
**Road vehicles — Engine EGR cooler —
Heat dissipation test methods**

*Véhicules routiers — Refroidisseur de la vanne EGR — Méthodes
d'essais de dissipation de chaleur*

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Internal combustion engines used in regulated environments are fitted with cooled exhaust gas recirculation (EGR) to reduce NO_x and improve fuel consumption. The EGR cooler receives gas from the exhaust system and gas is cooled by cooling liquid. This document provides manufacturers with a standardized method of measuring heat dissipation performance of the EGR cooler.

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Road vehicles — Engine EGR cooler — Heat dissipation test methods

1 Scope

This document defines the methodology for the measurement of heat dissipation and pressure loss of liquid cooled engine EGR coolers in internal combustion engines for road vehicles. The principles of this document are valid for clean and fouled EGR coolers.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 EGR

technology that recirculates a portion of an engine's exhaust gas back into the intake to control the concentration of oxygen taken into the engine

3.2 EGR gas

gas that has been extracted from the exhaust gas and is passed through the *EGR cooler* (3.5) *core* (3.14)

3.3 test gas

pressurized air or exhaust gas made by burners used in place of real *EGR gas* (3.2) during the heat dissipation performance test and when measuring *EGR gas pressure loss* (3.10)

3.4 cooling liquid

water or coolant mixture during the heat dissipation performance test and when measuring *cooling liquid pressure loss* (3.11)

3.5 EGR cooler

liquid cooled heat exchanger for cooling the *EGR gas* (3.2)

3.6 EGR gas heat dissipation amount

amount of heat lost by the *test gas* (3.3) during the heat dissipation performance test

Note 1 to entry: The EGR gas heat dissipation amount is expressed in kilowatts (kW).

3.7

EGR cooler heat dissipation amount

amount of heat lost after the *EGR gas heat dissipation amount* (3.6) is corrected for the *inlet temperature difference between both fluids* (3.8) as defined upon the agreement by the parties concerned

Note 1 to entry: The EGR cooler heat dissipation amount is expressed in kilowatts (kW).

3.8

inlet temperature difference between both fluids

difference between the inlet temperature of the *test gas* (3.3) and the *cooling liquid* (3.4) that pass through the *EGR cooler* (3.5) *core* (3.14)

Note 1 to entry: The inlet temperature difference between both fluids is expressed in Kelvin (K).

3.9

EGR gas temperature effectiveness

ratio of the temperature difference of the *test gas* (3.3) between the *EGR cooler* (3.5) outlet and inlet with respect to the difference of the inlet temperature between both fluids

Note 1 to entry: The EGR gas temperature effectiveness is expressed as a percentage (%).

3.10

EGR gas pressure loss

static pressure difference of the *test gas* (3.3) between the *EGR cooler* (3.5) outlet and inlet during heat dissipation or no heat dissipation

Note 1 to entry: The EGR gas pressure loss is expressed in kilopascals (kPa).

Note 2 to entry: Total pressure difference can be used behalf of static pressure difference in case of measurement conditions are agreed by the parties concerned.

3.11

cooling liquid pressure loss

static pressure difference of the *cooling liquid* (3.4) between the *EGR cooler* (3.5) outlet and inlet

Note 1 to entry: The cooling liquid pressure loss is expressed in kilopascals (kPa).

Note 2 to entry: Total pressure difference can be used behalf of static pressure difference in case of measurement conditions are agreed by the parties concerned.

3.12

EGR gas mass flow rate

mass flow rate of the *test gas* (3.3) that passes through the *EGR cooler* (3.5) *core* (3.14)

Note 1 to entry: The EGR gas mass flow rate is expressed in kilograms per second (kg/s).

3.13

cooling liquid mass flow rate

mass flow rate of the *cooling liquid* (3.4) that passes through the *EGR cooler* (3.5) *core* (3.14)

Note 1 to entry: The cooling liquid mass flow rate is expressed in kilograms per second (kg/s).

3.14

core

part at which heat is exchanged between the *EGR gas* (3.2) and the *cooling liquid* (3.4)

4 Test items

This test evaluates the following items:

- a) EGR gas heat dissipation amount or EGR gas temperature effectiveness;

- b) EGR gas pressure loss;
- c) cooling liquid pressure loss.

