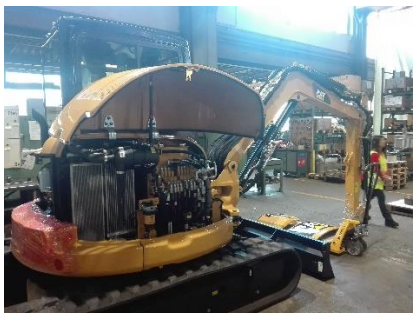
METHODOLOGICAL GUIDE

CALAC
Programa Clima y Aire limpio
en Ciudades de América Latina

GUIDE FOR CONTROLLING AND SUPERVISING DPF-RETROFITTED FLEETS



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Guide for controlling and supervising DPF-retrofitted fleets

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TECSUP headquarters in Lima, Peru; AVESCO Langenthal Switzerland (below); Skid-steer loader on public roads in Lima, Peru (above)

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The Climate and Clean Air project in Latin American Cities Plus (CALAC+) pursues a vision of healthier cities that seek to reduce their emissions of pollutants and greenhouse gases (GHGs) by encouraging a shift to soot-free, low-carbon city buses and non-road mobile machinery.

This guide is part of a series of 7 technical documents developed by CALAC+ to promote knowledge and environmental management of machinery emissions reduction in Latin America. The topics covered include the generation of inventories, estimation of pollutants, emission control systems, regulatory standards policies and monitoring of measures adopted.

The *Guide for controlling and supervising DPF-retrofitted fleets* provides a general framework for minimizing DPF system failures and consequently their impact on emissions generated. A new or retrofitted engine with DPF is much more reliant on maintenance to ensure its operation.

Content

1. INTRODUCTION

The elements of a retrofit program can be ordered chronologically as follows:

1. Selection of the fleet for retrofit: Depending on the strategy defined, the selection of the fleet can be made by the authority, based on its own experience, or by the operator, as per its specifications, in accordance with the goals and schedule defined by the authority.
2. Fleet maintenance: Before retrofitting, a regular and permanent preventive maintenance program must be implemented, as per the engine manufacturer's guidelines. This should be an obligation of the operating companies participating in the program.
3. Inspection: Following maintenance and prior to retrofitting, the operator is required to carry out a visual and instrumental inspection of the condition of the engine and its emissions. This inspection should be done every six months after the filter installation.
4. Implementation: This can be done gradually, i.e. start with a small number of vehicles or machinery and build on the experience before moving on to mass implementation. A joint pilot test with the operators is ideal.
5. Control and supervision: Its goal is to ensure that the authority examines the proper operation of the filter over time

Considering that the particulate filter is a highly efficient system for controlling mainly particulate matter, its failure has a high impact on the vehicle's emissions. As a result, the emission stability of retrofitted, or new engines with DPF[1], is more dependent on maintenance and prone to deterioration. Thus, while diesel engine deterioration can affect emissions by 20 to 50%, a DPF system failure can increase emissions by 2 to 3 orders of magnitude[2].

[1] As is the case with Stage V non-road diesel engines, or Euro VI heavy road vehicles.
[2] Yamada et al (NTSEL-2015)

2. CONTROL AND SUPERVISION SCHEMES

Criteria

a. Through control and supervision, the authority examines whether the maintenance of the exhaust over time is carried out properly by the company operating the vehicle or machinery.
b. Control and supervision are the responsibility of the authority.
c. It includes a measurement of the exhaust gas (specifically the particulate emission). The procedure and emission limit value will be determined by the authority.
d. The authority's control and supervision can be carried out through
   - a mandatory periodic **technical inspection**,
   - a **random inspection** that takes place on site (terminals or construction site) or on the road (for vehicles)

   Ideally, both types of schemes are combined. However, it should be noted that for non-road machinery, only a random inspection at the construction site is considered.
e. The Technical Inspection has only one disadvantage: if the measure is announced beforehand, the operating company can readjust the engine operation (engine and/or DPF) exclusively for the day of the inspection.
f. A more effective approach than the Technical Inspection may be the random inspection that can be performed as a:
   - Random roadside inspection of buses: it is the best approach since it is carried out randomly and directly on the road without any prior notice.
   - Random inspection in the companies' premises or operation sites: this is a variant that is carried out in the company's own terminal or work site. Compared to the roadside inspection it has certain disadvantages as it offers the operator the possibility to make excuses for not carrying out the inspection.
g. Beyond the scope of a retrofit program, inspection of the entire diesel fleet is important to ensure the expected benefits and success of an air pollution abatement program as it requires the private sector to undertake substantial environmental improvements and investments.

