

PathMaster®

SMOKE CURTAIN

A photograph showing three firefighters in full protective gear, including helmets, jackets with reflective stripes, and air tanks. They are positioned in a doorway, using a large, light-colored smoke curtain to block the opening. One firefighter is holding a tool, possibly a pry bar, against the curtain. The scene is set outdoors, with a concrete wall and a ladder visible in the background.

Tactical Considerations for Use of the PathMaster® Smoke Curtain

How German Fire Departments have Used the Device with Tremendous Success.

INTRODUCTION

The ability to control smoke/air flow during structure fires is essential for safe fire and rescue operations. The task has been discussed by authors of numerous German publications, firefighting magazines and books since 2005, yet is of vital importance to all firefighters.

Before fire crews are able to solve problems on the fire ground, they must often stabilize the situation first. For example, to do so in multi-story buildings, it is vital to prevent smoke from entering escape routes, creating life threatening hazards for civilians. For the safety of occupants and firefighters in any structure with a working fire, it is also of great importance to control both the flow of smoke and of fresh air due to their direct and immediate influence on the development and severity of the fire itself. For 10 years, firefighters in central Europe, have been using blocking devices to control these flows and flow paths with great success. This article presents the background of the *PathMaster*[®] smoke curtain and various fields of application. It also offers a number of examples for curtain use in real building fires taken from more than 1,600 documented incidents.

INITIAL CONCEPT & MULTI-STORY RESIDENTIAL USE

PathMasters[®] were originally invented to address smoke spread issues present in multi-story residential structures.

The most important task for firefighters is to save lives. In most cases of fire in multi-story residential buildings, this objective can be best achieved by using stairways as the preferred route of attack. This method of entering a multi-story dwelling assures that the most important escape route for occupants is immediately controlled as people are often found there on their way out of the building – either in a smoke filled or a still-safe, smoke free environment.

As a result, it can then be considered that an aim of significant importance for fire crews is to have a smoke free and safe stairway. However, choosing the stairway as the preferred route of attack to a fire in a building means opening doors. Basic firefighting operations sometimes enables smoke to travel through a building, entering stairways and leading to the endangerment of the inhabitants.

The hazard of smoke spread in a stairway is often not sufficiently solved with the use of PPV/ventilation alone. It's only when a ventilator is in an optimal position, with all windows and all other doors to the stairway closed, that a complete ventilation process can be ensured. But what can firefighters do when this is not the case? What can be done in larger and more complex buildings where positive pressure ventilation may not be available?

Considering this problem, there is a very simple objective that must be achieved: firefighters need a means of closing an opening quickly, sufficiently sealing it against smoke and air flow, but without hindering operations.

Fire crews must be able to prevent smoke from spreading easily, and be able to purge the building of smoke quickly. This would dramatically improve rescue operations and minimize smoke damage. It would also ensure a smoke free escape route for firefighters thereby leading to increased safety even for themselves.

These scenarios are illustrated by comparing *Figures 1* and *2*. Both figures are the results of a fire simulation which show the calculated smoke spread in a multi-story building with numerous open windows and doors either A), without a positive pressure ventilator in front of the main building entrance, or B), with one. *Figure 1* shows the results if the entrance door to the fire compartment is open and not controlled. Using a ventilator, there is increased airflow through the stairway and therefore a reduced density of smoke, but still smoke entering the stairway from the fire area through the upper part of the door. This smoke flow will be present in some amount even if the entrance door is somehow controlled (e. g. opened only in a small angle by controlling it with a fire fighter). Considering this, the situations *1A* and *1B* are not very effective. Furthermore, there is also significant turbulence at the entrance to the fire compartment due to the bi-directional flow through the door frame.

The utilization of a *PathMaster*[®], which blocks the flow in the upper part of the entrance door, hinders smoke from flowing into the stairway but also allows a small amount of fresh air to enter the fire compartment at floor level. Both situations in *Figure 1* can be transferred and

improved upon, shown in *Figure 2*. *Figure 2* demonstrates that flow paths in a building are much easier to control if the upper half of the entrance door is blocked. In this scenario, the stairway remains smoke free and/or can be freed from smoke quickly. Turbulences around the entrance to the fire area are reduced and fresh air only enters in small amounts at floor level, creating a safer fire compartment for both firefighters and potential victims through improved visibility and living conditions.