5 Test setup

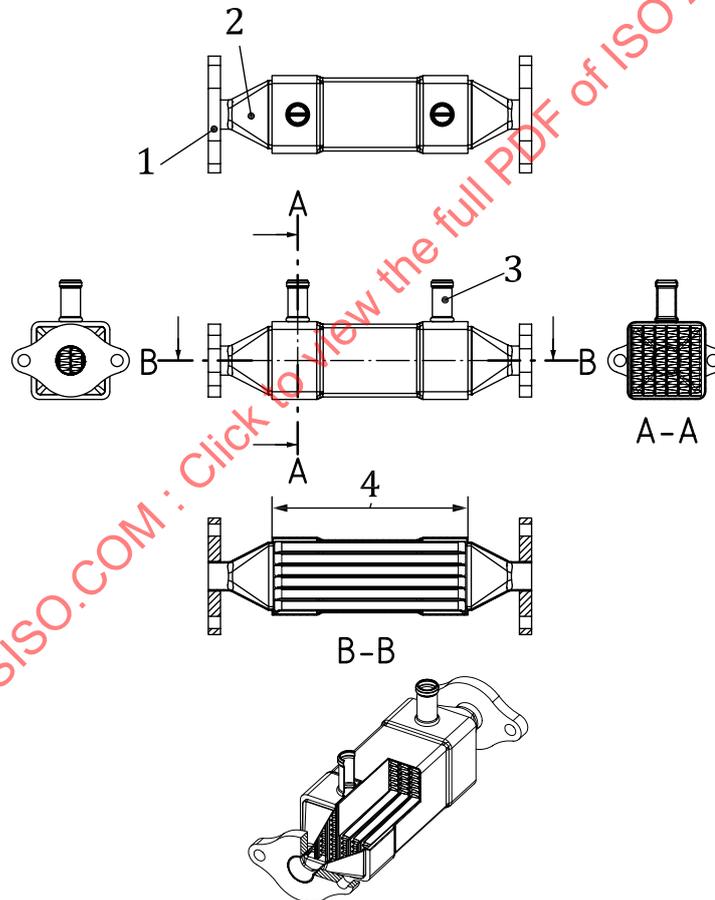
5.1 Test conditions

The EGR cooler, test gas, cooling liquid, and test location conditions are shown as follows.

In the case of measurement with the fouled EGR cooler, test conditions should be agreed by the parties concerned.

- a) EGR cooler:

The EGR cooler consists of main components such as the core, tank, flanges, and pipes, as well as supplementary parts. An example is shown in [Figure 1](#).



Key

- 1 flange
- 2 tank
- 3 pipe
- 4 core

NOTE The inlet and outlet flange can have a different flow through the cross-sectional area.

Figure 1 — EGR cooler (example)

b) Test gas:

Tests shall be run with a test gas inlet temperature, an inlet pressure and a mass flow rate that are defined upon the agreement by the parties concerned.

c) Cooling liquid:

Water used in the cooling liquid should be demineralized or treated. In the case of using a coolant mixture as the cooling liquid, the coolant type and properties of the mixture should be documented. The used fluid shall be regularly checked to confirm that the coolant mixture or properties haven't changed.

d) Test location:

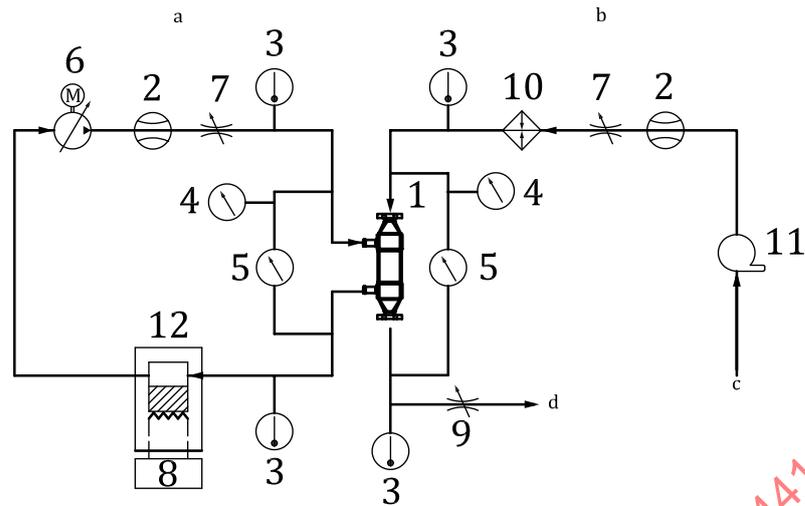
Unless otherwise specified, the test location shall be kept at room temperature (5 °C to 35 °C) and normal relative humidity (20 % to 85 %).

5.2 Test equipment

5.2.1 General test equipment

The test equipment shall be set up so that it can accurately measure the measurement items in 6.1. From the perspective of the test gas side structure, the test equipment can be roughly divided into two types: open type and sealed type. Both types consist of test gas and cooling liquid circuits. For sealed type test equipment, the test gas inlet pressure shall be set upon the agreement by the parties concerned.

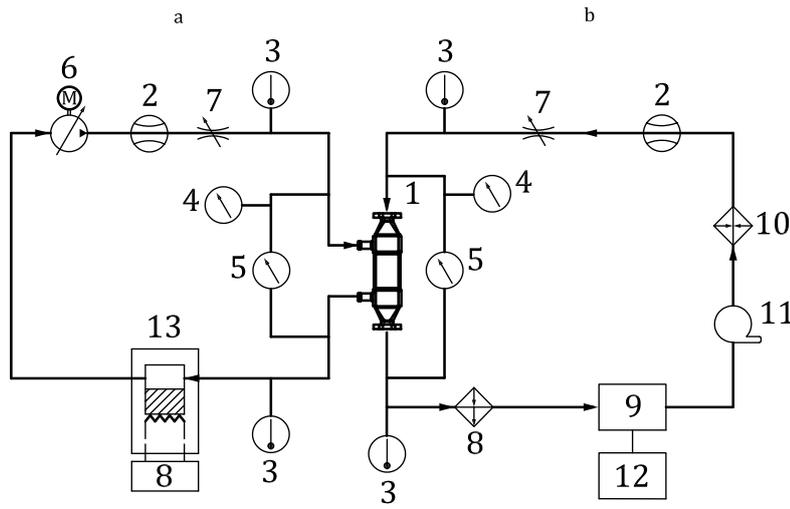
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Key

