COMMONWEALTH OF AUSTRALIA

AUSTRALIAN DESIGN RULE 36
FOR
EXHAUST EMISSION CONTROL FOR HEAVY DUTY VEHICLES

As Endorsed by the
Australian Transport Advisory Council

The intention of this Australian Design Rule is to limit exhaust emissions from motor vehicles in order to reduce air pollution.

The Australian Transport Advisory Council has recommended to Commonwealth, State and Territory Governments that all petrol fuelled motor vehicles specified below except those also equipped to use liquefied petroleum gas as an alternative fuel to petrol and those with an engine displacement of less than 850 millilitres shall comply with Australian Design Rule 36 - Exhaust Emission Control for Heavy Duty Vehicles.

VEHICLE CATEGORY	RULE	AMENDMENT	
	MANUFACTURED ON OR AFTER		
	36	.	.
Passenger Cars			
Forward Control Passenger Vehicles	1 Jan 1985		
Other Passenger Cars	N/A		
Passenger Car Derivatives	N/A		
Multi-Purpose Passenger Cars	1 Jan 1979		
Omnibuses			
up to 4.5 tonnes GVM	1 July 1978		
over 4.5 tonnes GVM	1 July 1979		
Motorcycles	N/A		
Mopeds	N/A		
Specially Constructed Vehicles	N/A		
Other Vehicles not listed above			
up to 4.5 tonnes GVM	1 July 1978		
over 4.5 tonnes GVM	1 July 1979		

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 which comply with the requirements of ADR 27A, 27B or 27C - Vehicle Emission Control need not comply with the requirements of ADR 36.

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The Australian Transport Advisory Council has also recommended to Commonwealth, State and Territory Governments that motor vehicles manufactured after 1 July 1985 which comply with the requirements of ADR 36A, ADR 37 or ADR 40 need not comply with the requirements of ADR 36. *

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AUSTRALIAN DESIGN RULE 36 - EXHAUST EMISSION CONTROL FOR HEAVY DUTY VEHICLES

36.1 DEFINITIONS

36.1.1 Abbreviations

'ASTM' - means American Society for Testing and Materials
'CO' - means carbon monoxide
'CO_2' - means carbon dioxide
'HC' - means hydrocarbons
'N_2' - means nitrogen
'IP' - means The Institute of Petroleum.

36.1.2 'Administrator' - means the Australian Motor Vehicle Certification Board or a person to whom the Board has delegated, by instrument in writing revocable at will, the powers and functions of the Administrator under this Design Rule.

36.1.3 'Annual Sales Volume' - means the number of engines projected for sale per annum for use as motive power in vehicles subject to this Design Rule.

36.1.4 'Approved' - means approved by the Administrator.

36.1.5 'Engine Family' - means a basic classification of engines having similar characteristics as defined in Clause 36.3.4.1 to 36.3.4.4.

36.1.6 'Exhaust Emissions' - means substances emitted to the atmosphere from the exhaust of a motor vehicle engine.

36.1.7 '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 emission control systems.

36.1.8 'Manifold Pressure' - means the pressure measured in the engine induction system.

36.1.9 'Mode' - means a particular operating condition during the dynamometer test cycle.

36.1.10 'Zero (0) Hours' - means the point at which testing and controlled service accumulation commence. This shall be a point after normal engine assembly line operations and adjustments and before one additional engine operating hour has been accumulated.

36.1.11 '125 Hours' - means 125 $\pm$ 8 hours.

36.2 REQUIREMENTS

36.2.1 Requirements for exhaust emission standards

Except for 0 hour tests and tests conducted during an emission stabilisation period, the propulsion engine of every motor vehicle subject to this Design Rule, when tested in accordance with the requirements of Clauses 36.4 to 36.11 inclusive, shall be such that the level of exhaust emissions does not exceed:

(a) Hydrocarbons - 180 millilitres per cubic metre (ml/m^3)(ppm) expressed as hexane equivalent; and

(b) Carbon monoxide - 1.00 percent by volume.

The emission stabilisation period shall be less than 125 hours and shall be approved by the Administrator.

36.2.2 Requirements for labelling

36.2.2.1 Every engine shall have affixed to it a durable legible label of the type described in Clause 36.2.2.2. The label shall show the information listed in Clause 36.2.2.3.

