

NON-ROAD MOBILE MACHINERY RETROFIT ACCREDITATION SCHEME (NRMM-RAS)

RETROFIT EMISSIONS CONTROL (REC) SYSTEM – TECHNICAL
REQUIREMENTS



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1. Introduction

There continues to be an increasing focus on the pollution emissions caused by construction site activity. The Greater London Authority (GLA) published its Control of Dust and Emissions from Construction and Demolition Supplementary Planning Guidance (SPG) in July 2014. This policy includes the Low Emission Zone for Non Road Mobile Machinery (NRMM). The SPG aims to reduce such emissions and includes measures to mandate the use of lower polluting construction site machinery operating within the Greater London area and at designated sites. Construction sites in London were identified in the Mayor of London's Air Quality Strategy as an area for future focus in terms of emissions reduction. The same issue is being considered in other areas throughout the UK where air pollution exceeds legally binding limits. The Energy Saving Trust has administered the certification scheme for NRMM to support policies such as the GLA's SPG and other potential local air quality initiatives.

The Energy Saving Trust is a non profit distributing company funded by Government and the private sector. It aims to reduce carbon dioxide (CO₂) emissions and improve air quality by promoting the sustainable, clean and efficient use of energy. The NRMM Retrofit Accreditation Scheme (NRMM-RAS) will offer independent certification of retrofit emission abatement technologies and provides an assurance scheme that technologies satisfy the technical requirements of policies such as the GLA's SPG. In the case of the GLA policies for acceptance of retrofit and any exemptions policy are determined under consultation within the GLA's NRMM Committee that is formed of representatives from local government, industry associations, academia, NGOs and major infrastructure projects.

Certification under the NRMM RAS is a two-stage process. The first stage of certification is an assessment of 'Company Eligibility'. Company Eligibility for NRMM-RAS and the on road Clean Vehicle Retrofit Accreditation Scheme (CVRAS) are harmonised. The second stage is an assessment of the emissions abatement technology or Retrofit Emissions Control (REC) device type. Applications to become an Eligible Company and to supply Approved Product(s) must be made consecutively. Full details of the certification conditions for technologies and an application form are available from Energy Saving Trust at the address shown in section 2.

This document sets out the conditions which emissions abatement systems shall meet in order to qualify for 'Approved Product' status under the NRMM RAS. A separate application form shall be completed for each REC type such as PM reduction only (e.g. Diesel Particulate Filter DPF), NO_x reduction technology (e.g. Selective Catalytic Reduction SCR) or combined PM and NO_x reduction technology for which approval is sought. If the Energy Saving Trust is satisfied that the conditions for obtaining Approved Product status have been met, including payment of all applicable fees, then companies will receive written confirmation of this from the Energy Saving Trust. If an application is successful, then the details of the Company and its Approved Product(s) will be entered by the Energy Saving Trust on the NRMM Approved Device List and NRMM Register. A means of identifying machines that have been retrofitted with EST NRMM RAS systems will be developed.

The Energy Saving Trust reserves the right to conduct an Emissions Conformity Monitoring and Testing programme to assess whether the required technical integrity and emissions reductions continue to be met by an Approved Product post-production.

The Energy Saving Trust reserves the right, at its discretion, to decline an application if it is not satisfied that all the relevant conditions have been met or will be met in the future in situations where testing is progress. If declined, an applicant company will not normally be able to submit a further application within 6 months of communication of the Energy Saving Trust's decision.

Only manufacturers or distributors of emissions abatement systems may apply for approval under the NRMM RAS. In addition, distributors must provide evidence that they have the manufacturer's authority to distribute the relevant equipment.

It should be noted that vehicles/machinery fitted with on-highway certified engines (directive 88/77/EC as amended) are not within the scope of this scheme.

2. Contact details

For further information or to make an application please contact:

- Programme Manager, Clean Vehicle Retrofit Transport Team
- Energy Saving Trust 30 North Colonnade, Canary Wharf
- London, E14 5GP
- Tel: 020 7222 0101
- Email: cvas@est.org.uk
- Fax: 020 7654 2444

The programme register can be accessed at: www.energysavingtrust.org.uk

Scope

1. NRMM Retrofit Accreditation Scheme (NRMM-RAS) technical requirements (the Technical Requirements) are applicable to Retrofit Emission Control (REC) devices for application to NRMM in order to comply with locally applied policy such as the GLA's SPG.
2. A REC device is a device, system or modification which reduces exhaust tailpipe emissions to enable a piece of NRMM/engine to meet the technical performance requirements specified in this document.
3. The Technical Requirements specified apply only to the retrofitting of emission control devices to existing NRMM or off road engines certified under Directive 98/67 as amended (see table below for the off highway heavy duty engine emission test cycles) and already meeting Stage II, IIIA, IIIB or IV performance requirements. Nothing in the technical requirements specified in this document precludes the use of hybrid systems combining electrical propulsion with internal combustion engine(s) employing either fossil or renewable fuels nor the use of natural gas in an internal combustion engine equipped with or without spark ignition, provided the resulting adaptation is able to meet the technical performance requirements specified.

