

Guidance on the environmental impact of large-scale fires involving plastics materials

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Committees responsible for this British Standard

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- Association of Building Component Manufacturers
- British Cables Association
- British Electrical Systems Association
- British Plastics Federation
- British Railways Board
- Building Research Establishment
- Electrical and Electronic Insulation Association (BEAMA Ltd.)
- Electricity Association
- ERA Technology Ltd.
- GAMBICA
- Home Office
- Lighting Industry Federation Ltd.
- MOD — UK Defence Standardization
- National Supervising Inspectorate
- RAPRA Technology Ltd.
- University of Ulster
- Warrington Fire Research Centre

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Foreword

This British Standard has been prepared by Technical Committee PRI/26.

This British Standard provides information, guidance and recommendations. It should not be quoted as though it were a specification and particular care should be taken to ensure that all claims of compliance are not misleading.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 37 and a back cover.

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Introduction

A number of incidents at plastics storage sites involving hundreds of tonnes of plastics have focused the attention of the public on the consequences and the safety issues resulting from storing plastics materials and products. This British Standard aims to complement the Home Office document on the fire safety of tyre storage sites [1]; much of this guidance may also be applicable to certain plastics storage sites.

In addition to providing information and guidance on the burning of plastics and the environmental impact zones following a major fire, this standard lists and briefly reviews the relevant legislation, regulations and guidelines that apply to such situations. An important and far-reaching example of such legislation is the EU Directive 96/82/EC [2], commonly referred to as the “Seveso II” Directive.

Directive 96/82/EC [2] was implemented in the United Kingdom as The Control of Major Accident Hazards Regulations 1999 (COMAH) [3]. It aims to minimize the consequences to people and the environment where accidents have occurred. COMAH applies to a wide range of activities including the storage, use and manufacture of large quantities of dangerous substances. It should be noted that these regulations do not apply directly to plastics since plastics are not considered to be dangerous substances per se. It is possible, however, that burning plastics might release potentially dangerous substances and the application of COMAH represents a cautious approach in such cases. Most importantly, COMAH emphasizes the need for site operators to assess the risks of incidents and also their consequences for people and the environment. The competent Government authority for COMAH lies jointly with the Department of Environment, Food and Rural Affairs (DEFRA) and the Health and Safety Executive (HSE).

1 Scope

This British Standard gives guidance to site operators, emergency planners and local authorities on the likely environmental impact of large-scale fires involving significant quantities of stored plastics. This includes:

- a) stocks of plastics raw materials stored prior to or during manufacture;
- b) stocks of fabricated articles stored after manufacture;
- c) stocks of articles for sale, e.g. in warehouses;
- d) stocks of articles awaiting recycling.

The environmental impact of effluents from incinerators and power stations is not included.

Rubber tyres are not within the scope of this standard as they are the subject of separate guidance issued by the Home Office [1].

NOTE 1 Stocks of finished plastics and rubber articles at point of sale (e.g. garden centres) that contain very large quantities of plastics form a further category. This category is different from the four cited in 1a) to 1d) because large numbers of people can often be involved. A major plastics fire in a confined area, such as on a ship, forms yet another category.

NOTE 2 Whilst rubbers and rubber products are not covered in this standard, much of the guidance may be applied to them as well as to plastics. There are many similarities in chemical composition between thermoplastic elastomers and more rigid thermoplastics and the fire effluents from the two families of products are similar. Much of the guidance issued by the Home Office [1] for the storage of rubber tyres may be used as an example of how to manage large stocks of plastic products.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS EN 2:1992, *Classification of fires*.

BS ISO 472, *Plastics — Vocabulary*.

BS EN ISO 13943, *Fire safety — Vocabulary*.

BS 5839-1:1988, *Fire detection and alarm systems for buildings — Part 1: Code of Practice for system design, installation and servicing*.

BS 5306-2:1990, *Fire extinguishing installations and equipment on premises — Part 2: Specification for sprinkler systems*.

BS EN ISO 1043-1, *Plastics — Symbols and abbreviated terms — Basic polymers and their special characteristics*.

3 Terms, definitions, symbols and abbreviations

For the purposes of this British Standard, the terms and definitions given in BS EN ISO 1043-1 and the following apply.

3.1

additive

substance added to polymers to improve or modify one or more properties
[BS ISO 472]

3.2

asphyxiant gas

gas that incapacitates victims by starving the body of oxygen, resulting in impairment of the nervous and cardiovascular systems causing loss of consciousness and ultimately death

3.3

environment

surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation

3.4

environmental impact

any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services

3.5

establishment

building or premises under the control of an operator where plastic or rubber materials are present in one or more installations, including common or related infrastructure or activities

NOTE This definition has been adapted from that of "establishment" in EU Council Directive 96/82/EC [2].

3.6

"exotic" organic compounds

organic compounds that may be toxic at very low concentrations, such as certain polychloro- and polybromo-dibenzodioxins/furans and organophosphates

3.7

filler

relatively inert solid material added to a plastic to modify its strength, permanence, working properties or other qualities, or to lower costs
[BS ISO 472]

3.8

fire effluent

totality of gases and/or aerosols (including suspended particles) created by combustion or pyrolysis
[BS EN ISO 13943]

3.9

foamed plastic

cellular plastic

plastic in which the density is reduced by the presence of numerous small cavities (cells), interconnecting or not, dispersed throughout the mass

NOTE A foamed plastic often is called simply a foam. Rigid foams normally have a closed-cell structure whilst flexible foams have an open-cell (interconnecting) structure.

3.10**hazard**

intrinsic property of a plastic or rubber material or physical situation, with a potential for creating damage to human health and/or the environment

NOTE This definition has been adapted from that of “hazard” in EU Council Directive 96/82/EC.

3.11**installation**

technical unit within an establishment, in which plastic or rubber materials are produced, used, handled or stored

NOTE 1 This includes all the equipment, structures, pipe work, machinery, tools, private railway sidings, docks, unloading quays serving the installation, jetties, warehouses or similar structures, floating or otherwise, necessary for the operation of the installation.

NOTE 2 This definition has been adapted from that of “installation” in EU Council Directive 96/82/EC.

3.12**irritant**

effluent that causes immediate painful sensory stimulation of the eyes, nose, throat and lungs, resulting in behavioural incapacitation and impairment of breathing

NOTE Irritants can cause inflammatory lung reactions and oedema which also result in impairment of respiration and may ultimately prove fatal several hours, or even days, after removal from a fire atmosphere.

3.13**major accident**

major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment, and leading to serious danger to human health and/or the environment, immediate or delayed, inside or outside the establishment, and involving dangerous material

NOTE This definition is taken from that of “major accident” in EU Council Directive 96/82/EC.

3.14**MEL**

maximum exposure limit

3.15**operator**

individual or corporate body who owns or operates an establishment or installation or, if provided for by national legislation, has been given decisive economic power in the technical operation thereof

NOTE This definition is taken from that of “operator” in EU Council Directive 96/82/EC.

3.16**OES**

occupational exposure standard

3.17**plastic**

material which contains as an essential ingredient a polymer of high molecular weight and which at some stage in its processing into finished products can be shaped by flow

NOTE Thermoplastic elastomeric materials, flexible polyurethane foams and coated fabrics are included for the purposes of this document.

3.18**PM₁₀**

a mass median aerodynamic diameter of 10 micrometres or less

3.19**pyrolysis**

that part of the irreversible chemical decomposition caused solely by a rise in temperature
[BS EN ISO 13943]

3.20**risk**

likelihood of a specific effect occurring within a specified period or in specified circumstances

NOTE This definition is taken from that of “risk” in EU Council Directive 96/82/EC.

3.21**storage**

presence of a quantity of plastic or rubber materials for the purposes of warehousing, depositing in safe custody or keeping in stock

NOTE This definition has been adapted from that of “storage” in EU Council Directive 96/82/EC.

3.22**thermoplastic**, noun

plastics material capable of being softened repeatedly by heating and hardened by cooling through a temperature range characteristic of the plastic and, in the softened state, of being shaped by flow repeatedly into articles by moulding, extrusion or forming
[BS ISO 472]

3.23**thermoset plastic**

plastics material that has been cured by heat or by other means such as radiation, catalysts, into a substantially infusible and insoluble state
[BS ISO 472]

3.24**LC₅₀**

term used to denote the concentration of material or fire effluent that causes death in 50 % of an exposed animal population in a given time

3.25**dioxins/furans**

abbreviated terms for certain polychloro- and polybromo-dibenzodioxins and dibenzofurans

4 Plastics and fire

The use of plastics in our modern society increased over thirty-fold between 1970 and 2000. Plastics, or synthetic polymers, are chemically similar to natural polymers such as wood, paper, cotton and wool. These are all composed largely of carbon, hydrogen and oxygen, and so can burn. Although their combustibility characteristics are similar, special precautions are required where large concentrations of plastics products become involved in a fire.

The thirteen types of plastics covered in this British Standard are the materials most likely to be encountered. All plastics can be divided into two categories: melting, or thermoplastic, and non-melting, or thermoset.

As heat is applied to thermoplastic products there is deformation followed by shrinkage, melting and finally combustion of vaporized material. The melting point for most thermoplastics is in the range 75 °C to 250 °C. Cooling of the molten masses can result in the formation of a bridge or shell covering a hot pool of molten, smouldering and/or flaming plastic. Thorough and prolonged cooling with a water fog is recommended. In the case of cellular plastics (e.g. those used in insulation and packaging) breaking up clumps and using hoses is recommended.

As heat is applied to thermoset materials there is no deformation, shrinking or melting but decomposition of the plastic takes place and the material once ignited burns.

Plastics require higher temperatures than natural polymers before they will ignite. Flash ignition temperatures of natural polymers are in the range 250 °C to 270 °C, whereas those for synthetic polymers are normally in the range 310 °C to 540 °C. However, once ignited, plastics can burn fiercely and can generate large quantities of smoke. The amount of smoke depends not only on the material but also on its shape, the ventilation, size of fire, and the presence of other materials.

Since most burning plastics generate toxic gases during combustion, wearing self-contained breathing apparatus before entering the scene of a fire is strongly recommended. Smouldering materials generate carbon monoxide, an odourless, colourless and tasteless gas, and this may present a hazard in premises even after the major part of the fire has been extinguished.

In this guide the major products of combustion are not listed in order of significance and there will be many other products of combustion in minor quantities. Those listed are known to be generated in quantities and/or concentrations that may be harmful.

Pre-planning to determine where large stocks of plastics are stored is recommended, since it can help ensure that any action taken in the event of a fire minimizes negative environmental impact.

Although this British Standard deals principally with the effects of plastics fires, such fires often involve the collateral burning of building elements. This can result, in particular, in the release of fibrous materials used in roofing and insulation products. In the case of older buildings, asbestos can be released and both individual fibres and larger lumps can be deposited over a wide area.

5 Overview of relevant legislation and guidance documents

The many detailed regulations and directives together with guidance documents from Government departments and agencies are summarized in Annex A.

6 Introduction to fires

6.1 Classification of fires according to BS EN 2:1992

BS EN 2:1992 classifies fires into four categories defined in terms of the nature of the fuel:

- Class A fires involving solid materials, usually of an organic nature, in which combustion normally takes place with the formation of glowing embers;
- Class B fires involving liquids or liquefiable solids;
- Class C fires involving gases;
- Class D fires involving metals.

NOTE Fires involving plastic materials are typically Class A fires, though if the fire results in runoff of melted plastics, these fires may be classified as Class B.

6.2 Flammability principles

The science of fire protection [4] rests upon the following principle: an *oxidizing agent*, a *combustible material* and an *ignition source* are essential for combustion. In the context of this British Standard:

- the combustible material is a plastics material and the oxidizing agent is the oxygen of the air;
- the combustible material has to be heated to its ignition temperature before it can be ignited or support flame spread;
- subsequent burning of a combustible material is governed by the heat feedback from the flames to the pyrolysing or vaporizing material.

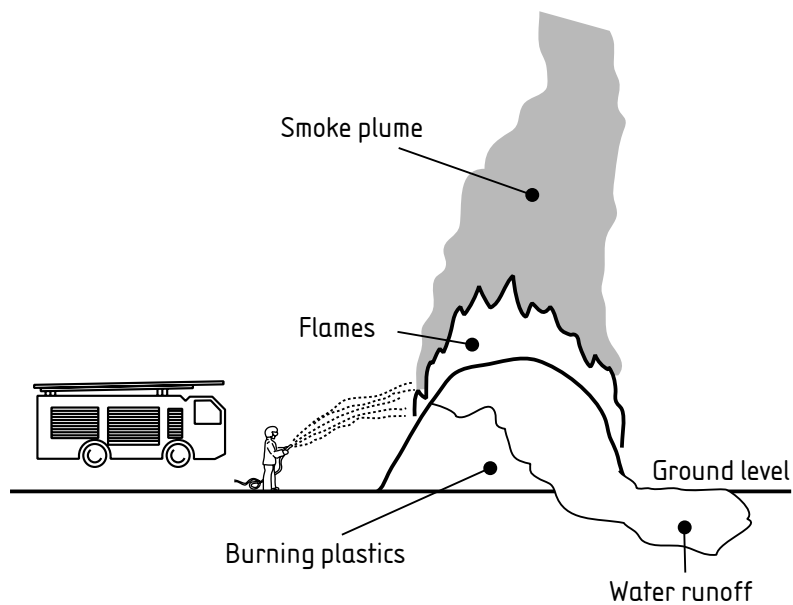
The burning rate of large fires is principally governed by the radiant heat transfer from the flames to the pyrolysing fuel surface. Burning will continue until any of the following occurs:

- a) the combustible material is consumed;
- b) the oxidizing agent concentration is lowered to below that necessary to support combustion;
- c) sufficient heat is removed or prevented from reaching combustible material to prevent further fuel pyrolysis; and
- d) the flames are chemically inhibited or sufficiently cooled to prevent further reaction.

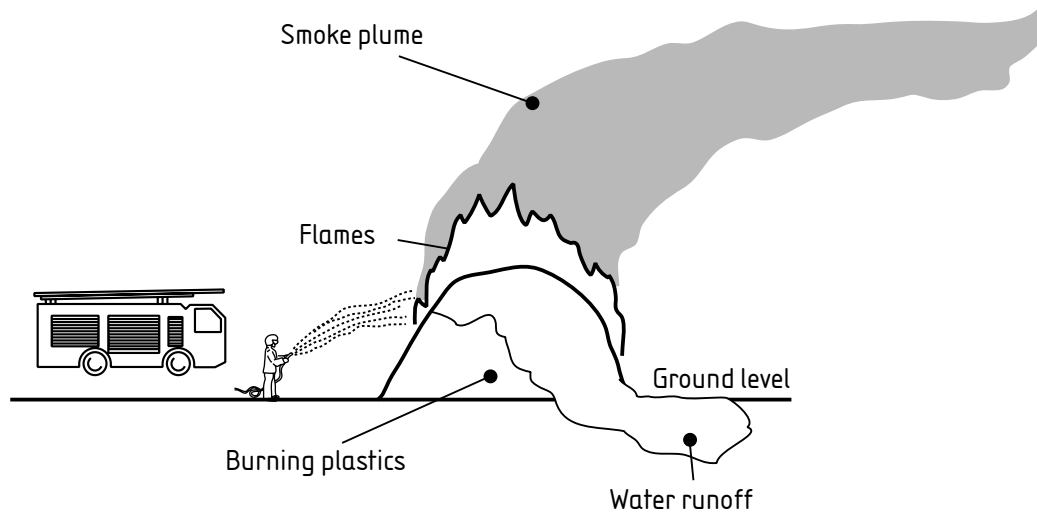
6.3 Possible environmental impacts

Figure 1 and Figure 2 are schematic representations of possible environmental effects in the open and in enclosures.

The fire-water from fire-fighters' hoses can threaten natural waterways as well as drains and sewers.

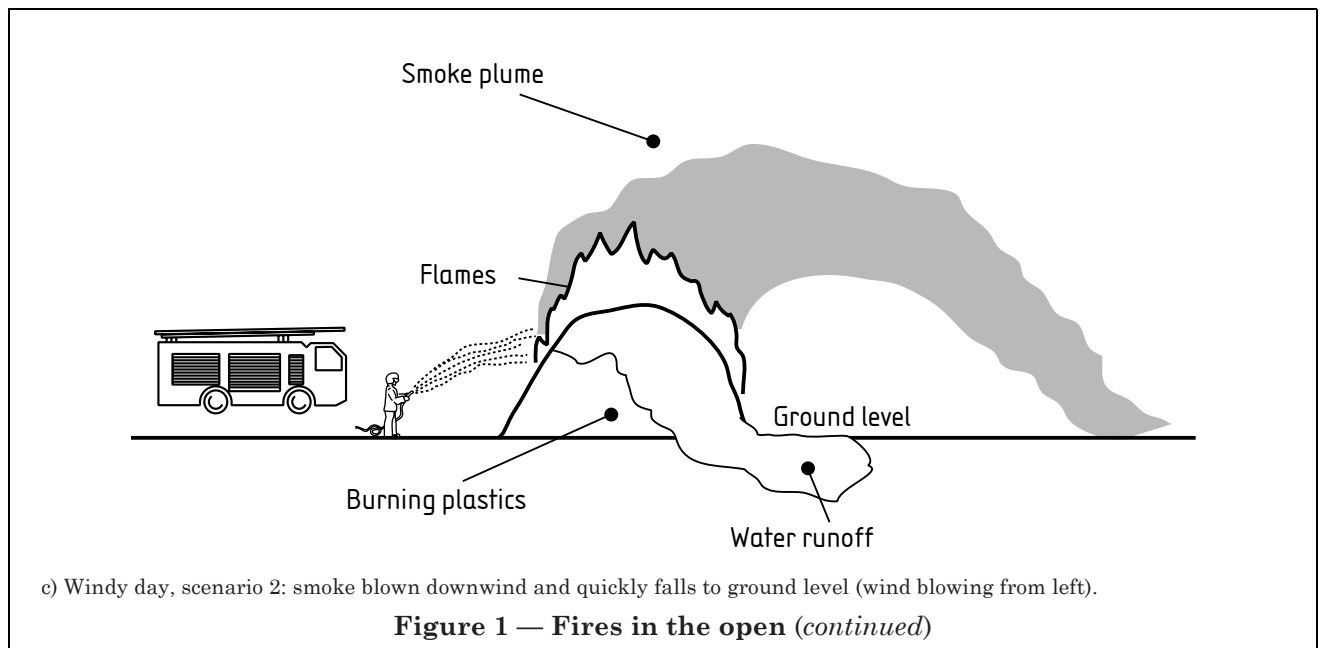


a) No wind: smoke travels mainly vertically, unaffected by wind.



b) Windy day, scenario 1: smoke blown by wind downstream with little settling near fire (wind blowing from left).

Figure 1 — Fires in the open



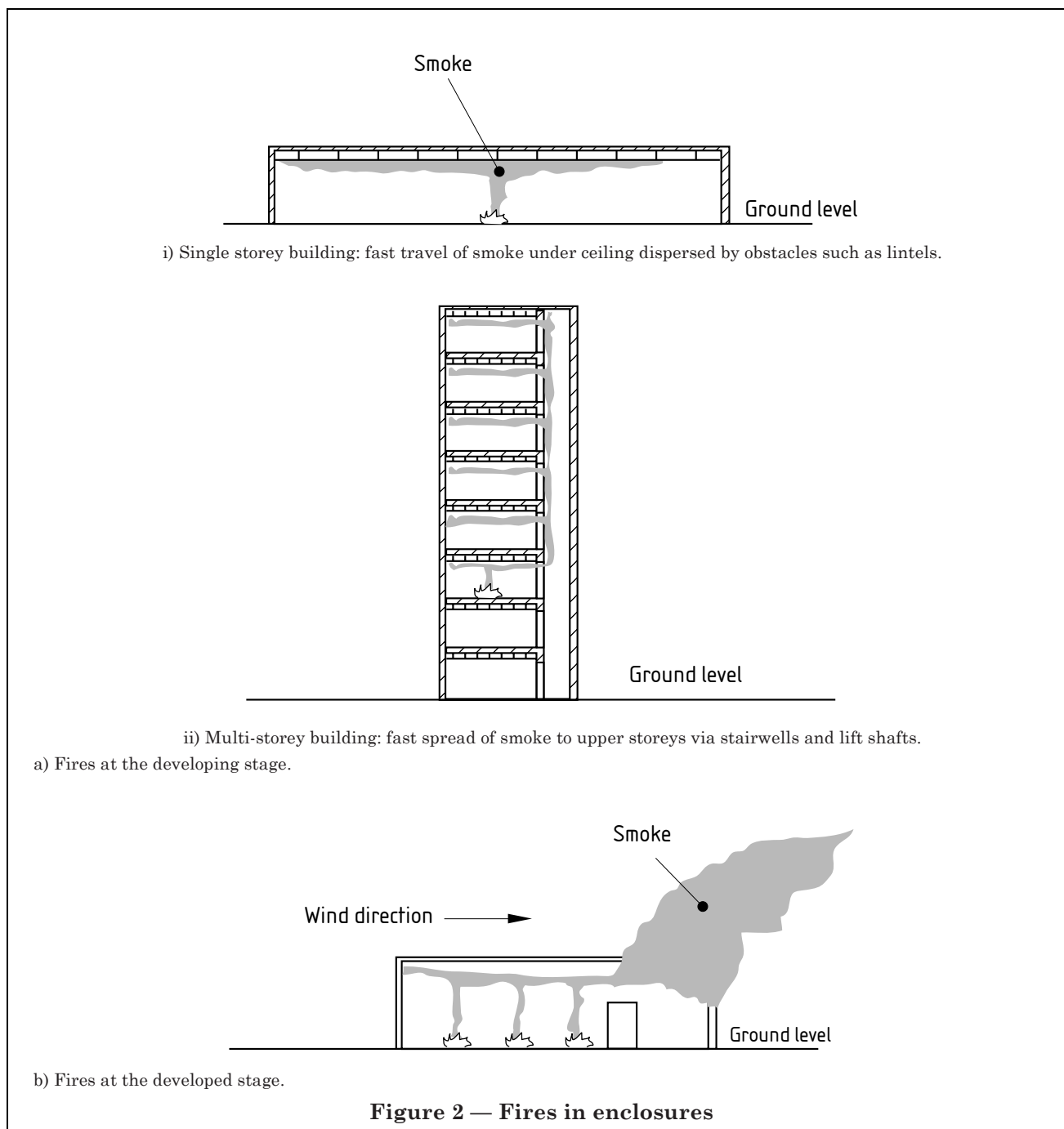


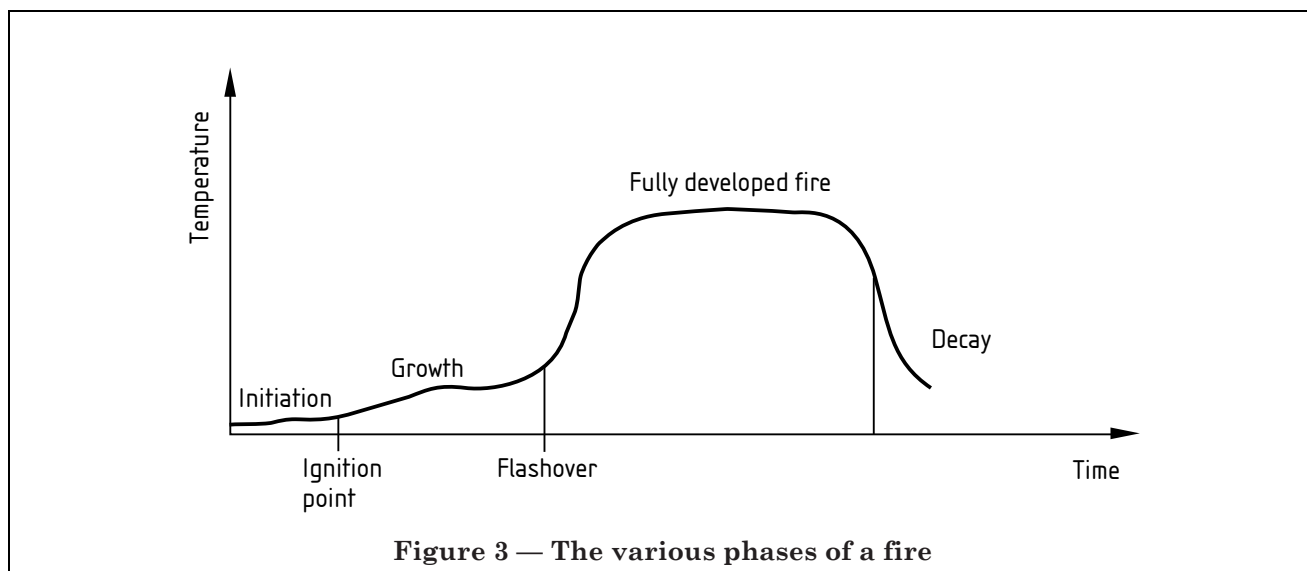
Figure 2 depicts structures such as large buildings, tunnels, ships, shopping malls and sports stadiums. A fully developed fire in a building with the smoke plume escaping to the atmosphere [Figure 2b)] will result in a scenario as shown in Figure 1b). Smoke scenarios as shown in Figure 1a) or Figure 1c) are also possible, with decomposition of the combustible material.

6.4 Fire development in enclosures

6.4.1 General

Large-scale fires are complex events and are the focus of current fire research. Their behaviour depends on many parameters, which include the level of ventilation, fire load, structure of the building and the burning properties of the combustible materials.

The various phases of a fire are summarized in Figure 3. This figure depicts a fire development that assumes no involvement of fire-fighters or the presence of active fire protection systems such as sprinklers.



6.4.2 Phase 1 — Initiation and early growth

The combustible plastics material is heated by an ignition source (e.g. cigarette, burning paper in a waste basket). The ignition source is able to generate enough heat to start the decomposition of the adjacent combustible materials.

NOTE The critical parameter for this phase is the ease of ignition.

6.4.3 Phase 2 — Fire growth

As adjacent material is ignited, flames spread and the temperature rises. The surrounding combustible materials (e.g. stacks of plastics materials) become hot enough to decompose and give off flammable gases. If these ignite, there can be a “flashover” and the rate of flame spread can increase dramatically. The fire in the original compartment is then out of control.

NOTE The important parameters for this phase are the rate of heat release, rate of smoke generation and flame spread.

6.4.4 Phase 3 — Fully developed fire

During this phase, all of the combustible materials within the fire compartment are burning. In addition, this is the stage at which the fire can spread to adjacent rooms or other buildings.

The important parameters for this phase are the fire resistance and structural characteristics of the fire compartment, the heat released and the smoke and toxic gases generated.

6.4.5 Phase 4 — Decay

During the decay stage, the fire is exhausting its supply of combustible materials and/or oxygen. In the case of oxygen depletion, the fire may appear to have burnt out. However, smouldering combustion can continue and, if the full oxygen concentration is restored, combustion may be restored in an explosive manner. This is known as “back draught”. The time-scales of events during the various phases of a fire are shown in Table 1.

Table 1 — Time-scales of events during the various phases of a fire

Event	Time-scale
Fire alarm	On discovery
Evacuation time	Minutes
Firefighting time	Hours
Post-fire clear up time	Days
Environmental monitoring	Months