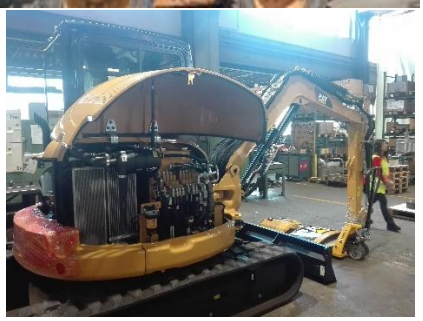
**METHODOLOGICAL GUIDE**

CALAC+
Programa Clima y Aire limpio
en Ciudades de América Latina

# GUIDE FOR DRAFTING TECHNICAL TERMS OF REFERENCE FOR THE ACQUISITION OF DPF SYSTEMS FOR RETROFITTING NON-ROAD MOBILE MACHINERY

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**Methodological guide for drafting technical terms of reference for the acquisition of DPF systems for retrofitting non-road mobile machinery**

Document prepared within the framework of the Climate and Clean Air project in Latin American Cities Plus - CALAC+ (Phase 1) financed by the Swiss Agency for Development and Cooperation - SDC and implemented by the Swiss Foundation for Technical Cooperation - Swisscontact



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Cover photo:

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

Edition: February 2020

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 *Methodological guide for drafting technical terms of reference for the acquisition of DPF systems for retrofitting non-road mobile machinery* is intended to be a reference document, which should be adapted to the provisions of law in each case, with technical and contractual requirements and recommendations to ensure good performance of DPF systems.

# Content

## 1. INTRODUCTION

This is a guide for drafting technical terms of reference for the acquisition of particulate filter systems in the retrofitting of the construction machinery fleet. In this regard, it includes recommendations with respect to the systems' technical requirements. However, it also includes contractual matters to be considered as legally binding obligations between the parties, and others the author considers relevant, in order to ensure good performance of the systems.

Everything stated in this document requires legal review, under the responsibility of the principal.

## 2. DEFINITIONS

**Diesel particulate filter (DPF):** Emission aftertreatment device that captures particles from diesel engines, by forcing all exhaust gases through a filter.

**DPF system:** The set of necessary elements that the DPF supplier must provide for proper operation of the filter. It comprises at least: filter element, regeneration system, monitoring unit (datalogger), housing and fastener.

**Filter element:** The component of the DPF system that contains the filter material, where diesel particles are retained. It must be a modular component that can be easily disassembled from the rest of the system to allow maintenance and cleaning operations.

**Regeneration system:** It comprises all the components that allow combustion of the soot or particulate matter accumulated in the filter element. For example, in continuous regeneration systems, the regeneration system is a diesel oxidation catalyst (DOC). In active regeneration systems (with a power supply in addition to the temperature of exhaust gases), it may be made up of on-board electric regeneration or fuel post-injection systems.

**Electronic Control Unit (ECU):** The system whose function is to monitor the parameters necessary for proper operation of the DPF system and control the components necessary for operation of the regeneration system, such as fuel post-injection dosing or startup of the electric regeneration system. In every case, the ECU must also monitor at least the backpressure of the exhaust gases upstream of the filter element and have alarm systems in case of improper operation of the system. One of these alarms must have a light or sound that indicates that the maximum allowable backpressure established by the manufacturer of the DPF system and/or the engine has been exceeded.

**Preventive maintenance:** Set of operations the bidder deems necessary to ensure proper operation and reliability of the DPF system, through the diagnosis, cleaning and replacement of components, based on an activity schedule. It includes periodic cleaning of the filter material.

**Diagnosis of the DPF system:** Includes follow-up or monitoring of information provided by the ECU, such as backpressure and others determined by the bidder to detect abnormal operation or the need for maintenance.

## 3. BIDDER REQUIREMENTS

The bidder must show proof, in the country where the systems are to be implemented, of their status as a manufacturer or a representative of the manufacturer of the DPF systems they offer. This may be by means of a first-party declaration, a representation agreement, a letter from the manufacturer or an equivalent legal document.