If the entrance door to the fire compartment requires forcible access, it may be possible to cut the lower half of the entrance door by using a saw or similar tool. This idea has been tested, but obviously comes with disadvantages and risks. Therefore the need to build a specific device (a *PathMaster*[®]) to perform this task fast and conveniently was identified in 2005.

Various designs for a smoke blocking device were built and tested in 2005. The best results in controlling all flows were achieved by using a combination of a metal frame with a spreader and a unique, textile fiber curtain. Obviously, the curtain had to meet many requirements for safety and practical reasons. In addition, it was found favorable if the curtain was also able to influence the characteristics of the fresh air flow into the fire compartment. Looking at the flow of smoke shown in *Figure 2*, the curtain must prevent smoke from traveling through the upper part of a door, but must still allow fresh air to travel into the fire area through the lower part of the door (this fresh air must flow with minimal turbulence in order to prevent excessive mixture of fresh air and smoke). This keeps the volume of smoke to be expelled from the building to a minimum and improves the conditions and safety for firefighters by lowering temperatures and increasing visibility in the lower layer. Keeping cold and heated smoke layers separated increases safety by ensuring any dangerous, oxygen mixed layers that may be present are kept to a minimum.

FLOW PATH USE

PathMasters[®] have been adopted into the use of Flow Path control after numerous tests confirmed their potential impact.

In recent years there have been multiple studies conducted in the US by NIST

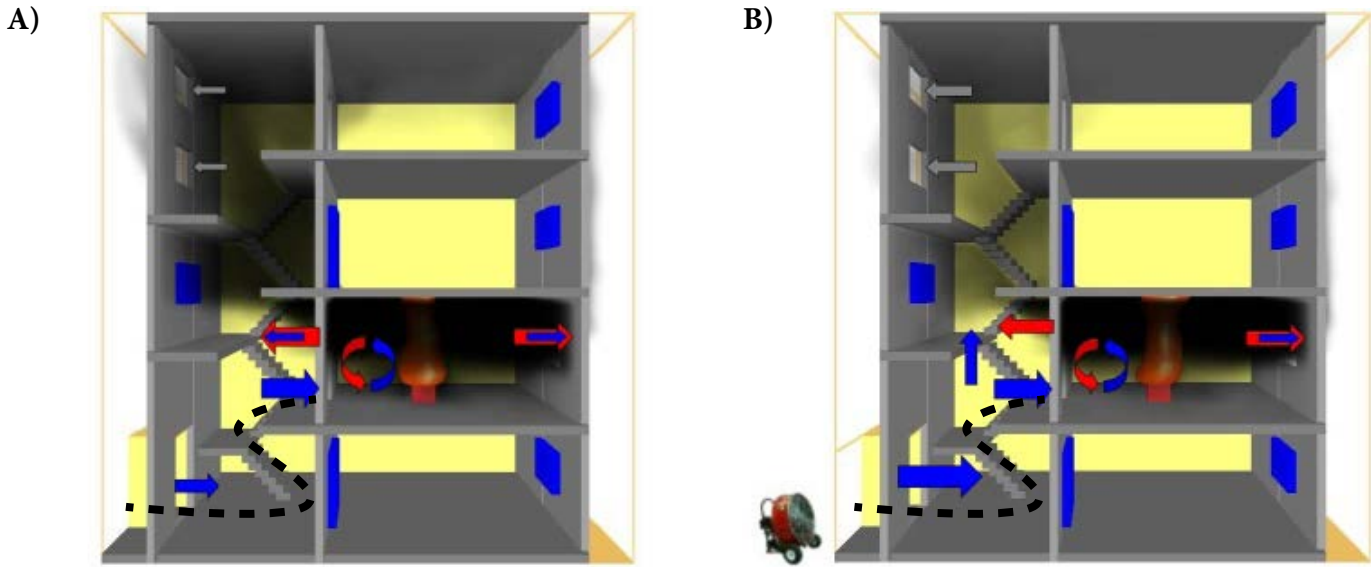


FIGURE 1: Smoke spread in a stairway with open windows and an open door to the fire area; A) without and B) with a ventilator in front of the main building entrance.

