

A large mobile ventilation unit can be used to rapidly ventilate even the highest multi-storey structures. Picture Courtesy of Tempest Technology Corporation



Defensive Use of PPV in Complex Structures



Arturo Amalich

CEIS Guadalajara

The right tactical approach when using PPV (Positive Pressure Ventilation) can be both life-saving and extremely safe in complex building fire environments.

When dealing with a fire in a complex structure such as a multi-tenant high-rise building, on arrival development of the fire is usually limited to a single apartment. However, in most cases the common stairwell within the structure is rapidly filled with heavy smoke, originating from the seat of the fire and spreading to the upper levels. This places occupants attempting to escape the building via the stairwell at tremendous risk.

We are then immediately confronted with a simple yet serious question: what should be done first? Deal with the fire, or take care of the potential victims inside?

When it comes to simple structures, making a fast push towards the seat of fire maybe an option, but in complex structures putting the fire out might be too time consuming. Something has to be done for the victims first.

Two approaches are possible:

- **Remove the victim or victims from the hazard:** This is the traditional approach used by interior crews assigned to search and rescue. In this case, crews must deal with low visibility,

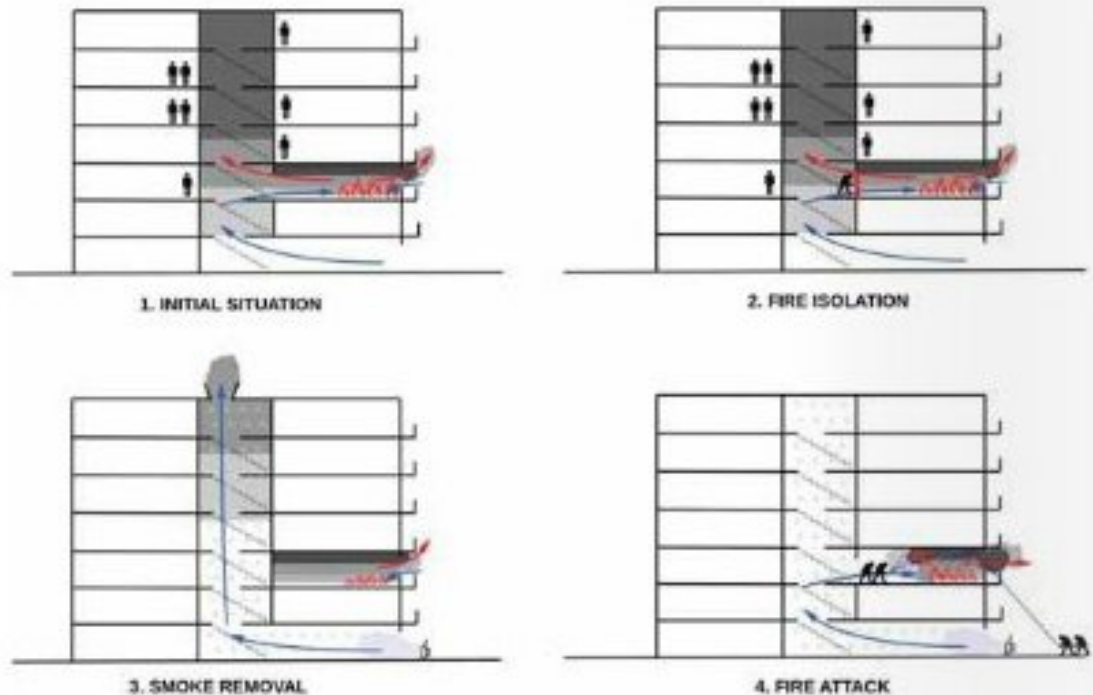
high temperature and toxic interior conditions. If multiple victims are involved, which is to be expected in multi-tenant buildings, completing this task within the survivability time range of the occupants can be extremely difficult.

- **Remove hazard from the victim or victims:** Removing the smoke from non-fire areas, such as the stairwell and unaffected apartments, will provide tenable conditions for trapped victims outside the fire area. This creates a clear egress path for occupants and safer interior conditions for firefighter progression. Positive pressure ventilation (PPV), along with fire isolation techniques or smoke curtain devices, is a highly effective means of removing smoke from enclosure structures.

