Annex 1b

FAD quality seal
for exhaust after-treatment systems of diesel engines

„Regulations for testing components and systems for exhaust after-treatment (EGN) of diesel engine exhaust gases for obtaining the FAD quality seal (FAD-QS)“

Part II: Quality requirements to exhaust after-treatment systems according to FAD-QS criteria

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Contents

1 Scope and range of FAD-QS

The scope or range of the FAD quality seal covers all kinds of diesel engine exhaust after-treatment, after-treatment systems, subsystems and sensors such as:

- Oxidation catalysts
- Diesel particulate filters (DPF)
- Particle reduction systems (PMS)
- DeNO$_X$ catalysts (SCR, NSC, etc.)
- Combined EGA systems
- Catalyst carriers
- Filter media
- Exhaust sensors (NO$_X$, NH$_3$, etc.)
- etc.

The scope of FAD-QS also covers all thermodynamic internal-combustion engines working according to the diesel process with different fuel variants (mixtures).

2 Quality requirements according to FAD-QS

The FAD quality seal is only awarded if all test criteria for the quality under application-specific conditions are permanently met concerning:

- Pollutant reduction,
- Functionality under application-specific conditions,
- Function-related secondary emissions,
- Excessive fuel consumption
- Maintenance concept

3 Quality requirements to DPF and PMS systems

3.1 Requirements to quality criterion of „Pollutant reduction“

The FAD-QS requirements to pollutant reduction are specified according to the category of QS (type and application of EGA system).
The pollutant reduction is related to the application-specific FAD cycle.

3.1.1 DPF systems

Requirement:
The pollutant emissions of NO$_X$, HC and CO according to the DPF system shall

not increase by more than 5% within the framework of the measuring tolerances.

- For the particulate matter (PM) a reduction rate of > 90 % applies in the application-specific FAD cycle.
- For the particulate number (PN) a reduction rate of > 90 % applies in the application-specific FAD cycle.

3.1.2 PMS systems

PM reduction:

The particulate reduction rates for PM of particulate reduction systems (PMS) are the same as the statutory requirements according to the regulations: Annex XXVI und XXVII of StVZO (Regulations Authorizing the Use of Vehicles for Road Traffic).

- Passenger cars and commercial vehicles (V_h < 0.75 l/cyl., n_{Nenn} > 3000 1/min): 30 %
- Commercial vehicles (V_h ≥ 0.75 l/cyl., n_{Nenn} ≤ 3000 1/min): 50 %

The minimum requirements to be met by PMS systems in the operating range are determined by means of NTE (not-to-exceed) values. The NTE-factor is 1.5.

- Passenger cars: 30 % / 1.5 → 20 %
- Commercial vehicles: 50 % / 1.5 → 33 %

To the particulate number (PN) the same reduction rate applies in the application-specific FAD cycle as the rate specified for the particulate matter (PM).

3.2 *Quality criterion of "Functionality under application-specific conditions"*

The proof of functionality of DPF and PMS systems under application-specific conditions is furnished, documented and evaluated within the framework of the QS test procedure.

3.3 *Quality criterion of „Function-related secondary emissions"*

The function-related secondary pollutant emissions shall be limited to the extent technologically and functionally feasible.

The function-related secondary pollutant emissions generated during the operation of the DPF or PMS systems under application-specific conditions are determined, documented and evaluated in the QS test procedure.

The measurement methods as well as the test processes are determined by the recognized state of the art.

The pollutant reduction is related to the application-specific FAD cycle.

3.3.1 DPF system

NO_2 emission with DPF system

For the NO_2 emission ≤ 20 % NO_2 apply in the application-specific FAD cycle compared to the NO_X basic emission (raw emission) in the FAD-QS test.

3.3.2 PMS system

NO_2 emission with PMS system

For the NO_2 emission ≤ 20 % NO_2 apply in the application-specific FAD cycle compared to the NO_X basic emission (raw emission) in the FAD-QS test.

3.4 *Quality criterion of „Excessive fuel consumption“*

Excessive fuel consumption arising during the operation of the EGA system is documented in the QS test procedure and evaluated in terms of the technical and operational necessity and economic feasibility.

3.5 *Quality criterion of „Maintenance concept“*

Cleaning and maintenance instructions are available and technologically reasonable.

