Running head: POSITIVE PRESSURE VENTILATION

Positive Pressure Ventilation; A seldom used tactic to save lives and decrease property loss within Rocky Mount Fire Department

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Certification Statement

I herby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

The problem was Rocky Mount Fire Department does not utilize positive pressure ventilation during initial fire attack on its structure fires. Interior fire crews along with all remaining occupants inside the structure are being exposed to an enormous amount of toxic heat and smoke which could result in serious injury or death. The purpose of this research is to implement research based changes of Positive Pressure Ventilation within Rocky Mount Fire Department to include addressing fire suppression strategies in a manner to prevent death, injuries, and excessive property damage. Descriptive research was used to answer the following research questions:

1. What is Positive Pressure Ventilation in relation to fire suppression techniques and technologies?
2. Why do fire departments utilize PPV or not?
3. What results have fire departments that utilize PPV with fire attack had with its use/implementation?
4. Why do fireground commanders throughout Rocky Mount Fire Department either utilize or not utilize PPV with fire attack?

The procedures employed to complete this research included a review of applicable literature, personal communication with several firefighters on special circumstances surrounding the use of PPV, as well as surveying two separate groups of fire personnel on PPV issues that would support answering the research questions. The result of this study indicated that there was a need for all fire departments to have training on PPV as well as to develop the overall concept to be applied on an as need arises basis. The criteria for application will vary from agency to agency depending on its capabilities of both resources and desires to place PPV

into use but all will have a common goal, which is to protect the lives of the firefighters and victims as well as to minimize property loss. The recommendations for Rocky Mount Fire Department totaled four which were to conduct a department-wide training class on PPV and to follow the class with a hands-on drill session conducted department-wide to support learned skills from the classroom. The third recommendation was for RMFD's management team to review and approve a standing order for RMFD personnel operating on the fireground. The last recommendation was to conduct a PPV usage evaluation approximately one year following the completion of both the department-wide training and standing order implementation.

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Introduction

The fire service is forever changing to meet the demands of today's new construction and design issues along with the problems that arise due to the types of materials used in structures. The significant dangers associated with the new era of construction can lead to an increase in firefighter injury and death as well as occupants that are still trapped inside the structures. Fire Departments throughout the world must address new techniques and tactics to keep firefighters and occupants as safe as possible when dealing with fires inside structures.

In addressing these tactics Positive Pressure Ventilation (PPV) has been at the forefront of some department's toolbox of tactics for many years, yet with other organizations the current theory and practices of PPV has managed to stay in the textbooks alone. The proper understanding and use of PPV is paramount in today's fire service. In November 2003, a Massachusetts firefighter died while engaged in extinguishing a basement fire inside a residence. The order of PPV was called for while firefighters were inside the basement and heat and smoke quickly filled the basement resulting in the death of a firefighter (Tarley, McFall, & Lutz, 2003).

The problem is Rocky Mount Fire Department does not utilize positive pressure ventilation during initial fire attack on its structure fires. Interior fire crews along with all remaining occupants inside the structure are being exposed to an enormous amount of toxic heat and smoke which could result in serious injury or death. The purpose of this research is to implement research based changes of Positive Pressure Ventilation within Rocky Mount Fire Department to include addressing fire suppression strategies in a manner to prevent death,

injuries, and excessive property damage. Descriptive research is used to answer the following research questions:

1. What is Positive Pressure Ventilation in relation to fire suppression techniques and technologies?
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4. Why do fireground commanders throughout Rocky Mount Fire Department either utilize or not utilize PPV with fire attack?

Background and Significance

Rocky Mount is located in eastern North Carolina at the intersection of Interstate 95 and U.S. 64 highway, two major thoroughfares for North Carolina. The town was incorporated in 1867 and the Tar River divided the two counties of Nash and Edgecombe. The City of Rocky Mount was recognized in 1970 and again in 1999 as an All-American city and has a population of about 60,000 people (Rocky Mount Fire Department, 1996).

The town council approved a bucket brigade fire company comprised of 26 men on March 11, 1896. From the bucket brigade, Rocky Mount Fire Department (RMFD) has grown to 150 uniformed personnel of whom 140 operation personnel staff 7 fire stations throughout the city's 43 square miles. In addition to fire suppression, RMFD provides the city with emergency response to medical calls requiring basic level emergency medical response (BLS), hazardous material mitigation, confined space rescue, and swift water rescue (Rocky Mount Fire Department, 1996).

Rocky Mount Fire Department has experienced 5 line of duty deaths since its inception. Three members of RMFD lost their lives due to heart attacks all following training events or structure fires. One member died after attempting to board a fire truck which was responding to alarm activation. One member died from a motor vehicle crash involving the fire truck he was operating (Rocky Mount Fire Department, 1996)

The author noticed that it appeared the majority of the Rocky Mount Fire Department's fireground officers were not using PPV to its fullest potential. This observation was based on time and the number of structure fires the author participated in a supportive role not as an incident commander. Since 1997, the author has taught many Rocky Mount Fire Department Recruit Training Classes on the topic of Ventilation. By the year 2008, the author's perception

of the correct use of PPV and ventilation techniques should have been accepted throughout the department by way of all the new recruits. This was only a thought by the ventilation instructor not an actual survey to support the thought.

During a two week residence class, the author participated in the Executive Analysis of Fire Service Operations in Emergency Management at the United Stated Fire Administration's National Fire Academy. This course is a required course for the Executive Fire Officer Program and is designed to prepare the student in the administrative functions which are necessary to manage the operational component of a fire and rescue department. The classroom and hands-on drills in this class focused heavily of firefighter safety through emphasis on specific incident command roles when dealing with specific types of disasters.

The fire service being the initial provider for most emergency incidents attempts to prepare each member to serve in other specific positions in an effort to support and carry out tasks that normally do not fit into a specific guideline approach to problem solving. In the classroom the students fulfilled different roles in the incident command staff positions which in theory should support the different roles on the fireground normally fulfilled by fire personnel. Positive Pressure Ventilation requires personnel to fill specific roles but communicate and coordinate in the same manner as the Incident Command System (ICS) requires. The author continued to ponder the use of PPV and the effectiveness throughout the RMFD. An instructor for the class described some lessons learned on a major structure fire that his former fire department participated in and reiterated several approaches that also supports PPV's relavenance with RMFD. The first arriving crew has many responsibilities and the Incident Commander (IC) needs to understand his/her role and the major impact it will have with the outcome of the incident. The officer must follow Standard Operating Guidelines (SOG) but have

the flexibility to determine what resources will be needed to mitigate the incident. All of the common approaches to incident management issues supported the need for RMFD to understand the current capability and use of PPV as well as what direction the organization must go to be ready for future emergency incidents (National Fire Academy, May 2007).

The final correlation the author used from the class that matched with firefighter safety and PPV use was the supporting self evaluation tool setup for department to evaluate their abilities to meet critical risks with the community. It is referred to as capabilities assessment. The normal approach is to use a given assessment process to evaluate the organization's community and its ability to meet critical risks identified by the process. The author decided since firefighter safety is paramount on the fireground that RMFD needed to be able to use a viable resource of PPV as a fireground tactic to support both the firefighters and victims inside the structure (National Fire Academy, May 2007).

This applied research supports the United States Fire Administration (USFA) operational objective to "reduce the loss of life from fire of firefighters" (2005, p.3). This research will also be used to meet two goals for students participating in the National Fire Academy's Executive Development Course which were the student seek creative approaches in their jobs and solve real world problems within their jobs (United States Fire Administration, 2005, p. 3).

Literature Review

The purpose of this literature review is to summarize the information other researchers have compiled which is relative to the research questions posed in this ARP. Since virtually the beginning uses of fire, people realized the need for ventilation. As defined by Hall & Adams (1998), "Ventilation is the systematic removal and replacement of heated air, gases, and smoke from a structure with cooler air" (p. 345). As the fire service developed newer and more

advanced techniques in extinguishing fires so arises the need for better and more efficient methods of ventilation. The fire service began introducing different methods of ventilation that complimented the natural progression of fire and smoke travel to support the operations (Hall & Adams).

The simplest method of ventilating a structure from the products of combustion is to use existing wind currents called natural ventilation. This method of ventilation can be accomplished by opening windows, doors, and other existing opening within a structure. There are factors that inhibit the smoke and heat from quickly leaving the structure like wind direction, number and size of openings, proximity of the openings in relationship to the contaminants, temperature differences, and humidity. Therefore, the need to overcome these factors existed for many years (Mittendorf, 1988).

In 1954, Los Angeles Fire Department (LAFD) is credited with becoming one of the first fire department throughout the world for implementing a technique called positive pressure ventilation. LAFD used electric exhaust fans to remove the contaminants in post fire conditions to make the environment safer until they determined that by reversing the action of the fan would improve the environment in a much faster time frame. By simply using the fan to blow fresh air into the structure accompanied by other supporting fans greatly improved the environment inside the structure ("The history of positive pressure ventilation", 2002).

The many experiments and test fire conditions conducted by LAFD resulted in the indentified benchmark of the one-third horsepower electric fans were not substantially powerful enough to overcome the larger structure’s contaminants. A member of LAFD and one of the pioneers of the current company of Tempest Technology, Inc. identified that the industrialized blowers used to inflate hot air balloons could be used for the fire service. This conversion of fans

from electric power to combustible gasoline engines began the revolution of what the fire service denotes today as positive pressure blowers (Garcia, Kauffmann, & Schelble, 2006).

Positive pressure ventilation use has grown over the years since its inception in the mid 1950s. In 1999, review of the market in the UK resulted in 42 % of the fire brigades were using PPV and the researchers predicted that amount to double by 2001. With the 42 % of UK fire brigades using PPV, 27 % were using it with initial fire attack. In the US 67 % of the users of PPV were using it with initial fire attack (Grimwood, n.d.)

As of the early 2000, PPV was used in the majority of the department in Germany but in the minority of the departments in Holland. Due to the majority of the building construction materials in the UK of masonry and tile, PPV has grown in use since it is very difficult to create ventilation ports in roofs and walls (Rimen & Thomas, 2000).

The theory behind positive pressure ventilation is that air will travel from a higher pressure to a lower pressure in an attempt to reach equal pressure. A blower is placed forcing air into a structure which due to the blower speed, size, and position will create a higher pressure than what is currently inside the structure. The pressure is then released to the exterior of the structure by means of exit opening in an attempt to reach equalization. By controlling the amount of air at the entrance and the size and number of exit openings positive pressure is created. This theory is also compared to the release of air from a balloon or a person inhaling and exhaling during the process of breathing (Garcia et al., 2006).