36.2.2.2 Unless otherwise approved the label shall be plastic or metal and shall be bonded, welded, rivetted or otherwise securely attached to a part of the engine necessary for normal engine operation and not normally requiring replacement during life and in a position in which it can be read after installation in the vehicle. *

36.2.2.3 The label shall contain the following information:

(a) The label heading: Engine Exhaust Emission Control Information;

(b) Name of engine manufacturer;

(c) Engine family identification and engine displacement (in litres);

(d) Date of engine manufacture (month and year);

(e) Engine tune-up specifications and adjustments either directly or by reference including idle speed, ignition timing and the idle air/fuel mixture setting procedure and value. The specifications shall state the transmission position during tune-up and any accessories which should be in operation;

(f) A statement to indicate that the engine was manufactured to comply with ADR 36.

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36.2.2.4 The provisions of this Clause shall not prevent a manufacturer from also reciting on the label that such engine conforms to any other applicable emission standards for new motor vehicle engines or any other information that such manufacturer deems necessary for, or useful to, the proper operation and satisfactory maintenance of the vehicle or engine.

36.2.2.5 A label approved by the Environmental Protection Agency (USA) and attached in accordance with Emission Regulations for New Gasoline Fuelled Heavy Duty Engines shall be deemed to satisfy the labelling requirements of this Design Rule provided it contains all of the information required by Clause 36.2.2.3.

36.2.3 Requirements for maintenance instructions

36.2.3.1 With every motor vehicle subject to this Design Rule the manufacturer shall provide such written instructions for the maintenance and use of the vehicle as may be reasonable and necessary to assure the proper functioning of the engine emission control systems.

36.3 SELECTION OF TEST ENGINES, AND DETERMINATION OF COMPLIANCE

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

36.3.2 In determining whether compliance has been established, the Administrator shall accept any approvals issued by the State of California (USA) Air Resources Board for 1972, 1973, 1974, 1975 or 1976 model year engines; or the Environmental Protection Agency (USA) with regard to Federal Regulation Part 85 - Control of Air Pollution, for 1974, 1975 or 1976 model year engines; or the Environmental Protection Agency (USA) with regard to Federal Regulation Part 86 - Control of Air Pollution, for 1977 or 1978 model year engines, provided that the engine was tested with fuel recognised in the Federal Regulations as leaded.

Approvals referred to other model years may be accepted at the discretion of the Administrator.

Furthermore, the Administrator may accept, at his discretion, approvals issued with respect to any standards equal to or more stringent that this Design Rule.

36.3.3 Types of test engines shall be selected by the Administrator in accordance with the selection procedure specified in Clause 36.3.4. The manufacturer shall provide identification information prior to initiating testing on the selected test engine.

36.3.4 For the purpose of establishing compliance the Administrator shall not have the power to select more test engines than the numbers indicated by the selection methods defined in this Design Rule.

36.3.4.1 Engines shall be divided into groupings of engines which are expected to have similar emission characteristics. Each group of engines with similar emission characteristics shall be defined as a separate engine family. To be classed in the same engine family all the conditions listed below shall be met:

They are identical with respect to:

(a) the nominal bore centre to centre dimensions;

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

(c) the nominal dimension from the centreline of the crankshaft to the top of the cylinder block head face;

(d) the number of cylinders and their configuration;

(e) the nominal location of the intake and exhaust valves;

(f) the method of air aspiration (i.e. natural or forced);

(g) the combustion cycle.

36.3.4.2 Engines identical in all the respects listed in Clause 36.3.4.1 may be further divided into different engine families if the Administrator determines that they may be expected to have different emission characteristics. This determination will be based upon a consideration of the following features of each engine:

(a) the bore and stroke;

(b) the surface-to-volume ratio of the nominally dimensioned cylinder at the top dead centre position;

(c) the intake manifold induction port size and configuration;

(d) the exhaust manifold port size and configuration;

(e) the intake and exhaust valve sizes;

(f) the fuel system;

(g) the camshaft timing and ignition timing characteristics.

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

36.3.4.4 In cases where the engines are of a type which cannot be classified according to the criteria of Clauses 36.3.4.1 and 36.3.4.2 the Administrator shall establish engine families based on features considered to be most related to their emission characteristics.

36.3.4.5 Engines shall be selected for test as follows:

(a) Engines of each engine family shall be divided into engine displacement - exhaust emission control system combinations. The combinations will be arranged in order according to the manufacturer's projected annual sales volume.

One engine of each combination shall be selected in decreasing order of Annual Sales Volume until 70 percent of the projected annual sales of the engine family is represented or until a maximum of 4 engines has been selected.

(b) The Administrator may select a maximum of 2 additional engines within each engine family based upon features indicating that they may have the highest emission levels of the engines in that engine family.

In selecting these engines the Administrator shall consider such features as the exhaust emission control system, induction system characteristics, ignition system characteristics, fuel system, rated power, rated torque, and compression ratio.

