



Variation to the National Environment Protection (Diesel Vehicle Emissions) Measure 2009 (No.1)

National Environment Protection Council Act 1994

The NATIONAL ENVIRONMENT PROTECTION COUNCIL makes this variation to the National Environment Protection (Diesel Vehicle Emissions) Measure under section 22A of the *National Environment Protection Council Act 1994*.

Dated 22 May 2009

This Variation was made on 22 May 2009.

1 Name of Variation

This Variation is the *Variation to the National Environment Protection (Diesel Vehicle Emissions) Measure 2009 (No.1)*.

2 Commencement

All provisions of this Measure commence on the day after registration on the Federal Register of Legislative Instruments.

3 Amendment of National Environment Protection (Diesel Vehicle Emissions) Measure

Schedule 1 amends the National Environment Protection (Diesel Vehicle Emissions) Measure.

Schedule 1 Amendments

(section 3)

Introductory Note

Section 22A of the *National Environment Protection Council Act 1994* and the equivalent provision of the corresponding Act of each participating State and Territory enables the National Environment Protection Council to vary a National Environment Protection Measure. This is a variation to the National Environment Protection (Diesel Vehicle Emissions) Measure made by the National Environment Protection Council on 29 June 2001.

The Variation is to be implemented by the laws and other arrangements participating jurisdictions consider necessary pursuant to section 7 of the Commonwealth Act and the equivalent provision of the corresponding Act of each participating State and Territory.

[1] Clause 1, Citation

substitute

1 Name of Measure

This Measure is the *National Environment Protection (Diesel Vehicle Emissions) Measure 2001*.

[2] Clause 3, Definitions

omit

NRTC means the National Road Transport Commission.

[3] Clause 14, Schedules

omit

five

substitute

four

[4] Clause 14, Schedules

omit

Schedule A(5): Guideline on Diesel Engine Rebuild Programs

[5] Schedule A: Guidelines for the Management of In-Service Diesel Emissions

omit

Schedule A(5)

Guideline on diesel engine rebuild programs

[6] Schedule A(1): Guideline on Smoky Vehicle Programs

substitute

Schedule A(1): Guideline on Smoky Vehicle Programs at Attachment 1

[7] Schedule A(2): Guideline on Diesel Vehicle Emission Testing and Repair Programs

substitute

Schedule A(2): Guideline on Diesel Vehicle Emission Testing and Repair Programs at Attachment 2

[8] Schedule A(3): Guideline on Audited Maintenance Programs for Diesel Vehicles, Clause 2: Scope

omit

NRTC

substitute

Australian Transport Council or successor body.

[9] Schedule A(4): Guideline on Diesel Vehicle Retrofit Programs

substitute

Schedule A(4): Guideline on Diesel Vehicle Retrofit Programs at Attachment 3

[10] Schedule A(5): Guideline on Diesel Engine Rebuild Programs

omit

SCHEDULE A(1): GUIDELINE ON SMOKY VEHICLE PROGRAMS

1. Objective

To improve the emissions performance of in-service diesel vehicles by:

- providing a means of detecting vehicles emitting excess smoke;
- requiring the repair of vehicles emitting excessive smoke; and/or
- encouraging vehicle owners to regularly tune and maintain their vehicles.

2. Scope

Excessive smoke emissions from diesel vehicles are visually offensive, odorous and potentially a risk to public health. Australian Design Rule 30/00, which was introduced in 1976, required all new vehicles to meet smoke opacity standards. However, deterioration of engine components frequently leads to an increase in smoke emissions, which can be rectified through service or repair.

A smoky vehicle program is intended to provide a means of detecting vehicles that have deteriorated to a point where excessive emissions can be visually observed. Smoky vehicle programs may require the owner to repair the vehicle or may simply encourage owners to make repairs to reduce smoke. Some programs combine both approaches.

Jurisdictions that currently operate smoky vehicle programs apply the “ten second smoke rule” to identify vehicles with excess smoke emissions. That is, smoky vehicles are those detected emitting smoke continuously for a period of ten seconds or more.

The correlation between smoke and other pollutants is uncertain. Therefore a smoky vehicle program which uses the ten second smoke rule cannot ensure detection of vehicles with excess emissions of NO_x, hydrocarbons (HC), carbon monoxide (CO) or particles. Other guidelines within this Measure describe emission management approaches which are specifically designed to detect and rectify excessive emissions of these pollutants. Jurisdictions should ensure that strategies are in place to detect the range of pollutants. Jurisdictions should also monitor developments in science and technology and seek expert advice where necessary.

Together with the use of the ten second smoke rule by authorised personnel, smoky vehicle programs normally make provision for the general public to report vehicles they observe to be emitting smoke. Clearly jurisdictions are not able to require owners to repair vehicles on the basis of reports made by the general public. Nevertheless, such reports provide the opportunity to inform the owner that their vehicle is emitting smoke, to educate them about the unacceptability of smoke to the public and the means by which their vehicle may be repaired.