EU Stage	Market placement year(s) See Note 1.	Engine emissions certification test cycle	
		Variable Speed	Constant Speed
Stage I	1999-2003	NRSC ISO 8178 C1 8 mode	Not applicable

Stage II	2001-2007 (variable speed) 2007-2011 (constant speed)	NRSC ISO 8178 C1 8 mode	NRSC ISO 8178 D2 5 mode
Stage IIIA	2006-2008 (variable speed) 2011-2019 (constant speed)	NRSC ISO 8178 C1 8 mode Optional to use NRTC	NRSC ISO 8178 D2 5 mode
Stage IIIB	2011-2019	ISO 8178 C1 8 mode plus NRTC	Not applicable
Stage IV	2014-2019	ISO 8178 C1 8 mode plus NRTC	Not applicable
Stage V	2019-onwards	ISO 8178 C1 8 mode plus NRTC	NRSC ISO 8178 D2 5 mode

Note 1. Dependent upon power category. Transition provisions allow placing on market in later years

3. General requirements

Each applicant seeking approval for after-treatment equipment or emissions abatement system shall first be registered as an Eligible Company by the Energy Saving Trust, and therefore must have been given written notification by the Energy Saving Trust of this status. Eligible Company status for NRMM is aligned with the Clean Vehicle Retrofit Accreditation Scheme (CVRAS) requirements for companies supplying retrofit technology for the on-road sector therefore a company that holds CVRAS company approval extends to NRMM company approval.

In order to achieve and maintain Eligible Company and Approved Product status, a company must at all times comply, to the Energy Saving Trust's satisfaction, with the following requirements:

- 3.1** any Approved Product(s) or relevant product(s) for which approval is sought must be safe, of good quality and fit for its intended purpose, must comply with all applicable legislative requirements (health & safety, CE marking) and must be backed by appropriate warranties (see In service durability clause).
- 3.2** any services (such as fitment of after-treatment systems) it provides must be carried out by competent, suitably trained, experienced and properly supervised personnel using all reasonable care, skill and diligence, and in accordance with good industry practice.
- 3.3** any Approved Product(s) must continue to meet all the Conditions relating to such approval including compliance with the Energy Saving Trust's Emissions Conformity Testing programme (see section 5).
- 3.4** it must accept that issues of non-conformity (whatever the source) with the certification requirements must be addressed in an effective and timely manner and that failure to do so may result in withdrawal of Eligible Company and/or Approved Product status.
- 3.5** where a retrofit emissions control (REC) device includes a diesel particulate filter (DPF) a back-pressure monitor (to monitor pressure drop across the REC device must be fitted and be operating effectively. As a minimum this shall consist of an alarm that is both visible and audible to the machine operator.
- 3.6** devices such as data-loggers, which monitor system performance and record data, such as NOx sensor readings, for inspection as evidence of satisfactory operation are mandated.
- 3.7** it must comply at all times with the conditions of the combined CVRAS/NRMM Eligible Company status.
- 3.8** it must comply with the Energy Saving Trust NRMM Standard Terms & Conditions contract.

4. Eligible machinery

Under the NRMM Retrofit Accreditation Scheme and according to the current GLA Control of Dust and Emissions from Construction and Demolition Supplementary Planning Guidance (SPG), machinery with a power rating above 37kW and below 560kW are required to meet the following emissions standards for the specified areas either from new or by retrofitting an EST NRMM RAS Approved Product supplied by a CVRAS/NRMM RAS Approved Company where compliance with the requirements set out in this document has been demonstrated to the satisfaction of EST.

For London the GLA has set the following standards

Area	From September 2017	From September 2020
Central Activities Zone (i.e. central London), Canary Wharf and opportunity areas	Stage IIIB*	Stage IV*
Rest of Greater London	Stage IIIA	Stage IIIB*

Outline of EU stage requirements and pollution reduction required for variable speed engines

Power Band (kW)	Stage II	Stage IIIA	Stage IIIB	Stage IV	Stage V	Equipment vs Standard		
	Power Band	Power Band	Power Band	Power Band	Power Band	Stage II Equipment for Stage IIIA Zone	Stage IIIA Equipment for Stage IIIB Zone	Stage IIIB Equipment for Stage IV Zone
37≤kW≤56	G	J	P	-		NO _x	PM	NO _x /Tel ¹
56≤kW≤75	G	J	N	R		NO _x	NO _x /PM	NO _x /Tel ¹
75≤kW≤130	F	I	M	R		NO _x	NO _x /PM	NO _x /Tel ¹
130≤kW≤560	E	H	L	Q		NO _x	NO _x /PM	NO _x /Tel ¹

Outline of EU stage requirements and pollution reduction required for constant speed* engines

Power Band (kW)	Stage II	Stage IIIA	Stage V*	Equipment vs Standard	
	Power Band	Power Band	Category/sub-category	Stage II Equipment for Stage IIIA Zone	Stage IIIA Equipment for Stage IIIB/IV Zone
37≤kW≤56	G	J	NRE-C-4	NO _x **	NO _x /PM/PN/TeI#
56≤kW≤75			NRE-C-5	NO _x **	NO _x /PM/PN/TeI#
75≤kW≤130	F	I		NO _x **	NO _x /PM/PN/TeI#
130≤kW≤560	E	H	NRE-C-6	NO _x **	NO _x /PM/PN/TeI#

* For constant speed engines, no Stage IIIB or Stage IV has been defined in the regulations therefore this is not referenced in table above

Stage V limit values

The above standards have implications for NRMM, such as diesel generators, fitted with type approved constant speed engines where EU Stage IIIB and Stage IV regulations did not apply. NRMM with these engines are not available at Stage IIIB or IV level and will move from Stage IIIA directly to Stage V. Stage V regulations will require the fitment of both PM and NOx emission control whereas Stage IIIB implemented a significant PM reduction and Stage IV implemented a significant NOx reduction. Retrofitting a Stage IIIA constant speed engine with PM and NOx control system that reduces PM by more than 97% and NOx by more than 90% effectively takes a Stage IIIA engine to Stage V equivalence.

