Licharz on the web
Behaviour in fire

1. Behaviour of plastics in fire and fire ratings

Generally, plastics are organic substances or modifications of organic substances, which, like other organic substances are threatened by chain breakage, cleavage of substitutes and oxidation at high temperatures. Therefore, apart from a few exceptions, plastics are more or less combustible which is something that can be a serious technical problem in the specific use of plastics.

1.1 Combustibility

If plastics are heated locally or over large surfaces to above their specific decomposition temperature, they release volatile, low molecular constituents. In many cases, together with the ambient oxygen, these form a flammable gas mixture which can ignite if an ignition source is added and an adequate supply of oxygen is available.

The amount of heat that is fed in and the volume of the combustible surface that this can affect are both very significant for the evolution of a fire and the course of the fire. Another decisive factor is the atmospheric oxygen concentration.

For instance, it is possible that a large quantity of heat which affects a large volume with a large surface area but a lack of oxygen only leads to pyrolytic cleavage in the beginning (release of highly flammable, volatile and low molecular constituents). If one adds oxygen in the right concentration, under unfavourable conditions this can result in a deflagration or an explosion.

However, with the same volumes and a lower heat input, as well as an adequately high oxygen concentration, the same substance only burns slowly.

Because of this behaviour, it is very difficult, if not impossible, to make any fire-technical forecasts.

1.2 Conflagration gases

As with the combustion of other substances, when plastics burn they produce various conflagration gases. As a rule, these are said to be highly toxic. This is not absolutely correct as, on the one hand, the toxicity depends on the type and quantity of the plastic involved in the fire and, on the other, all conflagration gases resulting from a (substance-independent) fire should be regarded as toxic.

One example is the conflagration gases resulting from the incineration of polyethylene, which, in addition to small quantities of soot and low molecular plastic constituents, almost exclusively contain carbon monoxide, carbon dioxide and water. This is comparable with the conflagration gases that occur when wood or stearine are burned.

On the other hand, when polyvinyl chloride is burned, there is a danger of chlorine being released, which in combination with atmospheric moisture or extinguishing water forms to hydrochloric acid.

Many plastics produce a lot of soot when they burn, which makes it difficult for the fire brigades to reach the source of the fire. These plastics include the polyolefin PE and PP as well as styrene plastics such as PS and ABS.

This must be considered for designs in fire-critical areas.
1.3 Behaviour in fire
Almost all plastics are combustible. Exceptions to this are PTFE and silicones, which are virtually non-combustible. Most plastics continue to burn after they have been ignited and the source of ignition has been removed. Several extinguish when the ignition source is removed, while others cannot be ignited. In many cases, the plastic melts due to the heat of combustion and forms burning droplets which can promote the spread of the fire. The degree of combustibility can be reduced by adding the corresponding additives.
Additives based on the following mechanisms are used:

• **Endothermy**
The temperature of the plastic is reduced by the decomposition or vaporisation of the additive. This is possible for example with water stores (aluminium hydroxide) or phosphorous compounds being added to the plastic.

• **Radical bonding**
The radicals that form during the fire are bonded by the additive, which slows down the thermal decomposition and consequently the release of flammable, volatile constituents.

• **Formation of heavy gases**
Heavy gases are formed through the thermal effects on the additive, preferably halogens, which shield the plastic from atmospheric oxygen and thus prevent oxidation.

But the use of fire retarding additives does not make plastics non-combustible. Only plastics that are regarded as being non-flammable are suitable for applications that demand non-combustibility of the plastic.

1.4 Fire ratings
Often, to assess how plastics behave in fire, imprecise terms such as “highly flammable” or “fire resistant” or “non combustible” are used. These terms inadequately reflect the actual behaviour of the plastics and only provide a limited inference for the usability of a plastic for a specific application. To assess how plastics behave in fire in the areas of electro-technology, traffic, building, etc. there are currently approx. 700 national and international test methods. In the electrical sector the method UL 94 HB or UL 94 V from Underwriters Laboratories (USA) has become the most widely accepted. These tests refer to the burning time and the burning behaviour of plastics. In test UL 94 V a distinction is made between classifications V0 to V2, V0 being the most favourable rating.

