Council of the
European Union

**Brussels, 21 December 2016**
**(OR. en)**

**15755/16**
**ADD 4**

**ENT 238**
**MI 809**
**ENV 821**
**DELACT 259**

**COVER NOTE**

| | |
|---|---|
| From: | Secretary-General of the European Commission,<br>signed by Mr Jordi AYET PUIGARNAU, Director |
| date of receipt: | 19 December 2016 |
| To: | Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union |
| No. Cion doc.: | C(2016) 8381 final ANNEXES 8 to 17 |
| Subject: | ANNEXES to the Commission Delegated Regulation (EU) .../... supplementing Regulation (EU) 2016/1628 of the European Parliament and of the Council with regard to technical and general requirements relating to emission limits and type-approval for internal combustion engines for non-road mobile machinery |

Delegations will find attached document C(2016) 8381 final ANNEXES 8 to 17.

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Encl.: C(2016) 8381 final ANNEXES 8 to 17

EUROPEAN
COMMISSION

Brussels, 19.12.2016
C(2016) 8381 final

ANNEXES 8 to 17

**ANNEXES**

**to the**

**Commission Delegated Regulation (EU) .../...**

**supplementing Regulation (EU) 2016/1628 of the European Parliament and of the Council with regard to technical and general requirements relating to emission limits and type-approval for internal combustion engines for non-road mobile machinery**

## ANNEX VIII

## Performance requirements and test procedures for dual-fuel engines

1. Scope

This Annex shall apply for dual-fuel engines as defined in Article 3(18) of Regulation (EU) 2016/1628 when they are being operated simultaneously on both a liquid and a gaseous fuel (dual-fuel mode).

This Annex shall not apply for testing engines, including dual-fuel engines, when they are being operated solely on liquid or solely on gaseous fuels (ie when the GER is either 1 or 0 according to the type of fuel). In this case the requirements are the same as for any single-fuel engine.

Type approval of engines operated simultaneously on a combination of more than one liquid fuel and a gaseous fuel or a liquid fuel and more than one gaseous fuel shall follow the procedure for new technologies or new concepts given in Article 33 of Regulation (EU) 2016/1628.

2. Definitions and abbreviations

For the purposes of this Annex the following definitions shall apply:

2.1. "GER (Gas Energy Ratio)" has the meaning defined in Article 3(20) of Regulation (EU) 2016/1628 based on the lower heating value;

2.2. "$GER_{cycle}$" means the average GER when operating the engine on the applicable engine test cycle;

2.3. "Dual-fuel Type 1A engine" means either:

(a) a dual-fuel engine of a sub-category of NRE $19 \leq kW \leq 560$, that operates over the hot-start NRTC test-cycle with an average gas energy ratio that is not lower than 90 % ($GER_{NRTC, hot} \geq 0,9$) and that does not idle using exclusively liquid fuel, and that has no liquid-fuel mode, or;

(b) a dual-fuel engine of any (sub-) category other than a sub-category of NRE $19 \leq kW \leq 560$, that operates over the NRSC with an average gas energy ratio that is not lower than 90 % ($GER_{NRSC} \geq 0,9$) and that does not idle using exclusively liquid fuel, and that has no liquid-fuel mode;

2.4. "Dual-Fuel Type 1B engine" means either:

(a) a dual-fuel engine of a sub-category of NRE $19 \leq kW \leq 560$, that operates over the hot-start NRTC test-cycle with an average gas energy ratio that is not lower than 90 % ($GER_{NRTC, hot} \geq 0,9$) and that does not idle using exclusively liquid fuel in dual-fuel mode, and that has a liquid-fuel mode, or;

(b) a dual-fuel engine of any (sub-) category other than a sub-category of NRE $19 \leq kW \leq 560$, that operates over the NRSC with an average gas energy ratio that is not lower than 90 % ($GER_{NRSC} \geq 0,9$) and that does not idle using exclusively liquid fuel in dual-fuel mode, and that has a liquid-fuel mode;

2.5. "Dual-Fuel Type 2A engine" means either:

(a) a dual-fuel engine of a sub-category of NRE $19 \leq kW \leq 560$, that operates over the hot-start NRTC test-cycle with an average gas energy ratio between 10 % and 90 % ($0,1 < GER_{NRTC, hot} < 0,9$) and that has no liquid-fuel mode or that operates over the hot-start NRTC test-cycle with an average gas energy ratio that is not lower than 90 % ($GER_{NRTC, hot} \geq 0,9$), but that idles using exclusively liquid fuel, and that has no liquid-fuel mode, or;

(b) a dual-fuel engine of any (sub-) category other than a sub-category of NRE $19 \leq kW \leq 560$, that operates over the NRSC with an average gas energy ratio between 10 % and 90 % ($0,1 < GER_{NRSC} < 0,9$), and that has no liquid-fuel mode or that operates over the NRSC with an average gas energy ratio that is not lower than 90 % ($GER_{NRSC} \geq 0,9$), but that idles using exclusively liquid fuel, and that has no liquid-fuel mode;

2.6. "Dual-Fuel Type 2B engine" means either:

(a) a dual-fuel engine of a sub-category of NRE $19 \leq kW \leq 560$, that operates over the hot-start NRTC test-cycle with an average gas energy ratio between 10 % and 90 % ($0,1 < GER_{NRTC, hot} < 0,9$) and that has a liquid-fuel mode or that operates over the hot-start NRTC test-cycle with an average gas energy ratio that is not lower than 90 % ($GER_{NRTC, hot} \geq 0,9$), and that has a liquid-fuel mode but that can idle using exclusively liquid fuel in dual-fuel mode, or;

(b) a dual-fuel engine of any (sub-) category other than a sub-category of NRE $19 \leq kW \leq 560$, that operates over the NRSC with an average gas energy ratio between 10 % and 90 % ($0,1 < GER_{NRSC} < 0,9$), and that has no liquid-fuel mode or that operates over the NRSC with an average gas energy ratio that is not lower than 90 % ($GER_{NRSC} \geq 0,9$), and that has a liquid-fuel mode but that can idle using exclusively liquid fuel in dual-fuel mode;

2.7. "Dual-Fuel Type 3B engine" means either:

(a) a dual-fuel engine of a sub-category of NRE $19 \leq kW \leq 560$, that operates over the hot-start NRTC test-cycle with an average gas energy ratio that does not exceed 10 % ($GER_{NRTC, hot} \leq 0,1$) and that has a liquid-fuel mode, or:

(b) a dual-fuel engine of any (sub-) category other than a sub-category of NRE $19 \leq kW \leq 560$, that operates over the NRSC with an average gas energy ratio that does not exceed 10 % ($GER_{NRSC} \leq 0,1$) and that has a liquid-fuel mode;

3. Dual-fuel specific additional approval requirements

3.1. Engines with operator-adjustable control of $GER_{cycle}$.

In the case for a given engine type the value of $GER_{cycle}$ can be reduced from the maximum by an operator-adjustable control, the minimum $GER_{cycle}$ shall not be limited but the engine shall be capable of meeting the emission limit values at any value of $GER_{cycle}$ permitted by the manufacturer.

4. General requirements

4.1. Operating modes of dual-fuel engines

4.1.1. Conditions for a dual-fuel engine to operate in liquid mode

A dual-fuel engine may only operate in liquid-fuel mode if, when operating in liquid-fuel mode, it has been certified according to all the requirements of this Regulation concerning operation solely on the specified liquid fuel.

When a dual-fuel engine is developed from an already certified liquid-fuel engine, then a new EU type approval certificate is required in the liquid-fuel mode.

4.1.2. Conditions for a dual-fuel engine to idle using liquid fuel exclusively

4.1.2.1. Dual-fuel Type 1A engines shall not idle using liquid fuel exclusively except under the conditions defined in point 4.1.3. for warm-up and start.

4.1.2.2. Dual-fuel Type 1B engines shall not idle using liquid fuel exclusively in dual-fuel mode.

4.1.2.3. Dual-fuel Types 2A, 2B and 3B engines may idle using liquid fuel exclusively.

4.1.3. Conditions for a dual-fuel engine to warm-up or start using liquid fuel solely

4.1.3.1. A Type 1B, Type 2B, or Type 3B dual-fuel engine may warm-up or start using liquid fuel solely. In the case that the emission control strategy during warm-up or start-up in dual-fuel mode is the same as the corresponding emission control strategy in liquid-fuel mode the engine may operate in dual-fuel mode during warm-up or start-up. If this condition is not met the engine shall only warm-up or start-up using liquid fuel solely when in liquid-fuel mode.

4.1.3.2. A Type 1A or Type 2A dual-fuel engine may warm-up or start-up using liquid fuel solely. However, in that case, the strategy shall be declared as an AECS and the following additional requirements shall be met:

4.1.3.2.1. The strategy shall cease to be active when the coolant temperature has reached a temperature of 343 K (70 °C), or within 15 minutes after it has been activated, whichever occurs first; and

4.1.3.2.2. The service mode shall be activated while the strategy is active.

4.2. Service mode

4.2.1. Conditions for dual-fuel engines to operate in service mode

When an engine is operating in service mode it is subject to an operability restriction and is temporarily exempted from complying with the requirements related to exhaust emissions and $NO_x$ control described in this Regulation.

4.2.2. Operability restriction in service mode

4.2.2.1. Requirement for engine categories other than IWP, IWA, RLL and RLR

The operability restriction applicable to non-road mobile machinery fitted with a dual-fuel engine of engine categories other than IWP, IWA, RLL and RLR operated in service mode is the one activated by the "severe inducement system" specified in point 5.4. of Appendix 1 of Annex IV.

In order to account for safety concerns and to allow for self-healing diagnostics, use of an inducement override function for releasing full engine power is permitted according to point 5.5. of Appendix 1 of Annex IV.

The operability restriction shall not otherwise be deactivated by either the activation or deactivation of the warning and inducement systems specified in Annex IV.

The activation and the deactivation of the service mode shall not activate or deactivate the warning and inducement systems specified in Annex IV.

4.2.2.2. Requirement for engine categories IWP, IWA, RLL and RLR

For engines of category IWP, IWA, RLL and RLR, in order to account for safety concerns operation in service mode shall be permitted without limitation on engine torque or speed. In this case whenever an operability restriction would have been active according to point 4.2.2.3. the on-board computer log shall record in non-volatile computer memory all incidents of engine operation where the service mode is active in a manner to ensure that the information cannot be intentionally deleted.

It shall be possible for national inspection authorities to read these records with a scan tool.

4.2.2.3. Activation of the operability restriction

The operability restriction shall be automatically activated when the service mode is activated.

In the case where the service mode is activated according to point 4.2.3. because of a malfunction of the gas supply system, the operability restriction shall become active within 30 minutes operating time after the service mode is activated.

In the case where the service mode is activated because of an empty gaseous fuel tank, the operability restriction shall become active as soon as the service mode is activated.

4.2.2.4. Deactivation of the operability restriction

The operability restriction system shall be deactivated when the engine no longer operates in service mode.

4.2.3. Unavailability of gaseous fuel when operating in a dual-fuel mode

In order to permit the non-road mobile machinery to move to a position of safety, upon detection of an empty gaseous fuel tank, or of a malfunctioning gas supply system:

(a) Dual-fuel engines of Types 1A and 2A shall activate the service mode;

(b) Dual-fuel engines of Types 1B, 2B and 3B shall operate in liquid mode.

4.2.3.1. Unavailability of gaseous fuel – empty gaseous fuel tank

In the case of an empty gaseous fuel tank, the service mode or, as appropriate according to point 4.2.3., the liquid fuel mode shall be activated as soon as the engine system has detected that the tank is empty.

When the gas availability in the tank again reaches the level that justified the activation of the empty tank warning system specified in point 4.3.2., the service mode may be deactivated, or, when appropriate, the dual-fuel mode may be reactivated.

4.2.3.2. Unavailability of gaseous fuel – malfunctioning gas supply

In the case of a malfunctioning gas supply system that causes the unavailability of gaseous fuel, the service mode or, as appropriate according to point 4.2.3., the liquid fuel mode shall be activated when gaseous fuel supply is not available.

As soon as the gaseous fuel supply becomes available the service mode may be deactivated, or, when appropriate, the dual-fuel mode may be reactivated.

4.3. Dual-fuel indicators

4.3.1. Dual-fuel operating mode indicator

The non-road mobile machinery shall provide to the operator a visual indication of the mode under which the engine operates (dual-fuel mode, liquid mode, or service mode).

The characteristics and the location of this indicator shall be left to the discretion of the OEM and may be part of an already existing visual indication system.

This indicator may be completed by a message display. The system used for displaying the messages referred to in this point may be the same as the ones used for $NO_x$ control diagnostics, or other maintenance purposes.

The visual element of the dual-fuel operating mode indicator shall not be the same as the one used for the purpose of $NO_x$ control diagnostics, or for other engine maintenance purposes.

Safety alerts always have display priority over the operating mode indication.

4.3.1.1. The dual-fuel mode indicator shall be set to service mode as soon as the service mode is activated (i.e. before it becomes actually active) and the indication shall remain as long as the service mode is active.

4.3.1.2. The dual-fuel mode indicator shall be set for at least one minute on dual-fuel mode or liquid-fuel mode as soon as the engine operating mode is changed from liquid fuel to dual-fuel mode or vice-versa. This indication is also required for at least one minute at key-on, or at the request of the manufacturer at engine cranking. The indication shall also be given upon the operator's request.

4.3.2. Empty gaseous fuel tank warning system (dual-fuel warning system)

Non-road mobile machinery fitted with a dual-fuel engine shall be equipped with a dual-fuel warning system that alerts the operator that the gaseous fuel tank will soon become empty.

The dual-fuel warning system shall remain active until the tank is refuelled to a level above which the warning system is activated.

The dual-fuel warning system may be temporarily interrupted by other warning signals providing important safety-related messages.

It shall not be possible to turn off the dual-fuel warning system by means of a scan-tool as long as the cause of the warning activation has not been rectified.

4.3.2.1. Characteristics of the dual-fuel warning system

The dual-fuel warning system shall consist of a visual alert system (icon, pictogram, etc.) left to the choice of the manufacturer.

It may include, at the choice of the manufacturer, an audible component. In that case, the cancelling of that component by the operator is permitted.

The visual element of the dual-fuel warning system shall not be the same as the one used for the purpose of $NO_x$ control diagnostics, or for other engine maintenance purposes.

In addition the dual-fuel warning system may display short messages, including messages indicating clearly the remaining distance or time before the activation of the operability restriction.

The system used for displaying the warning or messages referred to in this point may be the same as the one used for displaying the warning or messages related the $NO_x$ control diagnostics, or warning or messages for other maintenance purposes.

A facility to permit the operator to dim the visual alarms provided by the warning system may be provided on non-road mobile machinery for use by the rescue services or on non-road mobile machinery designed and constructed for use by the armed services, civil defense, fire services and forces responsible for maintaining public order.

4.4. Communicated torque

4.4.1. Communicated torque when a dual-fuel engine operates in dual-fuel mode

When a dual-fuel engine operates in dual-fuel mode:

(a) The reference torque curve retrievable shall be the one obtained when that engine is tested on an engine test bench in the dual-fuel mode;

(b) The recorded actual torques (indicated torque and friction torque) shall be the result of the dual-fuel combustion and not the one obtained when operating with liquid fuel exclusively.

4.4.2. Communicated torque when a dual-fuel engine operates in liquid-fuel mode

When a dual-fuel engine operates in liquid-fuel mode, the reference torque curve retrievable shall be the one obtained when the engine is tested on an engine test bench in liquid-fuel mode.

4.5. Additional requirements

4.5.1. Where used for a dual-fuel engine, adaptive strategies shall, in addition to satisfying the requirements of Annex IV, additionally comply with the following requirements:

(a) The engine shall always remain within the dual-fuel engine type (that is Type 1A, Type 2B, etc.) that has been declared for EU type-approval; and

(b) In case of a Type 2 engine, the resulting difference between the highest and the lowest maximum $GER_{cycle}$ within the family shall never exceed the % specified in point 3.1.1., except as permitted by point 3.2.1..

4.6 The type approval shall be conditional upon providing to the OEM and end-users, as required by in accordance with Annexes XIV and XV, instructions for installation and operation of the dual-fuel engine including the service mode set out in point 4.2. and the dual-fuel indicator system set out in point 4.3..

5. Performance requirements

5.1. The performance requirements, including emission limit values, and the requirements for EU type-approval applicable to dual-fuel engines are identical to those of any other engine of the respective engine category as set out in this Regulation and in Regulation (EU) 2016/1628, except as set out in this Annex.

5.2 The hydrocarbon (HC) limit for operation in dual-fuel mode shall be determined using the average gas energy ratio (GER) over the specified test cycle as set out in Annex II to Regulation (EU) 2016/1628.

5.3 The technical requirements on emission control strategies, including documentation required to demonstrate these strategies, technical provisions to resist tampering and the prohibition of defeat devices are identical to those of any other engine of the respective engine category as set out in Annex IV.

5.4 The detailed technical requirements on the area associated with the relevant NRSC, within which there is control of the amount that the emissions shall be permitted to exceed the limit values set out in Annex II to Regulation (EU) 2016/1628 are identical to those of any other engine of the respective engine category as set out in Annex IV.

6. Demonstration requirements

6.1. The demonstration requirements applicable to dual-fuel engines are identical to those of any other engine of the respective engine category as set out in this Regulation and in Regulation (EU) 2016/1628, except as set out in section 6...

6.2. Compliance with the applicable limit values shall be demonstrated in dual-fuel mode.

6.3. For dual-fuel engine types with a liquid-fuel mode (i.e. types 1B, 2B, 3B) compliance with the applicable limit values shall additionally be demonstrated in liquid-fuel mode.

6.4. Additional demonstration requirements in case of a Type 2 engine

6.4.1 The manufacturer shall present the approval authority with evidence showing that the $GER_{cycle}$ span of all members of the dual-fuel engine family remains within the % specified in point 3.1.1., or in the case of engines with an operator-adjustable $GER_{cycle}$ satisfy the requirements of point 6.5. (for example, through algorithms, functional analyses, calculations, simulations, results of previous tests, etc.).

6.5 Additional demonstration requirements in case of an engine with an operator-adjustable $GER_{cycle}$

6.5.1 Compliance with the applicable limit values shall be demonstrated at the minimum and maximum value of $GER_{cycle}$ permitted by the manufacturer.

6.6. Requirements for demonstrating the durability of a dual-fuel engine

6.6.1 Provisions of Annex III shall apply.

6.7. Demonstration of the dual-fuel indicators, warning and operability restriction

6.7.1 As part of the application for EU type-approval under this Regulation, the manufacturer shall demonstrate the operation of dual-fuel indicators and of the warning and operability restriction in accordance with the provisions of Appendix 1.

7. Requirements to ensure the correct operation of $NO_x$ control measures

7.1. Annex IV (technical requirements on $NO_x$ control measures) shall apply to dual-fuel engines, whether operating in dual-fuel or liquid mode.

7.2. Additional $NO_x$ control requirements in case of Type 1B, Type 2B and Type 3B dual-fuel engines

7.2.1. The torque considered to apply to the severe inducement defined in point 5.4. of Appendix 1 of Annex IV shall be the lowest of the torques obtained in liquid-fuel mode and in dual-fuel mode.

7.2.2 A possible influence of the mode of operation on the malfunction detection shall not be used to extend the time until an inducement becomes active.

7.2.3. In the case of malfunctions the detection of which does not depend on the operation mode of the engine, the mechanisms specified in Appendix 1 of Annex IV that are associated with the DTC status shall not depend on the operation mode of the engine (for example, if a DTC reached the potential status in dual-fuel mode, it will get the confirmed and active status the next time the failure is detected, even in liquid-fuel mode).

7.2.4. In the case of malfunctions where the detection depends on the operation mode of the engine, DTCs shall not get a previously active status in a different mode than the mode in which they reached the confirmed and active status.

7.2.5. A change of the mode of operation (dual-fuel to liquid fuel or vice-versa) shall not stop nor reset the mechanisms implemented to comply with the requirements set out in Annex IV (e.g. counters). However, in the case where one of these mechanisms (for example a diagnostic system) depends on the actual operation mode the counter associated with that mechanism may, at the request of the manufacturer and upon approval of the approval authority:

(a) Halt and, when applicable, hold their present value when the operation mode changes;

(b) Restart and, when applicable, continue counting from the point at which they have been held when the operation mode changes backs to the other operation mode.

## Appendix 1

**Dual-fuel engine dual-fuel indicator, warning system, operability restriction - Demonstration requirements**

1. Dual-fuel indicators

1.1. Dual-fuel mode indicator

The ability of the engine to command the activation of the dual-fuel mode indicator when operating in dual-fuel mode shall be demonstrated at EU type-approval.

1.2. Liquid-fuel mode indicator

In the case of a Type 1B, Type 2B, or Type 3B dual-fuel engine the ability of the engine to command the activation of the liquid-fuel mode indicator when operating in liquid-fuel mode shall be demonstrated at EU type-approval.

1.3. Service mode indicator

The ability of the engine to command the activation of the service mode indicator when operating in service mode shall be demonstrated at EU type-approval.

1.3.1. When so-equipped it is sufficient to perform the demonstration related to the service mode indicator by activating a service mode activation switch and to present the approval authority with evidence showing that the activation occurs when the service mode is commanded by the engine system itself (for example, through algorithms, simulations, result of in-house tests, etc. …).

2. Warning system

The ability of the engine to command the activation of the warning system in the case that the amount of gaseous fuel in the gaseous fuel tank is below the warning level, shall be demonstrated at EU type-approval. For that purpose the actual amount of gaseous fuel may be simulated.

3. Operability restriction

In the case of a Type 1A or Type 2A dual-fuel engine the ability of the engine to command the activation of the operability restriction upon detection of an empty gaseous fuel tank and of a malfunctioning gas supply system shall be demonstrated at EU type-approval. For that purpose the empty gaseous fuel tank and the malfunctioning of the gas supply may be simulated.

3.1. It is sufficient to perform the demonstration in a typical use-case selected with the agreement of the approval authority and to present that authority with evidence showing that the operability restriction occurs in the other possible use-cases (for example, through algorithms, simulations, result of in-house tests, etc).

## Appendix 2

## Emission test procedure requirements for dual-fuel engines

1. General

This point defines the additional requirements and exceptions of this Annex to enable emission testing of dual-fuel engines independent whether these emissions are solely exhaust emissions or also crankcase emissions added to the exhaust emissions according to point 6.10. of Annex VI. In the case that no additional requirement or exception is listed, the requirements of this Regulation shall apply to dual-fuel engines in the same way as they apply to any other approved engine types or engine families under Regulation (EU) 2016/1628.

Emission testing of a dual-fuel engine is complicated by the fact that the fuel used by the engine can vary between pure liquid fuel and a combination of mainly gaseous fuel with only a small amount of liquid fuel as an ignition source. The ratio between the fuels used by a dual-fuel engine can also change dynamically depending of the operating condition of the engine. As a result special precautions and restrictions are necessary to enable emission testing of these engines.

2. Test conditions

Section 6. of Annex VI shall apply.

3. Test procedures

Section 7. of Annex VI shall apply.

4. Measurement procedures

Section 8. of Annex VI shall apply except as set out in this Appendix.

A full-flow dilution measurement procedure for dual-fuel engines is illustrated in Figure 6.6. of Annex VI (CVS system).

This measurement procedure ensures that the variation of the fuel composition during the test will mainly influence the hydrocarbon measurement results. This shall be compensated via one of the methods described in point 5.1..

Raw gaseous/partial flow measurement illustrated in Figure 6.7. of Annex VI may be used with some precautions regarding exhaust gas mass flow determination and calculation methods.

5. Measurement equipment

Section 9. of Annex VI shall apply.

6. Particle number emissions measurement

Appendix 1 of Annex VI shall apply.

7. Emission calculation

The emission calculation shall be performed according to Annex VII except as set out in this section. The additional requirements set out in point 7.1. shall apply for mass-based calculations and the additional requirements set out in point 7.2. shall apply for molar-based calculations.

The emission calculation requires knowledge of the composition of the fuels being used. When a gaseous fuel is supplied with a certificate confirming the properties of the fuel (e.g. gas from bottles) it is acceptable to use the composition specified by the supplier. Where the composition is not available (e.g. pipeline fuel) the fuel composition shall be analysed at least prior to and after the engine emission test is conducted. More frequent analysis shall be permitted and the results used in the calculation.

Where the gas energy ratio (GER) is used it shall be consistent with the definition in Article 3(2) of Regulation (EU) 2016/1628 and the specific provisions on total hydrocarbon (HC) limits for fully and partially gaseous-fuelled engines in Annex II of that Regulation. The average value of GER over the cycle shall be calculated by one of the following methods:

(a) For hot-start NRTC and RMC NRSC by dividing the sum of the GER at each measurement point by the number of measurement points;

(b) For discrete-mode NRSC by multiplying the average GER for each test mode by the corresponding weighting factor for that mode and calculating the sum for all modes. The weighting factors shall be taken from Appendix 1 of Annex XVII for the applicable cycle.

7.1. Mass-based emission calculation

Section 2. of Annex VII shall apply except as set out in this section.

7.1.1. Dry/wet correction

7.1.1.1. Raw exhaust gas

Equations (7-3) and (7-4) of Annex VII shall be used to calculate the dry/wet correction.

The fuel specific parameters shall be determined in accordance with point 7.1.5..