Kriska (2001) also supports the same concept by referring directly to the ideal gas law of maintaining a confined area of higher pressure inside the structure. When the exit is made the higher pressure will flow to the area of lower pressure. The products of combustion will follow the path of least resistance to the area of lower atmospheric pressure.

The majority of the focus on blower pressurization at the entrance point of the structure is based on the blower facing the entry point and set back from the entrance enough to effectively cover the opening with the cone of air. The cone is invisible but can be distinguished by the operator's hand being placed on the outside of the entry point and physically noting the amount of air striking the hand verses inside the entry opening. The distances will vary depending upon the blower size and the entry opening size (Mittendorf, 1988). Pidgeon and Zingheim (1999) recommend another method called entrainment. This method opposes the previous method by placing the blower close enough to the entrance not to seal the opening but to pull air around the blower which seals the opening. This method pressurizes a building by forcing large volumes of air throughout the structure similar to the previous method just varying the setup at the entrance. The author did not indicate whether this method of pressurization would be effective if used for fire attack opportunities just that the effectiveness would vary depending upon present conditions.

The recommended operational sequence for introduction of positive pressure ventilation into a structure for the purposes of smoke removal is depicted the same by the researchers Goodson, Adams, & Sneed (1994) and Mittendorf (1987). They recommend covering the entrance opening with the cone of air emitted from the blower which will determine the exact location/position of the blower. Then control the exit or exhaust opening to maximize the efficiency of the blower. This recommendation is one to two times the size of the entrance opening. Then control the air flow between the entrance and exit openings by opening and closing interior doors.

A good example of the application of blower size verses size of the structure is depicted by taking a 1,800 square feet single story structure and showing the difference in blower

requirements. A single 18 inch blower powered by a 2-3 horsepower motor would be sufficient if the exhaust opening is maintained from three quarter to same size as the entrance opening. If the same blower was powered by a 5 horsepower motor the exhaust opening could range from one to one-half the size of the entrance opening. If multiple blowers of the same size in both blade diameter and horsepower were used in conjunction the exhaust opening could range up to one and three quarters the size of the entrance opening. It is simple to see the large the blower in size and horsepower the greater the required exhaust openings (Mittendorf, n.d.).

Paul Grimwood (n.d.) recommends five basic principles to implementing PPV. Blower capability is the first principle which is determined by the purchase needs and limitations. Blowers are rated by the cubic feet per minute which is the amount of air they are able to move over a given interval. Fan placements and configurations is the second principle but is not detailed in the article. Discharge opening which is the size and location of the exit orifice(s) that the contaminants are being released from the structure is the third principle. Wind direction and effects are the forth principle which denotes that wind speed as low as six miles per hour may change the effectiveness of the ventilation technique. Crosswinds as well as tailwinds may also affect the performance of the blower which adds to the considerations during ventilation practices. The last principle was sequential ventilation which is controlling of interior and exterior openings in order to control the movements of the contaminants from the structure.

There have been many studies conducted on PPV in an attempt to better understand its use and its potential in fireground situations. In a report on PPV use in the US and UK from Rimen & Thomas (2000), there was no evidence to suggest that PPV did not lead to an increase in backdraft conditions nor did it increase the potential for a flashover. The research showed significant reduction in the flashover potential. With this information many departments were led

to experiment with PPV use with initial fire attack. This coincides with Pidgeon and Zingheim (1999) that stated the main purpose of the initial fire attack crew is to support the rescue operation by containing or extinguishing the fire while maintaining the escape routes for all occupants. Effective early ventilation presence offers an array of support in accomplishing such goals as quick rescue, confinement and extinguishment of fire, and maintaining escape routes for all occupants.

The controversy does not seem to arise with smoke removal; it is when firefighters make entry into a burning structure. The stories and theories tend to conflict when the question arises of entry with or without PPV. Experts across the US and UK express their concerns with entering a structure with PPV on initial fire attack in many different ways. Garcia & Kauffmann (2005) say that the difference between PPV and Positive Pressure Attack (PPA) is that PPV is used for post fire knockdown primarily for smoke removal and PPA is deployed initially prior to the fire attack crew entering the structure. They go on to explain that many fire departments unless they have embraced the PPA position still use PPV in its conventional approach of post fire knockdown.

In a continuous approach to technology improvements and advancements, since the PPV blower's conception, different organizations continue to experiment with the tool. The National Institute of Standards and Technology (NIST) under the United States Department of Commerce conducted many actual fire tests to evaluate PPV's effectiveness. NIST (2008) reported that when PPV was introduced to the fire room that the maximum ceiling temperature increased 100 degrees. The temperature was 1100 degrees without PPV and 1200 degrees with PPV. PPV did increase the burn rate by 60 % but it was all outside the room of fire origin (exterior window). The flame extension increased from three feet without PPV to six feet with PPV outside the

building at the exit point. In conclusion NIST recommended in order to increase firefighter safety once the ventilation process had taken place delay the interior fire attack crew for 60 seconds before allowing them to enter the environment.

In another test conducted by NIST on PPV with one room on fire, the results showed that lower gas temperatures in both the room and the adjacent corridor during the use of PPV. The gas velocities were higher in the PPV experiment than the same fire with natural ventilation. The higher velocity significantly increased visibility. PPV did cause a heat release rate increase for 200 seconds at the initial initiation of PPV but the heat declined at a faster rate than the naturally ventilated experiment. NIST also recognized that it took 60 to 90 seconds for the fire to reach a peak burn rate. NIST recommends that firefighters should delay their entry based on this experiment from 60 to 120 seconds before entering the fire (Kerber & Walton, 2005).

Similar tests were conducted in the UK in 1996 to identify PPV effectiveness with fire attack. The testers found that the effects of natural wind currents affected PPV effectiveness and that a ratio of 2/1 on the entrance/exit ports should be maintained. Creating the exit point in the fire room will minimize the fire spread along with PPV accompaniment. Post fire smoke removal was very successful in both removing the contaminants and cooling the atmosphere inside the room. The use of PPV with initial fire attack operations was suitable for typical domestic structures especially ground floor fires (Rimen & Thomas, 2000).

In conjunction with increasing firefighter safety the issue of occupant safety is raised. Paul Grimwood (n.d.) denotes the issues of possible occupants caught between the entrance and exit point in a structure involved with fire. The author identifies the increased risk of injury to the victims as very important especially if PPV is not used correctly; however, the benefits that PPV bring far outweigh the risks. To be more specific, using PPV where the exit point of PPV

may be the same window location where the victim is standing is not recommended. The same would go for the occupant that is lying close to the exit opening. When PPV is introduced the heat, fire, and smoke will fill the room from top to bottom including the victim's location if near the exit point. These two scenarios are if the victim(s) are at or near the exit point. Grimwood remains open to say that it is far from proven that total PPV with fire attack applications are unlikely to worsen a trapped occupant's situation since the variables are so vast. Garcia & Kauffmann (2006) recommend precaution is duly warranted when the commander is considering PPV with fire attack. A significant precaution is when the firefighters or victims are standing at the windows which may/will become an exit opening. They recommend to not us PPA if the victim is standing at the window. If the victim is visualized following the initiation of PPA then advise the victim to close the door to avoid that particular window becoming an exit point for the fire. Safety of the firefighters as well as the victims is paramount when considering PPV with fire attack.

According to Turpin & Bowser (2000), several tests were conducted by the National Positive Pressure Ventilation Liaison Group in the UK in order to see what the effects of PPV could have on a casualty located between the fire and exit opening. Tests were conducted on a casualty mannequin when it was located between the fire and the exit opening. A polymer skin was used to cover the mannequin to show results near that of a human. Following the tests there was no change to the mannequin's polymer skin. The results of the test were that PPV reduced the heat level by 67% in 30 seconds and the CO level by 65% in 60 seconds. The use of PPV would cause less harm to the victim as compared to that of fire itself in the same timeframe of normal firefighting activities.

When considering other precautions on PPV, Garcia & Kauffmann (2006) recommend that PPV should not be introduced following firefighters entering the structure. Either use PPV prior to entry or remove all firefighters from the structure before establishing PPV. Since PPV creates higher pressures inside the structure the contaminants will move to the area of decreased pressure which is the exit opening. If firefighters are between the entrance and the exit opening it is possible they could be exposed to extreme high heat and toxic products.

On November 29, 2003 a firefighter from Massachusetts died in a basement fire. National Institute of Occupational Safety and Health (NIOSH) reports that the victim and another firefighter were working in a basement that was involved with fire but had been noted that the fire was knocked down. A request for ventilation was made from the interior Deputy Chief to the Incident Commander so PPV was initiated from the front door. The basement windows served as an exit opening. Before the interior crew could evacuate the entire basement was filled with thick black smoke and heat. The fire hampered the rescue efforts for the interior crew. In the report by NIOSH was along with many additional recommendations that the fire department ensure that ventilation efforts are closely coordinated with fire attack (Tarley, McFall, & Lutz, 2003).

Garcia and Kauffmann (2006) along with Grimwood (n.d.) addressed several areas of concern that PPV not be used like potential backdraft situations as well as combustible and flammable atmospheres. Due to the highly explosive atmospheres in both situations and issue of the influx of fresh air and/or the use of tools with possible ignitions sources blatantly point out the need for different methods of ventilation to handle the situation.

According to the authors, Garcia and Kauffmann (2006) along with Grimwood (n.d.), they support all of the positive advantages to PPV that are not contradictive in the articles. PPV will increase potential of victim survivability, ease of search and rescue, decrease time to locate

and extinguish the fire, decrease the potential for a flashover to occur, and should reduce both fire spread and property damage.

Turgeon (2004) recommends a word to help fire ground officers decide whether to use PPV and the word is LELO. Life means to evacuate every person from the structure prior to initiating PPV. Explosion means to assure there is no potential for an explosion. Locate means to locate the fire or PPV efforts that will be useless and Okay means you have worked through the previous letters and you have no problems establishing PPV. This was the only acronym the author found using PPV with fire attack to assist fire ground commanders make the decision whether or not to use PPV.

Tempest Technology Corporation (1998) produced a video along with Salt Lake City Fire Department on the usage of PPV during initial fire attack operations. They stated there are eight guidelines to correctly deploying effective PPV with initial fire attack. The first step is for the crew that is using the tactic to have thorough knowledge of fire ground ventilation practices and PPV. The second step is to have charged fire hose lines in place ready for entry. The third step is to assure a backdraft is not present. The fourth step is to establish an exit opening as close to the seat of the fire as possible. The fifth step is to correctly setup the blower at the entrance and confirm a good door seal. The sixth step is a guide that most residence can be ventilated using one blower of 21” or great and large commercial structures will take two or more blowers depending upon the size of the structure. The seventh step is to enter the structure on the attack line a few seconds following blower placement. The corporation recommended allowing the smoke and heat time to move from the entrance opening prior to entry. The eighth step is to maintain an open entrance to assure maximum effectiveness is gained from the blower.