Another possibility of comparing the flammability of plastics is the oxygen index. In a controllable O₂/N₂ mixture a vertical plastic sample is ignited and the minimum volume of O₂ required to burn the plastic is measured. This test also allows the effects of flame retardants to be observed. The diagram opposite contains several oxygen indices for comparison. Index values ≤ 21% can lead to continued burning after the source of ignition has been removed.
Our machining capabilities:
- CNC milling machines, workpiece capacity up to max. 2000 x 1000mm
- 5-axis CNC milling machines
- CNC lathes, chucking capacity up to max. 1560 mm diameter and 2000 mm long
- Screw machine lathes up to 100mm diameter spindle swing
- CNC automatic lathes up to 100mm diameter spindle swing
- Gear cutting machines for gears starting at Module 0.5
- Profile milling (shaping and molding)
- Circular saws up to 170mm cutting thickness and 3100mm cutting length
- Four-sided planers up to 125mm thickness and 225mm width
- Thickness planers up to 230mm thickness and 1000mm width
We process:
- Polyamide (PA)
- Polyacetal (POM)
- Polyethylene terephthalate (PET)
- Polyethylene 1000 (PE-UHMW)
- Polyethylene 500 (PE-HMW)
- Polyethylene 300 (PE-HD)
- Polypropylene (PP-H)
- Polyvinyl chloride (hard) (PVC-U)
- Polyvinylidene fluoride (PVDF)
- Polytetrafluoroethylene (PTFE)
- Polyetheretherketone (PEEK)
- Polysulphone (PSU)
- Polyether-imide (PEI)

Examples of parts:
- Rope sheaves and castors
- Guide rollers
- Deflection sheaves
- Friction bearings
- Slider pads
- Guide rails
- Gear wheels
- Sprocket wheels
- Spindle nuts
- Curved feed tables
- Feed tables
- Feed screws
- Curved guides
- Metering disks
- Curved disks
- Threaded joints
- Seals
- Inspection glasses
- Valve seats
- Equipment casings
- Bobbins
- Vacuum rails/panels
- Stripper rails
- Punch supports
All calculations, designs and technical details are only intended as information and advice and do not replace tests by the users in regard to the suitability of the materials for specific applications. No legally binding assurance of properties and/or results from the calculations can be deduced from this document. The material parameters stated here are not binding minimum values, rather they should be regarded as guiding values. If not otherwise stated, they were determined with standardised samples at room temperature and 50% relative humidity. The user is responsible for the decision as to which material is used for which application and for the parts manufactured from the material. Hence, we recommend that practical tests are carried out to determine the suitability before producing any parts in series.

We expressly reserve the right to make changes to this document. Errors excepted.

You can download the latest version containing all changes and supplements as a pdf file at www.licharz.de.

© Copyright by Licharz GmbH, Germany

Bibliography

The following literature was used to compile “Designing with plastics”:

- Ebeling, F.W. / Lümpke, G. Kunststoffverarbeitung; Vogel Verlag
- Schelter, W./Schwarz, O. Kunststoffe; Vogel Verlag
- Biederbick, K. Kunststofftabellen; Hanser Verlag
- Carlowitz, B. Kunststoffe; Vogel Verlag
- Böge, A. Das Techniker Handbuch; Vieweg Verlag
- Ehrenstein, Gottfried W. Mit Kunststoffen Konstruieren; Hanser Verlag
- Strickle, E. / Erhard G. Maschinenelemente aus thermoplastischen Kunststoffen Grundlagen und Verbindungselemente; VDI Verlag
- Strickle, E. / Erhard G. Maschinenelemente aus thermoplastischen Kunststoffen Lager und Antriebselemente; VDI Verlag
- Erhard, G. Konstruieren mit Kunststoffen; Hanser Verlag
- Severin, D. Die Besonderheiten von Rädern aus PolymerMaterialien; Specialist report, Berlin Technical University
- Severin, D. / Liu, X. Zum Rad-Schiene-System in der Fördertechnik, Specialist report, Berlin Technical University
- Severin, D. Teaching material Nr. 701, Pressungen
- Liu, X. Personal information
- Becker, R. Personal information
- VDI 2545 Zahnräder aus thermoplastischen Kunststoffen; VDI Verlag
- DIN 15061 Part 1 Groove profiles for wire rope sheaves; Beuth Verlag
- DIN ISO 286 ISO coding system for tolerances and fits; Beuth Verlag
- DIN ISO 2768 Part 1 General tolerances; Beuth Verlag
- DIN ISO 2768 Part 2 General tolerances for features; Beuth Verlag
For further information, detailed catalogs are available:

- Information on Licharz machining capabilities of component parts
- Brochure „Material Guiding Values/Chemical Resistance“
- Product information on semi-finished products of PA, POM und PET
- Delivery programme

Visit us on the internet at www.licharz.de