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## **EXECUTIVE SUMMARY**

This research project investigates Positive Pressure Ventilation (PPV) usage within the United Kingdom (UK) Fire Service, the research undertaken prior to its introduction, and any barriers that brigades have faced in introducing this item of equipment and associated procedures.

PPV appears to have its origins in the 1950s, yet has only been discussed in the UK since the late 1980s. An initial review of available literature would suggest that the use of PPV can have positive benefits for firefighter safety. With these issues in mind this research project tests the following hypothesis:

***Fire brigades in the UK are not using PPV to its fullest potential to enhance the ability of firefighters to carry out their fire fighting and rescue duties in safety.***

The investigation had four separate, but interwoven strands. Firstly a detailed literature review identified previous research into PPV and its usage. The most plentiful literature was found within journals, but these articles and papers were very much anecdotal and opinionated. A fruitful source of unbiased and well-researched information was the Fire Research and Development Group (FRDG), who completed a series of research papers throughout the 1990s. This series of research papers informed and assisted the production of a Home Office Dear Chief Officer Letter (DCOL) that gave guidance on the staged introduction of PPV. The DCOL was

issued following the completion of investigative work carried out by the National PPV Liaison Group, a group originally formed by the Chief Fire Officer (CFO) of Tyne and Wear Metropolitan Fire Brigade.

To assess PPV usage in the UK, a questionnaire was sent to all brigades, this survey achieving an 87% return rate. The level of return enabled the researcher to establish the level and stage of use and the type of research undertaken prior to decisions on implementation being taken. The returns also gave the researcher the ability to forecast potential usage in the short to medium term.

The next strand of investigation was that of case studies; three in total, including two international fire departments, Salt Lake City, USA and Aachen, Germany. Tyne and Wear Metropolitan Fire Brigade was also selected as a UK comparator case study, this brigade being the most proactive user of PPV in the UK according to the UK Brigade Survey. The three case studies examined implementation processes and the barriers that were found to this change of approach to firefighting.

To complement the views given by brigade representatives, a further survey sought the views of individual firefighters within the three case study fire brigades/departments. These views are compared to that of firefighters from UK brigades who either use PPV only for smoke clearance post fire, or do not use PPV at all.

The analysis of the four strands of research demonstrated different views on the worth of PPV, and if implemented, how it was used and its effects on casualties,

firefighters and building structures.

The literature, especially that of the FRDG, gives clear indication that PPV is a useful operational tactic that can enhance firefighters' safety and should warrant serious consideration by brigades. This consideration should ensure that training is given to all personnel prior to the operational use of PPV.

The surveys and case studies gave the researcher a valuable insight into UK PPV usage, the views of international fire departments and those of a UK brigade that has successfully implemented PPV to its fullest extent. The case studies highlighted many differences in the three studied brigades, including cultural differences and local building construction. Perhaps the starkest difference found was that of training, with one of the brigades giving almost no training whatsoever prior to implementation. The firefighters from each of the three studied brigades also gave differing opinions in their individual questionnaires. However, the differences between these three studied brigades were only slight in comparison to the UK firefighters who only use PPV for smoke clearance, or not at all. It became clear that the more PPV was used and the higher the stage of usage, the more positive the views were. It is also apparent that some negative views, as perceived by non-users, are not borne out by the reality as seen by the firefighters who actually use PPV operationally on a regular basis. Perhaps the most important findings of the Firefighter Opinion Survey were, that in general, all firefighters consider ventilation to be an important firefighting tactic in compartment fires, and crucially all firefighters - including non-PPV users - believe that the aggressive use of PPV can enhance firefighter safety.

These findings led the researcher to conclude that the hypothesis has been proved, in that PPV is not being used to its full potential to enhance firefighter safety - albeit that it is recognised that 'full potential' is a subjective judgement which is not easy to define.

The report concludes with a set of recommendations that are designed to assist the UK Fire Service to fully assess PPV, taking into consideration the local condition in each brigade. The recommendations indicate that brigades should not investigate the viability of PPV as an operational tactic. Investigations should focus on local conditions and the logistics of implementing a proper training regime and the financing of the equipment and training. As with any change to the norm, proper communication between the organisation and staff is required, and as such the researcher recommends that PPV is only implemented with staff being fully aware of the rationale for implementation.

This research is not a finite piece of work, with the researcher recognising the limitations of the time and resources available. Areas identified in the recommendations for additional research are that of senior managers' opinions, and the effect that the number of retained firefighters has on a brigade's ability to introduce PPV.

Both these areas of further research should complement the views obtained from operational firefighters and the recommendations the researcher has made based on the conclusions.

## **ACKNOWLEDGEMENTS**

This research project is an extensive piece of work which I could not have completed without the generous assistance of many other people.

To recognise this assistance I would like to put on record my gratitude to everyone that has assisted me to take a basic idea through to a completed report.

It appears to be traditional to make reference to my family at the end of this section, however I do not wish to follow that tradition. I would like to thank my wife Sarah, and children Gemma and Matthew for their patience and their totally unqualified support throughout the BCC, and in particular this project. They now realise that the light at the end of the tunnel was not turned off, it was merely obscured by the sheer volume of paperwork in the tunnel!

I am grateful to the tutorial staff at the Fire Service College who have assisted me, in particular Gibby Williams and Terry Shevels along with the staff of the Fire Service College library.

During the early stages of my research, CFO John McClelland was invaluable in ensuring that my mind was focused on that which was realistic and achievable, for this I thank him.

Salt Lake City Fire Department and Aachen Fire Department assisted me greatly, and without their contribution this report could not have been produced. In particular I wish to thank Kriss Garcia in Salt Lake City, who not only assisted my research but made sure that my visit was thoroughly enjoyable. And in Aachen Oliver Grooz and Ralf Johnen ensured that the barrier of language was overcome and that my research continued, despite fire calls.

I would also like to thank all UK brigades that assisted with my research, especially Tyne and Wear Metropolitan Fire Brigade, and in particular David Turpin and Graham Bowser.

I would like to thank Dr Martin Thomas, my technical assessor at the Fire Experimental Unit, who has always been available and shared his knowledge with me and given appropriate guidance.

There are two individuals within my own brigade who are deserving of my gratitude. Firstly my Chief Fire Officer, Mick Howell, who has not only supported me throughout the BCC and beyond, but has acted as my BCC personal mentor. Secondly, Abi Messenger who has assisted in the compilation of this report - her technical skills and tolerance continue to amaze me.

Finally I would like to place on record my thanks to all my BCC colleagues. The support that I have found in their company has been invaluable.

## **1. INTRODUCTION AND BACKGROUND TO RESEARCH**

### **1.1 Terms of Reference**

This research project was conducted as part of the researcher's attendance as a student on Brigade Command Course (BCC) 2001, between March 2001 and May 2002, and the 2002 MA (Management) programme at the Coventry University.

This research complies with the International Research Project objectives as laid down in the BCC guidance notes.

The project objectives are:

- To identify a research problem clearly.
- To identify the context of existing knowledge.
- To conduct appropriate research and use investigative techniques.
- To make appropriate recommendations on the basis of the foregoing.

### **Presentation of Report**

This report is presented so that the reader is led through its content to a set of logical conclusions, which are followed by a set of recommendations. The reader will firstly be introduced to Positive Pressure Ventilation (PPV) and then the methodology for the research. As with any research project there will be certain limitations, these are

identified. A key element to this research is the literature review, itself being an integral part of the investigation. The main section of the report details the findings of the investigations using graphical depiction to present the findings of the two quantitative surveys and clear descriptions for the case study findings. The report is completed by conclusions and subsequent recommendations.

## **1.2 Basic Theory of PPV**

To assist the reader to fully understand the contents of this report, it is considered useful to explain the following terms which are regularly used throughout the document. This section also gives an explanation of the basic principles of PPV.

### **Positive Pressure Ventilation (PPV)**

- (i) A generic term to explain the use of portable mechanical fans to blow air into a building or compartment to create an over-pressure and thereby forcing the products of combustion through an exhaust opening.
  
- (ii) The term can also be used to specifically indicate the use of fans to expel products of combustion from a fire compartment once a fire has been extinguished. This is sometimes termed 'post-fire' use.

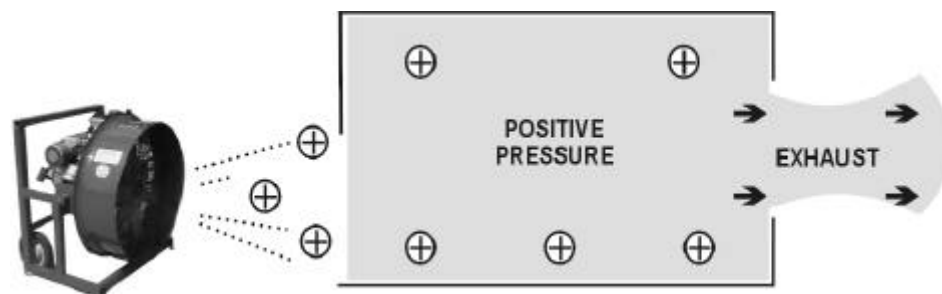
## **Positive Pressure Attack (PPA)**

- (i) A term which originated in the USA and indicates when PPV is used prior to a fire fighting team entering a building or compartment to assist the fire fighting team to rescue persons or extinguish the fire.

Many terms are used for this type of PPV usage, including fire attack and aggressive PPV or offensive PPV. PPA is the term used by the researcher to cover all these terms and relates to stage 3 of PPV implementation as described in DCOL 14/1999 (Home Office, 1999) and discussed in chapter 3.

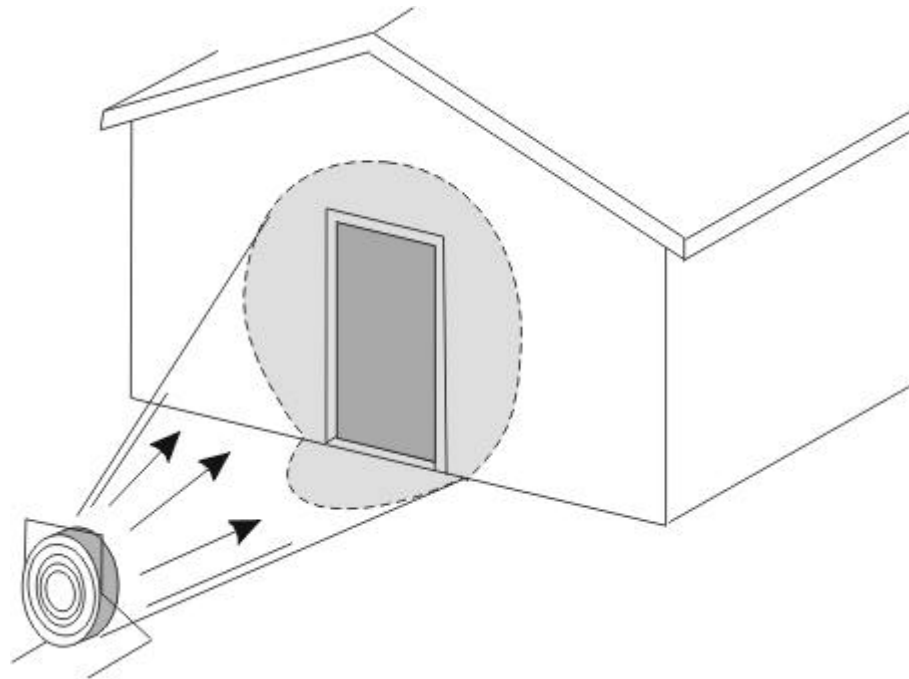
PPV appears to have its origins in the USA with Coffman (2000, p.23) claiming use by the Los Angeles Fire Department in the 1950s. There is also anecdotal evidence suggesting that PPV has its origins in Finland during the 1950s.

The principles of PPV could be considered to be relatively simple and are depicted in figure 1.



**Figure 1**

For a gas to move in a compartment there must be an over-pressure or an under-pressure in that compartment. PPV uses a mechanical fan to force air into a compartment, which creates an over-pressure. The over-pressure forces the gaseous contents of that compartment out through a previously formed exhaust opening - normally a window or door.



**Figure 2**

Until recently it has been accepted that for optimum use, the fan should seal the door by the use of an air cone (figure 2). The requirement for this cone is now being questioned by the use of the 'turbo' fans which force large quantities of air through an opening without creating a seal. This research does not discuss, nor investigate the operating theories of PPV and therefore the reader only needs to accept the principle

that if air is forced into a compartment, an over-pressure will occur and thereby gases will escape via an exhaust opening.

Fans used for compartment fires are normally powered by petrol engine or water turbine, are compact in nature and dependent on size, can be placed and operated by one or two personnel. Larger fans, which are vehicle mounted, are now marketed for tunnels or large structures but do not form part of this research.

