COMMONWEALTH OF AUSTRALIA

AUSTRALIAN DESIGN RULE 40

FOR

LIGHT DUTY VEHICLE EMISSION CONTROL

As endorsed by the
Australian Transport Advisory Council.

The intention of this Australian Design Rule is to limit fuel evaporative and exhaust emissions from motor vehicles in order to reduce air pollution, and to require new motor vehicles to be manufactured to operate on unleaded petrol.

The Australian Transport Advisory Council has recommended to Commonwealth, State and Territory Governments that all motor vehicles specified below equipped with petrol fuelled spark ignition internal combustion engines shall comply with Australian Design Rule 40 - Light Duty Vehicle Emission Control.

VEHICLE CATEGORY	RULE	AMENDMENT	
	MANUFACTURED ON OR AFTER		
	40		
Passenger Cars			
Forward Control			
Passenger Vehicles			
up to 2.7 tonnes GVM	1 Jan 1988		
over 2.7 tonnes GVM	N/A		
Other Passenger Cars	N/A		
Passenger Car Derivatives	N/A		
Multi-Purpose Passenger Cars			
up to 2.7 tonnes GVM	1 Jan 1988		
over 2.7 tonnes GVM	N/A		
Omnibuses			
up to 2.7 tonnes GVM	1 July 1988		
over 2.7 tonnes GVM	N/A		
Motorcycles	N/A		
Mopeds	N/A		
Specially Constructed Vehicles	N/A		
Other Vehicles not listed above			
up to 2.7 tonnes GVM	1 July 1988		
over 2.7 tonnes GVM	N/A		

N/A - Not Applicable
GROSS VEHICLE MASS - Abbreviated to 'GVM'

The Australian Transport Advisory Council has also recommended to Commonwealth, State and Territory Governments that motor vehicles manufactured on or after 1 July 1985 which comply with ADR 37 need not comply with ADR 40.

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40.1 DEFINITIONS - For the purpose of this Rule, the following definitions apply :

'Administrator' - means the Australian Motor Vehicle Certification Board (AMVCB) or a person to whom that Board has delegated by an instrument in writing, revocable at will, its powers and functions.

'Analyser Gas' - means either a zero-grade gas, a span gas used with an analyser or an analyser service gas.

'Approved' - means approved by the Administrator.

'Calibration Gas' - means a gas of known concentration which is used to establish the response curve of an analyser.

'Certification Vehicle' - means a vehicle tested by a vehicle manufacturer for the purpose of demonstrating that the vehicle does not exceed the specified emissions standards.

'Corrective Action' - means action, other than Scheduled Maintenance, taken to correct malfunctioning of the engine, fuel system, or emissions control system(s) during an emissions test, including stabilisation distance accumulation (refer Appendix VII).

'Dilution Factor' - means a correction factor used in exhaust emissions calculations; it is calculated by using Equation 7.14 of Clause 40.7.3.

'Distance Accumulation Fuel' - see Stabilisation Distance Accumulation Fuel.

'Diurnal Breathing Loss' - means the fuel evaporative emissions resulting from the daily variation in temperature to which the fuel system is exposed.

'Engine Family' - means a basic classification of vehicles having similar characteristics as defined in Clause 40.4.3.1 to 40.4.3.4.

'Engine-system Combination' - means an engine family - exhaust emissions control system - fuel evaporative emissions control system (where applicable) combination.

'Equivalent Test Inertia Mass' - means the value shown in the Table in sub-clause (e)(ii) of Clause 40.8.4, corresponding to the Reference Mass of the vehicle.

'Evaporative Emissions' - see Fuel Evaporative Emissions.

'Exhaust Emissions' - means substances emitted to the atmosphere from any opening downstream from the exhaust port of a vehicle engine.

'Fuel Evaporative Emissions' - means vaporised fuel emitted to the atmosphere from the fuel system of a vehicle.

'Fuel Evaporative Emissions Control System' - means a system which incorporates a particular principle of operation to control or cause the reduction of fuel evaporative emissions.

'Fuel System' - means the combination of fuel tank, fuel pump, fuel lines and carburettor or fuel injection components, and includes all fuel system vents and fuel evaporative emissions control systems.

'Gas Flow Measuring Device' - means a Positive Displacement Pump; Critical Flow Venturi; or other approved system.

'Hot Soak Loss' - means the fuel evaporative emissions after a simulated trip (a CVS-CH Driving Schedule) and measured during the 60 minutes period which begins after the simulated trip.

'Motor Spirit' - a synonym for petrol (refer Definition of 'Petrol').

'Nominal Fuel Tank Capacity' - means the volume of the fuel tank, specified by the manufacturer to the nearest 0.5 litre, which may be filled with fuel through the fuel tank filler inlet.

'Oxides of Nitrogen' - means the sum of the nitric oxide and nitrogen dioxide contained in a gas sample as if the nitric oxide were in the form of nitrogen dioxide.

'Petrol' - means any fuel sold in Australia for use in motor vehicles and motor vehicle engines and commonly or commercially known or sold as petrol (or motor spirit).

'Rated Speed' - means the speed at which the manufacturer specifies the maximum rated power of an engine.

Reference Mass' - means the actual or the manufacturer's estimated mass of the vehicle in operational status with all standard equipment, and mass of fuel at nominal tank capacity, and the mass of optional equipment where it is expected that more than 33 percent of an engine family will be equipped with that optional equipment, plus 136 kg.

'Rounding Off' - means the mathematical procedure as set out in ASTM E 29-67.

'SHED' - "Sealed Housing for Evaporative Determination"; means a sealed structure used to enclose a vehicle so that fuel evaporative emissions can be measured.

'Scheduled Maintenance' - means any adjustment, repair, removal, cleaning, or replacement of vehicle components or systems which is performed to prevent component failure or vehicle malfunction, to the extent recommended by, and at intervals recommended by, the vehicle manufacturer to the ultimate vehicle purchaser, as detailed in Clause 40.3.5. It does not include 'Corrective Action' (refer Definition of 'Corrective Action').

'Span Gas' - means a gas of known concentration which is used routinely to set the output level of an analyser.

'Stabilisation Distance' - means the distance chosen by the vehicle manufacturer for testing a certification vehicle.

'Stabilisation Distance Accumulation Fuel' - unless otherwise approved, means fuel complying with the specification of Appendix III.

'Standard Test Fuel' - unless otherwise approved, means fuel complying with specification of Appendix II.

'System' - includes any vehicle or engine modification which controls or causes the reduction of substances emitted from the vehicle.

'Tank Fuel Volume' - means the volume of fuel in the fuel tank(s), which is determined by multiplying the vehicle's nominal tank(s) capacity by 0.40, the result being rounded off using ASTM E 29-67 to the nearest 0.5 litre.

'Throttle' - means the mechanical linkage which either directly or indirectly controls the fuel flow to the engine.

'True Speed' - means actual speed as measured e.g. by a fifth wheel.

'Unleaded Petrol' - means petrol (or motor spirit) containing not more than 0.013 gram of lead per litre and not more than 0.0013 gram of phosphorus per litre.

'Unscheduled Maintenance' - means any adjustment, repair, removal, cleaning, or replacement of vehicle components or systems other than the vehicle engine, fuel system, or emissions control system, which is performed to correct a component failure or vehicle malfunction. It does not include 'Corrective Action' (refer Definition of 'Corrective Action').

'Useful Life' - means a period of use of 5 years or 80 000 km, whichever occurs first.

'Zero km' - means that point at which controlled stabilisation distance accumulation commences, subject to the requirements of Clause 40.3.2.4, after initial engine starting (not to exceed to 150 km of vehicle operation, or 10 hours of engine operation) and at which point normal assembly line operations and adjustments are completed, including predelivery procedures.

'Zero-grade air or nitrogen' - means air and nitrogen gases having allowable impurity concentrations not exceeding:

(A) For measurement of HC concentration in fuel evaporative emissions test - one ppm equivalent carbon response.

(B) For measurement of HC, CO, CO_2, NO_x concentrations in exhaust emissions test -

one ppm equivalent carbon response;
one ppm CO;
400 ppm (0.04 mole percent) CO_2;
0.1 ppm NO

Note: For the purpose of this Rule, air includes artificial air consisting of a blend of nitrogen and oxygen with the oxygen concentration between 18 and 21 mole (or volume) percent.

40.2 ABBREVIATIONS

ASTM - American Society for Testing and Materials

C - Celsius

CFV-CVS - critical flow venturi - constant volume sampler

CL - chemiluminescence

CO_2 - carbon dioxide

CO - carbon monoxide

conc - concentration

$conc_f$ - final concentration

$conc_i$ - initial concentration

CVS-CH - "Constant Volume Sampler - Cold cycle/Hot cycle"; a designation of the US 1975 (and later) Federal Test Procedure to test emissions

Eq, Eqn - equation

FID - flame ionisation detector

h - hour

H_2O - water

HC - hydrocarbon

kg - kilogram

km - kilometre

km/h - kilometres per hour

kPa - kilopascal(s)

kW - kilowatt

LFE - laminar flow element

max - maximum

mg - milligram

min - minimum

ml - millilitre

mole percent - percentage concentration expressed in moles

N_2 - nitrogen

NDIR - non-dispersive infra-red

NO - nitric oxide

NO_2 - nitrogen dioxide

NO_x - oxides of nitrogen or nitrogen oxides

O_2 - oxygen

PDP-CVS - positive displacement pump - constant volume sampler

ppm - parts per million by volume

ppm C - parts per million, carbon equivalent

rpm - revolutions per minute

^{o} - degrees

40.3 REQUIREMENTS

40.3.1 Requirements for emissions standards

40.3.1.1 Every vehicle, when tested in accordance with the requirements of Clauses 40.6 to 40.8 inclusive, shall be such that its emissions do not exceed:

(a) for fuel evaporative emissions, hydrocarbons: 2.0 grams per test

(b) for exhaust emissions,

(i) hydrocarbons: 1.24 grams per vehicle kilometre;
(ii) carbon monoxide: 12.4 grams per vehicle kilometre;
(iii) oxides of nitrogen: 1.93 grams per vehicle kilometre.

40.3.1.2 The emissions standards specified in Clause 40.3.1.1 apply to vehicles for their useful life.

40.3.1.3 Every vehicle shall be designed and constructed to operate on unleaded petrol and when constructed shall be tuned and adjusted in accordance with the label referred to in Clause 40.3.5.2.

40.3.2 Requirements for compliance of certification vehicles

40.3.2.1 Certification vehicle(s) (refer Definitions Clause 40.1), as selected in accordance with Clause 40.4, shall be used to establish compliance with this Rule (refer Clause 40.5).

40.3.2.2 Subject to the requirements of Clause 40.3.2.3 the requirements of Clauses 40.3.1.1 to 40.3.1.3 shall be deemed to have been complied with by a certification vehicle, on the basis of a single test, if:

when tested in accordance with the requirements of Clauses 40.6 to 40.8 inclusive, the emissions do not exceed:

(a) for fuel evaporative emissions, hydrocarbons: 1.9 grams per test

(b) for exhaust emissions,

(i) hydrocarbons: 1.13 grams per vehicle kilometre;
(ii) carbon monoxide: 11.3 grams per vehicle kilometre
(iii) oxides of nitrogen: 1.75 grams per vehicle kilometre.

40.3.2.3 Where a certification vehicle exceeds the emissions standards for a test, a single retest may be carried out on that vehicle. The vehicle may be checked to ensure that all components are within specification prior to the retest. Details of any such case are to be reported to the Administrator, with all results obtained and with an explanation as to the likely reasons. This explanation shall be taken into account by the Administrator in determination of compliance.

40.3.2.4 Unless otherwise approved, prior to the commencement of the vehicle's stabilisation distance accumulation, the engine and fuel system of any vehicle proposed by a manufacturer as a certification vehicle shall be untested with respect to compliance with this Rule, and the engine shall have been run for not more than 150 km of vehicle operation, or 10 hours of engine operation subsequent to normal production and predelivery procedures.

40.3.2.5 The certification vehicle shall be checked to ensure that all components and systems are within specification.

40.3.2.6 The certification vehicle shall be run using Standard Test Fuel (unless otherwise approved, complying with the specification in Appendix II) during emissions tests. However, it shall be permissible to use either Standard Test Fuel or Stabilisation Distance Accumulation Fuel (refer Appendix III), for stabilisation distance accumulation.

40.3.2.7 The certification vehicle shall be operated using lubricants in the engine and transmission which are recommended by the vehicle manufacturer.

40.3.2.8 Unless otherwise approved, maintenance on a certification vehicle shall be limited to scheduled maintenance (refer Definitions Clause 40.1).

40.3.2.9 Unless otherwise approved, unscheduled maintenance (refer Definitions Clause 40.1) shall be performed only as a result of component failure, or vehicle malfunction.

40.3.2.10 Refer to Appendix VII for allowable corrective action (refer Definitions Clause 40.1) for malfunctioning of vehicle engine, fuel system, or emissions control system(s) during an emissions test (including stabilisation distance accumulation).

40.3.3 Requirements for Nature and Extent of Testing

Each certification vehicle shall have exhaust and fuel evaporative emissions tests carried out at a stabilisation distance (refer Definitions Clause 40.1). The certification vehicle shall be driven for the chosen stabilisation distance in accordance with the procedure in Appendix VI.

40.3.4 Requirements for Recording of Results and Information

40.3.4.1 All test results obtained, including voided tests, shall be recorded and available to the Administrator.

40.3.4.2 The calculations for, and results of, all emissions tests shall be rounded off where appropriate, using the "rounding off" method specified in ASTM E 29-67. Emissions test results shall be calculated to one decimal place more than the number of decimal places contained in the relevant emissions standard of this Rule, and the last decimal place shall be "rounded off" for the purpose of reporting test results.

40.3.4.3 The following information shall be recorded with respect to the relevant test:

(a) Test number; and test cell number.

(b) Date of the test.

(c) Vehicle: Manufacturer - Model - Manufacturer's certification vehicle identification data - Engine Family - Fuel evaporative emissions control system - Basic engine description (including displacement, number of cylinders and exhaust emissions control system) - Engine number - Fuel system (fuel tank(s) capacity and location, fuel injection type, number of carburettors, number of carburettor barrels) - Reference Mass and Equivalent Test Inertia Mass - Transmission configuration - Axle ratio - Idle rpm - Drive wheel tyre pressure - Stabilisation distance at which the emissions test(s) were conducted.

(d) Actual and indicated road load power absorber settings at 80 km/h.

(e) A speed-time record, e.g. a driver's aid recorder chart.

(f) Recorder charts: Identify zero, span, exhaust gas, and dilution air sample traces, for hydrocarbons, carbon monoxide, carbon dioxide and oxides of nitrogen. In those facilities where computerised data acquisition systems are used, the printout facility may be used.

(g) The measurements of corrected test cell barometric pressure, ambient temperature, and humidity, during or immediately prior to the CVS-CH Driving Schedule.

A central laboratory barometer may be used, provided that individual test cell barometric pressures are shown to be within 0.1 percent of the barometric pressure at the central barometer location.

(h) Fuel temperatures, as prescribed.

(i) Pressure of the mixture of exhaust and dilution air entering the CVS metering device, the pressure increase across the device, and the temperature at the inlet. The temperature may be recorded continuously or digitally to determine temperature variations.

(j) Where appropriate, the number of revolutions of the positive displacement pump accumulated while the test is in progress and exhaust flow samples are being collected.

(k) Equivalent data to (i) and (j), as relevant to critical flow venturi equipment.

(l) Test fuel identification data.

(m) The times used as data in the fuel evaporative emissions test.

(n) All details of dynamometer roll counter settings, where the method chosen uses these for distance measurements.

(o) Details of any unscheduled maintenance, corrective action, and of any problems encountered during any test.

40.3.5 Requirements for Written Instructions and Engine Data Label

40.3.5.1 With every vehicle the manufacturer shall provide written instructions for starting the engine and for the maintenance and use of the vehicle as may be reasonable and necessary to ensure the proper functioning of emissions control systems.

40.3.5.2 Every vehicle shall have an engine data label fitted in a readily visible position in the engine compartment.

The label shall be legible, durable, permanently affixed, and shall state directly, or by reference if approved, engine tune-up data.

The data shall include:

- engine idle speed;
- ignition timing;
- cam dwell angle or contact breaker gap (where appropriate);
- the transmission position during adjustments and settings;
- the engine operation conditions and indicate any accessory which should be in operation;
- any other information required to enable the adjustments to be correctly carried out.

40.3.6 Requirements for Fuel Label

Every vehicle shall have the word "UNLEADED PETROL ONLY" or "UNLEADED FUEL ONLY" on a durable label or by other durable means permanently affixed to the area immediately adjacent to the petrol filler inlet(s), on the door to the filler inlet compartment, or within 150 mm of the door to the filler inlet compartment, or on or within 150 mm of the filler inlet cap, readily visible to any person intending to refuel the vehicle. The lettering shall be legible and in capital letters no smaller than 6.0 mm high.

Alternative wording or location may be used, if approved.

40.3.7 Requirements for Petrol Filler Inlet (refer Appendix IX)

The following requirements shall apply to every vehicle:

(a) Vehicles shall be equipped with a petrol tank filler inlet assembly which prevents the insertion of a nozzle having a spout with an external diameter of 23.6 mm or greater (leaded petrol nozzle) and allows the insertion of a nozzle having a spout with an external diameter of 21.34 mm or less (unleaded petrol nozzle).

For details of nozzles, refer Appendix IX.

(b) The design and construction of the filler inlet assembly shall be such that it is not possible for it to be readily altered to allow the insertion of a leaded petrol nozzle having a spout with an external diameter of 23.6 mm or greater, without causing such damage as would require its replacement or major repair to enable it to be restored to the design condition.

(c) The filler inlet assembly shall be designed to pass not more than 700 ml of petrol into the tank when the introduction of petrol into such filler inlet assembly is attempted from a leaded petrol nozzle complying with the characteristics specified in Appendix IX.

