Application Letter EAI-S MTU C&I + Agriculture 2011-001

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Ref.: Rudert

Stage 3B and Tier4i Emission Updates Mercedes Engines < 560 kW

Dear Sir or Madam,

There will be two different emission certifications available for the next emission levels leading to two different engine specifications:

1. **Euromot3b: Engine with European emission legislation only**
   No inducement required by legislation. Indicator lamps (symbols and colours are not mandatory) are required by legislation to inform the operator about emission related events. The engine will not de-rate due to non-emission compliance (e.g. low urea level). No export to EPA Tier4i countries permitted.
2. **Tier4i: EPA emission label (including European Euromot3b emission legislation)**
   EPA emission compliant Inducement functionality and de-rating implemented in engine ECU and ADM3. Defined indicator lamps (symbol and colours) as well as audible warning are required by legislation to inform the operator about emission related events. Export to EU countries with Euromot3b legislation is permitted.

For the Tier4i emission certified engines the **Inducement-System** has to be implemented by the engine manufacturer.

To support the OEM in implementing this into the vehicle installation, we provide information about the **final status of the inducement strategy** for Mercedes Tier4i engines (see following pages).

A conversion in emission certification after delivery is not possible. This would lead to hardware changes, documentation changes (emission labels, engine documents, after sales documents) as well as COP issues.

If you have further questions, please contact your partner in application engineering.

Yours sincerely,

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Comparison of Tier4i and Euromot3b indicator/lamp concepts

	Certified Tier4i and Euromot3b (with inducement)	Emission relevant	Symbol	Certified Euromot3b only (without inducement)	Emission relevant	Symbol
Indicators for engine and aftertreatment events	**CEL-Lamp (=AWL-Lamp)** - mandatory by emission legislation - indicates check engine events - Colour (amber) defined in certificate, symbol not mandatory	X	e.g. 	**CEL-Lamp (=AWL-Lamp)** - indicates check engine events - Part of the operator warning concept for EU - Colour and symbol not mandatory	X	e.g. 
	SEL-Lamp (= Stop Engine Lamp) - Indicates severe engine events that require an immediate engine stop. If theengine will not be stopped, major damages or destruction can occur to the engine - Colour and symbol not mandatory		e.g. 	**SEL-Lamp (= Stop Engine Lamp)** - Indicates severe engine events that require an immediate engine stop. If theengine will not be stopped, major damages or destruction can occur to the engine - Colour and symbol not mandatory		e.g. 
	MIL-Lamp - Not needed / No functionality with Tier4i. - Replaces For combined Tier4i/Euromot3b certified engines - If an OEM has also Euromot3b only certified engine it is recommended to keep the lamp in dasboard - Colour and symbol not mandatory		e.g. 	**MIL-Lamp** - Indicates DEF-quality and tampering - Part of the operator warning concept for EU - Colour and symbol not mandatory	X	e.g. 
	DEF-Lamp - mandatory by emission legislation - indicates low DEF-level, bad DEF-quality and tampering - Symbol and colour (amber) defined in certificate (- Was formerly the DEF/AdBlue-Lamp)	X		**DEF-Lamp** - mandatory by emission legislation - indicates low DEF-level - Part of the operator warning concept for EU - Colour and symbol not mandatory (- Was formerly the DEF/AdBlue-Lamp)	X	e.g. 
	LIM-Lamp - mandatory by emission legislation - indicates Inducement levels (torque limiter) solid: early inducment; blinking: severe inducment - Symbol and colour (amber) defined in certificate (- Was formerly the NOx-Lamp)	X		**LIM-Lamp** - Not needed / No functionality with Euromot3b - If an OEM has also Tier4i certified engine it is recommended to keep the lamp in dasboard (- Was formerly the NOx-Lamp)		e.g. 
	DEF/AdBlue-Level gauge - Indicates DEF level in DEF tank. - Gauge mandatory depending on tank sizes - EPA DEF tank size definition: For specific vocational applications, a smaller DEF tank size is appropriate (e.g., garbage truck, dump truck, concrete mixer, beverage truck, fire truck, airport refueler). These applications are generally refueled daily from a central location and conducive to refilling DEF in the same manner. The minimum DEF tank size must provide no less than: - Equal the range (in miles or hours) of the vehicle's fuel capacity (i.e., 1:1) For all other vehicle applications, the minimum DEF tank size must provide no less than: - Twice the range (in miles or hours) of vehicle's fuel capacity (i.e., 2:1); or, - Three times the range (in miles or hours) of the vehicle's fuel capacity (i.e., 3:1), if there is no constant DEF level indicator.	X	**No special requirement for gauge layout**	**DEF/AdBlue-Level gauge** - Indicates DEF level in DEF tank - Not mandatory by emmision legislation - DEF-tank sizes not defined	X	**No special requirement for gauge layout**