Exemptions are covered within the Greater London Authority – Statement of Policy – Exemptions to and retrofit procedures for the Non Road Mobile Machinery (NRMM) Low Emission Zone.

5. Test requirements

The applicant must follow all test procedures and requirements set by the Energy Saving Trust.

Applicants holding full Swiss FOEN/VERT Association certification or UN ECE Regulation 132 approval for the relevant retrofit emission control technology may, entirely at the Energy Saving Trust’s discretion, be awarded an exemption from additional testing. See sections 10 and 11 of this document.

All approval testing will be at the cost of the applicant.

5.1 Test Format and Test Cycle

An applicant for NRMM Product Approval shall choose one of the following options of test formats and cycles

For engines designated as **variable speed**

Option 1	Engine dynamometer in accordance with UN ECE Regulation 96	Combined Non Road Steady State Cycle (NRSC) and Non Road Transient Cycle (NRTC) as used for Stage IIIB, IV and V type approval testing
Option 2	In situ testing with PEMS	Replication of the ISO 8178-4 C1 eight mode test cycle (NRSC) and for NOx reducing products an in-service monitoring test conducted according to Regulation (EU) 2017/655. See Note 1.

Note 1: This test is in lieu of the NRTC. Therefore, the engine coolant must be cold (i.e. at ambient temperature) at the start of the test and the NRMM must be operated transiently while performing loaded work. The 90th percentile conformity factor based upon all working events and valid windows shall not exceed a value of 2.

For engines designated as **constant speed** (see Note 1)

Option 1	Engine dynamometer in accordance with UN ECE Regulation 96	shall meet the requirements of the ISO 8178-4 Type D2 five mode test cycle
Option 2	In situ testing with PEMS equipment	Replication of the ISO 8178-4 Type D2 five mode test cycle

Note 1: Previously the EST NRMM REC device standard for product approval only related to PM reduction systems (DPFs) and tests were conducted over the variable speed engine test cycle and extended to constant speed engines. The NRMM RAS scheme now allows for application for constant speed engines only.

The testing format shall be agreed with the Energy Saving Trust prior to the commencement of testing and where Option 1 is chosen (i.e. engine dynamometer tests for approval) then the test shall only be carried out by an engine or vehicle testing facility that is acceptable to the Type Approval Authority of an EU Member State. Testing will consist of a minimum of 2 repeated runs of an engine dynamometer test cycle with the standard exhaust system fitted (baseline tests) followed (within 1 week) by a further 2 runs with the emissions abatement system installed. Where variation between individual test runs shows a difference of greater than 10% in measured emissions parameters, a third test run shall be carried out to enable the rejection of statistical outliers.

In the case of in-situ tests of engines incorporated within machinery or equipment with emissions measured by Portable Emissions Measurement Systems (PEMS) then the average of a minimum of 3 repeated runs shall be conducted. Sufficient time to allow stabilisation of the system temperature shall be allowed for each mode test.

Where approval tests are conducted by the PEMS option then the NRMM-RAS applicant shall use a reputable PEMS testing provider using PEMS equipment and techniques as included in the EU regulation 2017/654 and 2017/655.

At the discretion of and in agreement with the certification body an applicant when using in-situ testing (PEMS) can use measurements of engine out emissions of the required pollutants. It should be noted that this may require two sets of measurement equipment. Where variation between individual test runs shows a difference of greater than 10% in measured emissions parameters, further test runs shall be carried out to enable the rejection of statistical outliers.

Solely at the discretion of the Energy Saving Trust, a retrofit emission control system awarded NRMM RAS Product Approval for variable speed engines via tests on an engine dynamometer over the combined NRSC and NRTC can be extended to constant speed engines. A retrofit emission control system awarded NRMM RAS Product Approval for constant speed engines with tests conducted via engine dynamometer or in situ PEMS testing will not be extended to NRMM fitted with variable speed engines.

Where an applicant is seeking approval across a range of power ratings for constant speed engines and via in situ emissions testing using PEMS (Option 2) then testing a range of engines in the following power ranges shall be conducted.

Engine size	Engine power range
Small	37kW to 150kW
Medium	150kW to 300kW
Large	300kW to 560kW

5.2 Test Engine and Machinery Requirements

5.2.1 For engine dynamometer tests

Agreement must have been made with the Energy Saving Trust on the engine to be used for approval testing prior to the start of testing. The engine must also have an up-to-date service record. The calibration of the engine or electronic control unit shall be identical to that of the original OEM Type Approved engine. This is to ensure that no modifications have been made to the engine calibration which might artificially enhance or provide favourable operating conditions for the after-treatment system.

The Energy Saving Trust reserves the right to decline an application for approval if it is judged that the baseline emissions measurements vary significantly from those normally expected for an engine of that type and age.

5.2.2 For in situ tests using PEMS

Agreement must have been made with the Energy Saving Trust on the machinery to be used for approval testing prior to the start of testing. The engine must also have an up-to-date service record. The calibration of the engine or electronic control unit shall be identical to that of the original OEM Type Approved engine. This is to ensure that no modifications have been made to the engine calibration which might artificially enhance or provide favourable operating conditions for the after-treatment system.

The Energy Saving Trust reserves the right to decline an application for approval if it is judged that the baseline emissions measurements vary significantly from those normally expected for an engine of that type and age.

