

Clean Air Zone (CAZ) - Clean Vehicle Retrofit Accreditation Scheme (CVRAS)

Technical requirements for approval of low emission adaptations

CVRAS (Adaptations) Technical Requirements

1. Scope

- 1.1. CVRAS (Adaptations) technical requirements (the Technical Requirements) are applicable to low emission adaptations for application to vehicles in order to comply with the provisions of the Joint Air Quality Unit (JAQU) Scheme Order to implement UK Clean Air Zones (CAZ). JAQU is a body comprised of UK government staff from the Department for Transport (DfT) and the Department for the Environment, Food and Rural Affairs (Defra), set up to improve UK air quality and specifically to focus on reduction in NO₂ emissions nationally.
- 1.2. A low emission adaptation is a device, system or modification which reduces exhaust tailpipe emissions to enable a vehicle/engine to meet the technical performance requirements specified in this document.
- 1.3. The Technical Requirements specified apply only to the retrofitting of low emission adaptations to existing vehicles/engines certified to ECE R49 (Euro II) and/or ESC/ELR (Euro III, Euro IV and Euro V) heavy duty emission standards and already meeting Euro II, III, IV or V performance requirements, or certified to ECE R83 Light duty emission standards and already meeting Euro 2, 3, 4 or 5 performance requirements. For avoidance of doubt, the performance requirements specified in this document apply only to commercial vehicles of greater than 3.5 tonnes gross weight and/or to passenger vehicles with more than 8 seats. Nothing in the technical requirements specified in this document precludes the use of hybrid vehicles 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.

2 Test Requirements

- 2.1 Under the provisions of the CAZ Scheme Order, exhaust emission measurements are performed using a vehicle driven to follow the test cycle specified by an approved certification body. Discussions between those seeking to achieve certification under the CAZ Scheme Order and the approved certification body must take place and an agreed test protocol be established in writing before test work is carried out.

These discussions constitute so-called “Worst-case Discussions”. Where a candidate company or other organisation elects to execute test work or to measure exhaust emission reductions with a power-train modification, after-treatment device or other system which is proposed for technical approval under the CAZ Scheme Order without holding Worst-case Discussions and agreeing a suitable test protocol, the approved certification body shall be under no obligation to accept such test data. EST reserves the right to ignore or reject any and all test data not obtained under an agreed Worst-case Discussion arrangement.

Different types and classifications of vehicles must be employed for the exhaust emissions test work to reflect the use and duties of vehicles within the CAZ. Selection of the type(s) of vehicle(s) to be tested constitutes an important part of Worst-

case Discussions. When certification of the CAZ Low Emissions Adaptation is desired to cover its application to more than one engine/vehicle type, one or more 'Worst-case' engines/vehicles will be selected for the test programme to enable the successful results to cover certification for a range of engines/vehicles. Vehicle classifications include but may not be limited to:

- 2.1.1 Large passenger carrying vehicles, for example but not necessarily limited to, coaches. For the purposes of the Technical Requirements a coach is defined as a heavy duty passenger vehicle with more than 8 seats operating to a journey plan whose origin may be located outside CAZ boundaries but whose destination lies within CAZ boundaries and which is not constrained to make scheduled stops to pick up or set down passengers as part of its journey plan
- 2.1.2 refuse collection vehicles and other specialised heavy duty commercial vehicles predominantly operating in densely-populated areas within the CAZ
- 2.1.3 heavy duty commercial vehicles employed for general haulage delivery and service duties within the CAZ
- 2.1.4 vehicles whose principal use is off-road, for example, mobile cranes. The main power unit of such vehicles is used for on-road propulsion; where an auxiliary power unit is employed in off-road applications the auxiliary power unit may be regulated in respect of exhaust emissions by different specifications.

JACU further reserves the right to extend the scope and application of the Technical Requirements to additional vehicle classifications as appropriate to the need to improve air quality within the CAZ through regulation of exhaust emissions from mobile sources.

Appropriate test vehicle(s) selected in Worst-case Discussions must meet emissions limits determined using the appropriate test cycle to demonstrate compliance with the Technical Requirements. Examples of acceptable test cycles employed to demonstrate the performance of vehicles fitted with low emission adaptations are given in a control document defining test procedures for measuring pollutant and greenhouse gas emissions of conventionally-powered (pre-Euro VI/6 diesel) vehicles equipped with retrofitted equipment (intended to meet or exceed Euro VI/6 in-service performance) on chassis dynamometers (CAZ CVRAS Chassis Dynamometer Test Procedures for Approval of Low Emission Adaptations v4.0 dated 02 Aug 2017)

- 2.2 A minimum of four emissions tests, one recording engine-out emissions, and three measuring tailpipe emissions shall be conducted using the vehicle(s) fitted with the low emission adaptation(s). Tests shall be executed using the appropriate test cycle agreed in Worst-case Discussions and defined in the Test Procedure Document. Data from the three tailpipe emissions tests shall be averaged to yield a mean result. If CO₂ tailpipe emissions recorded for any test vary by more than plus or minus 1% from the mean of the three tests, the outlying test results shall be rejected, and at

least one further emissions test shall be carried out to establish a recalculated mean value.

- 2.3 The low emission adaptation(s) fitted must control both particulate and gaseous emissions in the vehicle exhaust by whatever means is selected by the adaptation supplier. Emission limits to be attained by the adapted vehicle shall be as shown in the CAZ CVRAS Chassis Dynamometer Test Procedures for Approval of Low Emission Adaptations v4.0 dated 02 Aug 2017 document.
- 2.4 Where appropriate test equipment is available, particle number measurement shall be undertaken as part of the emissions testing. The measurement method shall be compatible with UN ECE regulation 83 (PnP method).
- 2.5 In order to enable satisfactory emissions testing with the vehicle(s) selected following conclusion of the Worst-case Discussions, suitable set-up coefficients must be determined correctly for any chassis dynamometer testing. Details of the procedures for dynamometer testing can be found in the Test Procedure Document. The cost of obtaining suitable dynamometer set-up coefficients shall be borne by the supplier of the low emission adaptation(s) to be assessed.
- 2.6 If the supplier of the low emission adaptation(s) desires to include vehicle(s) combining electric propulsion in combination with power derived from an internal combustion engine (hybrid(s)), among the selected test vehicle(s), emissions testing of the hybrid(s) shall be adapted as agreed during Worst-case Discussions. Hybrid vehicles shall be subjected to additional tests to include the transition from purely electric propulsion to driving under internal combustion power, thereby ensuring that any exhaust emissions generated during the start-up phase of the internal combustion engine are captured by emissions measuring equipment during the test.

3 Test fuel

- 3.1 Commercially available fuel is acceptable as an alternative to the regulated reference fuels (i.e. if diesel, fuel should meet the specifications of Directive 98/70/EC – BS EN 590). When vehicle(s) are prepared for emissions testing, a fuel sample of at least one litre shall be taken from each vehicle prior to test to permit necessary analysis to be carried out. If fuel contains bio-components (for example, but not necessarily limited to, rapeseed methyl ester) it must meet the specifications of EN 14214 to permit its use for emissions testing.
- 3.2 Manufacturers of low emission adaptations must also declare any special fuel/fuel additive requirements and/or exhaust reagents (for example but not necessarily limited to ‘Ad Blue’, ammonia, etc.) necessary for the correct functioning of the low emission adaptation(s) together with details of the measures taken to ensure the correct in-service operation of the adaptation(s). This requirement applies both to the device or system used to control particulate emissions and to the device or system used to control gaseous emissions.

4 Catalyst De-Greening

- 4.1 It is recognised that low emission adaptations 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.
- 4.2 To ensure that performance tests are only carried out on engines/vehicles which have reached a stable or 'plateau' phase after the completion of catalyst de-greening, vehicles fitted with low emission adaptations and intended for emissions testing must first complete a distance of 1800 road miles (2900 km). The supplier of the low emission adaptation(s) must provide evidence of completion of this pre-test de-greening distance accumulation to approved certification body prior to acceptance for emissions testing of the vehicle fitted with the low emission adaptation.