AWL= Amber Warning Light
TL = Torque Limiter
MIL = Malfunction Indicator Lamp
CEL = Check Engine Lamp
SEL = Stop Engine Lamp
LIM = LIMiter Lamp
DEF = Diesel Exhaust Fluid

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Inducement Strategy for Mercedes-Benz Tier 4i Nonroad Engines

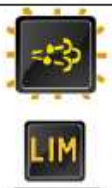
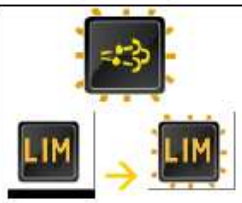
The SCR warning and inducement concept is intended to prevent operation of the nonroad equipment in case of no DEF, DEF of insufficient quality and tampering with the elements of the SCR system.

1. Instrument Panel Indicators

Three different indicators must be available on the dashboard for warning of the operator, as listed below. In addition, audible warning is required when LIM indicator is activated (continous tone). Escalation of audible warning (intermittent tone) will start when LIM indicator is blinking. ECU signal for audible warning corresponds to LIM signal.

Indicator	Indication	Symbol
Diesel Exhaust Fluid (DEF)	Warning & inducement	
Amber Warning Light (AWL)	Failures & tampering	
Torque Limiter Active (LIM)	inducement level solid→ early inducement blinking → severe inducement	

2. Operator Warning and Inducement for Low DEF

DEF Level	Indicator	System Reaction/Response
Trigger 1: 14 % ≥ DEF Level Trigger 2: 10 % ≥ DEF Level		• DEF solid
30 min after trigger 2		• DEF blinking 1Hz • LIM solid • Early inducement 5.1
60 min after trigger 2		• DEF blinking 1Hz • At torque > 50% : LIM solid • At torque ≤ 50% : LIM blinking 1HZ • Final inducement 5.2

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The final inducement time of 2 hours has been selected, since DEF tank has been calculated to be empty no longer than 2 hours after reaching the 10% tank level under worst case operating conditions. The tank level sensor must be calibrated with an off-set of 5 % so that 10 % DEF tank level in reality corresponds to 15 % DEF tank level.

The time sequence of warning and inducement is shown in Figure 1. Total time until final inducement is 120 minutes.

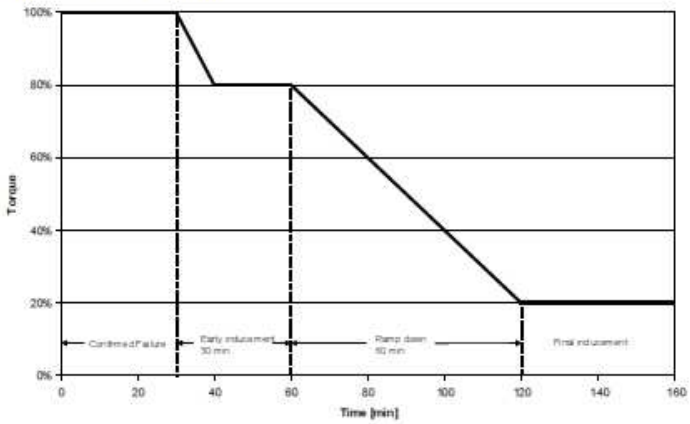
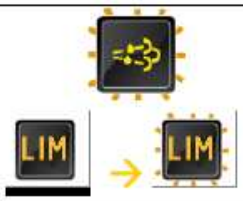


Figure 1 Low DEF warning and inducement sequence

3. Operator Warning and Inducement for Incorrect DEF Quality

Incorrect DEF quality is detected via the NOx sensor.