An evaluation of the manufacturer is recommended, for which the bidder can submit the number of applications they have done, indicating whether this was a retrofit or equipment from the original equipment manufacturer (OEM); the type of application (road vehicles, off-road vehicles, stationary engines, etc.); the type of system used (regeneration system and filter material); and where they took place (country, city and direct customer).

Regarding the experience of the local dealer, they can indicate their experience in DPF system sales, installation and support. For this purpose, it will be sufficient to submit a list of the systems sold and installed, indicating whether this was a retrofit or equipment from the original equipment manufacturer (OEM), the type of application (road vehicles, off-road vehicles, stationary engines, etc.), the type of system used (regeneration system and filter material), and the place where this was done (country, city and direct customer).

It is also important to state formally that that the bidder will provide maintenance and diagnostic services on the systems.

## 4. REQUIREMENTS FOR THE DPF SYSTEMS OFFERED

### a) Certification of the DPF system

The DPF system offered must comply with minimum quality and efficiency requirements. This may be verified through certification of the systems by a prestigious certifying agency. Among these are VERT[1], FOEN[2], and CARB Level 3[3] certification. The foregoing based on information submitted by the bidder, such as a test report certificate issued by the certifying agency, mention in the corresponding list of certified systems or another record the principal deems equivalent[4].

### a) Selection and design of the DPF system

In the Bidding Terms and Conditions, the principal must submit a specification chart for the fleet that allows the bidder to select and design the DPF system in each case. In addition to said chart, the Bidding Terms and Conditions may establish a schedule of onsite visits to the fleet that, in turn, allow gathering additional background information within the time available during the visit.

The selection and design of the regeneration system must be justified in the bid, whether based on the information shown on the fleet specification chart (Appendix 1) and its attachments, the results of the onsite visit, and/or the manufacturer's experience. If data in addition to the content of said specification chart is required, the bidder may request them in the question and answer process, which is provided in the bidding terms and conditions.

If necessary and if the information required for the proper design of the DPF system is not available by any of the aforementioned means, it may be gathered by the bidder, at their own cost and only after the contract award process, which does not exempt them from compliance with the technical and warranty requirements in the terms and conditions. Any change in the design of the system offered that is indispensable and the result of information that was unavailable and collected by the bidder after the tendering process may be admitted, provided that it complies with all of the specifications required in the terms and conditions and does not diminish the quality or performance with regard to the original design offered. Any changes subsequent to the awarding of the contract must not entail additional costs for the principal.

[1] A private association with offices in Switzerland dedicated to the promotion of the best emissions control technologies (https://www.vert-dpf.eu/). To see the list of certified systems, go to https://www.vert-dpf.eu/j3/images/pdf/article/48/VERT-Filter-Liste-Sept-2017.pdf

[2] Swiss Federal Office for the Environment, which has a list of certified systems at https://www.bafu.admin.ch/bafu/en/home/topics/air/info-specialists/particle-filter-list/particle-filter-system-types.html.

[3] California Air Resources Board, which has a list of certified systems at https://www.arb.ca.gov/diesel/verdev/vt/cvt.htm

[4] Ideally, there should be a certification agency in the country that can validate the technical documents submitted and perform local durability and compatibility tests for some prototype prior to local certification of the system.

**b) Minimum specifications of the product offered**

The design of the DPF system offered in aspects such as the volume of the filter element, the number of cells per $cm^2$ (or $inch^2$) and the regeneration system, among others, should be such that it ensures the efficiency values indicated in the preceding point. Proper regeneration of the filter should be ensured to maintain backpressure upstream of the filter element under the limit recommended by the manufacturer of the DPF system. In any case, said limit may not exceed 200 [mbar]; nor may it cause abnormal operation or damage to the engine of the retrofitted machinery. For this purpose, the regeneration system must always adapt to the operating temperatures of the exhaust gases.