(d) A test shall be conducted to establish compliance with Clause 40.3.7 (c), using a test fixture which positions the filler inlet assembly in the same position as it is installed in the vehicle. For the purpose of this test, an attempted introduction shall be conducted by inserting a leaded petrol nozzle such that its automatic shutoff vacuum port is at various depths within the filler inlet, except those locations which cause spillage (not including splash back) outside the filler inlet assembly shall not be used. The nozzle may have any orientation within the filler inlet assembly which may reasonably be expected to be encountered in use. The nozzle valve shall be fully and rapidly opened to a 30 $\pm$ 4 litres/minute flow setting.

40.3.8 Requirements for limiting access to the adjustability of idle air/fuel mixture

Every vehicle shall be equipped with an inaccessible or sealed idle mixture adjustment.

(a) An acceptable method is for the idle mixture screw to be recessed within the carburettor casting or the air flow meter of the fuel injection system and:

(i) sealed with metal or a metal alloy; or

(ii) sealed with thermosetting plastic; or

(iii) sealed with an inverted elliptical spacer; or

(iv) sheared off after adjustment; or

(v) its thread crimped after adjustment; and

the idle mixture screw cannot be accessed and/or adjusted with the use of simple tools.

(b) Other means of providing an inaccessible or sealed idle mixture adjustment may be used, if approved.

40.3.9 Requirements for Approval of Test Equipment and Procedures

The Laboratory test equipment and procedures shall be approved.

40.4 SELECTION CRITERIA FOR CERTIFICATION VEHICLES

40.4.1 Types of certification vehicles shall be selected by the manufacturer in accordance with the selection procedure specified in Clauses 40.4.3.1 to 40.4.3.6 inclusive. The manufacturer is required to obtain prior approval of the certification vehicle fleet, except in the case where the manufacturer has applied to the Administrator for, and has been granted, an exemption to the requirement for prior approval. The manufacturer shall provide identification information to the Administrator on the selected certification vehicles.

40.4.2 For the purpose of establishing compliance, the Administrator shall not have the power to select more certification vehicles than the numbers indicated by the selection methods defined in this Rule. If the manufacturer has been granted an exemption to the requirements for prior approval of the certification vehicle fleet, and has selected the type and number of certification vehicles in accordance with the selection methods defined in this Rule, the Administrator shall not have the power to select more vehicles, or different types of vehicles.

40.4.3.1 Vehicles shall be divided into groups according to engine family. To be classed in the same engine family all the conditions listed for (a) and (b) below shall be met:

(a) they are identical with respect to:

(i) the nominal bore centre to centre dimensions;

(ii) the nominal dimension from the centreline of the camshaft to the centreline of the crankshaft;

(iii) the nominal dimensions from the centreline of the crankshaft to the cylinder block head face;

(iv) the number of cylinders, their configuration and the cooling system (L6, 90° V8 etc, air cooled or water cooled);

(v) the nominal location of the intake and exhaust valves and the valve sizes (within a 4 mm range on the valve head diameter);

(vi) the method of air aspiration (e.g. natural or forced);

(vii) the combustion cycle;

(viii) catalytic converter characteristics;

(ix) thermal reactor characteristics;

(x) the method of fuel intake.

This is taken to include that:

(a) if by carburettion there shall be no variation in the number of carburettors, number of barrels or principle of operation;

(b) if by fuel injection, there shall be no variation in the type of flow, i.e. it shall be either continuous or non-continuous.

(b) Any variation in nominal engine displacement shall be within the following limits:

20 percent of the highest displacement value for a displacement of 2 000 millilitres or less, or 850 millilitres for a displacement above 2 000 millilitres.

40.4.3.2 Engines meeting the conditions of Clause 40.4.3.1 may be further divided into different engine families if the Administrator or the manufacturer determines that they may have different emissions characteristics. This determination shall be based upon a consideration of factors such as the intake manifold induction port size and configuration.

40.4.3.3 Engine families based on other engine features may be established by the Administrator or the manufacturer if the manufacturer can demonstrate that the engines incorporating such features have substantially similar emissions characteristics.

40.4.3.4 In cases where the engines are of a type which cannot be classified according to the criteria of Clauses 40.4.3.1 to 40.4.3.3 the Administrator shall establish engine families based on features considered to be most related to their emissions characteristics.

40.4.3.5 Certification vehicles shall be selected to be tested for emissions as follows:

(a) Vehicles of each engine family shall be divided into engine displacement - exhaust emissions control system - fuel evaporative emissions control system - combinations. The combinations shall be arranged in order according to the manufacturer's projected annual sales volume. One vehicle of each combination shall be selected in decreasing order of sales volume until 70 percent of the projected annual sales of the engine family is represented or until a maximum of 4 vehicles has been selected. If any single combination represents 70 percent or more, then 2 vehicles of that combination may be selected. The actual certification vehicles shall be designated by the Administrator or manufacturer as to transmission type, fuel system and reference mass;

(b) The Administrator or manufacturer may select a maximum of 2 additional vehicles within each engine family based upon features indicating that they may have the highest emissions levels of the vehicles in that engine family. In selecting these vehicles, such features as the emissions control characteristics, ignition system characteristics, fuel system, rated power, torque, compression ratio, reference mass, transmission type and axle ratios, shall be considered;

(c) If the vehicles selected in accordance with Clauses (a) and (b) above do not represent each engine family - exhaust emissions control system - fuel evaporative emissions control system combinations (hereinafter referred to as 'engine-system combination'), then one vehicle of each engine-system combination not represented may be selected by the Administrator or manufacturer. The vehicles selected shall be of the engine displacement with the largest projected sales volume of vehicles with the emissions control system combination in the engine family and shall be designated by the Administrator or manufacturer as to transmission type, fuel system and reference mass;

(d) The manufacturer may elect to operate additional certification vehicles to represent any engine-system combination. Emissions test data from these vehicles shall be taken into account in determining compliance with this Rule.

40.4.3.6 Any manufacturer whose projected annual sales of new vehicles of a particular engine family subject to the requirements of this Rule is less than 1 000 vehicles may request a reduction in the number of certification vehicles determined in accordance with Clause 40.4.3.5 above. The Administrator may agree to such lesser number as he determines would meet the intent of this Rule.

40.5 DETERMINATION OF COMPLIANCE

40.5.1 Compliance shall be established to the satisfaction of the Administrator in accordance with this Rule.

40.5.2 In determining whether compliance has been established the Administrator may accept, at his discretion, approvals issued with respect to other emissions standards in other countries equal to or more stringent than this Rule.

40.5.3 Tests conducted with unleaded fuels meeting overseas fuel specifications may be accepted, at the discretion of the Administrator.

40.6 EMISSIONS TEST PROCEDURE

40.6.1 General Requirements

40.6.1.1 Vehicles tested for exhaust emissions shall undergo a heat build (refer Clause 40.6.4.1).

40.6.1.2 Ambient temperatures encountered by the vehicle throughout the test sequence shall not be less than 20°C and not more than 30°C except for the stabilisation distance accumulation specified by Clause 40.6.3.2.

40.6.1.3 The vehicle shall be substantially level during the test sequence, to prevent abnormal fuel distribution.

40.6.1.4 Unless otherwise approved, the fuel used for the determination of fuel evaporative and exhaust emissions shall comply with the relevant specifications in Appendix II.

40.6.1.5 Two ambient temperature sensors, connected to provide one average output, shall be located in the Sealed Housing for Evaporative Determination (SHED) (refer Definitions Clause 40.1). These sensors shall be located at the approximate vertical centreline of each side wall extending 100 mm ± 20 mm into the SHED at a height of 900 mm ± 200 mm.

40.6.1.6 The manufacturer may take steps to provide certification vehicles with stabilised background (non-fuel) emissions.

40.6.1.7 Purge blower(s) shall be of such capacity as to be able to effectively reduce hydrocarbons concentration in the SHED to ambient levels.

40.6.1.8 Mixing fan(s) shall be used to ensure homogeneity of the gas in the SHED. The air stream from the mixing fan(s) shall not be directed towards the vehicle.

40.6.1.9 The net internal SHED volume shall be determined by subtracting 1.42 cubic metres from the calculated SHED internal volume, 1.42 cubic metres being taken as the nominal volume of a vehicle.

40.6.1.10 For information purposes, the sequence of events of the emission tests is shown in Appendix VIII.

40.6.2 Vehicle and Engine Preparation

40.6.2.1 Every vehicle shall be tuned and adjusted in accordance with the label(s) referred to in Clause 40.3.5.2.

40.6.2.2 Emissions control systems installed on or incorporated in the vehicle shall be functioning normally during the emission test(s).

40.6.2.3 The fuel tank(s) shall be prepared for recording the temperature of the fuel at approximately the mid-volume of the fuel at "tank fuel volume" (refer Definitions Clause 40.1).

40.6.2.4 Additional fittings and adaptors may be provided to accommodate a fuel drain at the lowest point possible in the fuel tank(s) as installed.

40.6.2.5 For vehicles with multiple tanks, the largest tank shall be designated as the primary tank and shall be heated in accordance with the procedures described in Clause 40.6.4.2. All other tanks shall be designated as auxiliary tanks and shall undergo a similar heat build such that fuel temperature shall be within 2°C of the primary tank.

40.6.3 Vehicle Preconditioning

40.6.3.1 For these operations, especially the tank draining and fuelling steps, the emissions control system shall neither be abnormally purged nor abnormally loaded.

40.6.3.2 Unless otherwise approved, the certification vehicle is driven to the stabilisation distance chosen by the manufacturer in Clause 40.3.3, in accordance with the procedure of Appendix VI, using either Standard Test Fuel (Appendix II) or Stabilisation Distance Accumulation Fuel (Appendix III).

40.6.3.3 The manufacturer may at his discretion conduct additional preconditioning to ensure that the fuel evaporative emissions control system is stabilised. This additional preconditioning shall consist of an initial one hour minimum soak, and one, 2 or 3 simulated trips of 1372 seconds duration (refer Clause 40.8 and Appendix 1) on a dynamometer, each followed by a soak of at least one hour with engine shut off, engine compartment cover closed and vehicle cooling fan off. The vehicle may be driven off the dynamometer following each simulated trip for the soak period. This additional preconditioning shall occur prior to Clause 40.6.3.4.

40.6.3.4 The fuel tank(s) shall be drained and filled with Standard Test Fuel to the prescribed "tank fuel volume" (refer Definitions Clause 40.1). The fuel added to the vehicle shall have a temperature of not more than 30°C.

40.6.3.5 Within one hour of filling the tank as required by Clause 40.6.3.4, the vehicle shall be placed on the dynamometer and operated over a simulated trip of 1372 seconds duration, (refer Clause 40.8 and Appendix 1).

40.6.3.6 Within 5 minutes of the completion of the simulated trip in Clause 40.6.3.5, the vehicle shall be driven off the dynamometer and parked.

40.6.4 Fuel Evaporative Emissions Test Procedure

The test comprises 2 phases: a diurnal breathing loss phase (refer Clause 40.6.4.2); and a hot soak loss phase (refer Clause 40.6.5).

40.6.4.1 Procedure followed where only an exhaust emissions test is involved

Vehicles to be tested only for exhaust emissions shall undergo a heat build. However, since no evaporative measurements are necessary, a SHED is not required, and any steps relevant to a SHED or associated hydrocarbons analysis are not applicable.

The step after the heat build in such a test only for exhaust emissions is the CVS-CH Dynamometer Schedule described in Clause 40.7.1 "General Requirements for Exhaust Emissions Test".

40.6.4.2 Diurnal Breathing Loss Phase

(a) Following vehicle preparation and vehicle preconditioning procedures described in Clauses 40.6.2 and 40.6.3 the vehicle shall be allowed to soak for a period of not less than 12 and not more than 36 hours prior to the exhaust emissions test. The diurnal breathing loss phase shall start not less than 10 or more than 35 hours after the end of the preconditioning procedure. The start of the exhaust emissions test shall follow the end of the diurnal breathing loss phase within one hour.

(b) Immediately prior to the test, the SHED shall be purged using the purge blower(s).

NOTE: If at any time the hydrocarbons concentration exceeds 15 000 ppm C the SHED should be immediately purged. This concentration provides a 4:1 safety factor against the lean flammability limit.

(c) The flame ionisation detector (FID) hydrocarbons analyser shall be zeroed and spanned immediately prior to the test.

(d) If not already on, the SHED mixing fan shall be turned on at this time.

(e) Immediately prior to the heat build, the fuel tank(s) of the vehicle shall be drained and filled with Standard Test Fuel, to the prescribed "tank fuel volume". The temperature of the fuel delivered to the fuel tank shall be between 10 and 16°C. The fuel tank cap(s) is not installed until the heat build begins.

(f) The vehicle, with the engine shut off, shall be moved into the SHED, the vehicle windows and luggage compartments shall be opened, the fuel tank temperature sensor shall be connected to the temperature recording system, and the heat source shall be positioned with respect to the fuel tank(s) and shall be connected to the temperature controller.

(g) The temperature recording system shall be started.

(h) The fuel may be artificially heated to the starting temperature.

(i) When the fuel temperature reaches 15°C ± 1°C immediately:

(i) Install fuel tank cap(s).

(ii) Turn off purge blower, if on.

(iii) Close and seal SHED doors.

(j) When the fuel temperature reaches 16°C ± 1°C immediately:

(i) Analyse the SHED atmosphere for hydrocarbons and record this initial (time = 0 minutes) hydrocarbons concentration HC $conc_i$ (refer Clause 40.6.7).

(ii) Start heat build and record the time. This commences the 60 minutes ± 2 minutes test period.

(iii) Record the temperature within the SHED.

(iv) Record the laboratory barometric pressure.

(k) The fuel shall be heated in such a way that its temperature change conforms to the following function to within 2°C.

$$C_t = T_0 + (2/9)t$$

where: C_t = fuel temperature at time t, in °C.

t = time since beginning of test, in minutes.

T_0 = initial temperature, in °C.

After 60 minutes ± 2 minutes of heating, the fuel temperature rise shall be 13.3 ± 0.5°C.

(l) The hydrocarbons analyser shall be zeroed and spanned immediately prior to the end of the diurnal breathing loss phase.

(m) The end of the diurnal breathing loss phase occurs 60 minutes $\pm$ 2 minutes after the heat build begins (refer sub-clause (j)(ii)).

(i) Analyse the SHED atmosphere for hydrocarbons and record this final (time = 60 minutes) hydrocarbons concentration HC $conc_f$ (refer Clause 40.6.7).

(ii) Record the time at which the analysis is made, and record the elapsed time since start of heat build.

(iii) Record the temperature within the SHED.

(iv) Record the laboratory barometric pressure.

(n) The heat source shall be turned off and the SHED doors unsealed and opened.

(o) The heat source shall be moved away from the vehicle, and disconnected from the temperature controller.

(p) The fuel tank temperature sensor shall be disconnected from the temperature recording system.

(q) The vehicle windows and luggage compartment(s) may be closed and the vehicle, without starting the engine, shall be removed from the SHED.

(r) The next step in the emissions tests is a CVS-CH Dynamometer Schedule (refer Clause 40.7.1) which shall follow the heat build by not more than one hour.

40.6.5 Hot Soak Loss Phase

The hot soak loss phase of the fuel evaporative emissions test is conducted following the CVS-CH Dynamometer Schedule, described in Clause 40.7.1.

(a) Immediately prior to the completion of the CVS-CH Dynamometer Schedule, the SHED shall be purged, using purge blower.

(b) The flame ionisation detector (FID) hydrocarbons analyser shall be zeroed and spanned immediately prior to the test.

(c) The SHED mixing fan shall be turned on.

(d) Upon completion of the CVS-CH Dynamometer Schedule, the vehicle engine compartment cover shall be closed, the vehicle cooling fan shall be moved, the vehicle shall be disconnected from the dynamometer and exhaust sampling system, and then driven at minimum throttle to the vehicle entrance of the SHED.

(e) The vehicle's engine shall be shut off and the purge blower turned off before any part of the vehicle enters the SHED. The time at which the engine is shut off shall be recorded, e.g. on the fuel evaporative emissions hydrocarbons data recording system. The vehicle may be pushed or coasted into the SHED.

(f) The vehicle windows and luggage compartment(s) shall be opened.

(g) The temperature recording system shall be started.

(h) The SHED doors shall be closed and sealed within 2 minutes of engine shut off and within 7 minutes after the completion of the CVS-CH Dynamometer Schedule.

(i) The 60 minutes ± 0.5 minute hot soak period begins when the SHED doors are sealed.

  (i) Analyse the SHED atmosphere for hydrocarbons and record this initial (time = 0 minutes) hydrocarbons concentration HC $conc_i$ (refer Clause 40.6.7).

  (ii) Record the temperature within the SHED.

  (iii) Record the laboratory barometric pressure.

(j) The vehicle shall soak for a period of 60 minutes ± 0.5 minute in the SHED.

(k) The FID hydrocarbons analyser shall be zeroed and spanned immediately prior to the end of the test.

(l) The end of the hot soak period occurs 60 minutes ± 0.5 minute after the sealing of the SHED doors. (refer step (i)).

  (i) Analyse the SHED atmosphere for hydrocarbons and record time. This gives the final (time = 60 minutes) hydrocarbons concentration HC $conc_f$ (refer Clause 40.6.7).

  (ii) Record the temperature within the SHED.

  (iii) Record the laboratory barometric pressure.

This operation completes the emission test procedure(s).

40.6.6 Fuel Evaporative Emissions Analytical System

40.6.6.1 Hydrocarbons concentrations are measured using a flame ionisation detector analyser calibrated with propane using air as a diluent. Details of calibration are given in Appendix X.

40.6.6.2 The analyser shall be zeroed with zero-grade air (refer Definitions Clause 40.1).

40.6.6.3 The analyser shall be scaled so that the expected maximum reading shall be between 20 percent and 100 percent of full scale deflection. The analyser shall be spanned using span gas of concentration approximately equal to 80 percent of full scale deflection.

