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Mechanical and electrical failures leading to major fires

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Abstract

Major fires cause very large financial losses every year and determination of their cause is important from the point of view of insurance and also to attempt to avoid future occurrences from the same cause. While arson, natural effects such as lightening strikes, hurricanes and earthquakes, and human carelessness contribute significantly to fire losses, many fires are caused as a result of electrical and mechanical failures and malfunctions. The authors describe a number of cases in which mechanical and electrical failures have been the initiating causes. The cases include one where fracture of a structure occurred as a result of poor design and construction, leading to discharge of flammable liquid that was ignited from a build-up of static electric charge; a refinery fire caused by the presence of hidden defects that propagated under transient loading conditions, and cases where vehicle fires occurred as a result of poor design or construction of electrical circuits, or from electrical discharges.

Keywords: Fires; Friction; Static electricity; Electrical shorts; Refinery

1. Introduction

Fires lead to many losses and insurance claims every year. The causes of fires are varied, including lightening strikes, arson, careless disposal of matches or cigarettes, spilling of flammable liquids, failures of electrical or mechanical components, and reactions between process chemicals.

For a fire to occur three ingredients are essential, namely fuel, oxygen and heat, providing the well-known fire triangle shown in Fig. 1. Fuel is an obvious requirement, while there must be a sufficient supply of oxygen for the fire to continue. If the oxygen supply is used up, the fire will be extinguished. If the supply of oxygen is limited, e.g., if the air must enter the region where the fire is in progress through a small opening, then the rate of burning will be low and the combustion may be incomplete. Heat is necessary both to cause ignition and also to sustain the fire. For example, liquids and solids burn because of gases that are produced from them: these in turn react with the surrounding air. Hence, if the dissipation of heat from the region of the fire is too great, the solids or liquids will cool down, the release of vapour will be reduced, the rate of combustion will

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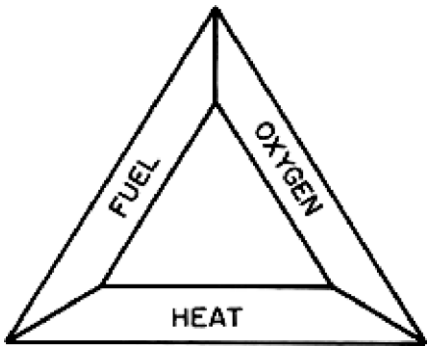

Fig. 1. The fire triangle, showing the three essential components for a fire to occur.

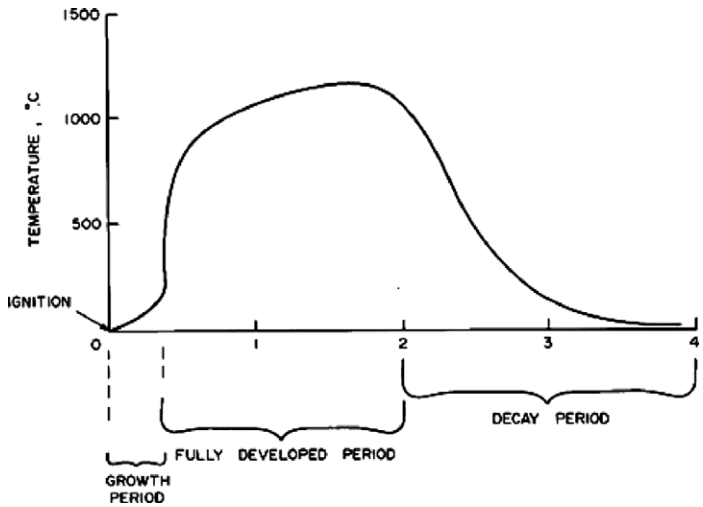

Fig. 2. The variation of temperature with time in a typical house fire. The three stages following ignition are shown.

decrease and the fire may be extinguished. Although obvious, these points are key ones to be remembered in determining the sequence of events during a fire when it is being investigated at a later date.

Investigative work relating to fires may involve evaluation of fire cause and origin, assessment of resulting damage, and checking for compliance with codes and design standards. In reconstructing the sequence of events taking place during a fire the process is similar to other failure analyses involving complex structures, and the primary basis used is one of establishing a time sequence of events. The time scale may involve days, weeks or years for pre-fire events, while the increments may be in seconds, minutes or hours for events occurring during the fire. Specific events may be used as markers in the time sequence, such as the collapse of a roof or wall, or the time of arrival of an individual or of fire fighters, and observations made at that time.

The determination of an accurate sequence of events becomes particularly critical where arson is suspected, and the time sequence must document not only the progress of the fire, but all events leading up to it, including the movement of persons who may have been involved in setting the fire. In this connection, it is valuable to examine how a fire develops. This depends on the availability of the three essentials, fuel, oxygen and heat. If any one of these becomes scarce it becomes the rate determining process. An example of the time sequence of a fire is shown in Fig. 2 for the case of a house.

2. The investigative process

The steps involved in the investigation of a fire are site examination and the selection, examination and testing of samples, collection of background data, and reconstruction and analysis.