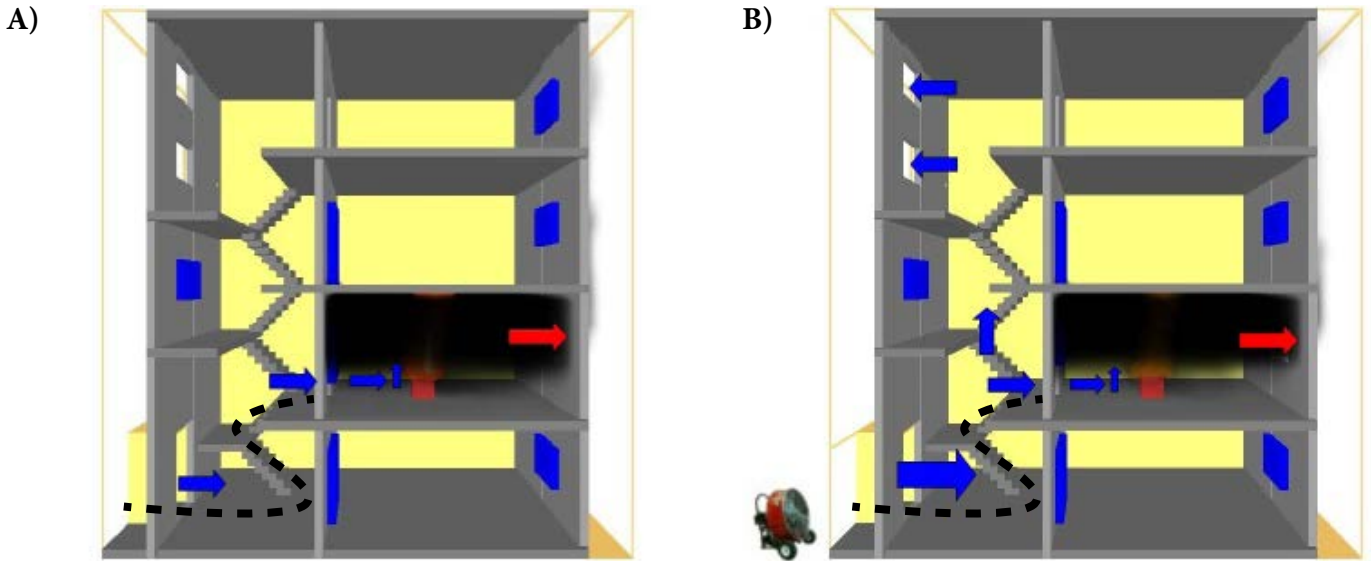


FIGURE 2: Smoke spread in a stairway with open windows and only the upper half of the door to the fire area sealed; A) without and B) with a ventilator in front of the main building entrance.

and UL proving the influence the flow of fresh air has on fire development. These organizations examined the time between opening a door to a fire compartment (ventilation!) and a resulting flashover. Due to the higher heat release rate of modern furnishings, it was shown that the time span from starting ventilation (e.g. opening a door) and flashover in the fire compartment has decreased to about 1 to 2 minutes. For the safety of all life in the fire compartment and the adjacent rooms in the building, this rapid fire development has to be prevented. One way to do just

that is to reduce the flow of fresh air in the structure. This can be done by keeping the door closed as much as possible, even after accessing the fire compartment by the fire crew. This “door control” can be executed by using a chock to fix the door in a nearly closed position. However, this may hinder the egress of firefighters, so it is recommended to instead control the entrance door by assigning a firefighter to do so. Unfortunately, the staffing this requires is often unavailable. “Door control” with a *PathMaster*® mounted into the door frame is most effective in the upper half

of the door, yet the curtain also positively influences the flow path in the lower half of the door by forcing the flow of fresh air to go low into the fire compartment. This prevents the dangerous mixing of smoke and fresh air, preventing it from reaching an ignitable state yet gives firefighters and potential victims in the fire room better conditions in the layer close to the floor – where it is needed.

In regards to allowing some fresh air into the structure while using the *PathMaster*®



FIGURE 3: Influence on the characteristic of the fresh air flow into the fire compartment by a *PathMaster*® with the curtain nearly covering the whole opening and forcing the fresh air flow to go in low.

for door control, it must be emphasized at this point that under-ventilating a fire in a compartment can lead to a dangerous level and concentration of combustible gases. Entering a fire compartment, even with the mandatory PPE, is dangerous, and smoke layers which are hot and contain combustible gases should be cooled and mixed with water vapor to further reduce their ability to ignite.

Experience in hundreds of real fires in buildings provided that blocking the upper

half of the entrance door and entering the fire compartment together with a limited but still present flow of fresh air (one-directional flow!) provided favorable results. Limited air flow still improves visibility, reduces the temperature in the lower layer and shows out-gassing and flaming combustion. Firefighters are able to use their hoseline and extinguish the fire, cool the smoke layer and other surfaces as they enter the fire compartment. The limited amount of in-flowing fresh air should increase the time between the start of ventilation (opening the door!) and flashover in the fire compartment by a few minutes, allowing firefighters to safely get water on the seat of the fire.