A "remove hazard from the victim" tactical approach is most useful in fire incidents with multiple victims involved, complex structures or fire departments short on staffing. In several European countries (Germany, the UK, Spain and others), the defensive use of PPV is a widespread, well proven and successful life-saving tactic.

The main objective of this tactic is to be able to

Operation evolution



break a complicated fire scene into two less daunting incidents. The "divide and rule (or conquer)" – "Divide et impera" – Julius Caesar, Roman Emperor, 1st Century, BC – applied to the fire ground creates two different fire scenes within the same incident:

- **Scene A:** Fire area. Generally one apartment involved upon arrival.
- **Scene B:** Smoke filled areas not directly affected by the fire, such as the stairwell and other apartments in the structure.

In order to divide the incident, we need to isolate the fire area from the rest of the building and use PPV to create airflow in the desired non-fire area contaminated with smoke. Since the fire room will not be supplied with fresh air from PPV operations, there is no risk of additional fire development. With that being said, this can be considered a conservative and extremely safe ventilation tactic, even among the strongest opponents of positive pressure.

If desired, PPV can be used to create airflow through the seat of fire (termed "offensive PPV" in Europe and "positive pressure attack" (PPA) in North America). Doing so can be tremendously helpful in improving interior conditions and victim tenability. Nevertheless, airflow through the seat of a fire will create a significant increase in the heat release rate (HRR) of a ventilation controlled fire (VCF), thus requiring perfect coordination and timing with water application on the seat of fire.

A Defensive PPV operation evolution takes place in five steps:

- 1 Isolate the fire.
- 2 Create an opening.
- 3 Remove smoke using PPV.
- 4 Close opening to increase interior pressure.
- 5 Fire suppression.

Step 1 will divide the problem (fire area from non-fire area). Steps 2, 3 and 4 take place in the non-fire area filled with smoke. Step 5 takes place in the fire area.

Although sufficiently staffed fire departments may be able to deal with the two problems

simultaneously, the most common approach is to remove smoke from stairwell from the non-fire area first, and then proceed to fire suppression.

1. Isolating the Fire

Unfortunately, many occupants exit their apartment leaving the door opened to the corridor or stairwell. This allows smoke to spread throughout the common corridor, stairwell and any other open spaces. In other cases, poor quality fire resistant doors may be damaged during fire evolution, allowing fire gases to creep into the stairwell.

Isolating the fire can be done from a very early stage. The crew commander assigned to recognise interior conditions may simply close the door to the apartment on fire. In addition, wetting the door as soon as water is available will improve its fire resistant capabilities.

The use of a smoke curtain device can also provide a solution whenever the door is damaged, and help to prevent smoke from leaking into the stairwell once the involved apartment is accessed for fire suppression (Step 5).

During initial interior inspection of the fire area, fire conditions and victim tenability are assessed. A fast search and rescue operation can be carried out in some cases, but a fully involved fire with poor victim tenability requires the focus of available resources towards the remaining smoke filled part of the building.

2. Creating an Opening

In order to create a unidirectional airflow through the building, both an inlet and an exhaust are needed. The main entrance to the building is – usually used as the inlet. Due to the buoyancy effect of smoke, higher temperatures mean lower density, thus forcing the smoke to "float" over heavier fluids (cool air). With this being said, the exhaust should be placed at the highest position possible to ensure complete and efficient smoke removal.

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exhaust point is by interior progression up the stairwell to open ventilation devices placed at the top. Exterior access with the use of an aerial vehicle or different stairwell to gain entry to the roof may be necessary when heavy smoke and extreme temperature conditions are encountered.

Having an exhaust point which may be easily closed or resealed is always most desirable. Therefore, a force opening is a better option than a break opening. Being able to reclose the exhaust point is important for a number of reasons; the operation may need to be aborted, a different airflow may be required and once the smoke has been removed from the stairwell, resealing the exhaust point will help to increase interior pressure.

A one square metre exhaust size can be enough to perform a defensive PPV operation although better results are achieved in the two square metres to four square metres range. While offen-



Firefighters using a smoke curtain device to isolate fire from stairwell.

Picture courtesy of Dr. Michael Reick

sive PPV (PPA) requires very fast smoke removal in order to minimise the increase in heat release, this parameter is not as critical in defensive PPV since the smoke in stairwells is colder and less likely to reach its ignition point.