- 1 EGR cooler
- 2 flow meter
- 3 thermometer
- 4 pressure gauge
- 5 differential pressure gauge
- 6 pump
- 7 flow control valve
- 8 temperature controller
- 9 pressure control valve
- 10 heater
- 11 blower
- 12 hot water tank
- a Cooling liquid side.
- b Test gas side.
- c Test gas.
- d Open to atmospheric air.

Figure 2 — Test equipment (open type)



Key

- 1 EGR cooler
- 2 flow meter
- 3 thermometer
- 4 pressure gauge
- 5 differential pressure gauge
- 6 pump
- 7 flow control valve
- 8 temperature controller
- 9 pressure regulator
- 10 heater
- 11 blower
- 12 compressor
- 13 hot water tank
- a Cooling liquid side.
- b Test gas side.

Figure 3 — Test equipment (sealed type)

5.2.2 Test gas circuit equipment

The test gas circuit equipment shall be set up as follows.

- a) The mass flow rate of the test gas that passes through the EGR cooler shall be adjustable.
- b) The test gas inlet temperature shall be adjustable over the entire range of the test.
- c) The measuring instrument of the test gas inlet pressure and the test gas differential pressure between the outlet and the inlet shall not be affected by the dynamic pressure and shall be connected so as not to disturb the flow of the test gas as much as possible.

5.2.3 Cooling liquid circuit equipment

The cooling liquid circuit equipment shall be set up as follows.

- a) The mass flow rate of the cooling liquid that passes through the EGR cooler shall be adjustable.

- b) The cooling liquid circuit piping and hot liquid tank shall be designed not to take in any air or steam, or there should be a separation tank.
- c) The cooling liquid pump shall be designed so that cavitation does not occur.
- d) The cooling liquid circuit shall be able to dissipate the amount of heat it receives over the entire range of the EGR cooler heat dissipation.
- e) Excessive heating temperatures that may degrade the coolant shall be avoided.

5.3 Measuring instruments

Errors of the measuring instruments used in the test shall be within the values shown in [Table 1](#) for both the test gas side and the cooling liquid side. Calibration shall be carried out prior to testing.

Table 1 — Measuring instrument error

Measuring instrument	Instrumental error
Test gas flow meter	±2 % of the measured value
Cooling liquid flow meter	±2 % of the measured value
Test gas inlet thermometer	±(0,3 + 0,005 × measured temperature) K
Test gas outlet thermometer	±1,5 K
Cooling liquid thermometer	±0,3 K
Differential pressure gauge	±5 % of the measured value
Pressure gauge	±3 % of the measured value

6 Test and measurement methods

6.1 Test methods

In the same manner as the examples of the test equipment shown in [Figures 2](#) and [3](#), the EGR cooler should be connected to both the test gas circuit and the cooling liquid circuit. The test and measurement methods are shown as follows. Test conditions shall be decided upon the agreement by the parties concerned.

6.1.1 Test with heat dissipation

Measurement of the mass flow rate, temperature, and pressure for both fluids that is required to calculate both the EGR cooler heat dissipation and the pressure loss for both fluids shall be carried out while the EGR cooler is in a state where it is dissipating heat. Items to be measured during the test are shown in [Table 2](#).

Table 2 — Items to be measured (EGR cooler heat dissipation amount, EGR gas pressure loss and cooling liquid pressure loss)

Measurement item	Unit
Atmospheric pressure	kPa abs
Test laboratory temperature	°C
Test gas humidity	g (water)/kg (dry air)
Test gas inlet temperature	°C
Test gas outlet temperature	°C
Test gas inlet static pressure	kPa abs
NOTE In the case of open type test equipment, the test laboratory humidity can be used as the humidity of the test gas except exhaust gas.	

Table 2 (continued)

Measurement item	Unit
Test gas differential pressure between outlet and inlet	kPa
Test gas mass flow rate	kg/s
Cooling liquid inlet temperature	°C
Cooling liquid outlet temperature	°C
Cooling liquid inlet static pressure	kPa abs
Cooling liquid differential pressure between outlet and inlet	kPa
Cooling liquid mass flow rate	kg/s
NOTE In the case of open type test equipment, the test laboratory humidity can be used as the humidity of the test gas except exhaust gas.	

6.1.2 Test without heat dissipation

Measurement of mass flow rate and test gas pressure that is required to calculate the EGR gas pressure loss shall be carried out while the EGR cooler is in a state where it is not dissipating heat. Items to be measured during the test are shown in [Table 3](#).