In addition, the danger of firefighters encountering a bi-directional flow (hot smoke out high and fresh air in low) while entering a fire compartment is significantly reduced. With a *PathMaster*® as described in this article, it is possible to transform typical bi-directional flow into a one-directional flow which has the same direction as the firefighters entering the compartment.

PathMaster® deployment for firefighting operations is shown in *Figure 4*.

There are numerous applications and reasons why a *PathMaster*® should be used in most general firefighting attack operations:

- In multi-story buildings: The stairway stays smoke-free and/or smoke which

is already in the stairway can be expelled much faster.

- The *PathMaster*® can serve to close an open or damaged door in order to prevent the spread of smoke in a building.
- A smoke-free stairway enables the rescue team to stay closer to the fire area and therefore communicate more easily with the attack team. This results in a shorter escape route and improved safety for firefighters.
- With a *PathMaster*®, positive pressure ventilation of a stairway is much easier to achieve, and ventilation operations can be effected section by section.
- The limitation of air flow can favorably lead to a lessened heat release rate and less severe fire development.
- In case of an under-ventilated fire, the time between the opening of an entrance door and a flashover in the fire compartment should be increased to an amount that allows fire crews to control and extinguish the fire before flashover happens.
- In case of unexpected events (e.g. the failure of a window or the opening of other doors in the building) which may lead to rapid and dangerous changes in the flow of smoke and hot fire gases, the installation of *PathMaster*® will help to stabilize the situation. Everything must be done to help prevent the interior attack crew from being trapped in the flow path between the fire and its outlet.



FIGURE 4: *PathMaster*®; A) Door before installation of the device, B) Installation of a *PathMaster*®, C) Easy access for firefighters to the fire area.



FIGURE 5: Fire in a multi-story dwelling in Heilbronn, Germany (Feb. 6, 2006). The fire room was totally damaged and the corridor was considerably damaged by heat and smoke. Meanwhile, the stairway was protected efficiently by deploying a **PathMaster®**.

SMOKE SPREAD AND DAMAGE

PathMasters® are used regularly to virtually eliminate smoke spread and resulting damage.

Damage caused by the spread of smoke is often underestimated by firefighters. In Germany, the use of a **PathMaster®** is used frequently to reduce/prevent smoke damage. For firefighters, a **PathMasters®** use creates a clearly visible separation of “black” and “white” areas and often leads to a very different behavior and more conscious strategy regarding smoke damage.

From one of many fire incidents over the years, **Figure 5** shows a fire in a residential building in Heilbronn, Germany which occurred on February 6, 2006. The fire area

itself (a child’s room) was totally damaged by heat and smoke while the corridor suffered considerable damage. However, a **PathMaster®** placed in the doorway to the apartment efficiently prevented smoke from entering the stairway. The images from the incident show the dramatic difference the curtain played in helping to isolate smoke damage and resulting property loss.

A combination of two **PathMasters®** is just as simple and easy as using one. **Figure 7** shows how doing so enables an almost total seal of an opening to prevent smoke spread. However, access to the room for firefighting operations is also limited.

The general utilization of a **PathMaster®** can prevent the spread of smoke caused by

fires in buildings, leading to reduced risks for occupants and a massive reduction in actual smoke damage. This is a simple and efficient method for preventing the spread of smoke not only in residential buildings, but also in modern structures with open architecture. The closing of an opening during a fire is a basic and important task. The utilization of a **PathMaster®** allows fire crews to control the flow of smoke in structural fires much better and more easily. This leads to improved safety for both occupants and firefighters, quicker rescue operations and less damage. More information from more than a thousand uses in real building fires can be found at www.smokeblockingdevice.eu

A)