Measures

a. All engines shall be subject to inspection by the authority as follows:
   - On-road vehicles: periodic technical inspection in an 'inspection facility', every 6 months, and random inspection in the bus operator's terminal and/or on the road.
   - Non-road machinery: Engine maintenance and self-diagnosis of emissions once a year and random inspection by the competent authority or accredited third party, at the construction site.
b. The periodic technical inspection: (1) makes a measurement of the particulate emission (2) issues a pass/fail certificate of inspection with vehicle data, emission limit and test results.
c. The random inspection: (1) checks the previous technical inspection certificate (or self-diagnostic certificate for non-road machinery), (2) makes a measurement of the particulate emission (3) issues an administrative report or infraction in case of non-compliance.
d. Vehicles that repeatedly fail to comply with the established limit will lose their license to operate.
e. In all cases the inspection consists of opacity measurement at free acceleration, for engines without DPF, and Particle Number measurement for DPF-equipped engines.

f. The emission measured in this way must comply with the limit value specified by the authority.
g. Both the measurement method and the particulate emission limit value (applicable as part of the inspection) must be defined by the authority. The method and value have to be defined separately for engines with and without DPF.

3. SWISS MODEL FOR CONTROLLING AND SUPERVISING CONSTRUCTION MACHINERY

In January 2009, the requirement for a particulate filter for diesel-engined machinery with a power output of more than 18 kW was introduced in Switzerland[3]. This requirement applied to all construction sites and was established under the Air Pollution Control Ordinance, according to a graded schedule differentiated by power ranges and machinery age.

This requirement was put into practice in new engines which had to comply with a PN emission limit (1 x10^{12} particles/kWh), in addition to meeting the emissions directive in force in Europe. Compliance was also possible through an equivalent alternative which was fitting the engine with a DPF certified by the Swiss Federal Office (FOEN).

From a control and supervision point of view, these two alternatives involved the following certification options for new engines:

1. Engine type approval including European standard plus PN emission limit (original equipment manufacturer, OEM).
2. Engine type approval for the European emission standard only plus a FOEN-certified DPF[4] fitted by the manufacturer (factory-retrofitted)

In turn, the engines in use had to implement a FOEN-certified DPF to fulfil the obligation (third-party retrofitting). Consequently, FOEN published two lists:

- List of engines with type approval for new engine requirements[5].
- List of DPFs approved for use on new or used engines.

For control and supervision purposes, machinery manufacturers or importers are required to place a visible, permanent and legible plate on all construction machines and particulate filter systems with the following information:

- Name of the manufacturer or importer;
- Serial number;
- Designation of the type of particulate filter;
- Name of the conformity assessment body.

In addition, the label of the construction machinery must also contain the following information:

- Year of manufacture of the construction machine;
- Engine power in kW;
- Type of particle reduction system.

[3] In 2002, it had already implemented a filter requirement with respect to underground construction machinery due to occupational health regulations and was regulated by the Swiss National Accident Insurance Fund (SUVA).

[4] Swiss Technical Standard SNR 277205, for the measurement and certification of particulate filter systems, with respect to nanoparticles and secondary emissions.

[5] This FOEN list recognized systems with VERT certification. VERT is a Swiss-based association of manufacturers of technology for controlling emissions from internal combustion engines.

In the case of used machinery fitted with a particulate filter system, the installer of the particulate filter system is responsible for placing the plates/labels described above.

The owner or operator of a construction machine is also required to have the exhaust gases measured and maintained at least every 24 months. He must keep the maintenance record and the results of the exhaust gas measurements for at least two years, carry them on the machinery and submit them to the authorities on request.

The authority may require this record and verify the measurement of the exhaust emissions at random. If excessive PM emissions are suspected, the authority may require that machinery be serviced and remeasured.

A maintenance and exhaust service for construction machinery includes:

a. control of vehicle parts and settings relevant to exhaust and smoke emissions, as per the manufacturer's instructions;
b. if necessary, repair or replacement of the relevant parts;
c. an opacity measurement or a particle number measurement

The comparison value for opacity measurement is 0.24 [1/m], measured at free acceleration, or $2.5x10^5$ [#/cm^3] for number of particles measured at maximum engine speed (or injection cut-off).

The authority does not need to inspect the machinery periodically but checks the maintenance record and performs random exhaust gas inspections.

4. CONCLUSIONS

a. Control and supervision are a fundamental component of a retrofit program as it ensures proper engine maintenance and filter operation over time.
b. For diesel engines, the DPF-retrofitted fleet is subject to severe emission deterioration in the event of filter failure, so control and supervision are a critical component.
c. Operators will be required to carry out annual engine maintenance and emission testing. Records of both will be kept on board in the machinery.
d. Due to the mobility restrictions of non-road mobile machinery, control and supervision should be carried out on the construction site and not in a technical inspection facility.
e. The measurement will be made in number of particles. Both the measurement method and the particulate emission limit value (applicable as part of the supervision) must be defined by the authority.
f. In a random process, the authority or an accredited third party will:
    - check the maintenance and emission diagnosis records;
    - perform its own emission measurement;
    - depending on the results of the inspection, request maintenance of the engine and/or revoke the machinery licence.

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