Table 3 — Items to be measured (EGR gas pressure loss)

Measurement item	Unit
Atmospheric pressure	kPa abs
Test laboratory temperature	°C
Test gas humidity	g (water)/kg (dry air)
Test gas inlet temperature	°C
Test gas outlet temperature	°C
Test gas inlet static pressure	kPa abs
Test gas differential pressure between outlet and inlet	kPa
Test gas mass flow rate	kg/s
NOTE In the case of open type test equipment, the test laboratory humidity can be used as the humidity of the test gas except exhaust gas.	

6.2 Measurement method

Each item of the measurement is conducted under the following conditions:

- a) measurement number: five times minimum;
- b) total measurement duration: 30 s minimum;
- c) stable condition: refer to [Table 4](#).

Table 4 — Stable condition for measurement

Observation time			100 s minimum
Test gas	Inlet side	Temperature	$\pm 5 \text{ K } (\leq 400 \text{ }^\circ\text{C})$ $\pm 8 \text{ K } (> 400 \text{ }^\circ\text{C})$
		Pressure	$\pm 2,0 \%$
		Flow rate	$\pm 2,5 \%$
	Outlet side	Temperature	$\pm 2 \text{ K}$
Cooling liquid	Inlet side	Temperature	$\pm 1 \text{ K}$
		Pressure	$\pm 2,0 \%$
		Flow rate	$\pm 2,5 \%$

6.2.1 Flow rate measurement

Flow rate measurement shall be carried out as follows.

- The test gas mass flow rate shall be measured after confirming that the test gas has reached a stable state of flow.
- The cooling liquid mass flow rate shall be measured after confirming that the cooling liquid has reached a stable state of flow.
- The flow rate measurement shall be preferably carried out by means of mass flow meters. Otherwise, if a volumetric flow meter is used, measure the test gas and cooling liquid temperature and pressure at the vicinity of the flow meter in order to calculate the mass flow rate.

6.2.2 Temperature measurement

Temperature measurement shall be carried out as follows.

- When measuring the test gas temperature of the inlet and the outlet, the measurement position shall be selected so as not to affect the pressure measurement taken and the temperature sensor is placed where it can control the target of the inlet temperature. One or more sensors can be used, but at least two measurement positions at same cross section are recommended.
- When measuring the cooling liquid temperature of the inlet and the outlet, the measurement position shall be selected so as not to affect the pressure measurement taken and the temperature sensor is placed where it can control the target of the inlet temperature. One or more sensors can be used, but at least two measurement positions at same cross section are recommended.

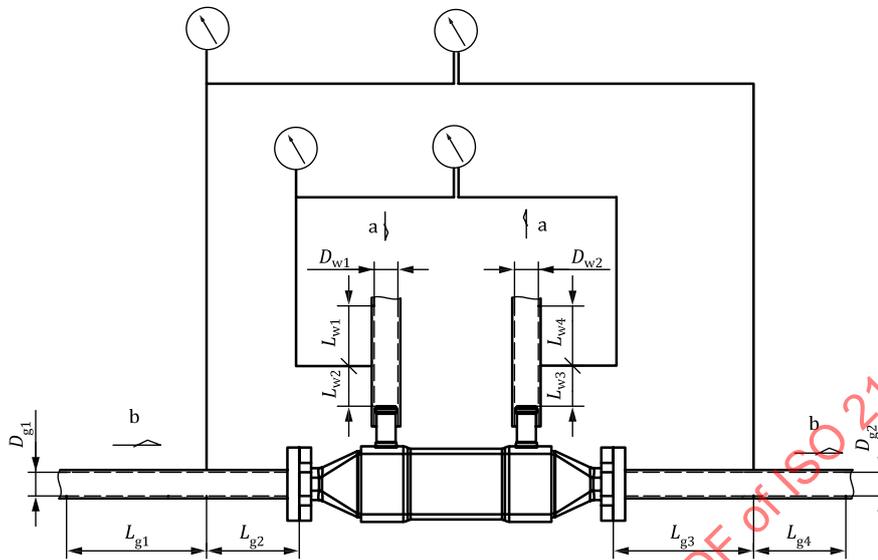
6.2.3 Pressure measurement

Pressure measurement shall be carried out as follows.

- When measuring the test gas static pressure of the inlet and the outlet, the static pressure should be measured at a fully developed flow. A fully and undisturbed developed flow can be considered with a straight length of at least 3 times (L_{g1} , L_{g3}) the inner diameter before the pressure pick up and at least 2 times (L_{g2} , L_{g4}) the inner diameter after the pressure pick up in the flow direction. This pressure measurement fixture should have an unchanged cross-sectional area. This is applicable for the inlet and the outlet side. The cross-sectional area of the inlet fixture may be different from the outlet fixture. An example of the measurement equipment is shown in [Figure 4](#).
- When measuring the cooling liquid static pressure of the inlet and the outlet, the static pressure should be measured at a fully developed flow. A fully and undisturbed developed flow can be considered with a straight length at least 3 times (L_{w1} , L_{w3}) the inner diameter before the pressure pick up and at least 2 times (L_{w2} , L_{w4}) the inner diameter after the pressure pick up in the flow direction. This pressure measurement fixture should have an unchanged cross-sectional area. This

is applicable for the inlet and the outlet side. The cross-sectional area of the inlet fixture may be different from the outlet fixture. An example of the measurement equipment is shown in [Figure 4](#).