(c) If the engines selected in accordance with paragraphs (a) and (b) above do not represent each engine displacement-exhaust emission control system combination in the engine family, then one engine of each engine displacement-exhaust emission control system combination not represented may be selected by the Administrator.

36.3.4.6 Any manufacturer whose projected Annual Sales Volume of a particular engine family subject to the requirements of this Design Rule is less than 700 engines may request a reduction in the number of test engines determined in accordance with Clause 36.3.4.5 above. The Administrator may agree to such lesser number as he determines would meet the intent of this Design Rule.

36.4 SERVICE ACCUMULATION AND EMISSION MEASUREMENTS

36.4.1 The engine dynamometer service accumulation schedule shall be approved by the Administrator and shall consist of operating conditions which give approximately the same percentage of time at various manifold pressures and the modes of operation as specified in the emission test cycle. The average speed shall be between 80 and 85 percent of the speed at which dynamometer emission tests are conducted. In addition and subject to the requirements as to average speed, there shall be operation at speeds in excess of 3 200 r.p.m. or 160 percent of the speed at which dynamometer emission tests are conducted whichever is the lower (but not in excess of governed speed for governed engines or rated speed for non-governed engines) not exceeding 0.5 percent of the total cycle time, excluding time in transient conditions. Maximum cycle time shall be one hour.

36.4.2 Each test engine shall be operated for 125 hours with all engine emission control systems installed and operating except that fuel evaporative emission controls need not be connected provided normal operating conditions are maintained in the engine induction system.

36.4.3 Emission tests shall be conducted at zero and 125 hours. Data from all tests (including voided tests) shall be submitted to the Administrator.

36.4.4 The results of all emission tests shall be rounded to 3 significant figures, but not more than 2 places to the right of the decimal point.

36.4.5 Once a manufacturer begins to operate an engine, as indicated by compliance with Clause 36.3.3 he shall continue to run the engine to 125 hours and the data from the engine will be used in the calculations under Clause 36.11. Discontinuation of an engine test shall be allowed only with the consent of the Administrator.

36.4.6 Unless otherwise approved engine and fuel system maintenance shall be limited to the extent and intervals recommended by the manufacturer as required by Clause 36.2.3.

For the purposes of determining maintenance intervals, one hour of dynamometer operation shall be deemed to be equivalent to 50 km of vehicle operation on the road.

36.4.7 Notwithstanding the requirements of Clause 36.4.6 one adjustment of the engine idle speed shall be allowed prior to the 125 hour test point.

36.4.8 Unscheduled maintenance may be conducted with the approval of the Administrator.

36.5 TEST PROCEDURES

The procedures described in this and subsequent sections will be the test program to determine the conformity of engines with the standards set forth in Clause 36.2.1.

36.5.1 The test consists of prescribed sequences of engine operating conditions to be conducted on an engine dynamometer. The exhaust gases generated during engine operation are sampled continuously for specific component analysis.

36.5.2 Except in cases of component malfunction or failure, all engine emission control systems installed on or incorporated in a new motor vehicle engine shall be functioning during all procedures in this and subsequent sections. Maintenance to correct component failure or malfunction shall be in accordance with Clauses 36.4.6 and 36.4.8.

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36.6 FUEL SPECIFICATIONS

36.6.1 Unless otherwise approved fuel used for service accumulation shall either be petrol commercially available in Australia of the grade or mix recommended by the engine manufacturer in accordance with Clause 36.2.3.1 or conform to the following specifications:

PROPERTY	TEST METHOD		SPECIFICATION	
	ASTM	IP	Low Octane	High Octane
Octane Number, Research	D 1656 or D 2699	237	88 minimum	97 minimum
Lead (organic) as Pb, gram/litre	D 526	96	0.37 minimum	0.37 minimum

Engines for which Australian Super-grade fuel is recommended shall use the 'High Octane' fuel specified. Engines for which Australian Standard-grade fuel is recommended may use either fuel specified.

36.6.2 Unless otherwise approved fuel used for emission testing shall conform to the following specifications. Where the Administrator determines that the vehicle represented by a test engine will be operated using fuels of a different lead content of octane number, than that prescribed, he may consent in writing to use of a fuel otherwise substantially equivalent but with a different lead content or octane number.