3. Program Outline

In developing an effective smoky vehicle program a jurisdiction should ensure its planning covers:

- identification of the level at which smoke emissions are unacceptable;
- establishment of a system for authorised officers to report smoky vehicle offences;
- training and authorisation of government officers;
- the need for a system for the public to report smoky vehicles;
- education of the public about the system, the issues and what they can do to prevent or correct the problem;
- development of a targeting strategy for reporting by authorised officers (random, roadside, targeted, periodic inspections, etc); and
- ensuring that the vehicle repair industry is trained to detect and rectify faults associated with excessive smoke emissions.

It is important that, Police, Transport and Environment agencies are involved with the development of any smoky vehicle program. It may also be advantageous to invite other government agencies to participate, particularly local government.

3.1. Identify the level at which smoke emissions are unacceptable

ADR 30/00 describes a range of acceptable smoke opacity tests for new vehicles. Given the expectation that there will be some level of deterioration, the '10 second smoke rule' was developed to provide a means for regulating in-service vehicle smoke emissions and has been legislated in several jurisdictions. A legislative model for the 10 second smoke rule has been agreed by transport Ministers and can be found in the schedule to the Road Transport Reform (Vehicle Standards) Regulations 1999.

3.2. Government reporting of offences

To help ensure that only valid sightings of smoky vehicles result in a defect notice or sanction, only reports by authorised officers should result in statutory measures being undertaken. Notices may be issued based on reports from trained government employees including Police, Transport or EPA enforcement officers or local government officers. Jurisdictions should seek to centralise this administration so that only standard notices are issued and the process can be independently audited. A reliable means of gathering evidence such as the use of video cameras should also be considered. These measures will reduce the likelihood of legal challenge.

Notices, or the letters accompanying them, should:

- clearly state the alleged offence
- state what action needs to be taken (eg. require that the vehicle be rectified within a certain period of time or require that it reports to a testing centre)
- state the nature of the sanction if the action is not taken
- state what action is required to clear the notice (ranging from provision of receipts from a qualified mechanic to a specified dynamometer test)
- explain why excessive smoke is unacceptable to the community and the role of maintenance in reducing smoke emissions from in-service vehicles
- explain what appeals measures are in place.

Jurisdictions should consider how they wish to 'clear' a notice. A requirement to provide receipts from a qualified repairer is commonly used with existing programs, but jurisdictions that introduce a vehicle testing program (Schedule A(2)) may wish to introduce a requirement that the vehicle must undergo a full emissions test. Alternatively, jurisdictions should consider whether requiring a full roadworthiness test would better encourage compliance. Results from a program can be improved when reports are followed up to ensure that those vehicles identified as emitting excessive smoke have been repaired.

3.3. Training and authorising authorised officers

As smoky vehicle reports may be received from a number of agencies (eg Police, Transport, EPA) it is important that officers in all relevant agencies are trained to ensure consistency of administration. Draft guidelines for compliance with the 10 second rule are publicly available from the National Transport Commission. Vehicle owners and operators may have an expectation of how the rule will be enforced based on the NTC guidelines.

The means by which officers are authorised will depend on the legal framework in each jurisdiction.

3.4. Public reporting program

Public reporting programs are an effective and popular mechanism to identify smoky vehicles and an alternative to general education campaigns. They may also be useful in helping to keep the issue of vehicle air pollution in the minds of the public and demonstrate to the community, in particular vehicle owners, that authorities are serious about improving air quality.

Reports by the public should generally require the:

- name, address and telephone number of the person making the report;
- time and place of the observation; and
- make, colour and registration number of the vehicle observed.

Due to the potential unreliability of public reports, a warning letter only should be sent to the vehicle owner advising that undue smoke is an offence and that they risk penalties under the authorised officer reporting scheme. The letter should seek to educate the person as to why excessive smoke is unacceptable to the community and how smoke emissions can be improved. The letter should not disclose the name or details of the person that made the report, but should state the time and location.

A telephone hotline with the appropriate recorded prompts should be considered as a means of reducing the administrative burden and encouraging the public to participate. An internet reporting facility should also be considered.

A dedicated database and on-line reporting system could potentially reduce administrative work. Such a system would help to ensure uniformity across reports, eg providing compulsory fields for identifying the reporter and a number of optional fields for identifying the vehicle, as set out above.

Requiring reporters to register would enable training or the provision of information to explain what constitutes a smoky vehicle. This will reduce the likelihood of false or vindictive reports received. If feedback indicates that these types of incidents are occurring, jurisdictions could prepare further guidance for reporters.

Jurisdictions could also consider running workshops to provide further information on what constitutes a smoky vehicle and how to improve smoke emissions.