NOTE Boiling affects pressure loss measurement stability on the cooling liquid side.



- a Cooling liquid flow.
- b Test gas flow.

Figure 4 — Pressure measurement positions

7 Calculation method

7.1 Items to be calculated

7.1.1 EGR cooler heat dissipation amount

The items that need to be calculated to record the EGR cooler heat dissipation amount results into the test report are as follows:

- a) test gas and cooling liquid mass flow rate;
- b) EGR gas and EGR cooler heat dissipation amounts;
- c) EGR cooler heat dissipation ratio;
- d) EGR gas pressure loss;
- e) cooling liquid pressure loss.

7.1.2 EGR gas temperature effectiveness

The items that need to be calculated in order to record the EGR gas temperature effectiveness results into the test report are as follows:

- a) test gas and cooling liquid mass flow rate;
- b) EGR gas temperature effectiveness;
- c) EGR gas pressure loss;

d) cooling liquid pressure loss.

7.2 Calculation formula

7.2.1 Mass flow rate

In the case that the mass flow rates of the test gas and the cooling liquid are not directly measured, they shall be calculated using Formulae (1) and (2).

$$q_{\text{mg}} = v_{\text{g}} \cdot \rho_{\text{g}} \quad (1)$$

where

q_{mg} is the test gas mass flow rate (kg/s);

v_{g} is the test gas volumetric flow rate (m³/s);

ρ_{g} is the test gas mass density (kg/m³).

$$q_{\text{mw}} = v_{\text{w}} \cdot \rho_{\text{w}} \quad (2)$$

where

q_{mw} is the cooling liquid mass flow rate (kg/s);

v_{w} is the cooling liquid volumetric flow rate (m³/s);

ρ_{w} is the cooling liquid mass density (kg/m³).

7.2.2 EGR gas and EGR cooler heat dissipation amounts

The logarithmic mean temperature shall be calculated as follows, see [Formulae \(3\) and \(4\)](#).

$$t_{\text{g}} = \frac{t_{\text{g1}} - t_{\text{g2}}}{\ln \frac{t_{\text{g1}}}{t_{\text{g2}}}} \quad (3)$$

where

t_{g} is the logarithmic mean temperature of the test gas (°C);

t_{g1} is the test gas inlet temperature (°C);

t_{g2} is the test gas outlet temperature (°C).

$$t_{\text{w}} = \frac{t_{\text{w1}} - t_{\text{w2}}}{\ln \frac{t_{\text{w1}}}{t_{\text{w2}}}} \quad (4)$$

where

t_w is the logarithmic mean temperature of the cooling liquid (°C);

t_{w1} is the cooling liquid inlet temperature (°C);

t_{w2} is the cooling liquid outlet temperature (°C).

The EGR gas heat dissipation amount shall be calculated using Formula (5).

$$Q_g = q_{mg} \cdot C p_g \cdot (t_{g1} - t_{g2}) \quad (5)$$

where

Q_g is the EGR gas heat dissipation amount (kW);

$C p_g$ is the test gas specific heat at the constant pressure when at temperature t_g [kJ]/(kg·K)].

NOTE The quotation table of specific heat that is used on the calculation is described in the test report. The $C p_g$ value is considered by the test gas humidity when calculating the heat dissipation amount.

The EGR cooler heat dissipation amount shall be calculated using Formula (6).

$$Q = Q_g \cdot \frac{\Delta T}{\Delta t} \quad (6)$$

$$= Q_g \cdot \frac{(T_{g1} - T_{w1})}{(t_{g1} - t_{w1})}$$

where

Q is the EGR cooler heat dissipation amount (kW);

ΔT is the difference in the inlet temperature between both fluids defined by all the concerned parties (K);

Δt is the measured difference in the inlet temperature between both fluids (K);

T_{g1} is the test gas inlet temperature defined upon the agreement by all the concerned parties (°C);

T_{w1} is the cooling liquid inlet temperature defined upon the agreement by all the concerned parties (°C);

The EGR cooler heat dissipation ratio shall be calculated using the Formula (7).

$$H = \frac{Q}{(t_{g1} - t_{w1})} \quad (7)$$

where

H is the EGR cooler heat dissipation ratio (kW/K).

7.2.3 EGR gas temperature effectiveness

The EGR gas temperature effectiveness shall be calculated using Formula (8).

$$\varepsilon_g = \frac{t_{g1} - t_{g2}}{t_{g1} - t_{w1}} \cdot 100 \quad (8)$$

where

ε_g is the EGR gas temperature effectiveness (%).