When considering entry time of the fire attack from the point at which the blower is set and entry point made to the time that the crew actually enters the door varies by different authors. Carlson (1988) recommends that attack crews should enter the building no more than 15 seconds after starting PPV. Garcia, Kauffmann, and Schelble (2006) recommend advancing the attack line after approximately 30 seconds. The 30 seconds allows enough time for the contaminants to clear the opening. NISTA (2008) recommends delaying the initial attack crew for 60 seconds in order to increase firefighter safety and Kerber and Walton (2005) recommended delaying entry from 60 to 120 seconds before entering the fire.

The authors of *Positive Pressure Attack for Ventilation & Firefighting* have published recommendations on how to deploy PPV with a minimum of a three person company. Recommendations have not been found in all other PPV resources used in this literature review. Most simply refer to a company assignment and leave the rest to the reader and their respective organization (Garcia et al., 2006).

The last review of special circumstances that will be addressed is the best solution to dealing with PPV and attic fires. Mittendorf explained when he addressed attic fires that prior to the implementation of PPV into a structure with a possible attic fire the situation should be thoroughly evaluated. The mere presence of attic ventilation vents is a major consideration. If the fire has involved the attic or the vents are capable of moving enough air to allow the fire in the attic then PPV should not be used until attack lines are in place. If the attic does not have attic vents then PPV should be used because the spread of the fire is not a large concern (Mittendorf, n.d.).

Garcia & Kauffmann (2006) addressed PPV with attic fires from the stance if the fire is in the attic alone use PPV on the lower level(s) to keep the fire in the attic. The higher pressure

should keep the fire and smoke from traveling back in the living quarters. Fire crews should make a small opening from below the attic to help maintain the contaminants in the attic and protect themselves. If the fire has breached into the attic but the exhaust opening is not made in the attic the fire should not travel further or gain headway in the attic. The fire and heat should continue to follow the path of least resistance on the lower level. This same concept is applied to balloon construction houses and fire in void areas.

The author also references a personal communication interview with a live fire instructor on a live fire training scenario that took place on May 05, 2008. A training fire was set inside a residence kitchen area simulating a stove fire that had breached the ceiling into the attic space. The attic did not have exit opening other than the normal soffit vents. Prior to completely extinguishing the fire a crew accessed the attic space to see what the fire was doing with PPV and found the fire was very visible through the breached opening and was burning clean and only the surrounding area of the breach opening. The fire did not appear to be growing since it did not have an exit opening. The complete exercise supported the idea of Garcia and Kauffman (2006) that without an exit opening fire that has breached into the attic is not a large concern and should not stop the use of PPV. If allowed to burn uncontrolled without being investigated then damage to the attic space maybe sustained (Mutzabaugh, personal communication, July 25, 2008).

The author also conducted another interview with a Fire Engineer Alvin Bailey that works with Rocky Mount Fire Department on a structure fire that took place on July 02, 2008. Bailey reported that flames were visible from one room at the rear of the structure prior to entry on the attack team. The incident commander established PPV with fire attack due to the fire appearing to be the normal room and contents fire. The fire responded appropriately to the PPV and the crews had positive reviews on clear visibility and lack of heat presence. During the fire

investigation the crew found the dropped ceiling and the existing ceiling had been consumed by the fire and allowed fire to the attic space through the existing fire room. The fire was never pushed out the soffit vents or through the remaining portion of the attic which also supports the previous recommendations when dealing with attic fires (Bailey, personal communication, July 02, 2008).

This literature review provided an overview of the information that is relevant in the functionality and use of PPV through the eyes of many people across the world. The information is also relevant in defining the continued use of PPV along with the often arising special circumstances. It is evident that the controversy across the US is not on PPV and the process and reliability or removing smoke from structures. The issue is with the lack of uniformity which arises when people attempt to use PPV with fire attack or face special circumstances during fire attack tactics. The decision to use PPV with the possibility of victims still inside the structure still remains debatable. The foundations for PPV with attic fires and the concrete entry time intervals for firefighters to enter the structure were denoted in the literature review but further examination should continue in both the research and actually fireground training as depicted by the respective authors used in the literature review. This information influenced this project by providing an overview of how other agencies view and use PPV in their fireground operations.

Procedures

The procedures for this topic began when the author noticed that it appeared the majority of the Rocky Mount Fire Department's fireground officers were not using PPV to its fullest potential. This observation was based on time and the number of structure fires the author participated in a supportive role not as an incident commander. By the year 2008, the author's perception of the correct use of PPV and ventilation techniques should have made it throughout

the department but it did not appear the said was present. This was only a thought for the author not an actual survey to support the thought.

During a two week residence class, the author participated in the Executive Analysis of Fire Service Operations in Emergency Management as stated in the Background and Significance portion of the paper. Since this class focused heavily of firefighter safety the PPV issue continued to arise the author continued to ponder the use of PPV and the effectiveness throughout the RMFD. The first arriving crew has many responsibilities and the Incident Commander (IC) needs to understand his/her role and the major impact it will have with the outcome of the incident. The final thought the author used from the class that matched with firefighter safety and PPV use was the supporting self evaluation tool setup for department to evaluate their abilities to meet critical risks with the community in this case internal department evaluation. The author decided since firefighter safety is paramount on the fireground that RMFD needed to be able to use a viable resource of PPV as a fireground tactic to its fullest potential to support both the firefighters and victims inside the structure (National Fire Academy, May 2007).

The author utilized meal breaks and afternoons to socialize with the class participants and found that throughout the class several other organizations appeared to struggle with similar PPV problems. With confirmation on the topic of PPV and its current use and the potential lack of true understanding of its capabilities, the author decided to begin researching the topic. The bulk of this information was to be used for the literature review section of this document. Time was spent in the Learning Resource Center (LRC) which is located on the campus of the National Fire Academy in Emmitsburg, Maryland. The online card catalog located in the LRC was used to search for articles and books that supported Positive Pressure Ventilation. The sources ranged

from current periodicals and a few books that dealt directly with PPV from the US and European countries. There was a considerable amount of information on the topic regarding PPV. Some photocopies were made of current articles in journals, and relative sections of various executive fire officer program research papers and relative material found in books. Much of the data was collected in March, 2008. The internet was used to gain further information that was not available through the LRC. The internet was a great resource which provided a variety of sources on the subject matter.

Then the author began a thorough review of all the literature collected. This was done to give the author more insight and knowledge about the subject. Articles were outlined to highlight the information that was directly related to this purpose of the research paper. The purpose of this research is to implement research based changes of Positive Pressure Ventilation for Rocky Mount Fire Department to include addressing fire suppression strategies in a manger to prevent death, injuries, and excessive property damage.

The author also conducted two personal interviews with RMFD personnel that actively participated in two specific structure fires in which PPV was used and had supporting results with its use. The first interview was conducted on May 10, 2008 with RMFD Fire Engineer Brian Mutzabaugh following a live fire training exercise. Mutzabaugh was chosen to be interview because of his live fire training background which included PPV experience and his position and assignment during the specific PPV test. The interview followed a PPV evaluation sheet developed by the author for this particular burn. A sample of the evaluation sheet which includes the questions asked during the interview is located in Appendix D.

The second interview was conducted on July 02, 2008 with RMFD Fire Engineer Alvin Bailey following an actual residential structure fire. PPV was used with the initial fire attack of

the fire and Bailey was instrumental in setting up the ventilation and making entry on the initial fire attack hand line. The same evaluation sheet was used to conduct this interview so refer to Appendix D for reference to the questions used during the interview.

With the background and supporting information attained from the review of the articles completed, the author needed to know how other fire departments of equal size and operation conducted the tactical use of PPV. The author developed a survey to gather information of the current usage of PPV to help compare RMFD's approach to other departments. The survey was developed using pertinent questions the author deemed necessary to compare organizations. The questions would also help answer the research questions: Why do fire departments utilize PPV or not? and What results have fire departments that utilize PPV with fire attack had with its use/implementation?

The first survey was created and placed on an internet site (www.surveymonkey.com) to easily accommodate both the author and the persons completing the survey. A copy of the survey distributed is located in Appendix A of this paper. Please refer to the appendix to review the questions used for this survey. The survey was designated for all executive fire officers that were participating in the EFO at the NFA. The survey was sent to a representative of the NFA but the distribution to all the candidates was no longer available. Since the author has completed three years in the program of EFO, he located 22 former classmates that represent fire departments throughout the United States & Canada to participate in the survey. The representatives all had prior knowledge of PPV and were located in different areas of the United States and Canada so representation of the US on a small scale could be presumed. The classmates represent both career and combination fire departments. Of the 22 classmates surveyed, the author received a 100% participation in the survey. The results of the survey did provide the author with the

needed information to answer the research question. The results of the survey are listed in the results section of this paper.

The author developed a second survey to gather information of the current use of PPV throughout RMFD. The author needed to identify how the current fireground commanders considered using such a concept as PPV. The survey was developed using pertinent questions the author deemed necessary to compare RMFD with other organizations as well as to the literature that was revealed through the research efforts. The questions would also help answer the research question: Why do fireground commanders throughout Rocky Mount Fire Department either utilize or do not utilize PPV with fire attack?

The second survey was created and placed on the same internet site to easily accommodate both the author and the person completing the survey. A copy of the survey distributed is located in Appendix C of this paper. Please refer to the appendix to review the questions used for this survey. The survey was directed to only Battalion Chiefs and Fire Captains in the RMFD. Since these particular personnel are the current fireground commanders the author thought it only pertinent to get distinctive feedback from the selected personnel. The officers were sent an email disclosing the requested information along with the web link to the internet survey site see Appendix C. The survey was sent to 30 officers and 22 officers replied to the survey. The author did not receive the recommended 28 responses to meet the 95 % confidence level; however, in the 22 people that did reply the author gained a lot of insight with the knowledge and use of PPV within RMFD.

The research and analyses were limited to the articles and text reviewed by the author. For the most part, limitations were self imposed. The researcher decided to limit the greater portion of the material from 2000 to present. However, some data, such as information on the

history of PPV, concept or theory of PPV and basic setup process of PPV, had to be retrieved from earlier dated documents. With current material, the author could get a reasonable idea of what other departments were presently doing with regard to PPV. There was a considerable amount of information on the topic regarding PPV but very limited information on PPV with specific circumstances like use with fire attack or considerations when dealing with significant extension outside the residence or in the attic. The research articles that were conducted outside of the US on special circumstances involving PPV were outside of the normal accepted range of current resources but were used since the tests were conducted by persons not directly affiliated with the United States. The first survey conducted the author received 100 % participation but the second survey resulted in 73 % participation. The limitations for the secondary survey were some part due to vacations and sickness but most impart on the officers simply refuse to participate.