### **1.3 Background To Research**

Fire produces smoke and heat - a very simple and obvious statement, but one that is at the heart of this research. Smoke on its own has two associated hazards, that of being explosive as well as being toxic. It is the smoke and other products of combustion that cause firefighters' greatest problem in tackling fires involving buildings. It is generally understood and accepted that in order to extinguish a fire and to rescue casualties quickly and effectively, firefighters are required to enter burning buildings. However 1,507 UK firefighters were seriously injured between 1994 and 1999 at domestic property fires (Gamble 2001), and although statistics are unavailable it could be expected that a significant number of these injuries would be as a result of exposure to the products of combustion whilst inside the property. Three firefighter fatalities also occurred during this period, two of them whilst inside a domestic property.

Based upon the assumption that the environment inside compartment fires is hostile, this research investigates whether the use of PPV can improve the conditions in which a firefighter works. The most overt protection to firefighters is the personal protective equipment (PPE) and breathing apparatus that is synonymous with any picture or image of firefighters. Within the 'General Principles of Prevention' (Health and Safety Executive 1992, p.40) it is clear that the provision of PPE is only considered following identification of all other methods of controlling or removing the risk of harm. Therefore can the risk - smoke and heat - be removed? In certain circumstances the answer must be 'yes' in that firefighters usually attempt to ventilate buildings to improve conditions and to ease the conditions of work when tactics allow. The success or otherwise of ventilation can be dependant on many factors, not least the direction of the wind. The direction of the wind is key in that natural ventilation relies on the wind entering a building through an opening, pressurising the structure and forcing products of combustion out through another opening. Fire creates its own pressure and, if circumstances are favourable, ventilation may automatically take place via windows, doors or burnt through areas of the structure. This type of natural ventilation is dependent upon firefighters encountering favourable conditions which are unpredictable and uncontrollable. Therefore other methods of ventilation should warrant serious consideration.

The researcher understands that PPV could be seen as a very simple concept in that a portable mechanical fan is placed so that a large amount of air enters a structure. The air pressurises the structure or compartment, forcing the products of combustion out through a previously formed exhaust outlet. The scientific theory of operation is no more difficult to understand than the inflation and deflation of a balloon. However

the practical application of PPV is far more complex in that consideration has to be made for many other factors. These factors include the location of fire, the type and layout of the structure and the potential for flashover or backdraught, two phenomenon that cause dangers to firefighters through the compartment being totally involved in fire. It would also be reasonable to state that blowing air, and thereby oxygen, into a compartment containing fire is at variance with one of the basic fire fighting principles that firefighters have for years been taught in recruit training: fire is extinguished by removing either heat, fuel or oxygen. It is because of these other factors having to be taken into consideration prior to using PPV that the Home Office issued a DCOL 14/1999 (Home Office, 1999) recommending three stages of implementation. These stages are progressive in nature, and will be discussed fully in chapter 3.

In the early 1990s interest in PPV was evident in the United Kingdom (UK) with a small number of brigades starting to investigate the procedure. Since that time there is much anecdotal evidence of use and indeed research commissioned by the Fire Research and Development Group (FRDG) has concluded that PPV is an acceptable tactic to be deployed. With this background in mind and PPV having been in the UK for well over ten years, the purpose of this research is to determine if fire brigades of the UK have embraced this tactic that appears to have benefits to firefighter safety.

## **1.4 Research Context**

This research has two distinct contextual areas. Firstly, firefighter safety has become one of the main priorities of the UK Fire Service. The researcher believes that firefighter deaths and injuries are not as acceptable as part of the role of the modern firefighter as perhaps they were in the past. The safety of firefighters has started to improve through brigades adopting a risk-assessed approach to all of its activities, especially fire fighting operations. It is apparent to the researcher that this risk-assessed approach has seen significant strides in incident command and the provision of PPE and operational equipment. It is within this more safety conscious environment and context that this research will endeavour to establish how and if potential benefits to firefighter safety exist by using PPV.

Secondly, this research should also be viewed within the context of the ongoing discussions throughout the UK Fire Service regarding PPV. The National PPV Liaison Group was formed in 1997, headed by CFO Richard Bull, which explored the training and implementation issues surrounding PPV. Anecdotal evidence appears to show varying degrees of interest amongst UK brigades, from those that are utilising PPV extensively, to those that have not even considered its use. There has been a slow but steady stream of research documents produced by the FRDG since 1994 which all support PPV as an acceptable operational fire fighting tactic. This previous research has however been directed towards the technicalities and science of the subject. These research papers have been readily available to brigades, and in 1999 the Home Office issued guidance to brigades in the form of DCOL 14/1999

(Home Office, 1999). This DCOL gave guidance to brigades regarding an appropriate manner of PPV implementation. How has the UK Fire Service reacted to this guidance? Prior to this research the answer to this question was unknown, as it appears that this type of research has never been undertaken. Fraser (1994) completed some basic research into PPV usage, but this was three years before Home Office (1997) and five years before DCOL 14/1999 (Home Office, 1999) was issued. Fraser (1994) produced some statistical information but within the context of DCOL 14/199 (Home Office, 1999) it is of limited value. This research aims firstly to resolve that gap in available knowledge, secondly to identify any lessons to be learnt from international brigades, and finally identify if there are any barriers to successful PPV implementation in the UK.

## **1.5 Research Aims and Objectives**

This research project has one over-arching aim; to obtain the facts and rationale surrounding the implementation of PPV in the UK fire service. To achieve this aim the following research objectives have been set:

- (a) To identify previous PPV research, its extent and findings.**
- (b) To establish the extent of PPV use in the UK Fire Service.**
- (c) To establish the reasons why brigades have or have not implemented PPV.**

- (d) To compare a UK brigade's implementation process with that of a selected European and a selected USA Fire Department which are using PPV extensively.
- (e) To obtain the views of firefighters as to the benefits and problems associated with the use of PPV.
- (f) To establish any barriers to PPV implementation within the UK.

## 1.6 Hypothesis

The research objectives above will be applied in order to test the following hypothesis:

***Fire brigades in the UK are not using PPV to its fullest potential to enhance the ability of firefighters to carry out their fire fighting and rescue duties in safety.***

## 1.7 Limitations of Research

### **Selection of Case Studies**

The limitations of any research project will affect the research methodology selected. To complete this project the researcher had to balance the time constraints imposed by the BCC and the MA programme against the required academic rigour and the

resources available to the researcher. These limitations restricted the researcher in the selection of brigades in which to undertake case studies. The three brigades selected were all using PPV in its PPA mode - a requirement of their selection - but they all had similar characteristics. They were geographically compact with a high proportion of wholetime or professional firefighters. To obtain a wider picture of PPV implementation, brigades could have been selected that have a predominance of retained or volunteer firefighters. However the time and resources available, on this occasion, limited the researcher to examining PPV used in the brigades selected.

### **Personnel Views Sought**

Again related to the time and resource implications of this project, the researcher selected personnel from the operational level for the Firefighter Opinion Survey. This level of personnel can give more relevant views regarding usage and their perceptions as to the value of that usage, but they are not the decision makers for procurement or implementation. On this occasion the researcher did not have the time or resource to explore the views of the managerial level of brigades, a level which would ultimately take the decision on whether PPV was adopted or whether a brigade utilised the equipment for PPA.

### **Potential for Bias**

It was found during the three case studies that the personnel involved in implementation displayed 'champion' characteristics. These personnel were very

enthusiastic and motivated towards the use and potential use of PPV and extolled many virtues of the equipment and procedure. Throughout the investigations the researcher kept this point in mind as these 'champions' may well have had inherent biases towards PPV to the exclusion of any negative impacts of the procedure.

### **Statistical Analysis**

There are numerous tests for statistical analysis, dependent on the type and detail of research undertaken, with Robson (1993) devoting 99 pages to data analysis and tests that may be applied. The researcher was aware of this plethora of available tests and consciously selected, with assistance from a college tutor, a small range that assisted the analysis of data obtained. Many more statistical tests could have been applied, but with the given time restraints and word limits of this project, they were not considered appropriate.

## 2. METHODOLOGY

### 2.1 Introduction

This research project has more than one facet and therefore has more than one methodology. This mix and match methodology is termed by Saunders *et al* (2000, p.98) as a multi-method approach. Robson (1993, p.125), quotes examples of what he terms a 'hybrid research strategy' when features of more than one methodology are combined into one study.

In its widest sense this study will focus on a single practice - PPV. This type of single practice study is termed evaluative and is described by Parahoo (1997, p.104) as a study which:

Tends to focus on a particular practice, policy or event. An evaluative study is normally carried out when the researcher wants to find out if, how and to what extent the objectives of particular activities have been or are being met.

Although this research focuses on a single practice, it covers many aspects of the implementation of the practice. As with most practices and procedures, they cannot operate in isolation of the prevailing environment. Therefore this research will be examining those external factors such as building construction and cultural or historic views, along with health and safety considerations.

Prior to and during data collection a thorough literature review was undertaken. There are two major reasons for this review (Sharp and Howard, 1996, cited by Saunders *et al*, 2000 p.42). The first reason is to help the researcher generate ideas and to formulate a hypothesis. The second reason, termed by Saunders *et al* (2000, p.42) as the critical review, is more extensive and exploratory in nature. This critical review forms a significant part of the research and continued throughout the research project. This critical review is especially important to this project as it forms part of the investigation into previous research, its extent and findings.

This study is 'positivist' in nature (Robson 1993, p.119), in that it starts with a theory, the hypothesis, which is tested using the acquired data and knowledge from the research. This positivist theory is further expanded by Saunders *et al* (2000, pp.87-88) and termed 'deductive'. Saunders *et al* (2000, p.91) recognise that deductive research is quicker than its opposite - inductive - although recognition is given to the time-consuming nature of the setting-up phase.

Robson (1993, p.19) suggests the five stages through which deductive research will progress. This research project followed these stages:

1. Deducting a hypothesis.
2. Expressing the hypothesis in operational terms.
3. Testing this operational hypothesis.
4. Examining the specific outcome of the enquiry.
5. If necessary, modifying the theory in light of findings.

## 2.2 UK Brigade Survey

The data collection commenced with a postal questionnaire which was sent to all brigades in the UK. The questionnaire (appendix 1) was self administered and sent direct to all Chief Fire Officers/Firemasters (CFO/Fmr) with a stamped addressed return envelope. Parahoo (1997, p.262) describes a self-administered questionnaire as "...one which respondents write their responses on the questionnaire without the research helping in any way".

The questionnaire was formulated to ensure the maximum return possible. Youngman (1987, pp.18-22), lays down some ground rules to assist maximum return; these rules revolve around the appearance and layout of the questionnaire with Saunders *et al* (2000, pp.303-304) giving advice regarding the content of the covering letter (appendix 1). The covering letter was key as to whether the questionnaire was completed, as it appears to be generally accepted by senior fire brigade officers that brigades are suffering survey fatigue, which has been exacerbated with the advent of Best Value consultation and benchmarking. The questionnaire was designed to elicit information from brigades to give an overall indication as to the current position in the UK Fire Service regarding PPV implementation.

Where possible brigades were asked to comment on issues of PPV implementation using a Likert Scale (Robson 1993, pp.256-257). A Likert Scale gives the respondent the opportunity to rate his or her belief or attitude. This rating method

gives the researcher an opportunity to explore, describe and assess (Parahoo 1997, p.259) attitudes towards PPV implementation. The questionnaire was piloted amongst BCC students and members of the researcher's brigade. The purpose of this piloting was to ensure that respondents had no problems with completion and that questions were valid. Saunders *et al* (2000 p.306) accepts that for a small scale survey extensive piloting is unrealistic, but he does still consider piloting to be important.

The survey had some limitations in that it could only elicit superficial knowledge and the data collected was not as wide ranging as most qualitative methods (Saunders *et al* 2000, p.94). Robson (1993, p.128) expands this further and indicates that the researcher needs to be aware of other shortcomings, such as low response rates, inaccuracies of completion and the respondents' attitudes and beliefs affecting the responses. The one advantage this survey had over most others is that it was totally inclusive in that all brigades were involved, whereas most surveys involve a 'sample' of potential respondents.

The survey returns gave the researcher an initial indication of how and if brigades were using PPV. This information was used to select a brigade to approach for a more in-depth analysis of their PPV usage and implementation, and also to select brigades for the Firefighter Opinion Survey.

## **2.3 Case Studies**

Upon completion of the UK Brigade Survey a case study methodology was adopted. Robson (1993, p.40) describes a case study as “development of detailed, intensive knowledge about a single case, or of a small number of related cases”. Tyne and Wear Metropolitan Fire Brigade was selected from the information supplied on the questionnaire as the only UK brigade using PPA on all stations. Similar case studies were carried out within Salt Lake City Fire Department (SLCFD) in the USA, and Aachen Fire Department in Germany. It was decided that the comparative case studies in the UK, USA and Europe would not only compare implementation strategies, but equally importantly, examine if there were any organisational, cultural or historic reason for any differences found. The data obtained from the case studies was qualitative in nature and provided the depth of detail that the questionnaire did not seek.