7.1.1.2. Diluted exhaust gas

Equation (7-3) with either equation (7-25) or (7-26) of Annex VII shall be used to calculate the wet/dry correction.

The molar hydrogen ratio $\alpha$ of the combination of the two fuels shall be used for the dry/wet correction. This molar hydrogen ratio shall be calculated from the fuel consumption measurement values of both fuels in accordance with point 7.1.5..

7.1.2. $NO_x$ correction for humidity

The $NO_x$ humidity correction for compression ignition engines as specified in equation (7-9) of Annex VII shall be used.

7.1.3. Partial flow dilution (PFS) and raw gaseous measurement

7.1.3.1. Determination of exhaust gas mass flow

The exhaust gas mass flow shall be determined using a raw exhaust flow meter as described in point 9.4.5.3. of Annex VI.

Alternatively the airflow and air to fuel ratio measurement method according to equations (7-17) to (7-19) of Annex VII may be used only if $\alpha$, $\gamma$, $\delta$ and $\varepsilon$ values are determined according to point 7.1.5.3.. The use of a zirconia-type sensor to determine the air fuel ratio is not allowed.

In the case of testing engines subject to steady-state test cycles only the exhaust gas mass flow may be determined by the air and fuel measurement method in accordance with equation (7-15) of Annex VII.

7.1.3.2. Determination of the gaseous components

Point 2.1. of Annex VII shall apply except as set out in this section.

The possible variation of fuel composition will influence all the $u_{gas}$ factors and molar component ratios used in the emission calculations. One of the following approaches shall be used to determine $u_{gas}$ factors and molar component ratios at the choice of the manufacturer.

(a) The exact equations in point 2.1.5.2. or 2.2.3. of Annex VII shall be applied to calculate instantaneous values of $u_{gas}$ using the instantaneous proportions of liquid and gaseous fuel (determined from instantaneous fuel consumption measurements or calculations) and instantaneous molar component ratios determined in accordance with point 7.1.5.; or,

(b) When the mass-based calculation in section 2. of Annex VII is used for the specific case of a dual-fuel engine operated on gas and diesel fuel, tabulated values may be used for the molar component ratios and $u_{gas}$ values. These tabulated values shall be applied as follows:

i. For engines operated on the applicable test cycle with an average gas energy ratio greater than or equal to 90 % ($GER \geq 0{,}9$) the required values shall be those for the gaseous fuel taken from Tables 7.1. or 7.2. of Annex VII.

ii. For engines operated on the applicable test cycle with an average gas energy ratio between 10 % and 90 % ($0{,}1 < GER < 0{,}9$) the required values shall be assumed to be represented by those for a mixture of 50 % gaseous fuel and 50 % diesel fuel taken from Tables 8.1. and 8.2..

iii. For engines operated on the applicable test cycle with an average gas energy ratio less than or equal to 10 % ($GER \leq 0{,}1$) the required values shall be those for diesel fuel taken from taken from Tables 7.1. or 7.2. of Annex VII.

iv. For the calculation of HC emissions the $u_{gas}$ value of the gaseous fuel shall be used in all cases irrespective of the average gas energy ratio (GER).

*Table 8.1.*

**Molar component ratios for a mixture of 50 % gaseous fuel and 50 % diesel fuel (mass %)**

| Gaseous fuel | $\alpha$ | $\gamma$ | $\delta$ | $\varepsilon$ |
|---|---|---|---|---|
| $CH_4$ | 2,8681 | 0 | 0 | 0,0040 |
| $G_R$ | 2,7676 | 0 | 0 | 0,0040 |
| $G_{23}$ | 2,7986 | 0 | 0,0703 | 0,0043 |
| $G_{25}$ | 2,7377 | 0 | 0,1319 | 0,0045 |
| Propane | 2,2633 | 0 | 0 | 0,0039 |
| Butane | 2,1837 | 0 | 0 | 0,0038 |
| LPG | 2,1957 | 0 | 0 | 0,0038 |
| LPG Fuel A | 2,1740 | 0 | 0 | 0,0038 |
| LPG Fuel B | 2,2402 | 0 | 0 | 0,0039 |

7.1.3.2.1. Mass per test of a gaseous emission

In the case that the exact equations are applied to calculate instantaneous values of $u_{\mathrm{gas}}$ in accordance with paragraph 7.1.3.2.1(a) then, when calculating the mass per test of a gaseous emission for transient (NRTC and LSI-NRTC) test cycles and RMC, $u_{\mathrm{gas}}$ shall be included in the summation in equation (7-2) of point 2.1.2 of Annex VII by means of equation (8-1):

$$m_{\mathrm{gas}} = \frac{1}{f} \cdot k_{\mathrm{h}} \cdot k \cdot \sum_{i=1}^{N} \left( u_{\mathrm{gas},i} \cdot q_{\mathrm{mew},i} \cdot c_{\mathrm{gas},i} \right) \quad (8\text{-}1)$$

Where:

$u_{\mathrm{gas},i}$ is the instantaneous value of $u_{\mathrm{gas}}$

The remaining terms of the equation are as set out in point 2.1.2 of Annex VII.

*Table 8.2.*

**Raw exhaust gas u gas values and component densities for a mixture of 50% gaseous fuel and 50% diesel fuel (mass %)**

| Gaseous fuel | | Gas | | | | | |
|---|---|---|---|---|---|---|---|
| | $\rho_e$ | $NO_x$ | CO | HC | $CO_2$ | $O_2$ | $CH_4$ |
| | | $\rho_{gas}$ [kg/m³] | | | | | |
| | | 2,053 | 1,250 | (a) | 1,9636 | 1,4277 | 0,716 |
| | | $u_{gas}$ (b) | | | | | |
| **CNG/LNG** (c) | 1,2786 | 0,001606 | 0,000978 | 0,000528 (c) | 0,001536 | 0,001117 | 0,000560 |
| **Propane** | 1,2869 | 0,001596 | 0,000972 | 0,000510 | 0,001527 | 0,001110 | 0,000556 |
| **Butane** | 1,2883 | 0,001594 | 0,000971 | 0,000503 | 0,001525 | 0,001109 | 0,000556 |
| **LPG** (e) | 1,2881 | 0,001594 | 0,000971 | 0,000506 | 0,001525 | 0,001109 | 0,000556 |

(a) depending on fuel

(b) at $\lambda = 2$, dry air, 273 K, 101,3 kPa

(c) $u$ accurate within 0,2 % for mass composition of: C = 58 - 76 %; H = 19 - 25 %; N = 0 - 14 % ($CH_4$, $G_{20}$, $G_{23}$, and $G_{25}$)

(d) NMHC on the basis of $CH_{2.93}$ (for total HC the $u_{gas}$ coefficient of $CH_4$ shall be used)

(e) $u$ accurate within 0,2 % for mass composition of: $C_3$ = 27 - 90 %; C4 = 10 - 73 % (LPG Fuels A and B)

7.1.3.3. Particulate determination

For the determination of particulate emissions with the partial dilution measurement method the calculation shall be performed according to the equations in point 2.3. of Annex VII.

The requirements of point 8.2.1.2. of Annex VI shall apply for controlling the dilution ratio. In particular, if the combined transformation time of the exhaust gas flow measurement and the partial flow system exceeds 0 s, look-ahead control based on a pre-recorded test run shall be used. In this case, the combined rise time shall be ≤ 1 s and the combined delay time ≤ 10 s. Except in the case that the exhaust gas mass flow is measured directly the determination of exhaust gas mass flow shall use values of $\alpha$, $\gamma$, $\delta$ and $\varepsilon$ determined according to point 7.1.5.3..

The quality check according to point 8.2.1.2. of Annex VI shall be performed for each measurement.

7.1.3.4. Additional requirements regarding the exhaust gas mass flow meter

The flow meter referred to in points 9.4.1.6.3. and 9.4.1.6.3.3. of Annex VI shall not be sensitive to the changes in exhaust gas composition and density. The small errors of e.g. pitot tube or orifice-type of measurement (equivalent with the square root of the exhaust gas density) may be neglected.

7.1.4. Full flow dilution measurement (CVS)

Point 2.2. of Annex VII shall apply except as set out in this section.

The possible variation of the fuel composition will mainly influence the tabulated hydrocarbon $u_{gas}$ value. The exact equations shall be applied for the calculation of the hydrocarbon emissions using the molar component ratios determined from the fuel consumption measurements of both fuels according to point 7.1.5..

7.1.4.1. Determination of the background corrected concentrations (point 5.2.5.)

To determine the stoichiometric factor, the molar hydrogen ratio $\alpha$ of the fuel shall be calculated as the average molar hydrogen ratio of the fuel mix during the test according to point 7.1.5.3..

Alternatively the $F_s$ value of the gaseous fuel may be used in equation (7-28) of Annex VII.

7.1.5. Determination of molar component ratios

7.1.5.1. General

This section shall be used for the determination of molar component ratios when the fuel mix is known (exact method).

7.1.5.2. Calculation of the fuel mixture components

Equations (8-2) to (8-7) shall be used to calculate the elemental composition of the fuel mixture:

$$q_{mf} = q_{mf1} + q_{mf2} \quad (8\text{-}2)$$

$$w_{\mathrm{H}} = \frac{w_{\mathrm{H1}} \times q_{mf1} + w_{\mathrm{H2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}3)$$

$$w_{\mathrm{C}} = \frac{w_{\mathrm{C1}} \times q_{mf1} + w_{\mathrm{C2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}4)$$

$$w_{\mathrm{S}} = \frac{w_{\mathrm{S1}} \times q_{mf1} + w_{\mathrm{S2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}5)$$

$$w_{\mathrm{N}} = \frac{w_{\mathrm{N1}} \times q_{mf1} + w_{\mathrm{N2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}6)$$

$$w_{\mathrm{O}} = \frac{w_{\mathrm{O1}} \times q_{mf1} + w_{\mathrm{O2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}7)$$

where:

$q_{mf1}$ is the fuel mass flow rate of fuel 1, kg/s

$q_{mf2}$ is the fuel mass flow rate of fuel 2, kg/s

$w_H$ is the hydrogen content of fuel, % mass

$w_H$ is the carbon content of fuel, % mass

$w_S$ is the sulphur content of fuel, % mass

$w_N$ is the nitrogen content of fuel, % mass

$w_O$ is the oxygen content of fuel, % mass

Calculation of the molar ratios of H, C, S, N and O related to C for the fuel mixture

The calculation of the atomic ratios (especially the H/C-ratio α) is given in Annex VII by means of equations (8-8) to (8-11):

$$\alpha = 11.9164 \cdot \frac{w_H}{w_C} \quad (8\text{-}8)$$

$$\gamma = 0.37464 \cdot \frac{w_S}{w_C} \quad (8\text{-}9)$$

$$\delta = 0.85752 \cdot \frac{w_N}{w_C} \quad (8\text{-}10)$$

$$\varepsilon = 0.75072 \cdot \frac{w_O}{w_C} \quad (8\text{-}11)$$

where:

$w_H$ is the hydrogen content of fuel, mass fraction [g/g] or [per cent mass]

$w_C$ is the carbon content of fuel, mass fraction [g/g] or [per cent mass]

$w_S$ is the sulphur content of fuel, mass fraction [g/g] or [per cent mass]

$w_N$ is the nitrogen content of fuel, mass fraction [g/g] or [per cent mass]

$w_O$ is the oxygen content of fuel, mass fraction [g/g] or [per cent mass]

$\alpha$ is the molar hydrogen ratio (H/C)

$\gamma$ is the molar sulphur ratio (S/C)

$\delta$ is the molar nitrogen ratio (N/C)

$\varepsilon$ is the molar oxygen ratio (O/C)

referring to a fuel $CH\alpha O\varepsilon N\delta S\gamma$

7.2. Molar-based emission calculation

Annex VII section 3. shall apply except as set out in this section.

7.2.1. $NO_x$ correction for humidity

Equation (7-102) of Annex VII (correction for compression ignition engines) shall be used.

7.2.2. Determination of exhaust gas mass flow when not using a raw exhaust flow meter

Equation (7-112) of Annex VII (molar flow rate calculation based on intake air) shall be used. Equation (7-113) of Annex VII (molar flow rate calculation based on fuel mass flow rate) may alternatively be used only when conducting an NRSC test.

7.2.3. Molar component ratios for determination of the gaseous components

The exact approach shall be used to determine the molar component ratios using the instantaneous proportions of liquid and gaseous fuel determined from instantaneous fuel consumption measurements or calculations. The instantaneous molar component ratios shall be input in the equations (7-91), (7-89), and (7-94) of Annex VII for the continuous chemical balance.

The determination of the ratios shall be either performed according to point 7.2.3.1. or point 7.1.5.3..

Gaseous fuels, either blended or sourced from a land line, may contain significant amounts of inert constituents such as $CO_2$ and $N_2$. The manufacturer shall either include these constituents in the atomic ratio calculations described in point 7.2.3.1. or point 7.1.5.3. as applicable, or, alternatively, the manufacturer shall exclude the inert constituents from the atomic ratios and allocate them appropriately to the chemical balance intake air parameters $x_{O2int}$, $x_{CO2int}$, and $x_{H2Oint}$ in point 3.4.3. of Annex VII.

7.2.3.1. Determination of molar component ratios

Instantaneous molar component ratios of the number of hydrogen, oxygen, sulphur, and nitrogen atoms to carbons atoms in the mixed fuel for the dual-fuel engines may be calculated by means of equations (8-12) to (8-15):

$$\alpha(t) = \frac{\frac{m_{liquid}(t)\times w_{H,liquid}}{M_H}+\frac{m_{gas}(t)\times w_{H,gas}}{M_H}}{\frac{m_{liquid}(t)\times w_{C,liquid}}{M_C}+\frac{m_{gas}(t)\times w_{C,gas}}{M_C}} = \frac{M_C\times[(\dot{m}_{liquid}(t)\times w_{H,liquid})+(\dot{m}_{gas}(t)\times w_{H,gas})]}{M_H\times[(\dot{m}_{liquid}(t)\times w_{C,liquid})+(\dot{m}_{gas}(t)\times w_{C,gas})]} \quad (8\text{-}12)$$

$$\beta(t) = \frac{\frac{m_{liquid}(t)\times w_{O,liquid}}{M_O}+\frac{m_{gas}(t)\times w_{O,gas}}{M_O}}{\frac{m_{liquid}(t)\times w_{C,liquid}}{M_C}+\frac{m_{gas}(t)\times w_{C,gas}}{M_C}} = \frac{M_C\times[(\dot{m}_{liquid}(t)\times w_{O,liquid})+(\dot{m}_{gas}(t)\times w_{O,gas})]}{M_O\times[(\dot{m}_{liquid}(t)\times w_{C,liquid})+(\dot{m}_{gas}(t)\times w_{C,gas})]} \quad (8\text{-}13)$$

$$\gamma(t) = \frac{\frac{m_{liquid}(t)\times w_{S,liquid}}{M_S}+\frac{m_{gas}(t)\times w_{S,gas}}{M_S}}{\frac{m_{liquid}(t)\times w_{C,liquid}}{M_C}+\frac{m_{gas}(t)\times w_{C,gas}}{M_C}} = \frac{M_C\times[(\dot{m}_{liquid}(t)\times w_{S,liquid})+(\dot{m}_{gas}(t)\times w_{S,gas})]}{M_S\times[(\dot{m}_{liquid}(t)\times w_{C,liquid})+(\dot{m}_{gas}(t)\times w_{C,gas})]} \quad (8\text{-}14)$$

$$\delta(t) = \frac{\frac{m_{liquid}(t)\times w_{N,liquid}}{M_N}+\frac{m_{gas}(t)\times w_{N,gas}}{M_N}}{\frac{m_{liquid}(t)\times w_{C,liquid}}{M_C}+\frac{m_{gas}(t)\times w_{C,gas}}{M_C}} = \frac{M_C\times[(\dot{m}_{liquid}(t)\times w_{N,liquid})+(\dot{m}_{gas}(t)\times w_{N,gas})]}{M_N\times[(\dot{m}_{liquid}(t)\times w_{C,liquid})+(\dot{m}_{gas}(t)\times w_{C,gas})]} \quad (8\text{-}15)$$

Where:

$w_{i,fuel}$ = the mass fraction of the element of interest, C, H, O, S, or N, of liquid or gaseous fuel;

$\dot{m}_{liquid}(t)$ = the instantaneous mass flow rate of the liquid fuel at time t, [kg/hr];

$\dot{m}_{gas}(t)$ = the instantaneous mass flow rate of the gaseous fuel at time t, [kg/hr];

In cases where exhaust gas mass flow rate is calculated based on the mixed fuel rate then $w_C$ in equation (7-111) of Annex VII shall be calculated by means of equation (8-16):

$$w_{\mathrm{C}} = \frac{\dot{m}_{liquid} \times w_{\mathrm{C},liquid} + \dot{m}_{gas} \times w_{\mathrm{C},gas}}{\dot{m}_{liquid} + \dot{m}_{gas}} \qquad (8\text{-}16)$$

Where:

$w_{\mathrm{C}}$ = the mass fraction of the carbon in the diesel or gaseous fuel;

$\dot{m}_{liquid}$ = the mass flow rate of the liquid fuel, [kg/hr];

$\dot{m}_{gas}$ = the mass flow rate of the gaseous fuel, [kg/hr].

7.3. CO2 determination

Annex VII shall apply except when the engine is tested on transient (NRTC and LSI-NRTC) test cycles or RMC using raw gas sampling.

7.3.1 $CO_2$ determination when testing on transient (NRTC and LSI-NRTC) test cycles or RMC using raw gas sampling

Calculation of $CO_2$ emissions from measurement of $CO_2$ in the exhaust gas in accordance with Annex VII shall not apply. Instead the following provisions shall apply:

The measured test-averaged fuel consumption shall be determined from the sum of the instantaneous values over the cycle and shall be used as the base for calculating the test averaged $CO_2$ emissions.

The mass of each fuel consumed shall be used to determine, in accordance with section 7.1.5, the molar hydrogen ratio and the mass fractions of the fuel mix in the test.

The total corrected fuel mass of both fuels $m_{\mathrm{fuel,corr}}$ [g/test] and $CO_2$ mass emission coming from the fuel $m_{\mathrm{CO2,\ fuel}}$ [g/test] shall be determined by means of equations (8-17) and (8-18).

$$m_{\mathrm{fuel,corr}} = m_{\mathrm{fuel}} - \left(m_{\mathrm{THC}} + \frac{A_{\mathrm{C}} + a * A_{\mathrm{H}}}{M_{\mathrm{CO}}} x m_{\mathrm{CO}} + \frac{w_{GAM} + w_{DEL} + w_{\mathrm{EPS}}}{100} * m_{\mathrm{fuel}}\right)$$

(8-17)

$$m_{\mathrm{CO_2,fuel}} = \frac{M_{\mathrm{CO_2}}}{A_{\mathrm{C}} + a * A_{\mathrm{H}}} * m_{\mathrm{fuel,corr}} \qquad (8\text{-}18)$$

Where:

$m_{fuel}$ = total fuel mass of both fuels [g/test]

$m_{THC}$ = mass of total hydrocarbon emissions in the exhaust gas [g/test]

$m_{CO}$ = mass of carbon monoxide emissions in the exhaust gas [g/test]

$w_{GAM}$ = sulphur content of the fuels [per cent mass]

$w_{DEL}$ = nitrogen content of the fuels [per cent mass]

$w_{EPS}$ = is the oxygen content of the fuels [per cent mass]

$\alpha$ = is the molar hydrogen ratio of the fuels (H/C) [-]

$A_C$ = is the atomic mass of Carbon: 12.011 [g/mol]

$A_H$ = is the atomic mass of Hydrogen: 1.0079 [g/mol]

$M_{CO}$ = is the molecular mass of Carbon monoxide: 28.011 [g/mol]

$M_{CO2}$ = is the molecular mass of Carbon dioxide: 44.01 [g/mol]

The $CO_2$ emission resulting from urea $m_{CO2,urea}$ [g/test] shall be calculated by means of equation (8-19):

$$m_{CO2,urea} = \frac{c_{urea}}{100} \times \frac{M_{CO2}}{M_{CO(NH2)2}} \times m_{urea} \qquad (8\text{-}19)$$

Where:

$c_{urea}$ = urea concentration [per cent]

$m_{urea}$ = total urea mass consumption [g/test]

$M_{CO(NH2)2}$ = Molecular mass of urea: 60,056 [g/mol]

Then the total $CO_2$ emission $m_{CO2}$ [g/test] shall be calculated by means of equation (8-20):

$$m_{CO2} = m_{CO2,fuel} + m_{CO2,urea} \qquad (8\text{-}20)$$

The total $CO_2$ emission calculated by means of equation (8-20) shall be used in the calculation of brake specific $CO_2$ emissions, $e_{CO2}$ [g/kWh] in section 2.4.1.1 or 3.8.1.1 of Annex VII. Where applicable, the correction for $CO_2$ in the exhaust gas arising from $CO_2$ in the gaseous fuel shall be performed in accordance with Appendix 3 to Annex IX.

## Appendix 3

**Types of dual-fuel engines operated on natural gas/biomethane or LPG and a liquid fuel – illustration of the definitions and main requirements**

| Dual-fuel type | $GER_{cycle}$ | Idle on liquid fuel | Warm-up on liquid fuel | Operation on liquid fuel solely | Operation in absence of gas | Comments |
|---|---|---|---|---|---|---|
| 1A | $GER_{NRTC, hot} \geq 0{,}9$ or $GER_{NRSC,} \geq 0{,}9$ | NOT allowed | Allowed only on service mode | Allowed only on service mode | Service mode | |
| 1B | $GER_{NRTC, hot} \geq 0{,}9$ or $GER_{NRSC} \geq 0{,}9$ | Allowed only on liquid-fuel mode | Allowed only on liquid-fuel mode | Allowed only on liquid-fuel and service modes | Liquid-fuel mode | |
| 2A | $0{,}1 < GER_{NRTC, hot} < 0{,}9$ or $0{,}1 < GER_{NRSC} < 0{,}9$ | Allowed | Allowed only on service mode | Allowed only on service mode | Service mode | $GER_{NRTC, hot} \geq 0{,}9$ or $GER_{NRSC} \geq 0{,}9$ Allowed |
| 2B | $0{,}1 < GER_{NRTC, hot} < 0{,}9$ or $0{,}1 < GER_{NRSC} < 0{,}9$ | Allowed | Allowed | Allowed | Liquid-fuel mode | $GER_{NRTC, hot} \geq 0{,}9$ or $GER_{NRSC} \geq 0{,}9$ allowed |
| 3A | Neither defined nor allowed | | | | | |
| 3B | $GER_{NRTC, hot} \leq 0{,}1$ or $GER_{NRSC} \leq 0{,}1$ | Allowed | Allowed | Allowed | Liquid-fuel mode | |

## ANNEX IX

## Reference Fuels

1. Technical data on fuels for testing compression-ignition engines

1.1. Type: Diesel (non-road gas-oil)

| *Parameter* | *Unit* | *Limits*[1] | | *Test Method* |
|---|---|---|---|---|
| | | *minimum* | *maximum* | |
| Cetane number[2] | | 45 | 56,0 | EN-ISO 5165 |
| Density at 15 °C | kg/m$^3$ | 833 | 865 | EN-ISO 3675 |
| Distillation: | | | | |
| 50 % point | °C | 245 | - | EN-ISO 3405 |
| 95 % point | °C | 345 | 350 | EN-ISO 3405 |
| - Final boiling point | °C | - | 370 | EN-ISO 3405 |
| Flash point | °C | 55 | - | EN 22719 |
| CFPP | °C | - | –5 | EN 116 |
| Viscosity at 40 °C | mm$^2$/s | 2,3 | 3,3 | EN-ISO 3104 |
| Polycyclic aromatic hydrocarbons | % m/m | 2,0 | 6,0 | IP 391 |
| Sulphur content[3] | mg/kg | - | 10 | ASTM D 5453 |
| Copper corrosion | | - | class 1 | EN-ISO 2160 |
| Conradson carbon residue (10 % DR) | % m/m | - | 0,2 | EN-ISO 10370 |
| Ash content | % m/m | - | 0,01 | EN-ISO 6245 |
| Total contamination | mg/kg | - | 24 | EN 12662 |
| Water content | % m/m | - | 0,02 | EN-ISO 12937 |
| Neutralization (strong acid) number | mg KOH/g | - | 0,10 | ASTM D 974 |
| Oxidation stability[3] | mg/ml | - | 0,025 | EN-ISO 12205 |
| Lubricity (HFRR wear scar diameter at 60 °C) | µm | - | 400 | CEC F-06-A-96 |
| Oxidation stability at 110 °C[3] | H | 20,0 | - | EN 15751 |
| FAME | % v/v | - | 7,0 | EN 14078 |

[1] The values quoted in the specifications are "true values". In establishment of their limit values the terms of ISO 4259 "Petroleum products – Determination and application of precision data in relation to methods of test" have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R = reproducibility).

Notwithstanding this measure, which is necessary for technical reasons, the manufacturer of fuels should nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the questions as to whether a fuel meets the requirements of the specifications, the terms of ISO 4259 should be applied.

[2] The range for the cetane number is not in accordance with the requirements of a minimum range of 4R. However, in the case of a dispute between fuel supplier and fuel user, the terms of ISO 4259 may be used to resolve such disputes provided replicate measurements, of sufficient number to archive the necessary precision, are made in preference to single determinations.

