



Car Park Ventilation (CPV)

Full scale live smoke tests

Impulse ventilation for smoke control



Full Scale 'Live' Smoke Tests

SUMMARY

Colt International and the Building Research Establishment (BRE) carried out a series of demonstrations in a simulated car park in Middlesborough that successfully demonstrated the effectiveness of smoke control using impulse fans. They also showed that conditions during the demonstrations were very similar to those predicted by the CFD modelling approach as used by Colt for system design.

The test rig was 35m x 30m x 3m. Ventilation was provided by two Colt Cyclone 100 fans. The fans were located to limit the smoke to one side of the test rig, keeping the other side substantially free of smoke.

A car shell contained a tray of diesel fuel which was ignited to give a 1MW fire size.

The aims were to show how an impulse fan system can be used to control the flow of smoke and to demonstrate the effectiveness of CFD to predict conditions in a car park fitted with an impulse ventilation system.

It was found that under design conditions the Colt Cyclones limited the flow of smoke as intended and that the conditions during the demonstrations were very similar to those predicted by CFD.



Cyclone fans controlled smoke flow CFD effectively predicted conditions

THE SETTING

Approved Document B 2000 edition (ADB) to the Building Regulations sets out recommended methods for ventilation of car parks in the event of fire. Three options are provided:

- Open sided car parks with ventilation openings equal to 5% of the floor area.
- Naturally ventilated car parks with ventilation openings equal to 2.5% of the floor area.
- Mechanically ventilated car parks with an extract rate of 10 air changes per hour (ACH).

Where car parks are underground they are invariably mechanically ventilated.

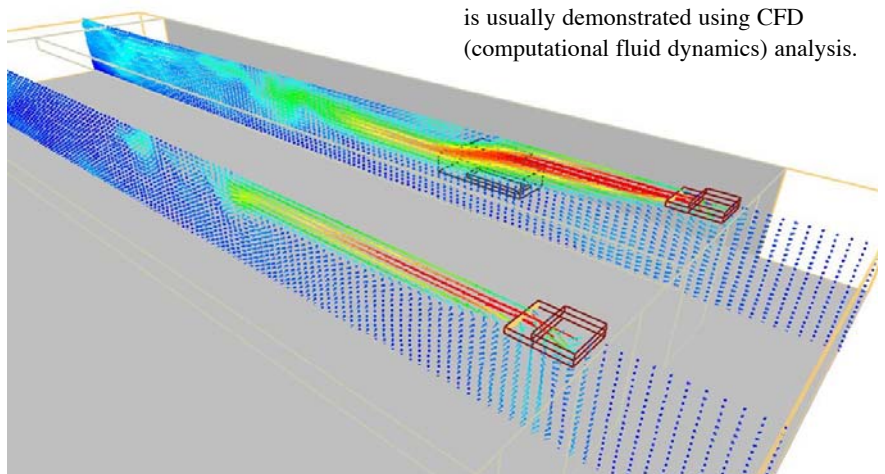
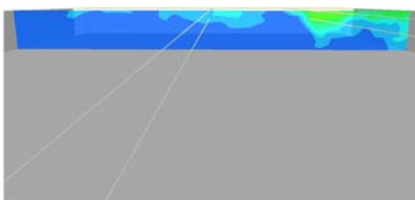
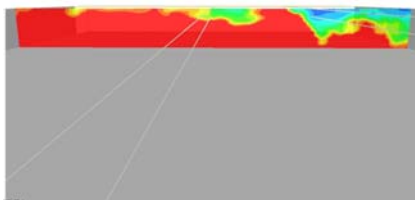
The ventilation system is also usually used to provide day to day ventilation for control of exhaust and petrol fumes in accordance with Approved Document F.

Mechanically ventilated car parks require a distributed ductwork system within the car park to ensure that there are no stagnant areas where smoke or petrol and exhaust fumes could collect. The ductwork is also required to extract equally from high and low level.

This ductwork is often difficult to design and install due to the restricted headroom in underground car parks and creates significant additional resistance for the extract fans to work against, increasing the power consumption and running costs for the ventilation system.

The impulse fan system was developed to replace the ductwork, the intent being to provide a system equivalent to the mechanical extract system described in ADB.

Impulse fans systems may also be used to control smoke and keep part of the car park smoke free during fire conditions. Such systems provide performance far in excess of Building Regulations requirements and are generally used either to avoid the use of sprinklers (in the limited circumstances when these are recommended) or as a compensating feature for excess travel distances. When used in this way it is critical that the system can restrict the spread of smoke to an agreed area and keep the remainder of the car park clear, either to allow clear access for fire fighters or to allow safe escape. The effectiveness of these systems is usually demonstrated using CFD (computational fluid dynamics) analysis.



