the Minister of Environment.

□ In order to obtain certification as described in the above □, an auto manufacturer should have its vehicles measured for fuel efficiency and GHG emissions by a test agency under Article 9 and submit measurement results within 30 days in the Appendix No. 1 to the Minister of Environment. When a auto manufacturer has equipment and personnel approved under □Fuel Use Rationalization Act □ or □Clean Air Conservation Act□, it may test fuel efficiency and GHG emissions by itself and submit results.

□ The Minister of Environment should provide the Minister of Knowledge Economy with fuel efficiency and GHG emissions information submitted by auto manufacturers under the above □.

□ If certified data such as vehicle fuel efficiency and GHG emissions under the above □ are changed, an auto manufacturer may request change in certification.

Article 8 (Measurement method of fuel efficiency and GHG emissions) The methods of measuring vehicle fuel efficiency and GHG emissions are described in Table 2.

Article 9 (Test agency, etc.) Agencies qualified to measure automobile fuel efficiency and GHG emissions are entities that have equipment and technical personnel as described in Table 3 and are as follows:

1. National Institute of Environmental Research
2. Korea Environment Corporation
3. Korea Institute of Fuel Research
4. Korea Automotive Technology Institute
5. Korea Institute of Petroleum Management
6. Other entities that the Minister of Environment permits in consultation with the Minister of Knowledge Economy

Article 10 (Follow-up) □ In its follow-up action, the Minister of Environment may check whether fuel efficiency and GHG emissions for automobiles are in line with what have been certified.

□ In the follow-up by the Minister of Environment, three vehicles in the same type from those possessed by an auto manufacturer shall be randomly chosen and their fuel efficiency and GHG emissions shall be measured by a test agency under the measurement method of Article 8 in the presence of a government official designated by the Minister of Environment. However, just one vehicle is chosen and tested for the same vehicle type if sales volume in the previous year was fewer than 100.

□ If the arithmetic mean values between fuel efficiency and GHG emissions certified under Article 7 and those measured in the above □ exceed the allowable error tolerance (5%), additional three vehicles should be tested. If the additionally measured results exceed the allowable error tolerance (5%) again, the arithmetic mean values measured in the two tests are set as new fuel efficiency and GHG emissions for the automobile. However, in case of the same vehicle type in the proviso in the above □, only one additional vehicle is tested.

Article 11 (Labeling of fuel efficiency and GHG emissions) Auto manufacturers should label fuel efficiency under Article 15 of □ Fuel Use Rationalization Act □ and automobile GHG emissions certified under Article 17 and others.

Chapter 4. Submission and Calculation of Actual Data

Article 12 (Submission of actual data) □ Every year, auto manufacturers should prepare and submit to the Minister of Environment by end of March in the form of Appendix No. 2 automobile sales volume for the year, fuel efficiency and GHG emissions data about the same vehicle type, the average fuel efficiency standard or the allowable emission standard of GHGs for auto manufacturers to follow and data about emission levels above or below the standards (“actual data” hereinafter), showing the satisfaction of the average fuel efficiency standard or the allowable emission standard of GHGs. In such case, the Minister of Environment should submit actual data from auto manufacturers to the Minister of Knowledge Economy.

□ When the Minister of Environment reviews actual data submitted by a auto manufacturer under the □ and finds nothing incorrect, the Minister should consult with the Minister of Knowledge Economy the auto manufacturer’s average fuel efficiency or average GHG emissions for the year, efficiency/emission levels below or above the standards in actual data or efficiency/emission levels than can be carried over or should be lowered and finalize and officially announce them by late June. However, when there is anything incorrect about actual data submitted by an auto manufacturer, it may be requested that the manufacturer should correct or complement it and the manufacturer should submit corrected or complemented actual data to the Minister of Environment within one month from the request date for correction or complement

Article 13 (Actual Data Calculation) □ Auto manufacturers shall calculate actual data about average fuel efficiency and average GHG emissions for automobiles sold for the year as follows, provided that in calculating average fuel efficiency under the 2 in the below, fuel efficiency certified under Article 7 should be multiplied by 1.26 for the result to be used as fuel efficiency in case of LPG-powered vehicles.

1. Average GHG emissions (g/km) = [∑(sales volumes of automobiles for each type (vehicle)× GHG emissions of automobiles for each type (g/km))/ total sales volume of automobiles (vehicle)]

2. Average fuel efficiency (km/l) = [total sales volume of automobiles (vehicle)/∑(sales volumes of automobiles for each type (vehicle)/ fuel efficiency for automobiles of each type (km/l))]

□ Auto manufacturers may calculate the average GHG emissions or average fuel efficiency under the following standards for automobiles emitting low-level GHGs or with high fuel efficiency.

1. If GHGs emitted by an automobile are less than 50g/km or fuel efficiency based on fuel type is higher than 46.9km/l for gasoline-powered automobile, 53.8km/l for diesel-powered automobile and 35.3km/l LPG-powered automobile, every vehicle or electric car that will have been sold each year until 2015 shall be multiplied by three in the calculation.

2. If GHG emitted by an automobiles is ≥50g/km and ≤100g/km or fuel efficiency based on fuel type is ≥ 23.4km/l and ≤ 46.9km/l for gasoline-powered automobile, ≥ 26.9km/l and ≤ 53.8km/l for diesel-powered automobile, ≥ 17.7km/l and ≤ 35.3km/l for LPG-powered automobile, every vehicle or electric

car that will have been sold in each year until 2015 shall be multiplied by two in the calculation.

 If technology applied to reduce GHGs and increase fuel efficiency cannot be measured in test method of Article 8, auto manufacturers may reflect it in calculating average GHG emissions or average fuel efficiency only when they can prove the effects of reducing vehicle GHG emissions and increase fuel efficiency.

 Based on the average consumption efficiency or the average GHG emissions calculated under the above to , auto manufacturers can calculate extra or insufficient achievement for the year with the following formula. If actual data meet the standards, it is considered as extra achievement, otherwise as insufficient achievement.

1. Extra achievement or insufficient achievement in GHGs emissions = (allowable emission standard of GHGs – average GHG emissions) × sales volume of automobiles subject to the standard

2. Extra achievement or insufficient achievement in fuel efficiency = (average fuel efficiency standard – average fuel efficiency) × sales volume of automobiles subject to the standard

 When an auto manufacturer changes the standards to follow under Article 5, its actual data shall be estimated again to calculate extra or insufficient achievement.

Article 14 (Carry-over, trade, etc. of extra achievement) When an auto manufacturer has extra achievement, the manufacturer may carry over the achievement to the next three years from the year of extra achievement or sell the achievement to other auto manufacturers. However, if the auto manufacturer has failed to meet the standards for the past three years, extra achievement should be first used to make up for insufficient achievement.

□ An auto manufacturer which is categorized as the one with small volume and therefore, to which different standards are applied may not trade extra achievement with other auto manufacturers.

Article 15 (Complement of insufficient achievement) □ If an auto manufacturer fails to achieve the average fuel efficiency standard or the allowable emission standard of GHGs, first, it should make up for insufficient achievement within three years from the year of insufficient achievement. In such case, the auto manufacturer should submit to the Minister of Environment a plan to do so.

□ In order to make up for insufficient achievement, an auto manufacturer may use its extra achievement carried over or buy extra achievement from other manufacturers.

Supplementary Provisions

This Notification takes effect from January 1st, 2012.

[Annex 1.]