Information was collected during case studies using semi-structured interviews with key officers and as the survey results and previous research gave the researcher a good insight into the subject it was confirmatory in nature rather than exploratory (Robson 1993, p. 157). The semi-structured interviews were ‘focused’ (Robson 1992, p.159) with the researcher indicating the key topic areas to be discussed but without a fixed order of questioning.

## **2.4 Firefighter Opinion Survey**

A further short questionnaire (appendix 2) was used to obtain the views of firefighters in Tyne and Wear, Salt Lake City (SLC), Aachen, UK brigades that used PPV for post-fire smoke clearance only (stage 1), and UK brigades that do not use PPV. To recognise the different stages of PPV usage, the three PPA user brigades (Tyne and Wear, SLC and Aachen) received a slightly modified questionnaire (appendix 3) to that of the non-PPA user brigades.

This questionnaire was again formulated using a Likert Scale (Robson 1993, pp.256-257) so that respondents could rate their beliefs on a scale of one to five. The questionnaire was piloted, this time using operational firefighters from the researcher's own brigade. This was considered appropriate as the questionnaire was to be completed by operational firefighters.

The survey focused on firefighters' perceptions of the benefits of PPV and PPA. The data from this survey gave the researcher a method of assessing PPV's potential by analysing the views of the firefighters who should have an informed judgement, that is PPA users, and comparing it against non-users, and users who had not yet achieved PPA implementation.

## 2.5 Statistical Analysis of Survey Data

The accumulated data from the UK Brigade Survey (appendix 4) was quantitative in nature and therefore the computer programme Statsoft Statistica was used to analyse the collected data. Prior to this analysis the data was entered into a Microsoft Excel spreadsheet and imported into Statsoft Statistica.

The test used was that of validity, with Statsoft Statistica producing graphs for each question incorporating a normal distribution curve. The researcher visually validated each question by observing any apparent anomalies and returning, if necessary, to the original questionnaires to ensure all data had been correctly entered. The UK Brigade Survey had, by design, a small sample size (maximum 61) with some questions realising only three responses. For this reason, only validity testing was carried out. The researcher analysed the data by using the charts and averages produced using Microsoft Excel.

The Firefighter Opinion Survey had a far greater number of cases and therefore a more detailed statistical analysis was completed. The data (appendix 5) was subjected to validity testing in the same manner as the UK Brigade Survey and then the computer software was used to test for statistical significance. Statistical significance is normally set at a probability of 0.05 (1 in 20) indicating a result as 'significant'; or at 0.01 (1 in 100) indicating a result as 'highly significant' (Robson 1993, p.351). This use of a parametric ANOVA test gave the researcher an indication whether further analysis was required to explore the significance identified.

A result that does not produce significance does not necessarily mean that the result is not important for this study. The results of the test for significance are depicted as a p value, for example  $p = 0.05$  (1 in 20).

Where the researcher considered it necessary, a further test was carried out, a parametric t test. This test was used to focus on two of the three independent variables, PPA users (Tyne and Wear , SLC and Aachen), stage 1 users or non-users. The results of this test are depicted using p values to indicate significance in the same manner as the ANOVA test.

This hybrid methodology gave the researcher the ability to be able to address the hypothesis through analysis of qualitative and quantitative data obtained. Once all the data was collected and analysed, the researcher was able to deduce conclusions and test the stated hypothesis. The final part of this research was to produce a set of recommendations for the UK Fire Service.

The methodology was selected by the researcher in the knowledge that the time allowed for data collection, data analysis and report writing was restricted by the requirements of the BCC course. These requirements ensured the researcher set a strict timetable which was adhered to from the data collection in October and November 2001, through to the report writing taking place in February 2002.

### 3. LITERATURE REVIEW

#### 3.1 Ventilation

It is neither correct nor possible to properly discuss previous literature regarding PPV without making reference to ventilation or, as it is often termed in fire services throughout the world, 'tactical ventilation'. Discussion and debate on this subject appears to have been raging for many years with James Braidwood, London's first Chief Fire Officer, offering his concerned opinion as early as 1866:

The men of the fire brigade were taught to prevent, as much as possible, the access of air to the burning materials. What the open door of the ash-pit is to the furnace of a steam boiler, the open street door is to the house on fire. In both cases the door gives vital air to the flames (Braidwood, 1866, cited by Grimwood, 1992 p.145).

Perhaps London's most famous Chief Fire Officer, Sir Eyre Massey Shaw, appears to agree with his predecessor in an article published in 1876:

I am strongly of the opinion that many heavy losses, in past times, may be traced to the injudicious breaking of windows... The firemen must not forget that in doing so [breaking windows] he consigns the house to almost certain destruction...(Shaw, 1876, cited by Grimwood, 1992 p.145)

However Massey Shaw (1869, cited by Grimwood 1992, p.147) appears to understand the value of ventilation in his writings, but acknowledges that “it [ventilation] requires a considerable amount of discretion...” Sir Aylmer Firebrace CBE continues this debate by London CFO’s when he wrote in his memoirs:

In fighting a fire, careful attention must be paid to ‘ventilating’ it. Put simply, the art of ventilating is the art of providing a way of escape for heat and smoke... Often slates have to be removed and a hole cut in the roof timbers...(Firebrace, undated, cited by Grimwood 1992, p.147).

It is interesting to note that Firebrace refers to the ‘art of ventilation’. Perhaps this is the first acceptance by a prominent fire service figure that tactical ventilation has a place on the fireground, although it is now a point for debate whether ventilation is an art or a science.

These writings by London Chief Fire Officers are from the mid to late nineteenth century, yet for the next 100 years the UK Fire Service appears not to have developed this debate much further. Home Office (1983) devotes eight pages to ‘ventilation of fires’ and covers the very basic principles of how to ventilate. The Manuals of Firemanship were the cornerstone of UK firefighter procedures and ran to fourteen books (at that time) containing many hundreds of pages, yet only eight were devoted to ventilation. It appeared to be the case that Firebrace’s “art of ventilation” had not caught the imagination of the UK Fire Service!

In the late 1980s ventilation started to appear as a subject for debate in technical journals with Grimwood (1989) providing debate on the merits of ventilation in his technical paper for discussion. Grimwood's paper examines case studies and forwards comments on the correct and incorrect use of tactical ventilation. It is interesting to note that this paper gives a very brief mention of PPV and suggests "...monitoring its progress and examining its potential for ourselves" (Grimwood 1989, p.58). This appears to be the first mention of PPV in UK publications.

The continuing debate on ventilation was perhaps started in earnest in the UK Fire Service with Hay (1994). This research started to quantify the use of tactical ventilation in the UK Fire Service and is discussed more fully later in this section. It was this paper that captured the differences between approaches to ventilation in the UK and other countries, in particular the USA. He states:

Ventilation tactics are ingrained in the US system and it appears that a need has never been felt to prove or demonstrate the merits through theoretical or practical research. (Hay 1994, un-numbered abstract)

Hay discusses the fundamental differences in approach to ventilation found between UK and US firefighters, a theme which appears to run throughout all subsequent literature and research. This difference is acutely demonstrated by Norman (1997). He describes ventilation as "one of our primary firefighting tactics" (Norman 1997, p.18) which, although published in 1997, appears to be borne out by all information from the USA as far back as Firebraces's memoirs, when Firebrace describes the comments of an American Fire Chief: "...an American Fire Chief told me that he

rubbed in the principle of ventilation...” (Firebrace, undated, cited by Grimwood, 1992, p.147). Norman (1993, p.18) further demonstrates the USA’s aggressive approach to ventilation by his description, “To me, ventilation is an ongoing battle between the fire and the firefighters for control of the building... Remember, this is a war, the war that never ends.”

To bring the subject of ventilation to the present day, reference should to be made to Home Office (1997). This publication recognises the debate on ventilation in the UK Fire Service and devotes nearly 50 pages to the subject and includes a comprehensive section on PPV, recognising the discussions that have taken place over the previous ten years. This publication has tactical differences with the USA advice in that it recommends that roof vents should only be made from a ladder or aerial appliance rather than the roof itself. This advice would strike at the very core of USA Ladder Company personnel who often see themselves as ‘roof men’.

### **3.2 Research and Associated Publications**

PPV appears to have been in use since the 1950s (Coffman 2000, p.23), however there appears to be little published research or literature prior to the late 1980s. This is not to say that research and investigations did not take place, merely that if it did it was either not published or has been lost with the passage of time.

The first published material to find its way to the UK appeared to be an article by Battalion Chief Allmon. Allmon (1988, pp.39-41) describes PPV for ‘fire attack’ (PPA)

and also gives a brief précis of tests conducted at the Manual Weapons Test Facility at China Lake, California. At this time Allmon recognises that PPV is “a controversial firefighting tactic” but also states that in his opinion PPV is a “giant step forward for firefighter safety”. The article seems to set the pattern for many journal articles of the future in that it addresses ‘frequently asked questions’, but is rather short of scientific facts. Much anecdotal evidence is given with authors acting as ‘champions’ for the technique. This pattern is followed by Carlson (1988, 1989) in that he describes the technique and answers questions, but makes the point that an “adequate size up” (Carlson 1989, p.9) is required for the technique to work properly. At about the same time that the brief articles by Carlson and Allmon were appearing, Robertson (1989a and 1989b) published papers which to this day could perhaps stand up to scrutiny as a PPV training manual, and gives a comprehensive description of the safe use of PPV and its advantages over negative pressure ventilation. As importantly in assessing these pieces of work they give some disadvantages of incorrect use and recognise that; “As an attack tool, it is just a tactic. Remember, no tactic can be used at every incident” (Robertson 1989b, p.45). This article further demonstrates its balance, something that not all articles have, by cautioning “Communications and training are key elements in utilising PPV...” (Robertson 1989b, p.40).

Hughes (1989, pp.56-59) continues the debate in his role as a fire training specialist from North Carolina. He describes tests that were run which demonstrated a significant decrease in carbon monoxide levels and increasing casualty survivability when PPV was used for PPA. The tests also showed a dramatic reduction in fire compartment temperature. This appears to be the first publication of ‘scientific’ tests utilising PPV for PPA.

To this point all research and journal publications appeared in the USA, but this changed when Grimwood (1989) made brief mention of PPV in his discussion paper. This 'brief mention' turned into a full chapter in Grimwood (1992), where he gives a comprehensive guide and comment on PPV and its uses and refers to many USA experiences and describes the work of Larry Hughes. He concludes that:

PPV tactics most certainly have a place on the fireground and the techniques practised by firefighters in the USA throughout the 1980s have been highly innovative and imaginative (Grimwood 1992, p.174).

He has however, reservations about PPV being used for PPA, although in support he states that:

...a large percentage of fire suppression efforts would benefit from the use of such tactics [PPA] and there is much to be said in support of ventilation techniques that greatly reduces search and rescue times, increasing survival rates of trapped occupants (Grimwood 1992, pp.174-175).

Grimwood (1992, p.174), perhaps prophetically, further states "pre-attack PPV [PPA] warrants further investigation by both scientists and firefighters alike." This publication of 1992 appears to have started a slow trickle of PPV related literature, with Grimwood again writing on the subject. Grimwood (1993, pp.38-40) reports on tests that were carried out in Valencia, Spain, which combined PPA and the use of

fog spray in firefighting, the tests seeming to impress the author of the article, however he reinforced his stance that more research was necessary.

Grimwood's desire to see further research was to be satisfied by the FRDG. A series of reports were published by the FRDG that investigated various aspects of PPV and ventilation, the first was published in 1994 with the final one being six years later in 2000. The first of these reports, which can be seen as the foundation for the others, was Hay (1994). This report investigated the use of 'tactical ventilation' as a fireground tactic within the UK Fire Service and, as importantly, the use of PPV within brigades. An important finding from this report was that only 15% of UK fire brigades promote tactical fire venting, the main advantages being stated as "improved working conditions" and "limitation of fire spread" (Hay 1994, p.36). To further demonstrate the difference between UK and USA fire departments, 100% of USA respondees stated they promoted tactical fire venting. Hay's research established that few brigades were using PPV in any form and that none were using it for PPA. However Hay (1994, p.57) states that:

...many firefighters have experienced the benefits of ventilation whilst attending fires which have self vented and a strong interest is developing in the use of such tactics, especially PPV.

This report could be considered to be a seminal work, in that its recommendations have now been progressively addressed with the subject of ventilation being raised significantly following its publication. The recommendations in Hay (1994, p.59) were:

On the basis of this study it is considered that further work is required to:

- a) demonstrate the effectiveness of tactical ventilation procedures,
- b) develop procedures appropriate to UK conditions,
- c) provide firefighter training and ensure safe implementation.

