TCC 918 – Avoiding Fire with Toxic Smoke Caused by Electronic Components

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Introduction

Plastic materials in general are excellent insulators. Due to their high mechanical strength and low weight, they are particularly suited for the electric and electronics (E&E) market as well as the transportation and appliances industries. One commonly used plastic material for such applications is from the polyamide family: PA 6, which features good surface quality, processability and slightly lower prices than other PAs, is especially well suited. In many of these applications, the plastic material is reinforced with short glass fibers to further improve mechanical performance.

However, these materials can catch fire when close enough to an ignition source like an electric spark. One common measure for ensuring fire safety is the addition of flame retardants (FR). The type and amount of flame retardant used depends on the application and the associated requirements set forth by various flammability standards.

1 Cone Calorimeter TCC 918

In general, a low amount of flame retardant is desired, in order to have the least effect on the plastic's properties and processing behavior. Like any additive, flame retardants increase the viscosity of polymer melts, which is especially critical in the electronics industry where miniaturization and thus very thin walls are standard. A variety of flame retardants exists for PA 6.

Fires initiated by even a single electric spark develop smoke right from the outset. hat's why most fire victims are killed by toxic smoke. Furthermore, the smoke can get dense enough to make visual orientation difficult or even obstruct the escape of a trapped person. Corrosive substances in the smoke can also damage equipment otherwise not affected by the fire. The toxicity and corrosiveness often observed come from halogenated polymers or flame retardants. For that reason, special non-halogenated flame retardants and graphite-based flame retardants are used to avoid these problems.

Measurement Conditions

To highlight the effect of different non-halogenated flame retardants on the fire behavior of PA 6, samples of the different compounds were injection-molded into 100 x 100 x 4-mm^3 plates and tested in the TCC 918 (figure 1). The instrument allows for the determination of the heat release, mass loss and density and composition of the smoke gas. The samples were positioned on a horizontal sample holder that is placed in the load cell. The load cell monitors the sample mass during the measurement. A conical radiant electrical heater uniformly

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irradiates the specimen from the top. A spark igniter is located between the specimen's surface and the cone heater. This ignites the flammable gases evolving from the specimen when it is heated. The combustion gases produced pass through the heating cone and are collected by an exhaust duct system with a centrifugal fan and hood. In the measuring section of the exhaust duct, the mass flow and temperature of the smoke gas can be measured, as well as O_2, CO_2, and CO concentrations and laser light transmission through the smoke gas.

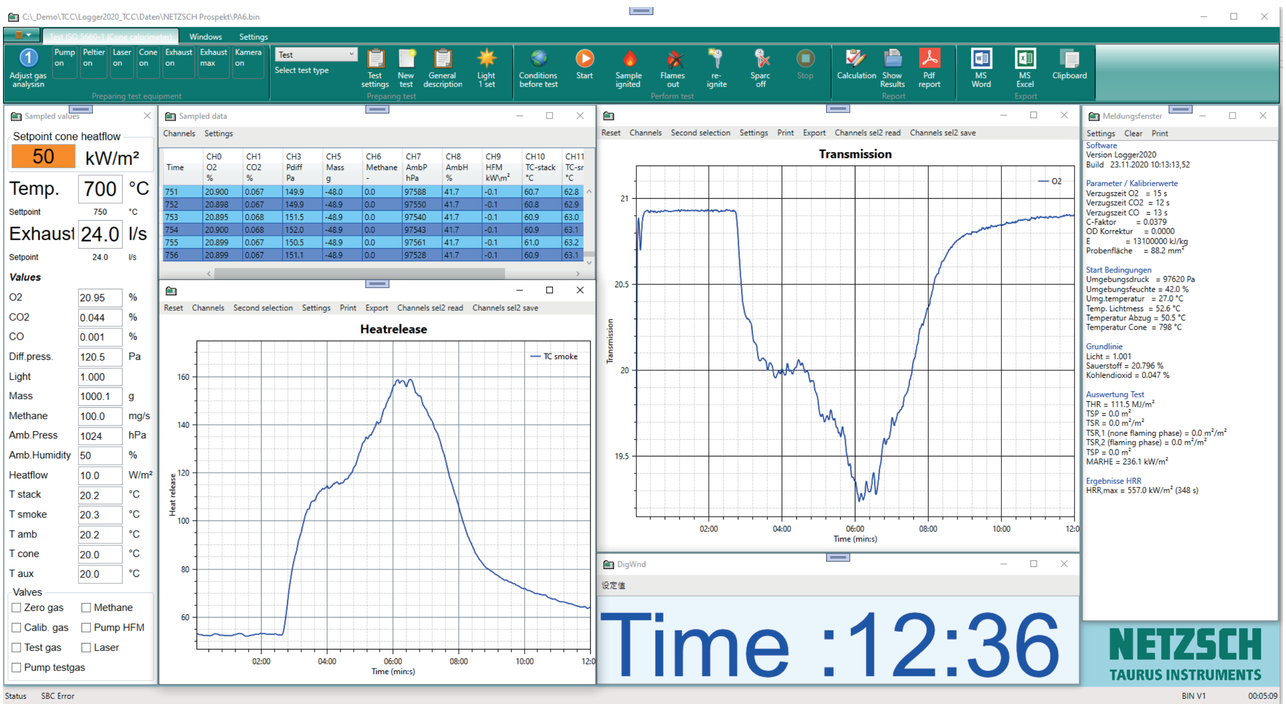
Before starting the tests, the gas analysis system (Siemens Oxymat/Ultramat) was calibrated with calibration gases and the C-factor was checked by using the methane burner with a defined heat release. The gas analyzer used was equipped with O_2 and a CO_2 option.