The most significant limitation encountered was the fact that the amount of lives saved by positive pressure ventilation will never be known. It is a proven method that does lend itself to measurement but every fire will burn different along with victim placement will vary as well. The only constant to PPV according to the literature is the sound theory and proven experiments conducted thus far that truly produce concrete results.

Definition of Terms

Flashover – the point at which the heat in a given area is high enough to ignite all the flammable material simultaneously (Hall & Adams, 1998).

Backdraft - an explosion or rapid burning of the heated gases which results from the introduction of oxygen into a building that is oxygen deficient and is heavily charged by heat and smoke from a fire (Hall & Adams, 1998).

NIST – National Institute of Standards and Technology is a non-regulatory federal agency within the U.S. Department of Commerce. NIST's job is to promote innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve quality of life (Kerber & Walton, 2005).

NIOSH - The National Institute for Occupational Safety and Health (NIOSH) is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH is part of the Centers for Disease Control and Prevention (CDC) in the Department of Health and Human Services (Tarley et al., 2003).

Results

The results of this study indicate that there is a need for all fire departments to have training on PPV as well as to develop the overall concept to be applied on an as need arises basis. The criteria for application will vary from agency to agency but all will have a common goal, which is to protect the lives of the firefighters and victims as well as to conserve property loss. In the past, PPV was developed and intended to be used for smoke removal only. The fire service has approached PPV with somewhat of the same determination as many other fireground issues and obstacles which is to take an idea or process and refine it to make it work on the fireground for many different circumstances ("The history of positive pressure ventilation", 2002).

Research Question 1: What is Positive Pressure Ventilation in relation to fire suppression techniques and technologies?

PPV was originally developed by LAFD in 1954. They continued to support the ventilation effort but changed the focus of negative pressure ventilation to PPV by forcing clean air into a structure ("The history of positive pressure ventilation", 2002). The idea of blowing air

into a structure was pioneered, evaluated, and revolutionized by LAFD along with help from one of the founders of the company known today as Tempest Technology. The change from electric smoke ejectors to gasoline powered blowers is credited to this group (Garcia et al., 2006).

In 1999, 42 % of the United Kingdom was using PPV and 27 % of them were using PPV with fire attack. In the US 67 % of the departments using PPV were using it with fire attack (Grimwood, n.d.)

A blower is placed outside the structure and blows air into the structure casing the pressure inside to build higher than normal atmospheric pressure. The size of the entrance and the size of the exit are crucial to maintain PPV. The recommendations are to maintain the exit opening one to two times the size of the entrance opening. The air flow is then controlled by the opening and closing of doors inside the structure (Mittendorf, 1988).

NIST PPV tests concluded with live fire scenarios that there was an increase in ceiling temperatures by 100 degrees Fahrenheit and an increase in the burn rate by 60 % outside the burn room when PPV was used. Flame extension increased from three to six feet with PPV use (NIST, 2008).

In a report on PPV use in the US and UK from Rimen & Thomas (2000), there was no evidence to suggest that PPV did not lead to an increase in backdraft conditions nor did it increase the potential for a flashover. The research showed significant reduction in the flashover potential. Several authors recommend not initiating PPV used if there was a visible victim at a window due to the possibility the window would become an exit opening. If a victim was trapped or lying between the entrance and exit opening PPV should not worsen the situation only increase their chances of survival (Grimqwood, n.d.; Garcia et al., 2006). The test results from Turpin & Bowser (2000) showed no change in the mannequin’s skin when the victim was placed

between the entrance and exit opening and PPV was used. PPV reduced the heat by 67 % in 30 seconds and the CO level by 65 % in 60 seconds.

It was recommended that PPV not follow firefighters entering the smoke filled environment of a structure (Garcia & Kauffmann, 2006). The NIOSH also demonstrated the tragic effects if PPV is introduced to a smoke filled environment and firefighters are inside the structure (Tarley et al., 2003).

Carlson (1988) recommended that attack crews should enter the building no more than 15 seconds after starting PPV. Garcia, Kauffmann, and Schelble (2006) recommend advancing the attack line after approximately 30 seconds. The 30 seconds allows enough time for the contaminants to clear the opening. NISTA (2008) recommends delaying the initial attack crew for 60 seconds in order to increase firefighter safety and Kerber and Walton (2005) recommended delaying entry from 60 to 120 seconds before entering the fire.

PPV use with attic fires should be thoroughly evaluated prior to introducing the blower. If the attic has attic ventilators or large vents this may deter the call for PPV due to the potential for vents to become exit points (Mittendorf, n.d.). Garcia & Kauffmann (2006) recommend PPV use with attic fires if the fire is contained to the attic space and the lower levels become defensible space for the firefighters. The continued use of PPV should support the firefighters. The personal communication with Bailey (July 02, 2008) and Mutzabaugh (July 25, 2008) also supported if fire is in the attic space and there is no exit opening inside the attic space PPV should not intensify the fire which is similar to the structure with major void areas and balloon construction.

Research Question 2: Why do fire departments utilize PPV or not?

The research questions on the survey that was sent to the NFA participants representing fire departments throughout the US provided support for research question 2. To assist in the ease of interpreting and understanding the data collected from this survey a percentage graph for each of the specifically answered questions are located in the appendix section of this project. Several of the questions for this survey were essay type which allowed the respondent to elaborate on their answers. The responses due to their length are also listed in Appendix B. The first survey question was: What type of organization do you represent? The results were that 59.1% of the respondents were combination department and 40.9% were representing career departments.

The second survey question was: What type of apparatus are your blowers transported on to the scene? The results were 86.4% were transported on engines companies, 72.7% were transported on ladder companies, 13.6% were transported on squad companies, and the remaining 9.1% of the department's blowers were transported on other types of apparatus.

The third survey question was: To what extent is Positive Pressure Ventilation used within your organization on structure fires? The response for PPV use for smoke removal with post fire conditions were 38%. The response for PPV use with initial fire attack was 62%.

The forth survey question was: Considering structure fires only, what is the percentage of use that positive pressure ventilation is deployed in initial fire attack operations? Of the responses 50% or 11 departments use PPV 0-25% of the time. There were 4 departments or 18.2% that used PPV 26-50% of the time along with the same response for 51-75%. The remaining 3 departments or 13.6% used PPV 76-100% of the time.

The fifth survey question was: Does specific positive pressure ventilation assignments have to be made to put this method of ventilation in place or is it a standing order of the

ventilation assignment? The department's response are all listed in the Appendix B and the response ranged from 16 responses of an assignment made by the incident commander and 6 responses of its use was based on standing orders.

The sixth survey question was: When positive pressure ventilation with initial fire attack is made, what time interval is used prior to the attack team making entry into the structure? Of the 22 respondents only 14 answered the question and 8 skipped the question. 1 department used 0-5 seconds, 3 departments used 5-15 seconds, 5 departments used 15-30 seconds, 2 departments used 30-60 seconds, and 3 departments used 60+ seconds.

The seventh survey question was: Does your organization use positive pressure ventilation on a structure fire with confirmed fire extension in the attic? Of the 22 responses, 13 stated no and 9 stated variable answers with certain situations or circumstances. See Appendix B for all the responses.

The eighth survey question was: How many personnel are assigned to place positive pressure ventilation with initial fire attack in place? Of the 22 respondents for the survey only 20 answered the question and 2 skipped the question. 15 departments use 2 personnel to establish PPV with fire attack, 4 departments use 3 personnel, and 1 department use 4 personnel. No response for 5 and 6 personnel used in establishing PPV with fire attack.

The tenth survey question was: Does your organization use a standard operating guideline for positive pressure. Of the 22 responses 16 departments or 73% stated they did not use an SOG and 6 departments or 27% stated they do use SOG for PPV.

Research Question 3: What results have fire departments that utilize PPV with fire attack had with its use/implementation?

The same survey was used to support this research question by using the ninth survey question. The survey question was: What are some positive and negative results your organization has experienced when considering positive pressure ventilation with fire attack? There were 22 full responses for this question. Most of the responses are long and they all vary in range so refer to Appendix B for details on the responses.

Research Question 4: Why do fireground commanders throughout Rocky Mount Fire Department either utilize or not utilize PPV with fire attack?

The survey that was sent to Rocky Mount Fire Department fire ground officers as detailed in the procedure section of this paper was used to answer this research question. The survey consisted of all essay type questions to allow the officers to respond with full informational based answers. Most of the responses are long and they all vary in range so refer to Appendix D for details on the responses.

Discussion

The author used Mittendorf (1988) and Pidgeon and Zingheim (1999) to describe PPV's still current setup procedure used for smoke removal from structures. Garcia & Kauffmann (2005) also supported the same basic principles used to establish PPV for smoke removal. Grimwood (n.d.) reported five basic principles to establishing to implementing PPV which is very similar to that of the other previous authors. The interesting part is when firefighters actually enter a burning structure with PPV's assistance. The author identified a couple of issues that may cause problems with establishing PPV with fire attack tactics like if a known victim was inside the structure and if the fire is confirmed to be in the attic space.

During the Literature Review NIST (2008) reported the ceiling temperature increase in the fire room was only 100 degrees more with PPV than not using it. They also noted the burn

rate increase with PPV but it was all outside the room of fire origin. This plays a large role when a fireground commander has to decide to use or not to use PPV. The test reported by Turpin & Bowser (2000) that PPV use with possible victim located between the entrance and the exit point showed no change to the mannequin's skin. PPV reduced the heat level by 67 % in 30 seconds and the CO level by 65 % in 60 seconds.

The reports definitely support PPV use with fire inside a structure along with the improvements it contributes just as seen in the simple smoke removal process. The author believes the victims that are in the room of origin are most likely deceased and if they are not, by the test conducted above, PPV has demonstrated should support life by lowering the temperatures and quickly removing the contaminants. The authors Garcia & Kauffmann (2006) as well as Grimwood (n.d.) recommend not using PPV with fire attack if the victim(s) is located in an opening like a window due to the likelihood of the opening becoming an exit point for the fire and contaminants. The author agrees with this approach as this would consistently or routinely support normal fireground rescue operations of removing obvious victims from the structure.