40.6.7 Calculation of Fuel Evaporative Emission Result

The final reported result shall be computed by using the following formula, and summing the individual fuel evaporative emissions results determined for the diurnal breathing loss phase (refer Clause 40.6.4.2) and the hot soak loss phase (refer Clause 40.6.5).

$$HC\ mass = K\ V_n\ 10^{-4} \left(\frac{HCconc_f \times PP_f}{T_f} - \frac{HCconc_i \times PP_i}{T_i} \right) \quad \text{......(Equation 6.1)}$$

where:

HC mass = hydrocarbons mass, in grams.

K = coefficient:
Diurnal = 17.20
Hot Soak = 17.04

V_n = net SHED volume - (refer Clause 40.6.1.9),
= calculated internal volume of SHED in cubic metres, less 1.42 cubic metres.

HC conc = hydrocarbons concentration, as ppm carbon equivalent.

PP = corrected laboratory barometric pressure, in kPa.

T = ambient temperature within the SHED, in degrees Kelvin.

Sub-script $_i$ = indicates initial reading.

Sub-script $_f$ = indicates final reading.

40.7 EXHAUST EMISSIONS TEST PROCEDURE

40.7.1 General Requirements for Exhaust Emissions Test

(a) The vehicle and engine having undergone preparation, preconditioning and heat build according to Clauses 40.6.1 to 40.6.4, the beginning of this part of the emissions test shall follow the heat build by not more than one hour. The vehicle shall be stored prior to this part of the emissions test in such a manner that precipitation (e.g. rain or dew) does not occur on the vehicle.

The complete CVS-CH dynamometer schedule consists of a cold start drive of 1372 seconds, a pause of 10 minutes with the engine shut off and a hot start drive of 505 seconds. The vehicle is allowed to stand on the dynamometer during the 10 minute pause between the cold and hot start drives. The cold start drive of 1372 seconds is divided into two periods. The first period, represents the cold start "transient" phase, and terminates at the end of the deceleration which is scheduled to occur at 505 seconds of the driving schedule. The second period, representing the "stabilised" phase, consists of the remainder of the 1372 seconds drive including engine shut off. The hot start drive similarly consists of two periods. The first period, representing the hot start "transient" phase, terminates at the same point in the driving cycle as the first period of the cold start drive, i.e. 505 seconds. The second period of the hot start drive, representing the "stabilised" phase, is assumed to be identical to the second period of the cold start drive. Therefore, the hot start drive terminates after the first period (505 seconds) is run.

The cycle, the schedule and the periods are shown in Figure I.1 of Appendix I.

(b) The following steps shall be taken for each test, after preparation of the test equipment. Any references to a distance counter only apply if the equipment uses such a device:

(i) Place drive wheels of vehicle on dynamometer without starting engine;

(ii) Open the vehicle engine compartment cover and position the vehicle cooling fan;

(iii) With the sample selector valves in the "dump" position, connect evacuated sample collection bags to the dilute exhaust sample collection system and to the dilution air sample collection system;

(iv) Start the CVS (if not already on), the sample pumps, the temperature recorder, and the vehicle cooling fan. The heat exchanger of the CVS, if used, and filter (if applicable) should be preheated to their respective operating temperatures before the test begins;

(v) Adjust the sample flow rates to the desired flow rate (minimum of 5 litres/minute), set the revolution counter (for PDP) or the timer (for CFV) to zero, and set the revolution counters to zero, where a distance counter is used;

(vi) Attach the flexible exhaust sample tube(s) to the vehicle tailpipe(s);

(vii) Simultaneously start the revolution counter (for PDP) or the timer (for CFV), position the sample selector valves to direct the sample flow into the "transient" exhaust sample bag and the "transient" dilution air sample bag and start cranking the engine;

(viii) 15 seconds after the engine starts, place the transmission in gear or drive;

(ix) 20 seconds after the engine starts, begin the initial vehicle acceleration of the driving schedule;

(x) Operate the vehicle according to the dynamometer driving schedule described in Appendix I;

(xi) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously switch the sample flows from the "transient" bags to the "stabilised" bags, switch off the revolution counter (for PDP) or the timer (for CFV) No. 1 and start the revolution counter (for PDP) or the timer (for CFV) No. 2. Before the acceleration which is scheduled to occur at 510 seconds, where a distance counter is used, record the measured roll or shaft revolutions and reset the counter or switch to a second counter. As soon as possible, and in no case longer than 20 minutes after the end of this phase of the test, analyse the samples according to Clause 40.7.2;

(xii) Shut the engine off 2 seconds after the end of the last deceleration (i.e. at 1369 seconds);

(xiii) 5 seconds after the engine stops running, simultaneously turn off the revolution counter (for PDP) or the timer (for CFV) No. 2 and position the sample selector valves to the "standby" position. If the engine 'diesels', the 5 second period commences when dieseling stops. This fact shall be noted. Where a distance counter is used, record the measured roll or shaft revolutions and reset the counter or switch to zero. As soon as possible, and in no case longer than 20 minutes after the end of this phase of the test, analyse the samples according to Clause 40.7.2;

(xiv) Immediately after the end of the sample collection period turn off the vehicle cooling fan and close the engine compartment cover;

(xv) Turn off the revolution counter (for PDP) or the timer (for CFV) or isolate the exhaust sample tube(s) from the tailpipe(s) of the vehicle;

(xvi) Repeat the steps in sub-clauses (b)(ii) to (x) of this Clause for the hot start drive, except only one evacuated sample bag is required for sampling exhaust gas and one for dilution air. The engine starting step described in sub-clause (b)(vii) of this Clause shall begin between 9 and 11 minutes after the end of the sample collection period for the cold start drive;

(xvii) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously turn off the revolution counter (for PDP) or the timer (for CFV) No. 1 and position the sample selector valve to the "standby" position. (Engine shut off is not part of the hot start drive sample period). Where a distance counter is used, record the measured roll or shaft revolutions;

(xviii) As soon as possible and in no case longer than 20 minutes after the end of this phase of the test, analyse the samples according to Clause 40.7.2;

(xix) Disconnect the exhaust sample tube(s) from the vehicle tailpipe(s) and drive vehicle from dynamometer;

(xx) Vehicles to be tested for fuel evaporative emissions shall now proceed according to the "hot soak loss phase" of Clause 40.6.5.

For tests where only an exhaust emissions test is involved this completes the test sequence.

40.7.2 Exhaust Emissions:
Sampling System; Analytical System; Sample Analysis

40.7.2.1 Exhaust Gas Sampling System

40.7.2.1.1 General

The exhaust gas sampling system is designed to measure the true mass emissions of vehicle exhaust. In the CVS concept of measuring mass emissions, two conditions must be satisfied; the total volume of the mixture of exhaust and dilution air must be measured, and continuously proportioned sample of volume must be collected for analysis. Mass emissions are determined from the sample concentration and totalised flow over the test period.

40.7.2.1.2 Positive Displacement Pump

The Positive Displacement Pump-Constant Volume Sampler (PDP-CVS), satisfies the first condition by metering at a constant temperature and pressure through the pump. The total volume is measured by counting the revolutions made by the calibrated PDP. The proportional sample is achieved by sampling at a constant flow rate.

40.7.2.1.3 Critical Flow Venturi

The operation of the Critical Flow Venturi-Constant Volume Sampler (CFV-CVS), is based upon the principles of fluid dynamics associated with critical flow. Proportional sampling throughout temperature excursions is maintained by use of a small CFV in the sample line. The variable mixture flow rate is maintained at sonic velocity, which is directly proportional to the square root of the gas temperature, and is computed continuously. Since the pressure and temperature are the same at both venturi inlets, the sample volume is proportional to the total volume.

40.7.2.1.4 Other Systems

Other CVS systems may be used if shown to yield equivalent results, and if approved in advance.

40.7.2.1.5 Component Description, PDP-CVS

The PDP-CVS consists of a dilution air filter and mixing assembly, heat exchanger, PDP, sampling system, and associated valves, pressure and temperature sensors. The PDP-CVS shall conform to the following requirements:

40.7.2.1.5.1 Static pressure variations at the tailpipe(s) of the vehicle shall remain within 1.2 kPa of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). Sampling systems shall be capable of maintaining the static pressure to within 0.25 kPa.

40.7.2.1.5.2 The gas mixture temperature, measured at a point immediately ahead of the displacement pump, shall be within plus or minus 6°C of the designed operating temperature at the start of the test. The gas mixture temperature variation from its value at the start of the test shall be limited to ± 6°C during the entire test. The temperature measuring system shall have an accuracy and precision of ± 1°C.

40.7.2.1.5.3 The pressure gauges shall have an accuracy and precision of ± 0.4 kPa.

40.7.2.1.5.4 The flow capacity of the CVS shall be large enough to eliminate water condensation in the system (140 to 165 litres/second is sufficient for most vehicles).

40.7.2.1.5.5 Sample collection bags for dilution air and exhaust samples shall be of sufficient size so as not to impede sample flow.

40.7.2.1.6 <u>Component Description CFV-CVS</u>

The CFV-CVS consists of a dilution air filter and mixing assembly, cyclone particulate separator, sampling venturi, critical flow venturi, sampling system, and assorted valves, pressure and temperature sensors. The CFV-CVS shall conform to the following requirements:

40.7.2.1.6.1 Static pressure variations at the tailpipe(s) of the vehicle shall remain within 1.2 kPa of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). Sampling systems shall be capable of maintaining the static pressure to within 0.25 kPa.

40.7.2.1.6.2 The temperature measuring system shall have an accuracy and precision of ± 1°C and a response time of 0.100 seconds to 62.5 percent of a temperature change (as measured in hot silicone oil).

40.7.2.1.6.3 The pressure measuring system shall have an accuracy and precision of ± 0.4 kPa.

40.7.2.1.6.4 The flow capacity of the CVS shall be large enough to virtually eliminate water condensation in the system (140 to 165 litres/second is sufficient for most vehicles).

40.7.2.1.6.5 Sample collection bags for dilution air and exhaust samples shall be of sufficient size so as not to impede sample flow.

40.7.2.2 Exhaust Gas Analytical System

The analytical system provides for the determination, in dilute exhaust samples, of hydrocarbons concentrations by flame ionisation detector (FID) analysis, the determination of carbon monoxide and carbon dioxide concentrations by non-dispersive infra-red (NDIR) analysis and the determination of oxides of nitrogen concentration by chemiluminescence (CL).

The analytical equipment shall be calibrated as provided for in Appendix X.

The CL method of analysis requires that the nitrogen dioxide present in the sample be converted to nitric oxide before analysis.

Recorder charts shall be used to provide permanent records of calibration, spanning and sample measurements. In those facilities where computerised data acquisition systems are used, the printout facility may be used.

40.7.2.3 Exhaust Gas Sample Analysis

HC, CO, CO_2 and NO_x measurements: Allow a minimum of 20 minutes warmup for the HC (FID) analyser and 2 hours for the CO, CO_2 (NDIR) and NO_x (CL) analysers. (Power is normally left on with NDIR and CL analysers but when not in use, the chopper motors of the NDIR analysers are turned off and the phototube high voltage supply of the CL analyser is placed in the standby position).

The following sequence of operations shall be performed in conjunction with each series of measurements:

(i) Zero the analysers and obtain a stable zero reading. Recheck after tests.

(ii) Introduce the span gases and set instrument gains. In order to avoid corrections, span and calibrate at the same flow rates used to analyse the test sample. Span gases shall have concentrations equal to 75 to 100 percent of full scale. If gain has shifted significantly on the analysers, check the calibrations. Show actual concentrations on the chart.

(iii) Check zeroes; repeat the procedure in sub-clauses (i) and (ii) of this Clause if required.

(iv) Check flow rates and pressures.

(v) Measure and record the HC, CO, CO_2 and NO_x concentrations of the dilution air and dilute exhaust sample bags from the instrument deflections or recordings making use of appropriate calibration data. These concentrations are used in calculation of exhaust emissions result (refer Clause 40.7.3).

(vi) Check zero and span points. If difference is greater than 2 percent of full scale, repeat the procedure in sub-clauses (i) and (iv) of this Clause.

(vii) Measure and record T_p (the average dilute exhaust mixture temperature). Use the temperature recorder trace if a recorder is used.

(viii) Record:

N = (the number of revolutions of the PDP during the test phases);

P_B = (the corrected barometric pressure during or immediately prior to the test, in kPa);

P_1 = (the pressure depression below atmospheric at the inlet to the PDP, in kPa);

R_a = (the relative humidity of ambient air, in percent);

V_{mix} = (the standard volume metered by the CFV during the test phases, in litres).

40.7.3 Calculation of Exhaust Emissions Result

40.7.3.1 The test results shall be calculated by use of one of the following equations 7.1(a) or 7.1(b):

ALTERNATIVE 1:

$$Y_{wm} = (0.43\ Y_{ct} + Y_s + 0.57\ Y_{ht})/12.07 \quad \text{(Equation 7.1(a))}$$

where: Y_{wm} = Weighted mass emissions for each emission (i.e. HC, CO, NO_x, CO_2), in grams per vehicle kilometre.

Y_{ct}, Y_s, Y_{ht} = mass emission for each test phase, in grams/phase.

Sub-script $_{ct}$ = cold start drive "transient" test phase.

Sub-script $_{s}$ = cold start drive "stabilised" test phase.

Sub-script $_{ht}$ = hot start drive "transient" test phase.

ALTERNATIVE 2:

$$Y_{wm} = 0.43\ ((Y_{ct} + Y_s)/(D_{ct} + D_s)) + 0.57\ ((Y_{ht} + Y_s)/(D_{ht} + D_s)) \quad \text{..................Equation 7.1(b))}$$

where, additionally to above designations,

D_{ct} = measured driven distance in "transient" phase of cold start test, in km.

D_s = measured driven distance in "stabilised" phase of cold start test, in km.

D_{ht} = measured driven distance in "transient" phase of hot start test, in km.

40.7.3.2 The mass of each emission for each phase of the test is determined from the following:

- for hydrocarbons

$$HC\ mass = V_{mix} \times Density_{HC} \times \frac{HC\ conc}{10^6} \quad \text{.........................(Equation 7.2)}$$

- for carbon monoxide

$$CO\ mass = V_{mix} \times Density_{CO} \times \frac{CO\ conc}{10^6} \quad \text{.........................(Equation 7.3)}$$

- for oxides of nitrogen

$$NO_x\ mass = V_{mix} \times Density\ NO_x \times \frac{NO_x\ conc.}{10^6} \times K_H \quad \text{................(Equation 7.4)}$$

- for carbon dioxide

$$CO_2\ mass = V_{mix} \times Density_{CO_2} \times \frac{CO_2\ conc}{10^2} \quad \text{.......................(Equation 7.5)}$$

PART A:

HC mass = hydrocarbons emissions, calculated using Equation 7.2, in grams/test phase

where: Density $_{HC}$ = density of exhaust hydrocarbons, assuming the average C:H ratio in the fuel is 1:1.85, at 293^{o}K and 101.3 kPa pressure

= 0.577 gram/litre.

HC conc = hydrocarbons concentration of the dilute exhaust emissions sample corrected for background, in ppm carbon equivalent i.e. equivalent propane times 3.

$= HC_e - HC_d\ (1-1/DF)$ ....(Equation 7.6)

and where: HC_e = hydrocarbons concentration of dilute exhaust emissions sample as measured, in ppm carbon equivalent.

HC_d = hydrocarbons concentration of the dilution air as measured, in ppm carbon equivalent.

DF = Dilution Factor.......(refer Equation 7.14)

PART B:

CO mass = carbon monoxide emission, calculated using Equation 7.3, grams/test phase.

where: Density $_{CO}$ = density of carbon monoxide, at 293^{o}K and 101.3 kPa pressure

= 1.164 grams/litre.

CO conc. = carbon monoxide concentration of dilute exhaust sample corrected for background, water vapour and CO_2 extraction, in ppm.

$= CO_e - CO_d\ (1-1/DF)$ ....(Equation 7.7)

and where: CO_e = carbon monoxide concentration in dilute exhaust emissions sample corrected for water vapour and CO_2 extraction, in ppm.

The calculation assumes the ratio of C:H in the fuel is 1:1.85.

CO_e = $(1-0.01925\ CO_{2e} - 0.000323R_a)\ CO_{em}$.....(Equation 7.6)

(CO_e = CO_{em} if instrument has no CO_2 or water vapour response.)

CO_{em} = carbon monoxide concentration in dilute exhaust emissions sample as measured, in ppm.

CO_{2e} = carbon dioxide concentration of dilute exhaust emissions sample, in mole percent.

R_a = relative humidity of the ambient air, in percent.

CO_d = carbon monoxide concentration of the dilution air corrected for water vapour extraction, in ppm.

CO_d = $(1-0.000323R_a)\ CO_{dm}$....................(Equation 7.9)

(CO_d = CO_{dm}, if instrument has no water vapour response)

CO_{dm} = carbon monoxide concentration of the background air sample as measured, in ppm.

DF = Dilution Factor.................(refer Equation 7.14)

PART C:

NO_x mass = oxides of nitrogen emission, calculated using Equation 7.4, in grams/test phase.

where: Density NO_x = density of oxides of nitrogen in exhaust gas, assuming they are in the form of nitrogen dioxide, at 293°K and 101.3 kPa pressure

= 1.913 grams/litre.

NO_x conc = oxides of nitrogen concentration of the dilute exhaust emissions sample corrected for background, in ppm.

= $NO_{xe} - NO_{xd}\ (1-1/DF)$........(Equation 7.10)

and where: NO_{xe} = oxides of nitrogen concentration in the dilute exhaust emissions sample as measured, in ppm.

DF = Dilution Factor.......(refer Equation 7.14)

NO_{xd} = oxides of nitrogen concentration of the dilution air as measured, in ppm.

K_H = Humidity Correction Factor.

$$K_H = \frac{1}{1-0.0329(H-10.71)} \quad \text{..........(Equation 7.11)}$$

where: H = absolute humidity, in grams of water per kilogram of dry air.

$$H = \frac{6.211 \times R_a \times P_d}{P_B - \frac{(P_d \times R_a)}{100}} \quad \text{............(Equation 7.12)}$$

R_a = Relative humidity of ambient air, in percent.

P_d = Saturated vapor pressure at the ambient dry bulb temperature, in kPa.