Average fuel efficiency standard &

allowable emission standard of GHGs for automobiles

1. Average fuel efficiency standard for automobile

Fuel efficiency standard for automobiles = 28.4577 - 0.007813 × m Average fuel efficiency standard for automobiles = [total sales volumes of automobiles (vehicle)/∑(sales volumes of automobiles for each type (vehicle) / fuel efficiency standard for automobiles of each type)]

Note: m is a complete vehicle curb weight of automobiles sold for each type for the year

2. Allowable emission standard of GHGs for automobiles

Allowable emission standard of GHGs for automobiles = 140 + 0.0484 × (M-1,423.2)

Note: 1. M is the average complete vehicle curb weight of automobile sold by each manufacturer for the year

2. Automobile GHG emissions (g/km) = CO_2(g/km)+23×$_{CH4}$(g/km)+296×N_2O(g/km)

3. Methane (CH_4), and nitrous oxide (N_2O) in GHGs emitted by automobiles, shall considered from 2015.

[Annex 2]

Vehicle energy consumption efficiency and greenhouse gas emissions measurement method

□ To measure vehicle energy consumption efficiency and greenhouse gas emissions, use the combined mode that consists of the CVS-75 (city drive) mode and the Highway (highway drive) mode.

□ Calculate energy consumption efficiency and greenhouse gas emissions measured in the combined mode as follows:

- Vehicle energy consumption efficiency (km/L) = 1/[0.55/fuel efficiency measured in the CVS-75 mode (km/L) + 0.45/ fuel efficiency measured in the Highway mode (km/L)]
- Vehicle greenhouse gas emissions (g/km) = 0.55* greenhouse gas emissions measured in the CVS-75 mode (g/km) + 0.45* greenhouse gas emissions measured in the Highway mode (g/km)

□ Measurement in CVS-75 mode (relevant to Article 7)

1. Device

A device to measure vehicle energy consumption efficiency and greenhouse gas emissions consists of a chassis dynamometer, an exhaust gas sampler, an exhaust gas analyzer, a data-processing unit and other parts.

A. Gasoline and gas-powered vehicle

(1) Chassis dynamometer

(A) It should be possible to use a load absorption unit to reproduce road driving conditions and use methods including a flywheel method to reproduce an inertia weight.

(B) There should be a RPM counter for a roll or an axis, or it should be possible to measure mileage in any other methods recognized by the Minister of Environment.

(C) The diameter of a nominal roll consisting of two small rolls should be 22cm (17in). And the diameter of a single roll in a dynamometer should be 122cm (48in). A dynamometer with a roll of a different diameter may be used if same road load can be reproduced and the Minister of Environment recognizes it better.

(2) Sampler

(A) Overview

It should be designed to measure actual vehicle gas emissions (Figure 1). A certain flow should be continuously collected from a sample. Emissions are calculated from a sample concentration and a total flow during the test.

(B) Device requirement

A critical flow venturi-constant volume sampling (CFV-CVS) is widely used and other samplers, if approved in advance by the Minister of Environment, may be used.

1) Change in constant pressure in vehicle vent pipe: When nothing is connected to a vent pipe, the constant pressure should be within ±127mm H_2O (1.2kpa) in one driving cycle of a dynamometer.

2) Accuracy and precision of thermometer: The temperature should be within ±1.1□ (2□) and it should be possible to read 62.5% of a temperature change within 0.100 sec. in terms of sensitive time.

3) Accuracy and precision of pressure measurement device: ±40mmH2O(0.4 kpa)

4) CVS flow: It should be sufficient to prevent moisture condensation. (In most vehicles, 0.140-0.165m^3/sec (300 - 350cfm) would be sufficient.)

5) Sampling pouch: It should be big enough not to prevent the flow of a sample.

(3) Exhaust gas analyzer

(A) NOx analyzer: Use a chemical luminescence method (CLD).

(B) CO and CO_2 analyzer: Use a non-dispersive infrared analyzer (NDIR).

(C) HC analyzer: Use Flame Ionization Detector (FID) as an HC (total hydrocarbon) analyzer. Ise Gas Chromatography-FID (GC-FID) or its equivalent or higher level as CH_4 (methane) analyzer.

[Figure 1] Exhaust gas sampler (CFV - CVS)

B. Diesel-powered vehicle

(1) Overview

It is intended to measure gas emissions from a diesel-powered vehicle by the CVS method in the same approach as in a gasoline-powered vehicle. And to measure hydrocarbon (HC), directly collect it from a diluted sample and measure it with heated FID (HFID).

(2) Device requirements

(A) CFV-CVS requirements for a diesel-powered vehicle are same with those in a gasoline-powered vehicle except the followings:

1) There should be a heat exchanger.

2) The temperature of the diluted emission gas measured right before CFV should be within ±11□(20□) from the temperature set at the start of the measurement. And the accuracy and precision of the thermometer should be within ±1.1□(2□).

(B) To minimize heat loss in exhaust gas, a pipe connecting a vent pipe and a dilution tunnel should be made of stainless steel at 610cm(20ft), if warmed, or 365cm(12ft)m if not warmed.

(C) The temperature of the diluted air should be 20-30□(68-86□) at the time of measurement.

(D) Dilution tunnel

1) A heated hydrocarbon sampling tube should be prepared in a way to collect sufficiently mixed gas.

2) Its diameter should be at least 20.3Cm (8.0in).

3) It should be electrically conductive that does not react with exhaust gas composition.

4) It should be earthed.

(E) The internal temperature of a dilution tunnel should be high enough to prevent moisture condensation but should not be higher than 52□ (125□) from a sampling point during measurement.

(F) Sampling tube for hydrocarbon measurement

1) It should be placed where diluted air and exhaust can be mixed enough.

2) The temperature should be maintained at 191±11□ (375±20□).

4) Its internal diameter should be at least 0.457cm (0.19").

(G) The degree of a temperature detector should be within ±1.1□ (±2□).

(H) Diluted exhaust gas flow in sampler for hydrocarbon measurement

1) The temperature inside a heating device should be 191±6□(375±10□) and temperature detector degree should be ±1.1□(2□).

2) The temperature of diluted exhaust gas in a hydrocarbon measurement device should be 185-197□(365-385□).

(I) An exhaust gas analyzer is all same with that for a gasoline-powered vehicle except a hydrocarbon analyzer.

2. Measurement of exhaust gas

During the test, the laboratory temperature should be kept at 20-30□(68-86□).

A. Test vehicle preparation and preliminary drive

(1) Before testing, drive a vehicle at mileage (breaking in) of more than 3,000km under durability driving schedule in □Clean Air Conservation Act□ or its equivalent schedule. However, the breaking-in may be omitted or shortened when energy consumption efficiency and greenhouse gas emissions are checked for a follow-up test vehicle as described in Article 10.

(2) Conduct mechanical inspection according to the vehicle specifications.

(3) Check fuel quantity in fuel tank. (Inject defined test fuel more than 40%.)

(4) Place a test vehicle onto a chassis dynamometer and drive it under Urban Dynamometer Driving Schedule (UDDS).

(5) Remove the vehicle from a dynamometer in 5 minutes after the completion of preliminary drive, and move it to a parking space to park it. The parking hour is 12 to 36

hours for a gasoline or gas-powered vehicle and more than 12 hours for a diesel-powered vehicle.

B. Exhaust gas measurement

On a dynamometer, drive a test vehicle in the following three stages and collect and analyze exhaust gas at each stage.

