TESTING OF IN-SERVICE ENGINES IN NON-ROAD MOBILE MACHINERY

EUROPEAN PILOT PROGRAMME

PROJECT PLAN

2016-2018
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Pilot Programme for testing in-service engines in NRMM: Project Plan
1. Introduction and background

This document presents the elements of a European pilot programme for the testing of in-service engines installed in Non-Road Mobile Machinery (NRMM). The document addresses the following points:

- Legislative background of in-service testing of engines
- Programme objectives
- Programme management: scope, participants, financing, timing
- Technical activities of the project

1.1. Background

Since the EURO V standards for heavy-duty engines, the European emissions legislation requires to verify the conformity of heavy-duty engines with the applicable emissions certification standards: these provisions are referred to as “In Service Conformity” (ISC).

It was considered impractical and expensive to adopt an ISC scheme for heavy-duty vehicles requiring the removal of engines from vehicles to test pollutant emissions against legislative limits. Therefore, it was proposed to develop a protocol for in-service conformity checking of heavy-duty vehicles based on the use of Portable Emission Measurement Systems (PEMS). As a result, ISC testing based on PEMS was introduced in the EURO V and the EURO VI standards. The corresponding administrative and technical provisions were formulated in the European Regulations 582/2011 and 64/2012.

The technical provisions included the applicable test conditions, the test protocol (i.e. the PEMS instrumentation performance requirements and the execution of on-vehicle emissions tests) and the data evaluation method. The data evaluation principle, i.e. a moving averaging window based on the engine work or CO2 mass emissions at type approval - differs from the US (Not-To-Exceed), found to be impractical for the European heavy-duty vehicle operating conditions.

The above route was followed for non-road engines as well: preliminary research activities studied and confirmed the possibility to apply the methods developed for heavy-duty engines with minor modifications. The basis for the introduction of ISC provisions based on the PEMS approach into the European NRMM type-approval legislation has been established in several texts. Amongst these texts, the Directive 2004/26/EC1 includes the following recitals under article 2:

The Commission shall (...):

- (g) consider the engine operating conditions under which the maximum permissible percentages by which the emission limit values laid down in Section 4.1.2.5 and 4.1.2.6 of Annex I may be exceeded and present proposals as appropriate to technically adapt the Directive in accordance with the procedure referred to in Article 15 of Directive 97/68/EC;
- (h) assess the need for a system for ‘in-use compliance’ and examine possible options for its implementation;
- (i) consider detailed rules to prevent ‘cycle beating’ and cycle ‘bypass’.

1.2. NRMM PEMS Pilot Program (2010-2012)

The 'NRMM PEMS Pilot Programme’ was launched to study the introduction into the European NRMM emissions legislation of the use of PEMS as a tool for ISC. This required the adaptation and improvement of the technical procedures available from the heavy-duty vehicles sector and increasing the awareness of the different stakeholders about PEMS as a possible new regulatory tool.

The objectives of the programme were defined as follows:

- To validate the use of PEMS for gaseous pollutants for testing in-service engines installed in NRMM;
- To evaluate the gaseous PEMS test protocol for NRMM and agricultural and forestry tractor engines and its implementation;
- To provide data to be subsequently used to set the PEMS test parameters at a level appropriate to the non-road technologies actually being used at that time to satisfy the type approval requirements of 97/68/EC;
- To provide further information on incorporating the gaseous PEMS approach in the European type-approval legislation;
- To develop and share ‘best practice’ information for the use of gaseous PEMS in NRMM and agricultural and forestry tractors with all relevant stakeholders;
- To benchmark the dialogue between manufacturers and type-approval bodies;

1.2.1. Scope

The Pilot Programme focused on the use of PEMS for Stage IIIB variable speed compression-ignition engines in the power range 56–560kW, installed in land-based NRMM or agricultural and forestry tractors. Stage IIIA or stage IV engines were also acceptable, provided that the data would be useful to the development of the technical procedures.

1.2.2. Technical elements

The envisaged technical elements were formulated in the project plan². Particular attention was paid to:

a. The application of the test protocol, e.g. to judge whether the mandatory data and its quality were appropriate for the final evaluation;
b. The method used to analyse the emission data, i.e. to answer the following question: “Once the data has been collected correctly, what is the most appropriate method to process the data measured with PEMS and to judge whether the engine is in conformity with the applicable emissions limits?”