Following the initial work commissioned by FRDG, Fraser (1994) published his BCC research project which examined ventilation and specifically PPV. Fraser identified cultural and tactical differences between UK and USA firefighting tactics and, as importantly, the major differences in building construction. The predominance of wooden construction in the USA meant that firefighters have to tackle fires quicker than their UK counterparts, and it also gives them the ability to create openings in roofs and walls to vent fires. Fraser (1994, p.18) also notes that UK firefighters have a concern that fire venting would increase the chances of flashover and backdraught yet USA firefighters use fire venting to reduce these risks. Fraser found that only 11% of responding brigades used PPV operationally and that 44% of respondees had either considered and discounted, or were not going to investigate PPV. He did not present any evidence to suggest that PPA was being used by any brigade.

Fraser assessed PPV usage in Britain and concluded that:

- a) PPV is led by fire officers rather than the industry.
- b) PPV is evaluated to assist ventilation (post fire) rather than as a fire venting tactic.
- c) Training is scattered.
- d) The majority of brigades who evaluated PPV have found it to be of operational benefit.
- e) A significant minority of brigades do not view PPV as being of operational value and do not intend to carry out evaluations.
- f) PPV still has a low profile in UK fire brigades.

(Adapted from Fraser 1994, p.18)

Fraser's recommendations included:

- a) A full survey of venting and ventilation in Britain.
- b) Manuals of Firemanship should be updated to take account of developments in ventilation techniques.
- c) Training in fire development, flashover and backdraught should form part of a firefighters basic training.
- d) Specific modules for PPV, fire venting and ventilation should be included in national training at watch commander level.

(Adapted from Fraser 1994, p.28).

The next in the FRDG series, Rimen (1995), does not feature PPV predominantly, but it does note, “In all cases the use of a PPV fan can greatly accelerate venting” (Rimen 1995, p.19). The more interesting point is that this work started the research of PPV in specific building or scenario types.

To continue the FRDG series, Hay (1996) explored the experiences of firefighters in the USA and mainland Europe in relation to PPV. Again this research found cultural and tactical differences but interestingly stated that, “In most cases the initial [USA firefighter] response to PPV was sceptical” and “The longest serving firefighters also tend to be the most sceptical” (Hay 1996, p.11).

Hay’s research uncovered the same themes as most of the previous work, although Hay presented evidence and case history – something that not all authors on PPV tend to do. Importantly in the context of this research, Hay discussed the scope for PPV application in the UK and concluded that:

- The use of PPV would significantly reduce time spent by crews on clean up and salvage operations.
- Differences in organisation or building construction between the USA and UK should not limit the potential usefulness of PPV.
- In many buildings PPV could be achieved without committing firefighters to roof top ventilation.
- The aggressive use of PPV should prevent flashovers.
- PPV should neither be expected to increase or decrease the incidence of backdraught provided appropriate training is given.

- PPV is particularly suited to single family dwellings.
- PPV can provide opportunity for firefighters to pressurise means of escape in buildings without these facilities.
- The effectiveness of PPV in large buildings is open to question.
- Significant additional training is required to implement PPV.
- A staged approach to implementation is required.
- A working party should be formed to develop operating procedures, training material and to exchange experiences.
- Mistakes will be made.
- The concept behind the technique is relatively easy to understand and the equipment is simple to operate. The training, organisation and skills required to apply the tactic safely and effectively are not as simple to develop

(Adapted from Hay 1996, pp.39-40).

Hay's report is a significant stage in PPV research and gives the UK Fire Service a very strong lead. This research project should go some way to establishing if the UK Fire Service has followed this lead.

The next published FRDG report, Rimen (1996), examined PPV with specific relation to domestic properties, and concluded that PPV has a role to play in firefighting in this type of structure. The tests conducted showed a reduction in temperature and an increase in visibility in the fire compartment when compared to not using PPV. The report gives some very definite advice on fan placement, size and opening ratios. This report does, however, appear to contradict or at least disagree with Hay

(1994) in that Hay found that only 15% of brigades promote tactical fire venting, yet Rimen (1996, p.61) states “Brigades have used natural ventilation to good effect for many years, and there is a vast pool of experience within brigades in this field.”

An explanation for this difference of opinion could be in the definitions used. Hay could be seen to be researching the use of fire ‘venting’ as a fire fighting tactic, whereas Rimen refers to ‘ventilation’, which can mean the removal of smoke following fire extinction. However there appears to be little more than anecdotal evidence to suggest that brigades have a “vast pool of experience in this field.” This potential confusion raises the question of universally accepted definitions. The FRDG reports remain consistent in differentiating ‘ventilation’ and ‘venting’; but the term ‘venting’ does not feature in Home Office (1997).

In 1997 the FRDG published a specific PPV report which examined the use of PPV in an unpressurised stairwell. Rimen (1997) concludes, in line with his previous work, that PPV can contribute to the effective tackling of incidents - in this case multi-storey buildings - both for smoke clearance and to keep means of escape clear for evacuation.

In 1998 the FRDG published its report which addressed the specific concern of many firefighters – the impact of PPV on a casualty lying between the fire and the exhaust vent. Thomas (1998) describes two days of testing at the Fire Service College by the Home Office Fire Experimental Unit (FEU) and Tyne and Wear Metropolitan Fire Brigade. The tests assessed casualty ‘survivability’ by measuring temperatures and

thermal radiation, and also assessed the potential for fire spread. The broad conclusions of this work were that:

PPV cooled the compartment more rapidly than was possible using natural ventilation alone and that, although the use of either form of ventilation increased the risk of fire spread when compared with not using ventilation, there was no apparent difference between fire spread under natural ventilation and when using PPV." (Thomas 1998, un-numbered abstract).

and that,

...overall the use of PPV would cause less harm to the casualty than the fire itself would already have done by the time the firefighting commenced (Thomas 1998, p.11)

By 1998 the picture had emerged from FRDG research that PPV was worth very serious consideration by brigades. The evidence suggested that potential for flashovers and salvage time can be reduced (Hay 1996, p.39), compartment temperatures can be reduced more quickly and casualty survivability is not worsened (Thomas 1998, p.11). This combination of temperature reduction and reduced flashover potential must clearly improve the safety of firefighters. This research project should go some way to assessing this from a firefighter's perspective by using the Firefighter Opinion Survey. The main fear of increased structural damage seems to be unfounded, with Hay (1996, p.36) stating, "Experience suggests that problems

arise through mis-application of the tactic, not as a result of any inherent danger in employing PPV.”

These ‘positive’ results need to be balanced against the agreement in general terms of all researchers who offer comment, that the key to correct use of PPV is proper and adequate training coupled with a logical and phased implementation programme. These pre-requisites form part of the recommendations of Hay (1996, p.39).

In recognising the requirements for training and a staged implementation, the Home Office, issued the Fire Service Manual covering ventilation (Home Office, 1997) and DCOL 14/1999 (Home Office, 1999), which laid out guidance for a PPV implementation strategy. The work of the National PPV Liaison Group contributed to the publication of DCOL 14/1999 and was further informed by the FRDG research. DCOL 14/1999 concluded that:

Recent research and experience in the UK has provided evidence that indicates that the balance of benefits from PPV in terms of:-

- occupant safety,
- crew safety,
- mitigation of property damage,
- mitigation of environmental damage,

far outweigh the perceived concerns, which have now largely been dispelled (Home Office 1999, p.9).

The DCOL gives guidance on a staged introduction of PPV in order to give firefighters the opportunity to build experience. This phased implementation can be seen in the diagram below which is reproduced from DCOL 14/1999 (Home Office, p.10).

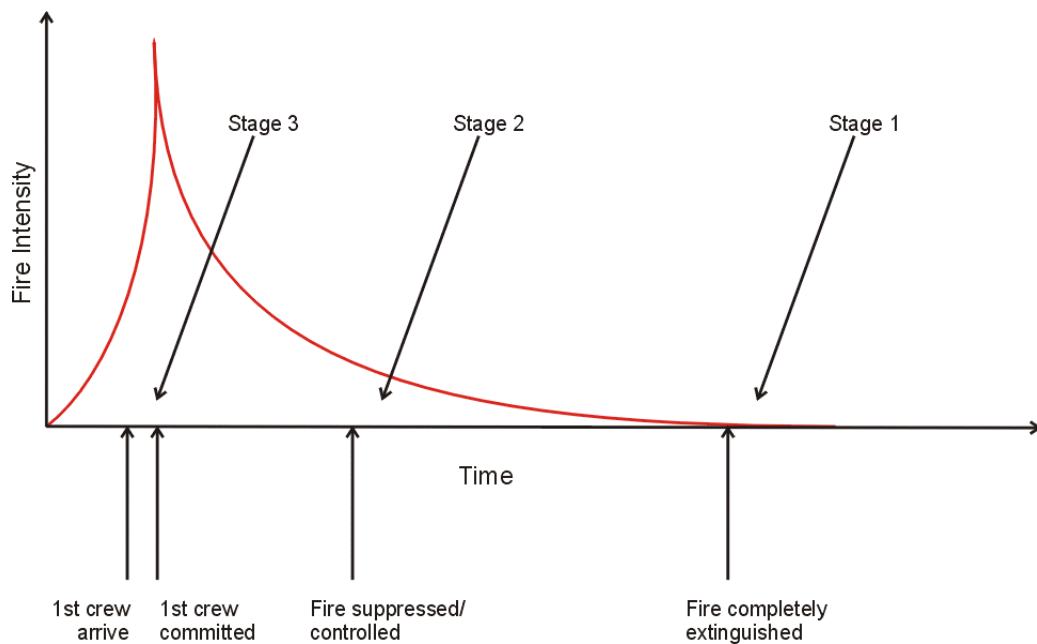


Figure 3

It is worth noting that although DCOL 14/1999 supports the introduction of PPV in the strongest terms and for quite explicit reasons, it does not give any instructions to brigades on whether they should implement, or any time scale for implementation.

In completing the FRDG series Rimen (2000) concluded that as with other tests, if used correctly PPV can assist in smoke clearance of large buildings dependant on fan and building size. This report brought the FRDG's research on PPV to a

conclusion with the recommendation for further research (Hay 1994, p.59) having been completed.

Articles continue to be published in fire related journals, but appear to recycle previous research or give anecdotal experiences. The researcher recognises that all research, with the exception of the FRDG, appears to have been conducted by PPV 'advocates' or 'champions', which can lead to bias or inaccuracies. It is for this reason that the researcher has described and analyse the FRDG work in detail as it appears to be the only consistent and independent work readily available in the UK.

## **4. RESULTS AND ANALYSIS OF INVESTIGATIONS**

### **4.1 Introduction**

There are three elements to this chapter, UK Brigade Survey, Case Studies and Firefighter Opinion Survey. Each element is presented in a similar manner with the analysis and findings presented first, this being followed by conclusions drawn from the analysis and findings. The three sets of individual conclusions are drawn together in chapter 5.

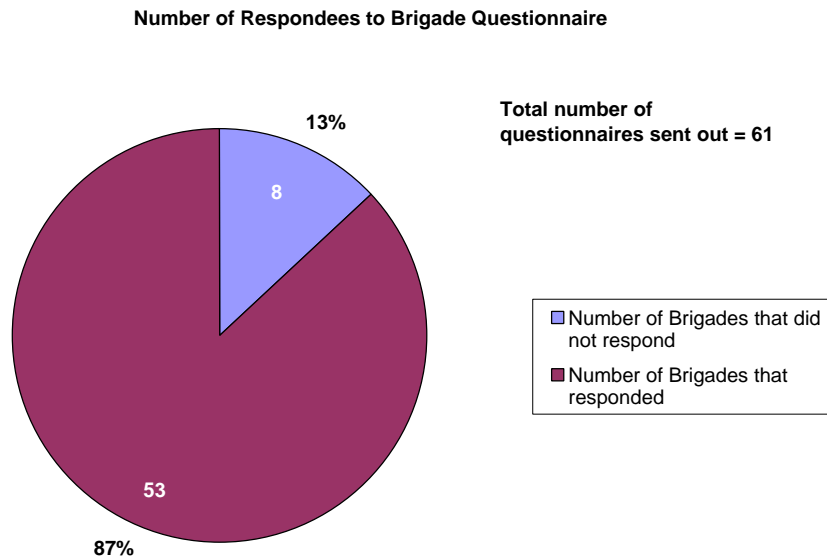
### **4.2 UK Brigade Survey**

#### **Introduction**

The UK Fire Service (including Jersey, Guernsey and the Isle of Man) consists of 61 fire brigades who may be either users or non-users of PPV. If an individual brigade is a user, it may be using PPV at any of the three stages detailed in DCOL 14/1999 (see figure 3). To establish the extent of PPV usage in the UK a questionnaire (appendix 1) was sent to every CFO/Fmr. The questionnaire also explored the reasons for usage and non-usage including the time-scales for any implementation in the future and allowed the researcher to select one brigade for a case study and other brigades for the Firefighter Opinion Survey. The results and analysis of this

survey are detailed in this chapter. The original data obtained from this survey is contained in appendix 4.