Stage	Time (sec.)	Distance	Note
Cold running test			
Initial stage	505	5.78km (3.59 mile)	Start at low temperature
Cold running test	865	6.29km (3.91 mile)	
Stable stage	9-11 min.	-	
Parking	505	5.78km (3.59 mile)	Start at high temperature
High running test			
Total	44 min.	17.85km (11.59 mile)	

(1) Sequence of exhaust gas measurement

(A) Push a vehicle onto a dynamometer, without starting the engine.

(B) Open the hood and place a cooling fan 30.5cm (12in) in front of the chassis.

(C) Connect a test sampling valve to a sampling pouch in vacuum to collect diluted exhaust and diluted air.

(D) Run CVS, a sampling pump, a temperature recorder and a vehicle cooling fan.

(E) Adjust a sampling flow to the defined one and set the gas flow measurement device to zero.

1) The minimum flow of gas sample (except hydrocarbon) is 0.08l/sec(0.17cfm).

2) The minimum flow of hydrocarbon sample is 0.031l/sec (0.067cfm).

(F) Connect an exhaust sampling tube to a vehicle vent pipe.

(G) Run the gas flow measurement device, and direct the sample gas flow over the sample selection valve toward exhaust sample pouch during “initial stage of cold running test” and toward diluted air pouch during “initial stage of cold running test”. In case of a diesel-powered vehicle, run the integrator of hydrocarbon analyzer.

(H) Shift the gear 15 sec. after starting the engine.

(I) Initially accelerate the vehicle 20 sec. after starting the engine under the driving schedule.

(J) Drive the vehicle under urban dynamometer driving schedule (UDDS).

(K) After driving the vehicle for 505 sec., decelerate it. Then, immediately change the sample flow from the pouch at the initial stage of cold running test to the pouch at the stable stage of cold running test, and stop No. 1 of the gas flow measurement device.

(L) Run No. 2 of the gas flow measurement device. In case of a diesel-powered vehicle, run No. 2 of the diesel hydrocarbon integrator.

(M) Record RPM of a roller or an axis before the acceleration that starts 510th sec. and set the counter to zero or replace it with the second counter.

(N) Send exhaust sample and diluted air at the initial stage of cold running test to the analyzer as soon as possible and analyze them in 20 minutes from sampling under the exhaust gas analysis method to get stable analysis results.

(O) Stop the engine 2 sec. after final deceleration of 1369 sec.

(P) After 5 sec. when the engine is stopped, turn off No. 2 of the gas flow measurement device

(Q) Set the sample selection valve to “Preparation”.

(R) Record RPM of a roller or an axis and the value on gas meter or flow meter and then set the counter back.

(S) Send exhaust gas and diluted air sample at the initial stage of cold running test to the analyzer as soon as possible and analyze them in 20 minutes from sampling to get stable analysis results.

(T) Turn off the cooling pan immediately after sampling.

(U) Turn off CVS, or separate exhaust gas sampling tube from a vehicle vent pipe.

(V) For high running test, repeat (B) to (K). Start operation in (H) between 9 and 11 min. after sampling for cold start is done.

(W) After driving the vehicle for 505 sec. decelerate it. Then, immediate turn off No. 3 of the gas flow measurement device. In case of a diesel-powered vehicle, set a sample selection valve to “Preparation”. Record RPM of a roller axis and also record a No. 3 gas meter value and a flow value measured.

(X) Send exhaust and diluted air “at the initial stage of hot running test” to an analyzer as soon as possible to analyze them in 20 min from sampling.

(Y) Separate a sampling tube from a vehicle vent pipe and move the vehicle from dynamometer to a sealed room. It is accepted to move it by driving.

(Z) Turn off CVS and CFV.

(2) Exhaust analysis

(A) CO, CO2, NOx, HC and CH4 analysis

1) Set an analyzer to zero to get a stable value and inspect the device after test.

2) Send span gas to calibrate gain on analyzer. To reduce error, set the span value at the same flow with the one used to measure a sample and calibrate it. Use the span gas with the 75-100% of full-scale concentration. If gain on analyzer gives big impact, check calibration and record accrual concentration of record note.

3) Check the zero and if necessary, repeat 1) and 2).

4) Check flow and pressure.

5) Measure CO, CO2, NOx, HC and CH4 concentrations of sample.

6) Check the zero and a span value. If a variance is bigger than 2% of full scale, repeat (A)-(B).

(B) Diesel hydrocarbon analysis

1) Calibrate the zero of a HFID analyzer and get stable zero.

2) Send span gas to calibrate gain on analyzer. Use the span gas with the 75-100% of full-scale concentration.

3) Check the zero. Zero gas and span gas in the analyzer can be adopted in any one of the following methods:

A) Close an HC sample heat valve and let gas flow into HFID.

B) Directly connect the zero and span gas tube to HC sample tube, and let the gas at 190-210% HFID flow.

Note: To minimize error, make HFID flow and pressure same at the time of zero span calibration and measurement.

4) During measurement, continuously record the exhaust concentration of diluted hydrocarbon.

5) Check the zero point and a span value. If the variance is bigger than 2% of full scale, stop the test and check HC “hang-up” or electric “drift” of an analyzer.

(3) Exhaust calculation

(A) Ywm = 0.43[Yct + Ys)/(Dct + Ds)] + 0.57[(Yht + Ys)/(Dht + Ds)]

Here,

Y_{wm} = CO, CO_2, NOx, HC, CH_4 and NMHC weighted exhaust gas mass (g/km, g/mile)

Y_{ct} = exhaust gas mass at the initial stage of cold running test (g/test step)

Y_{ht} = exhaust gas mass at the initial stage of hot running test (g/test stage)

Y_s = exhaust gas mass at the stable stage of cold running test (g/test stage)

D_{ct} = mileage at the initial stage of cold running test (km, mile)

D_h = Mileage at the initial stage of hot running test (km, mile)

D_s = Mileage at stable stage of cold running test (km, mile)

(B) Mass concentration of pollutants by stage in driving test

$HC_{mass} = V_{mix}$ x HC density x $(HC_{conc}/10^6)$

$CH_{4mass} = V_{mix}$ x CH_4 density x $(CH_{4conc}/10^6)$

$NMHC_{mass} = V_{mix}$ x NMHC density x $(NMHC_{conc}/10^6)$

$NO_{xmass} = V_{mix}$ x NO_2 density x $(NO_{xconc}/10^6)$

$CO_{mass} = V_{mix}$ x CO density x $(CO_{conc}/10^6)$

$CO_{2mass} = V_{mix}$ x CO_2 density x $(CO_{2conc}/10^2)$

Here,

HC_{mass} = hydrocarbon mass concentration (g/test stage)

$HC_{density}$ = 0.5768kg/m^3 (16.33g/ft^3) (ratio of carbon to hydrogen at

1:1.85 and at 20□101.3Kpa 68□ 760mmHg)

HC_{conc} = hydrocarbon concentration in diluted exhaust whose hydrocarbon concentration is adjusted in diluted air (ppmC)

$HC_{conc} = HC_e - HC_d (1-1/DF)$

Here,

HC_e : hydrocarbon concentration in diluted exhaust (ppmC)

HC_d : hydrocarbon concentration in diluted air (ppmC)

CH_{4mass} = CH_4 mass concentration (g/test stage)

CH_4density = 0.6672kg/m^3 (18.89g/ft^3) (20□, 101.3Kpa(at 68□, 760mmHg))

CH_{4conc} = CH_4 concentration in diluted exhaust whose CH_4 concentration is adjusted in diluted exhaust (ppmC)