1.2.3. Outcome

Following the conclusion of the 2010 – 2012 pilot programme a project report was published and a draft testing and data evaluation protocol produced. This was used as the basis for drafting the initial draft delegated act for testing variable speed Stage V engines of categories NRE-v-5 and NRE-v-6.

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Comment [A1]: Appropriate to record the outcome already achieved.
2. "Pilot Programme for testing in-service engines in NRMM": objectives and scope

After the successful completion of the 2010 – 2012 European NRMM PEMS Pilot Programme and in order to extend the testing to those NRMM engines and applications not covered by that programme, the 2016 – 2018 ‘Pilot Programme for testing in-service engines in NRMM’ shall help to implement the provisions contained in the new legislative NRMM proposal with respect to the monitoring of emissions of in-service engines.

Given that the new NRMM legislation covers a wide engine power and application range, it can be expected that the PEMS-based measurement studied so far will not be the only appropriate method to be applied: As a matter of fact, the extraction and bench testing of engines is likely to be more appropriate for small engines (e.g. small SI-engines in handheld or gardening equipment), whilst engines in particular applications or which very powerful engines (e.g. engines in vessels or rail vehicles, and those >560kW) might require particular PEMS configurations in order to cope with inaccessible exhaust systems or the high volumes of exhaust gases.

Against this background, the ‘Pilot Programme for testing in-service engines in NRMM’ shall propose appropriate technical procedures for the relevant measurement methods and increase the awareness of the different stakeholders for this new regulatory tool.

2.1. Scope

The 2016 – 2018 pilot programme shall apply to engine categories subject to Stage V limit values that are in scope of the draft Stage V Regulation, other than variable speed engines in the 56 – 560 kW engine categories NRE-\(v\)-5 and NRE-\(v\)-6.

2.2. Objectives

The objectives of the programme are as follows:

- To validate appropriate methodologies for the testing of in-service engines installed in NRMM, notably through the use of PEMS for gaseous pollutants or – where more appropriate - extraction of engines;
- To assess application-specific aspects regarding the use of PEMS;
- To evaluate the relevant test protocols and their implementation;
- To define the necessary measuring protocols for in-service engines at a level appropriate to the non-road technologies actually being used, with a view to satisfying the relevant requirements of the new NRMM regulation currently under preparation;
- To develop and share ‘best practice’ approaches for the testing of in-service engines installed in NRMM with all relevant stakeholders;
- To benchmark the dialogue between manufacturers and type-approval bodies.

A matrix of Stage V engine categories and specific tasks is provided in Annex I. For certain sub-categories an alternative to the use of PEMS should be evaluated. For other engine sub-categories where the use of PEMS is to remain the primary approach for the Stage V in-service monitoring programme the principle focus should be to assess the feasibility of applying the methodology developed via the 2010 – 2012 NRMM PEMS pilot programme and identifying how to adapt that methodology as necessary. Engine testing as part of the pilot programme should be minimised where the necessary adaptation is already clear or can be assessed by other means (e.g. design or data analysis). The resulting proposals for
in-service monitoring of Stage V engines should not be dis-proportionate to the production volume of the sub-category and particularities of the non-road machine sector in which the engines are used.

3. Project organisation

3.1. Participants and project management

European Commission

The European Commission through DG GROW acting in co-operation with the JRC sets up the ‘Pilot Programme for testing in-service engines in NRMM’ and will ensure its general co-ordination. DG GROW will primarily steer the programme, co-ordinate related activities and organise meetings and technical seminars.

JRC will provide the technical support to the Pilot Programme to make sure that the PEMS approach for ISM is applied consistently. JRC will provide technical co-ordination of the testing activities, advise DG GROW on technical issues, and provide ad-hoc support for the application of the test protocol when required.

In specific cases to be determined, JRC will provide the required equipment and the technical support for the installation and the execution of the tests.

Member State authorities

Member State authorities will support technical services in the execution of in-field tests and will provide expertise based on their type-approval experience. Their role also covers support for the Commission in issues concerning the introduction of the new legislative provisions on the testing of in-service engines in NRMM. The Member State authorities will ensure that ongoing national programmes are co-ordinated with the 'Pilot Programme for testing in-service engines in NRMM' and notably use the test protocols under development.

Technical services

The technical services in EU Member States will conclude appropriate tests in co-operation with machine and engine manufacturers. They will provide technical expertise in relation to the testing and will apply the test protocols under development consistently with the technical support of JRC.