5.3 Back Pressure Monitoring

Pressure drop over the exhaust system on the engine under test must be recorded during test, both before and after fitting the emissions control device. Any increase in exhaust back pressure measured with the emissions control device fitted shall not exceed 250mbar (25kPa) at maximum soot and ash loading or 120mbar (12kPa) for engines with uncontrolled exhaust gas recirculation (EGR). Where engines remain within OE engine manufacturers' warranty then back pressure limits set by the engine manufacturer shall apply.

5.4 Test Fuel

The fuel used during approval testing shall be agreed with the Energy Saving Trust in advance of the test. This shall normally be pump-grade ultra-low sulphur diesel (ULSD) with no more than 10ppm sulphur content, meeting the specifications of Directive 98/70/EC - BS EN 590:2013 or off-road diesel (gas oil) fuel meeting BS EN 2869:2017.

5.5 System Preconditioning

It is recognised that retrofit emission control devices employing catalysts to meet the required performance standards specified in this document are likely to undergo changes in

performance capability in the early phases of use. This phenomenon is generally termed 'catalyst de-greening', a description well-known within the exhaust after-treatment industry. Pre-conditioning of REC devices immediately prior to test is the responsibility of the applicant and the applicant shall demonstrate sufficient "de-greening" has been performed prior to testing.

5.6 Measurement Methods

5.6.1 Measurement methods for oxides of nitrogen (NO_x)

5.6.1.1 For engine dynamometer tests (Option 1)

Equipment referenced in UN ECE Regulation 96 (including exhaust emissions sampling and analytical systems) is required for emissions measurements, where appropriate. All test equipment must comply with ISO 8178-1:2017, and tests conducted according to ISO 8178-4:2017. Alternatively comply with the provisions of either 04 series or 05 series of UNECE Regulation R96 appropriate to the emission stage for the intended application, or with the provisions of Directive 97/68/EC (up to Stage IV) or Regulation (EU) 2017/654 (Stage V). All instrumentation shall be traceable to national standards.

5.6.1.2 For in-situ machinery tests

Using PEMS (Option 2)

Real-world Driving Emissions (RDE) measured using PEMS is not currently not well established in the off-highway sector, however where appropriate and wholly at the discretion of the Energy Saving Trust the use of PEMS to demonstrate a REC device meets the emissions limits and reductions within the NRMM RAS standard is a potential option. Where PEMS tests are chosen as the method of demonstrating REC device performance then the PEMS equipment and techniques as included in the EU regulation 2017/655 shall apply. For gaseous PEMS measurements Regulation (EU) 2017/655 identifies the necessary equipment requirements (refers to specifications in Regulation (EU) 2017/654).

5.6.2 Measurement methods for particulate matter and particle number (PM/PN)

5.6.2.1 For engine dynamometer tests (Option 1)

Equipment referenced in UN ECE Regulation 96 (including exhaust emissions sampling and analytical systems) is required for emissions measurements, where appropriate. All instrumentation shall be traceable to national standards.

Particulate matter will be measured gravimetrically using fluorocarbon-coated glass fibre filters by weighing the filters before and after testing. Filters will be conditioned to temperature and humidity conditions as specified by UN ECE R96.

Particle number upwards of 23nm is to be measured and reported (with and without filter) using a particle counter.

Where open crankcase ventilation systems are used on engines then emissions shall be included where Stage V equivalence is required.

5.6.2.2 For in-situ machinery tests

Using PEMS (Option 2)

Particulate Matter mass measurements (PM) using PEMS are very difficult to conduct and not currently viable therefore Particle Number measurements shall be used as a basis for determining compliance with PM limits. Where an applicant holds Swiss FOEN/VERT approval for their REC devices this can be used as evidence of PM emission reduction performance at the discretion of the certification body.

6. Emissions requirements

Applicants for approval of exhaust emissions abatement systems under the NRMM Retrofit Programme must provide evidence that the product meets the emissions standards specified below.

6.1 Primary emissions criteria

6.1.1 Particulate matter (PM) and Particle Number (PN)

When fitted, the emissions abatement system must achieve a value less than 0.015 g/kWh and a minimum reduction of 95% in the weighted engine-out brake-specific PM mass emissions, as determined in accordance with ISO 8178-1, using the C1 test cycle for variable speed engines or D2 test cycle for constant speed engines as defined in ISO 8178-4.

When fitted, the emissions abatement system must achieve a value for particle number of less than 1×10^{12} per kWh.

The maximum permitted exhaust opacity with the after-treatment system fitted is 0.12 m^{-1} measured over the C1 8 mode or D2 5 mode test cycles defined in ISO 8178-4, using the test protocol in ISO 8178-3, sub-section 4.

6.1.2 Oxides of nitrogen (NO_x)

When fitted, the emissions abatement system shall achieve a value less than 0.4g/kWh and a minimum reduction of 90% in the weighted engine-out brake-specific NO_x mass emissions, as determined in accordance with ISO 8178-1, using the C1 test cycle defined in ISO 8178-4.

6.1.3 Nitrogen dioxide (NO₂)

When fitted, the emissions abatement system shall achieve a value less than 0.08g/kWh.

6.2 Secondary emissions criteria

Further to achieving the limits for PM and NO_x, REC devices must not exceed a set of secondary emissions limits. The objective of these secondary limits is to ensure, as far as possible, that there are no adverse environmental effects caused by a REC device whilst achieving its primary aims of NO_x and PM reduction. The Energy Saving Trust devised these limits through benchmarking against other schemes. All of the following limits relate to the test protocol

specified by the Energy Saving Trust which is based on ISO 8178 -1, using C1 or D2 test cycles defined in ISO 8178-4. Regulated gaseous pollutants must not increase through the fitment of emissions reduction equipment, within the precision of the test as defined in ISO 8178 -1.