4 Quality requirements to DeNO$_X$ systems and combined EGA systems

4.1 Requirements according to quality criterion of „Pollutant reduction“

The FAD-QS requirements to pollutant reduction are specified according to the category of QS (type and application of EGA system).

The pollutant reduction is related to the application-specific FAD cycle.

4.1.1 DeNO$_X$ system (NO_X after-treatment system)

Requirements:

The pollutant emissions of PM, PN, HC and CO according to DeNOx system shall not increase by more than 5% within the framework of measuring tolerances.

4.1.1.1 NO_X emission with NH_3-SCR catalysts

In the application-specific FAD cycle a reduction rate of > 75 % applies to NO_X with NH_3-SCR.

4.1.1.2 NO_X emission with HC-SCR catalysts

In the application-specific FAD cycle a reduction rate of > 25 % applies to NO_X

with HC-SCR.

4.1.1.3 NO_X emission with NSC catalysts (NO_X storage catalyst)

NSC catalysts are practically unsuitable for retrofitting.

4.1.2 Combined EGA systems (PM+ NO_X after-treatment)

Requirements:

The pollutant emissions of HC and CO according to the combined exhaust after-treatment system shall not increase by more than 5% within the framework of measuring tolerances.

4.1.2.1 DPF + NH_3-SCR catalysts

- For the particulate matter (PM) a reduction rate of > 90 % applies in the application-specific FAD cycle.
- For the particulate number (PN) a reduction rate of > 90 % applies in the application-specific FAD cycle.
- For NO_X a reduction rate of > 75 % applies in the application-specific FAD cycle.
- In the NTE (not-to-exceed) range a NO_X-reduction of > 50 % applies under all application conditions. (Must be met in the operating range and is determined by means of NTE values. The NTE factor is 1.5).

4.1.2.2 DPF + HC-SCR catalysts

- For the particulate matter (PM) a reduction rate of > 90 % applies in the application-specific FAD cycle.
- For the particulate number (PN) a reduction rate of > 90 % applies in the application-specific FAD cycle.
- For NO_X a reduction rate of > 25 % applies in the application-specific FAD cycle.

4.1.2.3 PMS + NH_3-SCR catalysts

PM reduction:

The particulate reduction rates for PM of particulate reduction systems (PMS) are the same as the statutory requirements according to the regulations: Annex XXVI and XXVII of StVZO (Regulations Authorizing the Use of Vehicles for Road Traffic).

- Passenger cars and commercial vehicles (V_h < 0.75 l/cyl., n_{Nenn} > 3000 1/min): 30 %
- Commercial vehicles (V_h ≥ 0.75 l/cyl., n_{Nenn} ≤ 3000 1/min): 50 %

The minimum requirements to be met by PMS systems in the operating range are determined by means of NTE (not-to-exceed) values. The NTE factor is 1.5.

- Passenger cars: 30 % / 1.5 → 20 %

- Commercial vehicles: 50 % / 1.5 → 33 %

To the particulate number (PN) the same reduction rate applies in the application-specific FAD cycle as the rate specified for the particulate matter (PM).

NO_X reduction:

For NO_X a reduction rate of > 75 % applies in the application-specific FAD cycle. The minimum requirement to the NO_X reduction is > 50 % under all application conditions. (Must be met in the operating range and is determined by means of NTE values. The NTE factor is 1.5).

4.1.2.4 PMS + HC-SCR catalysts

PM reduction:

The particulate reduction rates (PM) of particulate reduction systems (PMS) are the same as the statutory requirements according to the regulations: Annex XXVI and XXVII of StVZO (Regulations Authorizing the Use of Vehicles for Road Traffic).

- Passenger cars and commercial vehicles (V_h < 0.75 l/cyl., n_{Nenn} > 3000 1/min): 30 %
- Commercial vehicles (V_h ≥ 0.75 l/cyl., n_{Nenn} ≤ 3000 1/min): 50 %

The minimum requirements to be met by PMS systems in the operating range are determined by means of NTE (not-to-exceed) values. The NTE factor is 1.5.

- Passenger cars: 30 % / 1.5 → 20 %
- Commercial vehicles: 50 % / 1.5 → 33 %

To the particulate number (PN) the same reduction rate applies in the application-specific FAD cycle as the rate specified for the particulate matter (PM).