5 Other Requirements

- 5.1 Where the low emission adaptation(s) involves exhaust after-treatment to meet the performance standards specified in this document, the length of the exhaust pipe between the outlet of the turbocharger and the adaptation system shall be as specified by the manufacturer of the low emission adaptation and shall be declared in the approval documentation. In addition, any modifications to the OE exhaust system necessary to accommodate the low emission adaptation(s) must not invalidate the Road Vehicles (Construction and Use) Regulations 1986, as amended after the adaptation is fitted.
- 5.2 Exhaust back pressure measured with the low emission adaptation(s) fitted shall comply with a limit (peak value) of 20kPa as measured during emissions testing.
- 5.3 Functionality of the original equipment (OE) emission control systems/technology of the vehicle must not be adversely affected by the installation of the low emission adaptation in any operating mode. Specifically, on-board diagnostics (OBD) and the vehicle's capability to impose 'limp-home mode' operation in accordance with the requirements of ECE 595/2009 regulations must continue to function in accordance with OE design specification.
- 5.4 In the case of a low emission adaptation employing one or more additives or reagents, the applicant shall submit evidence that there are no adverse effects from the combination of the additive and/or reagent and the low emission adaptation or any part of the OE of the vehicle fitted with the adaptation.
- 5.5 The low emission adaptation manufacturer shall submit a detailed description and analysis of potential operational modes where circumstances may exist in-service which significantly reduce the effectiveness of the low emission adaptation in controlling exhaust emissions. Any operation likely to result in emission of exhaust gas

without the required pollutant reduction will be taken into account during the emissions test procedure as part of Worst-case Discussions

- 5.6 The low emission adaptation fitted must process engine exhaust gases at all times when the vehicle to which it is fitted is in operation. Specifically, where the low emission adaptation 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 low emission adaptation(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.
- 5.7 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 low emission adaptation, this system must have the capability to function satisfactorily at low ambient temperatures, in accordance with the requirements of ECE 595/2009 regulations.
- 5.8 If required by an approved certification body, the applicant shall submit evidence that fitment of the low emission adaptation will not adversely affect the vehicle's noise level in service.
- 5.9 If the low emission adaptation includes any electronic units and/or control units, these must comply with the provisions of the EMC Directive (72/245/EEC as amended).
- 5.10 It is a requirement that any software, computer program or other electronic control system for the low emission adaptation must not constitute a 'defeat device' ie must not so affect vehicle 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 public roads.
- 5.11 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 low emission adaptation must be the same as employed during emissions testing.
- 5.12 All vehicles fitted with low emission adaptations may be subject to in-service testing and market surveillance to ensure that emission reduction performance continues to meet the CVRAS Technical Requirements during normal usage patterns after completion of emissions testing.
- 5.13 All vehicles fitted with low emission adaptations shall ensure performance is maintained in day-to-day operation. Options to provide this shall be either

5.13.1 the inclusion of robust Onboard Diagnostics (OBD) control equivalent to original

equipment manufacturer (OEM) Euro 6/VI type approval requirements according to UN ECE Regulation 49 as amended with particular reference to Annex 9B Technical Requirements for On-board Diagnostics Systems and Annex 11 Requirements to ensure the correct operation of NOx control measures that limits vehicle operation in a non-compliant mode and includes a two stage driver inducement system starting with a low level inducement (a performance restriction) followed by a severe inducement (effective disablement of vehicle operation).

Or

5.13.2 The capability to provide information about the satisfactory operation of the NOx control system remotely via telematics to permit performance observation and monitoring by the vehicle operator or the approved certification body (or appointed monitoring body).

5.13.3 Where fitted, telematic data shall be reported to an internet web-based interface (portal) accessible to the vehicle owner/operator and the approved certification body. The data shall be shared in real time. This is to allow vehicle operators to assess and monitor the performance of vehicle emissions control system performance. At a minimum, the data listed in Table 1 shall be reported.

Table 1: Real Time Telematics Reporting Requirements for NOx Tailpipe Emissions

Veh. Regn.	24h Ave. NOx Redn * g/km	Live NOx Redn. (%)	Live Tailpipe NOx (ppm)	Urea level ●/●	Tailpipe NOx below 100 ppm ●/●	DPF backpressure below 20 KPa ●/●
HG58 GHR	0.5	98	20	●	●	●

5.13.4 In addition, where fitted, telematics systems shall report the mandatory performance parameters listed in Table 2, for each vehicle equipped with low emission adaptation(s). If available, the supplier shall also record and report the optional performance parameters in Table 3 to aid fault finding for vehicles under-performing.