[3] Even though oxidation stability is controlled, it is likely that shelf life will be limited. Advice should be sought from the supplier as to storage conditions and life.

1.2. Type: Ethanol for dedicated compression ignition engines (ED95)1

| *Parameter* | *Unit* | *Limits*[2] | | *Test method*[3] |
|---|---|---|---|---|
| | | *Minimum* | *Maximum* | |
| Total alcohol (Ethanol incl. content on higher saturated alcohols) | % m/m | 92,4 | | EN 15721 |
| Other higher saturated mono-alcohols ($C_3$-$C_5$) | % m/m | | 2,0 | EN 15721 |
| Methanol | % m/m | | 0,3 | EN 15721 |
| Density 15ºC | kg/m³ | 793,0 | 815,0 | EN ISO 12185 |
| Acidity, calculated as acetic acid | % m/m | | 0,0025 | EN 15491 |
| Appearance | | Bright and clear | | |
| Flashpoint | ºC | 10 | | EN 3679 |
| Dry residue | mg/kg | | 15 | EN 15691 |
| Water content | % m/m | | 6,5 | EN 15489[4]<br>EN-ISO 12937<br>EN15692 |
| Aldehydes calculated as acetaldehyde | % m/m | | 0,0050 | ISO 1388-4 |
| Esters calculated as ethylacetat | % m/m | | 0,1 | ASTM D1617 |
| Sulphur content | mg/kg | | 10,0 | EN 15485<br>EN 15486 |
| Sulphates | mg/kg | | 4,0 | EN 15492 |
| Particulate contamination | mg/kg | | 24 | EN 12662 |
| Phosphorus | mg/l | | 0,20 | EN 15487 |
| Inorganic chloride | mg/kg | | 1,0 | EN 15484 or EN 15492 |
| Copper | mg/kg | | 0,100 | EN 15488 |
| Electrical Conductivity | µS/cm | | 2,50 | DIN 51627-4 or prEN 15938 |

*Notes:*

1 Additives, such as cetane improver as specified by the engine manufacturer, may be added to the ethanol fuel, as long as no negative side effects are known. If these conditions are satisfied, the maximum allowed amount is 10 % m/m.

2 The values quoted in the specifications are "true values". In establishment of their limit values the terms of ISO 4259 Petroleum products – Determination and application of precision data in relation to methods of test have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R = reproducibility). Notwithstanding this measure, which is necessary for technical reasons, the manufacturer of fuels shall nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify whether a fuel meets the requirements of the specifications, the terms of ISO 4259 shall be applied.

3 Equivalent EN/ISO methods will be adopted when issued for properties listed above.

4 Should it be necessary to clarify whether a fuel meets the requirements of the specifications, the terms of EN 15489 shall be applied.

2. Technical data on fuels for testing spark ignition engines

2.1. Type: Petrol (E10)

| *Parameter* | *Unit* | *Limits*[1] | | *Test method*[2] |
|---|---|---|---|---|
| | | *Minimum* | *Maximum* | |
| Research octane number, RON | | 91,0 | 98,0 | EN ISO 5164:2005[3] |
| Motor octane number, MON | | 83,0 | 89,0 | EN ISO 5163:2005[3] |
| Density at 15 °C | $kg/m^3$ | 743 | 756 | EN ISO 3675<br>EN ISO 12185 |
| Vapour pressure | kPa | 45,0 | 60,0 | EN ISO 13016-1 (DVPE) |
| Water content | | | Max 0,05 % v/v<br>Appearance at -7°C: clear and bright | EN 12937 |
| Distillation: | | | | |
| - evaporated at 70 °C | % v/v | 18,0 | 46,0 | EN-ISO 3405 |
| - evaporated at 100 °C | % v/v | 46,0 | 62,0 | EN-ISO 3405 |
| - evaporated at 150 °C | % v/v | 75,0 | 94,0 | EN-ISO 3405 |
| - final boiling point | °C | 170 | 210 | EN-ISO 3405 |
| Residue | % v/v | — | 2,0 | EN-ISO 3405 |
| Hydrocarbon analysis: | | | | |
| - olefins | % v/v | 3,0 | 18,0 | EN 14517<br>EN 15553 |
| - aromatics | % v/v | 19,5 | 35,0 | EN 14517<br>EN 15553 |
| - benzene | % v/v | — | 1,0 | EN 12177<br>EN 238, EN 14517 |
| - saturates | % v/v | Report | | EN 14517<br>EN 15553 |
| Carbon/hydrogen ratio | | Report | | |
| Carbon/oxygen ratio | | Report | | |
| Induction period[4] | minutes | 480 | | EN-ISO 7536 |
| Oxygen content[5] | % m/m | 3,3[8] | 3,7 | EN 1601<br>EN 13132<br>EN 14517 |
| Existent gum | mg/ml | — | 0,04 | EN-ISO 6246 |
| Sulphur content[6] | mg/kg | — | 10 | EN ISO 20846<br>EN ISO 20884 |
| Copper corrosion (3h at 50 °C) | rating | — | Class 1 | EN-ISO 2160 |
| Lead content | mg/l | — | 5 | EN 237 |
| Phosphorus content[7] | mg/l | — | 1,3 | ASTM D 3231 |
| Ethanol[4] | % v/v | 9,0[8] | 10,2[8] | EN 22854 |

*Notes*:

[1] The values quoted in the specifications are "true values". In establishment of their limit values the terms of ISO 4259 Petroleum products - Determination and application of precision data in relation to methods of test have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R = reproducibility). Notwithstanding this measure, which is necessary for technical reasons, the manufacturer of fuels shall nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify whether a fuel meets the requirements of the specifications, the terms of ISO 4259 shall be applied.

[2] Equivalent EN/ISO methods will be adopted when issued for properties listed above.

[3] A correction factor of 0,2 for MON and RON shall be subtracted for the calculation of the final result in accordance with EN 228:2008.

[4] The fuel may contain oxidation inhibitors and metal deactivators normally used to stabilise refinery gasoline streams, but detergent/dispersive additives and solvent oils shall not be added.

[5] Ethanol meeting the specification of EN 15376 is the only oxygenate that shall be intentionally added to the reference fuel.

[6] The actual sulphur content of the fuel used for the Type 1 test shall be reported.

[7] There shall be no intentional addition of compounds containing phosphorus, iron, manganese, or lead to this reference fuel.

[8] The ethanol content and corresponding oxygen content may be zero for engines of category SMB at the choice of the manufacturer. In this case all testing of the engine family, or engine type where no family exists, shall be conducted using petrol with zero ethanol content.

2.2. Type: Ethanol (E85)

| *Parameter* | *Unit* | *Limits*[1] | | *Test method* |
|---|---|---|---|---|
| | | *Minimum* | *Maximum* | |
| Research octane number, RON | | 95,0 | — | EN ISO 5164 |
| Motor octane number, MON | | 85,0 | — | EN ISO 5163 |
| Density at 15 °C | kg/$m^3$ | Report | | ISO 3675 |
| Vapour pressure | kPa | 40,0 | 60,0 | EN ISO 13016-1 (DVPE) |
| Sulphur content[2] | mg/kg | — | 10 | EN 15485 or EN 15486 |
| Oxidation stability | Minutes | 360 | | EN ISO 7536 |
| Existent gum content (solvent washed) | mg/100ml | — | 5 | EN-ISO 6246 |
| Appearance<br>This shall be determined at ambient temperature or 15°C whichever is higher | | Clear and bright, visibly free of suspended or precipitated contaminants | | Visual inspection |
| Ethanol and higher alcohols[3] | % v/v | 83 | 85 | EN 1601<br>EN 13132<br>EN 14517<br>E DIN 51627-3 |
| Higher alcohols ($C_3$-$C_8$) | % v/v | — | 2,0 | E DIN 51627-3 |
| Methanol | % v/v | | 1,00 | E DIN 51627-3 |
| Petrol[4] | % v/v | Balance | | EN 228 |
| Phosphous | mg/l | 0,20[5] | | EN 15487 |
| Water content | % v/v | | 0,300 | EN 15489 or EN 15692 |
| Inorganic chloride content | mg/l | | 1 | EN 15492 |
| pHe | | 6,5 | 9,0 | EN 15490 |
| Copper strip corrosion (3h at 50°C) | Rating | Class 1 | | EN ISO 2160 |
| Acidity, (as acetic acid $CH_3COOH$) | % m/m<br><br>(mg/l) | — | 0,0050<br><br>(40) | EN 15491 |
| Electric Conductivity | µS/cm | 1,5 | | DIN 51627-4 or prEN 15938 |
| Carbon/hydrogen ratio | | Report | | |
| Carbon/oxygen ration | | Report | | |

*Notes*:

1 The values quoted in the specifications are "true values". In establishment of their limit values the terms of ISO 4259 Petroleum products - Determination and application of precision data in relation to methods of test have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R = reproducibility). Notwithstanding this measure, which is necessary for technical reasons, the manufacturer of fuels shall nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify whether a fuel meets the requirements of the specifications, the terms of ISO 4259 shall be applied.

2 The actual sulphur content of the fuel used for the emission tests shall be reported.

3 Ethanol to meet specification of EN 15376 is the only oxygenate that shall be intentionally added to this reference fuel.

4 The unleaded petrol content can be determined as 100 minus the sum of the % content of water, alcohols, MTBE and ETBE.

5 There shall be no intentional addition of compounds containing phosphorus, iron, manganese, or lead to this reference fuel.

3. Technical data on gaseous fuels for single-fuel and dual-fuel engines

3.1. Type: LPG

| *Parameter* | *Unit* | *Fuel A* | *Fuel B* | *Test method* |
|---|---|---|---|---|
| Composition: | | | | EN 27941 |
| $C_3$-content | % v/v | 30 ± 2 | 85 ± 2 | |
| $C_4$-content | % v/v | Balance[1] | Balance[1] | |
| $< C_3$ , $> C_4$ | % v/v | Maximum 2 | Maximum 2 | |
| Olefins | % v/v | Maximum 12 | Maximum 15 | |
| Evaporation residue | mg/kg | Maximum 50 | Maximum 50 | EN 15470 |
| Water at 0 °C | | Free | Free | EN 15469 |
| Total sulphur content including odorant | mg/kg | Maximum 10 | Maximum 10 | EN 24260, ASTM D 3246, ASTM 6667 |
| Hydrogen sulphide | | None | None | EN ISO 8819 |
| Copper strip corrosion (1h at 40 °C) | Rating | Class 1 | Class 1 | ISO 6251[2] |
| Odour | | Characteristic | Characteristic | |
| Motor octane number[3] | | Minimum 89,0 | Minimum 89,0 | EN 589 Annex B |

*Notes*:

1 Balance shall be read as follows: balance = 100 - $C_3$ - $<C_3$ - $>C_4$.

2 This method may not accurately determine the presence of corrosive materials if the sample contains corrosion inhibitors or other chemicals which diminish the corrosivity of the sample to the copper strip. Therefore, the addition of such compounds for the sole purpose of biasing the test method is prohibited.

3 At the request of the engine manufacturer, a higher MON could be used to perform the type approval tests.

3.2. Type: Natural Gas/ Biomethane

3.2.1. Specification for reference fuels supplied with fixed properties (eg from a sealed container)

As an alternative to the reference fuels set out in this point, the equivalent fuels in point 3.2.2. may be used

| *Characteristics* | *Units* | *Basis* | *Limits* | | *Test method* |
|---|---|---|---|---|---|
| | | | *minimum* | *maximum* | |
| **Reference fuel $G_R$** | | | | | |
| Composition: | | | | | |
| Methane | | 87 | 84 | 89 | |
| Ethane | | 13 | 11 | 15 | |
| Balance[1] | % mole | — | — | 1 | ISO 6974 |
| Sulphur content | $mg/m^3$ [2] | — | | 10 | ISO 6326-5 |
| | | | | | |
| *Notes*: [1] Inerts + $C_{2+}$ [2] Value to be determined at standard conditions 293,2 K (20 °C) and 101,3 kPa. | | | | | |
| **Reference fuel $G_{23}$** | | | | | |
| Composition: | | | | | |
| Methane | | 92,5 | 91,5 | 93,5 | |
| Balance[1] | % mole | — | — | 1 | ISO 6974 |
| $N_2$ | % mole | 7,5 | 6,5 | 8,5 | |
| Sulphur content | $mg/m^3$ [2] | — | — | 10 | ISO 6326-5 |
| | | | | | |
| *Notes*: [1] Inerts (different from $N_2$) + $C_2$+ $C_{2+}$ [2] Value to be determined at 293,2 K (20 °C) and 101,3 kPa. | | | | | |
| **Reference fuel $G_{25}$** | | | | | |
| Composition: | | | | | |
| Methane | % mole | 86 | 84 | 88 | |
| Balance[1] | % mole | — | — | 1 | ISO 6974 |
| $N_2$ | % mole | 14 | 12 | 16 | |
| Sulphur content | $mg/m^3$ [2] | — | — | 10 | ISO 6326-5 |
| | | | | | |
| *Notes*: [1] Inerts (different from $N_2$) + $C_2$+ $C_{2+}$ [2] Value to be determined at 293,2 K (20 °C) and 101,3 kPa. | | | | | |

| **Reference fuel $G_{20}$** | | | | | |
|---|---|---|---|---|---|
| Composition: | | | | | |
| Methane | % mole | 100 | 99 | 100 | ISO 6974 |
| Balance (1) | % mole | — | — | 1 | ISO 6974 |
| $N_2$ | % mole | | | | ISO 6974 |
| Sulphur content | $mg/m^3$ (2) | — | — | 10 | ISO 6326-5 |
| Wobbe Index (net) | $MJ/m^3$ (3) | 48,2 | 47,2 | 49,2 | |
| (1) Inerts (different from $N_2$) + $C_2$ + $C_2$+. | | | | | |
| (2) Value to be determined at 293,2 K (20 °C) and 101,3 kPa. | | | | | |
| (3) Value to be determined at 273,2 K (0 °C) and 101,3 kPa. | | | | | |

3.2.2. Specification for reference fuel supplied from a pipeline with admixture of other gases with gas properties determined by on-site measurement

As an alternative to the reference fuels in this point the equivalent reference fuels in point 3.2.1. may be used.

3.2.2.1. The basis of each pipeline reference fuel ($G_R$, $G_{20}$, …) shall be gas drawn from a utility gas distribution network, blended, where necessary to meet the corresponding lambda-shift ($S_\lambda$) specification in Table 9.1., with an admixture of one or more of the following commercially[1] available gases:

(a) Carbon dioxide;

(b) Ethane;

(c) Methane;

(d) Nitrogen;

(e) Propane.

1 The use of calibration gas for this purpose shall not be required

3.2.2.2. The value of $S_\lambda$ of the resulting blend of pipeline gas and admixture gas shall be within the range specified in Table 9.1. for the specified reference fuel.

*Table 9.1.*

**Required range of $S_\lambda$ for each reference fuel**

| Reference fuel | Minimum $S_\lambda$ | Maximum $S_\lambda$ |
|---|---|---|
| $G_R$[2] | 0,87 | 0,95 |
| $G_{20}$ | 0,97 | 1,03 |

| | | |
|---|---|---|
| $G_{23}$ | 1,05 | 1,10 |
| $G_{25}$ | 1,12 | 1,20 |
| [2] The engine shall not be required to be tested on a gas blend with a Methane Number (MN) less than 70. In the case that the required range of $S_\lambda$ for $G_R$ would result in an MN less than 70 the value of $S_\lambda$ for $G_R$ may be adjusted as necessary until a value of MN no less than 70 is attained. | | |

3.2.2.3. The engine test report for each test run shall include the following:

(a) The admixture gas(es) chosen from the list in point 3.2.2.1.;

(b) The value of $S_\lambda$ for the resulting fuel blend;

(c) The Methane Number (MN) of the resulting fuel blend.

3.2.2.4. The requirements of Appendices 1 and 2 shall be met in respect to determination of the properties of the pipeline and admixture gases, the determination of $S_\lambda$ and MN for the resulting gas blend, and the verification that the blend was maintained during the test.

3.2.2.5. In the case that one or more of the gas streams (pipeline gas or admixture gas(es)) contain $CO_2$ in greater than a de-minimus proportion, the calculation of specific $CO_2$ emissions in Annex VII shall be corrected according to Appendix 3.

## Appendix 1

**<u>Supplementary requirements for conducting emission testing using gaseous reference fuels comprising pipeline gas with admixture of other gases</u>**

### 1. Method of gas analysis and gas flow measurement

1.1. For the purpose of this Appendix, where required the composition of the gas shall be determined by analysis of the gas using gas chromatography according to EN ISO 6974, or by an alternative technique that achieves at least a similar level of accuracy and repeatability.

1.2. For the purpose of this Appendix, where required the measurement of gas flow shall be performed using a mass-based flowmeter.

### 2. Analysis and flowrate of incoming utility gas supply

2.1. The composition of the utility gas supply shall be analysed prior to the admixture blending system.

2.2. The flowrate of the utility gas entering the admixture blending system shall be measured.

### 3. Analysis and flowrate of admixture

3.1. When an applicable certificate of analysis is available for an admixture (for example issued by the gas supplier) this may be used as the source of that admixture composition. In this case the on-site analysis of that admixture composition shall be permitted but shall not be required.

3.2. Where an applicable certificate of analysis is not available for an admixture the composition of that admixture shall be analysed.

3.3. The flowrate of each admixture entering the admixture blending system shall be measured.

### 4. Analysis of blended gas

4.1. The analysis of the composition of the gas supplied to the engine after leaving the admixture blending system shall be permitted in addition to, or as an alternative to the analysis required by points 2.1. and 3.1., but shall not be required.

### 5. Calculation of $S_{\lambda}$ and MN of the blended gas

5.1. The results of the gas analysis according to point 2.1., point 3.1. or 3.2. and, where applicable, point 4.1., combined with the mass flowrate of gas measured according to points 2.2. and 3.3., shall be used to calculate the MN according to EN16726:2015. The same set of data shall be used to calculate $S_{\lambda}$ according to the procedure set out in Appendix 2.

## 6. Control and verification of gas blend during the test

6.1 The control and verification of the gas blend during the test shall be performed using either an open loop or closed loop control system.

6.2 Open loop blend control system

6.2.1 In this case the gas analysis, flow measurements and calculations set out in points 1., 2., 3. and 4. shall be performed prior to the emission test.

6.2.2 The proportion of utility gas and admixture(s) shall be set to ensure that the $S_\lambda$ is within the permitted range for the relevant reference fuel in Table 9.1..

6.2.3 When the relative proportions have been set they shall be maintained throughout the emission test. Adjustments to individual flow rates to maintain the relative proportions shall be permitted.

6.2.4 When the emission test has been completed the analysis of gas composition, flow measurements and calculations set out in points 2., 3., 4. and 5. shall be repeated. In order for the test to be considered valid the value of $S_\lambda$ shall remain within the specified range for the respective reference fuel given in Table 9.1..

6.3 Closed loop blend control system

6.3.1 In this case the analysis of gas composition, flow measurements and calculations set out in points 2., 3., 4. and 5. shall be performed at intervals during the emission test. The intervals shall be chosen taking into consideration the frequency capability of the gas chromatograph and corresponding calculation system.

6.3.2 The results from the periodic measurements and calculations shall be used to adjust the relative proportions of utility gas and admixture in order to maintain the value of $S_\lambda$ within the range specified in Table 9.1. for the respective reference fuel. The frequency of adjustment shall not exceed the frequency of measurement.

6.3.3 In order for the test to be considered valid the value of $S_\lambda$ shall be within the range specified in Table 9.1. for the respective reference fuel for at least 90 % of the measurement points.

## Appendix 2

## Calculation of λ-Shift factor ($S_\lambda$)

1. Calculation

The λ-shift factor ($S_\lambda$)[1] shall be calculated by means of equation (9-1):

$$S_\lambda = \frac{2}{\left(1 - \frac{inert\%}{100}\right)\left(n + \frac{m}{4}\right) - \frac{O_2^*}{100}} \quad (9\text{-}1)$$

Where:

$S_\lambda$ = λ-shift factor;

inert % = % by volume of inert gases in the fuel (i.e. $N_2$, $CO_2$, He, etc.);

$O_2^*$ = % by volume of original oxygen in the fuel;

n and m = refer to average $C_nH_m$ representing the fuel hydrocarbons, i.e:

$$n = \frac{1 \times \left[\frac{CH_4\%}{100}\right] + 2 \times \left[\frac{C_2\%}{100}\right] + 3 \times \left[\frac{C_3\%}{100}\right] + 4 \times \left[\frac{C_4\%}{100}\right] + 5 \times \left[\frac{C_5\%}{100}\right] + ..}{\frac{1 - diluent\,\%}{100}} \quad (9\text{-}2)$$

$$m = \frac{4 \times \left[\frac{CH_4\%}{100}\right] + 4 \times \left[\frac{C_2H_4\%}{100}\right] + 6 \times \left[\frac{C_2H_6\%}{100}\right] + ...8 \times \left[\frac{C_3H_8\%}{100}\right] + ..}{\frac{1 - diluent\,\%}{100}} \quad (9\text{-}3)$$

Where:

$CH_4$ = % by volume of methane in the fuel;

$C_2$ = % by volume of all $C_2$ hydrocarbons (e.g.: $C_2H_6$, $C_2H_4$, etc.) in the fuel;

$C_3$ = % by volume of all $C_3$ hydrocarbons (e.g.: $C_3H_8$, $C_3H_6$, etc.) in the fuel;

[1] Stoichiometric Air/Fuel ratios of automotive fuels - SAE J1829, June 1987. John B. Heywood, Internal combustion engine fundamentals, McGraw-Hill, 1988, Chapter 3.4 "Combustion stoichiometry" (pp. 68 to 72).

$C_4$ = % by volume of all $C_4$ hydrocarbons (e.g.: $C_4H_{10}$, $C_4H_8$, etc.) in the fuel;

$C_5$ = % by volume of all $C_5$ hydrocarbons (e.g.: $C_5H_{12}$, $C_5H_{10}$, etc.) in the fuel;

diluent = % by volume of dilution gases in the fuel (i.e.: $O_2$*, $N_2$, $CO_2$, He, etc.).

2. Examples for the calculation of the λ-shift factor $S_\lambda$:

Example 1: $G_{25}$: $CH_4$ = 86 %, $N_2$ = 14 % (by volume)

$$n = \frac{1\times\left[\frac{CH_4\%}{100}\right]+2\times\left[\frac{C_2\%}{100}\right]+..}{\frac{1-\text{diluent}\,\%}{100}} = \frac{1\times 0.86}{1-\frac{14}{100}} = \frac{0.86}{0.86} = 1$$

$$m = \frac{4\times\left[\frac{CH_4\%}{100}\right]+4\times\left[\frac{C_2H_4\%}{100}\right]+..}{\frac{1-\text{diluent}\,\%}{100}} = \frac{4\times 0.86}{0.86} = 4$$

$$S_\lambda = \frac{2}{\left(1-\frac{\text{inert}\%}{100}\right)\left(n+\frac{m}{4}\right)-\frac{O_2^*}{100}} = \frac{2}{\left(1-\frac{14}{100}\right)\times\left(1+\frac{4}{4}\right)} = 1.16$$

Example 2: $G_R$: $CH_4$ = 87 %, $C_2H_6$ = 13 % (by vol)

$$n = \frac{1\times\left[\frac{CH_4\%}{100}\right]+2\times\left[\frac{C_2\%}{100}\right]+..}{\frac{1-\text{diluent}\,\%}{100}} = \frac{1\times 0.87+2\times 0.13}{1-\frac{0}{100}} = \frac{1.13}{} = 1.13$$

$$m = \frac{4\times\left[\frac{CH_4\%}{100}\right]+4\times\left[\frac{C_2H_4\%}{100}\right]+..}{\frac{1-\text{diluent}\,\%}{100}} = \frac{4\times 0.87+6\times 0.13}{1} = 4.26$$

$$S_\lambda = \frac{2}{\left(1-\frac{\text{inert}\%}{100}\right)\left(n+\frac{m}{4}\right)-\frac{O_2^*}{100}} = \frac{2}{\left(1-\frac{0}{100}\right)\times\left(1.13+\frac{4.26}{4}\right)} = 0.911$$

Example 3: USA: $CH_4$ = 89 %, $C_2H_6$ = 4,5 %, $C_3H_8$ = 2,3 %, $C_6H_{14}$ = 0,2 %, $O_2$ = 0,6 %, $N_2$ = 4 %

$$n = \frac{1\times\left[\frac{CH_4\%}{100}\right]+2\times\left[\frac{C_2\%}{100}\right]+..}{\frac{1-\text{diluent}\,\%}{100}} = \frac{1\times 0.89+2\times 0.045+3\times 0.023+4\times 0.002}{1-\frac{0.64+4}{100}} = 1.11$$

$$m = \frac{4 \times \left[\frac{CH_4\%}{100}\right] + 4 \times \left[\frac{C_2H_4\%}{100}\right] + 6 \times \left[\frac{C_2H_6\%}{100}\right] + \ .. \ + 8 \times \left[\frac{C_3H_8\%}{100}\right]}{1 - \frac{diluent\,\%}{100}} =$$

$$= \frac{4 \times 0.89 + 4 \times 0.045 + 8 \times 0.023 + 14 \times 0.002}{1 - \frac{0.6 + 4}{100}} = 4{,}24$$

$$S_\lambda = \frac{2}{\left(1 - \frac{inert\%}{100}\right)\left(n + \frac{m}{4}\right) - \frac{O_2^*}{100}} = \frac{2}{\left(1 - \frac{4}{100}\right) \times \left(1.11 + \frac{4.24}{4}\right) - \frac{0.6}{100}} = 0.96$$

As an alternative to the above equation, $S_\lambda$ may be calculated from the ratio of the stoichiometric air demand of pure methane to the stoichiometric air demand of the fuel blend supplied to the engine, as specified below.