The use of PPV with fire attack with changing the entry time of firefighters at which the blower follows the fire attack crew was addressed by Garcia & Kauffmann (2006). They stated to either use it prior to the fire attack crew entering the structure or remove all firefighters from the structure and then establish PPV. The NIOSH report of the firefighter death in Massachusetts in a basement fire which was written by Tarley, McGall, & Lutz (2003) supported this action at the highest price – firefighter death. Requesting PPV with firefighters still inside the structure is significantly dangerous and unpredictable. The author believes it is unpredictable from the standpoint of thermal balance upset, changing exit routes by crews inside along with conflicting

signs of fire extinguishment between inside and outside crews. This proves ventilation, especially PPV, is a systematic and coordinated effort by all participants.

This incident compared to the above information on victim location and exit points allows an interesting issue to surface like the difference between the Massachusetts firefighter and a victim. This comparison could be very detailed in major differences in the test conducted and the firefighter's death but one thing is given. It is that every fire will be different due to many factors and that exact guidelines for PPV use with victims (potential or confirmed) will have to be addressed on an individual case by case basis.

The Literature Review provided information on PPV use with attic fires. Mittendorf (n.d.) recommended to thoroughly evaluate the situation and attempt to identify if the attic space had attic vents. The vents have the potential to draw fire to them due to there ability to move volumes of air. Garcia & Kauffmann (2006) address attic fires from the stance if the fire is in the attic use PPV to keep it in the attic. The PPV will provide a defensible space for the firefighters to work from to keep them separate from the containments.

The personal communications with Mutzabaugh on July 25, 2008 and Bailey on July 02, 2008 also supported PPV use with attic extension. Both the interviews supported that if conducted correctly PPV would help maintain a tenable atmosphere in the area below the attic and the fire would not grow if the exit point is not in the attic area. The survey question that the EFO participants answered identified the use of PPV on a structure fire with confirmed fire extension in the attic. There were 20 respondents to the question out of a potential 22 participants and the answers were essay form which ranged from 13 respondents answering no to attic use to 9 respondents that had variable answers. The variable answers addressed issues like the amount

of fire extension, fire attack's readiness with attack hose lines, spreading the fire, leaving the decision up to the IC, etc.

The author draws several conclusions to PPV with attic fire use. Each department/fireground commander may view fire progression differently and PPV application to special circumstances too unique to support a standing order of PPV use with every attic fire. Most fireground commanders should be open minded to support changing tactics to increase life potential or property conservation. Due to building construction differences, departments must train in the different types of construction and be able to identify major problems to ease the decision of PPV use.

The Literature Review provided information from the inception of PPV to its current use based on the articles and reports reviewed. The history of PPV is dated back to LAFD in 1954 where negative pressure became positive pressure and blower capabilities began to change ("The history of positive pressure ventilation", 2002). The author used Mittendorf (1988); Pidgeon and Zingheim (1999) to describe PPV's still current setup procedure used for smoke removal from structures. Garcia & Kauffmann (2005) also supported the same basic principles used to establish PPV for smoke removal. The interesting part is the time span between 1954 and 2008 and some departments still do not understand PPV's use for smoke removal. This conclusion is based on several points that are derived from the respondents of the survey questions. Out of the 22 respondents that replied to the survey question on the extent of PPV used within the organization for smoke removal or fire attack 14 departments only use PPV for smoke removal. In the same survey, question 6 on the time interval for the fire attack crew to wait prior to entry 8 respondents did not answer the question to show they do not use PPV with any type of fire attack options.

In 1999, the UK reported only 42 % of the fire brigades use PPV. In Germany the majority of the departments used PPV but in Holland it was the minority of the number of departments used PPV. This data was collected in 1999 so one can only imagine how the numbers would report today with the use of PPV. The same concern arises is the time it takes for departments to grasp the concept of smoke removal and venture out to the new theories of PPV use on the fireground. The author believes through the results of this project that the answer is training. Training is the foremost key to learning a new idea or concept and developing the knowledge to go forth and make good sound decisions based on the prior training (Grimwood, n.d.).

The first survey question to the EFO participants asked: What was the type of organization the respondents represented? There were 13 respondents that are combination departments and 9 that are career departments. This makeup of organizations should support both a training program and procedures set forth to establish given fireground tactics. These issues should be relevant across the US with fire departments, yet in the time gap of 1954 to 2008, departments still struggle with PPV use during smoke removal. The officers of RMFD responded to a question in the survey concerning training with PPV. All the responses were positive toward more PPV training with regards to fire attack, problematic areas or wrong usage, and smoke removal from large structures. The author agrees that more training will always be needed but the concerns for training in certain areas have not changed in many years so that shows a lack of continuous ventilation training.

Along with the need to participate in more PPV training, the author has identified the different makeup of departments' surveyed and the possibility of staggered arriving companies and limited personnel to support such a tactic of PPV. The survey for the EFO participants

questioned the type of apparatus that carried PPV blowers. The results were that the engine and the ladder companies in the surveyed departments carry the majority of the blowers. This should prove to be an advantage with arriving personnel and companies given they respond primary engines and ladders to the structure fires. Another question identified the number of personnel assigned to place PPV with fire attack. The results were somewhat supportive of the recommendations in *Positive Pressure Attack for Ventilation & Firefighting* to use a minimum of a three person company to establish PPV with fire attack (Garcia et al., 2006). The results of the survey showed that 75 % of the departments use only two personnel, 20 % of the departments use three personnel, and 5 % use four personnel. The large number of departments that use two personnel may be a direct correlation to the response of apparatus and personnel to the scene. On one of the responses to another survey question the respondent addressed the issue of not having enough personnel to adequately setup PPV with initial fire attack. The author believes that if a department is committed to PPV and safety regardless of the number they use to establish PPV that they will be enough to adequately handle the tactic successfully and safely. Once again, the author supports the idea that the department's willingness to train on the correct use of PPV and ability to provide adequate support on scene will be the link to continuing PPV proactive approach. If a department decides not to address both of these issues the successfulness of fireground operations solely based on PPV use will remain stagnant at best.

A survey question addressed both the positive and negative results of PPV use with fire attack prompted both types of results. The responses that were positive revealed: PPV works very well if it is applied correctly given the appropriate number of personnel and the process is coordinated. PPV was noted to be easy, efficient, and effective. PPV also promotes a safer environment for the firefighters, and reduces delay for the interior attack. It increases visibility

and the heat smoke will clear quickly if ventilated properly. PPV works well on room and content fires. The author agrees with each of the positive comments which also coincide with the literature review results based on PPV theory and expectations when applied correctly.

There were many negative results when dealing with PPV as well for example a department does not have proper training and adequate personnel PPV will not be as advantageous. The author found that to be the problem with RMFD which will be discussed further in the next issue. The Literature Review also supported the same issue of proper training and personnel to conduct PPV use. The respondents also had some bad experiences with PPV with attic fire that were not properly detected before or during attack operations. Some more negative issues were fire traveling voids and not being detected along with crew either not being ready for entry or making bad ventilation exit ports. The author is in support that proper training can help crews avoid making both of these mistakes. The survey question that addressed entry time following PPV introduction to the structure demonstrated the vast time interval of 0-120 seconds. NIST (2008) proved that on different test there range varied from 60 seconds to 120 seconds. But the crews not being ready for entry due to issues not related to PPV are linked to be either bad communications between fireground crews or a training issue at least per the author's perspective.

The author was not only concerned about correct PPV use with fire attack and its associate problems but how RMFD officers viewed the current PPV usage throughout the department. Thus results in research question 4 of why do fireground commanders throughout RMFD either utilize or do not utilize PPV with fire attack. The results of the survey conducted were very long due to the essay form of questions but the information although limited proved very beneficial for the author. The RMFD officers that replied stated they use PPV on the

fireground and one officer stated unless they felt the fire would spread with PPV's use. The next survey question revealed opposite remarks. Even though in the previous question the officers felt they used PPV the remarks on question two which allowed them to comment on things to change with PPV in RMFD showed they desired to use PPV more because it is not used enough. They would like to use it more with fire attack as well as a faster deployment, immediate dangerous to life and health situations, and to use it sooner since it is only used in some situations following fire extinguishment. The lack of unity reveals several issues to the author like inconsistent fireground approach by company officers with PPV use which could be related to the need for more training. The faster deployment issue may need to be addressed both at a company level as well as a department level either through further evaluation/survey tools following fires or assure the issue is covered in department wide training of proper deployment operations of PPV.

RMFD does not have a standing order for PPV deployment. The use of a standing order may help address the inconsistencies within RMFD but the author has not addressed the issue at this time. The survey question to the EFO participants relative to standing order verse fireground assignment revealed that only three departments had a standing order for PPV use. Most departments allowed the fireground commander the option of if and when to use PPV.

RMFD officers that responded to the survey replied with 100% that they did feel more PPV training was needed. They elaborated to include training should cover PPV use with fire attack to include demonstrations of its correct use, as well as smoke removal from large commercial structures. The author agrees that more training is needed and given the many positive results associated with PPV use with fire attack that the officer replied the training should be received well.

RMFD officers noted in the survey of the same positive results to that of the EFO participants when using PPV with fire attack. This again demonstrates to the author that previous knowledge of PPV correct use is present but the confidence in dealing with special circumstance may be limiting the use of PPV in RMFD. The negative results the officers noted in the authors opinion are relevant to need of department wide PPV training because if the reply was that PPV was not used proper on the fireground and it was due to the need for training this sole respondent is not alone. The need is much greater than one person. The problems like inadequate exit openings or too many exit openings also suggest to the author of the need for more training.

In summary, the participants of this project have provided valuable insight and knowledge in the understanding of PPV relevance, its use in general and with specific circumstances, and how it is view and used throughout the sample of US departments that were represented in the survey. RMFD fireground officers input was very useful in concluding the need for more PPV training to assure the baseline information of its use and capabilities as well as its limitations is present throughout the department.

Recommendations

There are four recommendations identified for RMFD based on the research conducted. The recommendations follow in accordance with the research conducted from this project based on the author's interpretation of the results of both the literature reviewed and the surveys conducted.

The first recommendation is to conduct a department-wide training class on PPV. The author recommends this class consist of the theory of PPV, the systematic delivery process of removing contaminants from any structure, and blower capabilities relative to the units operated within RMFD. The class should also cover the correct procedure for a company to correctly

setup and operate PPV with initial fire attack operations. The limitations for such actions should also be covered to show relevance to the adequate number of personnel needed to deploy such operations. A considerable portion of the class should be directed to proper delivery of PPV use with fire attack to include but not be limited to special circumstance like attic fires and entry times for initial fire attack teams. This class should adequately address the cognitive learning process of the student. This class should prove very beneficial to all members of RMFD due to the desire and need based upon the current fireground leaders of the organization. Both the surveys especially the one directed for RMFD demonstrates the current need for quality based PPV training as well as refresher classes as the need arises following special circumstances that show up from incidents that occur within or outside RMFD.