Engine manufacturers

Engine manufacturers will provide technical input to the programme. Where possible they will locate test machines and provide the necessary equipment for the testing activities. When in-field tests are performed engine manufacturers will co-operate with the relevant type approval authority and technical service to perform the in-field tests applying the test protocols being developed.

In cases where the engine manufacturers have already conducted tests on NRMM either inside or outside of the EU (e.g. for meeting the requirements of the US EPA in-use test program), or plan to do so, manufacturers may submit technical information or data to this programme, so long as the data fulfils the requirements in the draft Delegated act on In-Service Monitoring of non-road engines, as adjusted according to the needs of the subject engine category. This will enable the data processing according to the data evaluation methods used within the 'Pilot Programme for testing in-service engines in NRMM'.

Comment [A9]: Particularly important for low-volume engine categories

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As engine manufacturers are responsible for the engine certification, they shall be mainly responsible and in charge of conducting the tests within the Programme. To develop and share the best practice approach, Member States' technical services, national laboratories and machine manufacturers are also encouraged to participate.

This pilot program applies to in-service engines installed in land-based NRMM in the power ranges <56kW and >560kW, as well as to those installed in inland waterway vessels and rail vehicles.

Comment [A10]: Additional measurement support from JRC is essential.

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Comment [A11]: For the 2016 – 2018 pilot programme manufacturers will be highly dependent upon other parties for certain engine categories, especially inland waterways and rail.

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Deleted: to the maximum extent possible.

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Deleted: Annex II of the heavy-duty EURO VI implementing measures

Comment [A12]: Should use the latest available procedures applicable to the NRMM sector.

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OEMs

OEMs are strongly encouraged to join the programme. In most cases they are likely to do so indirectly by working with an engine manufacturer. OEMs are encouraged to assist their engine suppliers by making available suitable machines for testing.

NRMM operators

For applications where engine and OEMs are usually not owners of the NRMM (e.g. inland waterway vessels, rail vehicles), particular arrangements and solutions must be sought as neither the engine manufacturer nor the OEM can provide access to suitable NRMM. Operators of NRMM are consequently encouraged to assist by making available suitable machines for testing.

PEMS equipment manufacturers

Manufacturers of PEMS equipment will be involved in the programme so as to receive feedback to help improve PEMS equipment before the launch of any official testing requirements. They are encouraged to make available, for loan or hire, PEMS equipment for use by engine manufacturers who do not currently possess their own equipment.

3.2. Groups and sub-groups

A two-stage approach will be adopted for the participation of technical services in the “Pilot Programme for testing in-service engines in NRMM”. The aim of having a two-stage approach is to concentrate testing efforts, but at the same time facilitate the learning process of all interested technical services in Member States. Two groups of technical services will be established, requiring different levels of participation.

1. Core group: A core group of technical services will be formed by those technical services that provide type-approval services to manufacturers. This group will manage the in-field tests for the “Pilot Programme for testing in-service engines in NRMM” in co-operation with engine manufacturers.

2. Observer group: Other technical services will form an observer group. They will be able to attend the testing activities of other technical services and the pilot programme meetings. The aim being to facilitate learning and the dissemination of information concerning the approach for the testing of in-service engines.

This approach will ensure that ‘best practice’ information is shared and all technical services have the opportunity to gain early experience concerning the testing of in-service engines in NRMM. It will also ensure effective co-operation of interested parties at an early stage.

In a similar manner other participants (engine manufacturers, OEMs and machine operators) making a technical contribution to the pilot programme in one or more engine categories shall be formed into a ‘core group’ to assist with the necessary tasks.

3.3. Dissemination of information

The GEME CIRCABC website set up by DG GROW will provide access to the documents related to the “Pilot Programme for testing in-service engines in NRMM”.

To encourage the exchange of information and effective co-operation of the participants, technical meetings will be organised by the European Commission on a regular basis during the “Pilot Programme for testing in-service engines in NRMM”.
Some training workshops might be organised by JRC (if required) to provide technical support for the application of the data processing reference tool (EMROAD©).

The data shall be submitted in electronic format via the VCA File Management System (VCA FMS), using the standard EMROAD© templates.