Full Scale 'Live' Smoke Tests

OBJECTIVES

The specific objectives of the demonstrations were:

- to demonstrate the effectiveness of impulse fans in limiting the spread of smoke.
- to demonstrate the effectiveness of CFD (and in particular the FDS software used by Colt) in predicting the spread of smoke.

A team of engineers from BRE and Colt carried out a series of demonstrations during October and November 2005.

THE CAR PARK

Due to the difficulty of finding a suitable car park in which a real fire could be lit, a test rig was built to simulate a section of a car park. The rig was 35m long, 30m wide and 3m high. The rig was built from a frame of scaffold tubing with vertical supports at 2.4m centres. The frame was canvas covered. The area close to the fire was internally lined using fire board to protect the canvas. The discharge end of the rig was left fully open to allow air and smoke to escape and the inlet end was left 50% open.

Two 600mm deep downstands were built using timber and board to replicate the down stands typically found in basement car park ceilings. These ran along the length of the rig at 7.2m centres.

Since the rig was built in the open, wind baffles were arranged around the rig to minimise wind effects.

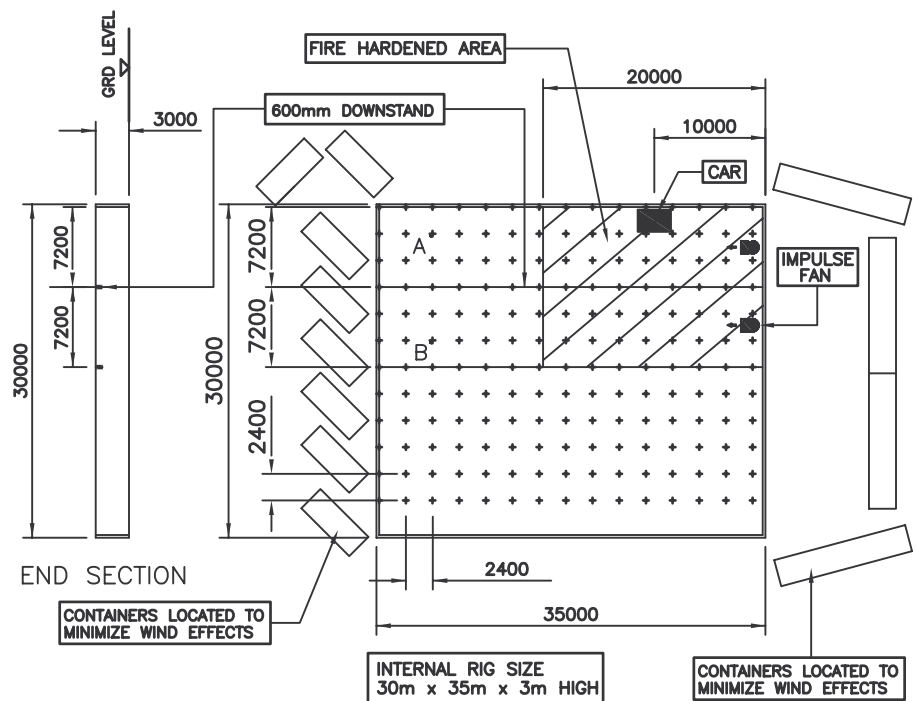
The fire was set adjacent to one side of the rig, using a diesel fuel tray fire inside a burnt out car body shell. This allowed a realistic fire with a controllable heat output. The fire was set to give a heat output of 1MW. The fire was set by the wall to imitate half a mirror image, replicating a 2MW fire in open space within the car park.

While 2MW is lower than the expected heat output from a car fire (a value of 4MW for a single car fire is suggested in the draft BS 7346-7 for car park smoke ventilation), it was selected to be large enough for a realistic demonstration and small enough to limit risk.



THE IMPULSE SYSTEM

Initial calculations indicated that the smoke from the 1MW fire could be suitably controlled using two Colt Cyclone 100 induction fans running at 80% full speed (and thus 64% thrust). These were located immediately at the inlet end of the rig in the centre of the bays formed by the downstands. They were supported immediately under the ceiling. The fan speed was set on site using an inverter.



INSTRUMENTATION

Since the purpose of the demonstration was to show the effectiveness of the impulse system it was not necessary to replicate the extract fan system that is usually used with the impulse system. Instead, smoke was allowed to spill by natural buoyancy from the open discharge end of the rig.

Since the purpose was to provide demonstration rather than full scientific validation (the FDS CFD model has been fully validated by others), limited instrumentation was provided.

Temperatures were recorded close to the fire for safety monitoring and at several locations downstream of the fire to provide ambient and smoke temperatures.

Air velocities were recorded in two locations downstream of the fire (A & B on the above layout) to provide smoke velocities and in the centre of the rig to record any wind effects.