The second recommendation is to follow the initial PPV training with a hands-on drill session conducted department-wide for RMFD. This class will support the previous recommendation by adding the psychomotor skill session to the learning process. The drill session should include a structure(s) that replicated areas commonly found in Rocky Mount and allow the students to physically see and conduct the complete recommended PPV operations. The areas of blower delivery to the scene, setup, and procedures for removing smoke from a structure along with the correct procedure for PPV use with fire attack should be both demonstrated for and by the students.

The third recommendation based on the research identified in this project is that management review and approve a standing order for RMFD personnel operating on the fireground and proper use of PPV. A standing order for PPV use on the fireground will address the uniformed delivery of a blower to the entry point of every structure fire or smoke related event. The standing order will address a particular type of apparatus that carries the correct type

of blower which is adequate for PPV with fire attack that when arrived on scene of an incident falling in the guidelines set forth by the organization that the crew properly remove and deliver the appropriate blower(s) to the proper established entry point of the structure. The on scene fireground commander will still have the option to use or not to use PPV with initial fire attack plus this will not hinder the commander from not using PPV due to the current uncoordinated blower delivery process. This recommendation also follows the majority of the departments that responded to the survey in which the only part of the standing order is the delivery of the blower not its automatic use on every incident. This recommendation will create a uniform deliver of PPV blowers at every smoke or fire related incident.

The fourth recommendation is to conduct a PPV usage evaluation approximately one year following the completion of both the department-wide training and standing order implementation. This evaluation should provide management with very useful feedback on PPV use as well both positive and negative problems associated with it use. This information could then be used as part of a refresher course in PPV to not only to demonstrate its actual use but provide information that may prove pertinent to the special circumstances defined throughout this project.

To other individuals conducting research on Positive Pressure Ventilation begin by collecting and analyzing information based on your department's current use and capabilities with PPV as well as any major problems associated with the delivery of the process. Understanding the problem at home helps when identifying specific needs from other departments. There are different views on the effectiveness of PPV so leaders must identify the direction the organization will follow and to what extent they will allow the members to use such a tool. Based on the research conducted in this project every department's capability needs are

different which will dictate the resources and commitment level to initiating and successfully sustaining PPV. Communication with local, state, and national departments and professional organizations already affiliated with successful use of PPV will help identify the need and level of support that your organization will need to begin with PPV use.

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Appendix A – Positive Pressure Ventilation Survey

Positive Pressure Ventilation

Exit this survey

1. Default Section

1. What type of organization do you represent?

- ☐ Career
- ☐ Volunteer
- ☐ Combination

2. What type of apparatus are your blowers transported on to the scene?

- ☐ Engines
- ☐ Ladders(Trucks)
- ☐ Squads (Support Apparatus)
- ☐ Other

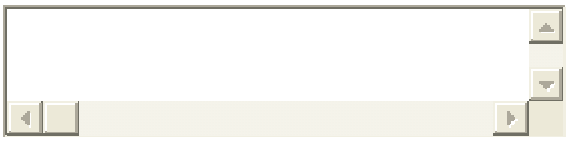
3. To what extent is Positive Pressure Ventilation used within your organization on structure fires?

- ☐ Smoke removal only during post fire knockdown
- ☐ During initial fire attack along with entry team

4. Considering structure fires only, what is the percentage of use that positive pressure ventilation is deployed in initial fire attack operations.

- ☐ 0-25%
- ☐ 26-50%
- ☐ 51-75%
- ☐ 76-100%

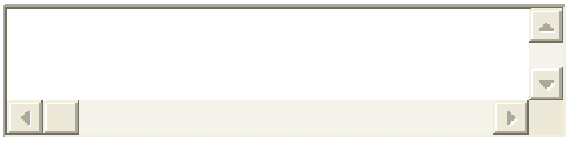
5. Does specific Positive Pressure Ventilation assignments have to be made to put this method of ventilation in place or is it a standing order of the ventilation assignment?



6. When positive pressure ventilation with initial fire attack is made, what time interval is used prior to the attack team making entry into the structure?

- 0-5 seconds
- 5-15 seconds
- 15-30 seconds
- 30-60 seconds
- 60 + seconds

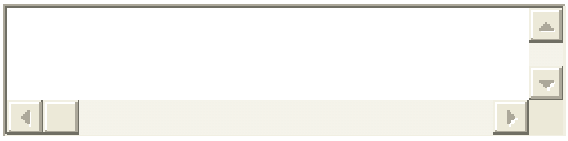
7. Does your organization use positive pressure ventilation on a structure fire with confirmed fire extension in the attic?



8. How many personnel are assigned to place positive pressure ventilation with initial fire attack in place?

- 2 personnel
- 3 personnel
- 4 personnel
- 5 personnel
- 6 + personnel

9. What are some positive and negative results your organization has experienced when considering positive pressure ventilation with fire attack?



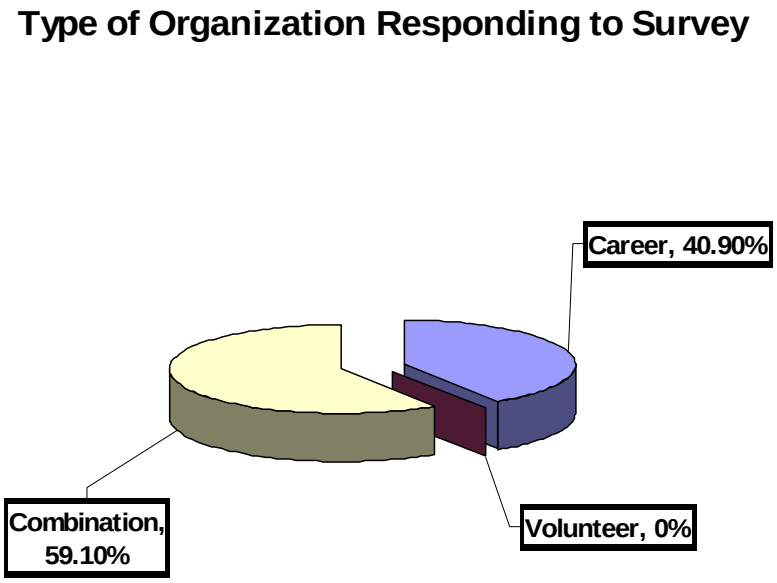
10. Does your organization use a standard operating guideline for positive pressure?

If yes please send a copy to jamie.vaughan@rockymountnc.gov

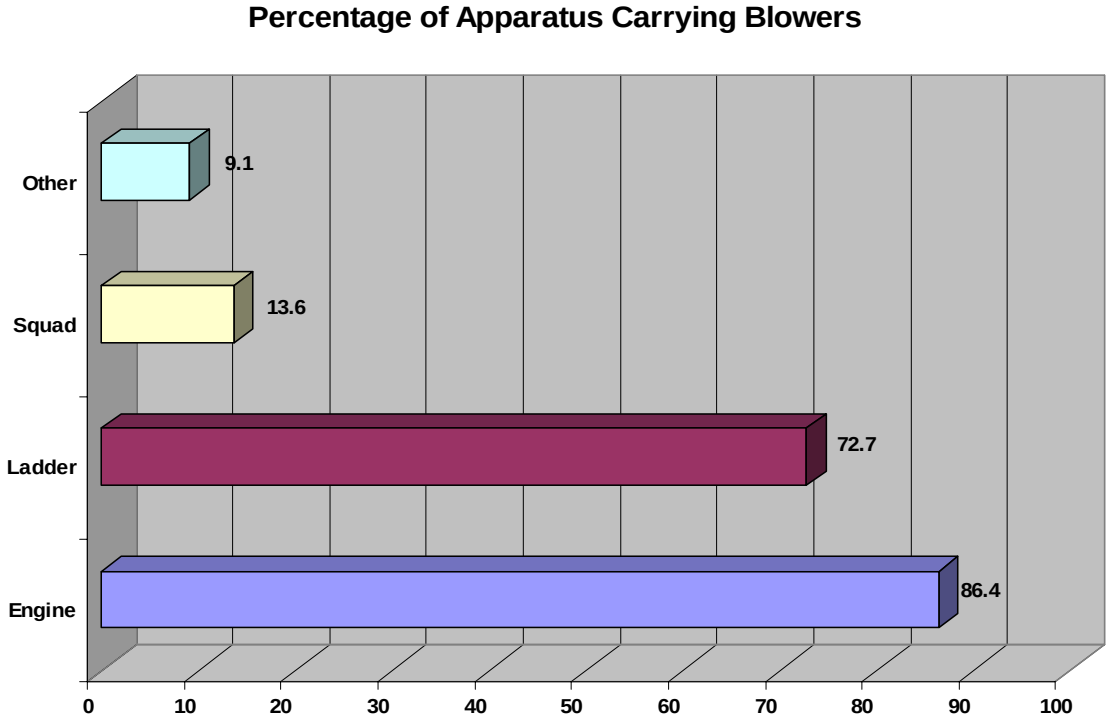
- [ ] Yes
- [ ] No

Appendix B – Positive Pressure Ventilation Survey Results

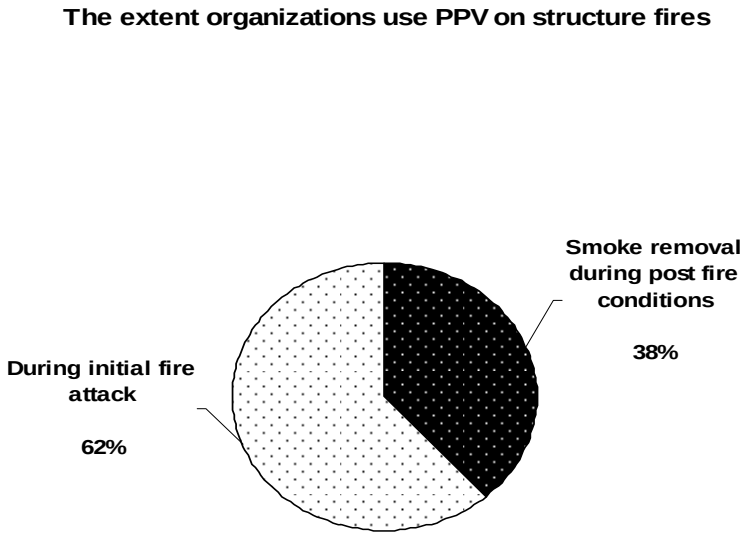
Question 1: What type of organization do you represent?



