# SLOVENSKI STANDARD
# kSIST-TP FprCEN/TR 1404:2023

**01-december-2023**

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**Določanje emisij iz plinskih aparatov pri tipskem preskušanju**

Determination of emissions from appliances burning gaseous fuel during tape-testing

Bestimmung von Emissionen von Gasgeräten während der Typprüfung

Determination of emissions from appliances burning gaseous fuel during tape-testing

**Ta slovenski standard je istoveten z:** **FprCEN/TR 1404**

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**ICS:**

| | | |
|---|---|---|
| 13.040.40 | Emisije nepremičnih virov | Stationary source emissions |
| 27.060.20 | Plinski gorilniki | Gas fuel burners |



**kSIST-TP FprCEN/TR 1404:2023** **en,fr,de**

TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER REPORT

# FINAL DRAFT
# FprCEN/TR 1404

September 2023

ICS 97.040.20; 13.040.40

Will supersede CR 1404:1994

English Version

# Test gases - Determination of emissions from appliances burning gaseous fuels during type-testing

Determination of emissions from appliances burning gaseous fuel during tape-testing

Bestimmung von Emissionen von Gasgeräten während der Typprüfung

This draft Technical Report is submitted to CEN members for Vote. It has been drawn up by the Technical Committee CEN/TC 238.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. FprCEN/TR 1404:2023 E

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## European foreword

This document (FprCEN/TR 1404:2023) has been prepared by Technical Committee CEN/TC 238 “Test gases, test pressures, appliance categories and gas appliance types”, the secretariat of which is held by AFNOR.

This document is currently submitted to the Vote on TR.

This document will supersede CR 1404:1994.

# Introduction

This document is based on CR 1404 and other information coming from the Guide for Laboratory Practice (GLP) for the measurement, conversions and corrections of CO and $NO_X$. CR 1404 was published by CEN in 1994. Several standards refer to it concerning the measurement, conversion and correction of the emissions of CO and $NO_X$.

The ECOTEST project under mandates M/534 - ECODESIGN WATER HEATERS and 535 ECODESIGN Central heating appliances under the "Specific agreement number: SA/CEN/GROW/EFTA/534/535/2015-14 Rev" used the CR 1404:1994 as a reference document for the measurements of the emissions of CO and $NO_X$ of gas and liquid fuel boilers and water heaters tested under this project.

After a brainstorming made by ECOTEST experts, it was recommended to CEN/TC 238 to revise this document. CEN/TC 238 decided to revise it and publish it as a CEN Technical Report (CEN/TR).

This document describes test methods and automatic measurements for the determination of $NO_X$ ($NO+NO_2$) CO, $CO_2$ and $O_2$ emissions in the flue gases including the sampling system and the calibration gases. Parts of this document are already introduced in the relevant gas appliances standards.

Gas cookers, flue less appliances and appliances especially designed for use in industrial processes carried out on industrial premises are excluded from the scope.

According to their principles of analysing the combustion products, the analysers are classified into the following families:

— Analysers- based on the chemiluminescent effect: NO an $NO_2$,

— Analysers based on the absorption of infra-red and ultra-violet radiation: NO and $NO_2$ (for concentrations higher than 100 ppm), CO and $CO_2$,

— Analysers based on the paramagnetic principle: $O_2$,

— Electrochemical analysers: they are considered to be inadequate for laboratory testing procedures.



This document presents the procedures to convert the measured values of $NO_X$ and CO to reference aeration conditions.



It also explains how to correct the emissions of $NO_X$ from the measured combustion air temperature and humidity to the reference conditions of 20 °C and 10 g of water/kg of air.

# 1 Scope

This document covers the measurements of the emissions of carbon monoxide (CO) and nitrogen oxides ($NO_X$) produced by the combustion of gaseous fuel in domestic appliances. It is also possible to adapt it to liquid fuel appliances.

It explains how to correct the measured values obtained at the testing conditions of temperature, humidity and gas used into the reference conditions, as well as their conversion to different aeration factor expressed as $\%O_2$ in the dry products of combustion.

The document also contains information on the types of sampling probes, mainly their form and their dimensions, which depend on the type of flue gas system.

It also gives detailed information on the sampling of the flue gas to be analysed, the transport / transfer lines and their components, and the materials recommended for their construction.

This document contains hints on the calculation of the uncertainties and the parameters to be considered in the whole analysis chain from the sampling probe to the analysers including the calibration gases.

The calculation of the uncertainties of the measurements of $NO_X$ and CO is not covered by this document.

# 2 Normative references

There are no normative references in this document.