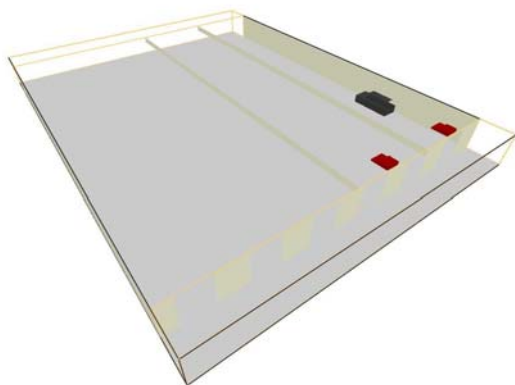
Fixed and roving video cameras were used to provide a record of smoke movement.

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THE CFD MODEL

Prior to the demonstration taking place a CFD model was constructed and run to predict the heat and smoke flows through the rig. The modelling followed normal Colt practice using the FDS (Fire Dynamics Simulator) CFD model from NIST (the National Institute of Science and Technology, in America).

The model simulated the size and layout of the rig but did not include any allowance for the effects of the vertical scaffold poles or the unusually rough ceiling and wall surfaces provided by the rig. These small scale effects could not be successfully modelled without use of a much finer grid resolution than would be normal for a car park model. It was anticipated that the effect of these omissions would be small.



PROCEDURE

The procedure was identical for all demonstrations.

The Cyclone fans were switched on at 80% full speed and the system left to stabilise for a minute or two. The fire was then lit and reached full heat output almost instantaneously. The fire continued to burn until the fuel was used up,

typically for between 3 and 10 minutes. Short duration fires were used for setting up purposes and a long duration fire for the final demonstration. The Cyclone fans were switched off once the smoke had cleared.

Some demonstrations were video recorded for later analysis.



RESULTS

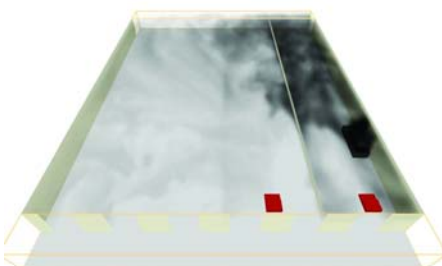
The table below shows time averaged smoke temperatures as recorded during the demonstrations and predicted by the CFD analysis.

Average smoke temperatures (°C)			
Time period from ignition	Location	Measured	CFD
210-310s	A, 1m above floor	23.4	25.8
210-310s	A, 2m above floor	25.9	30.0
210-310s	B, 1m above floor	22.0	20.7
210-310s	B, 2m above floor	25.8	25.3
210-310s	C, 1m above floor	22.6	22.1
210-310s	C, 2m above floor	32.1	30.2
Ambient		18.8-19.3	20.0

RESULTS *continued*

The illustrations show still video and CFD images showing the measured and predicted spread of smoke. In both the actual demonstrations and in the CFD analysis the smoke movement is dynamic and varies with time. It is thus unrealistic to take a set time into any demonstration and pick the images from these for comparison. The images chosen therefore represent qualitatively the typical conditions as indicated once the smoke flow had stabilised.

Following the tests BRE confirmed that “the smoke movement during the fire with the impulse fans running was substantially as predicted by the CFD modelling Colt had carried out before the tests”.



CONCLUSIONS AND RECOMMENDATIONS

The results of these demonstrations clearly indicated that impulse systems are capable of controlling the spread of smoke from a car fire and keeping significant areas of a car park effectively smoke free.

They also showed that CFD predictions, and in particular predictions by Colt using FDS, are capable of providing a realistic visualisation of the spread of smoke from a car fire.

Approving authorities may therefore accept suitable validated CFD analysis as proof of performance for an impulse system without the need for hot smoke tests on the completed system.

In some tests, adverse winds overcame the flow from the impulse system. While this is irrelevant for systems using mechanical exhaust systems in basement car parks it does confirm the expectation that impulse systems used to supplement natural ventilation in above ground car parks need to be designed to work with, and not against, wind conditions.

THE COLT PACKAGE

Colt can offer the complete package, including the design, supply and installation of:

CPV fans

Ductwork (extract)

Extract ventilators

Control system

CO and smoke detectors

**Strobe lighting and sounders
(if required)**

Wiring

CFD analysis

Commissioning

Service and Maintenance

Also, for traditional systems Colt can offer louvres for natural cross-flow ventilation.

COLT SERVICE

Part of the Colt Group of companies, Colt Service offers a comprehensive range of maintenance packages incorporating the maintenance and repair of all building services equipment including non Colt products.

Colt Service provide a 24 hour, 365 day emergency cover as standard.

MAINTENANCE

Maintenance of a smoke control system is essential. Regular maintenance protects your investment and brings peace of mind that the system will operate effectively in an emergency.

The British Standard, BS 7346 recommends that smoke control systems should be serviced at least once a year and tested weekly.



A Member of the British Parking Association



“People feel better in Colt conditions”



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