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PROPERTY	TEST METHOD		SPECIFICATION
	ASTM	IP	
Octane Number, Research	D 1656 or D 2699	237	97 minimum
Lead (organic) as Pb, gram/litre	D 526	96	0.37 minimum
Phosphorus, gram/litre			0.015 maximum
Distillation Range (°C)	D 86	123	
Initial Boiling Point			-
10 percent point			45-57
50 percent point			90-110
90 percent point			149-163
End Point			213 maximum
Hydrocarbon Composition	D 1319	156	
Olefins, percent			22 maximum
Aromatics, percent			40 maximum
Saturates			Remainder
Reid Vapour Pressure (kPa)	D 323	69	55.2-64.9

* Amended (by deletion) July 1984

36.7 DYNAMOMETER OPERATION CYCLE AND EQUIPMENT

36.7.1 Operation cycle

36.7.1.1 The following 9-mode cycle shall be followed in dynamometer tests:

Seq. No.	Mode	Manifold Pressure below atmospheric (kPa)	Time in Mode- (seconds)	Cumul- ative Time- (seconds)	Weighting factors
1.	Idle		70	70	0.036
2.	Cruise	54	23	93	0.089
3.	Part Throttle Acceleration	34	44	137	0.257
4.	Cruise	54	23	160	0.089
5.	Part Throttle Deceleration	64	17	177	0.047
6.	Cruise	54	23	200	0.089
7.	Full Load	10	34	234	0.283
8.	Cruise	54	23	257	0.089
9.	Closed Throttle		43	300	0.021

36.7.1.2 The engine dynamometer shall be operated at a constant speed of 2 000 r.p.m. $\pm$ 100 r.p.m. except during the idle operating mode. With the approval of the Administrator, the dynamometer may be operated at a representative engine speed for a given displacement engine as determined by its application, but not at less than 1 800 r.p.m. nor greater than 3 000 r.p.m. Speed deviations from the constant operating speed not to exceed 200 r.p.m. shall be allowed during the first 4 seconds of each mode. With the approval of the Administrator, the test cycle may be modified to allow for transition between modes. The maximum transition time permitted between any 2 modes is 20 seconds.

36.7.1.3 The idle operating mode shall be carried out at the manufacturer's recommended engine speed. The closed throttle operating mode shall be carried out at the same engine speed as in Clause 36.7.1.2 of this section.

36.7.1.4 If the specified manifold pressure can not be reached during the part throttle deceleration mode, the engine shall be operated at closed throttle during that mode. If the specified manifold pressure can not be reached during the full load mode, the engine shall be operated at wide open throttle during that mode.

36.7.2 Equipment

The following equipment shall be used for dynamometer tests.

36.7.2.1. An engine dynamometer capable of maintaining constant speed ± 100 r.p.m. from full throttle to closed throttle motoring shall be used.

36.7.2.2 A chassis-type exhaust system or substantially equivalent exhaust system shall be used.

36.7.2.3 A radiator typical of that used with the engine in a vehicle or other means of engine cooling which will maintain the engine operating temperatures at approximately the same temperature as would the radiator, shall be used. An auxiliary fixed speed fan may be used to maintain engine cooling during sustained operation on the dynamometer.

36.8 SAMPLING AND ANALYTICAL SYSTEM FOR MEASURING EXHAUST EMISSIONS

36.8.1 The sampling and analytical systems and the calibration procedures shall be approved by the Administrator.

36.8.2 Analytical system

36.8.2.1 Hydrocarbons in the exhaust emissions shall be determined using non-dispersive infra-red analysers calibrated with hexane or propane using air or N_2 as diluent. The hexane equivalent of propane when used as the normalising gas for calibrating non-dispersive infra-red analysers, is prescribed to be 0.52 (propane concentration x 0.52 = hexane equivalent concentration).

36.8.2.2 Carbon monoxide shall be determined using non-dispersive infra-red analysers calibrated with carbon monoxide using N_2 as a diluent. Multi-mixes of carbon monoxide and carbon dioxide in N_2 may be used.

36.8.2.3 Carbon dioxide shall be determined using non-dispersive infra-red analysers calibrated with carbon dioxide using N_2 as a diluent. Multi-mixes of carbon monoxide and carbon dioxide in N_2 may be used.

36.8.3 Sampling system

36.8.3.1 Exhaust gases shall be sampled continuously and passed through the analysers undiluted to give a continuous trace of exhaust emissions.

36.8.4 Calibration and instrument checks

36.8.4.1 The instrument assembly shall be calibrated using the same flow rate as when sampling exhaust:

(a) Zero on N_2 or zero-grade air;
(b) Calibrate the analysers with normalising gases as specified in Clause 36.8.2. Normalising gases shall be used to calibrate each analyser range and the concentrations shall be chosen so as to effectively cover the whole analyser range. Actual concentration shall be known to within 2 percent of the true value.

36.8.4.2 The following instrument check shall be performed before and after each test allowing a minimum of 2 hours warm-up for the infra-red analysers;

(a) The analysers shall be zeroed using either air or N_2;
(b) The analysers shall be spanned using span gases for each analyser range.

