APPLCATIONS OF POSITIVE PRESSURE VENTILATION DURING AIRPORT AND ARFF INCIDENTS

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ABSTRACT

Positive Pressure Ventilation (PPV) is the use of high-powered blowers to remove the hostile interior environment of an enclosed structure. Its purpose is to increase safety for fire fighters and rescue personnel, enhance the speed of fire fighting and rescue operations, and lessen property damage caused by smoke, heat, and fire. Over the past fifteen years, PPV has been proven effective for ventilating residential structures, high-rise buildings and even tunnels. Recently, new applications for PPV have been discovered for airport fire fighting operations involving aircraft, passenger terminals, hotels and other large structures.

INTRODUCTION to PPV

Positive Pressure Ventilation, or PPV as it is commonly known, is a fire fighting technique that uses air as a tool to control the hostile environment inside an enclosed structure. Specially designed blowers are used to replace the interior environment with fresh, ambient air.

PPV was first developed in the United States in the 1960's and was used on a limited basis by progressive fire departments. In the early 1990's, information about the use and applications of PPV became widely available and research was conducted to study the benefits it offered to fire fighters. Today, PPV is an accepted fire fighting technique used by fire departments and fire brigades around the world.

PPV works on the principle that air flows from high pressure to low pressure. Ventilation is accomplished by positioning a ducted fan on the outside of the structure, blowing inward, so that the cone shaped air pattern created by the fan "seals" the entrance opening and forces air into the structure. Once this seal is achieved, the air pressure increases equally at all points.

To remove the contaminants, an exhaust opening is created near the seat of the fire. The exhaust opening releases the air pressure and all of the contaminants are drawn towards this point of low pressure. Because the positive pressure is equal at all points inside the structure, contaminants are drawn from the ceiling, floor, and around obstructions.

PPV benefits fire fighting personnel by creating a safer environment inside an enclosed structure. The removal of smoke makes it easier for them to find victims and the location of the fire. The removal of heat allows them to move more freely

within the structure. Removal of hot gases reduces the possibility of flashover. Ultimately, PPV benefits victims by increasing their chances of survival.

PPV EQUIPMENT

The most common PPV blowers range in size from 18-27 inches (460-690mm) in diameter and deliver from 7,000-23,000 CFM (11,900 m^3/hr to 40,600 m^3/hr) airflow. They are gasoline or electric powered and are carried on the fire-fighting vehicle. Blowers of this size can effectively ventilate structures up to 6,000 square feet (560 square meters).

To be effective for PPV, a blower must be able to create a high level of pressure and produce a cone shaped air pattern. This is achieved through the use of an impeller with multiple blades and a duct or shroud to enclose it. The blower must also feature a tilt mechanism for adjusting the air cone to seal the entrance opening.

To apply PPV to large structures such as high-rise buildings, road tunnels, and passenger terminals, larger ventilation tools have been developed. Called mobile ventilation units (MVU), these truck or trailer mounted blowers produce airflows from 80,000-200,000 CFM (135,000 m^3/hr to 272,000 m^3/hr) and generate air velocities of up to 78 MPH (34 m/s).

Similar to the tilt mechanism on smaller PPV blowers, mobile ventilation units feature a means of adjusting the air cone to seal the entrance opening. This is accomplished through the use of a hydraulic control system to adjust the fan height, pitch, and direction. The ability to precisely adjust the air pattern is critical for effective PPV operations with a mobile ventilation unit.

PPV AND AIRPORT FIRE FIGHTING

The versatility of PPV as a fire fighting tool makes it ideally suited to protection of the various structures at airport facilities. With the right equipment and proper training, PPV can be used to ventilate aircraft, passenger terminals, hangars, airport hotels, and parking structures.

PPV and Aircraft Fire Fighting

One of the first tests of PPV for aircraft fire fighting was conducted by the fire department at Holmstead Air Force Base in Florida. The purpose of this test was to determine the potential benefits of using PPV on cargo and passenger aircraft fires. Small, portable PPV units were used for these tests.

Their tests produced the following conclusions about the benefits of PPV and how it should and should not be applied:

- To work effectively, the aircraft interior must be closed to allow pressurization by the blower. With too many openings, the blower is not capable of increasing the air pressure inside the cabin.

- PPV is not effective on aircraft crashes or ground fire situations in which ventilation has occurred before fire-fighters have arrived (i.e. doors, hatches, windows are opened, fuselage is broken open or split). This prevents pressurization and allows uncontrolled leaks.

- It is not effective to attempt to close openings after arrival. Interior fog nozzles or large hand lines are more effective using push/pull techniques.