3.5. Public Education

It is important that the public is made aware that:

- the public reporting scheme cannot be used vexatiously;
- the name of the person making the report will not be disclosed; and
- a sanction will only occur if an authorised officer makes the report.

To encourage the use of the public reporting program promotional material should be developed and launches held for the introduction of the public reporting scheme or the telephone hotline. Media coverage of occasional ‘blitzes’ by authorised officers can be used to promote the public reporting program.

Promotional material could include: a webpage, print advertising, media articles, report cards, stickers, information brochures and posters. In addition, highlighting the achievements of the program and companies that have improved their vehicle smoke emissions could contribute positively to the public education program

3.6. Targeting strategy for reporting

It is important that a strategy for reporting smoky vehicles is developed and regularly reviewed to monitor success. The form of the strategy will depend on the needs of a particular jurisdiction. Elements may include:

- occasional ‘blitzes’ which may combine smoky vehicle detection with other roadworthiness issues such as noise or safety defects. This may involve roadside inspection as well as intensified spotting campaigns;
- targeting specific vehicle classes which research indicates have high rates of deterioration;
- targeting locations where poorly serviced vehicles often congregate; and
- government and public reporting programs (Sections 3.2 and 3.4 respectively).

3.7. Vehicle repair industry

In most jurisdictions the vehicle repair industry has a peak body that is supportive of programs that detect poorly maintained vehicles. Jurisdictions are encouraged to liaise with these groups and other groups such as automobile associations and motor traders, to ensure the necessary training is in place and to explain the program so that repairers understand the importance of issuing a receipt with a precise description of the repairs carried out.

Jurisdictions should consider whether there is benefit in introducing an accreditation system for repairers.

3.8. Emerging Technologies

Technologies such as remote sensing devices used in conjunction with cameras are available. They provide the potential for efficient and continuous monitoring of on-road vehicle emissions. Jurisdictions should consider the application of these technologies to complement smoky vehicle and other programs.

3.9. Annual Reporting

Collection of annual statistics would assist the ongoing review of programs. Information to be collected could include:

- Total number of reports per year;
- Number of information packs sent out to the public per year;
- Number of vehicles reported more than once;
- Data from registration information including age and model of vehicle;
- Total number of responses from owners of reported vehicles; and
- Number of responses from owners of reported vehicles categorised as follows:
 - Vehicle details incorrect
 - Vehicle repaired;
 - Vehicle does not smoke;
 - Vehicle smokes but I cannot afford to repair it;
 - Vehicle smokes but I choose not to have it repaired;
 - Disposed of Vehicle
 - Other

SCHEDULE A(2): GUIDELINE ON DIESEL VEHICLE EMISSION TESTING AND REPAIR PROGRAMS

1. Objective

To minimise the deterioration in emission performance of diesel vehicles by testing vehicles to identify high emitters and then ensure they are effectively repaired.

2. Scope

A vehicle test and repair program involves:

- testing vehicles on a standardised test;
- assessing their emissions performance against a pass/fail level;
- requiring vehicles that fail to be repaired; and
- re-testing the repaired vehicle against the standardised test.

Because they involve the actual repair of high polluting vehicles, vehicle test and repair programs offer a high degree of certainty that effective emissions reductions will be achieved.

3. Program Outline

To develop and implement an effective test and repair program a jurisdiction will need to:

- specify appropriate target vehicle groups;
- specify target pollutants;
- implement a means of obliging or encouraging target vehicles to be tested and polluting vehicles to be repaired;
- implement a testing regime with appropriate infrastructure that is effective in identifying high polluting vehicles with repairable faults;
- educate and enlist the support of the vehicle repair industry;
- educate and prepare the community through a communications program;
- implement quality and fraud control mechanisms; and
- monitor the effectiveness of the program.

3.1. Target Vehicles

Studies commissioned by the National Environment Protection Council have shown that vehicles less than five years old have few faults and therefore small benefits from emission repairs. For vehicles older than five years, there is a poor correlation between vehicle age and pollutant emissions and between vehicle kilometres travelled and pollutant emissions. There is also a poor correlation between visible smoke or opacity and particle emissions.

Jurisdictions should consider one or more of the following means of targeting vehicles from the Australian fleet for testing under a test and repair program:

- All diesel vehicles over five years of age.
- Random sampling or targeting particular vehicle class/es within the diesel fleet over 5 years of age (refer table below for emissions related fault profile of the fleet).
- Random roadside testing.

Frequency of significant emission related faults in the Australian diesel fleet

Vehicle Mass	Vehicles < 5 years old ADR 70			Vehicle 6-20 years old Pre ADR 70		
	% with significant emission faults			% with significant emission faults		
	NO_x	Particles	Opacity	NO_x	Particles	Opacity
< 3.5 tonnes	4	13	4	5	32	10
3.5 to 12 tonnes	2	13	5	5	12	14
12 to 25 tonnes	0	11	0	3	20	3
> 25 tonnes	0	8	0	0	1	1

Note: Values based on the percentage of vehicles identified in NEPC Project 7 that have emission levels above the proposed in-service emission standards. Data is current at June 2001. During the conduct of test and repair programs, jurisdictions may obtain information that updates this table.