Lambda-shift factor ($S_\lambda$) expresses the oxygen demand of any fuel blend in relation to oxygen demand of pure methane. Oxygen demand means the amount of oxygen to oxidise methane in a stoichiometric composition of reaction partners to products of complete combustion (i.e. carbon-dioxide and water).

For the combustion of pure methane the reaction is as set out in equation (9-4):

$$1 \cdot CH_4 + 2 \cdot O_2 \rightarrow 1 \cdot CO_2 + 2 \cdot H_2O \qquad (9\text{-}4)$$

In this case the ratio of molecules in stoichiometric composition of reaction partners is exactly 2:

$$\frac{n_{O2}}{n_{CH4}} = 2$$

Where:

$n_{O2}$ = number of molecules of oxygen

$n_{CH4}$ = number of molecules of methane

The oxygen demand for pure methane is therefore:

$n_{O2} = 2 \cdot n_{CH4}$ with a reference value of $[n_{CH4}]$= 1kmol

The value of $S_\lambda$ may be determined from the ratio of the stoichiometric composition of oxygen and methane to the ratio of the stoichiometric composition of oxygen and the fuel blend supplied to the engine, as set out in equation (9-5):

$$S_\lambda = \frac{\left(\frac{n_{O2}}{n_{CH4}}\right)}{\left(\frac{n_{O2}}{n_{blend}}\right)} = \frac{2}{(n_{O2})_{blend}} \qquad (9\text{-}5)$$

Where:

$n_{blend}$ = number of molecules of the fuel blend

$(n_{O2})_{blend}$ = the ratio of the molecules in the stoichiometric composition of oxygen and the fuel blend supplied to the engine

Because air contains 21% oxygen the stoichiometric air demand $L_{st}$ of any fuel shall be calculated by means of equation (9-6):

$$L_{st,fuel} = \frac{n_{O2,\ fuel}}{0.21} \quad (9\text{-}6)$$

Where:

$L_{st,fuel}$ = the stoichiometric air demand for the fuel

$n_{O2,\ fuel}$ = the stoichiometric oxygen demand for the fuel

Consequently the value of $S_\lambda$ may also be determined from the ratio of the stoichiometric composition of air and methane to the ratio of the stoichiometric composition of air and the fuel blend supplied to the engine, i.e. the ratio of the stoichiometric air demand of methane to that of the fuel blend supplied to the engine, as set out in equation (9-7):

$$S_\lambda = \frac{\left(\frac{n_{O2}}{n_{CH4}}\right)/0.21}{\left(\frac{n_{O2}}{n_{blend}}\right)/0.21} = \frac{\left(\frac{n_{O2}}{0.21}\right)_{CH4}}{\left(\frac{n_{O2}}{0.21}\right)_{blend}} = \frac{L_{st,CH4}}{L_{st,blend}} \quad (9\text{-}7)$$

Therefore, any calculation that specifies the stoichiometric air demand may be used to express the Lambda-shift factor.

## Appendix 3

## Correction for $CO_2$ in the exhaust gas arising from $CO_2$ in the gaseous fuel

### 1. Instantaneous mass flow rate of $CO_2$ in the gaseous fuel stream

1.1. Gas composition and gas flow shall be determined according to the requirements of sections 1 to 4 of Appendix 1.

1.2 The instantaneous mass flow rate of $CO_2$ in a stream of gas supplied to the engine shall be calculated by means of equation (9-8).

$$\dot{m}_{CO2i} = (M_{CO2} / M_{stream}) * x_{CO2i} * \dot{m}_{streami} \quad (9\text{-}8)$$

Where:

$\dot{m}_{CO2i}$ = Instantaneous mass flow rate of $CO_2$ from the gas stream [g/s]

$\dot{m}_{streami,}$ = Instantaneous mass flow rate of the gas stream [g/s]

$x_{CO2i}$ = Molar fraction of $CO_2$ in the gaseous stream [-]

$M_{CO2}$ = Molar mass of $CO_2$ [g/mol]

$M_{stream}$ = Molar mass of gas stream [g/mol]

$M_{stream}$ shall be calculated from all measured constituents (1, 2, … , n) by means of equation (9-9).

$$M_{stream} = x_1 * M_1 + x_2 * M_2 + ... + x_n * M_n \quad (9\text{-}9)$$

Where:

$X_{1, 2, \ldots n}$ = Molar fraction of each measured constituent in the gas stream ($CH_4$, $CO_2$, …) [-]

$M_{1, 2, \ldots n}$ = Molar mass of each measured constituent in the gas stream [g/mol]

1.3. In order to determine the total mass flow rate of $CO_2$ in the gaseous fuel entering the engine the calculation in equation (9-8) shall be performed for each individual gas stream containing $CO_2$ that is entering the gas blending system and the result for each gas stream added together, or it shall be performed for the blended gas leaving the blending system and entering the engine by means of equation (9-10):

$$\dot{m}_{CO2i,\,fuel} = \dot{m}_{CO2i,\,a} + \dot{m}_{CO2i,\,b} + \ldots + \dot{m}_{CO2i,\,n} \quad (9\text{-}10)$$

Where:

$\dot{m}_{CO2i, fuel}$ = instantaneous combined mass flow rate of $CO_2$ arising from the $CO_2$ in the gaseous fuel entering the engine [g/s]

$\dot{m}_{CO2i, a, b, \ldots, n}$ = instantaneous mass flow rate of $CO_2$ arising from the $CO_2$ in each individual gas stream a, b, …, n [g/s]

2. Calculation of specific $CO_2$ emissions for transient (NRTC and LSI-NRTC) test cycles and RMC

2.1 The total mass per test of $CO_2$ emission from the $CO_2$ in the fuel $m_{CO2, fuel}$ [g/test] shall be calculated by summation of the instantaneous mass flow rate of $CO_2$ in the gaseous fuel entering the engine $\dot{m}_{CO2i, fuel}$ [g/s] over the test cycle by means of equation (9-11):

$$m_{CO2,fuel} = \frac{1}{f} \cdot \sum_{i=1}^{N} \dot{m}_{CO2i,fuel} \quad (9\text{-}11)$$

Where:

$f$ = data sampling rate [Hz]

N = number of measurements [-]

2.2 The total mass of $CO_2$ emission $m_{CO2}$ [g/test] used in equation (7-61), (7-63), (7-128) or (7-130) of Annex VII to calculate the specific emissions result $e_{CO2}$ [g/kWh] shall be replaced in those equations by the corrected value $m_{CO2, corr}$ [g/test] calculated by means of equation (9-12).

$$m_{CO2, corr} = m_{CO2} - m_{CO2, fuel} \quad (9\text{-}12)$$

3. Calculation of specific $CO_2$ emissions for discrete-mode NRSC

3.1 The mean mass flow of $CO_2$ emission from the $CO_2$ in the fuel per hour $q_{mCO2, fuel}$ or $\dot{m}_{CO2, fuel}$ [g/h] shall be calculated for each individual test mode from the measurements of instantaneous mass flow rate of $CO_2$ $\dot{m}_{CO2i, fuel}$ [g/s] given by equation (9-10) taken during the sampling period of the respective test mode by means of equation (9-13):

$$q_{mCO2,fuel} = \dot{m}_{CO2,fuel} = \frac{1}{3600 \cdot N} \cdot \sum_{i=1}^{N} \dot{m}_{CO2i,fuel} \quad (9\text{-}13)$$

Where:

N = number of measurements taken during the test mode [-]

3.2 The mean mass flow rate of $CO_2$ emission $q_{mCO2}$ or $\dot{m}_{CO2}$ [g/h] for each individual test mode used in equation (7-64) or (7-131) of Annex VII to calculate the specific emissions result $e_{CO2}$ [g/kWh] shall be replaced in those equations by the corrected value $q_{mCO2, corr}$ or $\dot{m}_{CO2, corr}$ [g/h] for each individual test mode calculated by means of equation (9-14) or (9-15).

$$q_{mCO2, corr} = q_{mCO2} - q_{mCO2, fuel} \quad (9\text{-}14)$$

$$\dot{m}_{CO2,\,corr} = \dot{m}_{CO2} - \dot{m}_{CO2,\,fuel} \tag{9-15}$$

## ANNEX X

## Detailed technical specifications and conditions for delivering an engine separately from its exhaust after-treatment system

1. Separate shipment, as set out in Article 34(3) of Regulation (EU) 2016/1628, occurs when the manufacturer and the OEM installing the engine are separate legal entities and the engine is shipped by the manufacturer from one location separately from its exhaust after-treatment system, and the exhaust after-treatment system is delivered from a different location and / or at a different moment in time.

2. In this case, the manufacturer shall:

2.1. Be considered responsible for the placing on the market of the engine and for ensuring that the engine is brought into conformity with the approved engine type;

2.2. Place all orders for the parts shipped separately before shipping the engine separately from its exhaust after-treatment system to the OEM;

2.3. Make available to the OEM the instructions for installation of the engine, including the exhaust after-treatment system, and the identification marking of the parts shipped separately as well as the information necessary for checking the proper functioning of the assembled engine according to the approved engine type or engine family.

2.4. Keep records of:

(1) the instructions made available to the OEM;

(2) the list of all parts delivered separately;

(3) the records returned from the OEM confirming that the engines delivered have been brought into conformity in accordance with section 3.;

2.4.1. keep these records for at least 10 years;

2.4.2. Make the records available to the approval authority, the European Commission or market surveillance authorities upon request.

2.5. Ensure that, in addition to the statutory marking required by Article 32 of Regulation (EU) 2016/1628, a temporary marking is affixed to the engine without exhaust after-treatment system, as required by Article 33(1) of that Regulation and in accordance with the provisions set out Annex III to Commission Implementing Regulation 2016/CCC on administrative requirements.

2.6. Ensure that the parts shipped separately from the engines have identification marking (for example part numbers).

2.7. Ensure that in the case of a transition engine, the engine (inclusive of the exhaust after-treatment system) has an engine production date prior to the date for placing on the market of engines set out in Annex III to Regulation (EU) 2016/1628, as required by Article 3(7), Article 3(30) and Article 3(32) of that Regulation.

2.7.1. The records set out in point 2.4 shall include evidence that the exhaust after-treatment system that is part of a transition engine was produced prior to the said date in the case that the production date is not apparent from the marking on the exhaust after-treatment system.

3. The OEM shall:

3.1. Confirm to the manufacturer that the engine has been brought into conformity with the approved engine type or engine family according to the instructions received and that all checks necessary to ensure the proper functioning of the assembled engine according to the approved engine type have been conducted.

3.2. Where an OEM receives a regular supply of engines from a manufacturer the confirmation set out in point 3.1. may be provided at regular intervals agreed between the parties, but not exceeding one year.

## ANNEX XI

## Detailed technical specifications and conditions for the temporary placing on the market for the purposes of field testing

The following conditions shall apply for the temporary placing on the market of engines for the purpose of field testing in accordance with Article 34(4) of Regulation (EU) 2016/1628:

1. The ownership of the engine shall remain with the manufacturer until the procedure set out in point 5. is completed. This does not preclude a financial arrangement with the OEM or end-users who participates in the test procedure.

2. Before placing the engine on the market, the manufacturer shall inform the approval authority of a Member State, indicating his name or trade mark, the unique engine identification number of the engine, the production date of the engine, any relevant information on the emission performance of the engine and the OEM or end-users who participates in the test procedure.

3. The engine shall be accompanied by a statement of conformity delivered by the manufacturer and complying with the provisions set out in Annex II to Commission Implementing Regulation 2016/CCC on administrative requirements; the statement of conformity shall indicate, in particular, that it is a field testing engine temporarily placed on the market in accordance with Article 34(4) of Regulation (EU) 2016/1628.

4. The engine shall bear the statutory marking set out in Annex III to Commission Implementing Regulation 2016/CCC on administrative requirements;

5. When the tests have been completed and in any case 24 months from the placing on the market of the engine, the manufacturer shall ensure that the engine is either withdrawn from the market or brought into conformity with Regulation (EU) 2016/1628. The manufacturer shall inform the authorising approval authority of the option taken.

6. Notwithstanding point 5., the manufacturer may apply for an extension of the duration of the test for up to 24 additional months, before the same approval authority providing due justification for the extension request.

6.1. The approval authority may authorise the extension, if deemed justified. In this case:

(1) a new statement of conformity shall be issued by the manufacturer for the additional period; and

(2) the provisions set out in point 5 shall apply by the end of the extension period or, in any case, 48 months after placing the engine on the market.

## ANNEX XII

## Detailed technical specifications and conditions for special purpose engines

The following conditions shall apply for placing on the market of engines that meet the gaseous and particulate pollutant emission limit values for special purpose engines set out in Annex VI to Regulation (EU) 2016/1628:

1. Before placing the engine on the market, the manufacturer shall take reasonable measures to ensure that the engine will be installed in a non-road mobile machinery to be exclusively used in potentially explosive atmospheres, in accordance with Article 35(5) of that Regulation, or for the launch and recovery of lifeboats operated by a national rescue service, in accordance with Article 35(6) of that Regulation.

2. For the purposes of point 1., a written statement from the OEM or economic operator receiving the engine confirming that it will be installed in a non-road mobile machinery to be exclusively used for such special purposes, shall be considered a reasonable measure.

3. The manufacturer shall:

   (1) keep the written statement set out in point 2. for at least 10 years; and

   (2) make it available to the approval authority, the European Commission or market surveillance authorities upon request.

4. The engine shall be accompanied by a statement of conformity delivered by the manufacturer and complying with the provisions set out in Annex II to Commission Implementing Regulation 2016/CCC on administrative requirements; the statement of conformity shall indicate, in particular, that it is a special purpose engine placed on the market under the conditions set out in Article 34(5) or 34(6) of Regulation (EU) 2016/1628.

5. The engine shall bear the statutory marking set out in Annex III to Commission Implementing Regulation 2016/CCC on administrative requirements.

# ANNEX XIII

## Acceptance of equivalent engine type-approvals

1. For engine families or engines types of category NRE the following type-approvals and, where applicable, the corresponding statutory marking, shall be recognised as equivalent to EU type-approvals granted and statutory marking required in accordance with Regulation (EU) 2016/1628:

   (1) EU type-approvals granted on the basis of Regulation (EC) No 595/2009 and its implementing measures, where a technical service confirms that the engine type meets:

      (a) the requirements set out in Appendix 2 of Annex IV, when the engine is exclusively intended for use in the place of Stage V engines of categories IWP and IWA, in accordance with Article 4(1), point (1)(b) of Regulation (EU) 2016/1628, or

      (b) the requirements set out in Appendix 1 of Annex IV for engines not covered by paragraph (a);

   (2) type-approvals in conformity with UNECE Regulation No 49.06 series of amendments, when a technical service confirms that the engine type meets:

      (a) the requirements set out in Appendix 2 of Annex IV, when the engine is exclusively intended for use in the place of Stage V engines of categories IWP and IWA, in accordance with Article 4(1), point (1)(b) of Regulation (EU) 2016/1628, or

      (b) the requirements set out in Appendix 1 of Annex IV for engines not covered by paragraph (a);

## ANNEX XIV

## Details of the relevant information and instructions for OEMs

1. As required by Article 43(2) of Regulation (EU) 2016/1628, the manufacturer shall provide to the OEM all relevant information and instructions to ensure that the engine conforms to the approved engine type when installed in non-road mobile machinery. Instructions for this purpose shall be clearly identified to the OEM.

2. The instructions may be provided on paper or a commonly used electronic format.

3. Where a number of engines requiring the same instructions are supplied to the same OEM it shall be necessary to provide only one set of instructions.

4. The information and instructions to the OEM shall include at least:

   (1) installation requirements to achieve the emissions performance of the engine type, including the emissions control system, that shall be taken into account to ensure the correct operation of the emissions control system;

   (2) a description of any special conditions or restrictions linked to the installation or use of the engine, as noted on the EU type-approval certificate set out in Annex IV to Commission Implementing Regulation (EU) 2016/CCC on administrative requirements;

   (3) a statement indicating that the installation of the engine shall not permanently constrain the engine to exclusively operate within a power range corresponding to a (sub-)category with gaseous and particulate pollutant emission limits more stringent than the (sub-)category the engine belongs to;

   (4) for engine families to which Annex V applies, the upper and lower boundaries of the applicable control area and a statement indicating that the installation of the engine shall not constrain the engine to exclusively operate at speed and load points outside of the control area for the torque curve of the engine;

   (5) where applicable, design requirements for the components supplied by the OEM that are not part of the engine and are necessary to ensure that, when installed, the engine conforms to the approved engine type;

   (6) where applicable, design requirements for the reagent tank, including freeze protection, monitoring of reagent level and means to take samples of reagent;

   (7) where applicable, information on the possible installation of a non-heated reagent system;

   (8) where applicable, a statement indicating that the engine is exclusively intended for installation in snow throwers;

   (9) where applicable, a statement indicating that the OEM shall provide a warning system as set out in Appendices 1 to 4 of Annex IV;

(10) where applicable, information on the interface between the engine and the non-road mobile machinery for the operator warning system, referred to in point (9);

(11) where applicable, information on the interface between the engine and the non-road mobile machinery for the operator inducement system, as set out in section 5.of Appendix 1 of Annex IV;

(12) where applicable, information on a means to temporarily disable the operator inducement as defined in point 5.2.1. of Appendix 1 of Annex IV;

(13) where applicable, information on the inducement override function as defined in point 5.5. of Appendix 1 of Annex IV;

(14) in the case of dual-fuel engines:

(a) a statement indicating that the OEM shall provide a dual-fuel operating mode indicator as described in point 4.3.1. of Annex VIII,

(b) a statement indicating that the OEM shall provide a dual-fuel warning system as described in point 4.3.2. of Annex VIII,

(c) information on the interface between the engine and the non-road mobile machinery for the operator indication and warning system, referred to in points (14)(a) and (b);

(15) in the case of a variable speed engine of category IWP that is type-approved for use in one or more other inland waterway application as set out in point 1.1.1.2. of Annex IX to Commission Implementing Regulation (EU) 2016/CCC on administrative requirements, the details of each (sub-)category and operating mode (speed operation) for which the engine is type approved and may be set when installed;

(16) In the case of a constant-speed engine equipped with alternative speeds as set out in section 1.1.2.3 of Annex IX to Commission Implementing Regulation (EU) 2016/CCC on administrative requirements:

(a) a statement indicating that the installation of the engine shall ensure that:

i. the engine is stopped prior to resetting the constant-speed governor to an alternative speed; and,

ii. the constant-speed governor is only set to the alternative speeds permitted by the engine manufacturer;

(b) details of each (sub-)category and operating mode (speed operation) for which the engine is type-approved and may be set when installed;

(17) In the case that the engine is equipped with an idle speed for start-up and shut-down, as permitted by Article 3 (18) of Regulation (EU) 2016/1628, a statement indicating that the installation of the engine shall ensure that the

constant-speed governor function is engaged prior to increasing the load-demand to the engine from the no-load setting.

5. As required by Article 43(3) of Regulation (EU) 2016/1628, the manufacturer shall provide to the OEM all information and necessary instructions that the OEM shall provide to the end-users in accordance with Annex XV.

6. As required by Article 43(4) of Regulation (EU) 2016/1628, the manufacturer shall provide to the OEM the value of the carbon dioxide ($CO_2$) emissions in g/kWh determined during the EU type-approval process and recorded in EU type-approval certificate. This value shall be provided by the OEM to the end-users accompanied of the following statement: '*This $CO_2$ measurement results from testing over a fixed test cycle under laboratory conditions a(n) (parent) engine representative of the engine type (engine family) and shall not imply or express any guarantee of the performance of a particular engine*'.

# ANNEX XV

## Details of the relevant information and instructions for end-users

1. The OEM shall provide to the end-users all information and necessary instructions for the correct operation of the engine in order to maintain the gaseous and particulate pollutant emissions of the engine within the limits of the approved engine type or engine family. Instructions for this purpose shall be clearly identified to the end-users.

2. The instructions to the end-users shall be:

2.1. written in a clear and non-technical manner using the same language that is used in the instructions to end-users for the non-road mobile machinery;

2.2. be provided on paper or, alternatively, a commonly used electronic format;

2.3. be part of the instructions to end-users for the non-road machinery or, alternatively, a separate document;

2.3.1. when delivered separately from the instructions to end-users for the non-road machinery, be provided in the same form;

3. The information and instructions to the end-users shall include at least:

(1) a description of any special conditions or restrictions linked to the use of the engine, as noted on the EU type-approval certificate set out in Annex IV to Commission Implementing Regulation (EU) 2016/CCC on administrative requirements;

(2) a statement indicating that the engine, including the emissions control system, shall be operated, used and maintained in accordance with the instructions provided to the end-users in order to maintain the emissions performance of the engine within the requirements applicable to the engine's category;

(3) a statement indicating that no deliberate tampering with or misuse of the engine emissions control system should take place; in particular with regard to deactivating or not maintaining an exhaust gas recirculation (EGR) or a reagent dosing system.

(4) a statement indicating that it is essential to take prompt action to rectify any incorrect operation, use or maintenance of the emissions control system in accordance with the rectification measures indicated by the warnings referred to in points (5) and (6);

(5) detailed explanations of the possible malfunctions of the emissions control system generated by incorrect operation, use or maintenance of the installed engine, accompanied by the associated warning signals and the corresponding rectification measures;

(6) detailed explanations of the possible incorrect use of the non-road mobile machinery that would result in malfunctions of the engine emissions control system, accompanied by the associated warning signals and the corresponding rectification measures;

(7) where applicable, information on the possible use of a non-heated reagent tank and dosing system;

(8) where applicable, a statement indicating that the engine is exclusively intended for use in snow throwers;

(9) for non-road mobile machinery with an operator warning system, as defined in section 4. Appendix 1 of Annex IV (category: NRE, NRG, IWP, IWA or RLR) and/or section 4. of Appendix 4 of Annex IV (category: NRE, NRG, IWP, IWA or RLR) or section 3. of Appendix 3 of Annex IV (category RLL), a statement indicating that the operator will be informed by the operator warning system when the emission control system does not function correctly;

(10) for non-road mobile machinery with an operator inducement system as defined in section 5. of Appendix 1 of Annex IV (category NRE, NRG), a statement indicating that ignoring the operator warning signals will lead to the activation of the operator inducement system, resulting in an effective disablement of non-road mobile machinery operation;

(11) for non-road mobile machinery with an inducement override function as defined in point 5.5. of Appendix 1 of Annex IV for releasing full engine power, information about the operation of this function;

(12) where applicable, explanations of how the operator warning and inducement systems referred to in points (9), (10) and (11) operate, including the consequences, in terms of performance and fault logging, of ignoring the warning system signals and of not replenishing, where used, the reagent or rectifying the problem identified;

(13) where records in the on-board computer log of inadequate reagent injection or reagent quality are made in accordance with point 4.1. of Appendix 2 of Annex IV (category: IWP, IWA, RLR),an statement indicating that national inspection authorities will be able to read with a scan tool these records;

(14) for non-road mobile machinery with a means to disable the operator inducement as defined in point 5.2.1. of Appendix 1 of Annex IV, information about the operation of this function, and a statement indicating that this function shall be only activated in case of emergencies, that any activation will be recorded in the on-board computer log and that national inspection authorities will be able to read these records with a scan tool;

(15) information on the fuel specification(s) necessary to maintain the performance of the emissions control system following the requirements of Annex I and in consistency with the specifications set-out in the engine EU type-approval including, where available, reference to the appropriate EU or international standard, in particular:

(a) where the engine is to be operated within the Union on diesel or non-road gas-oil, a statement indicating that a fuel with sulphur content not greater than 10 mg/kg (20 mg/kg at point of final distribution) cetane number not less than 45 and an FAME content not greater than 7 % v/v shall be used.

(b) where additional fuels, fuel mixtures or fuel emulsions are compatible with use by the engine, as declared by the manufacturer and stated in the EU type-approval certificate, these shall be indicated;

(16) information on the lubrication oil specifications necessary to maintain the performance of the emissions control system;

(17) where the emission control system requires a reagent, the characteristics of that reagent, including the type of reagent, information on concentration when the reagent is in solution, operational temperature conditions and reference to international standards for composition and quality, consistent with the specification set-out in the engine EU type-approval.

(18) where applicable, instructions specifying how consumable reagents have to be refilled by the operator between normal maintenance intervals. They shall indicate how the operator should refill the reagent tank and the anticipated frequency of refill, depending upon utilisation of the non-road mobile machinery.