3.4. Confidentiality

All data sent to the European Commission (DG GROW or JRC) by any of the participants will remain confidential under the conditions of the Regulation No. 1049/2001 of the European Parliament and the Council of 30 May 2001. Article 4(2) of that Regulation notes that “The institutions shall refuse access to a document where the disclosure would undermine the protection of...commercial interests.” This confidentiality agreement will apply to engine test data for instance.

In addition to the above statement:

With respect to all information concerning the data and information declared as confidential by one of the participants (whether in oral, written or computerised form), the data shall:

- Only be used for the development of the European NRMM testing procedures;
- Be processed, analysed and reported with a methodology and within a time frame approved by the said party.

Any publications making use of the data, i.e. objectives, content and text will be agreed in advance.

3.5. Financing

The “Pilot Programme for testing in-service engines in NRMM” shall be primarily financed by the participants. Those engine manufacturers, OEMs and operators, wishing to participate will provide the non-road machines for testing purposes and engine manufacturers will, where possible provide the measuring equipment, for the in-field tests. Engine manufacturers will also where possible conduct the in-field tests, or arrange for them to be conducted on their behalf. Where engine manufacturers are unable to conduct the tests or provide the equipment JRC shall assist to the extent possible.

The Commission shall manage and co-ordinate the “Pilot Programme for testing in-service engines in NRMM” and contribute directly through the technical support of the JRC.

Member State authorities and technical services shall finance additional testing expenses (costs of laboratory works, additional fuel costs, etc.).

3.6. Timing

The “Pilot Programme for testing in-service engines in NRMM” particularly targets engines with a net power <56kW and >560kW, respectively. For the >560kW class of engines, little or no experience exists using PEMS as a tool for testing in-service engines. The 2016 – 2018 ‘Pilot Programme for testing in-service engines in NRMM’ will start no later than May 2016 and last until December 2017. Data collected prior to commencement of the programme will be admissible, so long as it can be processed according to the data evaluation methods used by the ‘Pilot Programme for testing in-service engines in NRMM’.

Comment [A15]: Essential

Comment [A16]: Not feasible to have a pilot programme to the pilot programme.

Deleted: to the maximum extent possible

Deleted: NRMM manufacturers are encouraged to make available to engine manufacturers suitable machines for testing under this programme

Comment [A16]: Not feasible to have a pilot programme to the pilot programme.

Deleted: Therefore a preparatory campaign lasting no more than 3 months needs to be launched to support the “Pilot Programme for testing in-service engines in NRMM”, this preliminary campaign consists of experimental and/or data collection activities. Once test protocols/data from the preliminary campaign will be available and together with the existing provisions for heavy-duty engines and the experience gained in the NRMM PEMS Pilot Programme (2010-2012), the
The evaluation of final test results for gaseous pollutants and final results of the testing phase should be concluded by the end of 2017.

A review of the applicability of the procedures developed during the 2010 – 2012 European NRMM PEMS Pilot Programme will be conducted in the early stages of the program. The result of the review may be used as a first basis to develop legal text which shall then be progressively refined as the necessary adaptations are developed during the 2016 – 2018 pilot programme.

3.7. Project deliverables

The "Pilot Programme for testing in-service engines in NRMM" will provide the following deliverables:

- Consolidated test protocols for the measurement of gaseous emissions of in-service engines, both for in-field tests and in-service tests of extracted engines as applicable (with contributions from JRC, Member State authorities, technical services, engine and instrumentation manufacturers);

- Test data reports following the completion of in-field tests and for in-service tests of extracted engines (technical services, manufacturers), upon agreement of the parties that participated;

- A final technical report, compiling the various studies that may be conducted on the following topics:
  - (Updated) installation recommendations of PEMS equipment on various types of machines;
  - Guidance and recommendations for measurement procedures of extracted engines;
  - The data evaluation method and its settings. (E.g. calculation parameters, valid and invalid test data, or averaging windows).

3.8. International links

The project being set-up will be strongly connected to other international activities such as:

- Any Pilot Programme possibly launched by the United States Environmental Protection Agency (US-EPA);
- National projects having used PEMS to obtain real-world emission factors for different machines.

The success of the "Pilot Programme for testing in-service engines in NRMM" requires a high level of experience in the field, and further harmonization of standards is being considered by the EC. Therefore, other bodies and companies who are able to bring substantial expertise will be encouraged to participate in this work. For instance:

- US-EPA and CARB;
- The Japanese Ministry of Environment;
- Representatives from EUROMOT, EMA, (US Truck and Engine Manufacturers Association) and LEMA, (Japanese Land Engine Manufacturers Association);
• Manufacturers of portable instruments for measuring emissions with the assistance of their technicians and engineers.