3.2. Screening Testing

Jurisdictions may wish to consider the use of screening testing to identify suspected poor performing vehicles that need to be subjected to the full in-service emissions test. Screening testing could involve the use of mobile briefcase and remote sensing systems or visual inspections during routine vehicle examinations. The use of these technologies may allow for more effective vehicle selection, improve program efficiency and allow effective communication to the owners of gross polluting vehicles.

3.3. Emission Pass/Fail Levels

In implementing a vehicle test and repair program, a jurisdiction should nominate the pollutants it wishes to target. These should include particles and visible smoke measured according to the vehicle emission standards and test determined by the Australian Transport Council or successor body.

A jurisdiction may also choose to target NO_x emissions.

The pass/fail levels will be the appropriate in-service emissions standards as specified by the Australian Transport Council or successor body.

The emissions standards are specified in mass of pollutant emitted per kilometre travelled per vehicle mass, ie in grams per kilometre per tonne. Vehicle test results should therefore be reported in grams per kilometre per tonne and grams per kilometre (for use in calculating emissions inventories).

3.4. Obliging Vehicles to be Tested

To effectively implement test and repair programs, jurisdictions must identify a means of compelling or encouraging vehicles to be submitted for testing. To be effective the method should have a statutory basis. The method most commonly used in international programs is to require targeted vehicle owners to submit their vehicles for testing and repair before the vehicle registration is renewed. However, with a mobile dynamometer other options including random roadside testing can be used effectively.

3.5. Testing Regime and Infrastructure

3.5.1 In-service Emissions Test

The in-service emissions test to be employed in a diesel vehicle test and repair program is the test determined by the Australian Transport Council or successor body. At the date of commencement of this Measure, this is the DT80 transient short test. The protocol for conducting the test is determined by the Australian Transport Council or successor body. Vehicles should be tested using the fuel present in the vehicle tank when it is submitted for testing.

3.5.2 In-service Emissions Test Equipment

Required equipment specifications are detailed in the in-service vehicle emission standards and test determined by the Australian Transport Council or successor body.

The target pollutants may not be the only emissions measured during a test and repair program. Measurements of carbon dioxide and oxygen are required for quality control reasons. Jurisdictions may also choose to measure other emissions for inventory purposes. The emissions to be measured could include:

- total hydrocarbons (THC), parts per million as hexane (ppmh);
- methane (CH₄) ppm
- carbon monoxide (CO), percent
- carbon dioxide (CO₂), percent
- oxygen (O₂), percent
- nitric oxide (NO), ppm
- particulate matter less than 2.5 micrometres nominal diameter (PM_{2.5}), mg
- smoke opacity, percent.

Oxides of nitrogen should be calculated from the measured NO concentration using sample condition corrections and USEPA specified formulae.

The DT80 transient short test has been found to be a good test for identifying high polluting vehicles. For emissions inventory purposes results should be measured in g/sec on the DT80 and converted to CUEDC measurements using the correlation coefficient determined in NEPC Project 2.2. The CUEDC scores can then be used for inventory purposes as they reflect a better estimation of real world driving patterns.

All equipment should be calibrated and calibration gases regularly checked in accordance with the in-service vehicle emission standards and test determined by the Australian Transport Council or successor body.

3.5.3 In-service Emissions Test Stations – Vehicle Throughput

Jurisdictions will need to establish test stations (either fixed or mobile) that cater to the characteristics of the target vehicle group.

3.5.4 Test/Repair Procedure

Testing of vehicles will involve the following steps.

1. Conduct a safety check of the vehicle to determine its suitability for testing. Faults to be considered include underinflated or unsafe tyres, fuel or fluid leaks, overheated engines and excessive smoke. Vehicles that are unsafe for testing should be referred for repairs and re-testing.
2. Record vehicle details including vehicle identification number, fuel type, model year, make, model, vehicle type, gross vehicle mass, tare weight, vehicle ADR category, engine displacement, number of cylinders, turbocharger, fuel system, odometer reading, testing hazards identified if any. Depending on the computer software design and network linkages, much of this information may be automatically retrieved from registration records.
3. Test the vehicle.
4. Print a vehicle inspection report. The vehicle inspection report should include maximum allowable emissions values, results for the test vehicle, a pass/fail determination and emissions values that are considered good for that age and make of vehicle.
5. If the vehicle has failed, refer it for repair.
6. The repair facility should issue the client with a repair report detailing the type and cost of repairs carried out.
7. Re-test the vehicle.*
8. Repeat steps 4 – 7 until the vehicle passes or is granted a qualified waiver (see below).

