

How to design easily a smoke management system?

Enclosed car park: Jet Fans vs Ducts

Fire safety engineering approach vs Prescriptive methods

→ Prescriptive methods

The conventional methods and requirements described in *Aldes ME Flash 26* are **prescriptive**. They present an **easy way** to achieve a **correct and forecasted level of safety** for people to escape an enclosed car park, and they should work basically for any common type of enclosed car parks.

→ Fire safety engineering & need for CFD analysis

With the great development of the **computational fluid dynamics (CFD) modelling** as a tool for fire safety engineering, it is now possible to **assess and optimize the performance** of more **complex systems** and more **complex configurations**, as the jet fan system for car park ventilation and smoke extraction.

Indeed, the design of a jet fan system has to be validated through CFD analysis as **many inputs and parameters can compromise the performances of the system**: total number of jet fans, positions, orientations, group of jet fans for a specific zoning, number of jet fans in operation to control a fire, air intake positions, complex building geometry, beams and obstructions causing deviation & turbulence...

The CFD study and fire engineering report should be endorsed by an **independent Fire Safety Engineer** as it requires **experience** for a correct interpretation of the results as well as **fairness & objectivity**.

Jet fan system: principle & key advantages

Jet fan systems for car park come from systems used to **control smoke movement in road tunnels**. Contrary to a road tunnel which has only two opposite directions, the smoke inside a car park can flow away in all directions which is basically one of the main challenge for the jet fan system.



One of the main reasons behind the introduction of this system for car park application is **to avoid the constraints due to the bulky ductwork** (supply & extract ductwork removal) to guarantee:

- ✓ optimum use of car park space and better appearance,
- ✓ optimization of headroom for vehicles and pedestrians,
- ✓ quick and flexible installation,
- ✓ optimized indoor air quality (IAQ) with **no dead spot** (no local high-level pollution),
- ✓ good clearance of smoke,
- ✓ better CCTV coverage for security...

But this can ONLY be ensured obviously if the jet fan system is BOTH well-designed (specific study with CFD analysis) and well-installed as per the design!

A jet fan system replaces the distribution ductwork and works on the **principle of thrust** pushing forward and inducing the surrounding air with a **relatively high velocity** in the direction of the smoke exhaust fans. A jet fan system is creating some **turbulence** in the surrounding air and has a good **air mixing** for comfort ventilation (IAQ).

Jet fan system: important drawbacks

A jet fan system is **not a perfect system** and has also **many negative points** that have to be considered.

→ CFD analysis

As mentioned already, it requires a study with a **CFD analysis** which means a **more difficult approach** to make an efficient tailored solution.

→ Ventilation performances

Considering the ventilation performances, the **beams and obstructions** are also considered as obstacles for jet fans with **turbulence, deflection and air throw issues**. Jet fans should be at least 2m away from a beam. The **orientation** and **positions** of jet fans are also important considering that the best performance is reached with all jet fans oriented in the same direction (to avoid cross-air jets...). That's why a "no dead spot" objective can also be difficult to reach.

Some compromises have also to be done between cost and effectiveness of the thrust ventilation: to increase this effectiveness, **mutual distance between jet fans** should be reduced increasing the **number of fans** and the cost as well...



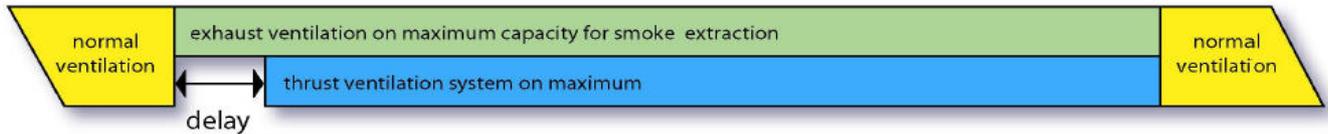
Beams and obstructions directly facing a jet fan (airflow directed on the left – cf arrow on the jet fan) – Dubai Mall (Dubai)

In theory, the jet fan system might be easy to implement, but **practically the installation may present a lot of difficulties** to position fans and avoid beams and obstructions (location and height issues) for correct operation and performances both for ventilation and smoke extraction.

→ Smoke extraction performances

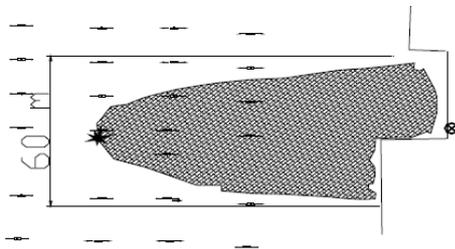
Considering the smoke extraction performances, a jet fan system is **not adapted to ensure a smoke free layer with good visibility to let the occupants escape safely the car park!** This is a major drawback in terms of safe smoke extraction system.

As a consequence, it is recommended **to switch on only the smoke exhaust fans** immediately after the fire detection. This should guarantee at least that the hot smoke will stratify at ceiling level ensuring some visibility for a very short time as the smoke extraction will be very limited especially if the fire is far from the smoke exhaust fans... While the car park is evacuated, **jet fans must stay switched off to prevent the air and smoke mixing with at least a delay of 5-8 minutes** before being switch on to start "controlling" and exhausting the smoke (cf full scale fire test TNO Novenco).



Enclosed car park – Jet fan system operation

If a jet fan system doesn't ensure a local smoke extraction as the conventional system, it can at least limit the smoke spread inside an **approximate 60m wide zone** (still quite important width), ease the location of the fire for the fire brigade, and clear the smoke quickly after the fire has been extinguished.