4. Technical elements

The objective of the ‘Pilot Programme for testing in-service engines in NRMM’ is to evaluate both the technical (i.e. the instruments, the protocol and the data processing methods) and the administrative elements (i.e. the dialogue between the machine and engine manufacturer and its type-approval authority). Therefore, the exchange of information between the main parties will be benchmarked throughout the entire process, i.e. from the selection of the machine up to the presentation of the test data. Good practice in the exchange of information will be profiled as a result of the benchmarking.

This section discusses the necessary technical elements of the programme. It establishes the requirements for the technical activities to be conducted by the machine and engine manufacturer and in particular for the following items:

- Applicability;
- Selection of machine and engines;
- Testing scheme;
- Quantity of data collected;
- Screening of test machines;
- Test conditions;
- Requirements for reporting;
- Measurement of gaseous emissions: Performance requirements for the test instruments and test protocol;
- Test protocol (execution of tests and data to be collected);
- Data analysis;
- Determination of reference work and reference CO2 quantity
- Adaptation of data evaluation procedure
- Assessment of PEMS installation constraints
- Assessment of alternative to PEMS

Some of the above elements are available before the ‘Pilot Programme for testing in-service engines in NRMM’ actually starts. Nevertheless:

- The PEMS test protocol for gaseous emissions of land-based NRMM engines in the power ranges <56kW and >560kW as well as of engines in inland waterway vessels and rail vehicles is not available. A draft test protocol will be ready for review before the testing activities start. This review shall involve national technical services, machine and engine manufacturers and PEMS instrument providers. At the end of the review, a consolidated test protocol will be produced.
- The elements of the dialogue between the machine and engine manufacturer and its type-approval body will be defined before machines are selected. In particular this will include the machine selection strategy for the designated engine family and the reporting requirements.
- The initial assessment method to be considered for the ‘Pilot Programme for testing in-service engines in NRMM’ will be the averaging window method, work or CO2 based, as implemented for the heavy-duty engines in the EURO VI implementing measures and the European NRMM PEMS Pilot Programme (2010-2012).
The items ‘pass-fail criteria’, ‘threshold specification’ and ‘remedial actions’ are not relevant for the execution of the programme and are therefore not detailed in the present document.

4.1. Applicability

The engines to be tested in the present program shall be those in the scope of the Commission proposal for a new NRMM Regulation.

4.2. Selection of engines

The definition of a strategy for the selection of engines is part of the pilot program. The selection process shall involve the engine manufacturers and their type approval authorities and be conducted under the supervision of the national technical services. The program shall mainly focus on engines with high sales volumes.

4.3. Testing scheme

Most preferably, a minimum of 3 machines per group of engine families shall be tested during the programme. These machines shall, to the extent possible, cover different engine applications.

4.4. Assessment

As stated above, the initial assessment methods to be considered for the “Pilot Programme for testing in-service engines in NRMM” is the moving averaging window method, work and CO2 based, as implemented for the heavy-duty engines in the EURO VI implementing measures and the 2010 – 2012 European NRMM PEMS Pilot Programme. The CO2 based window might be appropriate for non-electronically controlled engines.

For the averaging window calculations, the reference cycle shall be the appropriate test cycle for the engine being tested. The reference work and reference CO2 quantities shall be determined during the programme.

If the PEMS post-processors do not include the necessary features at that time, the data shall be processed using the European reference tool developed in the EU-PEMS project (EMROAD©) and a training workshop shall be organised by JRC to facilitate its use.

As far as the moving averaging window method is concerned, its settings shall be investigated in particular:

- The reference quantity (i.e. engine work or CO2 mass) and its value;
- The criteria to validate/invalidate windows (e.g. average power, percentage of non-working events);
- The handling of emissions during Diesel Particle Filter regeneration events;
- The statistical analysis of data from single tests (e.g. percentage of windows for a valid test);
- The potential exclusions from the ‘raw’ data (e.g. cold start, after-treatment temperatures,...).

Comment [A19]: 3 machines total per group of engine families is still an optimistic target based on what was achieved in 2010 -2012 pilot programme. 3 machines per manufacturer per engine family is not feasible.