* A jurisdiction may choose to accept evidence of vehicle repair other than re-testing such as a statement of repair from an accredited repairer. This may be necessary in cases where a vehicle is identified as not meeting the standard in a jurisdiction other than its jurisdiction of registration.

3.5.5 Repair Requirements

Any vehicle that fails to meet the in-service standard will be required to be repaired, and provide evidence of that repair. The Australian Transport Council or successor body may prescribe an acceptable level of evidence to show that the repairs have been undertaken. For reasons of practicality it is desirable in a test and repair program to place a limit on the scope of effort expended on repairs. Such provisions mean that once the limit is reached, vehicles are granted a waiver of the test requirement in that instance. Such a waiver does not preclude the vehicle from being targeted for testing in the future according to a jurisdiction's vehicle testing schedule (eg yearly, 2 yearly testing).

A national approach to waivers or exemptions may be set by the Australian Transport Council or successor body. The national approach may reflect the following criteria.

- The vehicle has failed a re-test after qualifying repairs (as listed below) have been made.
- All original emissions related components are present, intact and properly connected.
- Repairs have resulted in an improvement in vehicle emissions.

Repairs may include but are not limited to:

- corrections to air/fuel ratio control
- replacement of air filter
- correction of governor RPM setting
- repair of injectors, injection timing and pump settings.

3.6. Repair Industry

The success of a vehicle test and repair program in terms of reducing emissions is dependent on the ability of the repair industry to diagnose and repair vehicle faults. The cost effectiveness of the program will be affected by the industry's ability to repair vehicles efficiently and effectively, thereby minimising instances of successive failure of vehicles.

It is therefore essential that jurisdictions plan for and assist the repair industry to be effectively trained and equipped prior to the introduction of a test and repair program. Jurisdictions may wish to consider the desirability of certifying the industry for repair of high polluting vehicles.

An effective training program would include:

- types of vehicle exhaust pollution and their effects on health and the environment;
- description of the test and repair program, including the test and its implementation, emissions standards, repair waiver policies and general rules;
- vehicle emissions control technologies;
- how to interpret emissions test results;
- recommended test equipment and its use;
- diagnosis and fixing the problem; and
- completing the repair forms.

3.7. Communications Program

A successful vehicle test and repair program requires the support and cooperation of vehicle owners covered by the program and repairers. A communications program will be an essential first step in promoting their acceptance of the program. The communications program should help the target group of vehicle owners to understand why vehicle testing is needed and how to comply with the program requirements.

The communications program should include:

- methods of advising customers of the test process (eg type, frequency, locations, costs and payment options)
- methods of handling customer inquiries and complaints
- development of educational literature.

The information provided about the program should include but not be limited to:

- the purpose, benefits and objectives of the test and repair program
- the impacts of vehicle emissions, eg air quality, greenhouse and health impacts
- vehicles to be tested and vehicles to be exempt
- test method, frequency, and cost
- requirement for repairs
- common faults that result in poor emission performance
- location of vehicle repairers
- location of stations and hours of operation
- the problems caused by removed or damaged emissions components
- the benefits of regular maintenance
- customer inquiry contact points.

3.8. Monitoring Effectiveness

In order to assess the emissions benefit from programs, it is critical that data is collected and reported at the beginning, during and end of the program. The data will enable participants to assess and report the emissions reductions from their operations and will also assist regulatory authorities in assessing the impacts on emissions and air quality overall.

The data collected should include:

- vehicle information as outlined above
- vehicle test results for the complete test and repair cycle, before and after repair
- time taken per test
- cost of each vehicle repair and cumulative cost of repairs for each vehicle
- type of vehicle repairs per vehicle
- for initial inspections – the number of vehicles passing inspection, the number of vehicles failing inspection
- for subsequent inspections – the number of qualified and cost waivers issued, the number of vehicles passing subsequent inspection
- inspection lane down time, reason for the down time and length of down time
- inspection centre waiting time by time of day
- number of vehicles denied inspection because of testing hazards, by type of hazard
- gas analyser and dynamometer audit results ie passes and fails
- customer calls and complaints
- number of inspections and pass/fail results by inspection lane and inspector.

3.9. Quality Control and Audit

Effective quality control and audit procedures are essential to ensure that appropriate levels of customer service are maintained and that the owners of vehicles tested under the program have confidence in its integrity. A preventive maintenance and quality control program should be implemented to ensure:

- the operating reliability of inspection equipment and computer systems
- the timely detection of non-compliance with inspection procedures, including fraudulent inspections.

A quality control program should include:

- daily, weekly, monthly and any other periodic checklists needed to check the condition of all equipment
- the use of approved calibration gases
- maintenance of equipment calibration records, including the actual values of test gases contained in the calibration gas cylinders and calibration results
- complete documentation of all equipment used for emissions inspections
- development of a maintenance and calibration manual
- complete procedures manuals in each station
- development and maintenance of software documentation
- installation of surveillance cameras in queue lanes to monitor vehicle volumes and lane inspector performance.