Table 2: Mandatory CVRAS Approval Telematics Reporting Parameters

Data	Unit	Content	Timing
Vehicle Fleet / Asset number	-	Fleet/Asset Number that is recognised by portal and operators	-
Vehicle Registration Number	-	Registration Plate details	-
Operator	-	Name of Operator vehicle is registered to	-
Depot	-	Location where vehicle is based	-
24hr Avg. NOx Reduction	%	Overall average for previous 24 hours of vehicle usage	B
24hr NOx	g/km	Overall average of g/km NOx for previous 24 hours of vehicle usage	B
24hr Avg. AdBlue consumption	l/km	Overall average for previous 24 hours of vehicle usage	B

AdBlue Level	l	Level of AdBlue in tank at time of reporting	-
24hr Distance	km	Distance travelled in previous 24 hours	A
24hr Distance with telematics	km	Distance travelled in previous 24 hours with active telematics	B

Table 3 - Optional CVRAS Approval Telematics Reporting Parameters

Data	Unit	Content	Timing*
24hr Avg. NOx Reduction at temp	%	Overall average for previous 24 hours of vehicle usage when retrofit NOx reduction device operation conditions are met.	C
24hr Distance Travelled at temp	km	Distance travelled in previous 24 hours when retrofit NOx reduction device operation conditions are met.	C
24hr Avg. Exhaust Pressure	mbar	Average back pressure upstream of retrofit NOx reduction device	B
24hr Avg. Vehicle Speed	km/h	Average vehicle speed for previous 24 hours.	A
24hr Avg. Vehicle Speed at temp	km/h	Average vehicle speed for previous 24 hours when retrofit NOx reduction device operation conditions are met.	C
24hr Total operation time	min	Total time of vehicle usage over previous 24 hours.	A
24hr Total operation time at temp	min	Total time of vehicle usage over previous 24 hours when retrofit NOx reduction device operation conditions are met.	C
Fault codes	-	Fault codes (& description) on vehicle in previous 24 hours	-
Last seen	Date	Date on which vehicle last reported data	-

Note: The term 24 hour period and 24 hour average refers to time period 00:00 to 23:59.

*Refer to the timing chart in Appendix 1 for definitions of the expected duration of measurement.

Note: Where the actual duration of measurement is different due to system limitations, the corresponding requirements for expected performance in section 5.13.6. may be adjusted.

5.13.5 The telematics data listed in section 5.13.4 shall be provided to the approved certification body (or appointed monitoring body) for all vehicles equipped with low emission adaptation(s). This data can be provided on a weekly basis but data provided shall be daily 24 hour data. Daily average data shall be preserved and held for 12 months to permit low emission adaptation performance history reporting. The approved certification body shall advise the approved adaptation supplier the mechanism and data protocol for data exchange. Access to online telematics portals shall also be provided to the approved certification body (or appointed monitoring body).

5.13.6 The approved certification body reserves the right to remove a vehicle from the CVRAS retrofitted vehicle database (also referred to as the 'whitelist') if

reasonable efforts are not made to resolve an under-performing or under-reporting system, where fitted by a CVRAS approved supplier.

System under-reporting is defined as a significant period of time of non-reporting, where vehicle NOx data is not reported by the telematics system; or, where the period of NOx reporting is less than 85% of the total vehicle operational time. The approved certification body (or appointed monitoring body) reserves the right to amend reporting threshold value.

System under-performance is defined as a significant period of time where the 24hr Average NOx reduction % does not achieve 80% or greater. The approved certification body (or appointed monitoring body) reserves the right to amend reporting threshold value.

Where vehicles are driven less than 10km in any 24 hour period, the data will be disregarded for the purposes of vehicle under-reporting or under-performance.

6 In-Service Durability

6.1 The low emission adaptation should be designed and manufactured to have an objective working life as follows:

6.1.1 200,000 km or six years, whichever is the sooner, in the case of engines to be fitted to vehicles of category N₂, N₃ with a maximum technically permissible mass not exceeding 16 tonnes and M₂, or M₃ Class I, Class II and Class A, and Class B with a maximum technically permissible mass not exceeding 7.5 tonnes

6.1.2 500,000 km or seven years, whichever is the sooner, in the case of engines to be fitted to vehicles of category N₃ with a maximum technically permissible mass exceeding 16 tonnes and M₃, Class III and Class B with a maximum technically permissible mass exceeding 7.5 tonnes.