The DPF system must have an ECU that triggers an audible or visual alarm to alert the driver if any of the established limits are exceeded, particularly the backpressure limit. It must also store the backpressure data and record alarm events for at least the last two weeks. These data may be transmitted wirelessly to a supervision station determined by the principal.

With regard to its size and fastening system, the DPF system must adapt to the availability of space and the operating conditions of the retrofitted machinery to ensure its proper installation and operation. At an accessible place on the housing, before the filter element, it must have a port 5 cm in diameter with a screw-in plug that can be removed with a standard tool for measuring exhaust gases.

In the description of the DPF system offered, for each vehicle in the fleet, the manufacturer must provide at least the following information[5] for each DPF system offered:

- Indication of the machinery for which the application is offered (machine number, according to the specification chart)
- Make and model of the DPF system offered. Indicate the foregoing for each component of the system (filter element, regeneration system and ECU).
- Specifications of the regeneration system (type, catalyst used, additive, temperatures required in exhaust gases, etc.).
- Specifications of the filter element. Dimensions, weight, material and number of cells per $cm^2$. Describe the assembly and disassembly system for technical service operations.
- Specifications of the electronic control unit. Parameters monitored, control and operation diagram of the alarm system and activation thresholds. System description of additive dosing, if necessary.
- Specifications of additional elements (thermal insulation, housing, fasteners, etc.).

## 5. WARRANTIES AND PREVENTIVE MAINTENANCE AND DIAGNOSTIC SERVICE

The bidder should commit, as part of their bid, to a minimum guarantee period of 12 months. This must at least cover all the materials and the functionality of the system as a whole for the usual operating conditions of the machinery. It is recommended that the bid details the

[5] Receiving no objection from the principal to the specifications in the offer does not exempt the bidder from compliance with all of the technical requirements indicated herein.

warranty conditions, indicating the coverage and exclusions regarding the materials and functionality of every component of the system, including the regeneration system.

During the minimum warranty period (12 months), the company awarded the contract will be responsible for preventive maintenance and diagnostic services for the systems, the latter by means of information from the ECU and other means it deems appropriate, which should be detailed in their bid. In addition, the company will be responsible for preventive maintenance operations, such as cleaning or scheduled replacement of components, for which the company may propose a maintenance schedule and describe the work to be performed.

The preventive maintenance and diagnostic service should include, as a minimum, a periodic report (e.g., quarterly) that includes the results of a visual inspection of the fleet and of the monitoring information from the ECU.

The company awarded the contract must supply the principal with an operating and technical service manual for proper operation of the system, in Spanish. In addition, it must provide frequent training (e.g., quarterly) for operators and service technicians on how to operate and care for the system, at the principal's facilities.

## 6. INSTALLATION AND ACCEPTANCE TESTS

In the case of installation of DPF systems in the engine compartment, protection of the components in it that may be flammable or have a low melting temperature (fuel lines, brake lines, hydraulic lines located near the filter, etc.) should be considered. The type of insulation required should be determined by the DPF installer. For DPF installations outside the engine compartment, contact protection systems must be considered to prevent accidents.

When installation is outside the engine compartment, rollover and falling-object protective structures must not be damaged during assembly, whether by perforation or welding. Nor must the passageway or emergency exits from the driver's cab provided by the manufacturer be obstructed. All connecting cables must be laid abrasion-free and protected against overheating.

For safe operation, particulate filters shall be placed in such a manner that they do not obstruct the operator's view from the driver's seat. If installation within the driver's field of view cannot be avoided, safe use of the equipment must be ensured according to applicable technical criteria.

Regarding the field of view problem, reviewing the latest technical standard, such as ISO 5006 Earth-moving Machinery — Operator's field of view — Test method and performance criteria, is recommended.