$CH_{4conc} = CH_{4e} - CH_{4d}(1-1/DF)$

Here,

CH_{4e} = CH_4 concentration in diluted exhaust (ppmC)

CH_{4d} = CH_4 concentration in diluted air (ppmC)

$NMHC_{mass}$ = NMHC mass concentration (g/test stage)

$NMHC_{density}$ = 0.5768kg/m^3 (gasoline, diesel) and 0.04157(12.011 + H/C(1.008))kg/m^3(natural gas, LPG) (at 20□, 101.3Kpa (at 68□, 760mmHg))

Here,

H/C = ratio of carbon to hydrogen of test fuel

$NMHC_{conc}$ = NMHC concentration in diluted exhaust whose NMHC concentration is adjusted in diluted air (ppmC)

$NMHC_{conc} = HC_{conc} - (r_{CH4} \times CH_{4conc})$

Here,

r_{CH4} = FID response factor for methane, in case of a natural gas-powered vehicle

r_{CH4} = FIDppm / SAM ppm

Here,

FID ppm : methane concentration(ppmC) analyzed in FID,

SAM ppm: known methane concentration (ppmC), r_{CH4}=1 for other vehicle

NO_{xmass} = nitrogen oxide mass concentration(g/test stage)

$NO_{2density}$ = 1.913kg/m^3 (54.16g/ft^3)(20□, 101.3Kpa(NO_2 at 68□ 760mmHg))

NO_{xconc} = NO_x concentration in diluted exhaust whose NO_x concentration is adjusted in diluted air (ppm)

$NO_{xconc} = NO_{xe} - NO_{xd}(1-1/DF)$

Here,

NO_{xe} = NO_x concentration in dilute exhaust (ppm)

NO_{xd} = NO_x concentration in diluted air (ppm)

CO_{mass} = carbon monoxide mass concentration (g/test stage)

COdensity = 1.164kg/m^3(32.97g/ft^3) (20□, 101.3Kpa (68□ 760mmHg))

CO_{conc} = CO concentration in diluted exhaust whose CO concentration is adjusted in diluted air (ppm)

$CO_{conc} = CO_e - CO_d(1-1/DF)$

Here,

CO_e : CO concentration in diluted exhaust adjusted by water vapor pressure and CO_2 extraction (ppm), ratio of C to H assumed at 1:1.85

$CO_e = (1-0.01925\ CO_{2e} - 0.000323\ R)\ CO_{em}$

CO_d : CO concentration in diluted exhaust adjusted by water vapor pressure extraction (ppm)

$CO_d = (1 - 0.000323\ R) \times CO_{dm}$

R : relative humidity in diluted air (%)

CO_{em} : CO concentration in diluted exhaust (ppm)

CO_{dm} : CO concentration in diluted air sample (ppm)

CO_{2mass} : carbon dioxide mass concentration(g/test stage)

$CO_{2density}$ = 1.830kg/m^3(51.81g/ft^3)(20□, 101Kpa (68□ 760mmHg))

$CO_{2conc} = 1$

$CO_{2conc} = CO_{2e} - CO_{2d}(1-1/DF)$

Here,

CO_{2e} : CO_2 concentration in diluted exhaust (%)

CO_{2d} : CO_2 concentration in diluted air (%)

$DF = 13.4/[CO_{2e} + (HC_e + CO_e)10^{-4})$

KH = humidity adjustment factor

KH = 1/[1-0.0047(H-75)] or KH = 1/[1-0.0329 (H-10.71)] (in SI unit)

Here,

H = absolute humidity (H_2O grain/1b dry air, gH_2O/kg dry air)

$H = [(6.211)Ra \times P_d]/[P_b - (P_d \times Ra/100)]$

$H = [(43.478)Ra \times P_d]/[P_a - (P_d \times Ra/100)]$ (in SI unit)

Ra = relative humidity in the atmosphere (%)

P_d = saturated water vapor pressure at dry-bulb temperature in the atmosphere (mmHg, kPa)

P_b = air pressure (mmHg, kPa)

V_{mix} = total diluted exhaust adjusted by the standard conditions (293K, 101.3Kpa(528R 760mmHg) (m^3/test stage or ft^3/test stage)

3. Test fuel

A. Use the test fuels of gasoline, gas and diesel that satisfy the requirements in Clean Air Conservation Act and Petroleum Business Act . Diesel used in the test should be pure and clean whose pure point and cloud point should be appropriate to driving, and may contain Cetane number enhancer, metal deactivator, antioxidant, anticorrosive agent, pure point inhibitor, and nonmetallic additives such as pigment and dispersing agent.

B. A different test fuel may be used if a manufacturer determines there is no impact on test results.

4. Gas for analysis

A. Gas for an analyzer

(1) Gas for CO and CO2 analyzer

$CO + N_2$ gas and $CO_2 + N_2$ gas

(2) Gas for HC analyzer

C_3H_8 + air

(3) Gas for CH4 an analyzer and CH4 + air

(4) Gas for NOx analyzer

$NO + N_2$ (less than 5% of NO_2 concentration)

(5) Zero-adjustment gas (air or nitrogen)

Containing HC ≤ 1 ppmC, CO ≤ 1 ppm, CO_2 ≤ 400 ppm and NO ≤ 0.1 ppm

(6) Synthetic air

O_2(18 – 21 Mol. %) + N_2

B. Gas for calibration

As gas for calibration, use a standard gas (NBS standard gas) and in less than 1% of a standard gas as recognized by the Minister of Environment.

C. Span gas

Spangas should be within 2% of true value. Standard gas recognized by the Minister of Environment should used as true value.

5. UDDS and load setting

A. Driving cycle:

The driving cycle is described in Figure 2 and Table 2.

B. Allowable error in driving:

Allowable speed for a defined time while driving under the Figure 2 driving cycle is described in Figures 3 and 4.

(1) Upper limit speed is 3.2 kph (2mph) faster than the highest speed on the speed

curve in less than 1 sec. of defined time

(2) Lower limit speed is 3.2 kph (2mph) slower than the lowest speed on the speed curve in less than 1 sec. of defined time.

(3) Speed change bigger than allowable error at times such as gear shift is accepted if it occurs within 2 sec.

(4) If a vehicle is running on maximum horsepower, a speed lower than the above descriptions is accepted.

(5) Upper and lower limit speed during warming up driving is 6.4kph (4mph).

C. transmission

(1) Unless explained otherwise, all test conditions should be prepared as per the recommendations by a manufacturer given to a final consumer.

(2) For automatic transmission, set the idle mode into “Drive (D)" condition and set wheels into the brake mode. For manual transmission, put off the clutch and shift a gear to drive except the initial idle mode.

(3) Softly accelerate under the instructed transmission procedure. In manual transmission, a driver should take the foot off the accelerator at each transmission and shift the gear in a short time. If a vehicle does not accelerate to a defined speed, drive it to exert maximum power until it reaches the speed defined under the driving schedule.

(4) In the deceleration mode, use a brake or an accelerator, if necessary, to maintain required speed, and drive a vehicle with gear shifted. For a vehicle with manual transmission, a gear should not be shifted from a previous mode after the clutch is connected. During deceleration to the zero, step on the clutch if the speed drops to lower than 24.1kph (15mph), an engine is unstable, or an engine is about to stop.