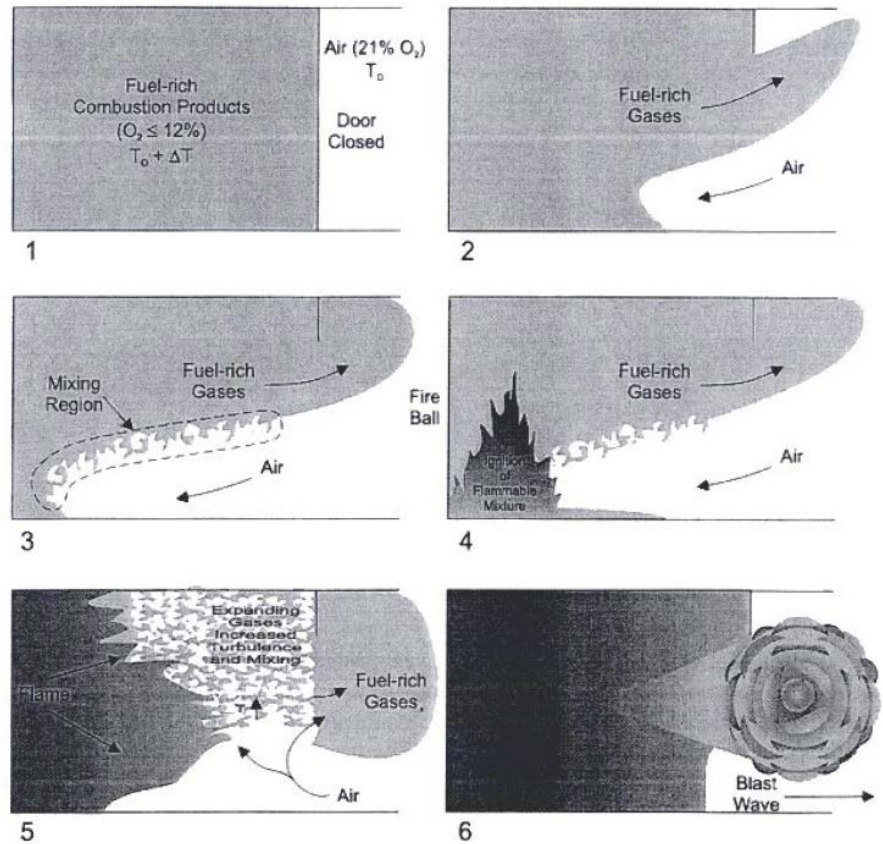


B)



FIGURE 7: A) A second **PathMaster®** is fastened in the middle of a door. Smoke spread is limited even further, but access to the room is still possible. B) A second **PathMaster®** is fastened at the bottom of a door. There is practically no smoke spread possible – however, access to the room is also hindered.

FIGURE 8: *Illustration shows the six stages of a backdraft (according to Gottuk). Figure 9 goes on to indicate how the use of a PathMaster® inhibits the process shown here.*



BACKDRAFT

PathMasters® can be utilized to help prevent the occurrence of a backdraft.

Opening a door to a fire area is always accompanied by the risk of a backdraft. This does not happen very often, but firefighters must always be aware of this hazard. **Figure 8** shows the six stages of the development of a backdraft (according to *Gottuk*).

To reduce the risk of a backdraft, it is valuable to consider the effect a *PathMaster®* has upon the movement of smoke and fresh air. The flow of smoke and fresh air without a *PathMaster®* is illustrated on the right side of **Figure 9**. Under the same conditions, but with a *PathMaster®* fastened in the door, the result is illustrated on the left side.

When opening a door, the movement of fresh air into the fire area can easily be seen when a *PathMaster®* is installed (**Figure 11**). If the room “sucks in fresh air” (one indication of an ensuing backdraft), or if the room seems to be very hot (perhaps just before a flashover occurs), the door can be closed again and safer tactics can then be employed such as that in **Figure 10**.

