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Impact of jet fan ventilation systems on sprinkler activation

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ABSTRACT

Jet fans are increasingly preferred over traditional ducted systems as a means of ventilating pollutants from large spaces such as car parking buildings.

Outside of tunnel applications jet fans are considered to have limitations as means of smoke control. This is because their effectiveness is limited without side walls and they de-stratify the smoke layer. Jet fans can however, aid post-event in smoke clearance under the control of the attending fire brigade.

The prudent fire mode strategy in those jurisdictions where jet fans are not used for smoke control is for the ventilation system to shut down on a fire alarm signal.

The problem lies in the jet fans receiving that signal. A fire has three basic signatures; heat, smoke, and light.

Large car parking buildings may be sprinkler-protected. Sprinklers operate on the heat signature. A jet fan is assumed to disrupt this signature by forcing the plume of heat downstream and diluting that plume with cool air. This may delay sprinkler activation.

In terms of the smoke signature, the presence of pollutants such as carbon monoxide that could be detected by a specialised detector, are the same signals that would cause a jet fan to increase its flow in normal mode. The response to a smoke signature is contradictory between the desired normal-mode reaction to speed up and the fire-mode reaction to shut down.

This leaves light. Fires are very rich across the non-visible light spectra and flame detectors are an effective way to provide a fire signal independent of the normal-mode operation of the jet fans. However, the cost-benefit of installing flame detectors in addition to sprinklers is questionable.

A series of detailed computational analyses are therefore undertaken to quantify the impact of the jet fans on delaying sprinkler activation on a typical car park sprinkler arrangement. This article assumes the perspective of a jurisdiction where the fire mode strategy is for the fans to shut down. However, the sprinkler delay will also be of interest where the fire mode strategy is to continue operating.

Once sprinkler activation had occurred a fire signal is assumed to have been generated to shut down the jet fans. Separate evaluations can then be made as to whether the delay was acceptable or not, dependent upon to the specific building geometry.

The results indicate that for a fast-growing design fire, sprinkler activation occurred at ~180 s with the jet fans off and at ~210 s with them on: an increase of ⩽30 s. A separate analysis was undertaken for the case-specific egress safety margin. Comparing the two, it was concluded, that the impact of jet fans upon sprinkler activation was not significant. It

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was further established that the smoke disturbance due to the jet fan flow did not adversely affect the visibility for those escaping.

Introduction

This paper discusses a case study undertaken on an underground car park building of approximately 30,000 m^2. This paper focuses on the sprinkler delay which is typical of many geometric arrangements. The safety margin is building specific and is not presented here for the sake of brevity and to keep the case study general in application.

Contemporary research into car park fires

In 2010 BRE published a comprehensive research report titled 'Fire Spread in Car Parks' [1]. The overall aim of the project was to gather information on the nature of fires involving modern cars and to use this new knowledge as a basis, where necessary, for updating current guidance in Approved Document B [2].

The key findings from the study are:

- The number of fires in car parks each year is about 260 per year. This represents a very small percentage of all fires in the UK and the trend is downward.
- Of these fires in car parks, about 50% did not start in a car.
- Many car fires are deliberately lit.
- Most fires in car parks do not spread (to a car or another car).
- About seven people are injured in car park fires each year and there are very few fatalities; on average less than one per year.
- Fires in car parks for which the building is classified as 'car park' show an injury rate which is low compared with other occupancy types.
- Fires which spread to involve more than one car can sometimes result in significant structural damage.
- Despite concerns, there is very little evidence (and no substantiated evidence) to show that cars fuelled by LPG are a particular danger in fire.
- The experimental programme demonstrated that where a fire starts in a car which is well-ventilated (i.e. open windows), very fast growing and severe fires have resulted, leading readily (when sprinklers are not present) to fire spread to all nearby cars and potentially, all cars in the car parks.
- The experimental programme also demonstrated that where a fire starts in a car which is poorly-ventilated (i.e. closed windows), the fire may go out, and has demonstrated that fires in engine compartments will grow slowly.
- These results largely account for the very few car park fires which cause substantial or significant structural damage.
- The effectiveness of sprinklers in limiting a fire to a single car has been demonstrated.
- There are no cases to date in the UK of structural collapse of a car park due to fire.

Description of the system (normal-mode)

Ventilation of the case study car park is achieved through mechanical exhaust at each level with make-up air provided from natural ventilation openings in the perimeter and transported via impulse ventilation from jet fans.

The jet fans provide advantages through elimination of air distribution ductwork within the car parks and reduction of supply and exhaust air flow resistance, thereby reducing the associated fans energy consumption.

The normal-mode criteria is to ensure minimum airflow velocities are maintained throughout the car park areas and that a maximum carbon monoxide concentration is not exceeded. Carbon monoxide monitoring control systems are provided to vary the fan speeds.

Description of the system (fire-mode)

As described above, this article assumes shut down in fire mode. Under normal operation the jet fans increase air flows upon detection of carbon monoxide. Unfortunately, carbon monoxide is a common product of fire and so there are contradictory system objectives for the fan to both speed up and shut down.

Alternative methods of generating a fire signal to shut down the jet fans were considered.

- Heat sensing devices suffer from the same delay as the sprinklers since they operate on the same principle.
- Smoke sensing devices are not effective as in normal mode operation the jet fans activate at a threshold many times lower than would be expected in a fire and dilute concentrations.
- Light sensing devices along the fan line of sight will detect fires at an early stage. The UV ranges are not notably effective in smoky environments but the IR are effective.