



Public Transport Companies Environmental Test Manual Part 3 – heaters

PREPARED BY

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ON BEHALF OF

TiD (Danish Public Transport Authorities)
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1. Introduction

For health and environmental reasons, the Danish Public Transport Authorities (PTAs) have focus on decreasing emissions from their buses as much as possible.

The same goes for the heaters in the buses. To ensure the lowest possible emissions of CO and soot particles as well as to achieve the highest possible efficiency of the heaters, the heaters in buses used on the routes of the transport companies are continuously controlled. The control is carried out as Environmental Test.

The PTAs' Environmental Test Manual is used to control if the heaters are well maintained and thus that the emissions are as low as possible. In addition, the Environmental Test ensures that Public Transport Operators (PTOs) comply with the requirements of the PTA concerned.

The manual describes the measurement requirements for controlling the heaters, and the manual can be used by the PTO for self-control or by a PTA-approved measuring company for third-part control.

The manual has been prepared by the Danish Technological Institute at the request of Movia.

2. Emission and temperature measurements on bus heaters

2.1. Requirements for the measuring equipment

The measuring equipment must be portable, as the measurements are often performed at the PTOs' bus depot premises.

The measurement system shall consist of a CO₂ and CO gas analyzer with exhaust gas temperature sensor.

The gas analyzer must have a measuring solution of 0.1 vol% for CO₂ and a solution of 1 ppm for CO.

The test report shall indicate the equipment used, including calibration equipment/gases.

If CO₂ is determined from O₂ measurement, the necessary fuel data for the conversion can, if necessary, be taken from similar common fuels. For example, data from fuel oil or fossil diesel can always be used when measuring on oil-fired heaters and data from natural gas can always be used when measuring on gas-fired heaters.

If applicable, this must be noted in the report.

2.2. Data collection requirements

Measurement data can be documented by paper printout, photo of the measurement equipment's display or by using a data collection system that can save data from the measurement process (for example as pdf, txt, csv, or similar).

2.3. Requirements for measurement companies / technicians

2.3.1 Requirements for measurement companies in the case of third part control

The measurements must be carried out by an independent measuring company approved by the PTA for the purpose. A company for third party control shall not have any personal or financial interests in the outcome of the measurements. For example, the workshops normally used by PTOs will not initially be considered impartial.

2.3.2 Requirements for measurement technician

Documentation shall be provided to prove that the measurements performed are carried out by personnel with appropriate training, including knowledge of general measurement techniques, calibration, quality assurance and reproducibility of measurements.

2.4. Maintenance and calibration

The measuring instrument must be maintained and calibrated in accordance with the manufacturer's recommendations.

2.5. Preparing for measurement

Before measurement, it must be ensured that the heater does not have defects or shortcomings causing the heater to not function normally. There must be no visible defects around the heater or significant waste of fuel or coolant.

Before starting the measurement, check that the bus does not have alarms on the instrument panel related to the heater.

The measurement may be carried out on a hot or cold heater. Before measurements can be considered applicable, the heater must run at least 6 minutes.

It shall be indicated on a measurement chart whether the heater was at operating temperature before the measurement. This is done to avoid questions of doubt regarding compliance with limit values.

The flap to the heater room shall be closed during the measurement unless access is made through the engine compartment.

2.6. Preparation measuring equipment

Before measuring, the instrument is prepared in accordance with the manufacturer's recommendations.

When the equipment is ready, the tip of the measuring probe is placed about 50 mm inside the exhaust pipe – as a starting point in the center of the pipe mouth. The pipe mouths can have many shapes, so it can be difficult to place the probes precisely in the center, but this is done to the extent possible. It is recommended to take a photo of the installation.

Due to the compact construction of the heaters, there is a relatively short way from the combustion zone to the mouth of the exhaust pipe, and there is a risk that the flue gas is not fully mixed up at the mouth. Thus, there may be examples of higher CO₂ elsewhere than in the center.

If the measurement must be performed anywhere else than at the pipe center, it is the PTO's responsibility to inform the measurement technician accordingly.

If it is not possible to measure 50 mm inside the exhaust pipe, it is to be noted in the measurement report.