P_B = Corrected barometric pressure during or immediately prior to the test, in kPa.

PART D:

CO_2 mass = carbon dioxide emission, calculated using Equation 7.5, grams/test phase.

where: Density CO_2 = density of carbon dioxide, at 293°K and 101.3 kPa pressure

= 1.830 grams/litre.

CO_2 conc = carbon dioxide concentration of the dilute exhaust emissions sample corrected for background, in mole percent.

$$= CO_{2e} - CO_{2d}\ (1-1/DF) \quad \text{........(Equation 7.13)}$$

and where: CO_{2e} = carbon dioxide concentration of the dilute exhaust emissions sample as measured, in mole percent.

CO_{2d} = carbon dioxide concentration of dilution air as measured, in mole percent.

DF = Dilution Factor

$$= \frac{13.4}{CO_{2e} + (HC_e + CO_e)\ 10^{-4}} \quad \text{.....(Equation 7.14)}$$

PART E:

V_{mix} = Total dilute exhaust volume, in litres per test phase, corrected to standard conditions (293°K and 101.3 kPa).

(i) For a Positive Displacement Pump - Constant Volume Sampler Unit:

$$V_{mix} = V_o \times N \times \frac{(P_B - P_1)}{101.3} \times \frac{293}{T_p} \text{ ....(Equation 7.15)}$$

where:

V_o = Volume of gas pumped by the PDP, in litres per revolution. This volume is dependent upon the pressure differential across the PDP and the absolute inlet pressure.

N = Number of revolutions of the PDP during the test phase.

P_B = Corrected barometric pressure during or immediately prior to the test, in kPa.

P_1 = Pressure depression below atmospheric, measured at the inlet to the PDP, in kPa.

T_p = Average temperature of the dilute exhaust entering the PDP during test while the samples for each phase are being collected, in degrees Kelvin.

(ii) For a Critical Flow Venturi - Constant Volume Sampler Unit:

V_{mix} is read directly from a calibrated instrument or is calculated:

$$V_{mix} = Q_m \times \frac{293}{T_p} \times t \times \frac{P_2}{101.3} \text{ ....(Equation 7.16)}$$

where:

Q_m = Flow rate, in litres per second at T_p, P_2.

P_2 = Average absolute pressure at inlet to CFV, in kPa.

t = Time, in seconds.

T_p = Average temperature of the dilute exhaust entering the CFV during test while the samples for each phase are being collected, in degrees Kelvin.

40.8 DYNAMOMETER SCHEDULE

General Requirements

40.8.1 Unless otherwise approved, the fuel used during the dynamometer schedule shall be the Standard Test Fuel, complying with the specification in Appendix II.

40.8.2 The dynamometer shall be run in accordance with the dynamometer driving schedule, procedure and driving requirements described in Clauses 40.7.1 and 40.8.4 to 40.8.6.

40.8.3 The dynamometer driving cycle over which the the vehicle is to be operated is shown in Appendix I.

40.8.4 Dynamometer Driving Cycle

(a) The dynamometer driving cycle to be followed consists of a non-repetitive series of idle, acceleration, cruise, and deceleration modes of various time sequences and rates. The cycle is defined by a smooth transition through the speed-time relationship listed in Appendix I. The time sequence begins upon starting the vehicle according to the startup procedure described in Clause 40.8.6.1.

The speed tolerance at any given time on the cycle prescribed in Appendix I is defined by upper and lower limits. The upper limit is 3.2 km/h higher than the highest point on the trace within one second of the given time. The lower limit is 3.2 km/h lower than the lowest point on the trace within one second of the given time. Speed variations greater than the tolerances (such as occur when shifting manual transmission vehicles) are acceptable provided they occur for less than 2 seconds on any one occasion. Speeds lower than those prescribed are acceptable provided the vehicle is operated at wide open throttle during such occurrences.

The speed tolerances are shown in Figures I.2 and I.3, in Appendix I.

When conducted to meet the requirements of Clause 40.6.3, the speed tolerances shall be as specified above, except the upper and lower limits shall be 6.4 km/h.

(b) During dynamometer operation, a fixed speed cooling fan shall be positioned so as to direct cooling air to the vehicle in an appropriate manner with the engine compartment cover open. The fan capacity shall normally not exceed 150 cubic metres/minute. If, however, the manufacturer can show that during service the vehicle receives additional cooling, the fan capacity may be increased or additional fans used. In the case of vehicles with front engine compartments, the fan(s) shall be squarely positioned between 200 and 300 mm in front of the cooling air inlets (grill). In the case of vehicles with rear engine compartments (or if special designs make the above impractical), the cooling fan(s) shall be placed in a position to provide sufficient air to maintain engine cooling.

(c) The vehicle shall be substantially level during the testing sequence to prevent abnormal fuel distribution.

IMPORTANT NOTE:

The provisions of sub-clauses (d) and (e) are especially relevant to vehicles with a gross vehicle mass over 2.7 tonnes which are being certified for compliance utilising the recommendation on the green sheets of ADR 36 and ADR 36A that vehicles manufactured after 1 July 1985 which comply with ADR 40 need not comply with ADR 36 and ADR 36A respectively.

(d) Flywheels, electrical devices or other means of simulating equivalent test inertia mass shall be used. If the equivalent test inertia mass specified in the table in sub-clause (e)(ii) is not available on the dynamometer being used, the next higher equivalent test inertia mass available shall be used.

If the maximum equivalent test inertia mass (2722 kg) is not available on the dynamometer being used, the maximum available equivalent test inertia mass shall be used, with advance approval.

(e) Dynamometer road load power absorption unit setting.

Note:

Vehicles to be tested may not be used to set dynamometer power.

(i) Calculation: The Road Load Power in kW may be calculated using Equation 8.1:

Road Load Power = b x B ....(Equation 8.1)

where: b = 4.01 for "van shaped" vehicles (see below).
= 4.66 for all other vehicles to which this Rule applies.

A vehicle is considered to have a "van shape" if it has an integral enclosure, fully enclosing the driver compartment, and has no body sections protruding more than 760 mm ahead of the leading edge of the windshield.

and where: B = Basic vehicle frontal area, in square metres plus additional frontal area, in square metres, of mirrors and optional equipment exceeding 0.01 square metres which are anticipated to be sold on more than 33 percent of vehicles in that engine family.
Frontal area measurements shall be computed to the nearest 0.01 square metres, using a method approved in advance.

(ii) As an alternative to (i), the road load power shown in the following table may be used:

Reference Mass (kg)	Equivalent Test Inertia Mass (kg)	Road Load Power at 80 km/h (kW)
Up to 481	454	4.4
482 to 538	510	4.6
539 to 595	567	4.8
596 to 652	624	5.0
653 to 708	680	5.3
709 to 765	737	5.5
766 to 822	794	5.7
823 to 878	850	6.0
879 to 935	907	6.2
936 to 992	964	6.4
993 to 1048	1021	6.6
1049 to 1105	1077	6.8
1106 to 1162	1134	7.0
1163 to 1219	1191	7.2
1220 to 1275	1247	7.4
1276 to 1332	1304	7.6
1333 to 1389	1361	7.7
1390 to 1445	1417	7.9
1446 to 1502	1474	8.0
1503 to 1559	1531	8.2
1560 to 1615	1588	8.4
1616 to 1672	1644	8.5
1673 to 1729	1701	8.6
1730 to 1786	1758	8.8
1787 to 1871	1814	9.0
1872 to 1984	1928	9.2
1985 to 2097	2041	9.5
2098 to 2211	2155	9.7
2212 to 2324	2268	10.0
2325 to 2438	2381	10.2
2439 to 2608	2495	10.4
Above 2608	2722	10.7

(iii) As an alternative to (i) and (ii), the vehicle manufacturer may determine the road load power by an alternative procedure requested by the manufacturer and approved in advance.

(iv) The road load power absorption unit shall be adjusted to reproduce road load power at 80 km/h true speed. The indicated road load power setting shall take into account the dynamometer friction. The relationship between actual (absorbed) road load power and indicated road load power for a particular dynamometer shall be determined by the procedure outlined in Appendix IV or other suitable means.

(v) Where it is expected that more than 33 percent of an engine family will be produced with air conditioning, the road load power as determined in this section (e) shall be increased by 10 percent for testing all certification vehicles representing that engine family. This power increment shall be added to the indicated dynamometer road load power prior to rounding off of this value.

(vi) The dynamometer road load power for vehicles shall be rounded off to the nearest 0.1 kW, using the "rounding off" method of ASTM E 29-67.

(f) The vehicle speed (km/h) as measured from the dynamometer idle roll shall be used for all conditions. A speed-time record shall be made as evidence of dynamometer test validity.

(g) Provided an emissions sample is not taken, practice runs over the prescribed driving schedule may be performed at test points for the purpose of finding the minimum throttle action to maintain the proper speed-time relationship to comply with the speed tolerances specified in Clause 40.8.4(a), or to permit sampling system adjustments.

(h) When using a twin-roll dynamometer, a speed-time trace of greater accuracy may be obtained by minimising the rocking of the vehicle on the rolls. The rocking of the vehicle changes the tyre rolling radius on each roll. The rocking may be minimised by restraining the vehicle horizontally (or nearly so) by using a cable and winch.

(i) The drive wheel tyres may be inflated up to 310 kPa in order to prevent tyre damage.

(j) If the dynamometer has not been operated during the 2 hour period immediately preceding the test it shall be warmed up for 15 minutes by operating it at 50 km/h using a non-test vehicle.

(k) If the dynamometer road load power setting has to be adjusted manually, it shall be done within one hour prior to the dynamometer run. A non-test vehicle shall be used to make this adjustment. Dynamometers using automatic control of pre-selectable road load power settings may be set any time prior to the beginning of the dynamometer run.

(l) The driving distance, as measured by counting the number of dynamometer roll or shaft revolutions, shall be determined for the cold start "transient" phase, the cold start "stabilised" phase, and the hot start "transient" phase. The revolutions shall be measured on the same roll or shaft used for measuring the vehicle's speed, i.e. the idle roll.

(m) As an alternative to this method of establishing driving distance, some means shall be provided for determining the accuracy of the driven distance, and the means shall be approved in advance.

40.8.5 Driving Requirements

The following driving requirements shall be met during the test:

40.8.5.1 For 3 speed manual transmissions -

(a) Unless otherwise specified, the test shall be run in highest gear. Appropriate downshifting is allowed at the beginning of, or during, an acceleration mode or when the engine obviously is lugging.

(b) Vehicles equipped with free wheeling or overdrive units shall be tested with this unit (free wheeling or overdrive)locked out of operation.

(c) Idle shall be run with transmission in gear and with clutch disengaged (except first idle; refer Clause 40.8.6.1).

(d) The vehicle shall be driven with minimum throttle movement to maintain the desired speed.

(e) Acceleration modes shall be driven smoothly with the shift speeds as recommended by the vehicle manufacturer. Where the manufacturer does not recommend shift speeds, the vehicle shall be shifted from first to second gear at 24 km/h and from second to third gear at 40 km/h. The operator shall release the accelerator pedal during the shift and accomplish the shift with minimum closed throttle time. If the vehicle cannot accelerate at the specified rates, the vehicle shall be accelerated at wide open throttle until the vehicle speed reaches the speed at which it should be at that time during the test.

(f) The deceleration modes shall be run with clutch engaged and without shifting gears from the previous mode, using brakes or throttle as necessary to maintain the desired speed. For those modes which decelerate to zero, the clutch shall be depressed when the speed drops below 24 km/h, when engine roughness is evident, or when engine stalling is imminent.

40.8.5.2 For 4 and 5 speed manual transmissions -

(a) The same procedure as for 3 speed manual transmissions shall be followed for shifting from first to second gear and from second to third gear. Where the vehicle manufacturer does not recommend shift speeds, the vehicle shall be shifted from third to fourth gear at 65 km/h. Fifth gear may be used at the manufacturer's option.

(b) Where the transmission ratio in first gear exceeds 5:1, the procedure for 3 or 4 speed manual transmission vehicles shall be followed as if the first gear did not exist.

40.8.5.3 For automatic transmissions -

(a) The test shall be run with the transmission in "Drive" (highest gear). Automatic "stick-shift" transmissions may be shifted as manual transmissions.

(b) Idle modes shall be run with the transmission in "Drive" and the wheels braked (except first idle; refer Clause 40.8.6).

(c) The vehicle shall be driven with minimum throttle movement to maintain the desired speed.

(d) Acceleration modes shall be driven smoothly allowing the transmission to shift automatically through the normal sequence of gears. If the vehicle cannot accelerate at the specified rates, the vehicle shall be accelerated at wide open throttle until the vehicle speed reaches the speed at which it should be at that time during the test.

(e) The deceleration modes shall be run in gear using brakes or throttle as necessary to maintain the desired speed.

40.8.6 Engine Operation

The following engine operational requirements shall be met during the test:

40.8.6.1 The engine shall be started according to the vehicle manufacturer's recommended starting procedures. The initial 20 second idle period shall begin when the engine starts.

40.8.6.2 Choke Operation

Vehicles equipped with an automatic choke shall be operated according to the instructions which shall be included in the vehicle manufacturer's operating instructions or owner's manual including choke setting and 'kick-down' from cold fast idle. If choke 'kick-down' time is not specified and 'kick-down' is not automatic, it shall be performed 13 seconds after the engine starts. The transmission shall be placed in gear 15 seconds after the engine is started. If necessary, braking may be employed to keep the drive wheels from turning.

40.8.6.3 Vehicles equipped with a manual choke shall be operated according to the vehicle manufacturer's operating instructions or owner's manual. If not specified, the choke shall be operated to maintain engine idle at 1 100 ± 50 rpm during the initial idle period.

40.8.6.4 The operator may use more choke, more throttle, etc, where necessary to keep the engine running.

40.8.6.5 If the vehicle manufacturer's operating instructions or owner's manual do not specify a warm engine starting procedure, the engine (automatic and manual choke engines) shall be started by depressing the acceleration pedal about half way and cranking the engine until it starts.

40.8.6.6 Failure to Start

If the vehicle does not start after 10 seconds cranking, cranking shall cease and a diagnosis made of the reasons for failure to start.

Whenever the engine stops unintentionally and cannot be restarted within 10 seconds, the revolution counter (for PDP) or the timer (for CFV) on the CVS shall be turned off and the sample valves placed in the 'stand-by' position during the diagnostic period. In addition, the CVS should be isolated from the tailpipe during the diagnostic period. If failure to start is an operational error, the vehicle shall be rescheduled for testing from a cold start.

(a) If a failure to start or restart occurs at the commencement of, or during, respectively, the cold start drive portion of the test and is caused by a vehicle malfunction, appropriate action of less than 30 minutes duration may be taken, and the test continued. The sampling system shall be reactivated at the same time cranking begins. When the engine starts, the driving schedule timing sequence shall begin. If failure to start is caused by vehicle malfunction and the vehicle cannot be started, the test shall be voided, the vehicle removed from the dynamometer, appropriate action taken, and the vehicle rescheduled for testing. The reason for the malfunction (if determined) and the action taken shall be reported.

(b) If a failure to start or restart occurs at the commencement of, or during, respectively, the hot start drive portion of the test and is caused by a vehicle malfunction, the vehicle must be started within one minute of the beginning of the attempt to start or restart. The sampling system shall be reactivated at the same time cranking begins. When the engine starts, the driving schedule timing sequence shall begin. If the vehicle cannot be started within the one minute, the test shall be voided, the vehicle removed from the dynamometer, appropriate action taken, and the vehicle rescheduled for testing. The reason for the malfunction (if determined) and the action shall be reported.

40.8.6.7 If the engine 'false starts', the operator shall repeat the recommended starting procedure (such as resetting the choke etc.). 'False start' means that the engine does start, but does not continue for a significant period, e.g. no longer than 10 seconds.

40.8.6.8 Stalling

If the engine stalls during an idle period, the engine shall be restarted immediately and the test continued. If the engine cannot be started soon enough to allow the vehicle to follow the next acceleration as prescribed, the driving schedule indicator shall be stopped. When the vehicle restarts, the driving schedule indicator shall be reactivated.

40.8.6.9 If the engine stalls during some operating mode other than idle, the driving schedule indicator shall be stopped, the vehicle restarted, accelerated to the speed required at that point in the driving schedule and the test continued.

40.8.6.10 If the vehicle will not restart within one minute, the test shall be voided, the vehicle removed from the dynamometer, appropriate action taken and the vehicle rescheduled for testing. The reason for the malfunction (if determined) and the action taken shall be reported.

40.8.6.11 <u>Allowable 'corrective action'</u>

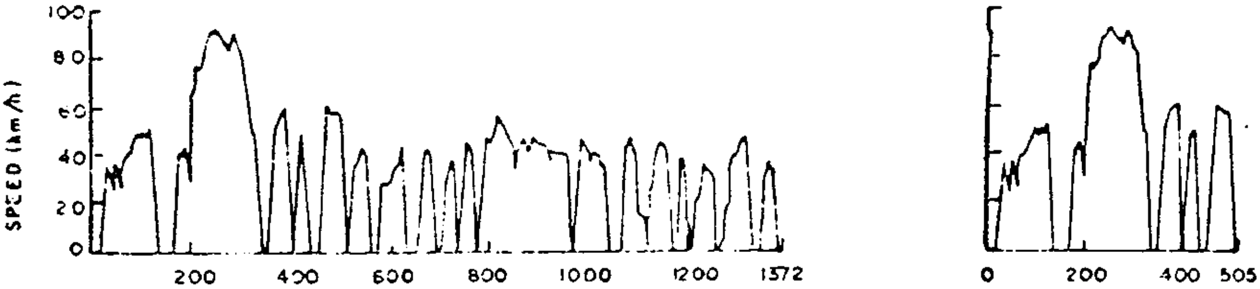
Refer to Appendix VII for allowable corrective action on the engine, emissions control system or fuel system of a vehicle malfunctioning during an emissions test, including stabilisation distance accumulation.