[Figure 2] Dynamometer driving cycle

[Table 2]

[Figure 3] Driving volume, acceptable range

[Figure 4] Driving volume, acceptable range

D. Determination of road load test weight and inertia weight grade

(1) As seen in Table 3, flywheels, electric or other methods may be used to set a test weight. If an equivalent inertia weight is not supported by a dynamometer, use an equivalent inertia weight at one level higher (no bigger than 113kg or 250lb).

(2) Adjustment of power absorption unit – small truck

(A) Adjust a power absorption unit to reproduce road load at 80.5kph (50mph). When setting the instructed road load force, consider dynamometer friction. Determine the relationship between absorption road load force and instructed road load force for certain dynamometer based on dynamometer calibration method.

(B) A manufacturer may use the road load force described in 1) Table or prepare and set road load force in a different way if the Minister of Environment recognizes so.

(C) If more than 50% of vehicles produced are expected to have an air conditioner installed with same engine group, increase the road load described in the above by 10% or maximum 1.3Hp.

(3) Adjustment of power absorption unit – light car and passenger car

(A) Adjust the power absorption unit to reproduce road load at 80.5kph (50mph). In dynamometer load absorption, consider dynamometer friction.

(B) Determine dynamometer road load based on an equivalent inertia weight, a basic front projected-area chassis shape, a vehicle protrusion and a tire shape in the following formula.

1) For small car tested on dynamometer with two rollers

$$Hp = aA + P + tW$$

Here,

Hp : dynamometer load absorption force set at 80.5kph (50mph) (kW, Hp)

A : vehicle basic front projected area (m^2,ft^2)

P : protrusion calibration factor (kW, Hp) (Table 4)

W : vehicle equivalent inertia weight in Table 3 (Kg,lb)

a : 3.452(hatch back style), 4.013 (others)

t : 0.0 for a vehicle with radial tires, 4.93 x 10 for others

Definition of hatch back style: The orthogonal projection at the rear of a vehicle has less than 20^{o} degree on the plane takes up more than 25% of front projected area. The surface should be smooth and continuous with no partial change of more than 4^{o}. The example of a hatch-back style is in Figure 5.

AP, the front projected area of the protrusion, is defined in the same way with the front projected area of a vehicle. In other words, it is the entire orthogonal projection area of mirror, hood ornament, roof rack, and other protrusions on the plane rectangular to each side of a vehicle and on the plane of a vehicle. protrusion refers to a fixture that is installed at more than 2.54cm(1 in) from the vehicle and whose projected area is more than 0.0093m3(0.01ft3) by the calculation approved in advance by the Minister of Environment. The entire front projected area of protrusion should include all of standard outfit. If there is any option expected to be installed in more than 50% of vehicle selected, it also should be included.

2) In case of light car and passenger car, round off power absorption setting value of vehicle dynamometer to 0.07kW (0.1 Hp).

3) For light car and passenger car tested on vehicle dynamometer with one big roller,

$$HP = aA + P + (8.22 \times 10^{-4} + 0.33t)W$$

$$HP = 0.746kW$$

Round off all symbols and numbers in the above formula to one decimal place.

[Table 3] Equivalent inertia weight of road load

80.5kph highway load (small truck) Note 1,2,3	Loaded vehicle weight		Equivalent inertia weight		Inertia weight	
	kg	ℓb	kg	ℓb	kg	ℓb
	481.8	1,062	453.6	1,000	453.6	1,000
	481.9-538.5	1,063-1,187	510.3	1,125	453.6	1,000
	538.6-595.2	1,188-1,312	567.0	1,250	567.0	1,250
	595.3-651.9	1,313-1,437	623.7	1,375	567.0	1,250
	652.0-708.6	1,438-1,562	680.4	1,500	680.4	1,500
	708.7-765.3	1,563-1,687	737.1	1,625	680.4	1,500
	765.4-822.0	1,688-1,812	793.8	1,750	793.8	1,750
	822.1-878.7	1,813-1,937	850.5	1,875	793.8	1,750
	878.8-935.4	1,938-2,062	907.2	2,000	907.2	2,000
	935.5-992.1	2,063-2,187	963.9	2,125	907.2	2,000
	992.2-1048.8	2,188-2,312	1,020.6	2,250	1,020.6	2,250
	1048.9-1105.5	2,313-2,437	1,077.3	2,375	1,020.6	2,250
	1105.6-1162.2	2,438-2,562	1,134.0	2,500	1,134.0	2,500
	1162.3-1218.9	2,563-2,687	1,190.7	2,625	1,134.0	2,500
	1219.0-1275.6	2,688-2,812	1,247.4	2,750	1,247.4	2,750
	1275.7-1332.3	2,813-2,937	1,304.1	2,875	1,247.4	2,750
	1332.4-1389.0	2,938-3,062	1,360.8	3,000	1,360.8	3,000
	1389.1-1445.7	3,063-3,187	1,417.5	3,125	1,360.8	3,000
	1445.8-1502.4	3,188-3,312	1,474.2	3,250	1,360.8	3,000
	1502.5-1559.1	3,313-3,437	1,530.9	3,375	1,587.6	3,500
	1559.2-1615.8	3,438-3,562	1,587.6	3,500	1,587.6	3,500
	1615.9-1672.5	3,563-3,687	1,644.3	3,625	1,587.6	3,500
	1672.6-1729.2	3,688-3,812	1,701.0	3,750	1,587.6	3,500
	1729.3-1785.9	3,813-3,937	1,757.7	3,875	1,814.4	4,000
	1786.0-1871.2	3,938-4,125	1,814.4	4,000	1,814.4	4,000
	1871.3-1984.6	4,126-4,375	1,927.8	4,250	1,814.4	4,000
	1984.7-2098.0	4,376-4,625	2,041.2	4,500	2,041.2	4,500
	2098.2-2211.4	4,626-4,875	2,154.6	4,750	2,041.2	4,500
	2,211.5-2,324.8	4,876-5,125	2,268.0	5,000	2,268.0	5,000
	2,324.9-2,438.2	5,126-5,375	2,381.4	5,250	2,268.0	5,000
	2,438.3-2,608.3	5,376-5,750	2,494.8	5,500	2,494.8	5,500
	2,608.4-2,835.1	5,751-5,250	2,721.6 (Note 4)	6,000	2,721.6	6,000
	2,835.2-3,061.9	6,251-6,750	2,948.3	6,500	2,948.3	6,500
	3,062.0-3,288.7	6,751-7,250	3,175.1	7,000	3,175.1	7,000
	3,288.8-3,515.5	7,251-7,750	3,401.9	7,500	3,401.9	7,500
	3,515.6-3,742.3	7,751-8,250	3,628.7	8,000	3,628.7	8,000
	3,742.4-3,969.1	8,251-8,750	3,855.5	8,500	3,855.5	8,500
	3,969.2-4,195.9	8,751-9,250	4,082.3	9,000	4,082.3	9,000
	4,196.0-4,422.6	9,251-9,750	4,309.1	9,500	4,309.1	9,500
	4,422.7-4,535.9	9,751-10,000	4,535.9	10,000	4,535.9	10,000

Note)

1. For a small truck except a van-style car and a heavy duty vehicle exceptionally recognized as a small truck, calculate the road load at 80.5kph by multiplying B (as defined in the below 3) rounded off by every 0.4km(0.5HP) by 0.58.

2. For a van-style vehicle, calculate the road load at 80.5kph by multiplying B (as defined in the below 3) rounded off by every 0.4kw (0.5HP) by 0.5.

3. “B" is the sum of a basic vehicle front area (□) and a front area that

exceeds 0.009 □ because of mirror and others options expected to be sold more than 50% of vehicle type. Calculate the front area to the five decimal points of □ by using a method approved in advance by the Minister of Environment.