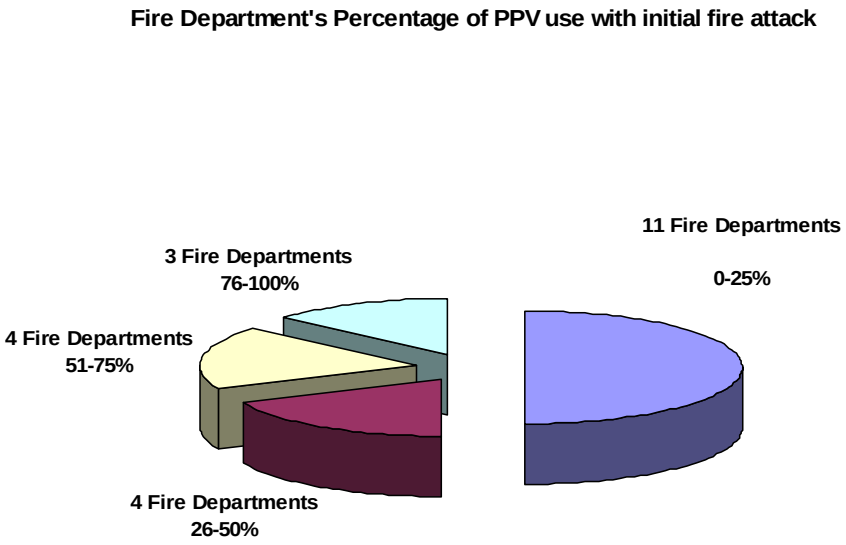
Question 2: What type of apparatus are your blowers transported on to the scene?



Question 3: To what extent is Positive Pressure Ventilation used within your organization on structure fires?



Question 4: Considering structure fires only, what is the percentage of use that positive pressure ventilation is deployed in initial fire attack operations?



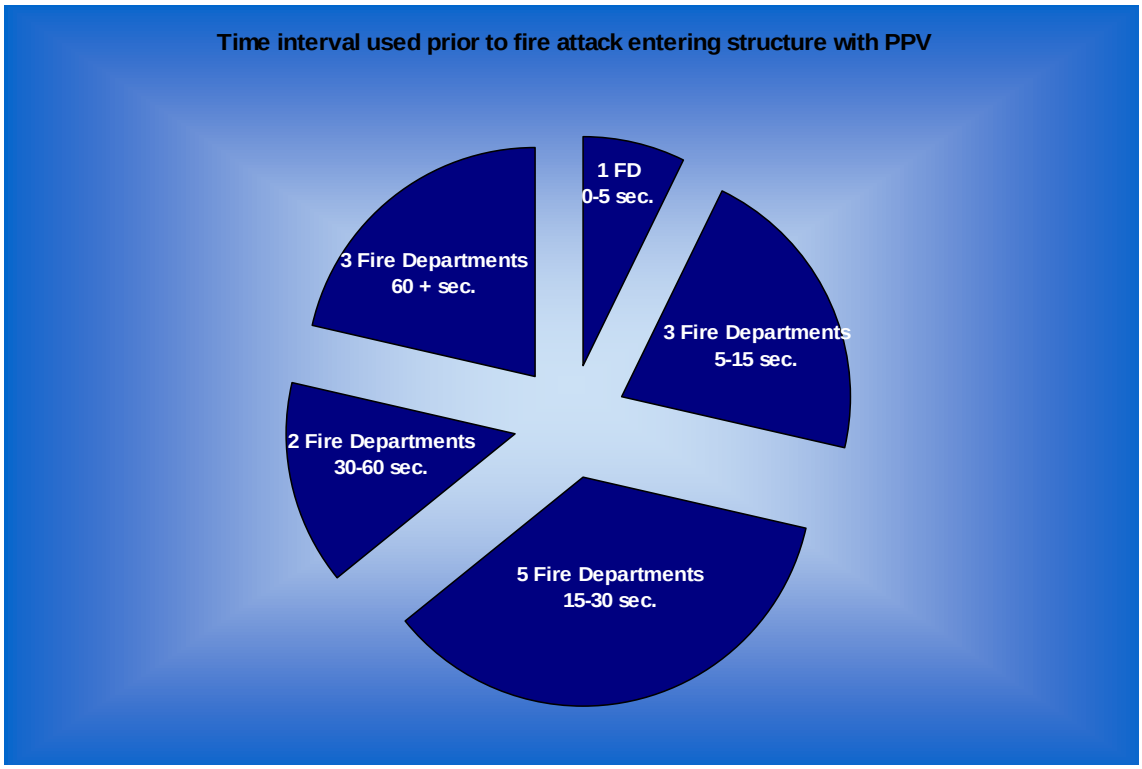
Question 5: Does Specific Positive Pressure Ventilation assignments have to be made to put this method of ventilation in place or is it a standing order of the ventilation assignment?

- It is a standing order to place a fan at the front door, but starting the fan for ventilation is not performed until directed so by the incident commander or his/her designee.
- it's up to the officer and man power on scene
- The Driver/Operator sets the fan at the front door and it is later turned on by one of the attack crews.
- assignment
- Yes, the IC and/or the Ladder Co. determine a vent profile during the 360 size-up and choose which vent technique, vertical, horizontal, PPV.
- not a standing order.
- standing order
- It is dictated by the IC. It is not in SOG form, but is normal procedure.
- IC orders ventilation.
- It is automatic for smoke removal, but would require an order during the initial fire attack.
- It is a standing order, usually assigned to the operator unless there is a extra person that the Officer assigns it to that will not be making entry
- As an unwritten standard guideline. Can be used if conditions are right.

- Fans are usually deployed, but the IC gives the command to start them after the interior companies' request.
- Blowers are initiated only on orders from command and only when fire is declared under control.
- Both usually done with first entry team, by that team if heavy smoke and heat are present.
- We have a crew assigned to set-up the task but because it is recognized as a coordinated effort, a specific order must be given to start the process.
- It is a standing practice and part of our normal evolutions.
- Called for as a specific tactic.. In the Northeast we have a lot of balloon construction PPV has to be used judiciously.
- A directive is issued by the IC upon arrival.
- One of the first assignments the first in engineer has to do is remove the ppv from his or her apparatus and place it at the entry point of the structure the first in line is going to go in. The first in officer has to do his or her walk around and make an opening to the building if he or she decides positive pressure ventilation is the way to go. if the attic is ventilated PPV will probably not be used. If the first in officer can't get a feel for where the fire is on his or her walk around PPV won't be used until we can locate the fire. We have been using these techniques for many years and have found PPV to be a great tool for the fire service.
- Standing order.

- Assignment by IC

Question 6: When positive pressure ventilation with initial fire attack is made, what time interval is used prior to the attack team making entry into the structure?



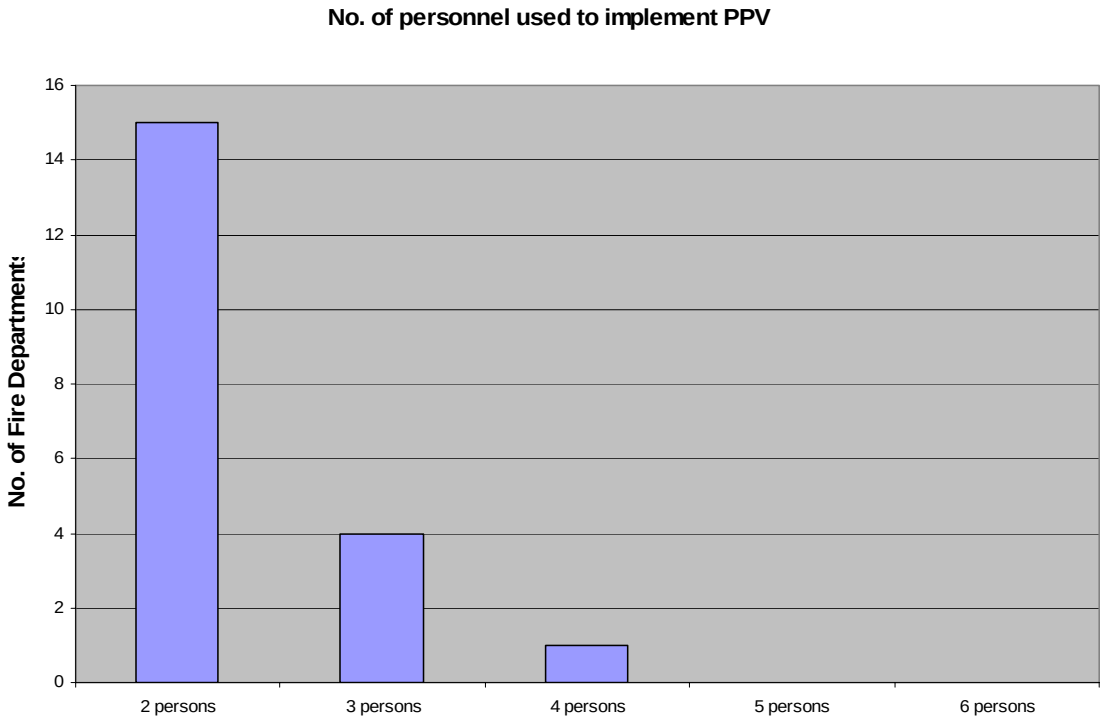
Question 7: Does your organization use positive pressure ventilation on a structure fire with confirmed fire extension in the attic?

- No
- Depends on the amount of extension
- Only if there is a crew in place with attic access and ready for fire attack .

- No
- No as a general rule, but it is not an absolute contra-indication.
- No.
- No
- No
- Not until fire is extinguished.
- Not until hand lines are in place to control the fire spread.
- No, because you don't want to push more fire up into the attic.
- No- never
- No
- PPV is only used for smoke removal.
- Finding the seat of the fire is priority before ppv, although not required if ppv is needed to enter. PPV will be avoided with attic extension unless to increase occupant survivability
- Again, the equipment is set-up and the IC determines the need and makes the call.
- We do not specify
- NO
- Not on initial attack.

- No
- Depends if attic has ventilated or is being ventilated.
- No. Exception is an identified fire wall (2 or 4 hour) when used in conjunction with vertical ventilation.

Question 8: How many personnel are assigned to place positive pressure ventilation with initial fire attack in place?



Question 9: What are some positive and negative results your organization has experienced when considering positive pressure ventilation with fire attack?