DEF Quality	Indicator	System Reaction/Response
Trigger: detection of incorrect quality		• DEF solid
60 min after detection		• DEF blinking 1Hz • LIM solid • Early inducement 5.1
180 min after trigger		• DEF blinking 1Hz • At torque > 50%: LIM solid • At torque ≤ 50%: LIM blinking 1 Hz • Final inducement 5.2

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The time sequence of warning and inducement is shown in Figure 2. Total time until final inducement is 240 minutes.

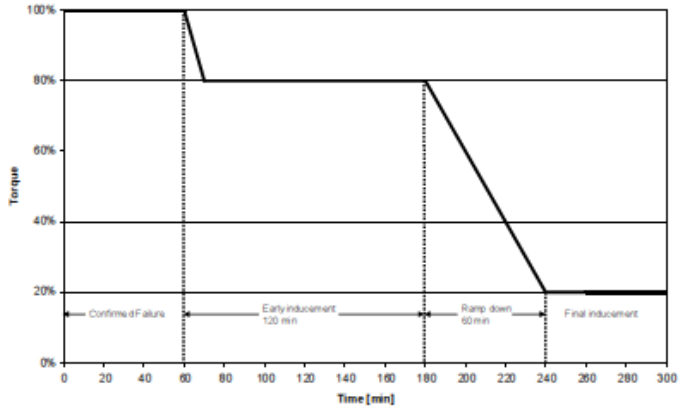

Figure 2 Incorrect DEF quality and tampering warning and inducement sequence

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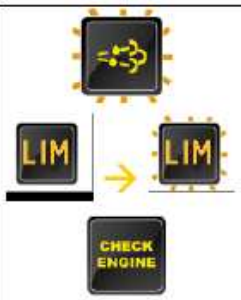
4. Operator Warning and Inducement for Tampering

Tampering	Indicator	System Reaction/Response
Trigger: Detection of Disconnect tank level sensor Disconnect DEF dosing line or valve Blocked DEF dosing line or valve Disconnect DEF dosing pump Disconnect SCR wiring harness Disconnect NOx sensor Disconnect DEF temperature sensor Disconnect exhaust temperature sensor		• DEF solid • AWL solid
60 min after trigger		• DEF blinking 1Hz • LIM solid • AWL solid • Early inducement 5.1
180 min after trigger		• DEF blinking 1Hz • AWL solid • At torque > 50% : LIM solid • At torque ≤ 50% : LIM blinking 1 Hz • Final inducement 5.2

The time sequence of warning and inducement is identical to section 3 as shown in Figure 2, above. Total time until final inducement is 240 minutes.

5. Implementation of the Inducement Strategy

5.1 Early Inducement

Maximum available torque is reduced to 80% of peak torque across the speed range, as shown in Figure 3 within 10 ± 1 minutes.

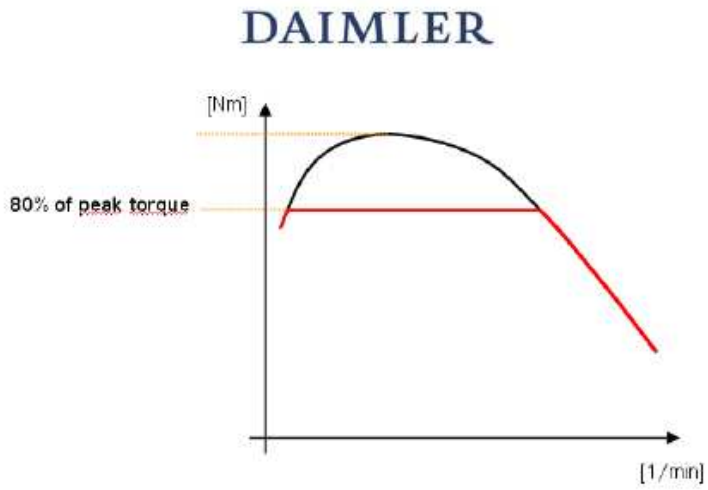


Figure 3 Engine derate during early inducement

5.2 Final Inducement

The final inducement engine operation is 1000 RPM and 20 % of peak torque, which is slightly above engine idling. Equipment operation will be severely impaired under these conditions.