36.9 ENGINE PRECONDITIONING AND DYNAMOMETER TEST RUN

36.9.1 An initial 5 minute idle, 2 warm-up cycles, and 2 hot cycles constitute a complete dynamometer run. Idle modes may be run at the beginning and end of each test, thus eliminating the need to change speed between cycles. One idle mode preceding the first cycle and one following the fourth cycle is sufficient. The results of the first idle shall then be used for calculation of the first and second cycle emissions and the final idle results shall be used for calculation of the third and fourth cycle emissions.

36.9.2 The engine shall be started and preconditioned by operation over one or more cycles prescribed for service accumulation (Clause 36.4.1) or dynamometer operation (Clause 36.7.1) until the engine has reached normal operating conditions.

36.9.3 The engine shall be turned off and allowed to stand for at least one hour but not more than 2 hours, before the exhaust emission test, at an ambient temperature which may vary between 15°C and 30°C. The engine shall be stored prior to the emission tests in such a manner that it is not exposed to precipitation or condensation. During the dynamometer run, the engine air inlet temperature shall be between 20°C and 30°C.

36.9.4 Upon completion of the test, purge the sample line with nitrogen to establish a constant hydrocarbon 'hang-up' level. The hydrocarbon concentration shall drop to 5 percent of scale in 10 seconds, and 3 percent of scale in 3 minutes, or the test is invalid. Check calibration of exhaust emission instruments. A drift in excess of $\pm$ 2 percent of scale in the calibration of any one of the exhaust emission analysers will invalidate the test results.

36.10 CHART READING

36.10.1 As the recorder response for measuring exhaust gas concentrations may lag the engine's operation because of variable exhaust system delay and fixed sample system delay, the concentrations for each mode may not be located on the charts at a point corresponding to the exact time of the mode. For each warm-up or hot cycle to be evaluated, proceed as follows:

(a) Determine whether the cycle was run in accordance with the specified cycle timing outlined in Clause 36.7.1 by observing either chart pips, speed trace, manifold pressure trace, or concentration traces. Deviation by more than 2 seconds from the specified time for the closed throttle mode (sequence 9) or deviation of more than one kPa from the specified mode pressure during the last 10 seconds of any mode except sequences 1 and 9 shall invalidate the data.

(b) Time correlate the HC, CO, and CO_2 charts. Determine the location on the chart of concentrations corresponding to each mode. Determine and compensate for trace abnormalities.

(c) Locate the last 3 seconds of the HC, CO and CO_2 traces obtained from each of the 10, 34, 54, 64 kPa and idle modes. Divide this portion of each trace into a minimum of 3 segments of equal length. Determine the chart reading at the end of each segment to within 0.5 percent of full scale. Convert these readings into concentration values in volume percent for CO and CO_2 and millilitres per cubic metre (ppm) for HC. Determine the average of these values.

(d) Locate the HC, CO and CO_2 closed throttle mode trace. Divide each trace into a minimum of 43 segments of equal length. Determine the chart reading at the end of each segment to within 0.5 percent of full scale. Convert these readings into concentration values. Determine the average of these values.

(e) Direct computer analysis of analyser output may be utilized provided that the analysis is sufficiently similar to the above procedures to result in comparable data results.

36.11 CALCULATIONS

36.11.1 The final test results shall be derived through the following steps:

(a) Since HC, CO and CO_2 are all measured with essentially the same moisture content, no moisture correction is required to convert the results to a dry basis. However the correction factor:

$$\frac{14.5}{\%\ CO_2 + (0.5)\ \%\ CO + (1.8 \times 6)\ \%\ HC}$$

shall be applied to each measured concentration of HC and CO to correct these observed values for dilution of the exhaust before proceeding to step (b).

Notwithstanding the above provision, the correction factor so determined for the Closed Throttle mode shall not be applied to measurements made during that mode where the engine is equipped with a type of emission control system whereby the fuel supply provided through the slow running system is shut off for a period during closed throttle deceleration. The correction factor to be applied to the HC and CO concentrations measured during the Closed Throttle mode shall be the correction factor determined for the Idle mode.

(b) Determine composite HC and CO concentrations for the first and second cycles as

Summation of (emission x weighting factor)

where the summation extends over the 9 modes of the dynamometer cycle. Average the results of these 2 cycles.

(c) Determine composite HC and CO concentrations for the third and fourth cycle as

Summation of (emission x weighting factor)

where the summation extends over the 9 modes of the dynamometer cycle. Average the results of these 2 cycles.

(d) Combine the results of sub-clauses (b) and (c) of this section according to the formula:

0.35 (b) plus 0.65 (c).