All test and repair program facilities should be accredited by the National Association of Testing Authorities.

SCHEDULE A (4): GUIDELINE ON DIESEL VEHICLE RETROFIT PROGRAMS

1. OBJECTIVE

To improve the emissions performance of in-service diesel vehicles by the fitment of exhaust after-treatment devices.

2. SCOPE

There are a large number of older vehicles in the diesel fleet which have limited emissions control technology. There is capacity to reduce harmful emissions from vehicles certified to pre-2002 standards by retrofitting exhaust system components.

There are a range of emission reduction technologies which could be considered for a retrofit program. Factors to consider in selecting suitable technologies include:

- commercial availability
- emissions reduced
- engine applicability (limited or widespread)
- durability
- cost and maintenance.

The principal after-treatment technologies currently in use in retrofit programs are diesel oxidation catalysts (DOCs) and diesel particle filters (DPF).

DOCs are well proven technology, commercially available and are used in retrofit programs in the United States, Europe, Asia and Australia. DOCs are effective in reducing PM, hydrocarbon and carbon monoxide emissions. DOCs are also effective in reducing odours from diesel exhaust.

DOCs are the cheapest after-treatment technology, require no maintenance and are very durable. Current retrofit programs often focus on the use of diesel oxidation catalysts. However, while the costs and other complexities with the use of particle filters tend to limit their adoption at this stage, they have the capacity to deliver substantial reductions in PM emissions, and may be a viable option where particular engine operating conditions can be achieved.

Diesel particle filters (DPFs) can deliver large particulate matter (PM) emission reductions in specific applications. To be effective they need to be carefully tailored to particular engines and in-service use patterns. Partial filter traps (PFT) are particulate filters that can provide a 50% particle reduction. Purchase and installation costs for PFTs are around half that of DPFs.

Under the NSW Diesel Exhaust Retrofit Program PM reduction efficiencies of around 30% for DOC and over 90% for DPF have been demonstrated. The cost effectiveness of both devices are very similar as purchase and installation costs for DOCs are around one third that of DPFs.

Original equipment manufacturers should be consulted before undertaking any retrofit activity.

3. PROGRAM OUTLINE

There are three parts to a diesel vehicle retrofit program:

- Vehicle Selection
- Technology Assessment
- Program Evaluation

3.1. Vehicle Selection

With the exception of newer models, most diesel vehicles are potential candidates for retrofit programs. The criteria for selection are a matter for the jurisdiction, and may be based purely on a cost/effectiveness assessment or involve other broader government objectives. This guideline sets out a range of possible criteria that jurisdictions may use in considering the introduction of a retrofit program.

3.1.1 General Principles

There are some general principles which apply, regardless of the target groups.

1. The emissions benefits are proportionally greater for earlier technology vehicles such as those provided to the Australian market before ADR70/00 (ie largely unregulated or "Euro O", late 1980's US), but there are still significant benefits from retrofitting vehicles meeting Euro 1/Euro 2, and US 91/US 94 standards.
2. There can still be some benefit in retrofitting vehicles that meet the newer emission standards in ADR80/00 and ADR79/00;
3. The vehicle engine must be in reasonable condition. In particular, retrofit devices should not be fitted to engines emitting excessive smoke or using excessive amounts of oil. Retrofitting engines in a poor state of repair may lead to catalyst or filter damage and increased smoke and odours from oil.
4. Emissions reductions are likely to be greatest when the DOC, DPF or PFT is tailored to the engine (in accordance with advice from the engine manufacturer).

3.1.2 Target Vehicle Criteria

Taking the above factors into account, possible criteria for selecting vehicles for retrofitting are outlined below:

- The target vehicles are significant sources of urban emissions or contribute to localised or "hot spot" air pollution problems (eg congested inner city areas, underground facilities).
- Cost effective technologies are available for target vehicles (DOCs, DPFs or PFTs are potentially available for any engine size, but may not be cost effective for smaller engines).
- Retrofitting is a cost effective measure for target vehicles, relative to other strategies (see section 3.3 for cost effectiveness tools).

Ideally, all criteria would need to be met in order for a jurisdiction to consider implementing a program for a particular fleet.

3.1.3 Implementation

DOCs, DPFs and PFTs can potentially be applied to a range of diesel vehicles, and their benefits can be significant. However, DOCs, DPFs and PFTs come at a cost, so regulation, incentives, or Government/corporate policy commitments may be required to make a program viable. Jurisdictions will need to make their decisions about target fleets based on the criteria above.