Comment [A20]: Key task

Comment [A21]: Not appropriate for pilot programme.
4.5. Quantity of data collected
Wherever possible, the first machine should be tested at least 3 times on a similar duty cycle. The test duration shall normally be selected to make the cumulative engine work during the test at least equal to 3 to 5 times the work or the CO2 emissions produced by the engine running the appropriate legislative test cycle.

4.6. Screening of test machines
- The machine’s engine must be representative of the selected engine family: Each prospective machine must be screened to ensure the engine is representative of the sub-classes or configurations within an engine family.
- The machine duty cycle must be representative of the machine type, i.e. the machine or engine manufacturers must screen machines to ensure testing is conducted within the normal range of applications for that machine type.
- The information gathered during the pre-screening process shall be recorded (maintenance reports, hours of operation..., see next paragraph).

Once the machines are selected, the machine screening can be conducted. The machines can be rejected on the following grounds:
- As a safety inspection of the test machine’s engine, chassis, and load must be conducted to ensure that the machine can be safely operated during the tests.
- PEMS installation constraints: A machine or engine manufacturer may reject a test machine if mounting or operating a PEMS is determined to be infeasible, or impractical. This should apply only to highly special machine configurations where installation would be too complex, time consuming, or potentially damaging to the machine. Similarly, any possibility that the installation of the PEMS unit damages the performance of the PEMS should be avoided.
- Machines are no longer available for testing.

Once the machines have passed the screening process, their engine (both hardware and software) and body shall not be modified.

4.7. Test conditions
The test machines shall be operated over their normal duty cycles, conditions and payloads.

4.8. Requirements for reporting
Screening and preparing machines for in-service testing under this programme requires that certain information be either collected or produced during the process. This information must be reported to the type-approval authorities as part of the test report and maintained as record-keeping material.

The report of the European NRMM PEMS Pilot Programme-Phase 1 contains a list of reportable data elements. It will be part of the preparation phase of the present programme to review and finalize these data elements. The test spreadsheets (or templates) are organized with separate tabs containing machine and engine family information, second-by-second test data and calculated data, integrated and averaged test results. During the dialogue between the manufacturer and its authority, the data shall be submitted in electronic format, using the standard EMROAD© reporting templates.
4.9 Measurement of emissions

4.9.1 Measurement with PEMS

4.9.1.1 Instruments

The PEMS systems shall comply with general requirements:
- To be small, lightweight and easy to install;
- To work with a low power consumption so that tests of at least three hours can be run either with a small generator or a set of batteries;
- To measure and record the concentrations of NOx, CO, CO2, THC gases in the machine exhaust;
- To record the relevant parameters (engine data, machine position from the GPS, weather data, etc.) on an included data logger.

The PEMS to test the machines shall be commercially available systems. It is recommended to use the PEMS tested in the previous phase of the program. Other PEMS than the ones previously mentioned can be used for the same application, provided that they offer at least equal characteristics in terms of dimensions, weight and measurement quality.

4.9.1.2 Test protocol

The tests shall be conducted according to the recommendations developed in the preliminary phases.

Mounting of the PEMS units on the machines shall use only pre-existing or temporary fixings that minimise modification of machines to the extent that would be acceptable to a machine customer/owner.

All stages of the testing, including preparation, PEMS mounting, calibration, conduct of test and dis-assembly, must comply with all aspects of Health & Safety law applicable in the country where the test is being conducted.

These recommendations will be formalised in the “Guide for the Preparation and the Execution of In-service Emissions Tests on non-road machines, to be drafted by JRC before the programme starts.

4.9.1.3 Data analysis

Data shall be initially analysed according to the recommendations developed in the previous European NRMM PEMS Pilot Programme (2010 – 2012).

The data may be processed using the post-processors of the PEMS instruments. However, the program foresees that the data processed in such a way will be benchmarked against the calculations made through the data processing reference tool developed in the EU-PEMS project (EMROAD©).

4.9.2 Measurements on extracted in-service engines

The option of extracting in-service engines in the smaller power-ranges to perform the required measurements will be addressed during the current pilot program. The measurements on these engines shall be initially performed following the existing
provisions applied to them at type-approval; however as a result of the pilot program a new protocol might possibly need to be developed.

5.0. Specific tasks for pilot programme
The following tasks shall be performed as part of the pilot programme:
- Determination of reference work and reference CO2 quantity
- Adaptation of data evaluation procedure
- Assessment of PEMS installation constraints
- Assessment of alternative to PEMS