APPENDIX I

DYNAMOMETER DRIVING CYCLE

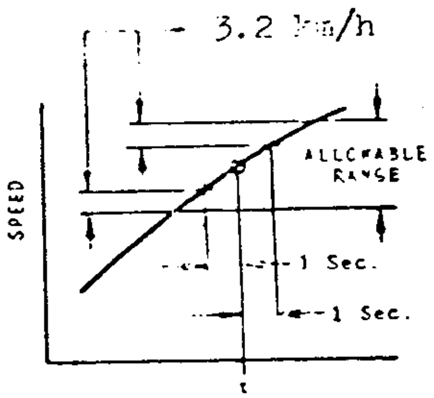
(Shown diagrammatically in Figure I.1)

The following Table sets out the equivalent vehicle speeds appropriate at one second intervals of time after the engine starts. The vehicle speed to be achieved at any particular time 't' seconds shall be within 3.2 km/h of at least one of the speeds indicated for (t-1), t, and (t+1). (See Figures I.2 and I.3 for diagrammatic representation of these tolerances). Speed variations outside the prescribed tolerance are permitted provided that their duration is less than 2 seconds. Speeds lower than those prescribed are permitted provided that the vehicle is being operated at maximum available power.

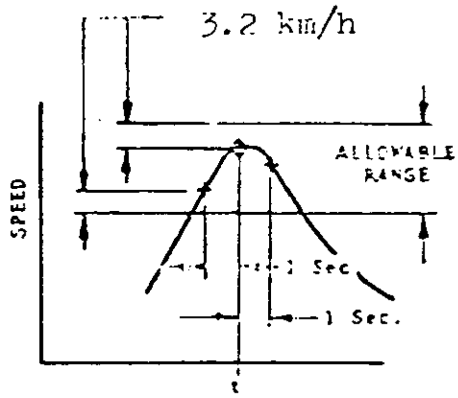


Cold start drive (1372 seconds) 10 minute pause Hot start drive (505 seconds)

CVS-CH DRIVING SCHEDULE
FIGURE I.1



TIME
Figure I.2



TIME
Figure I.3

Figures I.2 and I.3 show the range of acceptable speed tolerances for typical points. Figure I.2 is typical of portions of the speed curve which are increasing or decreasing throughout the 2 second time interval. Figure I.3 is typical of portions of the speed curve which include a maximum or minimum value.

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Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)
0	0.0	45	30.7	90	49.4	135	0.0
1	0.0	46	34.0	91	49.1	136	0.0
2	0.0	47	36.5	92	48.9	137	0.0
3	0.0	48	36.9	93	48.8	138	0.0
4	0.0	49	36.5	94	48.9	139	0.0
5	0.0	50	36.4	95	49.6	140	0.0
6	0.0	51	34.3	96	48.9	141	0.0
7	0.0	52	30.6	97	48.1	142	0.0
8	0.0	53	27.5	98	47.5	143	0.0
9	0.0	54	25.4	99	48.0	144	0.0
10	0.0	55	25.4	100	48.8	145	0.0
11	0.0	56	28.5	101	49.4	146	0.0
12	0.0	57	31.9	102	49.7	147	0.0
13	0.0	58	34.8	103	49.9	148	0.0
14	0.0	59	37.3	104	49.7	149	0.0
15	0.0	60	38.9	105	48.9	150	0.0
16	0.0	61	39.6	106	48.0	151	0.0
17	0.0	62	40.1	107	48.1	152	0.0
18	0.0	63	40.2	108	48.6	153	0.0
19	0.0	64	39.6	109	49.4	154	0.0
20	0.0	65	39.4	110	50.2	155	0.0
21	4.8	66	39.8	111	51.2	156	0.0
22	9.5	67	39.9	112	51.8	157	0.0
23	13.8	68	39.8	113	52.1	158	0.0
24	18.5	69	39.6	114	51.8	159	0.0
25	23.0	70	39.6	115	51.0	160	0.0
26	27.2	71	40.4	116	46.0	161	0.0
27	27.8	72	41.2	117	40.7	162	0.0
28	29.1	73	41.4	118	35.4	163	0.0
29	33.3	74	40.9	119	30.1	164	5.3
30	34.9	75	40.1	120	24.8	165	10.6
31	36.0	76	40.2	121	19.5	166	15.9
32	36.2	77	40.9	122	14.2	167	21.2
33	35.6	78	41.8	123	8.9	168	26.6
34	34.6	79	41.8	124	3.5	169	31.9
35	33.6	80	41.4	125	0.0	170	35.7
36	32.8	81	42.0	126	0.0	171	39.1
37	31.9	82	43.0	127	0.0	172	41.5
38	27.4	83	44.3	128	0.0	173	42.5
39	24.0	84	46.0	129	0.0	174	41.4
40	24.0	85	47.2	130	0.0	175	40.4
41	24.5	86	48.0	131	0.0	176	39.8
42	24.9	87	48.4	132	0.0	177	40.2
43	25.7	88	48.9	133	0.0	178	40.6
44	27.5	89	49.4	134	0.0	179	40.9

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Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)
180	41.5	225	85.6	270	82.9	315	50.7
181	43.8	226	87.1	271	83.0	316	49.2
182	42.6	227	87.9	272	83.4	317	49.1
183	38.6	228	88.4	273	83.8	318	48.3
184	36.5	229	88.5	274	84.5	319	46.7
185	31.2	230	88.4	275	85.3	320	44.3
186	28.5	231	87.9	276	86.1	321	39.9
187	27.7	232	87.9	277	86.9	322	34.6
188	29.1	233	88.2	278	88.4	323	32.3
189	29.9	234	88.7	279	89.2	324	30.7
190	32.2	235	89.3	280	89.5	325	29.8
191	35.7	236	89.6	281	90.1	326	27.4
192	39.4	237	90.3	282	90.1	327	24.9
193	43.9	238	90.6	283	89.8	328	20.1
194	49.1	239	91.1	284	88.8	329	17.4
195	53.9	240	91.2	285	87.7	330	12.9
196	58.3	241	91.2	286	86.3	331	7.6
197	60.0	242	90.9	287	84.5	332	2.3
198	63.2	243	90.9	288	82.9	333	0.0
199	65.2	244	90.9	289	82.9	334	0.0
200	67.8	245	90.9	290	82.9	335	0.0
201	70.0	246	90.9	291	82.2	336	0.0
202	72.6	247	90.9	292	80.6	337	0.0
203	74.0	248	90.8	293	80.5	338	0.0
204	75.3	249	90.3	294	80.6	339	0.0
205	76.4	250	89.8	295	80.5	340	0.0
206	76.4	251	88.7	296	79.8	341	0.0
207	76.1	252	87.9	297	79.7	342	0.0
208	76.0	253	87.2	298	79.7	343	0.0
209	75.6	254	86.9	299	79.7	344	0.0
210	75.6	255	86.4	300	79.0	345	0.0
211	75.6	256	86.3	301	78.2	346	0.0
212	75.6	257	86.7	302	77.4	347	1.6
213	75.6	258	86.9	303	76.0	348	6.9
214	76.0	259	87.1	304	74.2	349	12.2
215	76.3	260	87.1	305	72.4	350	17.5
216	77.1	261	86.6	306	70.5	351	22.9
217	78.1	262	85.9	307	68.6	352	27.8
218	79.0	263	85.3	308	66.8	353	32.2
219	79.7	264	84.7	309	64.9	354	36.2
220	80.5	265	83.8	310	62.0	355	38.1
221	81.4	266	84.3	311	59.5	356	40.6
222	82.1	267	83.7	312	56.6	357	42.8
223	82.9	268	83.5	313	54.5	358	45.2
224	84.0	269	83.2	314	52.3	359	48.3

AUSTRALIAN DESIGN RULE 40 - LIGHT DUTY VEHICLE EMISSION CONTROL

Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)
360	49.6	405	14.8	450	15.9	495	45.1
361	50.9	406	20.1	451	21.2	496	41.0
362	51.7	407	25.4	452	26.6	497	36.2
363	52.3	408	30.7	453	31.9	498	31.9
364	54.1	409	36.0	454	37.2	499	26.6
365	55.5	410	40.2	455	42.5	500	21.2
366	55.7	411	41.2	456	44.7	501	16.6
367	56.2	412	44.3	457	46.8	502	11.6
368	56.0	413	46.7	458	50.7	503	6.4
369	55.5	414	48.3	459	53.1	504	1.6
370	55.8	415	48.4	460	54.1	505	0.0
371	57.1	416	48.3	461	56.0	506	0.0
372	57.9	417	47.8	462	56.5	507	0.0
373	57.9	418	47.2	463	57.3	508	0.0
374	57.9	419	46.3	464	58.1	509	0.0
375	57.9	420	45.1	465	57.9	510	0.0
376	57.9	421	40.2	466	58.1	511	1.9
377	57.9	422	34.9	467	58.3	512	5.6
378	58.1	423	29.6	468	57.9	513	8.9
379	58.6	424	24.3	469	57.5	514	10.5
380	58.7	425	19.0	470	57.9	515	13.7
381	58.6	426	13.7	471	57.9	516	15.4
382	57.9	427	8.4	472	57.3	517	16.9
383	56.5	428	3.1	473	57.1	518	19.2
384	54.9	429	0.0	474	57.0	519	22.5
385	53.9	430	0.0	475	56.6	520	25.7
386	50.5	431	0.0	476	56.6	521	28.5
387	46.7	432	0.0	477	56.6	522	30.6
388	41.4	433	0.0	478	56.6	523	32.3
389	37.0	434	0.0	479	56.6	524	33.8
390	32.7	435	0.0	480	56.6	525	35.4
391	28.2	436	0.0	481	56.3	526	37.0
392	23.3	437	0.0	482	56.5	527	38.3
393	19.3	438	0.0	483	56.6	528	39.4
394	14.0	439	0.0	484	57.1	529	40.1
395	8.7	440	0.0	485	56.6	530	40.2
396	3.4	441	0.0	486	56.3	531	40.2
397	0.0	442	0.0	487	56.3	532	40.2
398	0.0	443	0.0	488	56.3	533	40.2
399	0.0	444	0.0	489	56.0	534	40.2
400	0.0	445	0.0	490	55.7	535	40.2
401	0.0	446	0.0	491	55.5	536	41.2
402	0.0	447	0.0	492	53.9	537	41.5
403	4.2	448	5.3	493	51.5	538	41.8
404	9.5	449	10.6	494	48.4	539	41.2

Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)
540	40.6	585	27.4	630	0.0	675	18.7
541	40.2	586	27.5	631	0.0	676	14.0
542	40.2	587	27.4	632	0.0	677	9.3
543	40.2	588	26.7	633	0.0	678	5.6
544	39.3	589	26.6	634	0.0	679	3.2
545	37.2	590	26.6	635	0.0	680	0.0
546	31.9	591	26.7	636	0.0	681	0.0
547	26.6	592	27.4	637	0.0	682	0.0
548	21.2	593	28.3	638	0.0	683	0.0
549	15.9	594	29.8	639	0.0	684	0.0
550	10.6	595	30.9	640	0.0	685	0.0
551	5.3	596	32.5	641	0.0	686	0.0
552	0.0	597	33.8	642	0.0	687	0.0
553	0.0	598	34.0	643	0.0	688	0.0
554	0.0	599	34.1	644	0.0	689	0.0
555	0.0	600	34.8	645	0.0	690	0.0
556	0.0	601	35.4	646	3.2	691	0.0
557	0.0	602	36.0	647	7.2	692	0.0
558	0.0	603	36.2	648	12.6	693	0.0
559	0.0	604	36.2	649	16.4	694	2.3
560	0.0	605	36.2	650	20.1	695	5.3
561	0.0	606	36.5	651	22.5	696	7.1
562	0.0	607	38.1	652	24.6	697	10.5
563	0.0	608	40.4	653	28.2	698	14.8
564	0.0	609	41.8	654	31.5	699	18.2
565	0.0	610	42.6	655	33.8	700	21.7
566	0.0	611	43.5	656	35.7	701	23.5
567	0.0	612	42.0	657	37.5	702	26.4
568	0.0	613	36.7	658	39.4	703	26.9
569	5.3	614	31.4	659	40.7	704	26.6
570	10.6	615	26.1	660	41.2	705	26.6
571	15.9	616	20.8	661	41.8	706	29.3
572	20.9	617	15.4	662	42.0	707	30.9
573	23.5	618	10.1	663	42.2	708	32.3
574	25.7	619	4.8	664	42.3	709	34.6
575	27.4	620	0.0	665	42.5	710	36.2
576	27.4	621	0.0	666	42.6	711	36.2
577	27.4	622	0.0	667	42.6	712	35.6
578	28.2	623	0.0	668	41.8	713	36.5
579	28.5	624	0.0	669	41.0	714	37.5
580	28.5	625	0.0	670	38.0	715	37.8
581	28.2	626	0.0	671	34.4	716	36.2
582	27.4	627	0.0	672	29.8	717	34.8
583	27.2	628	0.0	673	26.4	718	33.0
584	26.7	629	0.0	674	23.3	719	29.0

Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)
720	24.1	765	0.8	810	55.0	855	43.8
721	19.3	766	0.0	811	54.7	856	44.7
722	14.5	767	4.8	812	54.7	857	45.2
723	10.0	768	10.1	813	54.6	858	46.3
724	7.2	769	15.4	814	54.1	859	46.5
725	4.8	770	20.8	815	53.3	860	46.7
726	3.4	771	25.4	816	53.1	861	46.8
727	0.8	772	28.2	817	52.3	862	46.7
728	0.8	773	29.6	818	51.5	863	45.2
729	5.1	774	31.4	819	51.3	864	44.3
730	10.5	775	33.3	820	50.9	865	43.5
731	15.4	776	35.4	821	50.7	866	41.6
732	20.1	777	37.3	822	49.2	867	40.2
733	22.5	778	40.2	823	48.3	868	39.4
734	25.7	779	42.6	824	48.1	869	39.9
735	29.0	780	44.3	825	48.1	870	40.4
736	31.5	781	45.1	826	48.1	871	41.0
737	34.6	782	45.5	827	48.1	872	41.4
738	37.2	783	46.5	828	47.6	873	42.2
739	39.4	784	46.5	829	47.5	874	43.3
740	41.0	785	46.5	830	47.5	875	44.3
741	42.6	786	46.3	831	47.2	876	44.7
742	43.6	787	45.6	832	46.5	877	45.7
743	44.4	788	45.5	833	45.4	878	46.7
744	44.9	789	45.5	834	44.6	879	47.0
745	45.5	790	45.5	835	43.5	880	46.8
746	46.0	791	45.4	836	41.0	881	46.7
747	46.0	792	44.4	837	38.1	882	46.5
748	45.5	793	44.3	838	35.4	883	45.9
749	45.4	794	44.3	839	33.0	884	45.2
750	45.1	795	44.3	840	30.9	885	45.1
751	44.3	796	44.3	841	30.9	886	45.1
752	43.1	797	44.3	842	32.3	887	44.4
753	41.0	798	44.3	843	33.6	888	43.8
754	37.8	799	44.4	844	34.4	889	42.8
755	34.6	800	45.1	845	35.4	890	43.5
756	30.6	801	45.9	846	36.4	891	44.3
757	26.6	802	48.3	847	37.3	892	44.7
758	24.0	803	49.9	848	38.6	893	45.1
759	20.1	804	51.5	849	40.2	894	44.7
760	15.1	805	53.1	850	41.8	895	45.1
761	10.0	806	53.1	851	42.8	896	45.1
762	4.8	807	54.1	852	42.8	897	45.1
763	2.4	808	54.7	853	43.1	898	44.6
764	2.4	809	55.2	854	43.5	899	44.1

AUSTRALIAN DESIGN RULE 40 - LIGHT DUTY VEHICLE EMISSION CONTROL

Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)
900	43.3	945	40.4	990	34.6	1035	0.0
901	42.8	946	41.2	991	35.1	1036	0.0
902	42.6	947	40.4	992	36.2	1037	0.0
903	42.6	948	38.6	993	37.0	1038	0.0
904	42.6	949	35.4	994	36.7	1039	0.0
905	42.3	950	32.3	995	36.7	1040	0.0
906	42.2	951	27.2	996	37.0	1041	0.0
907	42.2	952	21.9	997	36.5	1042	0.0
908	41.7	953	16.6	998	36.5	1043	0.0
909	41.2	954	11.3	999	36.5	1044	0.0
910	41.2	955	6.0	1000	37.8	1045	0.0
911	41.7	956	0.6	1001	38.6	1046	0.0
912	41.5	957	0.0	1002	39.6	1047	0.0
913	41.0	958	0.0	1003	39.9	1048	0.0
914	39.6	959	0.0	1004	40.4	1049	0.0
915	37.8	960	3.2	1005	41.0	1050	0.0
916	35.7	961	8.5	1006	41.2	1051	0.0
917	34.8	962	13.8	1007	41.0	1052	0.0
918	34.8	963	19.2	1008	40.2	1053	1.9
919	34.9	964	24.5	1009	38.8	1054	6.4
920	36.4	965	28.2	1010	38.1	1055	11.7
921	37.7	966	29.9	1011	37.3	1056	17.1
922	38.6	967	32.2	1012	36.9	1057	22.4
923	38.9	968	34.0	1013	36.2	1058	27.4
924	39.3	969	35.4	1014	35.4	1059	29.8
925	40.1	970	37.0	1015	34.8	1060	32.2
926	40.4	971	39.4	1016	33.0	1061	35.1
927	40.6	972	42.3	1017	28.2	1062	37.0
928	40.7	973	44.3	1018	22.9	1063	38.6
929	41.0	974	45.2	1019	17.5	1064	39.9
930	40.6	975	45.7	1020	12.2	1065	41.2
931	40.2	976	45.9	1021	6.9	1066	42.6
932	40.2	977	45.9	1022	1.6	1067	43.1
933	40.2	978	45.9	1023	0.0	1068	44.1
934	39.8	979	44.6	1024	0.0	1069	44.9
935	39.4	980	44.3	1025	0.0	1070	45.5
936	39.1	981	43.8	1026	0.0	1071	45.1
937	39.1	982	43.1	1027	0.0	1072	44.3
938	39.4	983	42.6	1028	0.0	1073	43.5
939	40.2	984	41.8	1029	0.0	1074	43.5
940	40.2	985	41.4	1030	0.0	1075	42.3
941	39.6	986	40.6	1031	0.0	1076	39.4
942	39.6	987	38.6	1032	0.0	1077	36.2
943	38.8	988	35.4	1033	0.0	1078	34.6
944	39.4	989	34.6	1034	0.0	1079	33.2

Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)
1080	29.0	1125	40.2	1170	8.7	1215	34.6
1081	24.1	1126	40.9	1171	14.0	1216	35.1
1082	19.8	1127	41.5	1172	19.3	1217	35.1
1083	17.9	1128	41.8	1173	24.6	1218	34.6
1084	17.1	1129	42.5	1174	29.9	1219	34.1
1085	16.1	1130	42.8	1175	34.0	1220	34.6
1086	15.3	1131	43.3	1176	37.0	1221	35.1
1087	14.6	1132	43.5	1177	37.8	1222	35.4
1088	14.0	1133	43.5	1178	37.0	1223	35.2
1089	13.8	1134	43.5	1179	36.2	1224	34.9
1090	14.2	1135	43.3	1180	32.2	1225	34.6
1091	14.5	1136	43.1	1181	26.9	1226	34.6
1092	14.0	1137	43.1	1182	21.6	1227	34.4
1093	13.8	1138	42.6	1183	16.3	1228	32.3
1094	12.9	1139	42.5	1184	10.9	1229	31.4
1095	11.3	1140	41.8	1185	5.6	1230	30.9
1096	8.0	1141	41.0	1186	0.3	1231	31.5
1097	6.8	1142	39.6	1187	0.0	1232	31.9
1098	4.2	1143	37.8	1188	0.0	1233	32.2
1099	1.6	1144	34.6	1189	0.0	1234	31.4
1100	0.0	1145	32.2	1190	0.0	1235	28.2
1101	0.2	1146	28.2	1191	0.0	1236	24.9
1102	1.0	1147	25.7	1192	0.0	1237	20.9
1103	2.6	1148	22.5	1193	0.0	1238	16.1
1104	5.8	1149	17.2	1194	0.0	1239	12.9
1105	11.1	1150	11.9	1195	0.0	1240	9.7
1106	16.1	1151	6.6	1196	0.0	1241	6.4
1107	20.6	1152	1.3	1197	0.3	1242	4.0
1108	22.5	1153	0.0	1198	2.4	1243	1.1
1109	23.3	1154	0.0	1199	5.6	1244	0.0
1110	25.7	1155	0.0	1200	10.5	1245	0.0
1111	29.1	1156	0.0	1201	15.8	1246	0.0
1112	32.2	1157	0.0	1202	19.3	1247	0.0
1113	33.8	1158	0.0	1203	20.8	1248	0.0
1114	34.1	1159	0.0	1204	20.9	1249	0.0
1115	34.3	1160	0.0	1205	20.3	1250	0.0
1116	34.4	1161	0.0	1206	20.6	1251	0.0
1117	34.9	1162	0.0	1207	21.1	1252	1.6
1118	36.2	1163	0.0	1208	21.1	1253	1.6
1119	37.0	1164	0.0	1209	22.5	1254	1.6
1120	38.3	1165	0.0	1210	24.9	1255	1.6
1121	39.4	1166	0.0	1211	27.4	1256	1.6
1122	40.2	1167	0.0	1212	29.9	1257	2.6
1123	40.1	1168	0.0	1213	31.7	1258	4.8
1124	39.9	1169	3.4	1214	33.8	1259	6.4

Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)	Time (secs)	Speed (km/h)
1260	8.0	1293	40.9	1326	0.0	1359	28.2
1261	10.1	1294	41.2	1327	0.0	1360	26.6
1262	12.9	1295	41.4	1328	0.0	1361	24.9
1263	16.1	1296	41.8	1329	0.0	1362	22.5
1264	16.9	1297	42.2	1330	0.0	1363	17.7
1265	15.3	1298	43.5	1331	0.0	1364	12.9
1266	13.7	1299	44.7	1332	0.0	1365	8.4
1267	12.2	1300	45.5	1333	0.0	1366	4.0
1268	14.2	1301	46.7	1334	0.0	1367	0.0
1269	17.7	1302	46.8	1335	0.0	1368	0.0
1270	22.5	1303	46.7	1336	0.0	1369	0.0
1271	27.4	1304	45.1	1337	0.0	1370	0.0
1272	31.4	1305	39.8	1338	2.4	1371	0.0
1273	33.8	1306	34.4	1339	7.7	1372	0.0
1274	35.1	1307	29.1	1340	13.0		
1275	35.7	1308	23.8	1341	18.3		
1276	37.0	1309	18.5	1342	21.2		
1277	38.0	1310	13.2	1343	24.3		
1278	38.8	1311	7.9	1344	27.0		
1279	39.4	1312	2.6	1345	29.5		
1280	39.4	1313	0.0	1346	31.4		
1281	38.6	1314	0.0	1347	32.7		
1282	37.8	1315	0.0	1348	34.3		
1283	37.8	1316	0.0	1349	35.2		
1284	37.8	1317	0.0	1350	35.6		
1285	37.8	1318	0.0	1351	36.0		
1286	37.8	1319	0.0	1352	35.4		
1287	37.8	1320	0.0	1353	34.8		
1288	38.6	1321	0.0	1354	34.0		
1289	38.8	1322	0.0	1355	33.0		
1290	39.4	1323	0.0	1356	32.2		
1291	39.8	1324	0.0	1357	31.5		
1292	40.2	1325	0.0	1358	29.8		

APPENDIX II

STANDARD TEST FUEL SPECIFICATION

(unless otherwise approved)

PROPERTY	ASTM Test Method	SPECIFICATION
Octane Number, Research	D 2699	91 min., 93 max.
Octane Number, Motor	D 2700	82 min.
Lead (organic), gram/litre	D 3237	0.013 max.
Sulphur, percent by mass	D 1266 or D 2785	0.10 max.
Phosphorus, gram/litre	D 3231	0.0013 max.
Distillation Range (°C):	D 86	
Initial Boiling Point		24-35
10 percent Point		49-57
50 percent Point		93-110
90 percent Point		149-163
End Point		213 max.
Hydrocarbon Composition:	D 1319	
Olefins, percent by volume		10 max.
Aromatics, percent by volume		35 max.
Saturates, percent by volume		Remainder
Reid Vapour Pressure (kPa):	D 323 or D 2551	
For Fuel Evaporative Emissions Test and/or Exhaust Emissions Test		60.0-63.4 (8.7-9.2 psi)
For Exhaust Emissions Only Test		55.0-63.4 (8.0-9.2 psi)

APPENDIX III

STABILISATION DISTANCE ACCUMULATION FUEL SPECIFICATION

Unless otherwise approved, either standard test fuel as specified in Appendix II or unleaded petrol (refer Definitions Clause 40.1) representative of commercial unleaded petrol which will be generally available through retail outlets, and meeting the following specification, shall be used for stabilisation distance accumulation:

Property	ASTM Test Method	Specification
Lead (organic), gram/litre	D 3237	0.013 max.
Sulphur, percent by mass	D 1266 or D 2785	0.10 max.
Phosphorus, gram/litre	D 3231	0.0013 max.

APPENDIX IV

DYNAMOMETER CALIBRATION

The dynamometer shall be calibrated as described in Appendix XII - Calibrations : Frequency and Overview.

The calibration shall consist of the manufacturer's recommended calibration procedure plus a determination of the dynamometer frictional power absorption at 80 km/h.

This appendix describes a method for determining the road load power absorbed by a chassis dynamometer for a single equivalent test inertia mass. Similar calibrations should be established for all equivalent test inertia masses used. Alternative methods of calibration may be used, if approved. The actual absorbed road load power includes the dynamometer friction as well as the power absorbed by the power absorption unit. Where multiple rolls are used, the calculation of actual absorbed road load power may neglect the inertia and friction of the rear or idle roll(s). The dynamometer is driven above the test speed range. The device used to drive the dynamometer is then disengaged from the dynamometer and the roll(s) is allowed to coast down. The kinetic energy of the system is dissipated by the dynamometer friction and absorption unit.

The following method shall be used:

1. Determine the speed of the drive roll if not already measured. A fifth wheel, revolution pickup or other suitable means may be used.

2. Place a vehicle on the dynamometer or use another method of driving the dynamometer.

3. Engage inertia fly-wheel for the most common equivalent test inertia mass for which the dynamometer is used.

4. Drive dynamometer up to 80 km/h.

5. Record indicated road load power setting.

6. Drive dynamometer up to 100 km/h.

7. Disengage the device used to drive the dynamometer.

8. Record the time for the dynamometer drive roll to coast down from 90 km/h to 70 km/h.

9. Adjust the road load power absorption unit to a different level.

10. Repeat steps 4 to 9 above sufficient times to cover the range of road load power absorber settings used.

11. Calculate actual absorbed road load power from:

$$RP_d = \frac{1/2\ W(V_1^2 - V_2^2)}{1000t}$$

$$RP_d = 0.12354 \times \frac{W}{t}$$

where: RP_d = Actual absorbed road load power, in kW.

W = Equivalent test inertia mass, in kg.

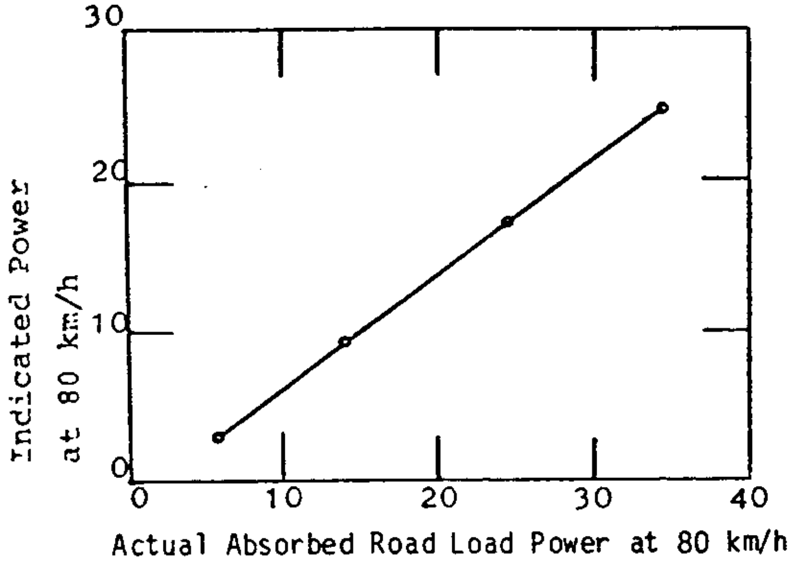
V_1 = initial velocity, in m/s (90 km/h = 25 m/s).

V_2 = final velocity, in m/s (70 km/h = 19.44 m/s).

t = elapsed time for rolls to coast from 90 km/h to 70 km/h, in seconds.

12. Plot indicated road load power at 80 km/h versus actual absorbed road load power at 80 km/h.

13. The required dynamometer power absorber setting for the test is obtained by entering the value from Clause Z.8.4(e) for road power absorber setting on the graph and reading off the indicated road power absorber setting for the dynamometer.



EXAMPLE OF A DYNAMOMETER CALIBRATION CURVE
FIGURE IV.1

APPENDIX V

C.V.S. SYSTEM CALIBRATION AND VERIFICATION

SECTION I - POSITIVE DISPLACEMENT PUMP-CONSTANT VOLUME SAMPLER CALIBRATION

The following calibration procedure outlines the equipment, the equipment configuration, and the various parameters which must be measured to establish the flow rate of the constant volume sampler pump. All the parameters related to the pump are simultaneously measured with the parameters related to a flowmeter which is connected in series with the pump. The calculated flow rate (litres/revolution at pump inlet absolute pressure and temperature) can then be plotted versus a correlation function which is the value of a specific combination of pump parameters. The linear equation which relates the pump flow and the correlation function is then determined. In the event that a CVS has a multiple speed drive, a calibration for each range should be performed.

This calibration procedure is based on the measurement of the absolute values of the pump and flowmeter parameters that relate the flow rate of each point. Three conditions must be maintained to assure the accuracy and integrity of the calibration curve. Firstly, the pump pressures should be measured at taps on the pump rather than at the external piping on the pump inlet and outlet. Pressure taps that are mounted at the top and bottom centre of the pump drive headplate are exposed to the actual pump cavity pressures, and therefore reflect the absolute pressure differentials. Secondly, temperature stability must be maintained during the calibration. The laminar flow element is sensitive to inlet temperature oscillations which cause the data points to be scattered. Gradual changes plus or minus 1°C) in temperature are acceptable as long as they occur over a period of several minutes. Finally, there shall be no leakage in any connection between the flowmeter and the CVS pump.

During a CVS emissions test the measurement of these same pump parameters enables the user to calculate the flow rate from the calibration equation.

After the calibration curve has been obtained, a verification test of the entire system can be performed by injecting a known mass of gas into the system and comparing the mass indicated by the system to the true mass injected. An indicated error does not necessarily mean that the calibration is wrong, since other factors can influence the accuracy of the system.

(A) Equipment

The following list of equipment will be needed to perform this calibration procedure. Figure V.1 illustrates a typical equipment arrangement used for calibration. All of the equipment involved should conform to the range and accuracy as specified in Table V.I.

Equipment List:

1. LFE - Laminar Flow Element (Flow meter)
2. Micro-manometer
3. Thermometers
4. Timer
5. U-Tube or inclined manometer
6. A variable flow restrictor with appropriate piping to connect the PDP, CFV and LFE.

After the system has been connected as shown in Figure V.1, set the variable restrictor in the wide open position and run the CVS pump for 20 minutes to stabilise. Record the calibration data.

Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression (about one kPa) that will yield a minimum of 6 data points for the total calibration.

Allow the system to stabilise for 3 minutes and repeat the data acquisition.

(B) Data Analysis - PDP System

The data recorded during the calibration are to be used in the following calculations:

1. The air flow rate at each test point is calculated in standard litres per minute (Q_s) from the flowmeter data using the manufacturer's prescribed method.
2. The air flow rate is then converted to pump flow, V_o in litres per revolution at absolute pump inlet temperature and pressure.

$$V_o = \frac{Q_s}{n} \times \frac{101.3}{P_p} \times \frac{T_P}{293}$$

where: Q_s = Air flow rate, in standard litres per minute (standard conditions are 293 degrees Kelvin and 101.3 kPa).

n = Pump speed, in revolutions per minute.

T_p = PTI, Air temperature at PDP inlet, in degrees Kelvin.

P_p = Absolute pump inlet pressure, in kPa.

P_p = $P_B - P_{PI}$.

3. The correlation function at each test point is then calculated from the calibration data, as follows:

$$X_o = \frac{1}{n} \times \sqrt{\frac{(P_o - P_p)}{P_o}}$$

where: $(P_o - P_p)$ = The pressure differential, pump inlet to pump outlet, in kPa.

P_o = Absolute pump outlet pressure, in kPa.

P_o = $P_B + P_{po}$.

P_{po} = Pressure at PDP outlet, in kPa.

4. A linear least-squares fit is performed to generate the calibration equations which have the forms:

$$V_o = D_o - M(X_o)$$

$$n = A - B\ (P_o)$$

where: D_o, M, A and B are the slope-intercept constants describing the lines.

A PDP system that has multiple speeds should be calibrated on each speed used. The calibration curves generated for the ranges will be approximately parallel and the intercept value D_o will increase as the pump flow range decreases.

If the calibration has been performed carefully, the calculated V_O values from the equation will be within 0.50 percent of the measured value of V_O. Values of M will vary from one pump to another, but values of D_O for pumps of the same make, model, and range should agree within 3 percent of each other. Particulate influx from use will cause the pump slip to decrease as reflected by lower values for M. Calibrations should be performed at 0, 50, 100, 200, and 500 hours of pump operation to assure the stability of the pump slip rate (refer Appendix XII, (e)). Thereafter it shall be recalibrated each 500 hours of pump operation or as system verification indicates necessary. Analysis of system verification data will also reflect pump slip stability.

5. Alternative methods of calibration may be used, if approved.

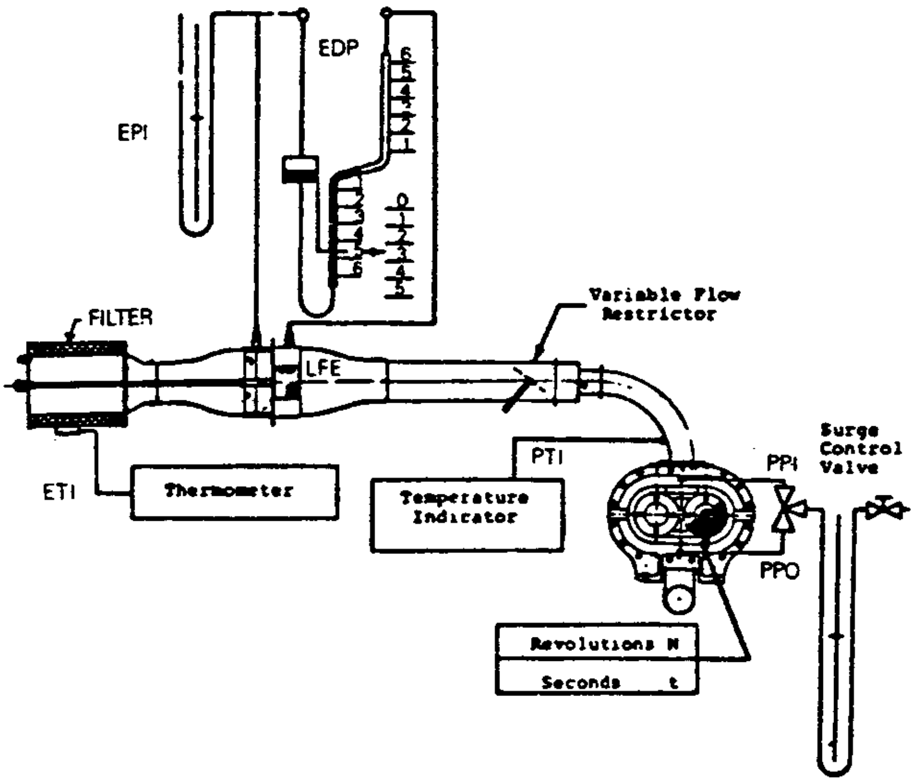


FIGURE V.1

PDP-CVS CALIBRATION CONFIGURATION

NOTE: The fluid level in the manometer tube should stabilise before the reading is made and the elapsed time for revolution counting should be greater than 120 seconds.

