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apropos

Combustion/ disposal of plastics

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Tips for the underwriter

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Plastics are to be found everywhere in our modern world. This edition of apropos is concerned with two problem areas arising from the large-scale use of plastics.

Firstly there is the problem of how plastics burn, an aspect brought to the fore by extensive media coverage of conflagrations requiring large-scale evacuation. Secondly there is the problem posed by the ever-growing mountain of plastic waste.

Combustion of plastics

The main components of plastic are carbon, hydrogen and oxygen. Like all organic substances they are combustible.

What happens when plastics burn depends on their structure and shape, and on the additives they contain. A plastic in powder or granulated form will combust more easily than a chemically identical plastic in a compact form.

The fire risk posed by a plastic depends on its combustibility and the intensity of the smoke it generates, and on the toxicity and corrosiveness of the gases and other substances produced.

Combustibility

For the purposes of fire prevention there are various methods of classifying materials in groups ranging from "not combustible" to "highly combustible". No matter what method is chosen, it is worth noting that most plastics are classified as "highly combustible".

The combustibility of plastics can be reduced by means of the following processes:

Flameproof/flame-resistant plastics

- Doping with flameproof or flame-retardant metallic salts, metallic oxides or compounds containing chlorine or bromide.
- Integration of combustion-retarding components into the molecular structure of the plastic by chemical reaction at the time of manufacture. These components are usually organic compounds containing fluorine, chlorine or bromine, or organic phosphorous compounds.
- Coating plastic parts with non-combustible or flame-retardant materials (mineral materials/fibres, fire-resistant chemicals).

Combustion gases

Burning plastics generally produce far more smoke than a wood fire (up to 300 times more, for instance, with some very dirty-burning plastics). Combustion of 1 kg of PVC, for example, generates over 500 m^3 of smoke gas. Smoke generation peaks after only two to three minutes, which makes it very difficult in an emergency to evacuate people and fight the fire itself. Especially dense smoke is generated during the combustion of polystyrene, polyurethane, polyvinyl chloride and acrylic butadiene styrene.

Combustion products

Some of the substances produced by the combustion of plastic can have immediate fatal effects, while others are carcinogenic or teratogenic (i.e. may cause foetal deformities). Besides this, the combustion gases may be highly corrosive.

All fires involving plastics release carbon dioxide (CO_2) and carbon monoxide (CO), both of which are poisonous if inhaled. What is more, most plastics produce polycyclical aromatic hydrocarbons, which have also been classified as carcinogenic. What other substances may be formed during combustion depends on the chemical structure of the plastics burnt. Since there is such a wide variety of different molecular compositions, the range of possible contaminants is also very broad. They are usually organic compounds derived from the hydrocarbon components (monomers). But heavy-metal contamination is also possible, if heavy-metal, e.g. cadmium, compounds have been used as softeners or flame-retardant additives.

The greatest hazard in terms of bodily injury, property damage and environmental impairment is presented by the combustion of halogenated or nitrogenated plastics.

– Halogenated plastics

These materials contain one or more halogens: fluorine (F), chlorine (Cl), bromine (Br) and Iodine (I).

Prominent members of this group are polyvinyl chloride, polyvinylidene chloride, polytretrafluor ethylene, chloroprene, chlorine rubber, chlorinated polyethylene, polyolefine as well as plastics containing chlorine and bromine as flame-retardant additives, especially in the form of polybrominated diphenyl ethers and polybrominated biphenyls.

Halogenated plastics give off not only respiratory poisons during combustion, but also highly toxic and corrosive hydrogen bromide, hydrogen chloride and/or hydrogen fluoride. These gases react with water to form aqueous acids (hydrobromic acid Hbr, hydrochloric acid HCl and hydrofluoric acid HF), which have an extremely corrosive effect on masonry, concrete and reinforcements as well as metal parts. Such corrosive chloride deposits have often caused quite expensive damage in the past.

Any fire involving halogenated plastics may give rise to chlorinated and brominated dibenzofuranes and dibenzodioxins – to which group the infamous Seveso poison belongs. As a rule, however, the amounts generated are very small. To date, almost 200 different dioxin and furane compounds have been discovered (cf. apropos 1.1 Dioxin).

– Nitrogenated plastics

The main members of this group are polyamide, polyurethane, polyacrylnitrile, melamine and carbamide resins.

When combusted, nitrogenated plastics can give off (highly) toxic nitrogen compounds such as

prussic acid (HCN) and cyanides,
nitric oxides (NO_X),
aromatic nitrol compounds, e.g. nitrobenzene,
ammonia (NH_3), and
aromatic amines, e.g. aniline.

Apart from their life- or health-threatening effects, prussic acid, ammonia and nitrogen oxides also exhibit highly corrosive properties.

Numerous further substances of a less toxic or corrosive nature may also be released through combustion:

– aliphatic amines;
– aliphatic nitrol compounds;
– organic acids, e.g. formic acid;
– phenols.