The step from early inducement to final inducement is done by gradually ramping engine speed and torque down within 60 minutes as follows:

- engine torque is ramped down from 80 % of peak torque by 1 % per minute to 20 % of peak torque
- in parallel, engine speed is ramped down from actual speed (at the start of the ramp) to 1000 RPM

5.3 Inducement Override

For emergency cases, an inducement override button is installed that can be activated by the operator. This function is also needed for self-healing of the system as validation phase to detect if the failure has been corrected (e.g. if the correct DEF quality has been re-filled). The button will release full engine power for a maximum of 30 minutes, and can be activated for a maximum of 3 times.

Inducement override is only possible between the start of the inducement sequence and final inducement engine operation. Once the engine reaches final inducement according to section 5.2 (1000 RPM, 20 % torque), the override function will be deactivated. Consequently, the override function will principally not extend the ramp times, as shown in figures 1 and 2. During engine operation with active override, the inducement system will continue to calculate inducement times, engine demand speed and engine demand torque in the background.

After returning from override and without healing the failure, engine speed and torque will be continued with the values corresponding to the demand values without override activation. This also means that the maximum override time of 90 minutes (3 activations) can only be used if activated early during the inducement period. For example, once the engine operates in its final 30 minutes ramp-down, only one override activation is possible. If the failure has not been healed during this override, the engine will directly go to final inducement without the possibility of another override activation.

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5.4 Erasing of Fault Code Memory

An active inducement failure can not be erased by clearing of the fault code memory by a generic scantool. Clearing of active inducement failures is only possible by an authorized pass code via the Daimler/MTU service system, after the failure has been corrected by authorized service staff. One pass code is good for one failure and will be documented incl. the name of service staff who issued the pass code.

5.5 Repeated offenses

In case of repeated offenses, the original time triggers and ramps are shortened by a factor, which depends on the number of repeated offenses. If a failure is healed (e.g. a NOx sensor is repaired or reconnected), the inducement will be reset and the normal engine operation will be achieved again. If any inducement related failure listed under sections 2 to 4 occurs within 40 hours of engine operation, a shortened inducement period will be activated as outlined below.

For example, if any failure occurs within 40 hours of correcting the previous failure, the time for triggering the low inducement and the time for triggering the severe inducement (incl. ramp down time) will be divided by a factor of 2. A further re-occurrence of any failure within 40 hours of correcting the second failure will lead to a further reduction of the time for triggering and for ramping down by dividing the original times by a factor of 4.

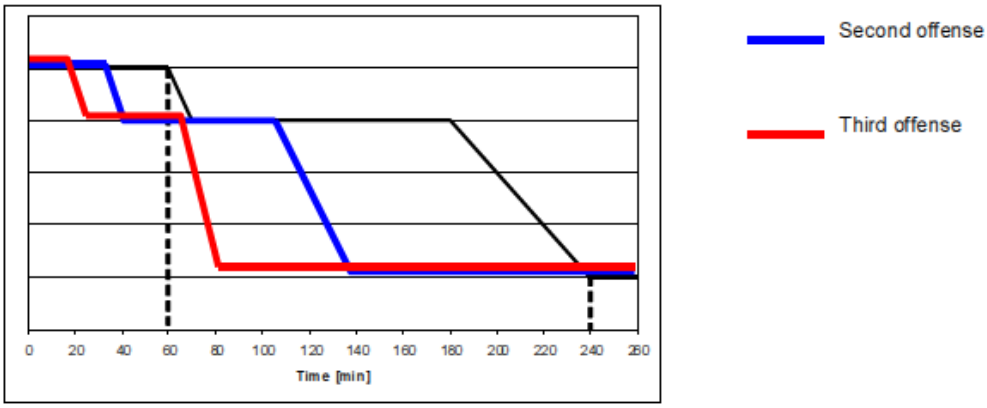

Figure 4 Inducement sequence for repetitive offenses