For final acceptance of installation jobs performed by the company awarded the contract, the principal must verify them and/or entrust a third party to do so by means of visual and instrument inspections. The list of instrument tests can be found in Appendix 3. As a result of the verification made, there must be compliance with at least the following:

- The DPF system must have at least 95% efficiency regarding the particle number (PN), measured at idle speed with a CPC or equivalent particle counter for solid particles measuring 23 - 200 nm[6], and must not exceed a PN emission limit of 2.5 10E+5 [#/cm$^3$] in exhaust gases.
- Noise levels recorded with the DPF installed must be less than or equal to those recorded with the original muffler.
- There must be no leaks in the intake or exhaust system.
- Proper mounting in the exhaust system must be verified.

[6] In accordance with INTERNATIONAL RECOMMENDATION, Particle Number Counter, Instrument for measuring vehicle exhaust particle number emissions, Part 1: Metrological and technical requirements. Equipment that complies with Swiss regulation SR 941.242 may also be used.

## 7. DELIVERY AND INSTALLATION DATES

The bidder must define delivery and installation times for the systems.

## 8. BID EVALUATION AND CONTRACT AWARD FORM

To evaluate bids, the principal may define a table that weights technical and economic aspects separately. In turn, the results of the technical evaluation and the economic evaluation (subtotals), are weighted against each other, according to the weight criterion established by the principal to obtain the final score of a bid.

As an alternative to the economic evaluation, this may be done for each machine in the fleet, as listed on the specification chart, with a contract awarded separately for each one, according to the specific technical and economic weight results. The technical evaluation may be made in general terms, with the same score applicable to all applications.

In this manner and pursuant to the foregoing, the bidder may select a subset or all of the applications to offer, with the possibility of being awarded the contract for all of the applications offered or only some of them.

Requirements stated in the technical terms and conditions that are not included in the evaluation are understood to be mandatory and assumed by the bidder, whether or not they are stated in the bid. Their express exclusion from the bid must be evaluated to determine whether it gives rise to disqualification of the bidder. The same is applicable in the case of the minimum requirements established, which are part of the evaluation, with the understanding that their rating is based on said minimum requirement.

The following technical and economic rating charts are presented as an example.

## TECHNICAL EVALUATION

| ITEM | EVALUATION CRITERION | SCORE (0-100) | WEIGHT (0-100) | WEIGHTED SCORE |
|---|---|---|---|---|
| Manufacturer's experience | • According to verifiable information submitted in the bid (at least in Appendix 1) | | | |
| Dealer's experience | • According to verifiable information submitted in the bid (at least in Appendix 1) | | | |
| Specifications of the DPF system preventive maintenance and diagnostic service | • Coverage and quality of the service offered<br>• Infrastructure and staff | | | |
| Warranty period | • Length, coverage and exclusions | | | |
| Delivery and installation dates | • Quick delivery | | | |
| | | Technical Evaluation Subtotal | 100 | |

## ECONOMIC EVALUATION

| ITEM | EVALUATION CRITERION | SCORE (0-100) | WEIGHT (0-100) | WEIGHTED SCORE |
|---|---|---|---|---|
| Price of the DPF system offered | • Percent of the low bid (low bid 100%) | | | |
| Price of the maintenance and diagnostic service | • Percent of the low bid (low bid 100%) | | | |
| | | Economic Evaluation Subtotal | 100 | |

## APPENDIX 1: FLEET SPECIFICATION CHART

| Mach. No. | Year of Manuf. | Hour Meter [Hrs] | Make | Model | Engine | Displacement [cc] | Opacity [1/m] | Lubricant Consumption [% - fuel consumption] | Exhaust Gas Temperature (file attached) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

## APPENDIX 2: MANUFACTURER AND DEALER EXPERIENCE CHART

MANUFACTURER EXPERIENCE

| TYPE OF APPLICATION[1] | QUANTITY | SYSTEM DESCRIPTION[2] | COUNTRY OR CITY | CUSTOMER | CUSTOMER CONTACT (NAME/EMAIL/PHONE) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

Notes: 1: Road vehicles, off-road vehicles, stationary engines, boats, trains, etc.
2: Describe the regeneration system and filter material.