Factors to consider when considering implementation options for a diesel retrofit program include:

- To date the target vehicles in overseas retrofit programs have been both Government and privately owned and/or operated vehicle fleets, particularly urban bus fleets. These programs rely either on mandatory retrofit of vehicles, or the adoption of a policy commitment by the authorities running the fleets, to improve the emissions of their fleet by retrofitting emission control devices.
- There is potential to extend retrofits by requiring companies tendering for urban based Government contracts (eg road building, construction, bus services) to meet certain standards in relation to the emissions performance of their diesel road vehicles. It could be made a condition of contract that any vehicles not built to current emission standards and/or over a certain age meet this guideline.
- The cost of retrofit, with no direct commercial benefit, is a major hurdle to encouraging retrofit in privately or company owned vehicles. Unless a Government is willing to mandate retrofit of vehicles over a certain age or odometer reading, then incentive based approaches are necessary. Potential incentives for retrofitting vehicles include:
 - Reduced registration charges
 - Rebates on vehicle inspection fees
 - Exemption from participation in mandatory Testing and Repair programs for a specified period after retrofit
 - Use of electronic tolling to restrict or charge non-retrofitted vehicles for access to specified areas in the urban environment
 - Rebates or other subsidies on approved retrofit technology
 - Bundling fuel-efficient technologies with emission control devices. Under this approach, successfully implemented in the USA, ongoing fuels savings can mitigate the retrofit device cost. Devices are available that reduce fuel use in trucks by reducing air drag (aerodynamic improvement devices), rolling resistance of tyres or improving drive train operations. By purchasing and installing a kit containing fuel efficiency devices and an exhaust retrofit device, truck operators can save money through reduced fuel use to reduce the cost of the exhaust retrofit.

3.2. Technology Assessment

Retrofit devices need to be objectively assessed for their:

- capacity to deliver emission reductions
- applicability to particular vehicles/engines
- durability and reliability.

3.2.1 Performance Requirements

Demonstration of compliance with performance requirements is a pre-requisite for acceptance of particular appliances in retrofit programs. This section is based on DOCs, DPFs and PFTs but could be adapted for other aftertreatment devices which comply with the requirements.

To be considered for use in a retrofit program, a DOC, DPF or PFT should meet the following requirements:

- (1) The DOC/DPF/PFT is:
 - (a) approved by the US EPA under the Urban Bus Rebuild/Retrofit Program;
 - (b) approved under the London Bus Retrofit Program; or
 - (c) emission tested under the relevant Composite Urban Emissions Drive Cycle, UN ECE Type I emission test under ECE R83/04 or later (or equivalent EC Directive), the UN ECE 13 mode steady state test under ECE R49/02 or later (or equivalent EC Directive), or the US CFR 40 Part 86 EPA Federal Test Procedure.
- (2) When tested in accordance with one of the options under (1c):
The device shall achieve particulate matters reductions to any one of the three classification levels, with no increase in emissions of other pollutants in the vehicle exhaust.

Pollutant	Classification Level	Reduction
PM	Level 1 (DOCs)	25%
	Level 2 Partial filter traps (PFT)	50%
	Level 3 DPF	85%

(These classification levels 1, 2 & 3 align with US Californian Air Resources Board (CARB) classification levels.)

- (3) The DOC/DPF/PFT is demonstrated (by means of specific testing or engineering analysis) to deliver the percentage reductions in (2) for the size and type of engines used in the target vehicles.
- (4) The DOC/DPF/PFT is demonstrated to deliver the reductions in (2) on diesel fuel with sulfur levels typical of the fuel used by the target vehicles in normal use.
- (5) The DOC is demonstrated (by means of an acceptable durability test or in-service testing) to remain effective over the life of the vehicle. The DPF is demonstrated to remain effective over the life of the vehicle if maintained correctly.
- (6) The DOC/DPF/PFT does not significantly increase vehicle noise in the target vehicles when tested in accordance with the requirements of ADR28/01.
- (7) The DOC/DPF/PFT does not significantly increase exhaust back pressure in the target vehicles to a level outside the manufacturer's specification.
- (8) The device shall be designed based on sound and proven scientific principle.

- (9) The device shall not require any fuel-additive to support its operation, nor shall it be an additive, by itself, for consumption in the combustion process of the engine.
- (10) The device shall not cause harmful effects to the engine of a vehicle to which it is installed or unduly affect the performance of the engine.

It is the DOC/DPF/PFT supplier/manufacture's responsibility to demonstrate that their aftertreatment device complies with the above requirements. The tests shall be carried out by independent and appropriately certified third party laboratories.

Note that there may be a potential for NO_x (and NO₂) emissions to increase with the retrofit of some particle traps which use oxidation catalysts and that jurisdictions may wish to assess the relative benefits of a retrofit program within their jurisdictions beyond particle emission considerations.

3.2.2. Selection of appropriate retrofit technology

Exhaust temperature determines the PM reduction efficiency of DOCs. The NSW Diesel Exhaust Retrofit Program has shown that PM reduction efficiency improves, as temperature increases, up to about 300 C. Over 300 C the efficiency decreases.