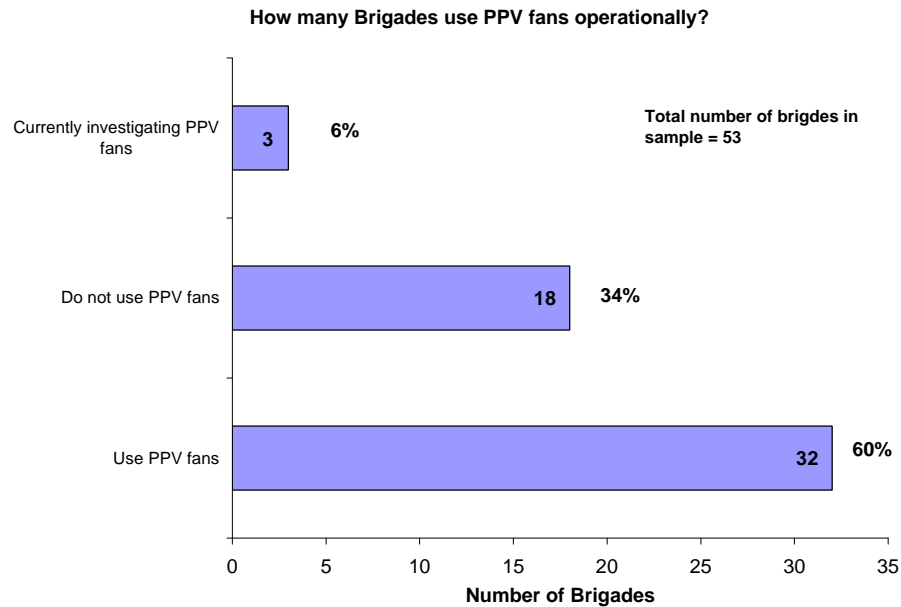
### **Response Rate**



The researcher considers a response rate of 87% to be extremely successful in comparison to other country wide surveys, especially considering the amount of questionnaires generated by fellow BCC students and Best Value initiatives. This high response rate may also be attributable to the topical nature of the subject and the simplicity of the questionnaire.

In discussing the responses to this survey, the figure of 100% is used to refer to the total respondees, that is 53 brigades. It must also be remembered that brigades' responses relate to a specific time - November 2001.

**Question 1 Does your brigade, at present have PPV fans that are being used operationally?**



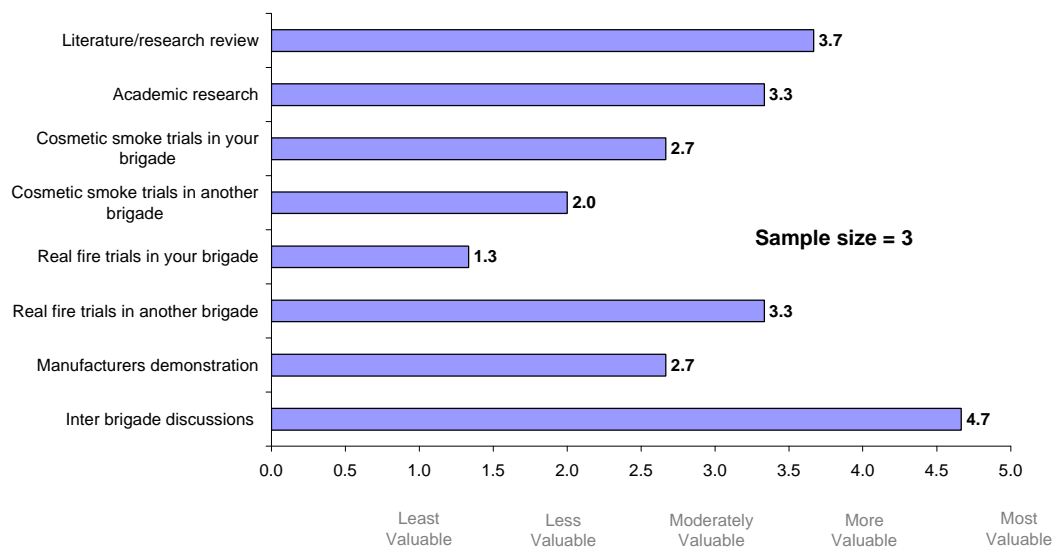
The above chart shows that 60% of brigades are using PPV operationally in one of the three stages. Brigades in the UK can be generically divided into County, Combined and Metropolitan Authorities, and there appeared to be no relationship between type of authority and whether PPV is used or not.

An analysis of staff level and type was undertaken which did show important findings. Comparison was undertaken to compare the quantity of wholetime or retained personnel and whether this had a bearing on the likelihood of PPV being used. Firstly, the amount of wholetime firefighters in a brigade did not appear to have a bearing on PPV usage. However, the amount of retained personnel in a brigade does appear to have a bearing, the higher the level of retained, the less the chance of a brigade using PPV.

**Question 2. Please indicate your opinion as to the value of research you are currently undertaking in being able to ultimately reach a decision whether to adopt PPV operationally.**

For Brigades Who Are Investigating The Use Of PPV

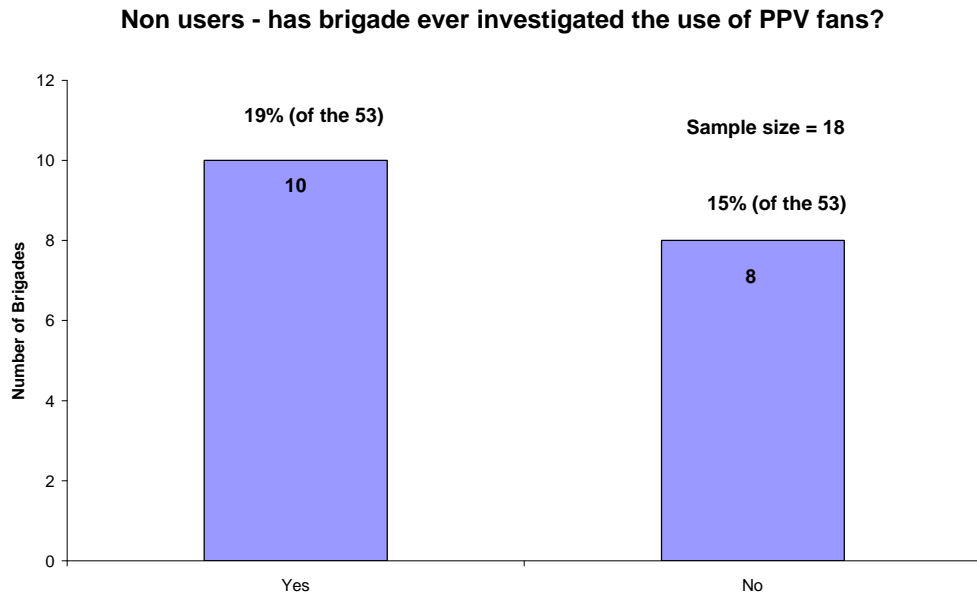
**Average scores of Brigades as to the value of research currently undertaken in being able to reach a decision whether to adopt PPV**



Only three brigades were investigating PPV and therefore the sample size was too small to draw any conclusions. The results from this question are amalgamated with questions 4 and 7 to give a larger sample size to analyse the value of research undertaken.

**Question 3. Has your brigade ever investigated the use of PPV fans?**

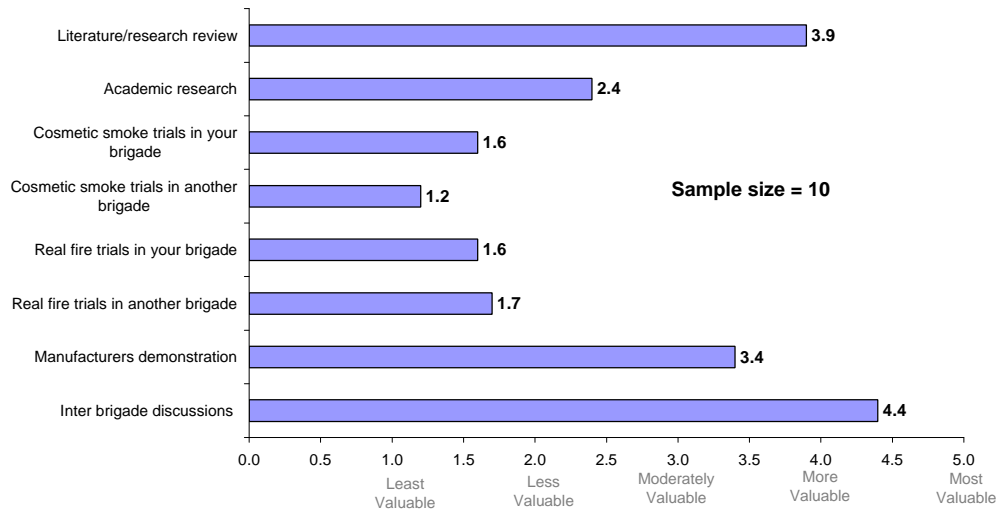
For those brigades answering 'No' to question 1



It is apparent that 79% (60% decided to use, 19% decided against use) of UK fire brigades have investigated the use of PPV, with 24% deciding not to proceed with implementation following their investigation. If this figure is used to establish the potential implementation for the three investigating brigades, and the brigades that have not yet investigated, it could be anticipated that another eight brigades will implement PPV. This would establish 40 brigades (75%) as PPV users. This statistic is prior to any re-investigation that takes place as discussed in question 6.

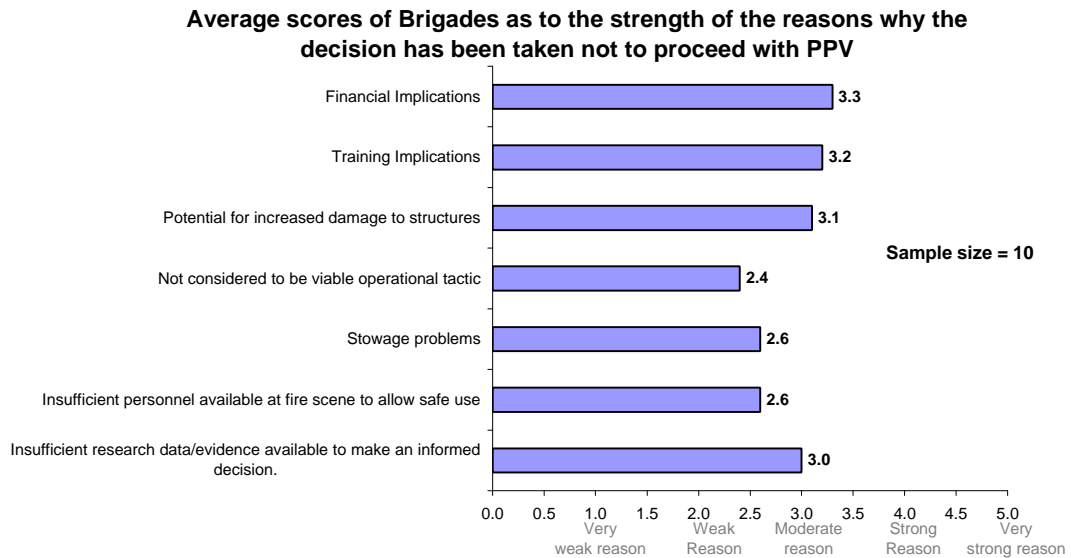
**Question 4. Please indicate your opinion as to the value of the PPV research that was undertaken by your brigade in relation to the decision not to proceed.**

**Average scores of Brigades as to the value of research that was undertaken in relation to the decision not to proceed with PPV**



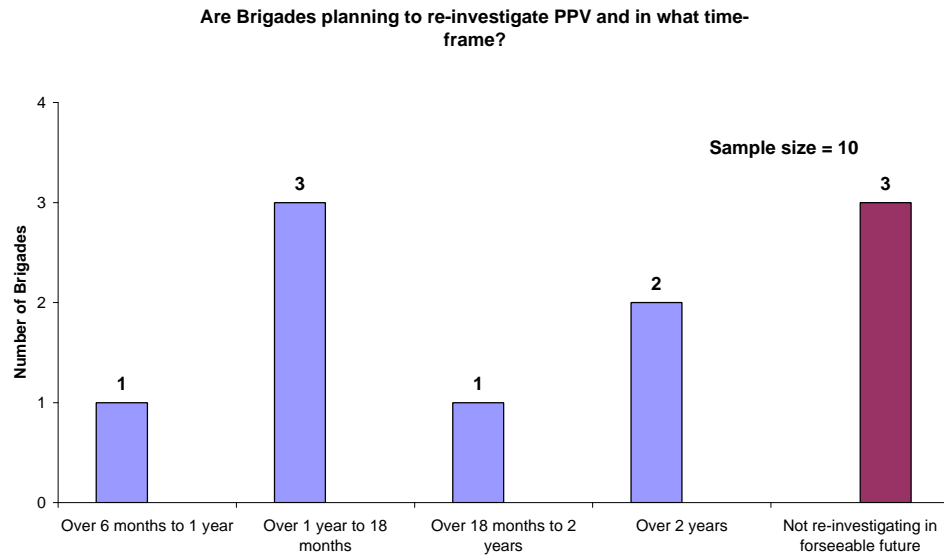
This question has given quite clear results as to the value of research; with inter-brigade discussions (4.4), literature/research review (3.9), and manufacturer's demonstration (3.4) valued more than other research avenues. It is interesting to note that question 7 reveals similar scores with inter-brigade discussions (4.1) and literature/research review (3.8) being the most valuable research prior to the decision to implement. This indicates that brigades value the same type of research regardless of whether the decision is taken to implement or not. The results of this question are amalgamated with questions 2 and 7 to give an overall indication of research value from all brigades.