- PPV applied to the center of the aircraft fuselage such as over-wing hatches or belly hatches will work but is not as effective as front-to-rear or rear-to-front ventilation. The best scenario is to have the exhaust opening as close to the seat of the fire as possible.

- When PPV is applied, smoke and heat quickly rise to the upper half of the interior and move toward the discharge openings thereby improving visibility and reducing toxicity and heat in the lower half of the cabin within 20 to 30 seconds.

- The angle of the air cone covering the opening is not critical. It can be from a vertical, horizontal, or varying degree of angle. A flat opening can also be sealed by the PPV cone.

Tactical Ventilation Trials at the Fire Service College, July 28, 1998

Tests on a 737 aircraft fire simulator were conducted during a series of PPV trails at the Fire Service College in Moreton-in-Marsh, England. The objective of the tests was to compare the effects of natural ventilation to the effects of PPV during an aircraft fire fighting operation.

As explained in the report, the 737 had four exits, two at the front and two at the rear. The fire crib was situated approximately ¾ of the way down the fuselage towards the front of the aircraft. The fire load consisted of a single crib containing eight pallets, one bale of straw and a small quantity of diesel fuel.

The first test using natural ventilation resulted in zero visibility within six minutes. When water was applied, the interior became very hot due to steam. Even after the fire was extinguished and the crew had exited the aircraft, visibility above the seat level was nil.

During the second test, visibility was reported to be good during the entire operation. Even when water was applied, the fire fighting crew maintained full visibility and the steam was moving away from them due to PPV.

The final conclusions of the Moreton PPV trials were that PPV resulted in quicker extinguishment of the fire due to greater visibility, less heat and water damage, enhanced firefighter safety, and an improved working environment.

PPV and Large Frame Aircraft

Large frame aircraft can be difficult to ventilate with small PPV blowers. Their large cubic volume can be too great for the blower to quickly ventilate and their access openings are too far above ground to seal with the air cone. It most cases, it is not practical to position a small blower on the wing of an aircraft or on the roof of a fire fighting vehicle.

Because of their high airflow output and elevating capabilities, mobile ventilation units have the potential to dramatically increase an ARFF team's ability to control the environment inside a large frame aircraft.

In May of 2001, tests of the capabilities of the MVU for aircraft ventilation were conducted with the fire department at the Ontario International Airport in Southern California.

For these tests, a stair truck was positioned against the front passenger door and the MVU was positioned approximately thirty feet from the doorway. There was a cross wind of 15-20 mph which did not pose any problems. The rear cargo door of the jet was used as the exhaust opening. Electric smoke generators were run inside the cargo hold until zero visibility was achieved.

A number of evolutions were performed to measure the speed with which the MVU could clear the cargo hold of smoke. The best time was 40 seconds to have good visibility from nose to tail and two minutes to completely clear the cargo hold with no residual smoke visible.

These tests proved that PPV can be used to quickly clear a 747cargo jet of smoke, heat, and gases. In a matter of minutes, there was clear visibility, which would make it easier for fire fighters to locate the seat of the fire and initiate search and rescue operations. The fact that the MVU can be located up to thirty feet from the entrance opening ensures access for fire and rescue personnel.

Passenger Terminals

Disruptions of passenger service can be very costly to airlines. Even a small fire in a trash bin or moving walkway can cause an entire terminal to be shut down. Fixed ventilation systems and smaller PPV blowers can take hours to remove the smoke. A mobile ventilation unit applying PPV can remove smoke or fumes in a fraction of the time and get the terminal back in operation much faster.

A Real Life Example:

On June 29, 1999, an early-morning fire under an automatic walkway at O'Hare International Airport forced the evacuation of one terminal and disrupted flights until the following day. The blaze broke out just after 4:15 a.m. in the corridor connecting Concourses B and C in O'Hare's Terminal 1, which houses United Airlines.

Investigators from the Fire Department later concluded that the blaze originated in the bearings under the moving sidewalk. Burning rubber on the walkway quickly filled the tunnel with dark, acrid smoke and about 100 people, mostly employees, were evacuated from the terminal by police around 4:30 a.m.

As a result of the blaze, 53 departures and 37 arriving flights were delayed an average of 45 minutes. Eighteen flights were canceled. Some delays were as long as two hours.

Testing Data:

In July of 2001, tests were conducted in a passenger terminal at the Dallas Ft. Worth International Airport. For this test, a portion of Passenger Terminal B was filled with cold smoke. A mobile ventilation unit was positioned on the tarmac and a passenger jet way in the middle of the terminal was used as the entrance opening. A jet way at the end of the terminal was used as the exhaust opening.