After heating up the cone heater, the shutter was closed, and the prepared sample holder was positioned onto the ground plate. Then, the system automatically removed the shutter for the start of the measurement. The evaporated gases were ignited by the automatic ignition system. The measurement conditions are summarized in table 1.

Figure 2 shows the results of the measurement on neat PA 6 and the visualization in the TCC software. The left column shows the measurement input data; in the middle, a table with the measured values from 751 to 756 s can be seen along with two example graphs of the measured data; and, the right column presents an overview of the selected analysis values for this particular measurement.

Tab 1. Measurement conditions

Sample holder	Horizontal
Heat flux	50 kW/m²
Nominal duct flow rate	24.0 l/s



2 Overview of the TCC measurement on neat PA 6 in the TCC software

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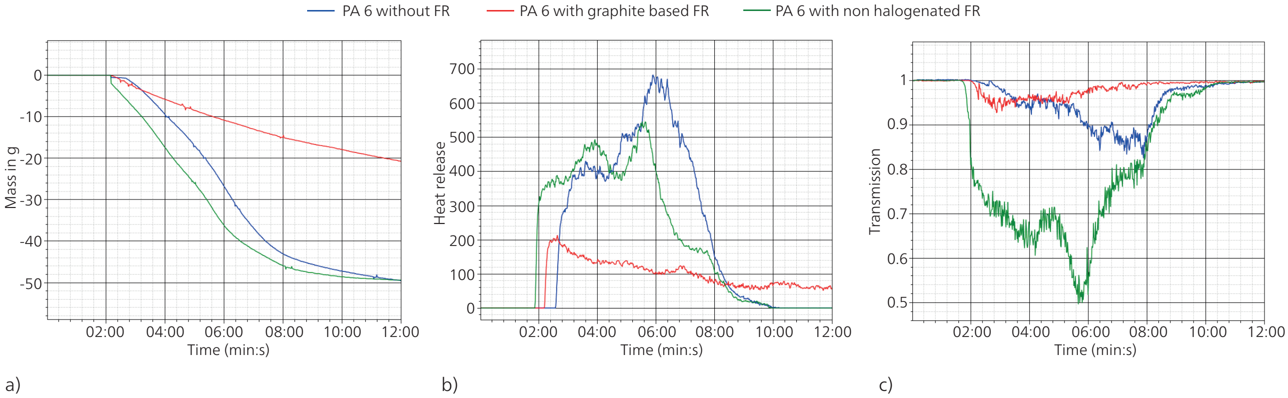

3 a) Mass loss, b) heat release rate and c) transmission of a neat PA 6 (blue), PA 6 w/graphite-based flame retardant (red) and PA 6 w/non-halogenated flame retardant (green) (Source: BPI)

Figure 3 allows a closer look at the results. Figure 3a shows the mass loss, b) shows the heat release rate and c) shows the transmission as a function of time for the three different samples.

It can be seen that the PA 6 sample with 20 wt% graphite-based flame retardant (red curve) shows the lowest mass loss, heat release and smoke release (lowest reduction in transmission) of all the samples. In comparison, the sample with 20 wt% non-halogenated flame retardant (green curve) behaves very similarly to the neat PA 6 material (blue curve). As pertains to the heat release, it shows slightly lower values and also the heat release ends earlier. As pertains to transmission, however, the smoke emission is much higher than for the neat PA 6.

Summary

These investigations show that in the case of this particular PA 6 as well as the investigated FR loadings, the graphite-based flame retardant performs much better and significantly reduces the detrimental effects a fire can have on its surroundings. In the case of the non-halogenated FR, additional loadings would need to be studied to identify a composition with better performance.

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