Science and Justice 50 (2010) 187–191

Contents lists available at ScienceDirect

Science and Justice

journal homepage: www.elsevier.com/locate/scijus

“Flashburning” — Interpreting the presence of heat damage to a suspect's clothing and footwear in the investigation of fires

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ARTICLE INFO

Article history:
Received 22 February 2010
Received in revised form 1 June 2010
Accepted 2 June 2010

Keywords:
Flashburning
Vapour
Ignition
Heat
Damage
Clothing

ABSTRACT

When volatile flammable vapours are released, they can mix with surrounding air and form a vapour cloud. Ignition of this fuel/air mixture will produce a flame front that will flash through the vapour. Items exposed to the flame front, including a suspect's clothing and footwear, may sustain superficial heat damage. At The Forensic Science Service Ltd this is referred to as *flashburning*. This paper describes the concept of flashburning, the laboratory methodology used to identify it and how an assessment on the overall distribution of that damage may allow a scientist to evaluate its evidential significance. Two anonymised casework examples are used to demonstrate how this information has been interpreted and used in evidence in United Kingdom courts of law.

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1. Introduction

The task of a scientist in the criminal investigation of fires within the parameters of forensic science is twofold; first, the practitioner must determine the origin and cause of the fire and second they will also be asked whenever possible to determine whether or not the physical evidence supports a link between a suspect and a scene.

Volatile flammable liquids, such as petrol (probably the most commonly encountered flammable liquid used as an accelerant in the United Kingdom), are often used to assist the development of deliberately started fires. Finding flammable liquid residues on a suspect's clothing and footwear may provide some primary evidence supporting allegations of involvement with a flammable liquid-accelerated fire. The presence of visible and microscopic damage on those garments and footwear can provide evidence that the suspect was close to a heat source, while the appearance and distribution of this damage may indicate that the wearer was in close proximity to the ignition of vapour from a volatile flammable liquid.

2. Flashburning

When a volatile flammable liquid such as petrol is poured onto a surface and it starts to evaporate, the vapour can mix with the surrounding air and form a cloud above the liquid. If the concentration of that vapour in air falls between the upper and lower flammability limits [1], then an ignition source, either a spark or a flame, introduced into the mixture will produce a flame front that will flash through that vapour cloud (Figs. 1 and 2).

Ventilation effects and convective air currents may affect the mixing process and any subsequent movement or flow of the vapour cloud. Ignition of a large volume of this vapour/air mixture within a confined space can often result in a dispersed phase explosion [2]. (Dispersed phase explosions and the ignition of flammable gases are outside the scope of this paper and are therefore not discussed further here.)

Items exposed to the flame front, including clothing and footwear worn by a suspect, may sustain directional heat damage that will depend on the orientation of the garments and footwear to the approaching flame front [3,4]. The extent of this damage will be determined by the amount of flammable vapour present, the susceptibility of the fibres or fabrics in question to heat damage (i.e. their physical properties such as melting points, thermal capacities and conformation), and the duration of the contact between the flame front and the material in question. In some cases, when there has been prolonged exposure to flame the damage can be gross and obvious to the naked eye (Fig. 3). However, in many cases, the contact is only transient due to the rapid propagation of the flame front, and the subsequent heat damage is therefore only superficial. In our laboratory this latter type of damage is referred to as *flashburning*, and such damage has to be searched for using low power microscopy. The expertise is not so much in identifying and locating the burning damage, but interpreting what it all means when due consideration is given to the specific scenario of an individual case.

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doi:10.1016/j.scijus.2010.06.002

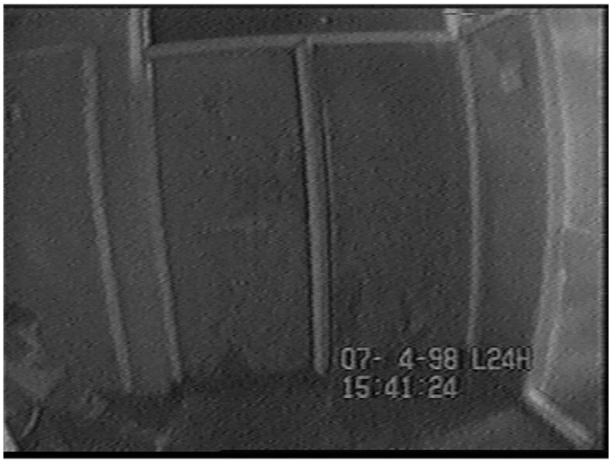

Fig. 1. Suspect attempts to ignite a pool of petrol that had been poured outside a front door.

3. Different types of fibres and their susceptibility to heat

Modern garments and footwear comprise both natural and synthetic fabrics and fibres; some of those commonly encountered together with the temperatures at which they become affected by heat and the nature of this effect [5,6] include the following:

(i) cotton scorches at approximately 150 °C
(ii) wool starts to decompose at around 130 °C
(iii) leather decomposes at 160–165 °C
(iv) acrylics begin to stick at 204–254 °C and melt at higher temperatures
(v) nylon 6 melts at approximately 215 °C
(vi) polyester melts at 249–290 °C
(vii) rayon decomposes at 150–204 °C
(viii) natural/synthetic mix such as cotton and polyester.

Each of the different fibre or fabric types have different thermal properties and will behave differently when subjected to intense heat, such as from the brief contact with a flash of flame. Mixed fibre fabrics will exhibit the thermal degrading characteristics of their individual component fibres although if different types of thread are used for the warp and weft the overall damage may have an anisotropic appearance.

Fig. 2. Petrol vapour above the pooled liquid is ignited and a flame front rapidly flashes across the vapour cloud.

Fig. 3. Gross heat damage to the lining along the hem of a jacket.

Natural fibres, such as cotton and wool, will burn and become singed, or charred, often giving the ends of their fibres a brown to black appearance (Fig. 4).

Different synthetic fibres have varying melting temperatures but will all generally melt when subjected to sufficient heat giving the ends of their fibres a beaded appearance (Fig. 5). The small molten beads on the ends of the affected fibres are sometimes referred to as "nubs" [7].

Leather is more resilient to heat than cotton and many synthetic fabrics. As a result it changes little in appearance unless it has been subjected to prolonged contact with intense heat, and is therefore unlikely to show obvious signs of heat damage (although lines of stitching on a leather garment may still sustain heat damage). However, after lengthy exposure to heat, leather may appear shrunken, discoloured and feel hardened to the touch (Fig. 6). This physical change is a gradual process, which may start at a temperature as low as 140 °C and become more pronounced at above 175 °C [8].

4. Heat damage caused by legitimate processes

The following list is only a number of common examples, and is by no means exhaustive:

(i) *Manufacturer's finish.* Textile and footwear manufacturers employ different heat-finishing processes [6], including thermal cutting and calendaring, during the production of textile fabrics and shoes. These heat finishes can, and often do, appear similar to heat damage caused by flammable vapour ignition.

Fig. 4. Singed/charred cotton fibres.

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