(19) a statement indicating that in order to maintain the emissions performance of the engine, it is essential to use and refill reagent in accordance with the specifications set out in points (17) and (18);

(20) scheduled emission-related maintenance requirements including any scheduled exchange of critical emission-related components;

(21) in the case of dual fuel engines:

(a) where applicable, information on the dual-fuel indicators set out in section 4.3. of Annex VIII,

(b) where a dual fuel engine has operability restrictions in a service mode as defined in point 4.2.2.1. of Annex VIII (excluding categories: IWP, IWA, RLL and RLR), a statement indicating that the activation of the service mode will result in an effective disablement of non-road mobile machinery operation,

(c) where an inducement override function for releasing full engine power is available, information about the operation of this function shall be provided,

(d) where a dual fuel engine operates in a service mode in accordance with point 4.2.2.2. of Annex VIII (categories: IWP, IWA, RLL and RLR), a statement indicating that the activation of the service mode will be recorded in the on-board computer log and that national inspection authorities will be able to read these records with a scan tool.

4. As required by Article 43(4) of Regulation (EU) 2016/1628, the OEM shall provide to the end-users the value of the carbon dioxide ($CO_2$) emissions in g/kWh determined during the EU type-approval process and recorded in EU type-approval certificate accompanied of the following statement: '*This $CO_2$ measurement results from testing over a fixed test cycle under laboratory conditions a(n) (parent) engine representative of the engine type (engine family) and shall not imply or express any guarantee of the performance of a particular engine*'.

## Annex XVI

## Performance standards and assessment of technical services

**1. General Requirements**

Technical services shall demonstrate appropriate skills, specific technical knowledge and proven experience in the specific fields of competence covered by Regulation (EU) 2016/1628 and the delegated and implementing acts adopted pursuant to that Regulation.

**2. Standards with which the technical services have to comply**

2.1. Technical services of the different categories set out in Article 45 of Regulation (EU) 2016/1628 shall comply with the standards listed in Appendix 1 of Annex V to Directive 2007/46/EC of the European Parliament and of the Council[2] which are relevant for the activities they carry out.

2.2. Reference to Article 41 of Directive 2007/46/EC in that Appendix shall be construed as a reference to Article 45 of Regulation (EU) 2016/1628.

2.3. Reference to Annex IV of Directive 2007/46/EC in that Appendix shall be construed as a reference to Regulation (EU) 2016/1628 and the delegated and implementing acts adopted pursuant to that Regulation.

**3. Procedure for the assessment of the technical services**

3.1. The compliance of the Technical services with the requirements of Regulation (EU) 2016/1628 and the delegated and implementing acts adopted pursuant to that Regulation shall be assessed in accordance with the procedure set out in Appendix 2 of Annex V to Directive 2007/46/EC.

3.2. References to Article 42 of Directive 2007/46/EC in Appendix 2 of Annex V to Directive 2007/46/EC shall be construed as references to Article 48 of Regulation (EU) 2016/1628.

[2] Directive 2007/46/EC of the European Parliament and of the Council of 5 September 2007establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (OJ L 263, 9.10.2007, p. 1).

# Annex XVII

## Characteristics of the steady-state and transient test cycles

1. Tables of test modes and weighting factors for the discrete-mode NRSC are set out in Appendix 1.

2. Tables of test modes and weighting factors for the RMC are set out in Appendix 2.

3. Tables of engine dynamometer schedules for transient (NRTC and LSI-NRTC) test cycles are set out in Appendix 3.

## Appendix 1

## Steady-state discrete-mode NRSC

### Test cycles type C

### Table of cycle C1 test modes and weighting factors

| **Mode number** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
|---|---|---|---|---|---|---|---|---|
| **Speed (a)** | 100% | | | | Intermediate | | | Idle |
| **Torque (b)** (%) | 100 | 75 | 50 | 10 | 100 | 75 | 50 | 0 |
| **Weighting factor** | 0,15 | 0,15 | 0,15 | 0,1 | 0,1 | 0,1 | 0,1 | 0,15 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** The % torque is relative to the maximum torque at the commanded engine speed.

### Table of cycle C2 test modes and weighting factors

| **Mode number** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|---|
| **Speed (a)** | 100% | Intermediate | | | | | Idle |
| **Torque (b)** (%) | 25 | 100 | 75 | 50 | 25 | 10 | 0 |
| **Weighting factor** | 0,06 | 0,02 | 0,05 | 0,32 | 0,30 | 0,10 | 0,15 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** The % torque is relative to the maximum torque at the commanded engine speed.

**Test cycles type D**

**Table of cycle D2 test modes and weighting factors**

| **Mode number** (cycle D2) | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| **Speed (a)** | 100% | | | | |
| **Torque (b)** (%) | 100 | 75 | 50 | 25 | 10 |
| **Weighting factor** | 0,05 | 0,25 | 0,3 | 0,3 | 0,1 |
| **(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.<br><br>**(b)** % torque is relative to the torque corresponding to the rated net power declared by the manufacturer. | | | | | |

## Test cycles type E

### Table of cycles type E test modes and weighting factors

| **Mode number** (cycle E2) | **1** | **2** | **3** | **4** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Speed (a)** | 100% | | | | | Intermediate | | | | |
| **Torque (b)** (%) | 100 | 75 | 50 | 25 | | | | | | |
| **Weighting factor** | 0,2 | 0,5 | 0,15 | 0,15 | | | | | | |

| **Mode number** (cycle E3) | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Speed (a)** (%) | 100 | 91 | 80 | 63 |
| **Power (c)** (%) | 100 | 75 | 50 | 25 |
| **Weighting factor** | 0,2 | 0,5 | 0,15 | 0,15 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % torque is relative to the torque corresponding to the rated net power declared by the manufacturer at the commanded engine speed.

**(c)** % power is relative to the maximum rated power at the 100 % speed.

**(d)** % torque is relative to the torque corresponding to the rated net power.

## Test cycle type F

### Table of cycle type F test modes and weighting factors

| **Mode number** | **1** | **2 (d)** | **3** |
|---|---|---|---|
| **Speed (a)** | 100% | Intermediate | Idle |
| **Power** (%) | 100 **(c)** | 50 **(c)** | 5 **(b)** |
| **Weighting factor** | 0,15 | 0,25 | 0,6 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % power at this mode is relative to the power at mode 1.

**(c)** % power at this mode is relative to the maximum net power at the commanded engine speed.

**(d)** For engines using a discrete control system (i.e. notch type controls) mode 2 is defined as an operation in the

| |
|---|
| notch closest to mode 2 or 35 % of the rated power. |

**Test cycle type G**

**Table of cycles type G test modes and weighting factors**

| **Mode number** (cycle G1) | | | | | | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Speed (a)** | 100% | | | | | Intermediate | | | | | Idle |
| **Torque (b)** % | | | | | | 100 | 75 | 50 | 25 | 10 | 0 |
| **Weighting factor** | | | | | | 0,09 | 0,20 | 0,29 | 0,30 | 0,07 | 0,05 |
| **Mode number** (cycle G2) | **1** | **2** | **3** | **4** | **5** | | | | | | **6** |
| **Speed (a)** | 100% | | | | | Intermediate | | | | | Idle |
| **Torque (b)** % | 100 | 75 | 50 | 25 | 10 | | | | | | 0 |
| **Weighting factor** | 0,09 | 0,20 | 0,29 | 0,30 | 0,07 | | | | | | 0,05 |
| **Mode number** (cycle G3) | **1** | | | | | | | | | | **2** |
| **Speed (a)** | 100% | | | | | Intermediate | | | | | Idle |
| **Torque (b)** % | 100 | | | | | | | | | | 0 |
| **Weighting factor** | 0,85 | | | | | | | | | | 0,15 |
| **(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds. **(b)** The % torque is relative to the maximum torque at the commanded engine speed. | | | | | | | | | | | |

**Test cycle type H**

**Table of cycle type H test modes and weighting factors**

| **Mode number** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| **Speed (a)** (%) | 100 | 85 | 75 | 65 | Idle |

| | | | | | |
|---|---|---|---|---|---|
| **Torque (b)** (%) | 100 | 51 | 33 | 19 | 0 |
| **Weighting factor** | 0,12 | 0,27 | 0,25 | 0,31 | 0,05 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % torque is relative to the maximum torque at the commanded engine speed.

## Appendix 2

## Steady-state ramped modal cycles (RMC)

### Test cycles type C

### Table of RMC-C1 test modes

| RMC Mode Number | Time in mode (seconds) | Engine speed (a)(c) | Torque (%) (b)(c) |
|---|---|---|---|
| 1a Steady-state | 126 | Idle | 0 |
| 1b Transition | 20 | Linear transition | Linear transition |
| 2a Steady-state | 159 | Intermediate | 100 |
| 2b Transition | 20 | Intermediate | Linear transition |
| 3a Steady-state | 160 | Intermediate | 50 |
| 3b Transition | 20 | Intermediate | Linear transition |
| 4a Steady-state | 162 | Intermediate | 75 |
| 4b Transition | 20 | Linear transition | Linear transition |
| 5a Steady-state | 246 | 100 % | 100 |
| 5b Transition | 20 | 100 % | Linear transition |
| 6a Steady-state | 164 | 100 % | 10 |
| 6b Transition | 20 | 100 % | Linear transition |
| 7a Steady-state | 248 | 100 % | 75 |
| 7b Transition | 20 | 100 % | Linear transition |
| 8a Steady-state | 247 | 100 % | 50 |
| 8b Transition | 20 | Linear transition | Linear transition |
| 9 Steady-state | 128 | Idle | 0 |

**a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % torque is relative to the maximum torque at the commanded engine speed.

**(c)** Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode, and simultaneously command a similar linear progression for engine speed if there is a change in speed setting.

## Table of RMC-C2 test modes

| RMC Mode number | Time in mode (seconds) | Engine speed (a)(c) | Torque (%) (b)(c) |
|---|---|---|---|
| 1a Steady-state | 119 | Idle | 0 |
| 1b Transition | 20 | Linear transition | Linear transition |
| 2a Steady-state | 29 | Intermediate | 100 |
| 2b Transition | 20 | Intermediate | Linear transition |
| 3a Steady-state | 150 | Intermediate | 10 |
| 3b Transition | 20 | Intermediate | Linear transition |
| 4a Steady-state | 80 | Intermediate | 75 |
| 4b Transition | 20 | Intermediate | Linear transition |
| 5a Steady-state | 513 | Intermediate | 25 |
| 5b Transition | 20 | Intermediate | Linear transition |
| 6a Steady-state | 549 | Intermediate | 50 |
| 6b Transition | 20 | Linear transition | Linear transition |
| 7a Steady-state | 96 | 100% | 25 |
| 7b Transition | 20 | Linear transition | Linear transition |
| 8 Steady-state | 124 | Idle | 0 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % torque is relative to the maximum torque at the commanded engine speed.

**(c)** Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode, and simultaneously command a similar linear progression for engine speed if there is a change in speed setting.

## Test cycles type D

### Table of RMC-D2 test modes

| RMC Mode Number | Time in mode (seconds) | Engine speed (%) (a) | Torque (%) (b)(c) |
|---|---|---|---|
| 1a Steady State | 53 | 100 | 100 |
| 1b Transition | 20 | 100 | Linear transition |
| 2a Steady-state | 101 | 100 | 10 |
| 2b Transition | 20 | 100 | Linear transition |
| 3a Steady-state | 277 | 100 | 75 |
| 3b Transition | 20 | 100 | Linear transition |
| 4a Steady-state | 339 | 100 | 25 |
| 4b Transition | 20 | 100 | Linear transition |
| 5 Steady-state | 350 | 100 | 50 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % torque is relative to the torque corresponding to the rated net power declared by the manufacturer.

**(c)** Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode.

## Test cycles type E

### Table of RMC-E2 test modes

| RMC<br>Mode Number | Time in mode (seconds) | Engine speed (%) (a) | Torque (%) (b)(c) |
|---|---|---|---|
| 1a Steady-state | 229 | 100 | 100 |
| 1b Transition | 20 | 100 | Linear transition |
| 2a Steady-state | 166 | 100 | 25 |
| 2b Transition | 20 | 100 | Linear transition |
| 3a Steady-state | 570 | 100 | 75 |
| 3b Transition | 20 | 100 | Linear transition |
| 4 Steady-state | 175 | 100 | 50 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % torque is relative to the maximum torque corresponding to the rated net power declared by the manufacturer at the commanded engine speed.

**(c)** Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode.

## Table of RMC-E3 test modes

| RMC Mode Number | Time in mode (seconds) | Engine speed (%) (a)(c) | Power (%) (b)(c) |
|---|---|---|---|
| 1a Steady-state | 229 | 100 | 100 |
| 1b Transition | 20 | Linear transition | Linear transition |
| 2a Steady-state | 166 | 63 | 25 |
| 2b Transition | 20 | Linear transition | Linear transition |
| 3a Steady-state | 570 | 91 | 75 |
| 3b Transition | 20 | Linear transition | Linear transition |
| 4 Steady-state | 175 | 80 | 50 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % power is relative to the maximum rated net power at the 100% speed.

**(c)** Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode, and simultaneously command a similar linear progression for engine speed.

## Test cycle type F

### Table of RMC-F test modes

| **RMC Mode Number** | **Time in mode (seconds)** | **Engine speed (a)(e)** | **Power (%) (e)** |
|---|---|---|---|
| 1a Steady-state | 350 | Idle | 5 (b) |
| 1b Transition | 20 | Linear transition | Linear transition |
| 2a Steady-state(d) | 280 | Intermediate | 50 (c) |
| 2b Transition | 20 | Linear transition | Linear transition |
| 3a Steady-state | 160 | 100 % | 100 (c) |
| 3b Transition | 20 | Linear Transition | Linear transition |
| 4 Steady-state | 350 | Idle | 5 (c) |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % power at this mode is relative to the net power at mode 3a.

**(c)** % power at this mode is relative to the maximum net power at the commanded engine speed.

**(d)** For engines using a discrete control system (i.e. notch type controls) mode 2a is defined as an operation in the notch closest to mode 2a or 35 % of the rated power.

**(e)** Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode, and simultaneously command a similar linear progression for engine speed if there is a change in speed setting.

## Test cycles type G

### Table of RMC-G1 test modes

| RMC Mode Number | Time in mode (seconds) | Engine speed (a)(c) | Torque (%) (b)(c) |
|---|---|---|---|
| 1a Steady-state | 41 | Idle | 0 |
| 1b Transition | 20 | Linear transition | Linear transition |
| 2a Steady-state | 135 | Intermediate | 100 |
| 2b Transition | 20 | Intermediate | Linear transition |
| 3a Steady-state | 112 | Intermediate | 10 |
| 3b Transition | 20 | Intermediate | Linear transition |
| 4a Steady-state | 337 | Intermediate | 75 |
| 4b Transition | 20 | Intermediate | Linear transition |
| 5a Steady-state | 518 | Intermediate | 25 |
| 5b Transition | 20 | Intermediate | Linear transition |
| 6a Steady-state | 494 | Intermediate | 50 |
| 6b Transition | 20 | Linear transition | Linear transition |
| 7 Steady-state | 43 | Idle | 0 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** The % torque is relative to the maximum torque at the commanded engine speed.

**(c)** Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode and simultaneously command a similar linear progression for engine speed if there is a change in speed setting.

## Table of RMC-G2 test modes

| RMC Mode Number | Time in mode (seconds) | Engine speed (a)(c) | Torque (%) (b)(c) |
|---|---|---|---|
| 1a Steady-state | 41 | Idle | 0 |
| 1b Transition | 20 | Linear transition | Linear transition |
| 2a Steady-state | 135 | 100 % | 100 |
| 2b Transition | 20 | 100 % | Linear transition |
| 3a Steady-state | 112 | 100 % | 10 |
| 3b Transition | 20 | 100 % | Linear transition |
| 4a Steady-state | 337 | 100 % | 75 |
| 4b Transition | 20 | 100 % | Linear transition |
| 5a Steady-state | 518 | 100 % | 25 |
| 5b Transition | 20 | 100 % | Linear transition |
| 6a Steady-state | 494 | 100 % | 50 |
| 6b Transition | 20 | Linear transition | Linear transition |
| 7 Steady-state | 43 | Idle | 0 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** The % torque is relative to the maximum torque at the commanded engine speed.

**(c)** Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode and simultaneously command a similar linear progression for engine speed if there is a change in speed setting.

## Test cycle type H

### Table of RMC-H test modes

| **RMC Mode Number** | **Time in mode (seconds)** | **Engine speed (a)(c)** | **Torque (%) (b)(c)** |
|---|---|---|---|
| 1a Steady-state | 27 | Idle | 0 |
| 1b Transition | 20 | Linear transition | Linear transition |
| 2a Steady-state | 121 | 100% | 100 |
| 2b Transition | 20 | Linear transition | Linear transition |
| 3a Steady-state | 347 | 65% | 19 |
| 3b Transition | 20 | Linear transition | Linear transition |
| 4a Steady-state | 305 | 85% | 51 |
| 4b Transition | 20 | Linear transition | Linear transition |
| 5a Steady-state | 272 | 75% | 33 |
| 5b Transition | 20 | Linear transition | Linear transition |
| 6 Steady-state | 28 | Idle | 0 |

**(a)** See sections 5.2.5., 7.6. and 7.7. of Annex VI for determination of required test speeds.

**(b)** % torque is relative to the maximum torque at the commanded engine speed.

**(c)** Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode, and simultaneously command a similar linear progression for engine speed if there is a change in speed setting.