2.7. Measurement procedure

The measurement is carried out at the PTO's bus depot premises with the engine idle or with a charger connected to the battery. Where a charger is used, it should be ensured that the voltage on the heater is sufficient and at least at the level required by the manufacturer of the heater.

Measured parameters

- CO₂ and CO
- Exhaust gas temperature

Requirements for

- CO₂
- CO average and CO max.
- Exhaust gas temperature

A total of four ignition periods are run through, and the heater is switched on and off manually for each run.

The first ignition period counts as pre-heating, while the last three are valid. To remove the heat produced, the thermostat in the bus is set to maximum heat, the cabin blowers are turned up and the doors are opened. If necessary, the bus engine flap may also be opened for cooling.

Before each ignition, it is assessed whether the temperature of the coolant is sufficiently low to allow the measurement to be carried out without the water becoming so hot that the thermostat will switch off the heater. Usually this happens at a coolant temperature around 60-70°C. If the coolant is assessed too hot, ignition must wait until the temperature is assessed sufficiently low.

Once the temperature is in place, the heater can be turned on.

During each ignition period, the heater runs up to 6 minutes or until CO and flue gas temperature over the last 20 seconds have not clearly changed more than 1%. The heater is then switched off and the procedure is repeated until three applicable ignition periods have been run through.

Measurement data for the last 20 seconds of each ignition period shall be averaged regarding CO and CO₂. Maximum exhaust gas temperature and maximum CO are determined for the entire ignition period.

2.7.1 Criteria for approval

The following must be met for the heater to be approved:

1. At least two of the three measurements comply with the requirements
2. The average of the three measurements shall comply with the requirements

3. Measurements must be performed immediately in succession

If it is estimated that the measured values are abnormally low/high because of defects, the PTA may require the heater to undergo a further Environmental Test once these defects have been rectified.

It is recommended, but not required, that the measurements are carried out at an ambient temperature below 20°C, as higher ambient temperatures can cause challenges in terms of drawing heat from the heater.

If it is not possible to complete the three measurements due to the way the ECU of the bus controls the heater, or other things not directly related to the heater, the measurement is carried out in the best possible way, and the measurement technician notes the reason for the deviation.

2.8. Limit values

The following limit values shall apply:

Table 1. Limit values. The emission limit values are indicated based on wet/raw flue gas.

Parameter		Limit
CO ₂	Oil-fired heaters	> 9%
	Gas-fired heaters	> 7%
CO (average)		< 300 ppm
CO (max.)		< 1500 ppm
Exhaust gas temperature (max.)		< 350 °C

3. Report and documentation

Measurement results must be entered in a test report which, together with measurement charts, photos, etc., is placed in an electronic database to which the PTA has access.

Measured concentrations of CO₂ and CO, flue gas temperatures, measuring site, heater manufacturer, heater model, heater heat output, bus number and which measurement technician/measuring company has carried out the measurements, must appear in the test report.

In addition, the measuring company concerned shall ensure that the following information is stored:

- Results from continuous calibration/adjustment of the measuring equipment
- Information on defects and repairs of measuring equipment relevant to the implementation of correct measurements.

The results are the property of the PTA and may not be published or used by PTOs' or the measuring company in any other context without the PTAs' permission.

3.1. Cases of disagreements

In the event of a reasoned disagreement between the PTO and the measuring company, the PTA is the supreme authority. The PTA may require documentation of the calibration interval and calibration protocol from the company performing the measurements.

Appendix A – Test report

Date, start time (yyyy-mm-dd hh:mm):	
Date, stop time (yyyy-mm-dd hh:mm):	
Site for measurement:	
Bus manufacturer:	
Bus model:	
Bus number:	
Bus registration number:	
Bus Euro norm:	
Heater manufacturer:	
Heater model:	
Heater heat output:	
Heater year of manufacture:	
PTO:	
PTO's bus depot premises:	
Method (Environmental Test Manual, version):	
Ordered by:	
Measurement performed by:	

Measurement equipment

Id	Type	Model	Range

Measurement results

	Meas. 1	Meas. 2	Meas. 3	Avg.	Limit value	Passed / not passed
CO ₂						
CO (average)						
CO (max.)						
Exhaust gas temp.						

Remark

Conclusion

Pass/fail: