

More Transparency in Combustion Gas Analysis: OMEGA FT-IR Coupling on the TCC 918

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Introduction

The fire behavior of materials is a crucial factor in safety assessments in areas such as construction, transportation, and electronics. The NETZSCH TCC 918 Cone Calorimeter (figure 1) determines key fire parameters based on the oxygen consumption principle, including:

- O₂, CO₂ and CO concentrations
- Heat release rate (HRR)
- Average heat release rate (ARHE)
- Smoke production rate (SPR)
- Mass loss rate (MLR)
- Time to ignition (TOI)
- Time to flame out (TOF)

These parameters provide a comprehensive picture of the thermal fire behavior of a material, from ignition to flame extinction, and serve as the basis for modeling and predicting real fire events.

Optional coupling with the Bruker OMEGA FT-IR gas analyzer allows the composition of the resulting smoke gases to be analyzed in detail. The quantitative detection of numerous decomposition and combustion products enables extensive assessment of toxic emissions and supports the development of safe, sustainable materials.

Measurement Principle

In the TCC 918, the sample is exposed to a defined heat flow using a cone heater, ignited, and burned under controlled conditions. The resulting flue gases are transferred via an exhaust system for further analysis.

As standard, the relevant flue gases, in particular O₂, CO, and CO₂, are analyzed using a Siemens Oxymat/Ultra-mat gas analyzer. These variables measured are used to



1 TCC 918 Cone Calorimeter

calculate the heat release rate (HRR) according to the oxygen consumption principle.

The optional FT-IR coupling extends this approach and also enables the quantitative detection of further decomposition and combustion products. This allows for the flue gas composition to be examined in much greater detail, particularly with regard to toxic components.

OMEGA FT-IR Coupling

The coupling (figure 2) is achieved via a heated transfer line, similar to the FT-IR transfer line coupling of other NETZSCH analyzers (e.g., TG-FT-IR). Temperature control prevents condensation, ensures fast gas transport, and enables real-time analysis of the flue gases.

FT-IR spectroscopy simultaneously quantifies various gases based on their characteristic absorption spectra. This allows for numerous combustion and decomposition products to be detected.

In addition to the typical combustion gases CO₂, CO, and H₂O, these include hydrocarbons (CH₄, ethene, ethyne), halogen compounds (HCl, HBr, HF), nitrogen compounds (HCN, NH₃, NO, NO₂, N₂O), organic substances (acrolein, formaldehyde, benzene, phenol), and sulfur compounds (SO₂).

This extended gas analysis provides valuable information about potentially toxic by-products, especially in applications with high fire safety requirements, such as in rail vehicle construction.

Typical examples are polyamides (PA), which are often used in interior trim, seats, cable insulation, and molded



2 Bruker OMEGA TG-FT-IR gas analyzer

parts due to their strength and heat resistance. They are also found in public buildings and households, for example, in floor coverings, furniture, and electrical components. As organic polymers, they can release considerable amounts of smoke and toxic gases in the event of a fire, so detailed investigation of their fire behavior is crucial for safe use.

Measurement Conditions

A PA6 textile measuring 50 x 50 x 7 mm³ (8 layers) and weighing 10.58 g was examined. The test parameters are summarized in table 1.

Table 1 Measurement conditions

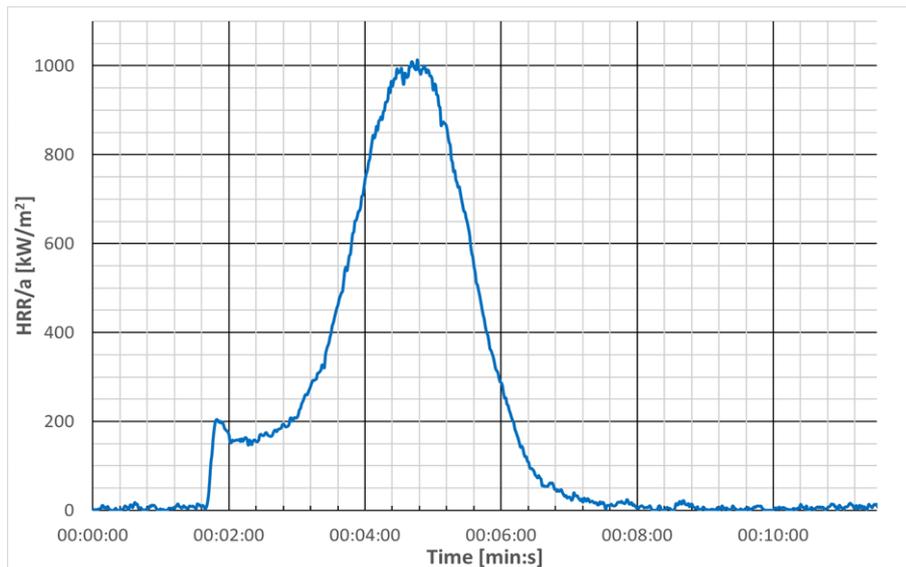
Sample holder	Horizontal
Heat flow	50 kW/m ²
Nominal flow rate	24.0 l/s
Distance to the cone heater	25 mm
FT-IR interface temperature	180°C
FT-IR measurement parameters	Transmission mode; resolution: 1 cm ⁻¹ ; averaged scans per spectrum: 10

Classic Cone Calorimeter Measurement Values

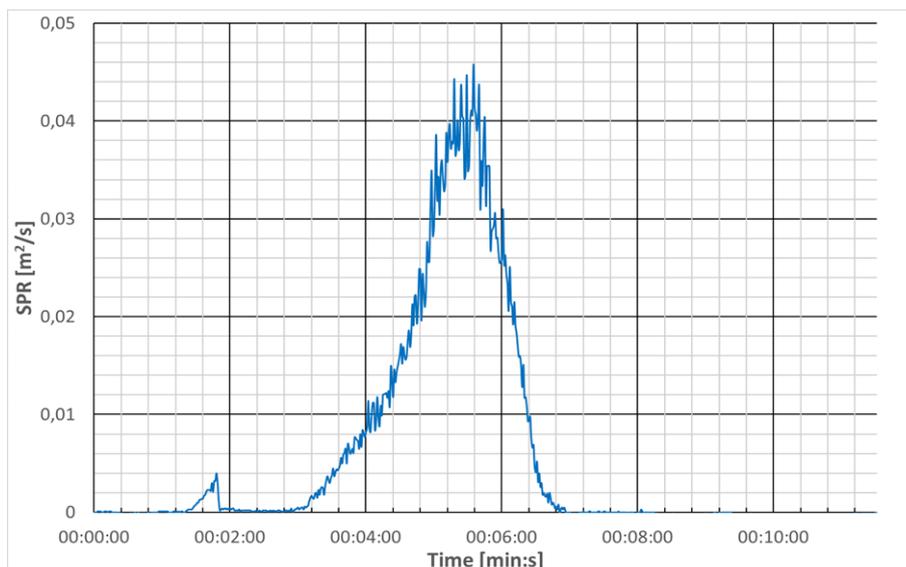
The following figures show the most important classic fire parameters that form the basis for assessing fire behavior:

The smoke production rate (SPR, figure 4) provides information on visibility impairment and possible toxic exposure.

The heat release rate (HRR, figure 3) is a measure of fire intensity and thus a key indicator of potential danger.