6.2.1 Carbon dioxide (CO₂)

Any emissions abatement system must not increase emissions of CO₂ by more than 4% in comparison to the baseline engine. An assessment of the increase in CO₂ gas emissions can be made directly from the routine measurement of this parameter, or assessed by reference to the change in weighted brake specific fuel consumption determined over the ISO 8178-4 C1 test cycle.

6.2.2 Nitrous oxide (N₂O) and methane (CH₄) as CO₂ equivalent (CO₂e)

Any emissions abatement system must not increase emissions of CO₂e by more than 5% of the total CO₂emissions. Nitrous oxide and methane shall be measured and converted using the following equation to calculate CO₂e:

$$\text{CO}_2\text{e} = (298 * \text{N}_2\text{O}) + (25*\text{CH}_4)$$

where CO₂e is defined as carbon dioxide equivalence and are the 100-year time horizon Global Warming Potential (GWP) values, as derived from greenhouse gas emissions studies conducted by Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report 2007 (IPCC AR4). This is consistent with reporting under the United Nations Framework Convention on Climate Change (UNFCCC) under which the UK GHG inventory is currently reported. Although the IPCC has issued a more recent assessment (IPCC AR5) with values of 265 for N₂O and 28 for CH₄, these have not been officially accepted for use under UNFCCC reporting.

Carbon dioxide equivalence levels must be calculated from N₂O and CH₄ emissions recorded during tests of the engine or machine fitted with the low emissions adaptation. The value of CO₂e calculated using equation above must not constitute more than 5% of the total carbon dioxide emissions recorded during the vehicle tests.

Note: Measurement of Nitrous oxide (N₂O) is currently not possible with existing PEMS technology. Other evidence will be considered on N₂O and CO₂e determination where applicable.

6.2.3 Ammonia (NH₃)

Ammonia tailpipe emissions of the machine fitted with the low emissions adaptation are limited to a mean concentration of 10 parts per million (ppm) with a peak value of 25ppm during the testing. This is in accordance with UN ECE Regulation 96.

6.2.4 Additional Pollutants

The Energy Saving Trust reserves the right to require the performance of additional analysis on equipment if there is reason to believe that an emissions abatement system may increase the emissions of other pollutants, not included in this document, beyond reasonable levels (to be determined at the discretion of the Energy Saving Trust). This decision may be taken as a result of findings in scientific literature, field experience, conformity testing, or if a particular emissions reduction system relies upon the use of any additives or other catalytic media that may cause concern. This additional analysis may include but is not limited to such pollutants as 1,3-butadiene, Formaldehyde, Acetaldehyde, Dioxins and Furans. The Energy Saving Trust has the right to refuse approval of the equipment if any additional pollutant is found to cause an increase beyond reasonable levels, to be judged by the Energy Saving Trust.

6.3 Emissions limits

The following emissions limits and reduction shall be applied.

For PM only emissions abatement systems (REC Class I) on variable and constant speed engines (e.g. Generators)

Exhaust emission parameter		Maximum permitted limit	Reduction performance
Primary emissions			
Particulate matter (PM)	PM	0.015 g/kWh	>97%
Number of particles (PN)	PN	1×10^{12} /kWh	
Secondary emissions			
Nitrogen dioxide	NO ₂	No increase	
Nitrous oxide/methane	N ₂ O/CH ₄ (as CO ₂ e)	< 5% of CO ₂	
Carbon dioxide	CO ₂	< 4% increase	

For NOx only emissions abatement systems (REC Class III) on variable and constant speed engines (e.g. Generators)

Exhaust emission parameter		Maximum permitted limit	Reduction performance
Primary emissions			
Mixed oxides of nitrogen	NOx	0.400 g/kWh	>90%
Nitrogen dioxide	NO ₂	0.080 g/kWh	
Secondary emissions			
Nitrous oxide/methane	N ₂ O/CH ₄ (as CO ₂ e)	< 5% of CO ₂	
Carbon dioxide	CO ₂	< 4% increase	
Ammonia	NH ₃	10ppm average	

In service Mixed oxides of nitrogen	NOx	25ppm peak	> 90% 24 hr average
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Note : For PEMS test for gaseous emissions in lieu of the NRTC. Therefore, the engine coolant must be cold (i.e. at ambient temperature) at the start of the test and the NRMM must be operated transiently while performing loaded work. The 90th percentile conformity factor based upon all working events and valid windows shall not exceed a value of 2.

For PM and NOx emissions abatement systems (REC Class IV) on variable and constant speed engines (e.g. Generators)

Exhaust emission parameter		Maximum permitted limit	Reduction performance
Primary emissions			
Mixed oxides of nitrogen	NOx	0.400 g/kWh	>90%
Nitrogen dioxide	NO ₂	0.080 g/kWh	
Particulate matter (PM)	PM	0.015 g/kWh	
Number of particles (PN)	PN	1 x 10 ¹² /kWh	
Secondary emissions			
Nitrous oxide/methane	N ₂ O/CH ₄ (as CO ₂ e)	< 5% of CO ₂	>97%
Carbon dioxide	CO ₂	< 4% increase	
Ammonia	NH ₃	10ppm average 25ppm peak	
In service			
Mixed oxides of nitrogen	NOx		> 90% 24 hr average

Note: Definitions of REC devices taken from UN ECE Regulation 132 that will be used to differentiate scope of application with EST NRMM RAS approved device list.