**Question 5. Please indicate your opinion as to the strength of the following reasons why the decision has been taken not to proceed with PPV at this time?**



This question (and question 14) gets to the very heart of the decision as to why brigades do or do not implement PPV (or move to stage 3). The results show only a small difference between scores with financial and training implications being the strongest reasons for non-implementation. The relative closeness of all scores may indicate that there are many reasons that influence the decision not to implement rather than one or two major reasons. The two highest scores, financial (3.3) and training (3.2) implications are obviously closely linked with all training having an associated cost.

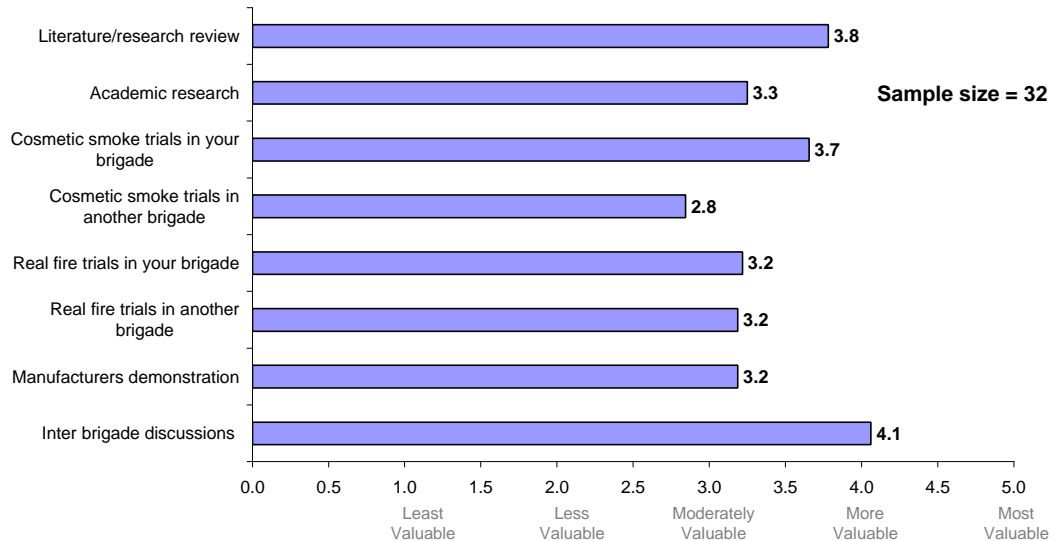
**Question 6. Please indicate whether your brigade is planning to re-investigate PPV and in what time frame?**



As can be seen, seven brigades will be re-investigating PPV, five within two years, representing 70% of the brigades that have taken the decision not to proceed with PPV at this time.

**Question 7. Please indicate your opinion as to the value of the research undertaken by your brigade prior to PPV being adopted operationally.**

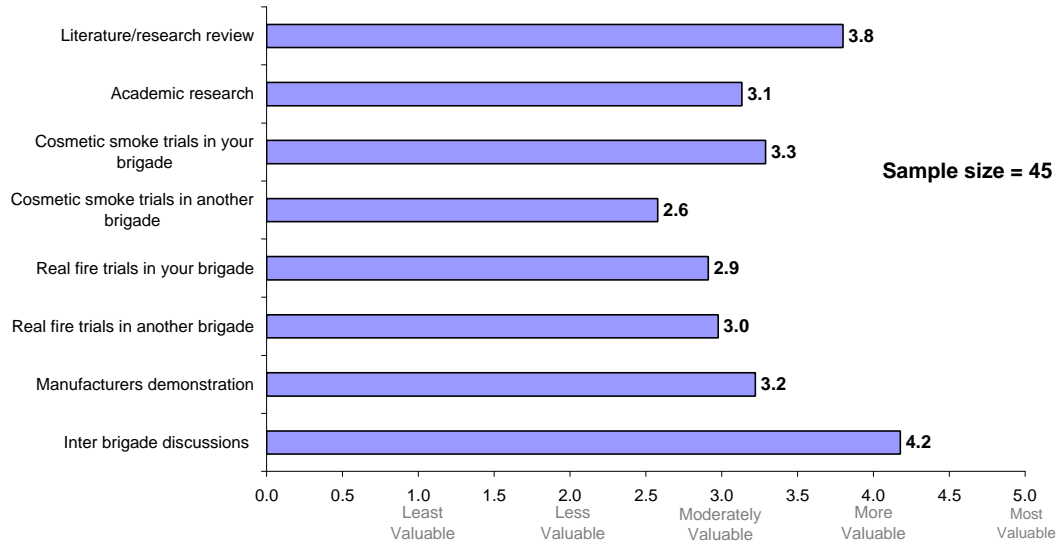
**Average scores of Brigades as to the value of the research undertaken prior to PPV being adopted operationally**



This is the first question that probed brigades that have implemented PPV, and in common with question 4, inter-brigade discussions (4.1) and literature/research review (3.8) were indicated as the most valuable research. However, the range of scores was not wide, indicating that all categories had a moderate or higher value, the exception being cosmetic smoke trials in another brigade (2.8).

**Questions 2, 4 and 7**

**Average scores of Brigades as to the value of research undertaken, prior to PPV being implemented, and in relation to the decision not proceed with PPV.**



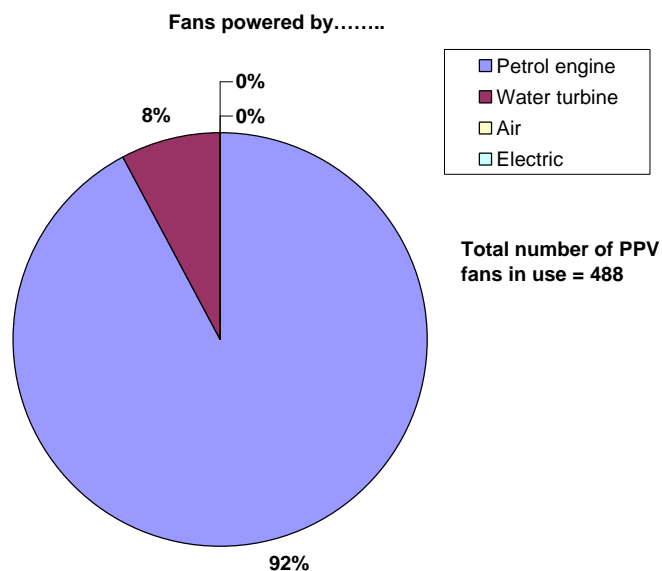
This chart shows the amalgamated scores of the three questions to give an overall indication as to the value of research undertaken by all brigades, whether investigating, already implemented, or the decision having been taken not to implement.

The amalgamated scores reflect the individual questions in that inter-brigade discussions (4.2) and literature/research reviews (3.8) are valued most.

**Question 8. How many fans does your brigade have in total?**

Total number of fans in use by the 32 brigades using PPV is 488. This figure cannot be used to accurately gauge the amount of fans in each brigade as the question showed that some brigades have a fan for each station and some have few fans held at strategic locations (see question 10).

**Question 9. Are these fans powered by petrol engine, water turbine, air or electric?**

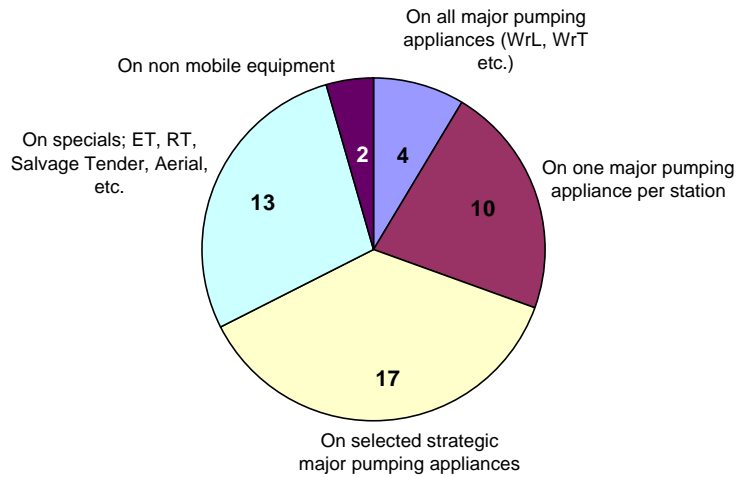


The vast majority (92%) of fans in use are powered by petrol engines, this giving the fan the advantage of being self-contained and portable.

**Question 10. Are fans placed on....**

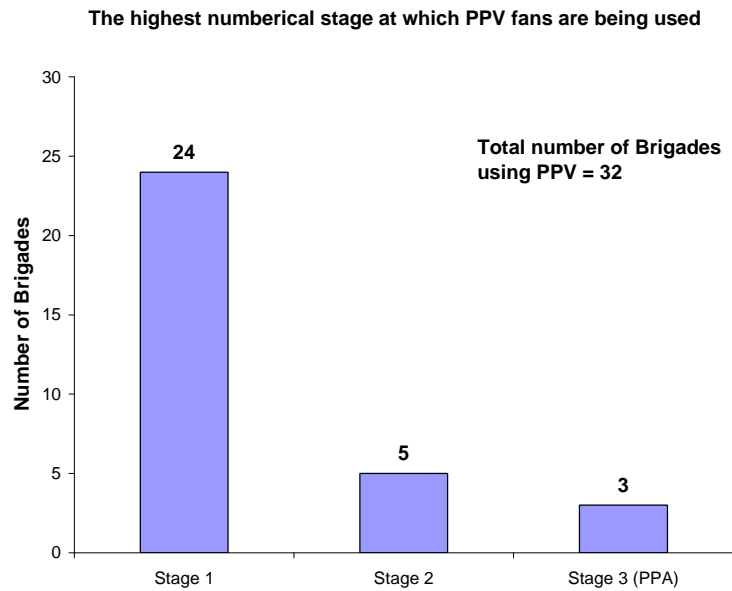
**Where are fans placed?**

Total number of fans = 488



This question gives a reasonable indication of how brigades are carrying fans. Some brigades have a combination of placement, such as on 'specials' and on 'selected strategic major pumping appliances' and therefore the total number of brigades exceeds the number using PPV operationally.

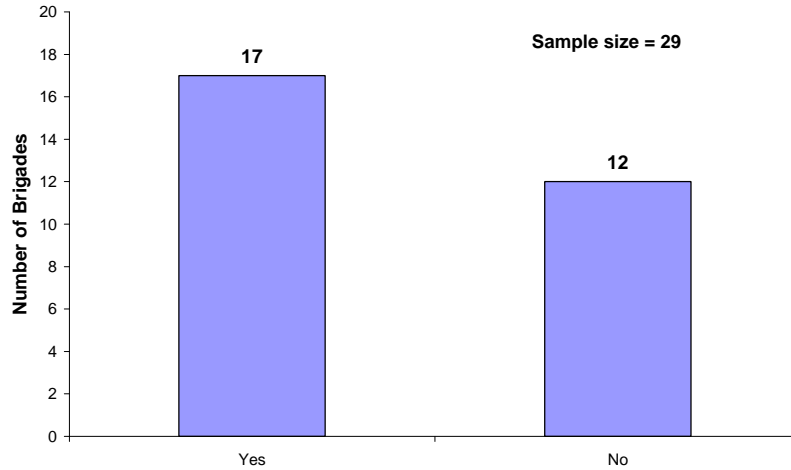
**Question 11. Please indicate the highest numerical stage in which your brigade currently uses PPV.**



This question identifies the stages (as defined in DCOL 14/1999) in which brigades are using PPV, and allows the researcher to be able to identify the number of brigades at each stage of use within the UK Fire Service.