## Appendix 3. 2.4.2.1. Transient (NRTC and LSI-NRTC) test cycles

### NRTC engine dynamometer schedule

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 0 | 0 |
| 3 | 0 | 0 |
| 4 | 0 | 0 |
| 5 | 0 | 0 |
| 6 | 0 | 0 |
| 7 | 0 | 0 |
| 8 | 0 | 0 |
| 9 | 0 | 0 |
| 10 | 0 | 0 |
| 11 | 0 | 0 |
| 12 | 0 | 0 |
| 13 | 0 | 0 |
| 14 | 0 | 0 |
| 15 | 0 | 0 |
| 16 | 0 | 0 |
| 17 | 0 | 0 |
| 18 | 0 | 0 |
| 19 | 0 | 0 |
| 20 | 0 | 0 |
| 21 | 0 | 0 |
| 22 | 0 | 0 |
| 23 | 0 | 0 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 24 | 1 | 3 |
| 25 | 1 | 3 |
| 26 | 1 | 3 |
| 27 | 1 | 3 |
| 28 | 1 | 3 |
| 29 | 1 | 3 |
| 30 | 1 | 6 |
| 31 | 1 | 6 |
| 32 | 2 | 1 |
| 33 | 4 | 13 |
| 34 | 7 | 18 |
| 35 | 9 | 21 |
| 36 | 17 | 20 |
| 37 | 33 | 42 |
| 38 | 57 | 46 |
| 39 | 44 | 33 |
| 40 | 31 | 0 |
| 41 | 22 | 27 |
| 42 | 33 | 43 |
| 43 | 80 | 49 |
| 44 | 105 | 47 |
| 45 | 98 | 70 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 46 | 104 | 36 |
| 47 | 104 | 65 |
| 48 | 96 | 71 |
| 49 | 101 | 62 |
| 50 | 102 | 51 |
| 51 | 102 | 50 |
| 52 | 102 | 46 |
| 53 | 102 | 41 |
| 54 | 102 | 31 |
| 55 | 89 | 2 |
| 56 | 82 | 0 |
| 57 | 47 | 1 |
| 58 | 23 | 1 |
| 59 | 1 | 3 |
| 60 | 1 | 8 |
| 61 | 1 | 3 |
| 62 | 1 | 5 |
| 63 | 1 | 6 |
| 64 | 1 | 4 |
| 65 | 1 | 4 |
| 66 | 0 | 6 |
| 67 | 1 | 4 |
| 68 | 9 | 21 |
| 69 | 25 | 56 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 70 | 64 | 26 |
| 71 | 60 | 31 |
| 72 | 63 | 20 |
| 73 | 62 | 24 |
| 74 | 64 | 8 |
| 75 | 58 | 44 |
| 76 | 65 | 10 |
| 77 | 65 | 12 |
| 78 | 68 | 23 |
| 79 | 69 | 30 |
| 80 | 71 | 30 |
| 81 | 74 | 15 |
| 82 | 71 | 23 |
| 83 | 73 | 20 |
| 84 | 73 | 21 |
| 85 | 73 | 19 |
| 86 | 70 | 33 |
| 87 | 70 | 34 |
| 88 | 65 | 47 |
| 89 | 66 | 47 |
| 90 | 64 | 53 |
| 91 | 65 | 45 |
| 92 | 66 | 38 |
| 93 | 67 | 49 |
| 94 | 69 | 39 |
| 95 | 69 | 39 |
| 96 | 66 | 42 |
| 97 | 71 | 29 |
| 98 | 75 | 29 |
| 99 | 72 | 23 |
| 100 | 74 | 22 |
| 101 | 75 | 24 |
| 102 | 73 | 30 |
| 103 | 74 | 24 |
| 104 | 77 | 6 |
| 105 | 76 | 12 |
| 106 | 74 | 39 |
| 107 | 72 | 30 |
| 108 | 75 | 22 |
| 109 | 78 | 64 |
| 110 | 102 | 34 |
| 111 | 103 | 28 |
| 112 | 103 | 28 |
| 113 | 103 | 19 |
| 114 | 103 | 32 |
| 115 | 104 | 25 |
| 116 | 103 | 38 |
| 117 | 103 | 39 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 118 | 103 | 34 |
| 119 | 102 | 44 |
| 120 | 103 | 38 |
| 121 | 102 | 43 |
| 122 | 103 | 34 |
| 123 | 102 | 41 |
| 124 | 103 | 44 |
| 125 | 103 | 37 |
| 126 | 103 | 27 |
| 127 | 104 | 13 |
| 128 | 104 | 30 |
| 129 | 104 | 19 |
| 130 | 103 | 28 |
| 131 | 104 | 40 |
| 132 | 104 | 32 |
| 133 | 101 | 63 |
| 134 | 102 | 54 |
| 135 | 102 | 52 |
| 136 | 102 | 51 |
| 137 | 103 | 40 |
| 138 | 104 | 34 |
| 139 | 102 | 36 |
| 140 | 104 | 44 |
| 141 | 103 | 44 |
| 142 | 104 | 33 |
| 143 | 102 | 27 |
| 144 | 103 | 26 |
| 145 | 79 | 53 |
| 146 | 51 | 37 |
| 147 | 24 | 23 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 148 | 13 | 33 |
| 149 | 19 | 55 |
| 150 | 45 | 30 |
| 151 | 34 | 7 |
| 152 | 14 | 4 |
| 153 | 8 | 16 |
| 154 | 15 | 6 |
| 155 | 39 | 47 |
| 156 | 39 | 4 |
| 157 | 35 | 26 |
| 158 | 27 | 38 |
| 159 | 43 | 40 |
| 160 | 14 | 23 |
| 161 | 10 | 10 |
| 162 | 15 | 33 |
| 163 | 35 | 72 |
| 164 | 60 | 39 |
| 165 | 55 | 31 |
| 166 | 47 | 30 |
| 167 | 16 | 7 |
| 168 | 0 | 6 |
| 169 | 0 | 8 |
| 170 | 0 | 8 |
| 171 | 0 | 2 |
| 172 | 2 | 17 |
| 173 | 10 | 28 |
| 174 | 28 | 31 |
| 175 | 33 | 30 |
| 176 | 36 | 0 |
| 177 | 19 | 10 |
| 178 | 1 | 18 |
| 179 | 0 | 16 |
| 180 | 1 | 3 |
| 181 | 1 | 4 |
| 182 | 1 | 5 |
| 183 | 1 | 6 |
| 184 | 1 | 5 |
| 185 | 1 | 3 |
| 186 | 1 | 4 |
| 187 | 1 | 4 |
| 188 | 1 | 6 |
| 189 | 8 | 18 |
| 190 | 20 | 51 |
| 191 | 49 | 19 |
| 192 | 41 | 13 |
| 193 | 31 | 16 |
| 194 | 28 | 21 |
| 195 | 21 | 17 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
| --- | --- | --- |
| 196 | 31 | 21 |
| 197 | 21 | 8 |
| 198 | 0 | 14 |
| 199 | 0 | 12 |
| 200 | 3 | 8 |
| 201 | 3 | 22 |
| 202 | 12 | 20 |
| 203 | 14 | 20 |
| 204 | 16 | 17 |
| 205 | 20 | 18 |
| 206 | 27 | 34 |
| 207 | 32 | 33 |
| 208 | 41 | 31 |
| 209 | 43 | 31 |
| 210 | 37 | 33 |
| 211 | 26 | 18 |
| 212 | 18 | 29 |
| 213 | 14 | 51 |
| 214 | 13 | 11 |
| 215 | 12 | 9 |
| 216 | 15 | 33 |
| 217 | 20 | 25 |
| 218 | 25 | 17 |
| 219 | 31 | 29 |
| 220 | 36 | 66 |
| 221 | 66 | 40 |
| 222 | 50 | 13 |
| 223 | 16 | 24 |
| 224 | 26 | 50 |
| 225 | 64 | 23 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 226 | 81 | 20 |
| 227 | 83 | 11 |
| 228 | 79 | 23 |
| 229 | 76 | 31 |
| 230 | 68 | 24 |
| 231 | 59 | 33 |
| 232 | 59 | 3 |
| 233 | 25 | 7 |
| 234 | 21 | 10 |
| 235 | 20 | 19 |
| 236 | 4 | 10 |
| 237 | 5 | 7 |
| 238 | 4 | 5 |
| 239 | 4 | 6 |
| 240 | 4 | 6 |
| 241 | 4 | 5 |
| 242 | 7 | 5 |
| 243 | 16 | 28 |
| 244 | 28 | 25 |
| 245 | 52 | 53 |
| 246 | 50 | 8 |
| 247 | 26 | 40 |
| 248 | 48 | 29 |
| 249 | 54 | 39 |
| 250 | 60 | 42 |
| 251 | 48 | 18 |
| 252 | 54 | 51 |
| 253 | 88 | 90 |
| 254 | 103 | 84 |
| 255 | 103 | 85 |
| 256 | 102 | 84 |
| 257 | 58 | 66 |
| 258 | 64 | 97 |
| 259 | 56 | 80 |
| 260 | 51 | 67 |
| 261 | 52 | 96 |
| 262 | 63 | 62 |
| 263 | 71 | 6 |
| 264 | 33 | 16 |
| 265 | 47 | 45 |
| 266 | 43 | 56 |
| 267 | 42 | 27 |
| 268 | 42 | 64 |
| 269 | 75 | 74 |
| 270 | 68 | 96 |
| 271 | 86 | 61 |
| 272 | 66 | 0 |
| 273 | 37 | 0 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 274 | 45 | 37 |
| 275 | 68 | 96 |
| 276 | 80 | 97 |
| 277 | 92 | 96 |
| 278 | 90 | 97 |
| 279 | 82 | 96 |
| 280 | 94 | 81 |
| 281 | 90 | 85 |
| 282 | 96 | 65 |
| 283 | 70 | 96 |
| 284 | 55 | 95 |
| 285 | 70 | 96 |
| 286 | 79 | 96 |
| 287 | 81 | 71 |
| 288 | 71 | 60 |
| 289 | 92 | 65 |
| 290 | 82 | 63 |
| 291 | 61 | 47 |
| 292 | 52 | 37 |
| 293 | 24 | 0 |
| 294 | 20 | 7 |
| 295 | 39 | 48 |
| 296 | 39 | 54 |
| 297 | 63 | 58 |
| 298 | 53 | 31 |
| 299 | 51 | 24 |
| 300 | 48 | 40 |
| 301 | 39 | 0 |
| 302 | 35 | 18 |
| 303 | 36 | 16 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 304 | 29 | 17 |
| 305 | 28 | 21 |
| 306 | 31 | 15 |
| 307 | 31 | 10 |
| 308 | 43 | 19 |
| 309 | 49 | 63 |
| 310 | 78 | 61 |
| 311 | 78 | 46 |
| 312 | 66 | 65 |
| 313 | 78 | 97 |
| 314 | 84 | 63 |
| 315 | 57 | 26 |
| 316 | 36 | 22 |
| 317 | 20 | 34 |
| 318 | 19 | 8 |
| 319 | 9 | 10 |
| 320 | 5 | 5 |
| 321 | 7 | 11 |
| 322 | 15 | 15 |
| 323 | 12 | 9 |
| 324 | 13 | 27 |
| 325 | 15 | 28 |
| 326 | 16 | 28 |
| 327 | 16 | 31 |
| 328 | 15 | 20 |
| 329 | 17 | 0 |
| 330 | 20 | 34 |
| 331 | 21 | 25 |
| 332 | 20 | 0 |
| 333 | 23 | 25 |
| 334 | 30 | 58 |
| 335 | 63 | 96 |
| 336 | 83 | 60 |
| 337 | 61 | 0 |
| 338 | 26 | 0 |
| 339 | 29 | 44 |
| 340 | 68 | 97 |
| 341 | 80 | 97 |
| 342 | 88 | 97 |
| 343 | 99 | 88 |
| 344 | 102 | 86 |
| 345 | 100 | 82 |
| 346 | 74 | 79 |
| 347 | 57 | 79 |
| 348 | 76 | 97 |
| 349 | 84 | 97 |
| 350 | 86 | 97 |
| 351 | 81 | 98 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 352 | 83 | 83 |
| 353 | 65 | 96 |
| 354 | 93 | 72 |
| 355 | 63 | 60 |
| 356 | 72 | 49 |
| 357 | 56 | 27 |
| 358 | 29 | 0 |
| 359 | 18 | 13 |
| 360 | 25 | 11 |
| 361 | 28 | 24 |
| 362 | 34 | 53 |
| 363 | 65 | 83 |
| 364 | 80 | 44 |
| 365 | 77 | 46 |
| 366 | 76 | 50 |
| 367 | 45 | 52 |
| 368 | 61 | 98 |
| 369 | 61 | 69 |
| 370 | 63 | 49 |
| 371 | 32 | 0 |
| 372 | 10 | 8 |
| 373 | 17 | 7 |
| 374 | 16 | 13 |
| 375 | 11 | 6 |
| 376 | 9 | 5 |
| 377 | 9 | 12 |
| 378 | 12 | 46 |
| 379 | 15 | 30 |
| 380 | 26 | 28 |
| 381 | 13 | 9 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 382 | 16 | 21 |
| 383 | 24 | 4 |
| 384 | 36 | 43 |
| 385 | 65 | 85 |
| 386 | 78 | 66 |
| 387 | 63 | 39 |
| 388 | 32 | 34 |
| 389 | 46 | 55 |
| 390 | 47 | 42 |
| 391 | 42 | 39 |
| 392 | 27 | 0 |
| 393 | 14 | 5 |
| 394 | 14 | 14 |
| 395 | 24 | 54 |
| 396 | 60 | 90 |
| 397 | 53 | 66 |
| 398 | 70 | 48 |
| 399 | 77 | 93 |
| 400 | 79 | 67 |
| 401 | 46 | 65 |
| 402 | 69 | 98 |
| 403 | 80 | 97 |
| 404 | 74 | 97 |
| 405 | 75 | 98 |
| 406 | 56 | 61 |
| 407 | 42 | 0 |
| 408 | 36 | 32 |
| 409 | 34 | 43 |
| 410 | 68 | 83 |
| 411 | 102 | 48 |
| 412 | 62 | 0 |
| 413 | 41 | 39 |
| 414 | 71 | 86 |
| 415 | 91 | 52 |
| 416 | 89 | 55 |
| 417 | 89 | 56 |
| 418 | 88 | 58 |
| 419 | 78 | 69 |
| 420 | 98 | 39 |
| 421 | 64 | 61 |
| 422 | 90 | 34 |
| 423 | 88 | 38 |
| 424 | 97 | 62 |
| 425 | 100 | 53 |
| 426 | 81 | 58 |
| 427 | 74 | 51 |
| 428 | 76 | 57 |
| 429 | 76 | 72 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 430 | 85 | 72 |
| 431 | 84 | 60 |
| 432 | 83 | 72 |
| 433 | 83 | 72 |
| 434 | 86 | 72 |
| 435 | 89 | 72 |
| 436 | 86 | 72 |
| 437 | 87 | 72 |
| 438 | 88 | 72 |
| 439 | 88 | 71 |
| 440 | 87 | 72 |
| 441 | 85 | 71 |
| 442 | 88 | 72 |
| 443 | 88 | 72 |
| 444 | 84 | 72 |
| 445 | 83 | 73 |
| 446 | 77 | 73 |
| 447 | 74 | 73 |
| 448 | 76 | 72 |
| 449 | 46 | 77 |
| 450 | 78 | 62 |
| 451 | 79 | 35 |
| 452 | 82 | 38 |
| 453 | 81 | 41 |
| 454 | 79 | 37 |
| 455 | 78 | 35 |
| 456 | 78 | 38 |
| 457 | 78 | 46 |
| 458 | 75 | 49 |
| 459 | 73 | 50 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 460 | 79 | 58 |
| 461 | 79 | 71 |
| 462 | 83 | 44 |
| 463 | 53 | 48 |
| 464 | 40 | 48 |
| 465 | 51 | 75 |
| 466 | 75 | 72 |
| 467 | 89 | 67 |
| 468 | 93 | 60 |
| 469 | 89 | 73 |
| 470 | 86 | 73 |
| 471 | 81 | 73 |
| 472 | 78 | 73 |
| 473 | 78 | 73 |
| 474 | 76 | 73 |
| 475 | 79 | 73 |
| 476 | 82 | 73 |
| 477 | 86 | 73 |
| 478 | 88 | 72 |
| 479 | 92 | 71 |
| 480 | 97 | 54 |
| 481 | 73 | 43 |
| 482 | 36 | 64 |
| 483 | 63 | 31 |
| 484 | 78 | 1 |
| 485 | 69 | 27 |
| 486 | 67 | 28 |
| 487 | 72 | 9 |
| 488 | 71 | 9 |
| 489 | 78 | 36 |
| 490 | 81 | 56 |
| 491 | 75 | 53 |
| 492 | 60 | 45 |
| 493 | 50 | 37 |
| 494 | 66 | 41 |
| 495 | 51 | 61 |
| 496 | 68 | 47 |
| 497 | 29 | 42 |
| 498 | 24 | 73 |
| 499 | 64 | 71 |
| 500 | 90 | 71 |
| 501 | 100 | 61 |
| 502 | 94 | 73 |
| 503 | 84 | 73 |
| 504 | 79 | 73 |
| 505 | 75 | 72 |
| 506 | 78 | 73 |
| 507 | 80 | 73 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 508 | 81 | 73 |
| 509 | 81 | 73 |
| 510 | 83 | 73 |
| 511 | 85 | 73 |
| 512 | 84 | 73 |
| 513 | 85 | 73 |
| 514 | 86 | 73 |
| 515 | 85 | 73 |
| 516 | 85 | 73 |
| 517 | 85 | 72 |
| 518 | 85 | 73 |
| 519 | 83 | 73 |
| 520 | 79 | 73 |
| 521 | 78 | 73 |
| 522 | 81 | 73 |
| 523 | 82 | 72 |
| 524 | 94 | 56 |
| 525 | 66 | 48 |
| 526 | 35 | 71 |
| 527 | 51 | 44 |
| 528 | 60 | 23 |
| 529 | 64 | 10 |
| 530 | 63 | 14 |
| 531 | 70 | 37 |
| 532 | 76 | 45 |
| 533 | 78 | 18 |
| 534 | 76 | 51 |
| 535 | 75 | 33 |
| 536 | 81 | 17 |
| 537 | 76 | 45 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 538 | 76 | 30 |
| 539 | 80 | 14 |
| 540 | 71 | 18 |
| 541 | 71 | 14 |
| 542 | 71 | 11 |
| 543 | 65 | 2 |
| 544 | 31 | 26 |
| 545 | 24 | 72 |
| 546 | 64 | 70 |
| 547 | 77 | 62 |
| 548 | 80 | 68 |
| 549 | 83 | 53 |
| 550 | 83 | 50 |
| 551 | 83 | 50 |
| 552 | 85 | 43 |
| 553 | 86 | 45 |
| 554 | 89 | 35 |
| 555 | 82 | 61 |
| 556 | 87 | 50 |
| 557 | 85 | 55 |
| 558 | 89 | 49 |
| 559 | 87 | 70 |
| 560 | 91 | 39 |
| 561 | 72 | 3 |
| 562 | 43 | 25 |
| 563 | 30 | 60 |
| 564 | 40 | 45 |
| 565 | 37 | 32 |
| 566 | 37 | 32 |
| 567 | 43 | 70 |
| 568 | 70 | 54 |
| 569 | 77 | 47 |
| 570 | 79 | 66 |
| 571 | 85 | 53 |
| 572 | 83 | 57 |
| 573 | 86 | 52 |
| 574 | 85 | 51 |
| 575 | 70 | 39 |
| 576 | 50 | 5 |
| 577 | 38 | 36 |
| 578 | 30 | 71 |
| 579 | 75 | 53 |
| 580 | 84 | 40 |
| 581 | 85 | 42 |
| 582 | 86 | 49 |
| 583 | 86 | 57 |
| 584 | 89 | 68 |
| 585 | 99 | 61 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 586 | 77 | 29 |
| 587 | 81 | 72 |
| 588 | 89 | 69 |
| 589 | 49 | 56 |
| 590 | 79 | 70 |
| 591 | 104 | 59 |
| 592 | 103 | 54 |
| 593 | 102 | 56 |
| 594 | 102 | 56 |
| 595 | 103 | 61 |
| 596 | 102 | 64 |
| 597 | 103 | 60 |
| 598 | 93 | 72 |
| 599 | 86 | 73 |
| 600 | 76 | 73 |
| 601 | 59 | 49 |
| 602 | 46 | 22 |
| 603 | 40 | 65 |
| 604 | 72 | 31 |
| 605 | 72 | 27 |
| 606 | 67 | 44 |
| 607 | 68 | 37 |
| 608 | 67 | 42 |
| 609 | 68 | 50 |
| 610 | 77 | 43 |
| 611 | 58 | 4 |
| 612 | 22 | 37 |
| 613 | 57 | 69 |
| 614 | 68 | 38 |
| 615 | 73 | 2 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 616 | 40 | 14 |
| 617 | 42 | 38 |
| 618 | 64 | 69 |
| 619 | 64 | 74 |
| 620 | 67 | 73 |
| 621 | 65 | 73 |
| 622 | 68 | 73 |
| 623 | 65 | 49 |
| 624 | 81 | 0 |
| 625 | 37 | 25 |
| 626 | 24 | 69 |
| 627 | 68 | 71 |
| 628 | 70 | 71 |
| 629 | 76 | 70 |
| 630 | 71 | 72 |
| 631 | 73 | 69 |
| 632 | 76 | 70 |
| 633 | 77 | 72 |
| 634 | 77 | 72 |
| 635 | 77 | 72 |
| 636 | 77 | 70 |
| 637 | 76 | 71 |
| 638 | 76 | 71 |
| 639 | 77 | 71 |
| 640 | 77 | 71 |
| 641 | 78 | 70 |
| 642 | 77 | 70 |
| 643 | 77 | 71 |
| 644 | 79 | 72 |
| 645 | 78 | 70 |
| 646 | 80 | 70 |
| 647 | 82 | 71 |
| 648 | 84 | 71 |
| 649 | 83 | 71 |
| 650 | 83 | 73 |
| 651 | 81 | 70 |
| 652 | 80 | 71 |
| 653 | 78 | 71 |
| 654 | 76 | 70 |
| 655 | 76 | 70 |
| 656 | 76 | 71 |
| 657 | 79 | 71 |
| 658 | 78 | 71 |
| 659 | 81 | 70 |
| 660 | 83 | 72 |
| 661 | 84 | 71 |
| 662 | 86 | 71 |
| 663 | 87 | 71 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 664 | 92 | 72 |
| 665 | 91 | 72 |
| 666 | 90 | 71 |
| 667 | 90 | 71 |
| 668 | 91 | 71 |
| 669 | 90 | 70 |
| 670 | 90 | 72 |
| 671 | 91 | 71 |
| 672 | 90 | 71 |
| 673 | 90 | 71 |
| 674 | 92 | 72 |
| 675 | 93 | 69 |
| 676 | 90 | 70 |
| 677 | 93 | 72 |
| 678 | 91 | 70 |
| 679 | 89 | 71 |
| 680 | 91 | 71 |
| 681 | 90 | 71 |
| 682 | 90 | 71 |
| 683 | 92 | 71 |
| 684 | 91 | 71 |
| 685 | 93 | 71 |
| 686 | 93 | 68 |
| 687 | 98 | 68 |
| 688 | 98 | 67 |
| 689 | 100 | 69 |
| 690 | 99 | 68 |
| 691 | 100 | 71 |
| 692 | 99 | 68 |
| 693 | 100 | 69 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 694 | 102 | 72 |
| 695 | 101 | 69 |
| 696 | 100 | 69 |
| 697 | 102 | 71 |
| 698 | 102 | 71 |
| 699 | 102 | 69 |
| 700 | 102 | 71 |
| 701 | 102 | 68 |
| 702 | 100 | 69 |
| 703 | 102 | 70 |
| 704 | 102 | 68 |
| 705 | 102 | 70 |
| 706 | 102 | 72 |
| 707 | 102 | 68 |
| 708 | 102 | 69 |
| 709 | 100 | 68 |
| 710 | 102 | 71 |
| 711 | 101 | 64 |
| 712 | 102 | 69 |
| 713 | 102 | 69 |
| 714 | 101 | 69 |
| 715 | 102 | 64 |
| 716 | 102 | 69 |
| 717 | 102 | 68 |
| 718 | 102 | 70 |
| 719 | 102 | 69 |
| 720 | 102 | 70 |
| 721 | 102 | 70 |
| 722 | 102 | 62 |
| 723 | 104 | 38 |
| 724 | 104 | 15 |
| 725 | 102 | 24 |
| 726 | 102 | 45 |
| 727 | 102 | 47 |
| 728 | 104 | 40 |
| 729 | 101 | 52 |
| 730 | 103 | 32 |
| 731 | 102 | 50 |
| 732 | 103 | 30 |
| 733 | 103 | 44 |
| 734 | 102 | 40 |
| 735 | 103 | 43 |
| 736 | 103 | 41 |
| 737 | 102 | 46 |
| 738 | 103 | 39 |
| 739 | 102 | 41 |
| 740 | 103 | 41 |
| 741 | 102 | 38 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 742 | 103 | 39 |
| 743 | 102 | 46 |
| 744 | 104 | 46 |
| 745 | 103 | 49 |
| 746 | 102 | 45 |
| 747 | 103 | 42 |
| 748 | 103 | 46 |
| 749 | 103 | 38 |
| 750 | 102 | 48 |
| 751 | 103 | 35 |
| 752 | 102 | 48 |
| 753 | 103 | 49 |
| 754 | 102 | 48 |
| 755 | 102 | 46 |
| 756 | 103 | 47 |
| 757 | 102 | 49 |
| 758 | 102 | 42 |
| 759 | 102 | 52 |
| 760 | 102 | 57 |
| 761 | 102 | 55 |
| 762 | 102 | 61 |
| 763 | 102 | 61 |
| 764 | 102 | 58 |
| 765 | 103 | 58 |
| 766 | 102 | 59 |
| 767 | 102 | 54 |
| 768 | 102 | 63 |
| 769 | 102 | 61 |
| 770 | 103 | 55 |
| 771 | 102 | 60 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 772 | 102 | 72 |
| 773 | 103 | 56 |
| 774 | 102 | 55 |
| 775 | 102 | 67 |
| 776 | 103 | 56 |
| 777 | 84 | 42 |
| 778 | 48 | 7 |
| 779 | 48 | 6 |
| 780 | 48 | 6 |
| 781 | 48 | 7 |
| 782 | 48 | 6 |
| 783 | 48 | 7 |
| 784 | 67 | 21 |
| 785 | 105 | 59 |
| 786 | 105 | 96 |
| 787 | 105 | 74 |
| 788 | 105 | 66 |
| 789 | 105 | 62 |
| 790 | 105 | 66 |
| 791 | 89 | 41 |
| 792 | 52 | 5 |
| 793 | 48 | 5 |
| 794 | 48 | 7 |
| 795 | 48 | 5 |
| 796 | 48 | 6 |
| 797 | 48 | 4 |
| 798 | 52 | 6 |
| 799 | 51 | 5 |
| 800 | 51 | 6 |
| 801 | 51 | 6 |
| 802 | 52 | 5 |
| 803 | 52 | 5 |
| 804 | 57 | 44 |
| 805 | 98 | 90 |
| 806 | 105 | 94 |
| 807 | 105 | 100 |
| 808 | 105 | 98 |
| 809 | 105 | 95 |
| 810 | 105 | 96 |
| 811 | 105 | 92 |
| 812 | 104 | 97 |
| 813 | 100 | 85 |
| 814 | 94 | 74 |
| 815 | 87 | 62 |
| 816 | 81 | 50 |
| 817 | 81 | 46 |
| 818 | 80 | 39 |
| 819 | 80 | 32 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 820 | 81 | 28 |
| 821 | 80 | 26 |
| 822 | 80 | 23 |
| 823 | 80 | 23 |
| 824 | 80 | 20 |
| 825 | 81 | 19 |
| 826 | 80 | 18 |
| 827 | 81 | 17 |
| 828 | 80 | 20 |
| 829 | 81 | 24 |
| 830 | 81 | 21 |
| 831 | 80 | 26 |
| 832 | 80 | 24 |
| 833 | 80 | 23 |
| 834 | 80 | 22 |
| 835 | 81 | 21 |
| 836 | 81 | 24 |
| 837 | 81 | 24 |
| 838 | 81 | 22 |
| 839 | 81 | 22 |
| 840 | 81 | 21 |
| 841 | 81 | 31 |
| 842 | 81 | 27 |
| 843 | 80 | 26 |
| 844 | 80 | 26 |
| 845 | 81 | 25 |
| 846 | 80 | 21 |
| 847 | 81 | 20 |
| 848 | 83 | 21 |
| 849 | 83 | 15 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 850 | 83 | 12 |
| 851 | 83 | 9 |
| 852 | 83 | 8 |
| 853 | 83 | 7 |
| 854 | 83 | 6 |
| 855 | 83 | 6 |
| 856 | 83 | 6 |
| 857 | 83 | 6 |
| 858 | 83 | 6 |
| 859 | 76 | 5 |
| 860 | 49 | 8 |
| 861 | 51 | 7 |
| 862 | 51 | 20 |
| 863 | 78 | 52 |
| 864 | 80 | 38 |
| 865 | 81 | 33 |
| 866 | 83 | 29 |
| 867 | 83 | 22 |
| 868 | 83 | 16 |
| 869 | 83 | 12 |
| 870 | 83 | 9 |
| 871 | 83 | 8 |
| 872 | 83 | 7 |
| 873 | 83 | 6 |
| 874 | 83 | 6 |
| 875 | 83 | 6 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 876 | 83 | 6 |
| 877 | 83 | 6 |
| 878 | 59 | 4 |
| 879 | 50 | 5 |
| 880 | 51 | 5 |
| 881 | 51 | 5 |
| 882 | 51 | 5 |
| 883 | 50 | 5 |
| 884 | 50 | 5 |
| 885 | 50 | 5 |
| 886 | 50 | 5 |
| 887 | 50 | 5 |
| 888 | 51 | 5 |
| 889 | 51 | 5 |
| 890 | 51 | 5 |
| 891 | 63 | 50 |
| 892 | 81 | 34 |
| 893 | 81 | 25 |
| 894 | 81 | 29 |
| 895 | 81 | 23 |
| 896 | 80 | 24 |
| 897 | 81 | 24 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 898 | 81 | 28 |
| 899 | 81 | 27 |
| 900 | 81 | 22 |
| 901 | 81 | 19 |
| 902 | 81 | 17 |
| 903 | 81 | 17 |
| 904 | 81 | 17 |
| 905 | 81 | 15 |
| 906 | 80 | 15 |
| 907 | 80 | 28 |
| 908 | 81 | 22 |
| 909 | 81 | 24 |
| 910 | 81 | 19 |
| 911 | 81 | 21 |
| 912 | 81 | 20 |
| 913 | 83 | 26 |
| 914 | 80 | 63 |
| 915 | 80 | 59 |
| 916 | 83 | 100 |
| 917 | 81 | 73 |
| 918 | 83 | 53 |
| 919 | 80 | 76 |
| 920 | 81 | 61 |
| 921 | 80 | 50 |
| 922 | 81 | 37 |
| 923 | 82 | 49 |
| 924 | 83 | 37 |
| 925 | 83 | 25 |
| 926 | 83 | 17 |
| 927 | 83 | 13 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 928 | 83 | 10 |
| 929 | 83 | 8 |
| 930 | 83 | 7 |
| 931 | 83 | 7 |
| 932 | 83 | 6 |
| 933 | 83 | 6 |
| 934 | 83 | 6 |
| 935 | 71 | 5 |
| 936 | 49 | 24 |
| 937 | 69 | 64 |
| 938 | 81 | 50 |
| 939 | 81 | 43 |
| 940 | 81 | 42 |
| 941 | 81 | 31 |
| 942 | 81 | 30 |
| 943 | 81 | 35 |
| 944 | 81 | 28 |
| 945 | 81 | 27 |
| 946 | 80 | 27 |
| 947 | 81 | 31 |
| 948 | 81 | 41 |
| 949 | 81 | 41 |
| 950 | 81 | 37 |
| 951 | 81 | 43 |
| 952 | 81 | 34 |
| 953 | 81 | 31 |
| 954 | 81 | 26 |
| 955 | 81 | 23 |
| 956 | 81 | 27 |
| 957 | 81 | 38 |
| 958 | 81 | 40 |
| 959 | 81 | 39 |
| 960 | 81 | 27 |
| 961 | 81 | 33 |
| 962 | 80 | 28 |
| 963 | 81 | 34 |
| 964 | 83 | 72 |
| 965 | 81 | 49 |
| 966 | 81 | 51 |
| 967 | 80 | 55 |
| 968 | 81 | 48 |
| 969 | 81 | 36 |
| 970 | 81 | 39 |
| 971 | 81 | 38 |
| 972 | 80 | 41 |
| 973 | 81 | 30 |
| 974 | 81 | 23 |
| 975 | 81 | 19 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 976 | 81 | 25 |
| 977 | 81 | 29 |
| 978 | 83 | 47 |
| 979 | 81 | 90 |
| 980 | 81 | 75 |
| 981 | 80 | 60 |
| 982 | 81 | 48 |
| 983 | 81 | 41 |
| 984 | 81 | 30 |
| 985 | 80 | 24 |
| 986 | 81 | 20 |
| 987 | 81 | 21 |
| 988 | 81 | 29 |
| 989 | 81 | 29 |
| 990 | 81 | 27 |
| 991 | 81 | 23 |
| 992 | 81 | 25 |
| 993 | 81 | 26 |
| 994 | 81 | 22 |
| 995 | 81 | 20 |
| 996 | 81 | 17 |
| 997 | 81 | 23 |
| 998 | 83 | 65 |
| 999 | 81 | 54 |
| 1000 | 81 | 50 |
| 1001 | 81 | 41 |
| 1002 | 81 | 35 |
| 1003 | 81 | 37 |
| 1004 | 81 | 29 |
| 1005 | 81 | 28 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1006 | 81 | 24 |
| 1007 | 81 | 19 |
| 1008 | 81 | 16 |
| 1009 | 80 | 16 |
| 1010 | 83 | 23 |
| 1011 | 83 | 17 |
| 1012 | 83 | 13 |
| 1013 | 83 | 27 |
| 1014 | 81 | 58 |
| 1015 | 81 | 60 |
| 1016 | 81 | 46 |
| 1017 | 80 | 41 |
| 1018 | 80 | 36 |
| 1019 | 81 | 26 |
| 1020 | 86 | 18 |
| 1021 | 82 | 35 |
| 1022 | 79 | 53 |
| 1023 | 82 | 30 |
| 1024 | 83 | 29 |
| 1025 | 83 | 32 |
| 1026 | 83 | 28 |
| 1027 | 76 | 60 |
| 1028 | 79 | 51 |
| 1029 | 86 | 26 |
| 1030 | 82 | 34 |
| 1031 | 84 | 25 |
| 1032 | 86 | 23 |
| 1033 | 85 | 22 |
| 1034 | 83 | 26 |
| 1035 | 83 | 25 |
| 1036 | 83 | 37 |
| 1037 | 84 | 14 |
| 1038 | 83 | 39 |
| 1039 | 76 | 70 |
| 1040 | 78 | 81 |
| 1041 | 75 | 71 |
| 1042 | 86 | 47 |
| 1043 | 83 | 35 |
| 1044 | 81 | 43 |
| 1045 | 81 | 41 |
| 1046 | 79 | 46 |
| 1047 | 80 | 44 |
| 1048 | 84 | 20 |
| 1049 | 79 | 31 |
| 1050 | 87 | 29 |
| 1051 | 82 | 49 |
| 1052 | 84 | 21 |
| 1053 | 82 | 56 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1054 | 81 | 30 |
| 1055 | 85 | 21 |
| 1056 | 86 | 16 |
| 1057 | 79 | 52 |
| 1058 | 78 | 60 |
| 1059 | 74 | 55 |
| 1060 | 78 | 84 |
| 1061 | 80 | 54 |
| 1062 | 80 | 35 |
| 1063 | 82 | 24 |
| 1064 | 83 | 43 |
| 1065 | 79 | 49 |
| 1066 | 83 | 50 |
| 1067 | 86 | 12 |
| 1068 | 64 | 14 |
| 1069 | 24 | 14 |
| 1070 | 49 | 21 |
| 1071 | 77 | 48 |
| 1072 | 103 | 11 |
| 1073 | 98 | 48 |
| 1074 | 101 | 34 |
| 1075 | 99 | 39 |
| 1076 | 103 | 11 |
| 1077 | 103 | 19 |
| 1078 | 103 | 7 |
| 1079 | 103 | 13 |
| 1080 | 103 | 10 |
| 1081 | 102 | 13 |
| 1082 | 101 | 29 |
| 1083 | 102 | 25 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1084 | 102 | 20 |
| 1085 | 96 | 60 |
| 1086 | 99 | 38 |
| 1087 | 102 | 24 |
| 1088 | 100 | 31 |
| 1089 | 100 | 28 |
| 1090 | 98 | 3 |
| 1091 | 102 | 26 |
| 1092 | 95 | 64 |
| 1093 | 102 | 23 |
| 1094 | 102 | 25 |
| 1095 | 98 | 42 |
| 1096 | 93 | 68 |
| 1097 | 101 | 25 |
| 1098 | 95 | 64 |
| 1099 | 101 | 35 |
| 1100 | 94 | 59 |
| 1101 | 97 | 37 |
| 1102 | 97 | 60 |
| 1103 | 93 | 98 |
| 1104 | 98 | 53 |
| 1105 | 103 | 13 |
| 1106 | 103 | 11 |
| 1107 | 103 | 11 |
| 1108 | 103 | 13 |
| 1109 | 103 | 10 |
| 1110 | 103 | 10 |
| 1111 | 103 | 11 |
| 1112 | 103 | 10 |
| 1113 | 103 | 10 |
| 1114 | 102 | 18 |
| 1115 | 102 | 31 |
| 1116 | 101 | 24 |
| 1117 | 102 | 19 |
| 1118 | 103 | 10 |
| 1119 | 102 | 12 |
| 1120 | 99 | 56 |
| 1121 | 96 | 59 |
| 1122 | 74 | 28 |
| 1123 | 66 | 62 |
| 1124 | 74 | 29 |
| 1125 | 64 | 74 |
| 1126 | 69 | 40 |
| 1127 | 76 | 2 |
| 1128 | 72 | 29 |
| 1129 | 66 | 65 |
| 1130 | 54 | 69 |
| 1131 | 69 | 56 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1132 | 69 | 40 |
| 1133 | 73 | 54 |
| 1134 | 63 | 92 |
| 1135 | 61 | 67 |
| 1136 | 72 | 42 |
| 1137 | 78 | 2 |
| 1138 | 76 | 34 |
| 1139 | 67 | 80 |
| 1140 | 70 | 67 |
| 1141 | 53 | 70 |
| 1142 | 72 | 65 |
| 1143 | 60 | 57 |
| 1144 | 74 | 29 |
| 1145 | 69 | 31 |
| 1146 | 76 | 1 |
| 1147 | 74 | 22 |
| 1148 | 72 | 52 |
| 1149 | 62 | 96 |
| 1150 | 54 | 72 |
| 1151 | 72 | 28 |
| 1152 | 72 | 35 |
| 1153 | 64 | 68 |
| 1154 | 74 | 27 |
| 1155 | 76 | 14 |
| 1156 | 69 | 38 |
| 1157 | 66 | 59 |
| 1158 | 64 | 99 |
| 1159 | 51 | 86 |
| 1160 | 70 | 53 |
| 1161 | 72 | 36 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1162 | 71 | 47 |
| 1163 | 70 | 42 |
| 1164 | 67 | 34 |
| 1165 | 74 | 2 |
| 1166 | 75 | 21 |
| 1167 | 74 | 15 |
| 1168 | 75 | 13 |
| 1169 | 76 | 10 |
| 1170 | 75 | 13 |
| 1171 | 75 | 10 |
| 1172 | 75 | 7 |
| 1173 | 75 | 13 |
| 1174 | 76 | 8 |
| 1175 | 76 | 7 |
| 1176 | 67 | 45 |
| 1177 | 75 | 13 |
| 1178 | 75 | 12 |
| 1179 | 73 | 21 |
| 1180 | 68 | 46 |
| 1181 | 74 | 8 |
| 1182 | 76 | 11 |
| 1183 | 76 | 14 |
| 1184 | 74 | 11 |
| 1185 | 74 | 18 |
| 1186 | 73 | 22 |
| 1187 | 74 | 20 |
| 1188 | 74 | 19 |
| 1189 | 70 | 22 |
| 1190 | 71 | 23 |
| 1191 | 73 | 19 |
| 1192 | 73 | 19 |
| 1193 | 72 | 20 |
| 1194 | 64 | 60 |
| 1195 | 70 | 39 |
| 1196 | 66 | 56 |
| 1197 | 68 | 64 |
| 1198 | 30 | 68 |
| 1199 | 70 | 38 |
| 1200 | 66 | 47 |
| 1201 | 76 | 14 |
| 1202 | 74 | 18 |
| 1203 | 69 | 46 |
| 1204 | 68 | 62 |
| 1205 | 68 | 62 |
| 1206 | 68 | 62 |
| 1207 | 68 | 62 |
| 1208 | 68 | 62 |
| 1209 | 68 | 62 |