4. For a light vehicle whose loaded weight exceeds 2,608kg(5,750lb), test it with the equivalent test weight of 2,495kg(5,500lb) and the road load force of 10.7kw (14.4HP).

[Table 4] Protrusion horsepower calibration factor

Ap(□) Area	P : kw (horsepower)
Ap □0.02787	0.0 (0.0)
0.02787≤Ap □ 0.05574	0.30(0.40)
0.05574≤Ap □ 0.08361	0.52(0.70)
0.08361≤Ap □ 0.11148	0.75(1.00)
0.11148≤Ap □ 0.13935	0.97(1.30)
0.13935≤Ap □ 0.16722	1.19(1.60)
0.16722≤Ap □ 0.19509	1.42(1.90)
0.19509≤Ap □ 0.22296	1.64(2.20)
0.22296≤Ap □ 0.25083	1.86(2.50)
0.25083≤Ap □ 0.2787	2.09(2.80)
0.2787≤Ap	2.31(3.10)

[Figure 5] Hatch back style example

(C) When more than 50% of vehicles with the same device group are expected to have air conditioner installed, and such vehicles are tested, increase the road load determined in 2) and the road load in Table of 1) by 10% or to a maximum 1kW (1.3Hp). Such increase for an air conditioner should be done before rounding off as instructed in Note 2 and 3 of Table 6. However, this is not applied when the test is done on the chassis dynamometer with one big roller.

(D) A manufacturer may calculate the road load as in the above way or determine the road load by using another method approved in advance by the Minister of Environment.

6. Device calibration

A. Since device calibration could have critical impact on a device or exhaust gas composition, calibrate it on a regular basis after maintenance as follows:

(1) Monthly inspection

(A) Analyzer calibration: CO, CO_2, HHC, NOx, HC, and CH_4 analyzer

(B) Chassis dynamometer calibration

(2) Weekly inspection

(A) NOx converter efficiency

(B) CVS inspection

(C) Dynamometer performance test

B. Calibration method of device

(1) Calibration method of chassis dynamometer device, etc.

(A) Calibration method of chassis dynamometer

There are two calibration methods of dynamometer: calibration under calibration procedure recommended by a dynamometer manufacturer and a method of measuring dynamometer frictional force absorption at 80.5kph (50mph). Another method may be used if dynamometer frictional force absorption can be measured. Measured absorption road load means the load absorbed by a load absorption unit. In terms of dynamometer frictional force on a dynamometer, after running a dynamometer at 80.5kph (50mph), remove a device used to run the dynamometer from the dynamometer to coast down a roller speed. At this time, kinetic energy of the device is consumed by the dynamometer. This method ignores the change from roller bearing friction that arises from a vehicle driving axis weight. And if a dynamometer with two rollers is used, it is acceptable to ignore the inertia of a free roller (rear roller).

1) Measure a speed of a driving roller, if not previously measured. At this time, use five wheels, RPM counter or any other appropriate method.

2) Place a vehicle onto a dynamometer or install a device that can run the dynamometer in a different way.

3) Install flywheels with a inertia weight in the range of most general vehicle

weights used in dynamometer or a different inertia mass device.

4) Run dynamometer up to 80.5kph (50mph).

5) Record shown road load.

6) Run the dynamometer up to 96.9kph (60.0mph).

7) Remove a device used to run the dynamometer.

8) Record the time taken to decelerate a driving roller of the dynamometer from 88.5kph (55mph) to 72.4kph (45mph).

9) Adjust a power absorption unit to another level.

10) Repeat (D)-(I) in the above to include the range of road load being used.

11) Calculate absorption road load (HPd)

$$HPd = (1/2)\ (W/9.807)(V_1 - V_2)/102t$$

Here, HPd : load force (kw,Hp)

W : equivalent inertia weight (kg,lb)

V_1 : initial speed (m/s,ft/s)

V_2 : final speed (m/s,ft/s)

t : time taken for a roller to decelerate from 88.5kph(55mph) to 72.4kph(45mph)

To simply the above formula,

HPd : 0.06073(w/t) (in English unit)

HPd : 0.09984(w/t)(in SI unit)

12) Draw the relationship diagram between instructed road load force and actual road load force at 80.5kph (50mph) in Figure 6.

[Figure 6] actual/marked road load

(B) Chassis dynamometer performance test

Do a coast down test of chassis dynamometer in one or more inertia-horse power setting and compare the result with the coast time acquired in recent calibration. If a variance is bigger than 1 sec., calibrate it again.

(C) CVS calibration method

1) Calibration method

A) CFV calibration is based on the following flow equation of critical venturi:

$$Q_s = K_v P / T$$

Here,

Q_s : flow

K_v : calibration factor

P : absolute pressure

T : absolute temperature

In the calibration procedure described in the below, a calibration factor can be obtained from pressure, temperature and flow values.

B) The test procedure recommended by a manufacturer can be achieved by calibrating the previous part of CFV.

C) Measured values for flow calibration are described in Table 5.

[Table 5] Calibration value measurement

Parameter symbol	Unit	Error range

Pressured (modified) .... Pb	KPa(in, Hg)	±0.03KPa(±0.01inHg)
Air temperature, flow meter...... ETI	□(F)	±0.14□(±0.25□)
LFE upstream pressure decrease..... EPI	KPa(inH20)	±0.012KPa(±0.05inH20)
LFE mattress pressure increase................................ EDP	KPa(inH20)	±0.001KPa(±0.005inH20)
Air flow .... Qs	□ /min(ft^3/min)	±0.05%
Pressure decrease at CFV inlet.. PPI	KPa(in, fluid)	±0.022KPa(±0.05influid)
Temperature at Venturi, Inlet................................. Tv	□(F)	±0.25□(±0.5□)
Proportion in mano meter flow (1.75 Oil) .... SP.GR		

D) Check gas leakage. Gas leakage between flow measurement device and CFV will give a huge impact on calibration level.

E) Leave a flexible hydraulic controller open and run an air blower to stabilize the device. Then, record values from all devices.

F) Alter the hydraulic controller and measure values at least eight times within the range of critical flow range of venturi.

G) Use the value recorded during measurement analysis and calibration in the following calculations:

□ Use a method suggested by a manufacturer to calculate air flow Qs at each measurement point from flow meter value in m3/min(ft3 /min) in the standard condition.

□ Calculate a calibration factor at each measurement point as follows:

$$K_v = \frac{Q_s \quad T_v}{\qquad}$$

Pv

Here,

Qs: flow (m^3/min(ft^3,min)) in the standard condition [20□, 101.3kpa(68□, 29.92 in Hg)]

T_v : temperature at venturi inlet (K, R)

P_v : pressure at venturi inlet (kpa, mmHg) Pb-PPI(SP.GR/13.57in English unit)

SP.GR: Proportion of mamometer fluid to water

□ Draw the relationship with K_v as a function of venturi inlet pressure. It will be relatively constant for sonic fluid K_v. Since pressure is reduced (vacuum increase), venturi will be open with K_v decreased.

□ For at least 8 points from critical range, calculate the mean K_v and standard deviation. □ If the standard deviation exceeds 0.3% of the mean, take calibration action.

2) CVS device inspection

The following weight method is used to check whether CVS and analyzer can accurately measure the weight of gas injected into the device. Use a constant flow measurement device using critical flow orifice devices to check the CVS device.

A) Prepare a small cylinder charged with pure propane.