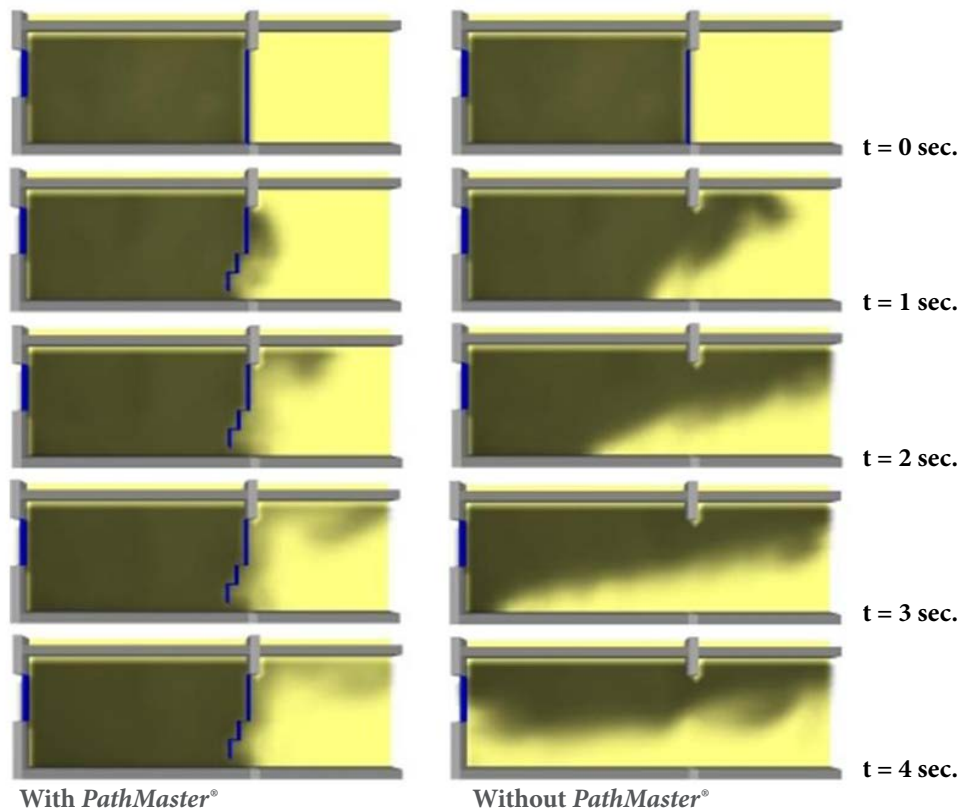


FIGURE 9: *Smoke spread and mixing of smoke and fresh air after opening a door to a fire area. (The steps in the flexible material of the portable smoke blocking device are a result of the modelling and are necessary for the numerical calculations.)*

BLACK AREAS / WHITE AREAS
PathMasters® can establish beneficial barriers to separate involved and uninvolved areas.

In order to prevent unnecessary damage and pollution in the adjacent rooms surrounding the fire area, it is advisable to create an easily recognizable sign and/or barrier restricting all unnecessary access

to the main fire area. *Figure 12* shows that a brief look into the fire area is often enough for most investigation purposes and how a *PathMaster®* can help prevent unwanted and damaging interaction with the damaged rooms.

Figure 13 shows the creation of a black, a gray and a white area in a building by using two portable smoke blocking devices in two

different doors.

In addition, fire crews often have to open walls to find the fire. When this occurs, dirt and dust will find their way throughout the building. When used, a *PathMaster®* acts as a barrier that can serve to limit the spread of dirt and dust.



FIGURE 10: *Utilizing two PathMasters®*
The second metal frame holds the fire proof curtain of the first PathMaster® in place. A nozzle can be used through the nearly closed opening; a very safe firefighting technique that avoids the introduction of fresh air (and oxygen!) into the fire area itself. This might also be used in wind influenced or wind driven fires.



FIGURE 11: *A PathMaster® makes airflow visible. The movement of air into a fire area can be seen and a safe view into the room can be facilitated by using a PathMaster®.*



FIGURE 12: *Indicates black areas. A PathMaster® is a barrier between black and white areas.*

FIGURE 13: *Black/Grey/White Areas.*
Utilization of two PathMasters® is an effective method for creating a “grey” area between the “black” and the “white” areas. This helps to prevent the spread of smoke and dirt throughout the building.