**Question 12. Has your brigade taken the decision to move progressively towards stage 3?**

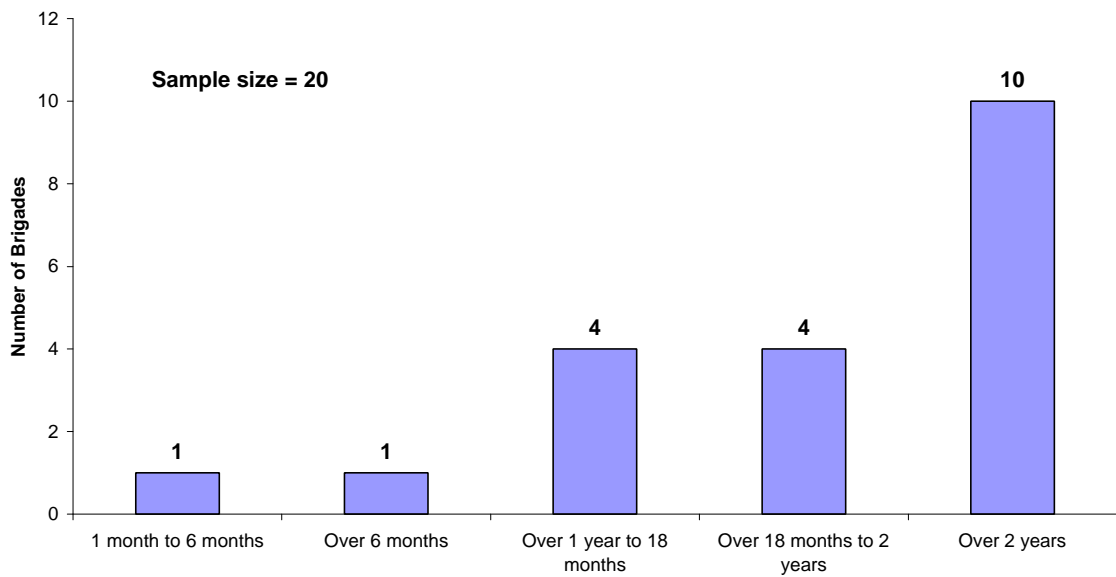
How many Stage 1 and 2 brigades have taken the decision to move to Stage 3



Seventeen brigades have taken the decision to move to stage 3 use (PPA). These, added to the three that are already using at stage 3, mean that 20 brigades, or at least 38% of UK brigades, will be using PPV at stage 3 in the future.

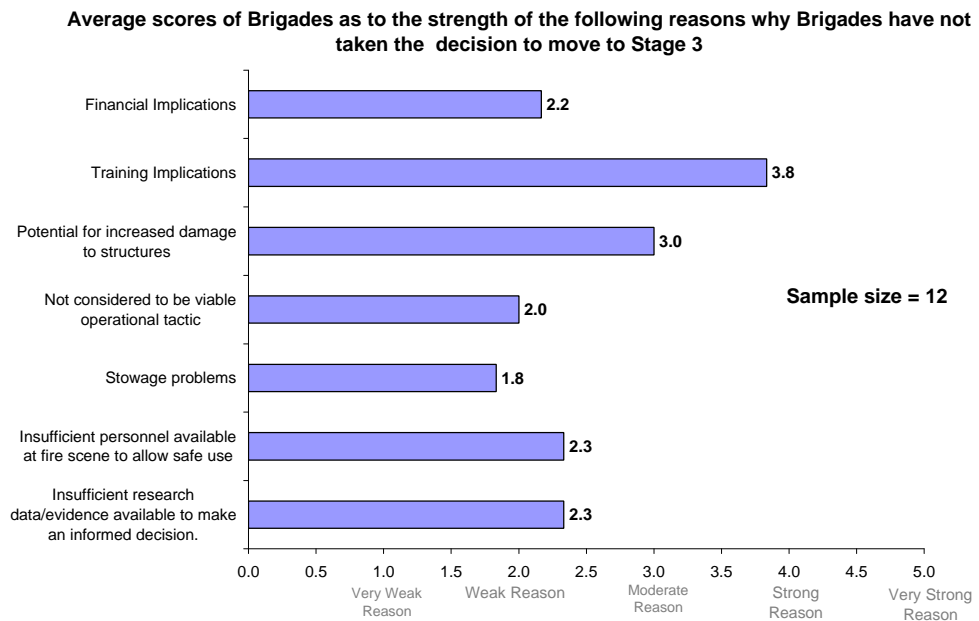
**Question 13. Please indicate (or estimate if you intend to progress to stage 3), the approximate time scale between your brigade starting to use PPV (stage 1) and starting to use PPV in stage 3.**

Actual or estimated time for moving from Stage 1 to Stage 3 use by brigade using at Stage 3 or that have taken the decision to move progressively to Stage 3



This question demonstrates that half of the brigades believe they will need over two years to progress from stage 1 to stage 3. However, the same number of brigades believe that this progression can be achieved in less than two years. These apparently opposite stances may be explained by the prevailing local conditions in brigades.

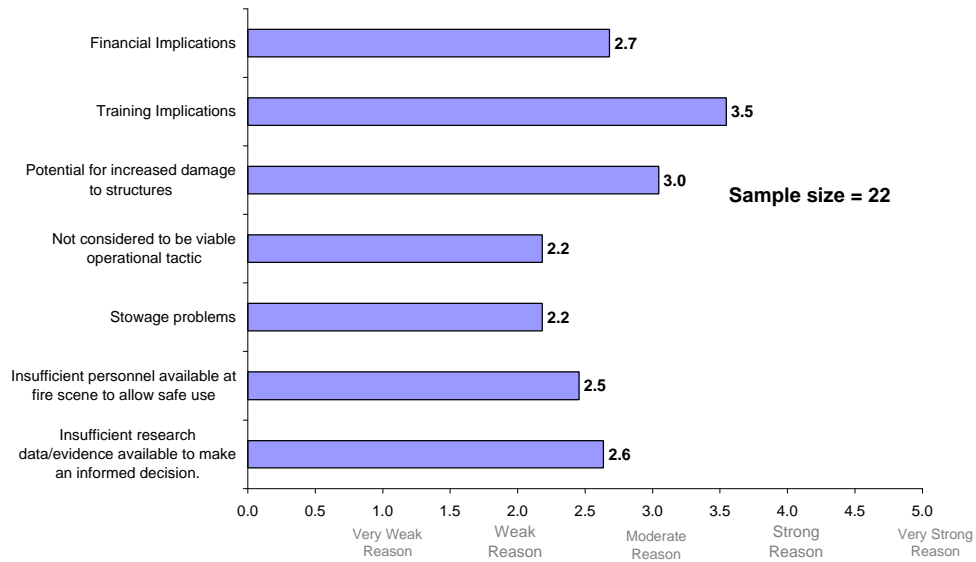
**Question 14. Please indicate your opinion as to the strength of the following reasons why your brigade has taken the decision not to move to stage 3?**



It is apparent from the data displayed in the chart above that there are two reasons why brigades at stage 1 have not taken the decision to move to stage 3; the training implications and the potential for increased damage to structures. These two reasons rate as 'strong reason' and 'moderate reason' respectively, with all other criteria being 'weak reasons'. This indicates that there are no particular problems with the other criteria.

**Question 5 and 14**

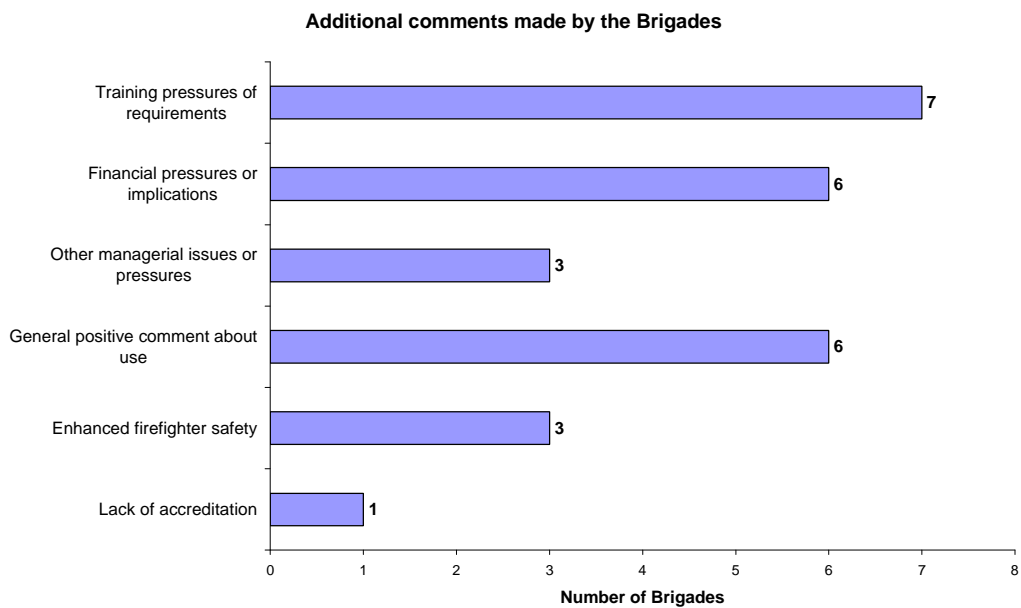
**Average scores of Brigades as to the strength of the reason why Brigades have not proceeded with PPV or have not taken the decision to proceed to Stage 3**



This chart shows amalgamated scores of the reasons why brigades have taken the decision not to implement, or not to move from stage 1 to stage 3. Training implications again rate highly with potential structural damage and the financial reasons being second and third. The main difference between question 5 and question 14 is that financial implications score far higher (3.3), for brigades that have decided not to implement rather than brigades (2.7) who have not taken the decision to move to stage 3. This suggests that brigades seem to believe that the financial cost of introduction are high and therefore impact upon the decision whether to introduce PPV, but are not such a consideration when deciding whether to progress to stage 3.

## **Comments**

This section of the questionnaire gave respondees the opportunity to add additional comments if they so desired. These comments have been analysed by categorising them according to subject matter.



The comments reflect the analysis of the survey in that training and financial considerations are at the top of brigades' concerns for PPV implementation.

It is interesting to note that six brigades offered general positive comments regarding PPV but no negative comments were offered.

### **4.3 UK Brigade Survey Conclusions**

This survey and its results directly relate research objective (b) as stated in the introduction of this research project, that is:

**(b) To establish the extent of PPV use in the UK Fire Service.**

The questionnaire was designed in such a manner as to obtain a high response rate so that any statistical analysis could be considered to be representative of the entire UK Fire Service. A response rate of 87%, that is 53 out of 61 brigades, was considered to be a good return, and enables the researcher to analyse the returns in the knowledge that they should be representative of the UK Fire Service.

The literature review established that Fraser (1994) found operational PPV usage to be 11% of UK brigades. The results of this survey show an increase to 60% of UK brigades, and further detail in the number of brigades at each stage of use in accordance with DCOL 14/1999 (Home Office, 1999). DCOL 14/1999 (Home Office, 1999) suggests an implementation programme, which culminates with stage 3 PPA use. As of November 2001, only three brigades were using PPV at this stage, and therefore it could be argued that only 6% of UK brigades were, at that time, using PPV to 'its full potential'. There appears to be no identifiable trends regarding which brigades are at which stage when analysed against brigade type, CFA, County or Metropolitan.

Having stated that only 6% of brigades are using PPV to its full potential, only 15% of brigades have stated 'no' to PPV implementation, this being after 79% of brigades have investigated the technique. It could be anticipated using the results of this survey that 75% of UK brigades will become users, this being prior to any reinvestigations that may take place.

The survey indicates that 20 brigades have already taken the decision to move to stage 3 usage, and therefore the November 2001 figure of 6% is likely to increase to at least 38% in the foreseeable future. This far higher percentage of brigades that have already decided to move to stage 3 is perhaps demonstrating that, although there are problems surrounding PPV implementation, these problems are not perceived to be insurmountable.

The survey does give a good indication as to the main concerns of brigades, that of training and finance for PPV and PPA. The two main concerns are obviously linked, with every training event having an associated cost. The issue of training may have a direct link to which stage brigades are at present using PPV. Analysis of brigades by the amount of retained personnel in their establishment shows a correlation regarding whether PPV is used; the higher the amount of retained, the less the chance of a brigade using PPV. Anecdotal evidence indicates that due to the amount of training time available to the retained, and the geographical isolation of many retained stations, training of this group of staff is difficult to achieve and perhaps more costly than their wholetime colleagues.

This concern regarding the level of training for PPV implementation, or progression to stage 3 usage, is reflected within the comments offered within the questionnaires. The most frequent comment was that of concerns regarding the training implications of PPV, indeed a CFO who personally completed the questionnaire listed the training issues he already had within his own brigade, these precluding him from introducing PPV at that time.

The survey indicates that brigades see PPV and PPA as a viable operational tactic. This suggests that the research, especially that of the FRDG, has been accepted and that the concerns of brigades revolve around barriers to implementation rather than the lack of operational application. This position appears to be supported by the lack of negative comments regarding PPV as a procedure; the comments suggesting issues surrounding the difficulty of implementation - training and finance especially.

This survey gives an indication as to the research methods that brigades have used in reaching decisions regarding PPV implementation. The most used and highly rated methods of research are that of inter-brigade discussion and literature and research review. These two avenues of research are the cheapest and logistically most easy to facilitate, and therefore it is perhaps understandable that they are frequently used. The issue of the logistics of researching and testing, including the associated costs, is amplified by 'real fire tests' being least used, these tests perhaps having the greater logistical and cost implications.