DPFs periodically require high exhaust temperatures, so that the carbon trapped in the filter, can be burnt off. Failure to burn off the carbon will cause the filter to become blocked and will affect engine performance. Typically, exhaust temperature should exceed 260 C for at least 40 percent of the duty cycle.

It is understood that DPFs may not perform well in pre-Euro 2 emission standard vehicles, and that neither DPF nor DOC should be fitted to vehicles burning excessive amounts of oil.

Overall cost effectiveness of DPFs compared to DOCs appears to be similar. DPFs are around three times more efficient than DOCs in terms of PM reduction but also cost around three times more. The need for extra maintenance and possible price increases for DPFs may swing the cost benefit balance towards DOCs in the future.

PFTs do not have the exhaust temperature restriction and will not block up if the duty cycle requirements are not achieved. With PFTs, there is a reduced need to data log the exhaust temperatures and backpressures (see below).

Assessment of candidate vehicles

Due to the importance of duty cycle and exhaust temperature, it can be useful to log exhaust temperatures of candidate retrofit vehicles, before deciding on a suitable aftertreatment device.

Data loggers can be fitted to candidate vehicles to record and store exhaust temperature data over a period to establish the exhaust temperature profile for a vehicle's typical duty cycle. A DPF, for example, could be fitted to a truck engine with exhaust temperatures that exceed 260° C for 40 percent of the time, or to similar trucks working similar duty cycles. A DOC fitted to this vehicle would always reduce PM to some extent but less than that achieved by a DPF.

It has been established that there is a relationship between exhaust temperature and PM emissions. As exhaust temperature rises, PM emissions rise. As a result, exhaust temperature can potentially be used to estimate likely percentage PM emission reductions from installation of a DOC or DPF. The average reduction in PM emissions for a particular vehicle on a particular duty cycle can be calculated by using the DOC/DPF temperature/efficiency curve.

3.3. Program Evaluation

The evaluation of a retrofit program serves two main purposes:

- (1) To support the vehicle selection process in section 3.1 for a proposed program.
- (2) To provide a means of assessing and reviewing the effectiveness of a program in operation.

3.3.1 To Support Target Vehicle Selection

As indicated in section 3.1, one of the criteria in selecting target vehicles is the cost effectiveness of any proposed program for the target group. Determining the cost effectiveness of particular approaches enables the objective comparison of different measures and the consideration of the need for further incentives.

One basic formula for such an estimation is as follows:

$\text{Cost Effectiveness (\$/kg Emissions)} = (\text{Cost}) / (\text{Emission Reduction})$

Where:

Cost(\$)	=	(no. vehicles fitted)*(DOC/DPF/PFT unit cost)/(DOC/DPF/PFT unit life years)
Emission Reduction	=	(emissions,fleet,year)*(DOC/DPF/PFT emission reduction factor)
Emission, fleet, year	=	(emission, vehicle, year)*(fleet size)*(fleet suitability)* (fleet penetration)
Emission,vehicle, year	=	(emission rate)*(annual vehicle kilometres travelled)

Notes:

“Fleet suitability”

Refers to the estimate of the proportion of the fleet that will actually be suitable for retrofit. For example, it may be determined that 15% of a particular fleet is too old to warrant the cost of retrofit, or conversely 10% of the fleet meets ADR80/00 (Euro 3) and would not benefit significantly from retrofit.

“Fleet penetration”

Refers to the rate at which the fleet is retrofitted over the period of the program. For example, in a five year program, the target may be to retrofit all the pre-ADR70 vehicles in the first year and the balance over the next four years. Where there is phased implementation, the emission reduction calculation will need to be adjusted in the early years of the implementation period to reflect the number of vehicles retrofitted each year.

3.3.2 Program Assessment

Once it is decided to proceed with a particular retrofit program, it is important to collect key data, so that the worth of the program can be properly assessed and lessons can be learned for any future programs.

For an effective assessment, it is desirable that data are collected at the beginning, during and end of any retrofit program. The data will enable participants to assess and report the emissions reductions from their operations (which may be important to support government/corporate commitments) and will also assist regulatory authorities in assessing the impacts on emissions and air quality overall.

The level and detail of data collected will obviously be subject to available budget but ideally the following data should be collected:

- Results from engine temperature duty cycle tests used to estimate PM reductions for installed DOCs and DPFs.
- Results from monitoring the emissions performance of all, or a sub-set of vehicles, over the expected life of the device.
- The costs of purchase and fitment of the device and ongoing maintenance (if any), including any problems associated with the device.

The above data may be integrated with other data collected on the target fleet, such as numbers of public complaints about smoky vehicles.

Participants in a retrofit program should be required to keep records of the above tests which must be made available on request to the regulatory authority. The regulatory authority could assist by developing standard reporting formats. In jurisdictions that operate Testing and Repair programs Schedule A(2), the emission testing for the retrofit program could be integrated with the Testing and Repair program.