NO_X reduction:

For NO_X a reduction rate of > 40 % applies in the application-specific FAD cycle. The minimum requirement to the NO_X reduction is > 25 % under all application conditions. (Must be met in the operating range and is determined by means of NTE values. The NTE factor is 1.5).

4.2 Quality criterion of "Functionality under application-specific conditions"

The proof of functionality of $DeNO_X$ and combined systems under application-specific conditions is furnished, documented and evaluated within the framework of the QS test procedure.

4.3 Quality criterion of „Function-related secondary emissions"

The function-related secondary pollutant emissions shall be limited to the extent technologically and functionally feasible.
The function-related secondary pollutant emissions generated during the operation of the $DeNO_X$ system or combined system under application-specific conditions are determined, documented and evaluated in the QS test procedure.
The measurement methods as well as the test processes are determined by the recognized state of the art.
The pollutant reduction is related to the application-specific FAD cycle.

4.3.1 $DeNO_X$ system (NO_X after-treatment system)

4.3.1.1 NH_3-SCR catalysts

NO_2 emission with NH_3-SCR catalysts

The NO_2 emission with NH_3-SCR in the application-specific FAD cycle shall not be increased compared to the NO_2 basic emission (raw emission).

NH_3 emission (slip) with NH_3-SCR catalysts

For NH_3 emission **≤ 20 ppm** applies with NH_3-SCR in the application-specific FAD cycle for the whole test cycle.
The maximally permissible NH_3 slip is **≤ 30 ppm** under all application conditions. (Must be met in the operating range and is determined by means of NTE values. The NTE factor is 1.5).

4.3.1.2 NO_X emission with HC-SCR catalysts

NO_2 emission with HC-SCR catalysts

The NO_2 emission with HC-SCR in the application-specific FAD cycle shall not be increased compared to the NO_2 basic emission (raw emission).

HC emission (slip) with HC-SCR catalysts

For the HC emission **≤ +10 % HC** applies with HC-SCR in the application-specific FAD cycle compared to HC- before HC-SCR in the FAD-QS test.
The minimum requirement to HC-slip is **≤ +15 % HC** under all application

conditions compared to the HC-basic emission (raw emission) in the FAD-QS test. (Must be met in the operating range and is determined by means of NTE values. The NTE factor is 1.5).

4.4 Combined EGA systems (PM+ NO_X)

4.4.1 DPF + NH_3-SCR catalysts

NO_2 emission with DPF + NH_3-SCR catalysts

The NO_2 emission with DPF+NH_3-SCR catalysts in the application-specific FAD cycle shall not be increased compared to the NO_2 basic emission (raw emission).

NH_3 emission (slip) with DPF + NH_3-SCR catalysts

For the NH_3 emission **≤ 20 ppm** applies with NH_3-SCR in the application-specific FAD cycle of the FAD-QS test.

The maximally permissible NH_3 slip is **≤ 30 ppm** under all application conditions. (Must be met in the operating range and is determined by means of NTE values. The NTE factor is 1.5).

4.4.2 DPF + HC-SCR catalysts

NO_2 emission with DPF + HC-SCR catalysts

The NO_2 emission with HC-SCR in the application-specific FAD cycle shall not be increased compared to the NO_2 basic emission (raw emission).

HC emission (slip) with DPF+HC-SCR catalysts

For HC emission **≤ +10 % HC** applies with HC-SCR in the application-specific FAD cycle compared to HC- before HC-SCR in the FAD-QS test.

The minimum requirement to HC-slip is ≤ **+15 % HC** under all application conditions compared to the HC-basic emission (raw emission) in the FAD-QS test. (Must be met in the operating range and is determined by means of NTE values. The NTE factor is 1.5).

4.4.2.1 PMS + NH_3-SCR catalysts

To NO_2 and NH_3 the same requirements apply as those specified for the NH_3-SCR catalysts.

4.4.2.2 PMS + HC-SCR catalysts

To NO_2 and NH_3 the same requirements apply as those specified for the HC-SCR catalysts.

4.5 Quality criterion of „Excessive fuel consumption“

Excessive fuel consumption arising during the operation of the EGA system is documented in the QS test procedure and evaluated in terms of the technical and operational necessity and economic feasibility.

4.6 Quality criterion of „Maintenance concept“

Cleaning and maintenance instructions are available and technologically reasonable.