The relationship between the EGR gas temperature effectiveness and the EGR gas heat dissipation amount can be shown with Formula (9).

$$Q_g = q_{mg} \cdot c_{p_g} \cdot \frac{\varepsilon_g \cdot (t_{g1} - t_{w1})}{100} \quad (9)$$

7.2.4 EGR gas pressure loss

The EGR gas pressure loss shall be measured by the static pressure of the inlet side and the outlet side with Formula (10) (see [Figure 5](#)).

$$\begin{aligned} \Delta p_g &= p_{gs1} - p_{gs2} - \Delta p_{gp} \\ &= p_{gs1} - p_{gs2} - \left(\lambda_{g1} \cdot \frac{L_{g1}}{D_{g1}} \cdot \frac{\rho_g \cdot v_{g1}^2}{2} + \lambda_{g2} \cdot \frac{L_{g2}}{D_{g2}} \cdot \frac{\rho_g \cdot v_{g2}^2}{2} \right) \\ &= \Delta p_{g0} - \left(\lambda_{g1} \cdot \frac{L_{g1}}{D_{g1}} \cdot \frac{\rho_g \cdot v_{g1}^2}{2} + \lambda_{g2} \cdot \frac{L_{g2}}{D_{g2}} \cdot \frac{\rho_g \cdot v_{g2}^2}{2} \right) \end{aligned} \quad (10)$$

The values of λ_{g1} and λ_{g2} in the formula are defined as follows:

$$\lambda_{g1} = 0,3164 \cdot \text{Re}_{g1}^{-0,25}$$

$$\lambda_{g2} = 0,3164 \cdot \text{Re}_{g2}^{-0,25}$$

where

Δp_g is the EGR gas pressure loss (kPa);

p_{gs1} is the test gas inlet static pressure (kPa abs);

p_{gs2} is the test gas outlet static pressure (kPa abs);

Δp_{gp} is the test gas piping pressure loss (kPa);

Δp_{g1} is the test gas inlet piping pressure loss (kPa);

Δp_{g2} is the test gas outlet piping pressure loss (kPa);

Δp_{g0} is the test gas differential pressure gauge measurement value (kPa);

- v_{g1} is the inlet test gas flow velocity (m/s);
- v_{g2} is the outlet test gas flow velocity (m/s);
- λ_{g1} is the inlet pipe friction coefficient of the test gas (Blasius' formula);
- λ_{g2} is the outlet pipe friction coefficient of the test gas (Blasius' formula);
- L_{g1} is the test gas inlet pipe length (m);
- D_{g1} is the test gas inlet pipe inner diameter (m);
- L_{g2} is the test gas outlet pipe length (m);
- D_{g2} is the test gas outlet pipe inner diameter (m);
- Re_{g1} is the Reynolds number of the inlet side ($3 \times 10^3 < Re < 10^5$);
- Re_{g2} is the Reynolds number of the outlet side ($3 \times 10^3 < Re < 10^5$).

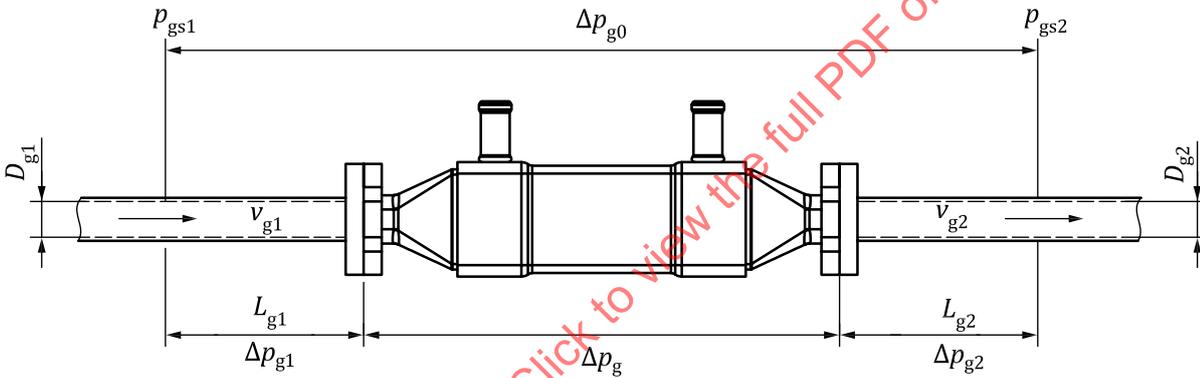


Figure 5 — Test gas pressure measurement positions

7.2.5 Cooling liquid pressure loss

The cooling liquid pressure loss is equal to the measured cooling liquid differential pressure between the outlet and the inlet. After measuring the outlet and inlet pressure, use [Formula \(11\)](#) to calculate the final value (see [Figure 6](#)).

$$\begin{aligned}
 \Delta p_w &= p_{ws1} - p_{ws2} - \Delta p_{wp} \\
 &= p_{ws1} - p_{ws2} - \left(\lambda_{w1} \cdot \frac{L_{w1}}{D_{w1}} \cdot \frac{\rho_w \cdot v_{w1}^2}{2} + \lambda_{w2} \cdot \frac{L_{w2}}{D_{w2}} \cdot \frac{\rho_w \cdot v_{w2}^2}{2} \right) \\
 &= \Delta p_{w0} - \left(\lambda_{w1} \cdot \frac{L_{w1}}{D_{w1}} \cdot \frac{\rho_w \cdot v_{w1}^2}{2} + \lambda_{w2} \cdot \frac{L_{w2}}{D_{w2}} \cdot \frac{\rho_w \cdot v_{w2}^2}{2} \right)
 \end{aligned}
 \tag{11}$$