6.1.3 160,000 km or 5 years whichever is the sooner, in the case of systems to be fitted to vehicles of category M₁, or N₁ with a maximum technically permissible mass not exceeding 3.5 tonnes

6.2 The manufacturer of the low emission adaptation(s) must 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.

7 Conformity of Production

7.1 The manufacturers of all approved low emission adaptations will be assessed for suitable conformity of production procedures and will additionally be subject to the CVRAS Company Audit Process.

- 7.2 Every low emission adaptation granted a component approval under the CAZ Scheme must be so manufactured as to conform to the specification(s) identified in the approval documentation.
- 7.3 A control plan will be agreed with the manufacturer at the time of application for CVRAS 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.
- 7.3.1 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
- 7.4 Product conformity may also be verified via inspection at the vehicle's annual CVRAS renewal and any apparent non-conformity may be followed up by factory visits to verify the manufacturer's quality systems/procedures.
- 7.5 Any non-conformity could result in withdrawal of the approval.
- 7.6 The costs and expenses related to conformity of production verification will be borne by the low emission adaptation manufacturer.

8 Information Required from Low Emission Adaptation Manufacturer

8.1 Before approval

- 8.1.1 Upon application for approval, the manufacturer of a low emission adaptation shall submit a completed 'CVRAS (Adaptations) Information Document' together with all necessary drawings and any other technical data, including but not limited to photographs, needed to fully describe the specification of (and technology used for) the adaptation.

8.2 After Approval

- 8.2.1 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 clean vehicle retrofit accreditation scheme installation certificate.
- 8.2.2 Every low emission adaptation shall be indelibly marked with at least the following information:

8.2.2.1 Manufacturer's name

- 8.2.2.2 CVRAS approval number
 - 8.2.2.3 Part number/type identification of the adaptation
 - 8.2.2.4 Adaptation serial number
 - 8.2.2.5 Substrate batch number (if applicable and if not traceable from the information provided in 8.2.2.4).
- 8.2.3 The installation manual shall contain at least the following information:
- 8.2.3.1 The name or trademark of the manufacturer of the low emission adaptation
 - 8.2.3.2 The type of low emission adaptation
 - 8.2.3.3 The engine/vehicle types for which the low emission adaptation has been approved
 - 8.2.3.4 Adequate information for a suitably qualified person to install the low emission adaptation on the vehicle correctly in line with any restrictions or other criteria identified in the CVRAS approval documentation
 - 8.2.3.5 The location on the low emission adaptation where, after installation of the system on the vehicle, the identifying part number and CVRAS approval number must be located (when the original marking is not visible).
- 8.2.4 An Installation/Warranty record shall be provided to the vehicle owner/registered keeper, which identifies the:
- 8.2.4.1 Vehicle Registration Mark
 - 8.2.4.2 Vehicle VIN/chassis number
 - 8.2.4.3 Vehicle make and model
 - 8.2.4.4 Vehicle GVM (kg) and category (N₂, N₃, M₂, M₃)
 - 8.2.4.5 Engine type
 - 8.2.4.6 Engine base approval level (Euro V, etc.)