# 3 Terms, definitions, symbols and abbreviations

## 3.1 Terms and definitions



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

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp/



**3.1.1**
**$NO_X$ emissions**
sum of the concentrations of nitrogen monoxide (NO) and nitrogen dioxide ($NO_2$) in dry flue gases in measured in ppm (vol/vol) and expressed in mg/MJ and mg/kWh

**3.1.2**
**$NO_2$ emissions**
concentration of nitrogen dioxide ($NO_2$) in dry flue gases expressed in ppm (vol/vol)

**3.1.3**
**NO emissions**
concentration of nitrogen monoxide (NO) in dry flue gases expressed in ppm (vol/vol)

**3.1.4**
**$CO_2$ concentration**
concentration of carbon dioxide in dry flue gases expressed in % (vol/vol)

**3.1.5**
**water vapour concentration**
**$H_2O$**
concentration of water vapour in wet flue gases expressed in % (vol/vol)

**3.1.6**
**oxygen concentration**
**$0_2$**
concentration of oxygen in dry flue gases expressed in % (vol/vol)

**3.1.7**
**measured value**
**mv**
concentration of pertinent gases measured in the dry or wet flue gases (CO, NO, …) expressed in ppm (vol/vol) and ($CO_2$, $O_2$, $H_2O$) expressed in % (vol/vol)

**3.1.8**
**calibration gases**
gases to be analysed mixed with air, nitrogen and other gases used to calibrate the analysers

**3.1.9**
**full scale calibration gas**
gas diluted in nitrogen to be used to check the maximum content of the gas to be analysed

**3.1.10**
**zero calibration gas**
gas, usually nitrogen or air, used to set the zero



**3.1.11**
**span gases**
gases at different concentrations of the full scale which are used to check the linearity, the repeatability and other parameters:



Gas span I: 30 % of full scale

Gas span II: 60 % of full scale

Gas span III: 90 % of full scale

**3.1.12**
**parts per million**
**ppm**
part (in volume) of a gas (e.g. CO or $NO_X$) diluted in one million parts (volume) of the gas to be analysed

Note 1 to entry: 1 % CO or $NO_X$ (in volume)= 10 000 ppm CO or $NO_X$ (in volume).

### 3.2 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

fs full scale at which the analyser is calibrated for a given gas

$T_{cal}$ temperature during calibration

$T_{use}$ temperature during use

$P_{cal}$ pressure during calibration

$P_{use}$ pressure during use

$CO_{2cal}$ $CO_2$ concentration in $NO_X$ calibration gas

$O_{2cal}$ $O_2$ concentration in $NO_X$ calibration gas

$H_2O_{cal}$ $H_2O$ concentration in $NO_X$-calibration gas

## 4 Parameters impacting the uncertainty of the measurements

### 4.1 General

The following elements impact the uncertainty of the measurement of the emissions of CO and $NO_X$:

— the sampling probe, and sampling line;

— the accuracy of the analysers, NO, $NO_2$, $CO_2$, CO, $O_2$;

— the calibration gases and procedures;

— the test conditions.



### 4.2 Calculation of individual sources of uncertainties



The uncertainties are either:

— random uncertainties (U); or

— uncertainties caused by not correcting for systematic errors (E).

In some cases, when the uncertainty of an individual source is unknown, it is acceptable to assume worst case uncertainty (Uwc) or worst-case error (Ewc).

The uncertainty of measurements of emissions depends on the following:

— the sampling probe;

— the characteristics of the transfer line and the treatment of the sample;

— the analysers;

— the calibration method and calibration gases;

— the measurement;

— the uncertainty in the reproducibility of the sources of emissions;

— the conversion and calculations to different air dilution factors or $\%O_2$ in dry flue gases.

The uncertainty concerning the calculation and conversion depends on the following:

— the $NO_2$ absorption by water;

— the interferences between the different gases;

— the linearity of the analysers;

— the drift with temperature and the drift with pressure;

— the converter efficiency ($NO/NO_2$);

— the influence of the temperature and humidity of combustion air;

— the gas or fuel oil composition.

## 4.3 Total systematic error

It is possible that systematic errors be caused by temperature, pressure, absorption of $NO_2$, interference and non-linearity.

If the total systematic error exceeds 2 % of the measured value, then the cause of it is investigated and corrected. Correction is made to limit the systematic error to an acceptable value (e.g. 2 %).

## 4.4 Reproducibility / repeatability of the CO and $NO_X$ emissions

It is possible that the number of factors, such as relative humidity and temperature of the combustion air and the gas used, affect the level of $NO_X$ emissions.