The values of λ_{w1} and λ_{w2} in the formula are defined as follows.

$$\lambda_{w1} = 0,3164 \cdot Re_{w1}^{-0,25}$$

$$\lambda_{w2} = 0,316 4 \cdot \text{Re}_{w2}^{-0,25}$$

where

- Δp_w is the cooling liquid pressure loss (kPa);
- p_{ws1} is the cooling liquid inlet static pressure (kPa abs);
- p_{ws2} is the cooling liquid outlet static pressure (kPa abs);
- Δp_{wp} is the cooling liquid piping pressure loss (kPa);
- Δp_{w1} is the cooling liquid inlet piping pressure loss (kPa);
- Δp_{w2} is the cooling liquid outlet piping pressure loss (kPa);
- Δp_{w0} is the cooling liquid differential pressure gauge measurement value (kPa);
- v_{w1} is the inlet cooling liquid flow velocity (m/s);
- v_{w2} is the outlet cooling liquid flow velocity (m/s);
- λ_{w1} is the inlet pipe friction coefficient of cooling liquid (Blasius' formula);
- λ_{w2} is the outlet pipe friction coefficient of cooling liquid (Blasius' formula);
- L_{w1} is the cooling liquid inlet pipe length (m);
- D_{w1} is the cooling liquid inlet pipe inner diameter (m);
- L_{w2} is the cooling liquid outlet pipe length (m);
- D_{w2} is the cooling liquid outlet pipe inner diameter (m);
- Re_{w1} is the Reynolds number of inlet side ($3 \times 10^3 < \text{Re} < 10^5$);
- Re_{w2} is the Reynolds number of outlet side ($3 \times 10^3 < \text{Re} < 10^5$).

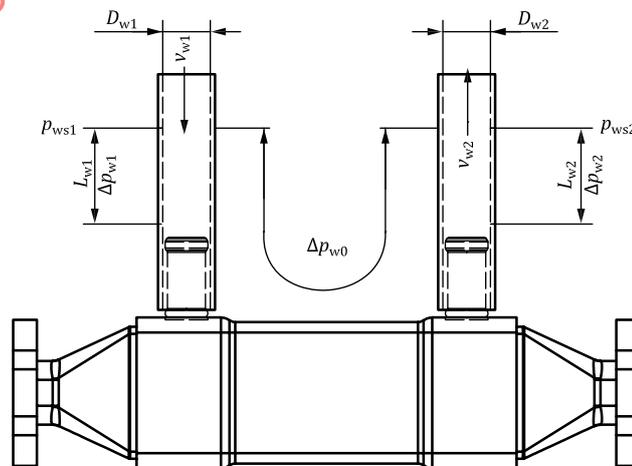


Figure 6 — Cooling liquid pressure measurement positions

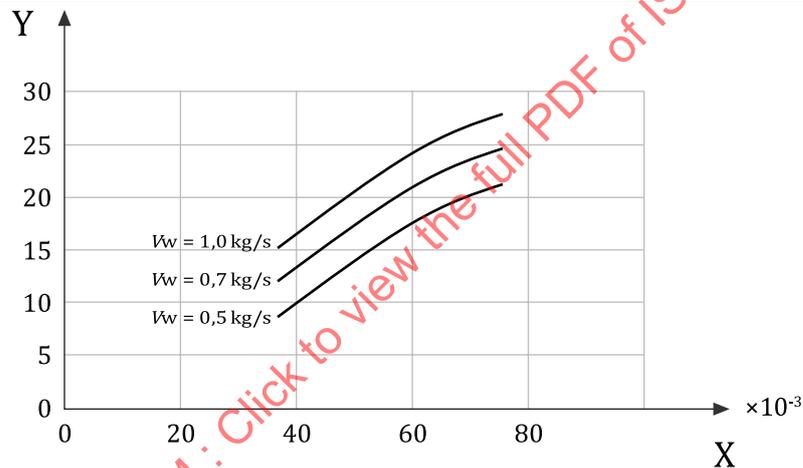
8 Test report preparation

As a test report, heat dissipation performance diagrams based on the measurement results as illustrated in [Tables 5, 6, 7, and 8](#) are recommended. It is allowed to measure at different operating conditions and to calculate within the re-interpolation on the required operating conditions. This procedure should be agreed by the parties concerned.