DEALER EXPERIENCE

| TYPE OF APPLICATION[1] | QUANTITY | SYSTEM DESCRIPTION[2] | COUNTRY OR CITY | CUSTOMER | CUSTOMER CONTACT (NAME/EMAIL/PHONE) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

Notes: 1: Road vehicles, off-road vehicles, stationary engines, boats, trains, etc.
2: Describe the regeneration system and filter material.

## APPENDIX 3: ACCEPTANCE TEST FORM

| Sistma DPF | |
|---|---|
| Fabricante (marca-modelo) | |
| Identificación (número de repuesto, número de serie) | |
| Tipo regeneración | |
| Código de certificación | |
| Fecha de instalación | |
| Monitor/Datalogger | |
| Identificación (marca, modelo, N° de serie) | |
| Sistema de dosificación de aditivo | |
| Identificación (marca, modelo, N° de serie) | |
| Vehículo/unidad | |
| Tipo maquinaria | |
| Fabricante (marca-modelo) | |
| Año de fabricación | |
| VIN | |
| Motor | |
| Fabricante (marca-modelo) | |
| Año de fabricación | |
| Potencia nominal de acuerdo con la etiqueta del vehícuo | |
| Horas de funcionamiento o km al momento de la instalación | |
| Mediciones sin filtro | |
| NP en [#/$cm^3$] en ralentí | |
| Opacidad en K [1/m] en aceleración libre | |
| Medición de ruido en el escape a 45°/0.5 m a la velocidad del motor [1/min] | |
| Mediciones con filtro | |
| NP en [#/$cm^3$] en ralentí | |
| Opacidad en K [1/m] en aceleración libre | |
| Medición de ruido en el escape a 45°/0.5 m a la velocidad del motor [1/min] | |
| Contrapresión del filtro a la velocidad del motor [1/min] | |
| Contador de partículas | |
| Fabricante (marca) | |
| Tipo | |
| Opacímetro | |
| Fabricante (marca) | |
| Tipo | |
| Sonómetro | |
| Fabricante (marca) | |
| Tipo | |
| Inspección | |
| Fecha de inspección | |
| Inspector | |
| Timbre instalador/Fecha/Firma | |

## APPENDIX 3: ACCEPTANCE TEST FORM

| DPF System | |
|---|---|
| Manufacturer (make, model) | |
| Identification (part number, serial number) | |
| Regeneration type | |
| Certification code | |
| Installation date | |
| Monitor/Datalogger | |
| Identification (make, model, serial number) | |
| Additive dosing system | |
| Identification (make, model, serial number) | |
| Vehicle/Unit | |
| Equipment type | |
| Manufacturer (make, model) | |
| Year of manufacture | |
| VIN | |
| Engine | |
| Manufacturer (make, model) | |
| Year of manufacture | |
| Rated power according to vehicle sticker | |
| Hours of operation or km at the time of installation | |
| Measurements without a filter | |
| PN (# /cm3) at idle speed | |
| Opacity at K (1/m) in free acceleration | |
| Exhaust noise measurement at 45°/0.5 m at engine speed (1/min) | |
| Measurements with a filter | |
| PN (# /cm3) at idle speed | |
| Opacity at K (1/m) in free acceleration | |
| Exhaust noise measurement at 45°/0.5 m at engine speed (1/min) | |
| Backpressure of the filter at engine speed (1/min) | |
| Particle counter | |
| Manufacturer (make) | |
| Type | |
| Opacimeter | |
| Manufacturer (make) | |
| Type | |
| Sound level meter | |
| Manufacturer (make) | |
| Type | |
| Inspection | |
| Inspection date | |
| Inspector | |
| Installer’s stamp/date/signature | |

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