Note : For PEMS test for gaseous emissions, in lieu of the NRTC. Therefore, the engine coolant must be cold (i.e. at ambient temperature) at the start of the test and the NRMM must be operated transiently while performing loaded work. The 90th percentile conformity factor based upon all working events and valid windows shall not exceed a value of 2.

6.4 Emissions Certificate Requirements

Where engine dynamometer approval testing is chosen by the NRMM-RAS applicant, it shall only be carried out by an exhaust emissions testing agency that is acceptable to the Type Approval Authority of an EU Member State. Evidence of current test laboratory accreditation must be provided. An emission test certificate must be generated at the time of the testing that has been formally approved and issued by the test laboratory. Where approval tests are

conducted by the PEMS option then the NRMM-RAS applicant shall use a reputable PEMS testing provider using PEMS equipment and techniques as included in the EU regulation 2017/654 and 2017/655.

The information required is:

6.4.1 Test details:

6.4.1.1 name and address of test laboratory and details of its accreditation or PEMS test provider

6.4.1.2 name and signature of authorised personnel conducting the test

6.4.1.3 name and signature of witness(es), if applicable

6.4.1.4 date of test

6.4.1.5 fuel composition

6.4.1.6 test cycle

6.4.2 Engine details comprising:

6.4.2.1 make, type, family designation

6.4.2.2 model

6.4.2.3 rating

6.4.2.4 identification number

6.4.2.5 type approval number

6.4.2.6 production year and month

6.4.2.7 number of cylinders and swept volume

6.4.2.8 rated power and speed, maximum torque

6.4.2.9 ECU information

6.4.3 Emission abatement system description comprising:

6.4.3.1 after-treatment system type

6.4.3.2 after-treatment system brand/trade name

6.4.3.3 part number or other identification that verifies the specification

6.4.3.4 inspection report confirming acceptable condition for testing and any mandatory installation requirements (e.g. maximum distance of system catalysts from exhaust manifold)

6.4.4 Non road mobile machinery information

6.4.4.1 Non-road mobile machinery owner

6.4.4.2 Category(ies) of non-road mobile machinery

6.4.4.3 Non-road mobile machinery manufacturer

6.4.4.4 Non-road mobile machinery identification number

6.4.4.5 Non-road mobile machinery registration number and country of registration (if available)

6.4.4.6 Non-road mobile machinery commercial name(s) (if applicable)

6.4.4.7 Non-road mobile machinery production year and month

In determining the scope of any approval, the Energy Saving Trust may request additional data from the applicant to accompany an application, such as the intended application drive/duty cycle (which may require typical in-service data such as exhaust temperature profiles).

The applicant shall be responsible for collecting and providing, at its own cost, any such data and information as the Energy Saving Trust may reasonably require.

7. Installation standards

The Approved Product(s) shall be installed in accordance with industry best practice and machinery shall comply with the Provision and Use of Workplace Equipment Regulations 1998 (PUWER) after fitment of the emissions abatement system. A record of this verification shall be transmitted to the customer so that it may be used to demonstrate machine compliance post-modification.

Details of the PUWER can be found via the following links

<http://www.hse.gov.uk/work-equipment-machinery/puwer.htm>

<http://www.legislation.gov.uk/uksi/1998/2306/contents/made>

Approved Product(s) shall comply with CE standards relevant to the exhaust system covering areas such as noise, visibility and ensuring the machine operator is not exposed to excessive exhaust gas. Any electronic components shall comply with relevant CE marking requirements. The manufacturer of the REC device shall issue to the machine owner a declaration of conformity with the above requirements and shall advise and provide the machinery owner or operator a list of points from Annex I of the Machinery Directive which may be affected by the retrofit emission control system. Also, equipment and any associated component(s) fitted to construction equipment shall be designed and manufactured to be reliable and durable for their normal operational life. Fitment shall ensure high standards of workmanship such that the installation is safe and able to operate effectively during all anticipated modes of operation and normal ranges of ambient conditions. Inspection of installed emissions abatement equipment shall take place as part of production conformity tests.

Failure by a Company to comply with the above requirements, and/or the discovery of evidence that equipment does not meet required conformity of production standards may lead to disciplinary action being taken by the Energy Saving Trust. This may include the withdrawal of Approved Product(s) or Eligible Company status.

8. Emissions conformity testing programme

As part of the NRMM Retrofit Programme, the Energy Saving Trust reserves the right to conduct Emissions Conformity Testing (ECT). Checks shall be carried out to verify whether certified emissions abatement systems continue to match the specification and performance for which approval was originally awarded, both in production and in service, in the following respects:

- 8.1** specification and installation, including type, location and layout of components.
- 8.2** exhaust emissions
- 8.3** compliance with industry standards/codes of practice where appropriate.

Evidence of emissions failures, poor quality installations, missing/removed equipment, absence of warranty cover, or substantiated un-rectified, repeated or serious complaints may lead to suspension or termination of Eligible Company and/or Approved Product status.