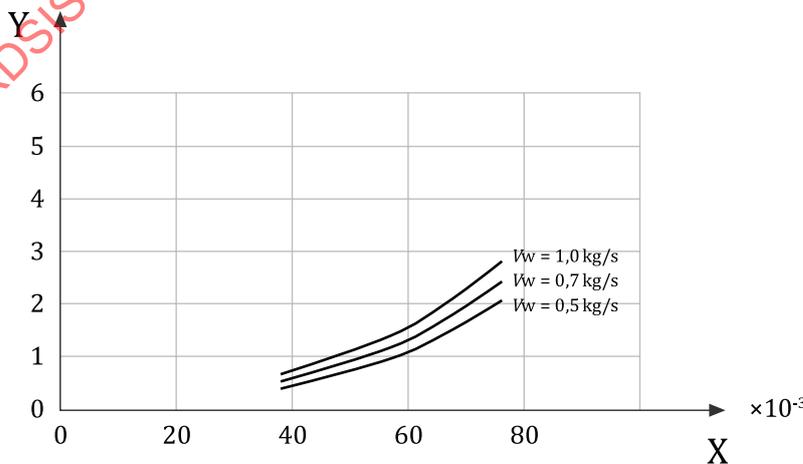
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Table 5 — Example of the test report (EGR cooler heat dissipation amount)

EGR cooler heat dissipation performance test report			
Date of test (mm/dd/yyyy)		Test laboratory temperature	deg. C
Manufacturer		Test gas humidity	g/kg
Product number		Atmospheric pressure	kPa abs
EGR cooler specifications		Test equipment model	Type
Core dimension		Test supervisor	
Test gas static pressure of inlet side	kPa abs	Cooling liquid static pressure of inlet side	kPa abs
Test gas temperature of inlet side	deg. C	Cooling liquid temperature of inlet side	deg. C
Test gas mass flow rate of inlet side	kg/s	Cooling liquid mass flow rate of inlet side	kg/s
Test gas mass density of inlet side	kg/m ³	Cooling liquid mass density of inlet side	kg/m ³
Specific heat of test gas	kJ/kg·K	Specific heat of cooling liquid	kJ/kg·K
Quotation table of specific heat of test gas		Quotation table of specific heat of cooling liquid	
Difference of inlet temperature between test gas and cooling liquid (defined upon agreement by the concerned parties)			K

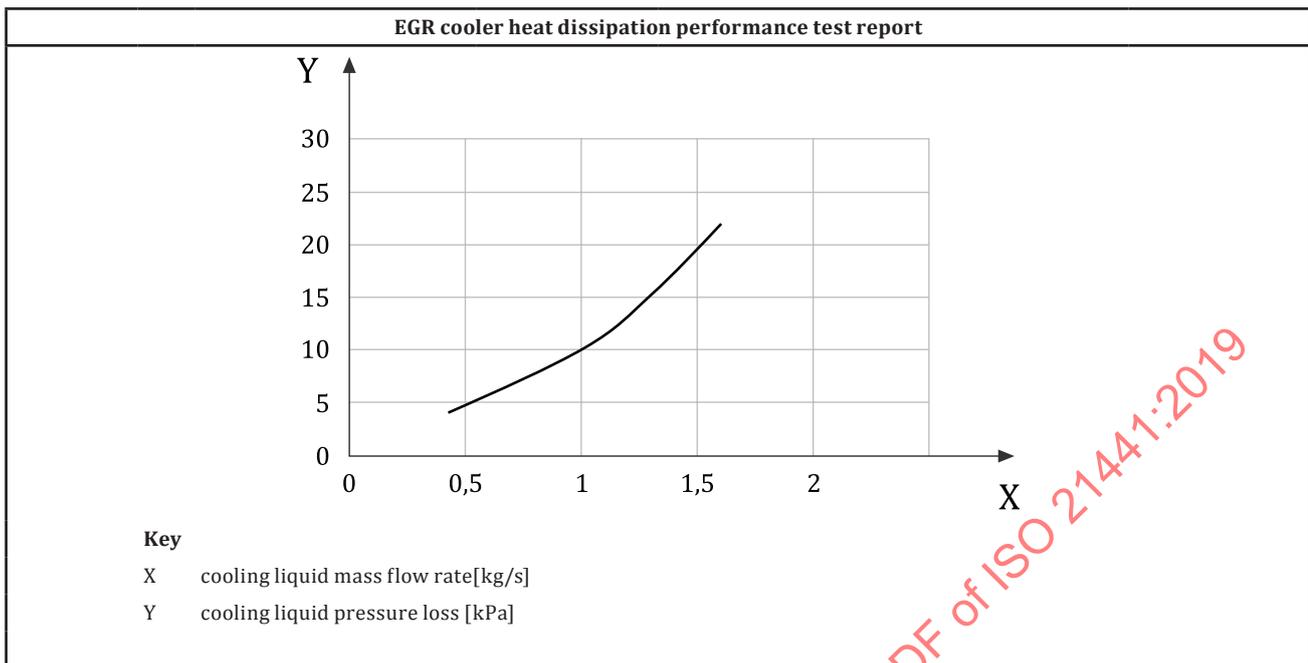


Key
 X test gas mass flow rate [kg/s]
 Y test gas heat dissipation amount [kW]



Key
 X test gas mass flow rate [kg/s]
 Y test gas pressure loss [kPa]

Table 5 (continued)



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