Smoke expansion restriction

VISIBILITY	SYSTEM		
	Traditional	Impulse	Induction
10 metres	At start	1 minute	1.5 minutes
20 metres	3.5 minutes	8 minutes	6 minutes
30 metres	13 minutes	13 minutes	9.5 minutes
40 metres	23 minutes	16 minutes	12.5 minutes
Rear wall details	27 minutes	18.5 minutes	16.5 minutes
Clear of smoke	41.5 minutes	32.5 minutes	28 minutes

Smoke clearance

The table here above shows that if a jet fan system is more efficient to clear the smoke from a car park, a traditional system is still relatively fast considering that smoke clearance is not the main priority of the smoke extraction system.

➔ **Cost**

Concerning the cost of the jet fan system, it is quite difficult to give easily an exact answer because of many direct and indirect parameters are involved:

Jet Fan System & Cost Impacts	
Positive impacts	Negative Impacts
Reduced headroom and space	cost of CFD analysis / FSE review
No ductwork, no VCDs, no grilles...	Number & unit cost of jet fans (distance to be reduced for good performances)
Quick installation	More wiring & controls with larger control panels
Less pressure loss for smoke exhaust fans (lower static pressure)	More air change rate required ie higher airflows for smoke exhaust fans

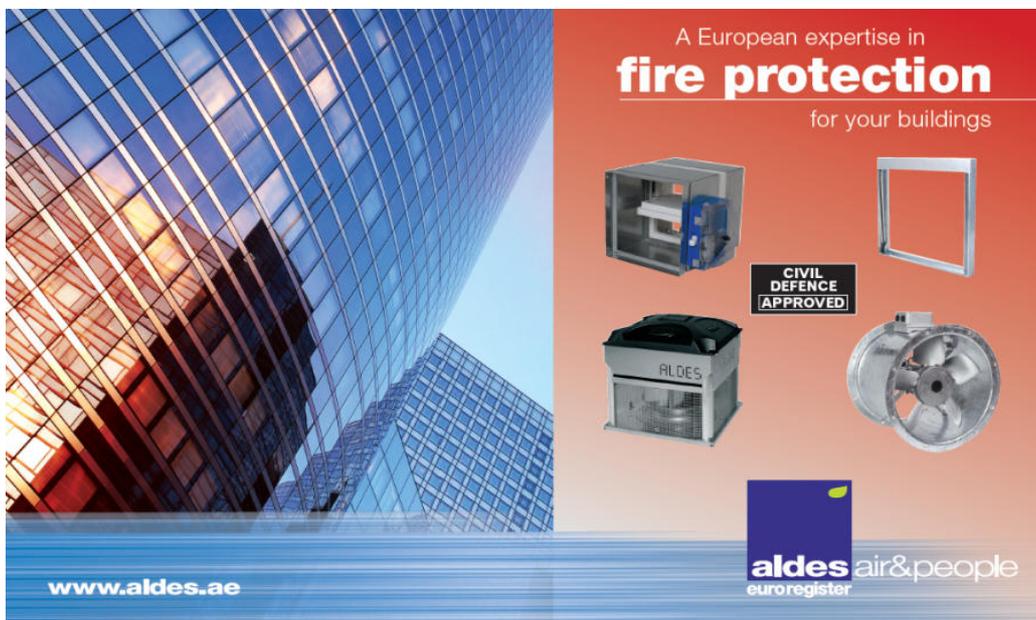
It may be admitted that the **cost of a jet fan system can be slightly higher than a traditional system with ducts** especially for smoke control application where emphasis is given to the effectiveness of the jet fan system (increased number of fans). In case of very large car parks and/or many car park levels, the reduced headroom could become significant and make a jet fan system cheaper than a traditional system with ducts...

Comparative study between traditional system with ducts and jet fan system

Here below is a comparative table between the different types of car park ventilation and smoke extraction systems and their key features to allow you to select the right system for your projects:

Type of systems		Car Park Smoke Extraction System		
		Conventiønnal System with Ductwork (Basic system)	Jet Fan System (More complex & optimized system)	
Easy approach		<u>Prescriptive method</u> --> Easy way	<u>Fire Safety Engineering</u> --> more difficult with a need for CFD analysis & fire engineering report for validation by FSE	
Building construction	Car Park Height Reduction	No: need for ductwork installation going under downstand beams	Space saving: no ductwork	
Performances	Ventilation	IAQ (CO level...)	Optimized air distribution with no dead spot	
		Demand-control ventilation & Energy saving	Yes	
	Smoke extraction	Smoke free layer & visibility for safe escape	Perfectly adapted	Not adapted!
		Reduced temperature	Yes: around 400°C (less with sprinkler system)	Yes: around 400°C (less with sprinkler system)
		Smoke control & extraction	Local expansion restriction + Local extraction	Expansion restriction (60m width) + Extraction
	Fire Fighting	Easy location of the fire	Correct	Well adapted (high airflows pushing the smoke)
Smoke clearance		Correct	Faster	
Installation		Long time requested for ductwork & equipments	Fast installation <i>but to be careful about position & orientation</i>	
Maintenance		Periodic maintenance	Periodic maintenance (less equipments but more wiring & controls)	
Cost		Baseline cost	No ductwork, <u>but</u> CFD study, more fans, more ACH requested, more wiring & controls...	

If you are looking for a **basic system** at **reasonable cost** ensuring a **high level of safety** for your buildings, a **traditional car park ventilation and smoke extraction system with ducts** will fully fit your needs.



A European expertise in
fire protection
for your buildings

CIVIL DEFENCE APPROVED

aldes air&people
euroregister

www.aldes.ae

For any information or enquiry, please contact us!
www.aldes.ae

And let's come to visit our factory and showroom!