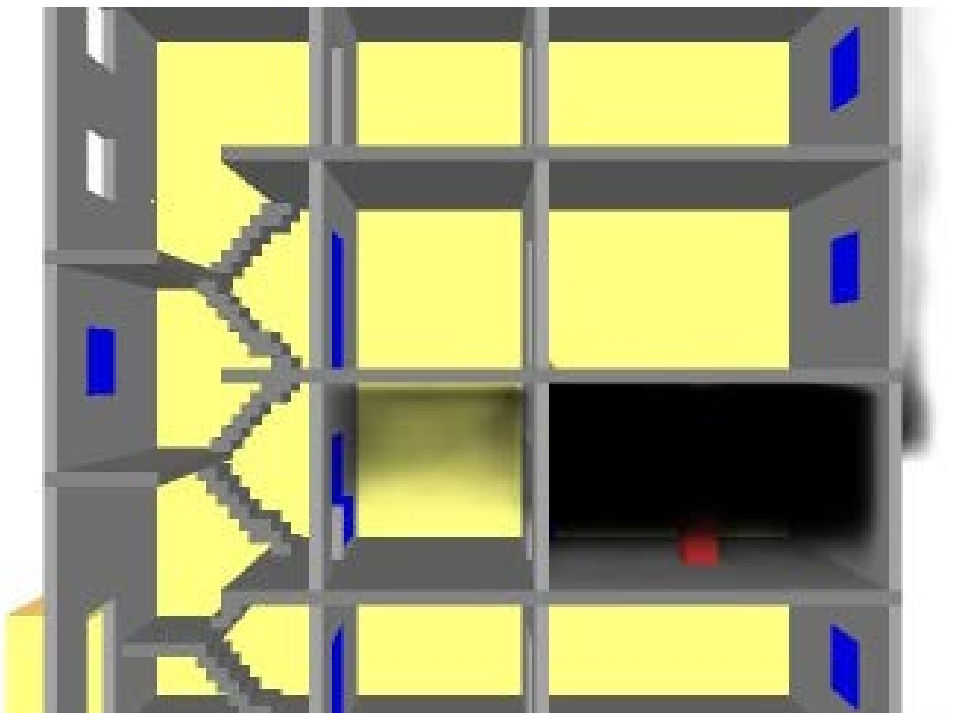




FIGURE 14: *Barrier for dirt and dust. A PathMaster® used to prevent the spreading of dirt and dust.*

AN ADDITIONAL TOOL FOR POSITIVE AND NEGATIVE PRESSURE VENTILATION

PathMasters® are frequently used to enhance positive and negative pressure ventilation operations.

Figure 15 shows the setup for negative pressure ventilation using a PathMaster® after a small fire in a room at an airport terminal in Stuttgart, Germany.

Figure 16 shows the use of a PathMaster® used in a hospital. Hazards for patients were limited because smoke spread was hindered effectively and ventilation could be controlled to a greater level.

For effective positive pressure ventilation (PPV) it is often recommended to cover

the entire opening of a door with the flow of air. Therefore, it should be the aim to achieve a best fit between the air pattern and the opening. Depending on the geometry of the entrance, this could require placing the ventilator far away from the door which is sometimes unfeasible or can limit ventilation rates. By closing the upper part of the door, the entrance area for PPV is reduced in height and the area is transformed into the shape of a square (Figure 20). This increases the effects of using PPV as it allows the ventilator to be placed closer to the entrance, covering the entire opening.

Tests in a 4-story structure showed that the differential pressure in the stairway could be increased using one blocking device by 50% and with two blocking devices by 100% (Figure 21). This is a very easy method to



FIGURE 15: *Room fire at an airport terminal in Stuttgart. To prevent smoke from spreading during the ventilation process, the door can be closed with a PathMaster®.*



FIGURE 16: *Room fire in a hospital in Würzburg, Germany (Nov. 26, 2009).*



FIGURE 17: *Stairs in front of the entrance.* By utilizing a **PathMaster**® in the upper part of the door (the lower part of the fire proof curtain is hung over the spreader bar of the metal frame), the PPV-method becomes more effective.



FIGURE 18: *Stairs in front of the entrance.* The figure shows that a large ventilator can even be placed very close to the door when a **PathMaster**® is utilized. The PPV-method then becomes even more effective.



FIGURE 19: *Corridor situation in a multi-story or high-rise building.* The ventilator can be placed in an effective position in a small corridor in a building when the upper part of the entrance door is blocked with a **PathMaster**®.

increase the power of a smaller blower – or used with a stronger blower, can ensure a sufficient differential in higher buildings.

In addition, the use of a **PathMaster**® in an entrance door is an excellent way to show all non-fire personnel at a fire scene that nobody should access the building in this stage. The **PathMaster**® together with a ventilator directly in front of the building is a very effective method to achieve limited access.

USAGE AND SPREAD OF PATHMASTER®

PathMasters® are a proven and valuable resource.

Developed in 2005, the first portable smoke blocking devices were first used in Germany by several innovative fire departments. After tremendous amounts of experience in real fires, numerous improvements, a high level of acceptance and impressive

performance – more than 17,000 portable smoke blocking devices are actually in use today.