SECTION II - CRITICAL FLOW VENTURI - CONSTANT VOLUME SAMPLER CALIBRATION

The general comments made at the beginning of Section I of this Appendix V and the equipment detailed there, also apply, as and where appropriate, to calibration of a CFV-CVS unit.

(C) Data Analysis - CFV-CVS system

(i) Calibration of the Critical Flow Venturi (CFV) is based upon the flow equation for a critical venturi. Gas flow is a function of inlet pressure and temperature:

$$Q_s = \frac{K_v P}{\sqrt{T}}$$

where: Q_s = Flow rate, in litres per minute.

K_v = Calibration co-efficient.

P = Absolute pressure, in kPa.

T = Absolute temperature, in degrees Kelvin.

The calibration procedure described below establishes the value of the calibration co-efficient at measured values of pressure, temperature and air flow.

(ii) The manufacturer's recommended procedure shall be followed for calibrating electronic portions of the CFV.

(iii) Measurements necessary for flow calibration are as follows:

(Refer to Table V.1 for measurement tolerances).

(a) Set up equipment as shown in Figure V.2 and check for leaks. Any leaks between the flow measuring device and the critical flow venturi will seriously affect the accuracy of the calibration.

(b) Set the variable flow restrictor to the open position, start the blower and allow the system to stabilise. Record data from all instruments.

(c) Vary the flow restrictor and make at least 8 readings across the critical flow range of the venturi.

(iv) Data analysis. The data recorded during the calibration are to be used in the following calculations:

(a) The air flow rate, Q_s, at each test point is calculated from the flow meter data using the manufacturer's prescribed method.

(b) Calculate values of the calibration co-efficient for each test point:

$$K_v = \frac{Q_s \times \sqrt{T_v}}{P_v}$$

where: Q_s = Flow rate, in standard litres/minute (standard conditions are 293oK and 101.3 kPa).

T_v = Temperature at venturi inlet, in degrees Kelvin.

P_v = Pressure at venturi inlet, in kPa.

P_v = $P_B - P_{PI}$.

P_{PI} = Venturi inlet pressure depression, in kPa.

(c) Plot K_v as a function of venturi inlet depression. For sonic flow, K_v will have a relatively constant value. As pressure decreases (vacuum increases), the venturi becomes unchoked and K_v decreases (is no longer constant) (refer Figure V.3).

(d) For a minimum of 8 points in the critical region calculate an average K_v and the standard deviation.

(e) If the standard deviation exceeds 0.3 percent of the average K_v, take corrective action.

(v) Alternative methods of calibration may be used, if approved.

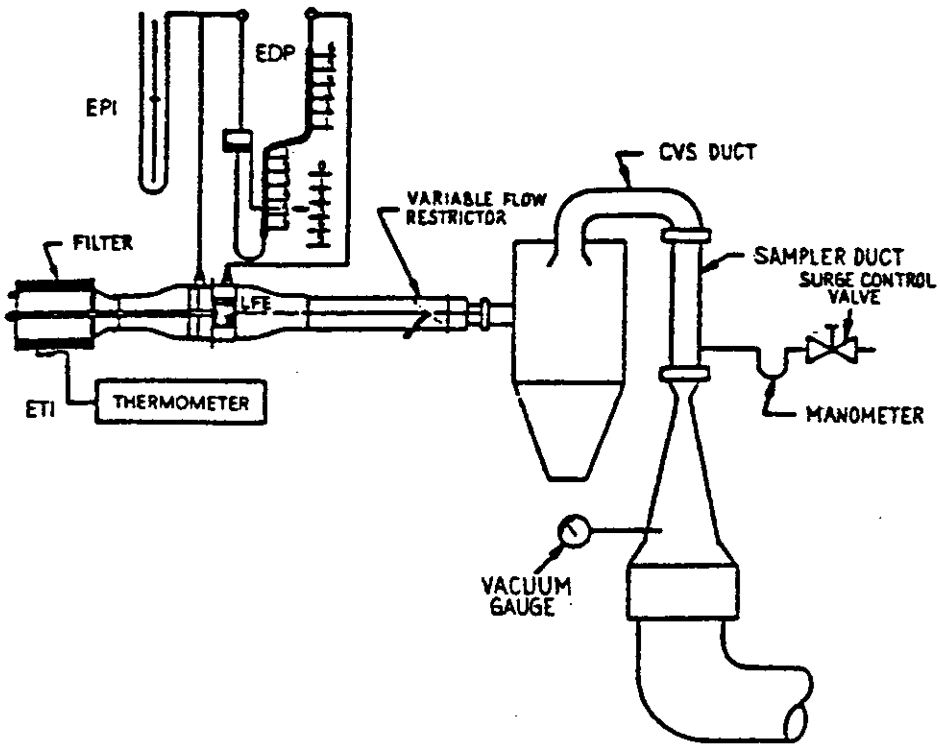


FIGURE V.2

CFV-CVS CALIBRATION CONFIGURATION

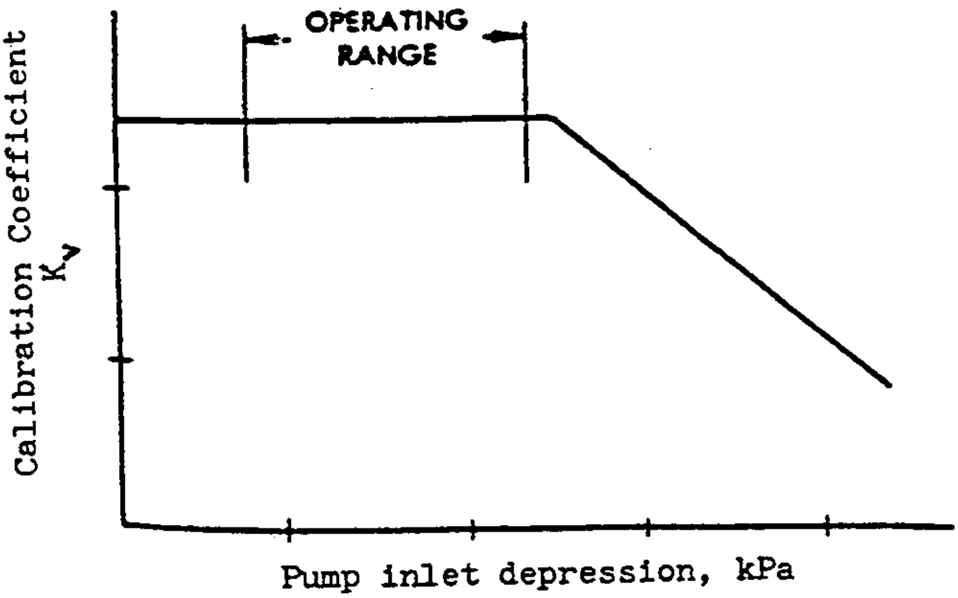


FIGURE V.3

SONIC FLOW CHOKING IN CFV SYSTEM

SECTION III - SYSTEM VERIFICATION

(D) CVS System Verification:

One of the following methods shall be used to verify that the CVS and analytical instruments can accurately measure a mass of gas that has been injected into the system.

METHOD 1: A critical flow orifice (CFO) may be used for injecting a measured amount of propane or CO into the sampling system, and for constant flow metering, using the instrument manufacturers' procedures for operating the equipment.

METHOD 2:

(i) Obtain a small cylinder that has been charged with propane or carbon monoxide gas.

(ii) Determine a reference cylinder mass to the nearest 0.01 gram.

(iii) Operate the CVS in the normal manner and release a known quantity of propane or carbon monoxide into the system during the sampling period.

(iv) The calculations are performed in the normal way except, in the case of propane, the density of propane (0.611 gram/litre/carbon atom) is used in place of the density of exhaust hydrocarbons. In the case of carbon monoxide, a density of 1.164 grams/litre is used.

(v) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(vi) The cause for any discrepancy greater than 2 percent should be found and corrected.

(E) Error Detection

The following list of parametric errors may assist the operator in locating the cause of large errors.

TYPE 1: Positive Error (Indication is higher than true value):

(i) Calculated V_0 is greater than actual V_0:

(a) Original calibration in error.

(ii) Pump inlet temperature recorder is reading low. A 3.5°C discrepancy will give a one percent error.

(iii) Pump inlet pressure indicator is reading high. A one kPa high reading will give a one percent error.

(iv) Background concentration reading is too low. Check analyser zero. Check leakage at floor inlet.

(v) Analyser is reading high. Check span.

(vi) Barometer reading is in error (too high). Barometric pressure reading should be gravity-corrected and temperature-corrected.

(vii) Revolution counter is reading high. Check pump speed and counters.

(viii) Mixture is stratified causing the sample to be higher than the average concentration in the mixture.

TYPE 2: Negative Error (Indication is lower than true value):

(i) Calculated V_O is less than actual V_O:

(a) Original calibration in error.

(b) Pump clearances decreased due to influx of some surface adherent material. Recalibration may be needed.

(ii) Pump inlet temperature recorder is reading high.

(iii) Pump inlet pressure indicator is reading low.

(iv) Background concentration reading is too high.

(v) Analyser is reading low.

(vi) Barometer reading is in error (too low).

(vii) Revolution counter is reading low.

(viii) There is a leak into the sampling system. Pressure check the lines and fittings on the intake side of sample transfer pumps on both the CVS and analyser console.

TABLE V.1

CALIBRATION DATA MEASUREMENTS - FOR A CONSTANT VOLUME SAMPLER (CVS) OF:

(i) Positive Displacement Pump (PDP) Type; or
(ii) Critical Flow Venturi (CFV) Type.

PARAMETER	SYMBOL	TOLERANCE	INSTRUMENT
Atmospheric pressure	P_B	± 0.03 kPa	Barometer
Ambient Temperature	T_A	± 0.3oC	Thermometer
Air Temperature into LFE	E_{TI}	± 0.15oC	Thermometer
Pressure depression upstream of LFE	E_{PI}	± 0.01 kPa	Manometer
Pressure differential across LFE	E_{DP}	± 0.001 kPa	Manometer
Air Temperature at:			
(i) PDP inlet; or (ii) CFV inlet	P_{TI} T_V	± 0.3°C ± 0.3°C	Thermometer
Pressure depression at: (i) PDP inlet; or (ii) CFV inlet	P_{PI}	± 0.01 kPa	Manometer
Pressure at PDP outlet	P_{PO}	± 0.01 kPa	Manometer
Air temperature at PDP outlet (optional)	P_{TO}	± 0.3°C	Thermometer
PDP revolutions during test phase	N	± one rpm	Revolution counter
Elapsed time for test phase	t	± 0.1 seconds	Stopwatch or equivalent
Air Flow (litres/minute)	Q_s	± 0.5 percent	Laminar flow element.

APPENDIX VI

STABILISATION DISTANCE ACCUMULATION PROCEDURE

1. As specified in Clause 40.3.3, each certification vehicle is tested for emissions at a stabilisation distance chosen by the manufacturer.

2. A certification vehicle which is to undergo emissions testing shall be driven for the stabilisation distance chosen by the manufacturer in accordance with the following Stabilisation Distance Accumulation Procedure. Unless otherwise approved, the fuel used for stabilisation distance accumulation shall be the Standard Test Fuel as specified in Appendix II, or the Stabilisation Distance Accumulation Fuel as specified in Appendix III.

3. Stabilisation Distance Accumulation Procedure

3.1 Except with advance approval all vehicles shall accumulate distance at a mass which is within 45 kg of the reference mass.

3.2 A certification vehicle shall be driven to its stabilisation distance with all emission control systems installed and operating.

3.3 Unless otherwise approved, stabilisation distance accumulation shall be performed in such a manner that, for each 1 000 km of distance:

(i) the number of stops shall be not less than 310;

(ii) not more than 20 percent of the distance shall be at speeds in excess of 75 km/h;

(iii) the average travelling speed shall be not greater than 60 km/h;

(iv) not more than 10 percent of the distance shall be at speeds in excess of 90 km/h;

(v) the total idle time shall be not less than 2.5 hours; and

(vi) the pattern of operation shall be designed in such a way that the average conditions determined from the above, could be expected to be experienced in any single hour of operation.

3.4 Stabilisation distance accumulation may be undertaken by approved chassis dynamometer methods which accurately reflect the requirements of this Stabilisation Distance Accumulation Procedure.

3.5 A modified procedure may also be used, if approved in advance.

APPENDIX VII

CORRECTIVE ACTION FOR VEHICLE MALFUNCTION DURING EMISSIONS TEST (INCLUDING THE STABILISATION DISTANCE ACCUMULATION)

(Refer to Clauses 40.3.2.10 and 40.8.6.11.)

Corrective action (refer Definitions Clause 40.1) on the engine, emissions control system, or fuel system of a vehicle may be undertaken during an emissions test subject to the following requirements:

(a) A preliminary determination has been made that the component failure or system malfunction, or the repair of such failure or malfunction, does not render the vehicle unrepresentative of vehicles in use, and does not require direct access to the combustion chamber, except for spark plug, fuel injection component, or removable prechamber removal or replacement (as applicable); and

the need for maintenance or repairs is indicated by an overt indication of malfunction such as persistent misfiring, vehicle stalling, overheating, fluid leakage, loss of oil pressure, or charge indicator warning.

(b) Equipment, instruments, or tools may not be used to identify malfunctioning, maladjusted, or defective engine components unless the same or equivalent equipment, instruments, or tools will be available to dealerships and other service outlets; and

are used in conjunction with scheduled maintenance on such components.

(c) Corrective action may be performed on the engine, emissions control system(s) and fuel system only under the following provisions:

(i) Any persistently misfiring spark plug may be replaced.

(ii) Readjustment of the engine cold starting enrichment system may be performed if there is a problem of stalling or if there is visible black smoke.

(iii) Readjustment of the engine idle speed (kerb idle and fast idle) may be performed if the idle speed differs from the manufacturer's recommended idle speed by 300 rpm or more, or if there is a problem of stalling.

(iv) A defective EGR system may be serviced once only, if there is an overt indication of malfunction and if the malfunction or repair of the malfunction does not render the vehicle unrepresentative.

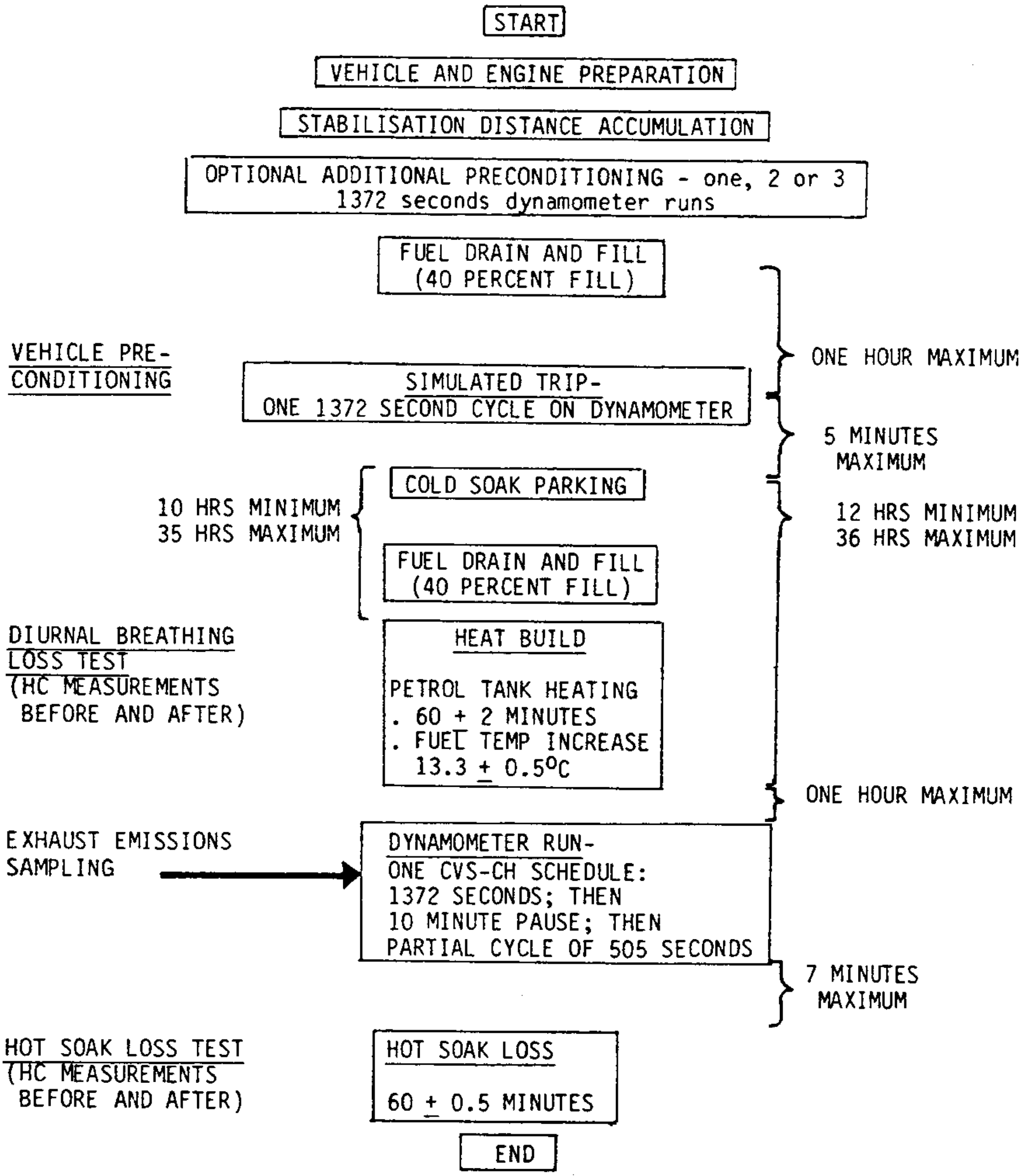
(v) The idle mixture may be set once only, without advance approval.