After starting Positive Pressure Ventilation with the MVU, it took only ten minutes for the terminal building to become pressurized as the smoke could be seen moving towards the exhaust opening. After 20 minutes, the smoke began to clear and visibility improved significantly. After 38 minutes, the terminal was completely cleared of smoke.

A similar emergency involving fumes and odors previously occurred in the same terminal, and had taken four hours to ventilate. The estimated cost to the airline of the terminal closure was $80,000 per gate, per hour (ten gate-hours total).

PPV and Fixed Emergency Ventilation Systems

Many passenger terminals have fixed ventilation systems designed to control the movement of smoke during a fire. PPV is not intended to replace a fixed ventilation system. It is recommended as an alternative or supplement to an existing ventilation system. PPV can be applied in the following situations:

1. **When a terminal does not have a fixed ventilation system in place.**

There are many terminals with no emergency ventilation system installed. The technology was either not available at the time the terminal was built or it was deemed unnecessary by the people who designed it.

2. **When the fixed ventilation system in a terminal is not operational.**

A fixed emergency ventilation system is designed to withstand the extreme conditions that exist inside a terminal during a fire. However, there are limitations to the length of time that it will continue to function in this environment. In the event that a fixed system fails due to prolonged exposure to extreme heat, an MVU is capable of providing ventilation.

3. **To supplement and enhance a fixed ventilation system.**

In some cases, a terminal ventilation system may not be effective for controlling heat and smoke from a fire. The smoke may be in a location that can not be controlled with a fixed system. In these cases, an MVU can be an effective supplement to this system.

Hotels and Other Large Structures

In addition to aircraft and terminal incidents, a mobile ventilation unit can be used to ventilate other large structures found at airport facilities. High-rise hotels, aircraft hangars, underground tunnels, and parking structures can all be ventilated with PPV.

The Hyatt Regency West Hotel at the Dallas Fort Worth International Airport is a typical airport hotel. It has twelve floors, a large below-ground ballroom, and a large lobby area. In July 2001, Tempest Technology worked with the Dallas Forth Worth International Airport fire department to test the MVU in the Hyatt Regency. Two simulations were performed.

For the first scenario, the below-ground ballroom was filled with cold smoke. The MVU was positioned near the rear entrance of the hotel, and a standard man-door was used as the exit point. Once ventilation was started, visibility improved significantly after only two minutes. After ten minutes, the ballroom was completely cleared of smoke.

The second scenario was a test of the MVU's ability to ventilate the upper floors of a hotel while keeping the stairwell clear for victims and rescue personnel. For this test, the entire tenth floor of the hotel was filled with cold smoke. Using the emergency exit stairwell to direct the airflow, the MVU was positioned at ground level, blowing through the main entrance. The doors in the lobby and on the tenth floor were opened to create an exhaust opening. It took only five minutes to completely clear the tenth floor of smoke.

MVU Misting System and Mass Decontamination

In the event of a chemical attack, personnel and property must be decontaminated using water and a neutralizing agent. When large numbers of people are involved, setting up a mass decontamination system can be complicated and time consuming. The misting system of the MVU has shown potential as a fast and effective mass decontamination tool.

By introducing water into the air stream of the blower, a fine mist can be distributed over a large area with enough velocity to effectively wash down contaminated people, vehicles, and equipment. Because the amount of water flowing through the misting system is only 80 gallons per minute (288 lpm), the amount of waste water can be reduced.

The mist can also be used to cool the air during PPV operations and knock down suspended gases. Breaking the water down to a very small droplet size increases the surface area, improving the heat absorption properties of a given amount of water. Water flow averaging only about 275 liters per minute can absorb up to 20,000 kJ of heat per second.

CONCLUSIONS

Positive Pressure Ventilation is a fire fighting tool that offers many benefits to ARFF departments. With the development of larger ventilation tools such as the MVU, PPV can be applied to large structures in ways that were impossible before. As with the development of techniques for the application of PPV for structural fire fighting, fire departments need to share their knowledge and research to develop standards for PPV implementation during ARFF incidents.

1. PPV is a proven ventilation technique that offers clear benefits for fire and rescue personnel when fighting fires at airport facilities. The large structures common at airport facilities can be difficult to ventilate, increasing the risks for fire and rescue personnel. The application of PPV can quickly and effectively reduce heat, improve, visibility, and create a safer environment for fire and rescue personnel. There are also clear benefits to victims.

2. The mobile ventilation unit is an effective tool for applying PPV during airport fires. It is designed specifically for large structure ventilation. Because the MVU can be elevated, it is capable of ventilating large frame aircraft, passenger terminals and hotels.

3. Further research and testing are required to develop operational and tactical guidelines for fire and rescue personnel to follow. As with any fire fighting tool, training and coordination of personnel are important for safe and effective operations.

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