For $NO_X$ emissions, a correction formula derived from the BCR programme is proposed in E.1 "Conversion to reference conditions".

NOTE CETIAT propose an alternative formula based on measurements performed on 6 low-$NO_X$ gas boilers. This alternative method is also shown in E.2.

## 4.5 Warming up



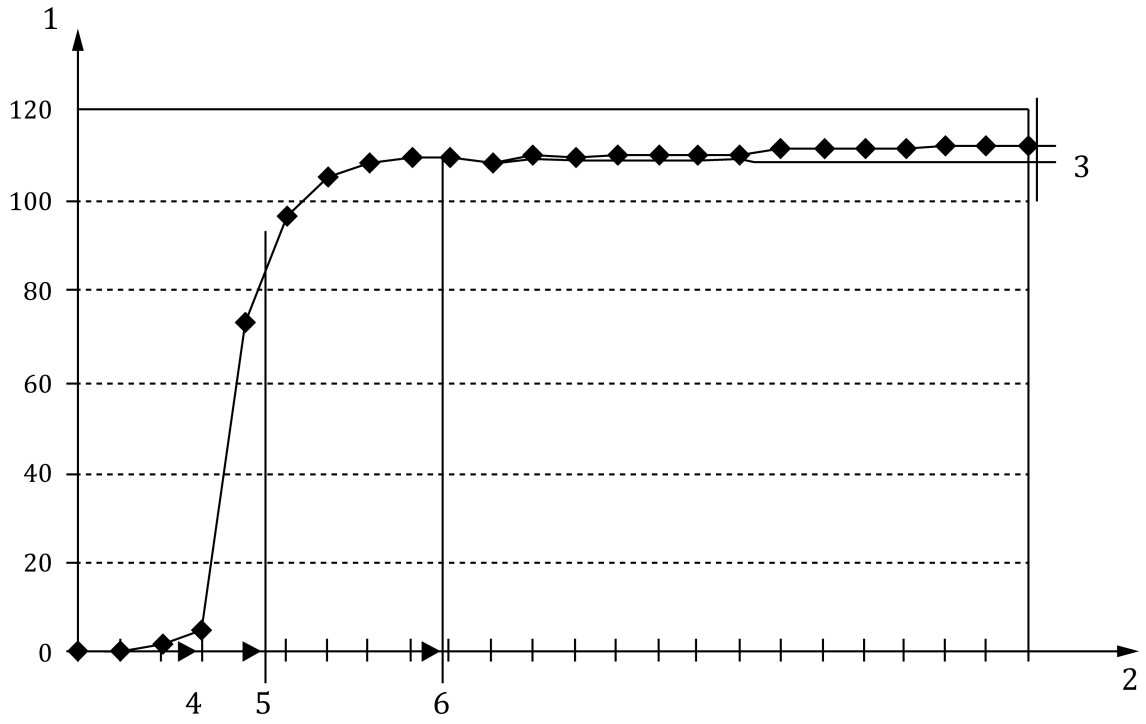
To avoid the influence of start-up phenomena, the analyser is warm before use. At least the warm-up period prescribed by the supplier of the analyser is observed. The warm-up period required is determined as follows:

Connect a recorder to the output of the analyser to register the form of the output signal with time.

Connect the calibration gas cylinder (span gas III, 90 % of full scale) to the analyser.

Switch on the analyser and supply span gas III.

Readings are recorded until the output signal becomes stable (variation < ± 3 %) for at least 30 min (Figure 1). A period of 3 times the warm up determined this way is observed after switching on the analyser before every test. If the warm up period determined this way is shorter than the warm-up period prescribed by the supplier, the latter is used during test in practice.




**Key**

1 concentration
2 time
3 drift
4 $t_{dead}$
5 $t_{response}$
6 $t_{warm-up}$
◆ measured value



**Figure 1 — The path of the reading due to warming up phenomena**

If an analyser of $NO_X$ containing a converter to measure $NO_2$ is checked, an extra test is performed. This test is used to check if the converter has reached the operation temperature during warm-up.

To do so, supply the analyser with a calibration gas containing $NO_2$ diluted in synthetic air and check if at least 90 % of the $NO_2$ reacts at the surface of the converter as shown in Table 1.

**Table 1 — Use of calibration gas to check the operation of the converter**

| *Calibration gas* | *Reading* |
|---|---|
| *$NO_2$ in synthetic air* | *$NO_2 > 0{,}9 \times [NO_2]_{cal\ gas}$ and/or $NO_X > 0{,}9 \times [NO_2]_{cal\ gas}$* |