- It is not a practice that has been a general practice that has been accepted by my department

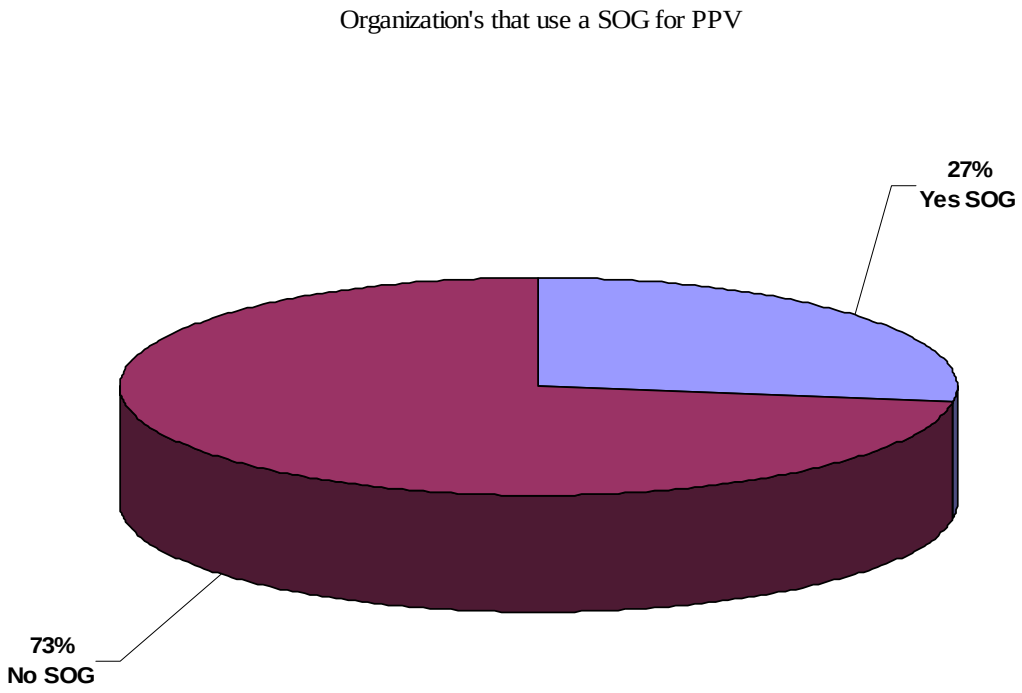
- It’s worked well when I've used it.
- It is very under utilized!
- If the crews are not ready to make entry the fire does not slow down when the PPV is initiated.
- Once initiated, IC's are reluctant to stop PPV if and when conditions change that do not support the use of PPV (e.g. extension into confined spaces, attic, etc.)
- Pos- Easy, quick and very efficient. Neg-None
- None
- To my knowledge, we have experienced no negative results.
- Pushing fire into void areas.
- We use PPV very rarely during the initial fire attack, but when used it has been very effective in providing an easier attack for the initial crews. The negatives have been the timing and coordination of the attack and PPV.
- Positives: If the structure has been ventilated prior to PPV start up it helps clear the smoke and reduce heat. Helps you locate the fire and victims quicker by increasing visibility. Cons: can be a trip hazard for entry crew as they go in. If done too early can increase the amount of O2 to the fire and cause a flashover if the structure is not vented prior.
- I proposed a class (denied) to FDIC named the "Don’ts and Do's of PPV". There are only

a few conditions where it is appropriate in offensive attack, namely room and content fires. We have had fire spread into attic and crawl spaces unintentionally on training burns and have had personnel apply PPV on a vertically ventilated structure - increasing fire intensity interior. Great positive results on room and content fires where fire had yet to breach sheetrock.

- We have had several fires with extension into the attic. Unaware of the extension, the fans intensify the fire greatly. We usually don't have the required manpower to have a coordinated attack and that’s the main reason we don't use them during the attack. If you have the manpower and everyone working off the same sheet of music, works great.
- When used in fire attack, some fires only burned out when the blower ran out of gas. When used for smoke removal, it works very well.
- We have gone to long tubes for ppv motor exhaust, and started looking into electric ppv fans due to CO. We do not use them after initial operations or fire is under control because of CO. We found that overhaul and investigations were slowed waiting for CO levels to be safe with prolonged ppv use.
- Positive-safer environment, better visibility, comfort in knowing that the potential for backdraft is drastically reduced. Negative-if suppression and ventilation are not well coordinated, the fire can be pushed to an uninvolved part of the structure, use of staffing that could be filling other positions in suppression efforts.
- Positive- improves visibility, reduces delay. Is part of a coordinated attack.
- Mostly the challenges associated with balloon construction.

- Positive results are a safer environment for the entry team(s). Negative would be the time and personnel commitment needed to accomplish the tactic.
- Positive, it works very well if used correctly. Keeps firefighters safe, gets deadly smoke out of the structure quickly. Negative, you really have to train on the use of PPV and show your people why you must make an exit for the flame and smoke, you also need to train them on how to remove smoke from the structure once the fire is out. It has to be done one room at a time and don't open a bunch of windows or doors because that negates the positive pressure.
- We have had significant success with utilizing PPV with the initial attack. Crews just need to be conscious of where the fire may be running (ex. un-ventilated attic).
- Identifying the fire's location prior to initiating PPV (e.g., Is the fire in the attic?). Controlling openings is critical. Noise from the fans can be a problem. Timing of event is crucial. Visibility is dramatically increased with the proper use of PPV.

Question 10: Does your organization use a standard operating guideline for positive pressure.



Appendix C – Positive Pressure Ventilation Survey for RMFD

Positive Pressure Ventilation in RMFD

Exit this survey

1. Default Section

1. As a fire ground commander, do you call for positive pressure ventilation on all structure fires with exceptions of a known Backdraft situation?

If no, please explain.

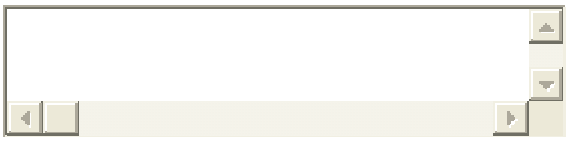
2. If you could change the way positive pressure ventilation is used within RMFD what would you recommend.

3. Do you think RMFD personnel need more training on Positive Pressure Ventilation?

If yes explain.

4. What are some positive results you have experienced when considering positive pressure ventilation with fire attack?

5. What are some negative results you have experienced when considering positive pressure ventilation with fire attack?



Appendix D – Positive Pressure Ventilation Survey for RMFD Results

Question 1: As a fire ground commander, do you call for positive pressure ventilation on all structure fires with exception of a known Backdraft situation?

Results for Question 1:

- There were 6 “yes” only answers.
- There was 1 “normally” answer.
- Yes, unless positive pressure will make the fire grow faster and spread.
- In most cases PPV is called for as long as the structure is intact enough to do PPV.
- Yes, very useful in locating the seat of the fire and clearing the structure as well as locating spot or hidden areas of concern.

Question 2: If you could change the way positive pressure ventilation is used within RMFD what would you recommend.

Results for Question 2:

- In most cases our utilization of PPV is appropriate for the circumstances; however, we sometimes do not utilize it in conjunction with fire attack when it could be advantageous to us.
- Use when crews enter an IDLH with attack lines unless flame spread would be caused.
- that it be used more often
- I would like to see us do either riding assignments or Company assignments for Ventilation task. Such as Ladder Company assigned as Vent, Enter, and Search teams. Maybe would could consider doing something to this nature with out having to assign this task to a company each time we will know that when the (ladder co.) arrives they will

handle ventilation once it is called for. They should already have the needed tools that are required to do the job ready to go.

- Faster deployment for use during fire attack.
- I am not aware of any other way
- Not always utilizing doors, porches and entry points for personnel as the fan placement area, but possibly utilizing large window openings etc. to keep entry/exit points clear.
- Use PPV earlier during fire attack. We usually use it once the fire has been extinguished.
- Utilize more of the electric PPV fans to reduce the CO levels within structures.
- Integrated into fire attack

Question 3: Do you think RMFD personnel need more training on Positive Pressure Ventilation?

Results for Question 3:

- Yes, in the area of set up for fire attack purposes.
- yes, good demonstrations of positive pressure to show benefits and demonstrations of poor use of pp to cause more damage
- I think we have so many new people and they surely don't know as much as they should about positive pressure
- I would like to see some PPV fire attack training and train our personnel to bring needed tools such as PPV fans to the fire scene prior to them being called for.
- Yes, particularly utilizing it in conjunction with fire attack.
- Yes. Until a recent structure fire that idea was in the back of my mind. IT should be a hot

training item.

- A refresher class and review is always a good thing and with the department as young as it is, reinforcement of skills is always excellent and advantageous training.
- Yes, some
- Yes, I have been on several situations in which PPV was needed at large warehouses or commercial structures and the ventilation process did not flow smooth due to poor communication, unfamiliar with procedures for large structures, etc.
- Yes

Question 4: What are some positive results you have experienced when considering positive pressure ventilation with fire attack?

Results for Question 4:

- It used correctly; it will increase visibility and reduce smoke and heat levels.
- better visibility, less flammable gases, reduced heat
- proceeding to the seat of the fire more quickly limiting damage in other parts of structure quicker extinguishment if used correctly better results with search
- Fast access to the fire when used in fire attack situations.
- Increased visibility and reduction in heat. Interior crew moving more quickly as a result of it.
- Location of hidden fire and an increase in visibility due to extinguishment.

- Reaching the seat of the fire quicker, cooling the structure faster, reduction of fatigue of firefighters, faster search and rescue with better visibility and removal of a greater percentage of toxic gases.
- Reaching the seat of the fire quicker due to better visibility. Less heat during fire attack.
- Proper PPV has increased visibility to better access the fire and better complete search activities. PPV seems to work well with our typical residential fires.
- lessening of harmful effects upon personnel (improved visibility, lessening of heat and smoke intensity, more efficient suppression tactics, etc.)

Question 5: What are some negative results you have experienced when considering positive pressure ventilation with fire attack?

Results for Question 5:

- Incorrect use due to training.
- flame spread to other areas of house when a proper exit was not created. Also build up of smoke. Exit point is critical
- exit ports not large enough on some incidents fans not put in prior to entry enough
- Firefighter not being fast enough on deployment of ventilation and vent group personnel not doing a 360 of the structure to ensure a vent port as been created. This is the vent team’s job.
- Have not personally experienced any; however, crews must be ready to enter with charged hose line to prevent fire growth and increased damage.

- None to day.
- Broken up structures that with only one fan available occasionally creates movement of the smoke into areas undesired, cannot control the building layouts, therefore beyond actual span of control or ability to change, just must, adapt to each situation and often try various techniques.
- Poor movement of smoke due to opening too many exit ports. PPV fan causes some obstructions for hose lines and personnel.
- People not understanding the principles of using PPV on large commercial structures with bay doors. I think this can be solved with simple training using the engine rooms of the fire stations if smoke and PPV can be provided.
- increased fire spread...limited at best though...personnel safety overrides the property damage (within reason of course)