B) Weigh the cylinder at the 0.01g level.

C) Operate CVS in a normal way and inject a certain quantity of pure propane into a sampler inlet (for about 5 minutes).

D) Based on calculation in exhaust analysis method, calculate a quantity of hydrocarbon. Use the propane density of 0.6109kg/m^3/ C atom (17.30g/ft^3/C atom) as hydrocarbon density.

E) Subtract CVS measurement value from the injected propane mass concentration and divide the result by mass concentration of the injected propane. If it is bigger than ±2%, find and correct a reason.

(D) Hydrocarbon analyzer calibration (including methane analyzer)

1) Initial and regular optimization of detector sensitivity

Before use and at least once a year, calibrate optimum sensitivity of a hydrocarbon and methane analyzer. A different method may be used if same results can be obtained and the Minister of Environment accepts so.

A) To use a device and adjust driving on a regular basis with appropriate fuel and pure air (synthetic air), follow a manufacturer's guideline.

B) Optimize the device within the working range that is most widely used. Mix air with propane (methane for a methane analyzer) whose concentration is within about 90% of the working range most widely used, and put the result into an analyzer.

C) Determine working fuel flow that shows almost maximum sensitivity and minimum change in sensitivity at minor change of in fuel flow.

D) While using the fuel flow determined in the above, change air flow to determine the optimum air flow.

E) After determining the optimum flow, record the flow to make reference to it in the followings.

2) Initial and regular calibration

Before and after using a hydrocarbon and methane analyzer, calibrate it every month for the range most widely used. At this time, use the same flow with that used for sample analysis.

A) Control the analyzer to optimum performance.

B) Calibrate the hydrocarbon and methane analyzer to the zero with pure air.

C) Calibrate it with the propane (methane for a methane analyzer) calibration gas with the concentrations of 15, 30, 45, 60, 75 and 90%, the working range most generally used. For each measurement range, if a deviation from optimum straight line in the least squares method is less than 2% of each measurement point, calculate concentration with a single concentration factor for the measurement range. If a deviation exceeds 2% at a certain measurement point, use an optimum non-linear equation representing the value within 2% of each measurement point to measure concentration.

(E) Carbon dioxide an analyzer calibration

1) Initial and regular interference inspection

After the installation and use of an analyzer, inspect analyzer sensitivity to vapor and CO_2 on a regular basis every year.

A) To run and operate an analyzer, follow a manufacturer's guideline. Adjust the so that it can show optimum performance within the range of best sensitivity.

B) Calibrate the analyzer with pure air or nitrogen to the zero.

C) Pass N2 gas containing 3% of CO2 through water at room temperature and send it to an analyzer to record analyzer sensitivity.

D) For measurement range ≤ 300ppm, if the analyzer shows sensitivity at more than 1 % of the entire scale range or more than 3ppm, it requires calibration.

2) Initial and regular calibration

Upon installation and after use of an analyzer, calibrate it every month.

A) Control an analyzer to optimum performance.

B) Calibrate the analyzer to the zero with pure air or N2 gas.

C) Calibrate it with the CO (N2 balance gas) calibration gas with the nominal concentrations of 15, 30, 45, 60, 75 and 90%, the working range generally used. For each measurement range, if a deviation from optimum straight line in the least squares method is less than 2% of each measurement point, calculate concentration with a single calibration factor for the measurement range. If a deviation exceeds 2% at a certain measurement point, use concentration in an optimum non-linear equation representing the value within 2% of each measurement point.

(F) Nitrogen oxide an analyzer calibration

1) NO2 → NO conversion inspection

Before and after using an analyzer, every week inspect the rate of conversion from NO_2 to NO in NOx CLD analyzer.

A) Follow a manufacturer's guideline for device manipulation and control the analyzer to optimum performance.

B) Calibrate the analyzer to the zero with pure air or nitrogen.

C) Connect the outlet of a NOx generator to inlet of sample in nitrogen oxide analyzer that is sent to most general manipulation range.

D) Put NO gas (balance gas N2) whose NO concentration is about 80% of most general manipulation range to the analyzer of a NOx generator. The content of NO_2 in the mixed gas should be less than 5% of NO concentration.

E) Record the NO concentration analyzed by the NOx analyzer in the NO mode.

F) Run the NOx generator, supply O_2 and adjust O_2 flow so that NO displayed on the analyzer is less than 10% of the concentration in the above (E). Record NO concentration in the mixed gas of NO and N2.

G) Run the NOx generator on the generation mode and control generation rate so that NO measured by the analyzer is 20% of the value measured in (E). At this point, a minimum 10% will be non-reactive NO. Record the concentration of remnant NO.

H) Set a NOx analyzer on the NOx mode and measure and record total NOx.

I) Turn off the NOx generator and continue to provide gas to the device. The NOx analyzer will show NOx from NO+O_2. Record the value.

J) Stop providing O2 from the NOx generator. The initial NO concentration on analyzer will show NOx in the N2 mixed gas. It should be less than 5% of the value instructed in (D).

K) Apply the concentrations into the following formula and calculate efficiency of converted NOx.

$$\text{Converted efficiency} = (1 + (a - b) / (c - d)) \times 100$$

Here, a: concentration from (H)

b: concentration from (I)

c: concentration from (F)

d: concentration from (G)

If the conversion rate is less than 90%, calibration is necessary.

2) Initial and regular calibration

Upon installation and after use of an analyzer, calibrate a NOx analyzer every month for all measurement ranges most generally used. At this time, use the same flow as in sample analysis.

A) Control the analyzer to optimum performance.

B) Calibrate the analyzer to the zero with pure air or nitrogen gas.

C) Calibrate it with the NO (balance gas N_2) calibration gas with the nominal concentrations of 15, 30, 45, 60, 75 and 90%, the working range most generally used. For each measurement range, if a deviation from optimum straight line in the least squares method is less than 2% of each measurement point, calculate concentration with a single calibration factor for the measurement range. If a deviation exceeds 2% at a certain measurement point, determine concentration in an optimum non-linear equation representing the value within 2% of each measurement point.

(G) Carbon dioxide analyzer calibration

1) Upon installation and after use of an analyzer, calibrate an NDIR CO_2an analyzer every month.

A) Follow a manufacturer's guideline for device manipulation and control the analyzer to optimum performance.

B) Calibrate the CO_2 analyzer to the zero with pure air or nitrogen.

C) Calibrate it with the CO_2 (balance gas N_2) calibration gas with the nominal concentrations of 15, 30, 45, 60, 75 and 90%, the working range generally used. For each measurement range calibrated, if a deviation from optimum straight line in the least squares method is less than 2% of each measurement point, calculate concentration with a single calibration factor for the measurement range. If a deviation exceeds 2% at a certain measurement point, measure concentration in an optimum non-linear equation representing the value within 2% of each measurement point.

 Highway mode measurement method (related to Article 7)

1. Device requirements

Requirements for devices used in all fuel efficiency tests are same as in the CVS-75 mode. In addition, calibration of devices used in fuel efficiency test follows the rules for the CVS-75 mode.

2. Fuel specifications.

Fuel specifications are same as in the CVS-75 mode.

3. Gas for analyzer

Gas for analyzers in fuel efficiency test should satisfy the requirements for the CVS-75 mode.

4. Highway driving schedule

(1) Highway driving schedule is as in Figure 2. The driving schedule is defined as smooth trace drawn from the relation between time and certain time.

(2) Allowable error in driving speed follows the requirements in the CVS-75 mode.