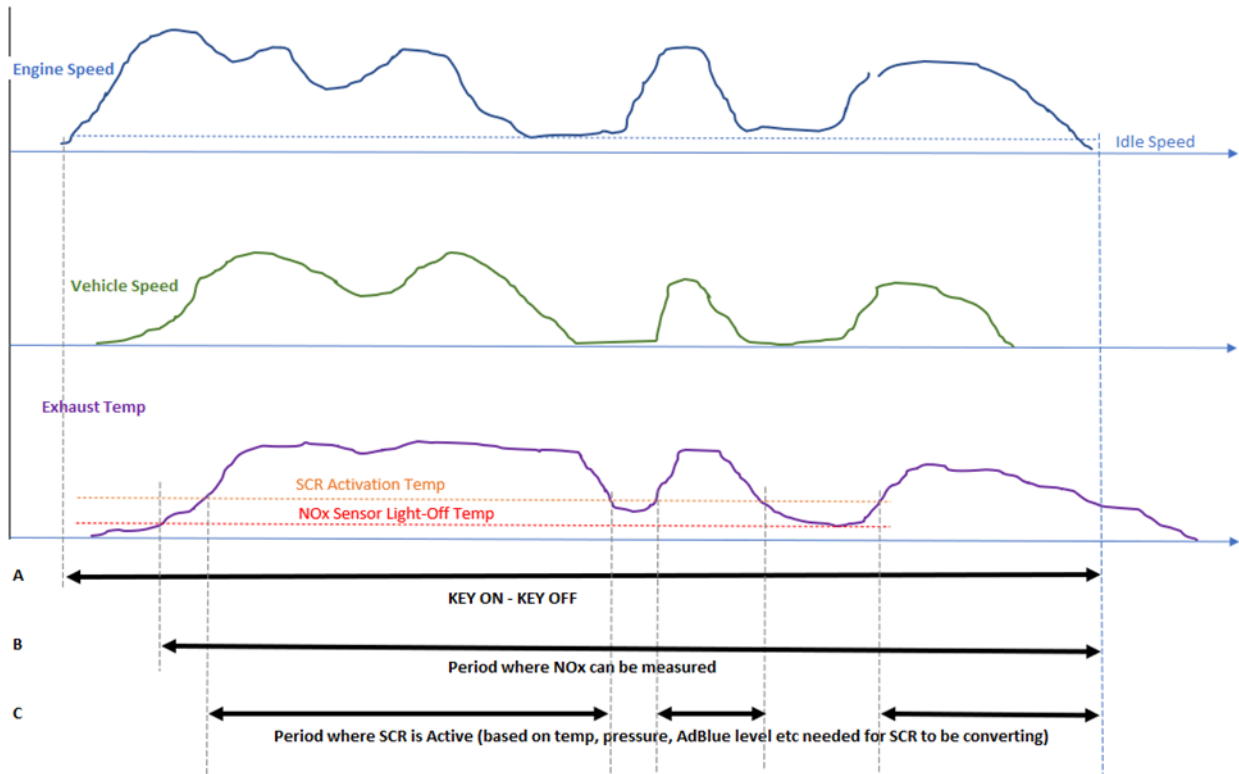
- 8.2.4.7 Engine capacity/displacement
- 8.2.4.8 Engine maximum power
- 8.2.4.9 Adaptation details (type code, part and serial numbers)
- 8.2.4.10 Euro level (particulates and NOx levels) with approved adaptation fitted (Euro VI)
- 8.2.4.11 Installer contact details (name, company, address, telephone number)
- 8.2.4.12 Installation date

9. **Test cycles**

Details of test cycles applicable to vehicles to be submitted for testing under the CVRAS Scheme are given in the CVRAS Chassis Dynamometer Test Procedures for Approval of Low Emission Adaptations v4.0 dated 01 Aug 2017 document.

This document also lists exhaust emissions performance standards to be obtained by vehicles fitted with emissions abatement adaptations and other details of test protocol to be followed.

Appendix 1 – Timing Chart for Telematics Data Measurement



(A) Telematics data with timing period ‘A’ must include the sum (or average) of all key-on to key-off data over the 24 hour period (as shown by ‘A’ in the above timing chart).

‘Key On’ is defined as the point after ignition on when the engine speed reaches 150rpm below the normal, warmed-up idle speed.

‘Key Off’ is defined as the point where the ignition is intentionally switched off.

For vehicles that employ engine shut-off strategies that are commanded by the engine control system (for example bus with engine shut-off at idle) and that are followed by an engine cranking, the (engine shut-off – engine cranking) sequence shall be considered as part of the existing driving cycle.

(B) Telematics data with timing period ‘B’ must include the sum (or average) of all data measured over the 24 hour period, when the exhaust temperature is sufficient for the NOx sensors to operate correctly (‘light-off’). The measurement must not be stopped at periods of idle unless the temperature drops below the acceptable sensor temperature as defined by sensor manufacturer.

(C) Telematics data with timing period ‘C’ must include the sum (or average) of all data measured over the 24 hour period, when the conditions are sufficient for the retrofit NOx reduction device to operate correctly. These may include temperature, pressure, urea level as defined by the system manufacturer.

Note: Where Distance is used as part of a calculation, it shall be taken from the same period as the rest of the calculation e.g. 24hr Avg NOx (g/km) shall take both NOx measurement and Distance measurement over period B.