| | | |
|---|---|---|
| 1210 | 54 | 50 |
| 1211 | 41 | 37 |
| 1212 | 27 | 25 |
| 1213 | 14 | 12 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1214 | 0 | 0 |
| 1215 | 0 | 0 |
| 1216 | 0 | 0 |
| 1217 | 0 | 0 |
| 1218 | 0 | 0 |
| 1219 | 0 | 0 |
| 1220 | 0 | 0 |
| 1221 | 0 | 0 |
| 1222 | 0 | 0 |
| 1223 | 0 | 0 |
| 1224 | 0 | 0 |
| 1225 | 0 | 0 |
| 1226 | 0 | 0 |
| 1227 | 0 | 0 |
| 1228 | 0 | 0 |
| 1229 | 0 | 0 |
| 1230 | 0 | 0 |
| 1231 | 0 | 0 |
| 1232 | 0 | 0 |
| 1233 | 0 | 0 |
| 1234 | 0 | 0 |
| 1235 | 0 | 0 |

| | | |
|---|---|---|
| 1236 | 0 | 0 |
| 1237 | 0 | 0 |
| 1238 | 0 | 0 |

**LSI-NRTC engine dynamometer schedule**

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 0 | 0 |
| 2 | 0 | 0 |
| 3 | 0 | 0 |
| 4 | 0 | 0 |
| 5 | 0 | 0 |
| 6 | 0 | 0 |
| 7 | 0 | 0 |
| 8 | 0 | 0 |
| 9 | 1 | 8 |
| 10 | 6 | 54 |
| 11 | 8 | 61 |
| 12 | 34 | 59 |
| 13 | 22 | 46 |
| 14 | 5 | 51 |
| 15 | 18 | 51 |
| 16 | 31 | 50 |
| 17 | 30 | 56 |
| 18 | 31 | 49 |
| 19 | 25 | 66 |
| 20 | 58 | 55 |
| 21 | 43 | 31 |
| 22 | 16 | 45 |
| 23 | 24 | 38 |
| 24 | 24 | 27 |
| 25 | 30 | 33 |
| 26 | 45 | 65 |
| 27 | 50 | 49 |
| 28 | 23 | 42 |
| 29 | 13 | 42 |
| 30 | 9 | 45 |
| 31 | 23 | 30 |
| 32 | 37 | 45 |
| 33 | 44 | 50 |
| 34 | 49 | 52 |
| 35 | 55 | 49 |
| 36 | 61 | 46 |
| 37 | 66 | 38 |
| 38 | 42 | 33 |
| 39 | 17 | 41 |
| 40 | 17 | 37 |
| 41 | 7 | 50 |
| 42 | 20 | 32 |
| 43 | 5 | 55 |
| 44 | 30 | 42 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 45 | 44 | 53 |
| 46 | 45 | 56 |
| 47 | 41 | 52 |
| 48 | 24 | 41 |
| 49 | 15 | 40 |
| 50 | 11 | 44 |
| 51 | 32 | 31 |
| 52 | 38 | 54 |
| 53 | 38 | 47 |
| 54 | 9 | 55 |
| 55 | 10 | 50 |
| 56 | 33 | 55 |
| 57 | 48 | 56 |
| 58 | 49 | 47 |
| 59 | 33 | 44 |
| 60 | 52 | 43 |
| 61 | 55 | 43 |
| 62 | 59 | 38 |
| 63 | 44 | 28 |
| 64 | 24 | 37 |
| 65 | 12 | 44 |
| 66 | 9 | 47 |
| 67 | 12 | 52 |
| 68 | 34 | 21 |
| 69 | 29 | 44 |
| 70 | 44 | 54 |
| 71 | 54 | 62 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 72 | 62 | 57 |
| 73 | 72 | 56 |
| 74 | 88 | 71 |
| 75 | 100 | 69 |
| 76 | 100 | 34 |
| 77 | 100 | 42 |
| 78 | 100 | 54 |
| 79 | 100 | 58 |
| 80 | 100 | 38 |
| 81 | 83 | 17 |
| 82 | 61 | 15 |
| 83 | 43 | 22 |
| 84 | 24 | 35 |
| 85 | 16 | 39 |
| 86 | 15 | 45 |
| 87 | 32 | 34 |
| 88 | 14 | 42 |
| 89 | 8 | 48 |
| 90 | 5 | 51 |
| 91 | 10 | 41 |
| 92 | 12 | 37 |
| 93 | 4 | 47 |
| 94 | 3 | 49 |
| 95 | 3 | 50 |
| 96 | 4 | 49 |
| 97 | 4 | 48 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 98 | 8 | 43 |
| 99 | 2 | 51 |
| 100 | 5 | 46 |
| 101 | 8 | 41 |
| 102 | 4 | 47 |
| 103 | 3 | 49 |
| 104 | 6 | 45 |
| 105 | 3 | 48 |
| 106 | 10 | 42 |
| 107 | 18 | 27 |
| 108 | 3 | 50 |
| 109 | 11 | 41 |
| 110 | 34 | 29 |
| 111 | 51 | 57 |
| 112 | 67 | 63 |
| 113 | 61 | 32 |
| 114 | 44 | 31 |
| 115 | 48 | 54 |
| 116 | 69 | 65 |
| 117 | 85 | 65 |
| 118 | 81 | 29 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 119 | 74 | 21 |
| 120 | 62 | 23 |
| 121 | 76 | 58 |
| 122 | 96 | 75 |
| 123 | 100 | 77 |
| 124 | 100 | 27 |
| 125 | 100 | 79 |
| 126 | 100 | 79 |
| 127 | 100 | 81 |
| 128 | 100 | 57 |
| 129 | 99 | 52 |
| 130 | 81 | 35 |
| 131 | 69 | 29 |
| 132 | 47 | 22 |
| 133 | 34 | 28 |
| 134 | 27 | 37 |
| 135 | 83 | 60 |
| 136 | 100 | 74 |
| 137 | 100 | 7 |
| 138 | 100 | 2 |
| 139 | 70 | 18 |
| 140 | 23 | 39 |
| 141 | 5 | 54 |
| 142 | 11 | 40 |
| 143 | 11 | 34 |
| 144 | 11 | 41 |
| 145 | 19 | 25 |
| 146 | 16 | 32 |
| 147 | 20 | 31 |
| 148 | 21 | 38 |
| 149 | 21 | 42 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 150 | 9 | 51 |
| 151 | 4 | 49 |
| 152 | 2 | 51 |
| 153 | 1 | 58 |
| 154 | 21 | 57 |
| 155 | 29 | 47 |
| 156 | 33 | 45 |
| 157 | 16 | 49 |
| 158 | 38 | 45 |
| 159 | 37 | 43 |
| 160 | 35 | 42 |
| 161 | 39 | 43 |
| 162 | 51 | 49 |
| 163 | 59 | 55 |
| 164 | 65 | 54 |
| 165 | 76 | 62 |
| 166 | 84 | 59 |
| 167 | 83 | 29 |
| 168 | 67 | 35 |
| 169 | 84 | 54 |
| 170 | 90 | 58 |
| 171 | 93 | 43 |
| 172 | 90 | 29 |
| 173 | 66 | 19 |
| 174 | 52 | 16 |
| 175 | 49 | 17 |
| 176 | 56 | 38 |
| 177 | 73 | 71 |
| 178 | 86 | 80 |
| 179 | 96 | 75 |
| 180 | 89 | 27 |
| 181 | 66 | 17 |
| 182 | 50 | 18 |
| 183 | 36 | 25 |
| 184 | 36 | 24 |
| 185 | 38 | 40 |
| 186 | 40 | 50 |
| 187 | 27 | 48 |
| 188 | 19 | 48 |
| 189 | 23 | 50 |
| 190 | 19 | 45 |
| 191 | 6 | 51 |
| 192 | 24 | 48 |
| 193 | 49 | 67 |
| 194 | 47 | 49 |
| 195 | 22 | 44 |
| 196 | 25 | 40 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 197 | 38 | 54 |
| 198 | 43 | 55 |
| 199 | 40 | 52 |
| 200 | 14 | 49 |
| 201 | 11 | 45 |
| 202 | 7 | 48 |
| 203 | 26 | 41 |
| 204 | 41 | 59 |
| 205 | 53 | 60 |
| 206 | 44 | 54 |
| 207 | 22 | 40 |
| 208 | 24 | 41 |
| 209 | 32 | 53 |
| 210 | 44 | 74 |
| 211 | 57 | 25 |
| 212 | 22 | 49 |
| 213 | 29 | 45 |
| 214 | 19 | 37 |
| 215 | 14 | 43 |
| 216 | 36 | 40 |
| 217 | 43 | 63 |
| 218 | 42 | 49 |
| 219 | 15 | 50 |
| 220 | 19 | 44 |
| 221 | 47 | 59 |
| 222 | 67 | 80 |
| 223 | 76 | 74 |
| 224 | 87 | 66 |
| 225 | 98 | 61 |
| 226 | 100 | 38 |
| 227 | 97 | 27 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 228 | 100 | 53 |
| 229 | 100 | 72 |
| 230 | 100 | 49 |
| 231 | 100 | 4 |
| 232 | 100 | 13 |
| 233 | 87 | 15 |
| 234 | 53 | 26 |
| 235 | 33 | 27 |
| 236 | 39 | 19 |
| 237 | 51 | 33 |
| 238 | 67 | 54 |
| 239 | 83 | 60 |
| 240 | 95 | 52 |
| 241 | 100 | 50 |
| 242 | 100 | 36 |
| 243 | 100 | 25 |
| 244 | 85 | 16 |
| 245 | 62 | 16 |
| 246 | 40 | 26 |
| 247 | 56 | 39 |
| 248 | 81 | 75 |
| 249 | 98 | 86 |
| 250 | 100 | 76 |
| 251 | 100 | 51 |
| 252 | 100 | 78 |
| 253 | 100 | 83 |
| 254 | 100 | 100 |
| 255 | 100 | 66 |
| 256 | 100 | 85 |
| 257 | 100 | 72 |
| 258 | 100 | 45 |
| 259 | 98 | 58 |
| 260 | 60 | 30 |
| 261 | 43 | 32 |
| 262 | 71 | 36 |
| 263 | 44 | 32 |
| 264 | 24 | 38 |
| 265 | 42 | 17 |
| 266 | 22 | 51 |
| 267 | 13 | 53 |
| 268 | 23 | 45 |
| 269 | 29 | 50 |
| 270 | 28 | 42 |
| 271 | 21 | 55 |
| 272 | 34 | 57 |
| 273 | 44 | 47 |
| 274 | 19 | 46 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 275 | 13 | 44 |
| 276 | 25 | 36 |
| 277 | 43 | 51 |
| 278 | 55 | 73 |
| 279 | 68 | 72 |
| 280 | 76 | 63 |
| 281 | 80 | 45 |
| 282 | 83 | 40 |
| 283 | 78 | 26 |
| 284 | 60 | 20 |
| 285 | 47 | 19 |
| 286 | 52 | 25 |
| 287 | 36 | 30 |
| 288 | 40 | 26 |
| 289 | 45 | 34 |
| 290 | 47 | 35 |
| 291 | 42 | 28 |
| 292 | 46 | 38 |
| 293 | 48 | 44 |
| 294 | 68 | 61 |
| 295 | 70 | 47 |
| 296 | 48 | 28 |
| 297 | 42 | 22 |
| 298 | 31 | 29 |
| 299 | 22 | 35 |
| 300 | 28 | 28 |
| 301 | 46 | 46 |
| 302 | 62 | 69 |
| 303 | 76 | 81 |
| 304 | 88 | 85 |
| 305 | 98 | 81 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 306 | 100 | 74 |
| 307 | 100 | 13 |
| 308 | 100 | 11 |
| 309 | 100 | 17 |
| 310 | 99 | 3 |
| 311 | 80 | 7 |
| 312 | 62 | 11 |
| 313 | 63 | 11 |
| 314 | 64 | 16 |
| 315 | 69 | 43 |
| 316 | 81 | 67 |
| 317 | 93 | 74 |
| 318 | 100 | 72 |
| 319 | 94 | 27 |
| 320 | 73 | 15 |
| 321 | 40 | 33 |
| 322 | 40 | 52 |
| 323 | 50 | 50 |
| 324 | 11 | 53 |
| 325 | 12 | 45 |
| 326 | 5 | 50 |
| 327 | 1 | 55 |
| 328 | 7 | 55 |
| 329 | 62 | 60 |
| 330 | 80 | 28 |
| 331 | 23 | 37 |
| 332 | 39 | 58 |
| 333 | 47 | 24 |
| 334 | 59 | 51 |
| 335 | 58 | 68 |
| 336 | 36 | 52 |
| 337 | 18 | 42 |
| 338 | 36 | 52 |
| 339 | 59 | 73 |
| 340 | 72 | 85 |
| 341 | 85 | 92 |
| 342 | 99 | 90 |
| 343 | 100 | 72 |
| 344 | 100 | 18 |
| 345 | 100 | 76 |
| 346 | 100 | 64 |
| 347 | 100 | 87 |
| 348 | 100 | 97 |
| 349 | 100 | 84 |
| 350 | 100 | 100 |
| 351 | 100 | 91 |
| 352 | 100 | 83 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 353 | 100 | 93 |
| 354 | 100 | 100 |
| 355 | 94 | 43 |
| 356 | 72 | 10 |
| 357 | 77 | 3 |
| 358 | 48 | 2 |
| 359 | 29 | 5 |
| 360 | 59 | 19 |
| 361 | 63 | 5 |
| 362 | 35 | 2 |
| 363 | 24 | 3 |
| 364 | 28 | 2 |
| 365 | 36 | 16 |
| 366 | 54 | 23 |
| 367 | 60 | 10 |
| 368 | 33 | 1 |
| 369 | 23 | 0 |
| 370 | 16 | 0 |
| 371 | 11 | 0 |
| 372 | 20 | 0 |
| 373 | 25 | 2 |
| 374 | 40 | 3 |
| 375 | 33 | 4 |
| 376 | 34 | 5 |
| 377 | 46 | 7 |
| 378 | 57 | 10 |
| 379 | 66 | 11 |
| 380 | 75 | 14 |
| 381 | 79 | 11 |
| 382 | 80 | 16 |
| 383 | 92 | 21 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 384 | 99 | 16 |
| 385 | 83 | 2 |
| 386 | 71 | 2 |
| 387 | 69 | 4 |
| 388 | 67 | 4 |
| 389 | 74 | 16 |
| 390 | 86 | 25 |
| 391 | 97 | 28 |
| 392 | 100 | 15 |
| 393 | 83 | 2 |
| 394 | 62 | 4 |
| 395 | 40 | 6 |
| 396 | 49 | 10 |
| 397 | 36 | 5 |
| 398 | 27 | 4 |
| 399 | 29 | 3 |
| 400 | 22 | 2 |
| 401 | 13 | 3 |
| 402 | 37 | 36 |
| 403 | 90 | 26 |
| 404 | 41 | 2 |
| 405 | 25 | 2 |
| 406 | 29 | 2 |
| 407 | 38 | 7 |
| 408 | 50 | 13 |
| 409 | 55 | 10 |
| 410 | 29 | 3 |
| 411 | 24 | 7 |
| 412 | 51 | 16 |
| 413 | 62 | 15 |
| 414 | 72 | 35 |
| 415 | 91 | 74 |
| 416 | 100 | 73 |
| 417 | 100 | 8 |
| 418 | 98 | 11 |
| 419 | 100 | 59 |
| 420 | 100 | 98 |
| 421 | 100 | 99 |
| 422 | 100 | 75 |
| 423 | 100 | 95 |
| 424 | 100 | 100 |
| 425 | 100 | 97 |
| 426 | 100 | 90 |
| 427 | 100 | 86 |
| 428 | 100 | 82 |
| 429 | 97 | 43 |
| 430 | 70 | 16 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 431 | 50 | 20 |
| 432 | 42 | 33 |
| 433 | 89 | 64 |
| 434 | 89 | 77 |
| 435 | 99 | 95 |
| 436 | 100 | 41 |
| 437 | 77 | 12 |
| 438 | 29 | 37 |
| 439 | 16 | 41 |
| 440 | 16 | 38 |
| 441 | 15 | 36 |
| 442 | 18 | 44 |
| 443 | 4 | 55 |
| 444 | 24 | 26 |
| 445 | 26 | 35 |
| 446 | 15 | 45 |
| 447 | 21 | 39 |
| 448 | 29 | 52 |
| 449 | 26 | 46 |
| 450 | 27 | 50 |
| 451 | 13 | 43 |
| 452 | 25 | 36 |
| 453 | 37 | 57 |
| 454 | 29 | 46 |
| 455 | 17 | 39 |
| 456 | 13 | 41 |
| 457 | 19 | 38 |
| 458 | 28 | 35 |
| 459 | 8 | 51 |
| 460 | 14 | 36 |
| 461 | 17 | 47 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 462 | 34 | 39 |
| 463 | 34 | 57 |
| 464 | 11 | 70 |
| 465 | 13 | 51 |
| 466 | 13 | 68 |
| 467 | 38 | 44 |
| 468 | 53 | 67 |
| 469 | 29 | 69 |
| 470 | 19 | 65 |
| 471 | 52 | 45 |
| 472 | 61 | 79 |
| 473 | 29 | 70 |
| 474 | 15 | 53 |
| 475 | 15 | 60 |
| 476 | 52 | 40 |
| 477 | 50 | 61 |
| 478 | 13 | 74 |
| 479 | 46 | 51 |
| 480 | 60 | 73 |
| 481 | 33 | 84 |
| 482 | 31 | 63 |
| 483 | 41 | 42 |
| 484 | 26 | 69 |
| 485 | 23 | 65 |
| 486 | 48 | 49 |
| 487 | 28 | 57 |
| 488 | 16 | 67 |
| 489 | 39 | 48 |
| 490 | 47 | 73 |
| 491 | 35 | 87 |
| 492 | 26 | 73 |
| 493 | 30 | 61 |
| 494 | 34 | 49 |
| 495 | 35 | 66 |
| 496 | 56 | 47 |
| 497 | 49 | 64 |
| 498 | 59 | 64 |
| 499 | 42 | 69 |
| 500 | 6 | 77 |
| 501 | 5 | 59 |
| 502 | 17 | 59 |
| 503 | 45 | 53 |
| 504 | 21 | 62 |
| 505 | 31 | 60 |
| 506 | 53 | 68 |
| 507 | 48 | 79 |
| 508 | 45 | 61 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 509 | 51 | 47 |
| 510 | 41 | 48 |
| 511 | 26 | 58 |
| 512 | 21 | 62 |
| 513 | 50 | 52 |
| 514 | 39 | 65 |
| 515 | 23 | 65 |
| 516 | 42 | 62 |
| 517 | 57 | 80 |
| 518 | 66 | 81 |
| 519 | 64 | 62 |
| 520 | 45 | 42 |
| 521 | 33 | 42 |
| 522 | 27 | 57 |
| 523 | 31 | 59 |
| 524 | 41 | 53 |
| 525 | 45 | 72 |
| 526 | 48 | 73 |
| 527 | 46 | 90 |
| 528 | 56 | 76 |
| 529 | 64 | 76 |
| 530 | 69 | 64 |
| 531 | 72 | 59 |
| 532 | 73 | 58 |
| 533 | 71 | 56 |
| 534 | 66 | 48 |
| 535 | 61 | 50 |
| 536 | 55 | 56 |
| 537 | 52 | 52 |
| 538 | 54 | 49 |
| 539 | 61 | 50 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 540 | 64 | 54 |
| 541 | 67 | 54 |
| 542 | 68 | 52 |
| 543 | 60 | 53 |
| 544 | 52 | 50 |
| 545 | 45 | 49 |
| 546 | 38 | 45 |
| 547 | 32 | 45 |
| 548 | 26 | 53 |
| 549 | 23 | 56 |
| 550 | 30 | 49 |
| 551 | 33 | 55 |
| 552 | 35 | 59 |
| 553 | 33 | 65 |
| 554 | 30 | 67 |
| 555 | 28 | 59 |
| 556 | 25 | 58 |
| 557 | 23 | 56 |
| 558 | 22 | 57 |
| 559 | 19 | 63 |
| 560 | 14 | 63 |
| 561 | 31 | 61 |
| 562 | 35 | 62 |
| 563 | 21 | 80 |
| 564 | 28 | 65 |
| 565 | 7 | 74 |
| 566 | 23 | 54 |
| 567 | 38 | 54 |
| 568 | 14 | 78 |
| 569 | 38 | 58 |
| 570 | 52 | 75 |
| 571 | 59 | 81 |
| 572 | 66 | 69 |
| 573 | 54 | 44 |
| 574 | 48 | 34 |
| 575 | 44 | 33 |
| 576 | 40 | 40 |
| 577 | 28 | 58 |
| 578 | 27 | 63 |
| 579 | 35 | 45 |
| 580 | 20 | 66 |
| 581 | 15 | 60 |
| 582 | 10 | 52 |
| 583 | 22 | 56 |
| 584 | 30 | 62 |
| 585 | 21 | 67 |
| 586 | 29 | 53 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 587 | 41 | 56 |
| 588 | 15 | 67 |
| 589 | 24 | 56 |
| 590 | 42 | 69 |
| 591 | 39 | 83 |
| 592 | 40 | 73 |
| 593 | 35 | 67 |
| 594 | 32 | 61 |