(d) Details of any corrective action shall be submitted to the Administrator.

(e) If the Administrator determines that component failure or system malfunction occurrence and/or repair rendered the certification vehicle unrepresentative, the vehicle shall not be used for determination of compliance.

APPENDIX VIII
SEQUENCE OF EVENTS FOR EMISSIONS TESTS

(Ambient temperature shall be 20°C to 30°C throughout, except during stabilisation distance accumulation).



APPENDIX IX

PETROL NOZZLE CHARACTERISTICS

(This Appendix is to be read in conjunction with Clause 40.3.7 - Requirements For Petrol Filler Inlet.)

Filler pipes and openings of motor vehicle fuel tanks may be as described in Society of Automotive Engineers, Incorporated "Recommended Practice" J1140, entitled "Filler Pipes and Openings of Fuel Tanks", to accommodate petrol dispenser nozzle spouts as described in Society of Automotive Engineers, Incorporated "Recommended Practice" J285a entitled "Gasoline Dispenser Nozzle Spouts".

Leaded Petrol Nozzle - a nozzle used for demonstrating compliance with Clause 40.3.7 having a spout with an external diameter of 23.6 mm or more.

This leaded petrol nozzle shall have an automatic shutoff vacuum port, the centre of which shall be located within 22.1 mm of the tip of the terminal end.

This leaded petrol nozzle shall pass less than 120 ml of petrol when fully and rapidly activated with the automatic shutoff vacuum port plugged.

Unleaded Petrol Nozzle - a nozzle having:

(i) a spout with an external diameter of 21.34 mm or less;

(ii) the terminal end of the spout shall have a straight section of at least 63 mm in length;

(iii) any retaining spring fitted to the nozzle shall terminate 76 mm from the terminal end.

APPENDIX X

CALIBRATION OF EMISSIONS ANALYSIS EQUIPMENT AND OTHER TEST EQUIPMENT

(Alternative approved methods which yield equivalent results may be used.)

SECTION I - HYDROCARBONS ANALYSER CALIBRATION

The flame ionisation detector (FID) hydrocarbons analyser shall receive the following initial and periodic calibration:

(a) Initial and periodic optimisation of detector response. Prior to its introduction into service and at least annually thereafter the FID hydrocarbons analyser shall be adjusted for optimum hydrocarbons response.

(1) Follow the manufacturer's instructions for instrument startup and basic operating adjustment using the appropriate fuel and zero-grade air (refer Definitions Clause 40.1), or equivalent high purity oxygen.

(2) Optimise on the most common operating range. Introduce into the analyser, a propane in air fuel mixture with a propane concentration equal to approximately 90 percent of the most common operating range.

(3) Select an operating fuel flow rate that will give near maximum response and least variation in response with minor fuel flow rate variations.

(4) To determine the optimum air flow rate, use the fuel flow rate setting determined above and vary air flow.

(5) After the optimum flow rates have been determined, they are recorded for future reference.

(b) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the FID hydrocarbons analyser shall be calibrated on all normally used instrument ranges, using the same flow rate as when analysing samples, and as determined from (a) above.

(1) Adjust analyser to optimise performance.

(2) Zero the analyser with zero-grade air.

(3) Calibrate on each normally used operating range with propane in air calibration gases having nominal concentrations of 15, 30, 45, 60, 75 and 90 percent of that range. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

SECTION II - CARBON MONOXIDE ANALYSER CALIBRATION

The non-dispersive infra-red (NDIR) carbon monoxide (CO) analyser shall receive the following initial and periodic interference check and calibration:

(a) Initial and periodic interference check. Prior to its introduction into service and annually thereafter the analyser shall be checked for response to water vapour and carbon dioxide (CO_2).

(1) Follow the manufacturer's instructions for the instrument start-up and operation. Adjust the analyser to optimise performance on the most sensitive range to be used.

(2) Zero the analyser with either zero-grade air or zero-grade nitrogen (N_2) (refer Definitions Clause 40.1).

(3) Bubble a mixture of 3 percent CO_2 in N_2 through water at room temperature (20-30°C) and record analyser response.

(4) An analyser response, as measured on the most sensitive CO range, of more than one percent of full scale for ranges above 300 ppm full scale or of more than 3 ppm on ranges below 300 ppm full scale will require corrective action. (Use of sample conditioning columns is one form of corrective action which may be taken. One form of sample conditioning column consists of anhydrous calcium sulphate or indicating silica gel to remove water vapour and containing ascarite to remove CO_2 from the CO sample stream).

(b) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the analyser shall be calibrated.

(1) Adjust the analyser to optimise performance.

(2) Zero the analyser with either zero-grade air or zero-grade N_2.

(3) Calibrate on each normally used operating range with CO in N_2 calibration gases having nominal concentrations of 15, 30, 45, 60, 75 and 90 percent of that range. Additional calibration points may be generated. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

SECTION III - OXIDES OF NITROGEN ANALYSER CALIBRATION

The chemiluminescent (CL) oxides of nitrogen (NO_x) analyser shall receive the following initial and periodic converter efficiency check and calibration:

Initial and periodic converter efficiency check.

(a) Prior to its introduction into service and weekly thereafter the analyser shall be checked for nitrogen dioxide (NO_2) to nitric oxide (NO) converter efficiency. Figure X.1 is a reference for the following steps:

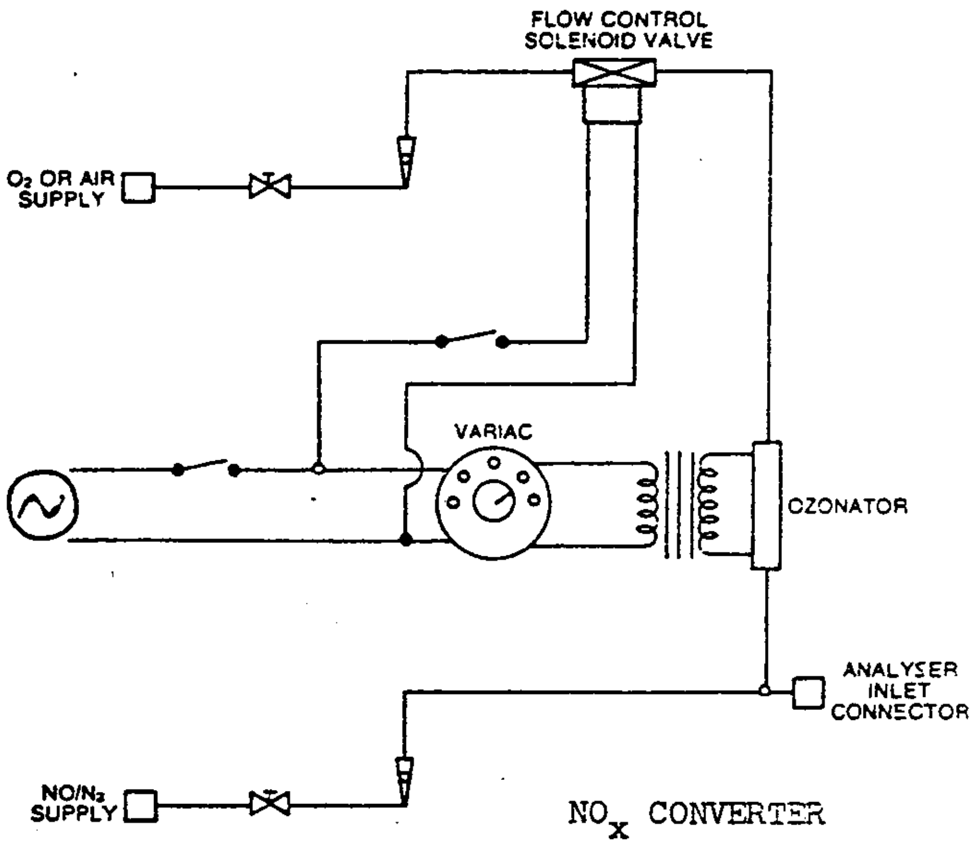


FIGURE X.1 NO_x CONVERTER EFFICIENCY DETECTOR

(1) Follow the manufacturer's instructions for instrument startup operation. Adjust the analyser to optimise performance.

(2) Zero the analyser with zero-grade air or zero-grade N_2.

(3) Connect the outlet of the NO_x generator to the sample inlet of the NO_x analyser which has been set to the most common operating range.

(4) Introduce into the NO_x generator-analyser system an NO in N_2 mixture with an NO concentration equal to approximately 80 percent of the most common operating range. The NO_2 content of the gas mixture shall be less than 5 percent of the NO concentration.

(5) With the analyser in the NO mode, record the concentration of NO indicated by the analyser.

(6) Turn on the NO_x generator O_2 (or air) supply and adjust the O_2 (or air) flow rate so that the NO indicated by the analyser is about 10 percent less than indicated in step (5). Record the concentration of NO in this (NO + O_2) mixture.

(7) Switch the NO_x generator to the generation mode and adjust the generation rate so that the NO measured on the analyser is 20 percent of that measured in step (5). There must be at least 10 percent unreacted NO at this point. Record the concentration of residual NO.

(8) Switch the analyser to the NO_x mode and measure total NO_x. Record this value.

(9) Switch off the NO_x generation but maintain gas flow through the system. The analyser will indicate the NO_x in the (NO + O_2) mixture. Record this value.

(10) Turn off the NO_x generator O_2 (or air) supply. The analyser will not indicate the NO_x in the original NO in N_2 mixture. This value should be no more than 5 percent above the value indicated in step (4).

(11) Calculate the converter efficiency by substituting the concentrations obtained into the following equation:-

Converter Efficiency = (1 + (a - b)/(c - d)) x 100 percent

where: a = concentration obtained in step (8).
b = concentration obtained in step (9).
c = concentration obtained in step (6).
d = concentration obtained in step (7).

If converter efficiency is not greater than 90 percent corrective action will be required.

(b) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the analyser shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analysing samples. Proceed as follows:

(1) Adjust analyser to optimise performance.

(2) Zero the analyser with zero-grade air or zero-grade N_2.

(3) Calibrate on each normally used operating range with NO in N_2 calibration gases having nominal concentrations of 15, 30, 45, 60, 75 and 90 percent of that range. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

SECTION IV - CARBON DIOXIDE ANALYSER CALIBRATION

Prior to its introduction into service and monthly thereafter the NDIR carbon dioxide (CO_2) analyser shall be calibrated as follows:

(a) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyser to optimise performance.

(b) Zero the analyser with either zero-grade air or zero-grade N_2.

(c) Calibrate on each normally used operating range with CO_2 in N_2 calibration gases with nominal concentrations of 15, 30, 45, 60, 75 and 90 percent of that range. Additional calibration points may be generated. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

SECTION V - CALIBRATION OF OTHER TEST EQUIPMENT

Other emissions laboratory equipment used for testing shall be calibrated as often as required by the equipment manufacturer or as necessary according to good practice.

APPENDIX XI

SHED CALIBRATIONS

(Alternative approved methods which yield equivalent results may be used.)

The calibration of the SHED consists of three parts: Initial and periodic determination of SHED background emissions; initial determination of SHED internal volume; and periodic hydrocarbons retention check and calibration.

SECTION I - INITIAL AND PERIODIC DETERMINATION OF SHED BACKGROUND EMISSIONS

Prior to its introduction into service, annually thereafter, and after any repair which can affect the SHED background emissions, the SHED shall be checked to determine that it does not contain materials which will themselves emit hydrocarbons. Proceed as follows:

(1) Zero and span (calibrate if required) the hydrocarbons analyser.

(2) Purge the SHED until a stable background hydrocarbons reading is obtained.

(3) Turn on the mixing fan.

(4) Seal SHED and measure background hydrocarbons concentration, temperature, and barometric pressure. These are the initial readings C_{HCi}, and P_{Bi} for the SHED background determination.

(5) Allow the SHED to stand undisturbed without sampling for 4 hours.

(6) Measure the hydrocarbons concentration on the same analyser. This is the final concentraction, C_{HCf}. Also measure final temperature and barometric pressure.

(7) Calculate the mass change of hydrocarbons in the SHED according to the equations in Section IV of this Appendix. The SHED background emissions shall not be greater than 0.4 gram for the 4 hours.

SECTION II - INITIAL DETERMINATION OF SHED INTERNAL VOLUME

Prior to its introduction into service the SHED internal volume shall be determined by the following procedure:

(1) Carefully measure the internal length, width and height of the SHED, accounting for irregularities (such as braces) and calculate the internal volume.

(2) Perform a SHED calibration check according to steps (1) to (7) of Section III of this Appendix.

(3) If the calculated mass does not agree within 2 percent of the injected propane mass, then corrective action is required.

SECTION III - HYDROCARBONS RETENTION CHECK AND CALIBRATION

The hydrocarbons retention check provides a check upon the calculated volume and also measures the leak rate. Prior to its introduction into service and at least monthly thereafter the SHED leak rate shall be determined as follows:

(1) Zero and span (calibrate if required) the hydrocarbons analyser.

(2) Purge the SHED until a stable background hydrocarbons reading is obtained.

(3) Turn on the mixing fan.

(4) Seal SHED and measure background hydrocarbons concentration, temperature and barometric pressure. These are the initial readings C_{HCi}, T_i and P_{Bi} for the SHED calibration.

(5) Inject into the SHED a known quantity of propane (4 grams is a convenient quantity). The propane may be measured by volume flow or by mass measurement. The method used to measure the propane shall have an accuracy and precision of $\pm$ 0.5 percent of the measured value.

(6) After a minimum of 5 minutes of mixing, analyse the SHED atmosphere for hydrocarbons content; also record temperature and pressure. These measurements are the final readings for the SHED calibration as well as the initial readings for the hydrocarbons leak rate check.

(7) To verify the SHED calibration, calculate the mass of propane using the measurements taken in steps (4) and (6), and the equation in Section IV of this Appendix. This quantity must be within 2 percent of that measured in step (5) above.

(8) Allow the SHED to remain sealed for a minimum of 4 hours without sampling and with the mixing fan operating. After 4 hours analyse the SHED atmosphere for hydrocarbons content; record temperature and barometric pressure. This the final reading for the hydrocarbons leak rate check.

(9) Calculate the hydrocarbons mass change, using the equation in Section IV of this Appendix and the readings taken in step (8). It must not differ by more than 4 percent of that measured in step (5).

SECTION IV - CALCULATIONS

A calculation of hydrocarbons mass change is used to determine SHED background emissions and hydrocarbons leak rate. It is also used to check the SHED volume measurements. The mass change is calculated from the initial and final readings of hydrocarbons concentration, temperature and pressure according to the following equation:

$$M_{HC} = kV\ 10^{-4} \left(\frac{C_{HC_f} P_{B_f}}{T_f} - \frac{C_{HC_i} P_{B_i}}{T_i} \right)$$

where:

M_{HC} = Hydrocarbons mass change, in grams.

k = 17.60

V = SHED volume, in cubic metres, as measured in Section II(1) of this Appendix.

C_{HC} = Hydrocarbons concentration, as ppm carbon equivalent.

NOTE: Hydrocarbons concentration is stated in ppm carbon equivalent, i.e. ppm propane times 3.

P_B = Corrected laboratory barometric pressure, in kPa.

T = SHED ambient temperature, in degrees Kelvin.

Sub-script $_i$ = Indicates initial reading.

Sub-script $_f$ = Indicates final reading.

APPENDIX XII

CALIBRATIONS: FREQUENCY AND OVERVIEW

(a) Calibrations of equipment and systems shall be performed by the methods specified in the relevant Appendices, or by alternative approved methods which yield equivalent results:

Dynamometer Calibration:	Appendix IV
CVS System Calibration:	Appendix V
Emissions Analysis Equipment and other Test Equipment Calibration:	Appendix X
SHED Calibrations:	Appendix XI

(b) SHED background emissions measurements shall be performed at least yearly or after any maintenance which could alter background emissions levels.

(c) At least monthly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Calibrate the HC analysers (both fuel evaporative and exhaust instruments), CO_2 analyser, CO analyser, and NO_x analyser.

(2) Calibrate the dynamometer. If the dynamometer receives a weekly performance check (and remains within calibration) the monthly calibration need not be performed.

(3) Perform a HC retention check and calibration on the SHED.

(d) At least weekly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Check the converter efficiency of the NO_x analyser; and

(2) Perform a CVS system verification; and

(3) Run a performance check on the dynamometer. This check may be omitted if the dynamometer has been calibrated within the preceding month.

(e) The CVS-PDP or -CFV shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification (described in Appendix V - Section III; refer Appendix V, Sections I and II).

(f) Sample conditioning columns, if used in the CO analyser train, should be checked at a frequency consistent with observed column life or when the indicator of the column packing begins to show deterioration.

APPENDIX XIII

ANALYSER GASES AND CALIBRATION GASES

SECTION I - ANALYSER GASES (REFER DEFINITIONS CLAUSE Z.1)

(1) Gases for the CO and CO_2 analysers shall be single blends of CO and CO_2 respectively using N_2 as the diluent.

(2) Gases for the HC analyser shall be single blends of propane using air as the diluent.

(3) Gases for the NO_x analyser shall be single blends of NO named as NO_x with a maximum NO_2 concentration of 5 percent of the nominal value using N_2 as the diluent.

(4) HC Analyser Fuel

(a) the fuel shall contain less than one ppm equivalent carbon response;

(b) for exhaust emission and for fuel evaporative emission measurement, fuel for the HC analyser shall be a blend of 40 $\pm$ 2 percent by volume hydrogen with the balance being helium.

(5) For allowable zero-grade gas (air or N_2) impurity concentrations, refer Definitions Clause 40.1.

(6) The use of proportioning and precision blending devices to obtain the required analyser gas concentration is allowable provided their accuracy has been established.

SECTION II - CALIBRATION GASES

Calibration gases should be known to within 2 percent of the true values.