The culmination of testing and experience that has occurred since 2005 has proven the effectiveness of the **PathMaster**® in fire situations which occur on a regular basis in the US and the rest of the world. Regardless of a department's preferred tactics or the particular/unique conditions they may find in their area, the **PathMaster**® can be of

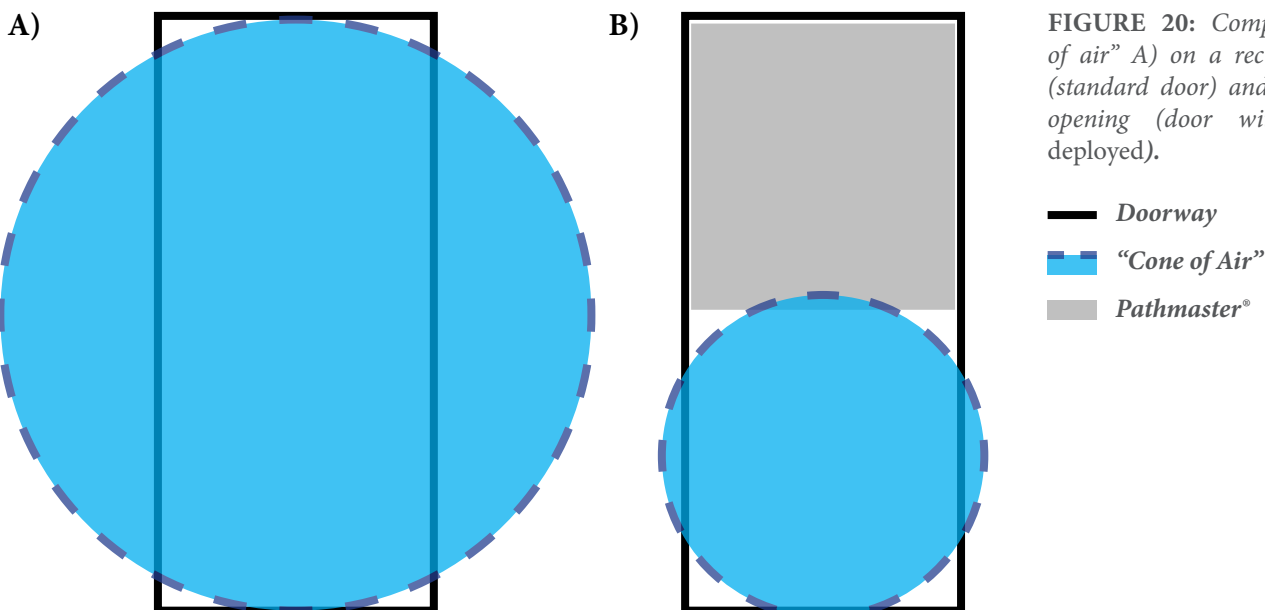


FIGURE 20: Comparison of “cone of air” A) on a rectangular opening (standard door) and B) on a square opening (door with **PathMaster**® deployed).

tremendous value. In summary, here are a few of the real world applications discussed in this resource where the **PathMaster**[®] has and can be utilized easily and safely:

- The **PathMaster**[®] can be deployed during structure fires to effectively and safely control interior flow paths without the use of additional staffing or blocking the point of egress. This application was discovered as a result of modern fire research.
- **PathMasters**[®] can be used proactively or reactively to stabilize a fire situation in anticipation for or following environmental changes (wind gusts, window failure, etc.).
- When a department utilizes PPV or PPA, a **PathMaster**[®] can be used to increase interior pressures and resulting ventilation rates.
- The **PathMaster**[®] can be used to identify and prevent the occurrence of

a backdraft.

- Interior smoke spread can be drastically reduced with the use of a **PathMaster**[®]. This allows firefighters to keep essential exit/egress points clear for crews and escaping occupants. This also greatly reduces property damage caused by smoke.

FIGURE 21: Using a **PathMaster**[®] in the entrance door of a building increases the differential pressure and helps to show personnel present that this access is blocked by the fire department.



The pressure difference can be increased by 50 % by using one **PathMaster**[®] installed in the entrance door of a building. The distance from the blower to the entrance door should be about the open height of the door.



The pressure difference can be increased by 100 % by using two **PathMasters**[®] installed in the entrance door of a building. The distance from the blower to the entrance door should be about the open height of the door.

REFERENCES

All original content, information and images provided by **PathMaster**[®] inventor, Michael Reick. Some copy has been edited to better suit the intended audience but does not affect any significant or critical information.

1. *Smoke Flow Control during Fire Fighting, Tactical Consideration for the Use of Portable Smoke Blocking Devices*
Prof., Dr., -Ing., Michael Reick, *Regional Fire Commander, Germany* - March 2016



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