| 595 | 30 | 65 |
| 596 | 30 | 72 |
| 597 | 48 | 51 |
| 598 | 66 | 58 |
| 599 | 62 | 71 |
| 600 | 36 | 63 |
| 601 | 17 | 59 |
| 602 | 16 | 50 |
| 603 | 16 | 62 |
| 604 | 34 | 48 |
| 605 | 51 | 66 |
| 606 | 35 | 74 |
| 607 | 15 | 56 |
| 608 | 19 | 54 |
| 609 | 43 | 65 |
| 610 | 52 | 80 |
| 611 | 52 | 83 |
| 612 | 49 | 57 |
| 613 | 48 | 46 |
| 614 | 37 | 36 |
| 615 | 25 | 44 |
| 616 | 14 | 53 |
| 617 | 13 | 64 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 618 | 23 | 56 |
| 619 | 21 | 63 |
| 620 | 18 | 67 |
| 621 | 20 | 54 |
| 622 | 16 | 67 |
| 623 | 26 | 56 |
| 624 | 41 | 65 |
| 625 | 28 | 62 |
| 626 | 19 | 60 |
| 627 | 33 | 56 |
| 628 | 37 | 70 |
| 629 | 24 | 79 |
| 630 | 28 | 57 |
| 631 | 40 | 57 |
| 632 | 40 | 58 |
| 633 | 28 | 44 |
| 634 | 25 | 41 |
| 635 | 29 | 53 |
| 636 | 31 | 55 |
| 637 | 26 | 64 |
| 638 | 20 | 50 |
| 639 | 16 | 53 |
| 640 | 11 | 54 |
| 641 | 13 | 53 |
| 642 | 23 | 50 |
| 643 | 32 | 59 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 644 | 36 | 63 |
| 645 | 33 | 59 |
| 646 | 24 | 52 |
| 647 | 20 | 52 |
| 648 | 22 | 55 |
| 649 | 30 | 53 |
| 650 | 37 | 59 |
| 651 | 41 | 58 |
| 652 | 36 | 54 |
| 653 | 29 | 49 |
| 654 | 24 | 53 |
| 655 | 14 | 57 |
| 656 | 10 | 54 |
| 657 | 9 | 55 |
| 658 | 10 | 57 |
| 659 | 13 | 55 |
| 660 | 15 | 64 |
| 661 | 31 | 57 |
| 662 | 19 | 69 |
| 663 | 14 | 59 |
| 664 | 33 | 57 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 665 | 41 | 65 |
| 666 | 39 | 64 |
| 667 | 39 | 59 |
| 668 | 39 | 51 |
| 669 | 28 | 41 |
| 670 | 19 | 49 |
| 671 | 27 | 54 |
| 672 | 37 | 63 |
| 673 | 32 | 74 |
| 674 | 16 | 70 |
| 675 | 12 | 67 |
| 676 | 13 | 60 |
| 677 | 17 | 56 |
| 678 | 15 | 62 |
| 679 | 25 | 47 |
| 680 | 27 | 64 |
| 681 | 14 | 71 |
| 682 | 5 | 65 |
| 683 | 6 | 57 |
| 684 | 6 | 57 |
| 685 | 15 | 52 |
| 686 | 22 | 61 |
| 687 | 14 | 77 |
| 688 | 12 | 67 |
| 689 | 12 | 62 |
| 690 | 14 | 59 |
| 691 | 15 | 58 |
| 692 | 18 | 55 |
| 693 | 22 | 53 |
| 694 | 19 | 69 |
| 695 | 14 | 67 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 696 | 9 | 63 |
| 697 | 8 | 56 |
| 698 | 17 | 49 |
| 699 | 25 | 55 |
| 700 | 14 | 70 |
| 701 | 12 | 60 |
| 702 | 22 | 57 |
| 703 | 27 | 67 |
| 704 | 29 | 68 |
| 705 | 34 | 62 |
| 706 | 35 | 61 |
| 707 | 28 | 78 |
| 708 | 11 | 71 |
| 709 | 4 | 58 |
| 710 | 5 | 58 |
| 711 | 10 | 56 |
| 712 | 20 | 63 |
| 713 | 13 | 76 |
| 714 | 11 | 65 |
| 715 | 9 | 60 |
| 716 | 7 | 55 |
| 717 | 8 | 53 |
| 718 | 10 | 60 |
| 719 | 28 | 53 |
| 720 | 12 | 73 |
| 721 | 4 | 64 |
| 722 | 4 | 61 |
| 723 | 4 | 61 |
| 724 | 10 | 56 |
| 725 | 8 | 61 |
| 726 | 20 | 56 |
| 727 | 32 | 62 |
| 728 | 33 | 66 |
| 729 | 34 | 73 |
| 730 | 31 | 61 |
| 731 | 33 | 55 |
| 732 | 33 | 60 |
| 733 | 31 | 59 |
| 734 | 29 | 58 |
| 735 | 31 | 53 |
| 736 | 33 | 51 |
| 737 | 33 | 48 |
| 738 | 27 | 44 |
| 739 | 21 | 52 |
| 740 | 13 | 57 |
| 741 | 12 | 56 |
| 742 | 10 | 64 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 743 | 22 | 47 |
| 744 | 15 | 74 |
| 745 | 8 | 66 |
| 746 | 34 | 47 |
| 747 | 18 | 71 |
| 748 | 9 | 57 |
| 749 | 11 | 55 |
| 750 | 12 | 57 |
| 751 | 10 | 61 |
| 752 | 16 | 53 |
| 753 | 12 | 75 |
| 754 | 6 | 70 |
| 755 | 12 | 55 |
| 756 | 24 | 50 |
| 757 | 28 | 60 |
| 758 | 28 | 64 |
| 759 | 23 | 60 |
| 760 | 20 | 56 |
| 761 | 26 | 50 |
| 762 | 28 | 55 |
| 763 | 18 | 56 |
| 764 | 15 | 52 |
| 765 | 11 | 59 |
| 766 | 16 | 59 |
| 767 | 34 | 54 |
| 768 | 16 | 82 |
| 769 | 15 | 64 |
| 770 | 36 | 53 |
| 771 | 45 | 64 |
| 772 | 41 | 59 |
| 773 | 34 | 50 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 774 | 27 | 45 |
| 775 | 22 | 52 |
| 776 | 18 | 55 |
| 777 | 26 | 54 |
| 778 | 39 | 62 |
| 779 | 37 | 71 |
| 780 | 32 | 58 |
| 781 | 24 | 48 |
| 782 | 14 | 59 |
| 783 | 7 | 59 |
| 784 | 7 | 55 |
| 785 | 18 | 49 |
| 786 | 40 | 62 |
| 787 | 44 | 73 |
| 788 | 41 | 68 |
| 789 | 35 | 48 |
| 790 | 29 | 54 |
| 791 | 22 | 69 |
| 792 | 46 | 53 |
| 793 | 59 | 71 |
| 794 | 69 | 68 |
| 795 | 75 | 47 |
| 796 | 62 | 32 |
| 797 | 48 | 35 |
| 798 | 27 | 59 |
| 799 | 13 | 58 |
| 800 | 14 | 54 |
| 801 | 21 | 53 |
| 802 | 23 | 56 |
| 803 | 23 | 57 |
| 804 | 23 | 65 |
| 805 | 13 | 65 |
| 806 | 9 | 64 |
| 807 | 27 | 56 |
| 808 | 26 | 78 |
| 809 | 40 | 61 |
| 810 | 35 | 76 |
| 811 | 28 | 66 |
| 812 | 23 | 57 |
| 813 | 16 | 50 |
| 814 | 11 | 53 |
| 815 | 9 | 57 |
| 816 | 9 | 62 |
| 817 | 27 | 57 |
| 818 | 42 | 69 |
| 819 | 47 | 75 |
| 820 | 53 | 67 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 821 | 61 | 62 |
| 822 | 63 | 53 |
| 823 | 60 | 54 |
| 824 | 56 | 44 |
| 825 | 49 | 39 |
| 826 | 39 | 35 |
| 827 | 30 | 34 |
| 828 | 33 | 46 |
| 829 | 44 | 56 |
| 830 | 50 | 56 |
| 831 | 44 | 52 |
| 832 | 38 | 46 |
| 833 | 33 | 44 |
| 834 | 29 | 45 |
| 835 | 24 | 46 |
| 836 | 18 | 52 |
| 837 | 9 | 55 |
| 838 | 10 | 54 |
| 839 | 20 | 53 |
| 840 | 27 | 58 |
| 841 | 29 | 59 |
| 842 | 30 | 62 |
| 843 | 30 | 65 |
| 844 | 27 | 66 |
| 845 | 32 | 58 |
| 846 | 40 | 56 |
| 847 | 41 | 57 |
| 848 | 18 | 73 |
| 849 | 15 | 55 |
| 850 | 18 | 50 |
| 851 | 17 | 52 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 852 | 20 | 49 |
| 853 | 16 | 62 |
| 854 | 4 | 67 |
| 855 | 2 | 64 |
| 856 | 7 | 54 |
| 857 | 10 | 50 |
| 858 | 9 | 57 |
| 859 | 5 | 62 |
| 860 | 12 | 51 |
| 861 | 14 | 65 |
| 862 | 9 | 64 |
| 863 | 31 | 50 |
| 864 | 30 | 78 |
| 865 | 21 | 65 |
| 866 | 14 | 51 |
| 867 | 10 | 55 |
| 868 | 6 | 59 |
| 869 | 7 | 59 |
| 870 | 19 | 54 |
| 871 | 23 | 61 |
| 872 | 24 | 62 |
| 873 | 34 | 61 |
| 874 | 51 | 67 |
| 875 | 60 | 66 |
| 876 | 58 | 55 |
| 877 | 60 | 52 |
| 878 | 64 | 55 |
| 879 | 68 | 51 |
| 880 | 63 | 54 |
| 881 | 64 | 50 |
| 882 | 68 | 58 |
| 883 | 73 | 47 |
| 884 | 63 | 40 |
| 885 | 50 | 38 |
| 886 | 29 | 61 |
| 887 | 14 | 61 |
| 888 | 14 | 53 |
| 889 | 42 | 6 |
| 890 | 58 | 6 |
| 891 | 58 | 6 |
| 892 | 77 | 39 |
| 893 | 93 | 56 |
| 894 | 93 | 44 |
| 895 | 93 | 37 |
| 896 | 93 | 31 |
| 897 | 93 | 25 |
| 898 | 93 | 26 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 899 | 93 | 27 |
| 900 | 93 | 25 |
| 901 | 93 | 21 |
| 902 | 93 | 22 |
| 903 | 93 | 24 |
| 904 | 93 | 23 |
| 905 | 93 | 27 |
| 906 | 93 | 34 |
| 907 | 93 | 32 |
| 908 | 93 | 26 |
| 909 | 93 | 31 |
| 910 | 93 | 34 |
| 911 | 93 | 31 |
| 912 | 93 | 33 |
| 913 | 93 | 36 |
| 914 | 93 | 37 |
| 915 | 93 | 34 |
| 916 | 93 | 30 |
| 917 | 93 | 32 |
| 918 | 93 | 35 |
| 919 | 93 | 35 |
| 920 | 93 | 32 |
| 921 | 93 | 28 |
| 922 | 93 | 23 |
| 923 | 94 | 18 |
| 924 | 95 | 18 |
| 925 | 96 | 17 |
| 926 | 95 | 13 |
| 927 | 96 | 10 |
| 928 | 95 | 9 |
| 929 | 95 | 7 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 930 | 95 | 7 |
| 931 | 96 | 7 |
| 932 | 96 | 6 |
| 933 | 96 | 6 |
| 934 | 95 | 6 |
| 935 | 90 | 6 |
| 936 | 69 | 43 |
| 937 | 76 | 62 |
| 938 | 93 | 47 |
| 939 | 93 | 39 |
| 940 | 93 | 35 |
| 941 | 93 | 34 |
| 942 | 93 | 36 |
| 943 | 93 | 39 |
| 944 | 93 | 34 |
| 945 | 93 | 26 |
| 946 | 93 | 23 |
| 947 | 93 | 24 |
| 948 | 93 | 24 |
| 949 | 93 | 22 |
| 950 | 93 | 19 |
| 951 | 93 | 17 |
| 952 | 93 | 19 |
| 953 | 93 | 22 |
| 954 | 93 | 24 |
| 955 | 93 | 23 |
| 956 | 93 | 20 |
| 957 | 93 | 20 |
| 958 | 94 | 19 |
| 959 | 95 | 19 |
| 960 | 95 | 17 |
| 961 | 96 | 13 |
| 962 | 95 | 10 |
| 963 | 96 | 9 |
| 964 | 95 | 7 |
| 965 | 95 | 7 |
| 966 | 95 | 7 |
| 967 | 95 | 6 |
| 968 | 96 | 6 |
| 969 | 96 | 6 |
| 970 | 89 | 6 |
| 971 | 68 | 6 |
| 972 | 57 | 6 |
| 973 | 66 | 32 |
| 974 | 84 | 52 |
| 975 | 93 | 46 |
| 976 | 93 | 42 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 977 | 93 | 36 |
| 978 | 93 | 28 |
| 979 | 93 | 23 |
| 980 | 93 | 19 |
| 981 | 93 | 16 |
| 982 | 93 | 15 |
| 983 | 93 | 16 |
| 984 | 93 | 15 |
| 985 | 93 | 14 |
| 986 | 93 | 15 |
| 987 | 93 | 16 |
| 988 | 94 | 15 |
| 989 | 93 | 32 |
| 990 | 93 | 45 |
| 991 | 93 | 43 |
| 992 | 93 | 37 |
| 993 | 93 | 29 |
| 994 | 93 | 23 |
| 995 | 93 | 20 |
| 996 | 93 | 18 |
| 997 | 93 | 16 |
| 998 | 93 | 17 |
| 999 | 93 | 16 |
| 1000 | 93 | 15 |
| 1001 | 93 | 15 |
| 1002 | 93 | 15 |
| 1003 | 93 | 14 |
| 1004 | 93 | 15 |
| 1005 | 93 | 15 |
| 1006 | 93 | 14 |
| 1007 | 93 | 13 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1008 | 93 | 14 |
| 1009 | 93 | 14 |
| 1010 | 93 | 15 |
| 1011 | 93 | 16 |
| 1012 | 93 | 17 |
| 1013 | 93 | 20 |
| 1014 | 93 | 22 |
| 1015 | 93 | 20 |
| 1016 | 93 | 19 |
| 1017 | 93 | 20 |
| 1018 | 93 | 19 |
| 1019 | 93 | 19 |
| 1020 | 93 | 20 |
| 1021 | 93 | 32 |
| 1022 | 93 | 37 |
| 1023 | 93 | 28 |
| 1024 | 93 | 26 |
| 1025 | 93 | 24 |
| 1026 | 93 | 22 |
| 1027 | 93 | 22 |
| 1028 | 93 | 21 |
| 1029 | 93 | 20 |
| 1030 | 93 | 20 |
| 1031 | 93 | 20 |
| 1032 | 93 | 20 |
| 1033 | 93 | 19 |
| 1034 | 93 | 18 |
| 1035 | 93 | 20 |
| 1036 | 93 | 20 |
| 1037 | 93 | 20 |
| 1038 | 93 | 20 |
| 1039 | 93 | 19 |
| 1040 | 93 | 18 |
| 1041 | 93 | 18 |
| 1042 | 93 | 17 |
| 1043 | 93 | 16 |
| 1044 | 93 | 16 |
| 1045 | 93 | 15 |
| 1046 | 93 | 16 |
| 1047 | 93 | 18 |
| 1048 | 93 | 37 |
| 1049 | 93 | 48 |
| 1050 | 93 | 38 |
| 1051 | 93 | 31 |
| 1052 | 93 | 26 |
| 1053 | 93 | 21 |
| 1054 | 93 | 18 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1055 | 93 | 16 |
| 1056 | 93 | 17 |
| 1057 | 93 | 18 |
| 1058 | 93 | 19 |
| 1059 | 93 | 21 |
| 1060 | 93 | 20 |
| 1061 | 93 | 18 |
| 1062 | 93 | 17 |
| 1063 | 93 | 17 |
| 1064 | 93 | 18 |
| 1065 | 93 | 18 |
| 1066 | 93 | 18 |
| 1067 | 93 | 19 |
| 1068 | 93 | 18 |
| 1069 | 93 | 18 |
| 1070 | 93 | 20 |
| 1071 | 93 | 23 |
| 1072 | 93 | 25 |
| 1073 | 93 | 25 |
| 1074 | 93 | 24 |
| 1075 | 93 | 24 |
| 1076 | 93 | 22 |
| 1077 | 93 | 22 |
| 1078 | 93 | 22 |
| 1079 | 93 | 19 |
| 1080 | 93 | 16 |
| 1081 | 95 | 17 |
| 1082 | 95 | 37 |
| 1083 | 93 | 43 |
| 1084 | 93 | 32 |
| 1085 | 93 | 27 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1086 | 93 | 26 |
| 1087 | 93 | 24 |
| 1088 | 93 | 22 |
| 1089 | 93 | 22 |
| 1090 | 93 | 22 |
| 1091 | 93 | 23 |
| 1092 | 93 | 22 |
| 1093 | 93 | 22 |
| 1094 | 93 | 23 |
| 1095 | 93 | 23 |
| 1096 | 93 | 23 |
| 1097 | 93 | 22 |
| 1098 | 93 | 23 |
| 1099 | 93 | 23 |
| 1100 | 93 | 23 |
| 1101 | 93 | 25 |
| 1102 | 93 | 27 |
| 1103 | 93 | 26 |
| 1104 | 93 | 25 |
| 1105 | 93 | 27 |
| 1106 | 93 | 27 |
| 1107 | 93 | 27 |
| 1108 | 93 | 24 |
| 1109 | 93 | 20 |
| 1110 | 93 | 18 |
| 1111 | 93 | 17 |
| 1112 | 93 | 17 |
| 1113 | 93 | 18 |
| 1114 | 93 | 18 |
| 1115 | 93 | 18 |
| 1116 | 93 | 19 |
| 1117 | 93 | 22 |
| 1118 | 93 | 22 |
| 1119 | 93 | 19 |
| 1120 | 93 | 17 |
| 1121 | 93 | 17 |
| 1122 | 93 | 18 |
| 1123 | 93 | 18 |
| 1124 | 93 | 19 |
| 1125 | 93 | 19 |
| 1126 | 93 | 20 |
| 1127 | 93 | 19 |
| 1128 | 93 | 20 |
| 1129 | 93 | 25 |
| 1130 | 93 | 30 |
| 1131 | 93 | 31 |
| 1132 | 93 | 26 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1133 | 93 | 21 |
| 1134 | 93 | 18 |
| 1135 | 93 | 20 |
| 1136 | 93 | 25 |
| 1137 | 93 | 24 |
| 1138 | 93 | 21 |
| 1139 | 93 | 21 |
| 1140 | 93 | 22 |
| 1141 | 93 | 22 |
| 1142 | 93 | 28 |
| 1143 | 93 | 29 |
| 1144 | 93 | 23 |
| 1145 | 93 | 21 |
| 1146 | 93 | 18 |
| 1147 | 93 | 16 |
| 1148 | 93 | 16 |
| 1149 | 93 | 16 |
| 1150 | 93 | 17 |
| 1151 | 93 | 17 |
| 1152 | 93 | 17 |
| 1153 | 93 | 17 |
| 1154 | 93 | 23 |
| 1155 | 93 | 26 |
| 1156 | 93 | 22 |
| 1157 | 93 | 18 |
| 1158 | 93 | 16 |
| 1159 | 93 | 16 |
| 1160 | 93 | 17 |
| 1161 | 93 | 19 |
| 1162 | 93 | 18 |
| 1163 | 93 | 16 |

| Time (s) | Normalized speed (%) | Normalized torque (%) |
|---|---|---|
| 1164 | 93 | 19 |
| 1165 | 93 | 22 |
| 1166 | 93 | 25 |
| 1167 | 93 | 29 |
| 1168 | 93 | 27 |
| 1169 | 93 | 22 |
| 1170 | 93 | 18 |
| 1171 | 93 | 16 |
| 1172 | 93 | 19 |
| 1173 | 93 | 19 |
| 1174 | 93 | 17 |
| 1175 | 93 | 17 |
| 1176 | 93 | 17 |
| 1177 | 93 | 16 |
| 1178 | 93 | 16 |
| 1179 | 93 | 15 |
| 1180 | 93 | 16 |
| 1181 | 93 | 15 |
| 1182 | 93 | 17 |
| 1183 | 93 | 21 |
| 1184 | 93 | 30 |
| 1185 | 93 | 53 |
| 1186 | 93 | 54 |
| 1187 | 93 | 38 |
| 1188 | 93 | 30 |
| 1189 | 93 | 24 |
| 1190 | 93 | 20 |
| 1191 | 95 | 20 |
| 1192 | 96 | 18 |
| 1193 | 96 | 15 |
| 1194 | 96 | 11 |
| 1195 | 95 | 9 |
| 1196 | 95 | 8 |
| 1197 | 96 | 7 |
| 1198 | 94 | 33 |
| 1199 | 93 | 46 |
| 1200 | 93 | 37 |
| 1201 | 16 | 8 |
| 1202 | 0 | 0 |
| 1203 | 0 | 0 |
| 1204 | 0 | 0 |
| 1205 | 0 | 0 |
| 1206 | 0 | 0 |
| 1207 | 0 | 0 |
| 1208 | 0 | 0 |
| 1209 | 0 | 0 |