Some buildings do not have ventilation openings in the stairwell. In such a case, smoke must be carried out through one of the apartments on the uppermost floor. Property damage should be expected, but should not be a concern when considering the hazard of a smoke filled egress path.

3. Removing Smoke

It is strongly recommended that crews return from the fire floor and exit the structure before starting ventilation to avoid being exposed to smoke flow. Otherwise, if a door is to fail or an accidental opening is created, crews may be positioned directly in the flow path of hot fire gases.

In a general setup, a unidirectional airflow is created from the entrance door (where a positive pressure ventilation fan is placed) leading to the exhaust opening in the upper portion of the building. The setback distance between the fan and entrance varies upon inlet size and fan performance, ranging from two metres to four metres for a typical two-metre by one-metre building entrance door.

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The capacity of a fan to perform ventilation will depend on the building configuration, air leakages and friction loss along the established airflow. PPV fans sized 460 mm to 534 mm are used regularly for structures up to ten stories, and even more in air tight buildings commonly found in Europe and North America.

Larger fans or the use of multiple fans can be deployed if higher performance is necessary. The "V" shape setup has proven to provide up to 35 percent more airflow. "Master and rely" fan setups, which involve the setting of one fan at the entrance and another along the path of airflow in an upper floor, yield even better results, although it is not always possible to deploy a fan at an upper level within the structure.

Most fans used today are rated around 30,000 cubic metres an hour. At 50 percent of this rated capacity, a five-metre by two-and-a-half-metre plan and a 20-metre high stairwell can be cleared out in one minute if no additional smoke is drawn into the stairwell.

4. Closing the Exhaust

Once the smoke is removed from the stairwell, closing the exhaust point, while continuing to conduct positive pressure ventilation, will create a differential pressure between the stairwell and



Fan placed at an entrance of a high-rise building. Picture courtesy of Tempest Technology Corporation

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A typical "V" shape PPV fan setup.
Picture courtesy of Kriss Garcia



exterior. There are several advantages to this positive pressure differential:

- Prevents smoke flowing back into the stairwell. A smoke curtain blocking the upper part of the door to the involved room will improve the result.
- Reduces the chances of fire spread and propagation. The differential pressure will create airflow against the fire room at the opening; therefore, fire propagation is less likely to happen.

the structure. Transitional attack does not require a full interior team, so it can be performed by a backup team working the exterior.

- **Indirect Attack:** Conducted from the apartment door or outside window to fill the fire area with steam for fire suppression.
- **Interior Progression by Attack Team:** An attack done while keeping the door closed (or a smoke curtain in place) to avoid smoke spreading into the stairwell.

Positive Pressure Ventilation can clear smoke rapidly from stairwells and smoke filled areas to provide a safe path of egress. Suppression can begin as soon as the fire is isolated and can be conducted while the PPV operations are taking place.

5. Fire Suppression

Although numbered as Step 5, fire suppression can start as soon as the fire is isolated and enough staff are on the scene. A second due crew can start fire attack while the first due crew is still performing defensive PPV. If only one operation can be conducted at a time (due to short staffing or no mutual aid) interior attack for fire suppression should begin only after the smoke has been cleared out of the structure.

There are a number of tactical choices to be considered in the fire attack:

- **Transitional Attack:** An offensive exterior attack using a straight stream aimed to the room ceiling has proven to be an effective way to "reset the fire" and increase victim survivability by reducing temperatures throughout

Conclusion

In complex structures (high-rise, multi-tenant), isolating the fire area from the rest of the building divides a fire operation into two, less complex, incidents where different tactical approaches can then take place.

Removing the hazard (smoke) from the victim or victims is more effective and efficient than performing a search and rescue operation (remove the victim or victims from the hazard) in complex structures.

Positive Pressure Ventilation (PPV) can rapidly clear smoke from stairwells and smoke filled areas to provide a safe path of egress.

Suppression can begin as soon as the fire is isolated and be conducted while the PPV operations are taking place.

Arturo Arnalich is a Battalion Chief in the Madrid metro area for CEIS Guadalajara, responsible for the Operational Division. He is a member of Underwriters Technical Panel for the PPV study

For further information, go to www.artarnalich.wordpress.com or www.tempest.us.com