9. Other technical requirements

- 9.1.** The REC device fitted must process engine exhaust gases at all times when the NRMM to which it is fitted is in operation. Specifically, where the REC uses exhaust filtration as a means of particulate reduction the entire exhaust aerosol must be filtered under all operating conditions. In addition, where exhaust gases are treated with a reagent, additive, catalyst or other device, technique or method to reduce tailpipe NOx emissions, the entire exhaust gas volume must be so treated when the vehicle to which the REC device(s) is fitted is in operation. No circumstance likely to result in emission of exhaust gas without the required tailpipe exhaust emission reduction will be accepted.
- 9.2.** Where a reagent, additive, catalyst or other device, technique or method to control tailpipe NOx emissions, including the injection of urea ($\text{CO}(\text{NH}_2)_2$) constitutes part of the REC device, this system must have the capability to function satisfactorily at low ambient temperatures, in accordance with the requirements of UN ECE 96, 04 series in case of Stages IIIB/IV, 05 series in case of Stage V regulations.
- 9.3.** If liquid reagent containers are installed on or connected to a non-road mobile machine, means for taking a sample of the reagent inside the containers shall be included. The sampling point shall be easily accessible without requiring the use of any specialised tool or device.
- 9.4.** If required by the approved certification body, the applicant shall submit evidence that fitment of the REC device will not adversely affect the machine's noise level in service. At the discretion of the certification body this evidence may not be required where the following applies
- Original emission control device substrates are replaced with larger substrates and no silencer or muffler is removed
 - Additional REC device substrates are fitted and no silencer or muffler is removed
 - The complete volume of the REC device is higher than the complete volume of the OE exhaust system
- 9.5.** If the REC device includes any electronic units and/or control units, these must comply with the provisions of the EMC Directive (72/245/EEC as amended) or UN ECE Regulation No.10.
- 9.6.** It is a requirement that any software, computer program or other electronic control system for the REC device must not constitute a 'defeat device' i.e. must not so affect engine/NRMM operation during the emissions testing as to meet the Technical Requirements while permitting a different higher emissions mode of operation when not under test and in use on site.
- 9.7.** The requirement not to incorporate any kind of defeat device also extends to the selection of any subassembly piece part or element of the low emission adaptation(s)

including catalyst(s) reagents fuel additives or injection systems which might be beneficially employed for the purposes of meeting the Technical Requirements during emissions testing. In-service equipment comprising the REC device shall be the same as employed during emissions testing.

- 9.8.** All NRMM fitted with REC devices may be subject to in-service testing and market surveillance to ensure that emission reduction performance continues to meet the Technical Requirements during normal usage patterns after completion of emissions testing.
- 9.9.** All NRMM fitted with REC devices for the reduction of NOx (e.g. Selective Catalytic Reduction systems) shall ensure performance is maintained in day to day operation. NRMM RAS Approved Products shall include either robust OBD equivalent to original equipment manufacturer (OEM) requirements or have the capability to provide information about the satisfactory operation of the NOx control system by datalogging capability and remote monitoring capability (i.e. telemetry) to permit performance observation and monitoring by the operator or an approved monitoring body. Where required in the absence of robust OBD fitted, datalogging and telematics systems shall report the performance parameters listed in Table 1 below, in real time, for each NRMM equipped with REC devices. Telematic data reports shall be made available to an internet web-based interface accessible to the approved certification body. Daily average data shall be preserved and held for 12 months to permit REC device performance history reporting. Table 1 below shows the minimum acceptable level of reporting. Coloured dot indications (“Traffic-light” columns) shall be used to emphasise system performance pass/fail criteria.

Table 1. Telematic reporting requirements for NOx tailpipe emissions

NRMM Unique ref.	24h Ave. NOx Redn * g/kWh	Live NOx Redn. (%)	Live Tailpipe NOx (ppm)	Urea level ●/●	Tailpipe NOx below ppm ●/●	DPF backpressure below 20 KPa ●/●
ABCXYZ	0.5	98	20	●	●	●

*modelled using molar mass of 46 g/mol for NOx

10. Swiss FOEN (and VERT Association) approvals

The Energy Saving Trust will, at its discretion, accept Swiss Federal Office for the Environment and Nature certification and VERT Association approvals for emissions abatement systems (either PM reduction or NOx reduction) as a means of verification that the relevant technical requirements of the NRMM Retrofit Programme have been met. Evidence must be provided confirming that inclusion on the FOEN Filter List and meeting the requirements of the Swiss Federal Ordinance on Air Pollution Control (OAPC) is current and covers the specific product(s) for which NRMM Retrofit Programme approval is being sought. Full VERT reports must always be submitted as evidence.

11. UN ECE Regulation 132 approvals

The Energy Saving Trust will, at its discretion, accept approvals obtained using UN ECE Regulation 132 - Uniform provisions concerning the approval of Retrofit Emission Control devices (REC) for heavy duty vehicles, agricultural and forestry tractors and non-road mobile machinery equipped with compression ignition engines.

12. In-service durability

The manufacturer of the low emission adaptation(s) shall supply an in-service warranty (to cover both technical performance & function and quality of manufacture & installation) valid for **at least two years** to provide **full cover for parts, labour and on-site support costs**.

An Eligible Company shall provide the comprehensive parts and labour warranty for NRMM Approved Products and comply with one or more of the following requirements:

- a. a recognised Original Equipment Manufacturer or client (or one that warrants the whole machine) must provide a warranty for a minimum of two years from the date of delivery of the machine to the customer.
- b. a company that manufactures or supplies low emission adaptation(s) to third-party installers must provide a warranty in respect of the after-treatment system for a minimum of two years from the date of delivery of the modified machine to the customer.
- c. a company that fits low emission adaptation(s) to, or modifies, existing machines itself, must provide a warranty for the after-treatment system for a minimum of two years from the date of delivery of the machine to the customer.