3 Heat release rate (HRR) of the PA6 sample



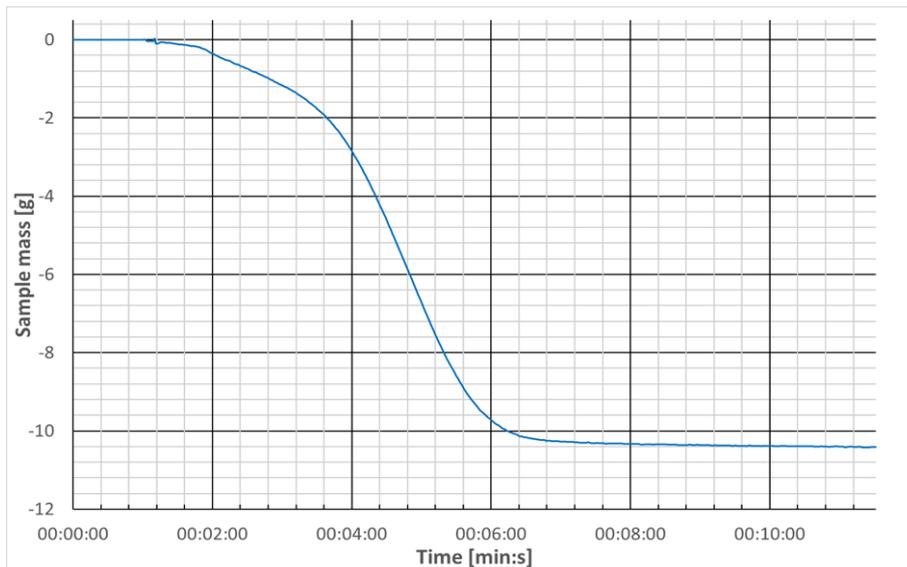
4 Smoke production rate (SPR) of the PA6 sample

The mass loss (ML, figure 5) correlates directly with material combustion and provides information on stability and residue formation.

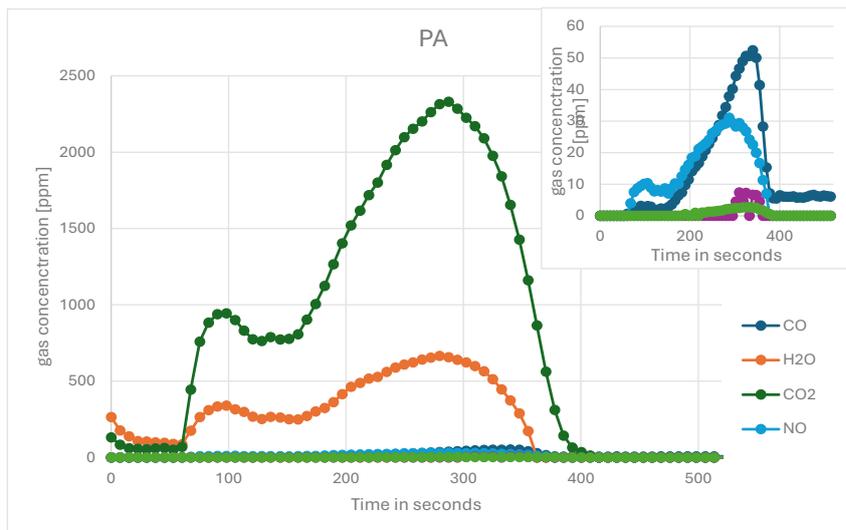
With the OMEGA FT-IR coupling, the flue gas composition during combustion could be precisely determined (figure 6).

Advanced FT-IR Gas Analysis

In addition to these established parameters, supplementary FT-IR analysis now provides new insights into the chemical composition of the flue gases produced.



5 Mass loss (ML) of the PA6 sample



6 FT-IR analysis of the smoke gas composition during combustion

The following components were recorded in particular (see also figure 6):

- CO₂ – Main product of combustion, correlates with oxygen consumption
- H₂O – Water vapor from material and additive decomposition
- CO – Indicator of incomplete combustion (colorless and odorless asphyxiant)
- NO – Formed from nitrogen compounds in the polyamide
- N₂O – Byproduct of nitrogen oxidation (highly irritating to the respiratory tract)
- HCN – Highly toxic, inhibits cellular respiration

The simultaneous detection of these gases enables comprehensive evaluation of the materials, both in terms of their thermal fire behavior (HRR, SPR, MLR) and their toxicological relevance.

Summary

Coupling of the TCC 918 Cone Calorimeter with the Bruker OMEGA FT-IR gas analyzer expands classic fire gas analysis to include simultaneous detection of numerous toxic and fire-relevant gases. In addition to the standard parameters of the TCC 918, detailed information on the composition of the smoke gas can thus be obtained.

This allows for holistic evaluation of materials in terms of fire behavior, toxic emissions, and safety requirements – a considerable added value for research, product development, and safety assessment.

With this combination of precise calorimetry and modern FT-IR spectroscopy, NETZSCH offers a powerful tool for innovative material analysis and safety assessment in fire testing.