Disposal of plastics	More than 80 million tons of plastics are produced annually around the world, over 9 million tons in Germany alone (in 1995). Currently 2.5 million tons of waste plastic is generated in Germany each year (an amount equal to 7 % of all household waste). 50 % of this is simply thrown away and not recycled. As the space for landfills is quite limited, the disposal of this plastic creates considerable problems, the more so since the amount of plastic waste is expected to grow even more in future. Environmental experts estimate that the amount of plastic waste committed to landfills every year is worth several billion dollars in unused resources. The industrialised nations are working on a legal framework for plastic recycling that will require ⅔ of all plastic waste to be recycled.
Plastic recycling	Many methods for recycling plastic are still in the pilot phase and often suffer from the fact that the facilities are not yet economically viable. The following is a survey of the most important methods.
– Physical recycling	The plastics are reprocessed mechanically; their structure is not altered through chemical treatment. The waste plastic is sorted by type, cleaned and re-milled. The quality of the recycled plastic depends to a great extent on how thoroughly the different types are segregated. The proportion of "alien" plastics in the recycled product vitiates its characteristic properties (strength, colour, surface texture, resistance to temperature and light, etc.). Amenability to recycling depends crucially on the type of plastic.
Thermoplastics	Since they are not adversely affected by heat, thermoplastics can be melted down and reprocessed. Problems may arise because thermoplastics with quite different melting points (e.g. PE and PVC) are difficult, if not impossible, to process together. Thus, after milling and cleaning, the waste plastic is physically segregated by density.
Duroplastics	Duroplastics cannot be thermally remoulded and reprocessed. Instead they are finely ground and used as fillers in the production of new duroplastics.
Elastomers	Physical recycling of elastomers is of minor importance only. Elastomers are recycled in granular form for use in the construction of sports tracks, the manufacture of floor coverings and for insulation purposes.
– Chemical recycling	Chemical recycling means using chemical processes to break down plastic waste into its original components (monomers). These components are then recombined to produce new plastics. The various methods of chemical recycling are still in the pilot phase. Large-scale chemical facilities would be required to make this form of recycling economically viable.
Hydrogenation	This involves the processing of unsorted comminuted plastic waste. The plastic is exposed to hydrogen under extremely high pressure (up to 400 times normal pressure) at a temperature of up to 500 °C in a hydrogenation reactor. This breaks down the polymers. The cracking products can be used as raw materials for the chemical industry.

Pyrolysis	In the context of plastics recycling, pyrolysis means the thermal decomposition of plastic waste. The plastic is broken down in a reactor into its constituent parts (monomers) at temperatures of over 700 °C. The resulting monomers, in the form of either gases or oils, are used to sustain the pyrolysis process itself, as fuels, or for the production of new plastics or other petrochemicals. The pyrolysis method is both technically complicated and very expensive.
Alcoholysis/ methanolysis	Plastics that are soluble in alcohol or methanol are dissolved in these liquids and partly broken down in a thermal process. The plastic is then cleansed, resulting in raw materials of high purity. PET (polyethyleneterephthalate) bottles, for instance, are dissolved in methanol.
Glycolysis	Polyesters, polyamides and polyurethanes can be thermally cracked with the addition of glycol to break them down into their constituents, which are then re-synthesised into new plastics.
Hydrolysis	Some plastic waste can be broken down by exposure to superheated steam in the presence of a catalyst in a process reactor.
Plastic waste in steel-making	Plastics can partially replace the oil used as a reducing agent in blast furnaces for smelting iron ore into pig iron.
– Thermal or calorific recycling	In this method, plastic waste is used as a substitute for oil, natural gas or coal to fire combustion facilities. As a rule, 1 ton of plastic yields the calorific equivalent of about 250 litres of fuel oil. Although re-use through incineration is the lowest-quality form of recycling, it is technically and economically viable and the plastic waste does not have to be cleaned or sorted beforehand.

Machinery breakdown insurance

- If plastic components or cables are subjected to high temperatures they can give off corrosive fumes without a fire actually breaking out. This can result in damage to machinery and machine components.
- Owing to their superior characteristics, many special plastic components are already used in place of metal alloys in motors and plant equipment and not, as in the past, just for expendable parts.

Fire insurance

Experience in fighting fires involving plastics – rapid spread of fire, large amounts of smoke and soot generated, high temperatures, toxic and corrosive fumes – has shown that, even only a short time after such fires have broken out, firemen cannot get them under control.

Special attention must therefore be paid to preventing such fires in the first place. This means taking the necessary fire-prevention measures at the

- structural,
- engineering, and
- organisational level.

Marine/goods-in-transit insurance

The difficulties faced by Marine insurers in assessing the risk posed by plastics are exacerbated by the broad range of applications, from cheap mass-produced goods to expensive, specially tailored high-tech components.

Apart from the wide product range, other aspects worthy of attention are the diverse forms plastics may take (powder, granulate, foil, sheets, preforms, etc.), the method of packing for transportation purposes, susceptibility to vibration, moisture and other climatic influences during transport and temporary storage.

Liability insurance

Fires involving plastic are dangerous not only in that they can cause bodily injury, property damage and financial loss in the surrounding area, but also because of the potential for polluting the environment with contaminated firefighting water (third-party fire).

In the plastics production and processing industry in Germany, many of the facilities used are subject to stringent liability under the Environmental Liability Act, while others are subject to approval/licensing requirements under the Federal Pollution Control Act.

As plastics are used in all walks of life, all sorts of claims are possible under Product Liability policies, from bodily injury and property damage to loss series, e.g. through a defect in a mass-produced plastic. Thus, unpredictable losses could occur at any time and even extend beyond national boundaries.

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