13. Conformity of production

- 13.1** The manufacturers of all approved low emission adaptations will be assessed for suitable conformity of production procedures and will additionally be subject to the EST CVRAS/NRMM Company Audit Process.
- 13.2** Every low emission adaptation granted a component approval under the NRMM Scheme shall be so manufactured as to conform to the specification(s) identified in the approval documentation.
- 13.3** A control plan will be agreed with the manufacturer at the time of application for NRMM Scheme approval. An Initial review of the control plans will be conducted during the first 6 months' production. Ongoing assessments will then be based on projected annual production (but at least once per year). The manufacturer shall submit annual sales data to the certification body as required. Where deemed necessary, these reviews may include witnessed tests.
- 13.4** A control plan is the documented description of those procedures checks or assigned activities necessary to verify that production units continue to conform to approval requirements with regard to specification, marking and performance. This could consist of information on activities such as product specification sign-off procedures, in-process controls during manufacture and product testing and inspection.
- 13.5** Product conformity may also be verified via inspection on site and any apparent non-conformity may be followed up by factory visits to verify the manufacturer's quality systems/procedures.
- 13.6** Any non-conformity could result in withdrawal of the approval.
- 13.7** The costs and expenses related to conformity of production verification will be borne by the low emission adaptation manufacturer.

14. Control of sub-contractors

The applicant shall ensure that all employees, agents or sub-contractors carrying out activities on its behalf are made aware of and comply with the requirements set out in this document. The applicant shall be aware that it is ultimately responsible for non-conformity of any employee, agent or sub-contractor, howsoever caused, and shall therefore take appropriate steps to ensure accountability in all such relationships. The applicant shall:

- a. specify whether it uses or intends to use sub-contractors or third parties as part of the installation process.
- b. provide full details of these organisations and of the aspects of the installation process for which they will be responsible.

describe the inspection process in place to monitor and evaluate all work undertaken by any and all sub-contractors and/or third parties.

15. Information Required from Low Emission Adaptation Manufacturer

15.1 Before approval

Upon application for approval, the manufacturer of a low emission adaptation shall submit a completed NRMM Product Application Form together with all necessary drawings and any other technical data, including but not limited to photographs, schematic drawings, parts lists needed to fully describe the specification of (and technology used for) the adaptation.

15.2 After Approval

The manufacturer shall provide every new retrofit low emission adaptation with an installation and maintenance manual, a copy of the guarantee/warranty statement and a copy of the Machinery Certificate of Compliance/Installation record.

15.2.1 Every low emission adaptation shall be indelibly marked with at least the following information:

15.2.1.1 Manufacturer's name

15.2.1.2 NRMM product approval number

15.2.1.3 Part number/type identification of the adaptation

15.2.1.4 Adaptation serial number

15.2.2. The installation manual shall contain at least the following information:

15.2.2.1 The name or trademark of the manufacturer of the low emission adaptation

15.2.2.2 The type of low emission adaptation

15.2.2.3 The engine/vehicle types for which the low emission adaptation has been approved

15.2.2.4 Adequate information for a suitably qualified person to install the low emission adaptation on the NRMM correctly in line with any restrictions or other criteria identified in the NRMM Product approval documentation

15.2.2.5 The location on the low emission adaptation where, after installation of the system on the vehicle, the identifying part

number and NRMM approval number must be located (when the original marking is not visible).

15.2.3 An Installation/Warranty record shall be provided to the NRMM plant owner/operator, which identifies the:

- 15.2.3.1** Unique machinery/equipment reference mark
- 15.2.3.2** Vehicle VIN/chassis or machine serial number
- 15.2.3.3** Machinery make and model
- 15.2.3.4** Engine type
- 15.2.3.5** Engine base approval level (e.g. Stage IIIA, etc.)
- 15.2.3.6** Engine capacity/displacement
- 15.2.3.7** Engine maximum power
- 15.2.3.8** Adaptation details (type code, part and serial numbers)
- 15.2.3.9** Resultant Stage level (for Particulate Matter and NOx levels) with approved adaptation fitted (e.g. Stage IIIB, IV or V)
- 15.2.3.10** Installer contact details (name, company, address, telephone number)
- 15.2.3.11** Installation date

16. Certification fees

Certification fees are set out below.

	Cost
Company approval fee (renewed annually)	£2,500
Initial product approval (per device type) fee	£1,000
Product renewal fee (renewed annually)	£750

Renewal fees are due annually on the anniversary of the initial approval.

The issue of NRMM RAS Approved Product certificates will take place 20 working days from receipt of a complete and fully supported product application.

17. Issue of certificates

17.1 Certificates of company and product approval

At the time of approval, the Energy Saving Trust shall issue certificates for

- NRMM company approval
- NRMM product approval

to confirm conformity with the NRMM RAS rules. These certificates shall remain the property of the Energy Saving Trust and may be withdrawn by the Energy Saving Trust (e.g. as a result of disciplinary action arising from conformity testing).

17.2 Machinery Certificate of Compliance

An Eligible Company shall issue a Machinery Certificate of Compliance with each fitment of an approved retrofit emissions abatement system to the machinery owner. The Eligible Company shall keep a record of all installations on the Energy Saving Trust issued NRMM Retrofit Installation Log and supply a copy of this log to Energy Saving Trust on a regular basis.

A machine with a Certificate of Compliance will continue to be eligible to operate on sites providing the abatement equipment service requirements are adhered to. The certificate shall remain in force even where the technical standards of the scheme are subsequently changed.

NRMM should be subject to site registration and inspection, where this is implemented by local authority. NRMM that is claimed to have been retrofitted with EST NRMM RAS approved product and it is subsequently found not to be the case will be removed from any database or listing.