[Figure]

5. Procedure for highway driving test

(1) Highway driving test cycle (HEET) consists of a preliminary driving cycle and a driving cycle to measure fuel efficiency. In each test cycle, it is required to repeat the driving schedule with the same relationship between speed and time twice and therefore reproduce driving in non-urban area with mileage of 16.4km, average speed at 78.2km/h and maximum speed at 96.5km/h. A preliminary driving cycle requires warming up of a test vehicle on chassis dynamometer.

(2) Continuously collect diluted exhaust with CVS (variable dilutor) to analyze hydrocarbon, carbon dioxide and carbon dioxide. In a diesel-powered vehicle, continuously analyze diluted exhaust with a sample heated for hydrocarbon line and an analyzer.

(3) Except malfunction or breakdown of a component, all exhaust control systems installed or embedded in a test vehicle should work in the course of all procedures.

(4) During highway fuel efficiency test, apply the CVS-75 mode in the Annex for vehicle transmission manipulation.

(5) To determine road load force and test weight for highway fuel efficiency test, apply the criteria in the CVS-75 mode.

(6) Preliminary drive

Highway driving test cycle (HEET) is designed to be taken under the exhaust gas measurement procedure described in the criteria for the CVS-75 mode. If the test cannot be completed in 3 hours under UDDS, a vehicle should be preliminary driven as follows:

(A) If three hours has passed at room temperature parking condition (20□30□) or a vehicle has remained in the environment that does not maintain 20□30□ since the test procedure of the CVS-75 mode is completed for the vehicle, the vehicle should be preliminarily driven on dynamometer for one cycle under UDDS in the CVS-75 mode.

(B) If a manufacturer wants additional preliminary drive, apply the CVS-75 mode.

(7) Highway fuel efficiency dynamometer test procedure

(A) The dynamometer procedure consists of two cycles of highway driving schedule (Figure 3) characterized by the 15-sec. idle mode (Figure 3). The first cycle of highway fuel efficiency driving schedule is for preliminary drive of a test vehicle while the second cycle is intended to measure fuel efficiency.

(B) Apply urban driving test procedure for the CVS-75 mode to highway fuel efficiency test.

(C) To collect and analyze hydrocarbon (except diesel hydrocarbon subject to analysis), carbon monoxide and carbon dioxide, one exhaust sample pouch and one diluted air pouch are used.

(D) The fuel test measurement includes 2-sec. idle mode at the start of the second cycle and 2-sec idle mode at the end of the second cycle.

(8) Engine start and re-start

(A) If an engine stops during the preliminary drive, follow a manufacturer's recommenced procedure for re-start.

(B) If a test vehicle stops during driving cycle to measure highway fuel efficiency measurement, cancel the test, take action for improvement and re-test a vehicle.

(9) Take the following steps in each test with dynamometer.

(A) Place a test vehicle onto a dynamometer. Run the vehicle onto a dynamometer.

(B) Open the vehicle engine partition cover and put a necessary cooling fan. A manufacturer may demand the use of an additional cooling fan to cool an additional engine partition or the lower part of chassis or control a high temperature at brake during dynamometer operation.

(C) CVS should be prepared before highway driving cycle is measured.

(D) Except the connection between one exhaust sample pouch and one diluted gas sample pouch to a sampler, apply the sequence of measuring exhaust gas defined for the CVS-75 mode to highway fuel efficiency driving test.

(E) Drive the vehicle in driving cycle under dynamometer driving schedule to measure highway fuel efficiency defined in Table 1.

(F) To measure fuel efficiency, start driving cycle 17 sec. after vehicle speed becomes zero at the end of preliminary drive.

(G) Drive the vehicle in one driving cycle at highway fuel efficiency under dynamometer driving schedule defined in Table 1 while exhaust is collected.

(H) Start sampling 2 sec. before the start of first acceleration in driving cycle of fuel efficiency measurement and finish sampling 2 sec. after deceleration to stop the vehicle.

6. Exhaust sample analysis

Analyze exhaust sample according to the rules for the CVS-75 mode in this paper.

7. Fuel efficiency and carbon dioxide calculation in highway drive

Calculate fuel efficiency and carbon dioxide on highway under the procedure for the CVS-75 mode.

[Annex 3]

Equipment and Technical Personnel of Test Agency

1. Equipment

Equipment name	Standard
A. Chassis dynamometer and its part equipment	1 set or more
B. Gas emissions measurement device for chassis dynamometer and part equipment	1 set or more

2. Technical personnel

Qualification	Standard

A. Technical certificate holders of vehicle technician, air environmental technician, motor vehicles inspection engineer or higher, motor vehicles maintenance engineer, general machinery engineer or higher, construction equipment engineer or higher, construction equipment maintenance engineer or higher, electronics engineer or higher, and air pollution environmental engineer or higher	2 or more persons
B. Technical certificate holders of air pollution environmental industrial engineer, motor vehicles inspection craftsman or higher, motor vehicles maintenance craftsman or higher and electronic apparatus craftsman or higher	3 or more persons

Note: Technical personnel in the second table should technical personnel as described in A and B respectively or have at least one person who has run and managed equipment as described in the first table for more than two years.

[Appendix 1]

Fuel efficiency and GHG Emissions Test Results

Fuel efficiency and GHG emissions test results					
Manufacturer					
Address					
Name of representative			Test date		
□ **Basic specifications about vehicle**					
Production Company		Vehicle type		Year of production	
Vehicle class		Vehicle category		Vehicle use	
Fuel name		Displacement (cc)		Complete vehicle curb weight (kg)	
Transmission type and gear mode		Fuel injection		Wheel base (mm)	
Engine type		Drive method		Tread (mm)	
Max. Power (ps/rpm)		Max. Torque (kg.m/rpm)		Mileage (km)	
Passenger capacity (person)		Fuel tank capacity (ℓ)			
□ **Fuel efficiency and GHG emissions**					
Fuel efficiency (km/ℓ)	City drive				
	Highway drive				

	Combined mode	
GHG emissions (g/km)	City drive	
	Highway drive	
	Combined mode	

Attachments

1. A copy of test results analysis (raw data sheet)
2. A picture of vehicle appearance

YYYYMMDD

Test Agency (seal)

Minister of Environment

[Appendix 2]

Actual data about fuel efficiency and GHG emissions

1. Fuel efficiency and GHG emissions for manufacturer

Manufacturer	Manufacturer, average weight (kg)	Manufacturer, allowable emission standard of GHGs (g/km)	Manufacturer, average fuel efficiency standard (km/L)	Total sales volume (vehicles)	Manufacturer, average GHG emissions (g/km)	Manufacturer, average fuel efficiency (km/L)	Difference (extra, insufficient)	Details about trade of extra/insufficient achievement	Note

2. Vehicle type fuel efficiency and GHG emissions details

Manufacturer	Year	Vehicle name	Vehicle type	Fuel	Basic specifications about vehicle								Sales volume (vehicle)	GHG emissions measured (g/km)			Fuel efficiency measured (km/L)			Individual GHG standard (g/km)	Individual Fuel efficiency standard (km/L)
					Engine type	Drive Method	Transmission type	Passenger capacity	Displacement (cc)	Complete vehicle curb weight (kg)	Total vehicle weight (kg)	Vehicle area of occupancy [footprint?] (□)		CVS-75	Highway	Combined mode	CVS-75	Highway	Combined mode		

Note 1. Individual GHG standard and individual fuel efficiency standard for vehicle type are calculated in Table 1.