This survey has identified UK PPV and PPA usage, also identifying the increase in usage since the survey conducted by Fraser in 1994. The survey also gives a good

indication as to the barriers to implementation - training and finance. These reasons are not exclusive but they do form the largest body of concern. The results also demonstrate that many brigades use PPV, with many having the intention to progress to PPA usage, thereby demonstrating the acceptance by many of the validity and worth of the technique.

## **4.4 Case Studies**

### **Introduction**

The UK Brigade Survey could only elicit basic facts and opinions regarding PPV and its introduction. The survey gave evidence of PPV usage and at which stage. Based upon this information Tyne & Wear Metropolitan Fire Brigade was selected as a case study, contact being made with the nominated officer as indicated at the rear of the questionnaire.

The international brigades were selected following information received from fellow BCC students. This information led to an introduction with a UK fire brigade officer who had a good knowledge of PPV and its perceived usage on the international scene. The researcher indicated to this officer the requirements he had of any international brigade selected and took the advice given. Following this advice a decision was taken to select a fire department in the USA and a department on mainland Europe. SLC and Aachen were both contacted with exploratory discussion taking place to establish whether these brigades satisfied the requirements of the research. These discussions resulted in the international case studies as described in this section.

The researcher has attempted to set out the three case studies in a consistent manner. However it became apparent that the three brigades had different implementation methods and drivers for this implementation. For this reason there is a slight variation in the manner of presentation, especially that of chronology.

## **Tyne and Wear Metropolitan Fire Brigade**

This case study has been completed following semi-structured interviews with the two officers who have been the focal point in Tyne and Wear's PPV implementation programme - Divisional Officers David Turpin and Graham Bowser.

### **The Brigade**

Tyne and Wear Metropolitan Fire Brigade is situated in the North East of England, bounded by the North Sea to the east, Durham and Darlington Fire Brigade to the south and west, and Northumberland to the north. The brigade is predominantly urban, with Newcastle, Gateshead and Sunderland providing the largest areas of population, the total area covered being approximately 210 square miles with a population of 1.1 million. Tyne and Wear provides its fire cover from 18 wholetime and 1 retained stations with a total workforce of 1,107 wholetime firefighters and 24 retained firefighters.

In late 2001 Tyne and Wear had one PPV fan per station, these fans being used regularly for PPA. This level of usage makes Tyne and Wear the only brigade in the UK to be using PPA on all stations, and as such Tyne and Wear could be seen to be the UK's leading exponent of PPV usage.

Chronology of PPV Implementation

1993            During 1993 the brigade's Technical Services Department investigated the options available in replacing smoke extraction units, and subsequently purchased an Angus Turbex Hi-Ex foam generator to use in the negative pressure mode. It was during this time that PPV fans came to the brigade's attention, initially as a method of smoke extraction. Two units were purchased for trial purposes, although the research staff remained sceptical regarding their worth for PPV.

1994            A twelve month trial took place during 1994 with a manufacturer's manual providing the only written guidance for the fans use.

1995            This year provided a turning point in what was, to this point in time, an ad hoc investigation and implementation. This turning point came when the CFO obtained first hand experience of PPV and decided, in collaboration with his management team, that his brigade should attempt to fully grasp the concept and explore all avenues for available use.

A four day watch instructors course was devised to allow all personnel to receive cascade training in post fire (stage 1) PPV use. The two PPV 'champions' - David Turpin and Graham Bowser - who taught the watch instructors, gained their knowledge and experience through

previous usage and trials rather than through any laid down learning process.

1996 A week of live fire tests took place in Gateshead using derelict domestic properties. The test results showed significant benefits in using PPV, both for smoke clearance and PPA. They also showed that if used incorrectly additional fire damage could be caused. The Brigade Management Team gave permission for previously devised cascade training to be commenced after receiving full reports on the Gateshead tests.

It was following these tests and training that the brigade went 'live' with PPV for smoke clearance, in what would now be termed as stage 1 use.

1997 During 1997 the CFO of Tyne and Wear decided to explore PPV usage within the UK Fire Service. Tyne and Wear had performed extensive and lengthy internal trials but had not fully involved the wider UK fire service. To establish UK usage the brigade organised a seminar at Tyne and Wear Training Centre, this acting as a catalyst for the formation of the National PPV Liaison Group. The brigade also took the step of organising a one-day seminar for FBU officials.

Starting in 1996, but mainly falling within 1997, all personnel received additional training to use PPV in PPA mode, this took ten months to fully complete throughout the brigade.

1998 Following the training given in 1997 and the real fire tests, the brigade went 'live' with PPA at any incident that was not 'persons reported' and when fire was contained to a single room. In March 1998 the recently formed National PPV Liaison Group met at the Fire Service College for the first time, where it was agreed that two sub groups would be formed to explore training requirements and an implementation strategy. This work, upon completion, formed the basis of DCOL 14/1999 (Home Office, 1999).

However a question mark remained regarding the survivability of a casualty that lay between the fire and the exhaust outlet. In July 1998 Tyne and Wear assisted in trials at the Fire Service College and then commissioned its own tests through Chiltern Fire, to establish casualty survivability when PPA was used. Both sets of tests showed no significant change in the condition of the casualty, a conclusion reached by Thomas (1998).

1999 In 1999 the work commenced by CFO Bull came to fruition with the publication of DCOL 14/1999, and with its publication Tyne and Wear went fully offensive at any incident that the incident commander deemed necessary.

1999 – 2002 Tyne and Wear continue to play a leading role within the PPV National Liaison Group, organising six monthly meetings, and also supplying PPV training to other brigades. PPA continues to be used throughout the brigade with all new recruits receiving training during the recruit courses run at the Brigade Training Centre.

### Previous Research

The most significant barrier to PPV implementation found by Tyne and Wear was that of a lack of knowledge or research on PPV. It could be considered that Tyne and Wear 'learnt the hard way' by conducting their own trials and gaining experience along the way. A lack of guidance (prior to DCOL 14/1999) also meant that the brigade, and perhaps the CFO in particular, was open to criticism and even litigation should the use of PPV not have been successful, or have caused additional damage or injuries.

All training and written guidance was self produced based on experience and acquired knowledge, although the use of a manufacturer's manual proved invaluable to the early stages of the learning process during 1993 and 1994.

### Fire Brigades Union

The FBU were identified at an early stage as a key player within the implementation process. Throughout the investigation and implementation the FBU have been kept informed and participated in trials. Indeed the FBU National Officer for Health and

Safety has attended Tyne and Wear to view the procedure and also discuss the implications of PPV. A Regional FBU Official from Tyne and Wear now acts as an advisor to the FBU National Executive on PPV issues.

### Training

As indicated by the UK Brigade Survey, training is considered to be the single biggest barrier to implementation of PPV, especially for PPA usage. All personnel in Tyne and Wear have received training but a costing exercise for this training has not been conducted. Tyne and Wear benefits from being a small (geographically), compact brigade staffed almost entirely with wholetime personnel. The nature of fire cover has meant that crews could attend the training centre by taking themselves off the run, this being an option that is not available to many larger rural brigades. Having stated this, the instructional staff in Tyne and Wear do not consider the training to be complicated and with logistical support, they believe adequate training could be delivered at, or near any station.

### Resistance to Change

Divisional Officers Bowser and Turpin were open and honest in admitting that the change of fire fighting ethos— that of blowing air into a fire - was not universally embraced by Tyne and Wear personnel. Pockets of staff remain who show resistance, this being demonstrated by one firefighter who stated “I’ve been fighting fires for 29 years without PPV, why should I use it now?” The uncertainty of the technique also caused an understandable unease among brigade managers,

especially as Tyne and Wear felt it was pushing the boundaries of PPV use in isolation. This feeling of isolation acted as a catalyst for the creation of the National Liaison Group, and ultimately DCOL 14/1999 (Home Office 1999). The uncertainty amongst brigade managers was not felt as acutely at watch level, with it becoming apparent that firefighters were using PPA before official sanction by the brigade. Both interviewees felt sure that PPA was used between 1994 and 1998, well before the Brigade Management Team gave official sanction. This was cited as a demonstration of how PPV and PPA has been introduced by the brigade but driven forward by the firefighters themselves.

### Compartment Fire Behaviour Training

During the 1990s many UK brigades have introduced compartment fire behaviour training to their staff with many brigades installing flashover simulators. During this period Tyne and Wear concentrated more on PPV than on fire behaviour training to the point where the interviewees believe Tyne and Wear are now playing 'catch up'. As stated in the literature review, research suggests a holistic approach to tactical firefighting, which includes fire behaviour training before, or at least at the same time as PPA training. In hindsight Tyne and Wear would have liked to have done this, however both interviewees did not consider that this lack of training to have caused any significant problems.

## **Salt Lake City Fire Department**

This case study has been completed following a six-day visit to SLCFD. The visit involved semi-structured interviews with Battalion Chiefs Kriss Garcia and Reinhard Kauffman and extensive un-structured discussions with operational firefighters.

### The Fire Department

SLC is situated in the north of the state of Utah in the USA. It is the primary city of Utah and contains the state's administrative and political centres. The city has a resident population of approximately 300,000 people, this rising to over 400,000 during the working day as people converge on the city for work.

SLCFD provides fire cover and primary emergency medical cover, utilising 375 professional firefighters, from 13 fire stations located throughout the city, including the airport. The vast majority of the area covered by the fire department is urban or sub-urban, with very little rural area. Areas outside of the city jurisdiction are covered by other fire departments such as, South Salt Lake City and Salt Lake County. Each of the 13 fire stations houses an Engine Company with three stations also having a Ladder Company. There is also one Hazardous Materials Company in the city. The medical response is provided by the fire appliances rather than from dedicated ambulances and should a patient require transportation to hospital, a Gold Cross private ambulance performs this function. Medical calls account for over 85% of the

25,000 calls per year received by the SLCFD. All Engine Companies carry one PPV fan and all Ladder Companies carry two larger fans.

### Firefighting Culture

Prior to discussing any aspect of firefighting within SLCFD an understanding must be gained of the firefighting philosophy that is inherent within the fire department. As has been demonstrated in the literature review, ventilation has a large role in any USA firefighting operation, much more so than would be found in traditional UK brigades. This is reflected in the structure of attendance to property fires, the pre-determined attendance being three Engine Companies and a Ladder Company, the Ladder Company having the dedicated primary task of ventilation at all incidents. Historically, ventilation in SLC was performed vertically by cutting a hole in the roof, a common practice throughout the USA. Upon arrival, and after quick consultation with the Engine Company Captain, the Ladder Company would immediately commence ventilation operations from the roof. The rationale for this historical practice has two factors, both revolving around the traditional domestic building structure. In SLC, again in common with much of the USA, wood is the predominant domestic building material, including that used for roof tiles. This means that unlike UK traditional block or stone construction, the actual fabric of the building will burn, and burn quickly. Secondly the wooden construction allows for easy access by the use of chainsaws or similar equipment. For these reasons vertical ventilation has historically been performed at the same time as, or prior to, fire attack. Standing on a roof has obvious dangers, especially pitched roofs without safety rails; standing on a pitched roof directly above a developing fire has even more obvious dangers, these dangers

provided one of the main drivers as to why the two Battalion Chiefs advocated and eventually succeeded in getting all SLC stations to fully adopt PPA.

### Chronology of Implementation

In 1986 two Lieutenants, Kriss Garcia and Reinhard Kauffman attended a lecture in Kern County, California, given by Chief Cliff Allmon where many scenarios were put to students for discussion. One of these scenarios was a typical house fire with all students putting forward a tactical plan which included traditional vertical ventilation. The instructor suggested there was a better way, the use of PPA. Both Kriss and Reinhard were very sceptical and returned to their fire department without giving the subject much more thought.

Within the next 12 months both Lieutenants attended the same incident where a young girl lost her life. The incident was a 'typical' house fire with breathing apparatus crews entering and searching for the casualty. It was this incident that rekindled both Lieutenants' thoughts on PPV, and over the following weeks they discussed whether PPA could have been used at the incident to give the young girl a better survival chance. Although neither of the Lieutenants were convinced of the benefits, they both had an open mind and without specific official sanction a PPV fan was obtained for trial and placed on Kriss Garcia's station. The Lieutenants' open minds were not replicated among other staff. At one stage the PPV fan was placed on the Engine when Kriss was on duty, and then removed by the other crews when he was not. This situation continued with Kriss and Reinhard trialling the PPV fan in as many scenarios as possible as well as being used at incidents. Slowly staff that

came into contact with the concept were persuaded of PPV's potential, although at this stage it was only a few members of SLCFD.

In 1991 Kriss was promoted into the role of equipment officer. Whilst performing this specialist function he had the opportunity to influence many more individuals including his superiors. Although some resistance remained, the fire department purchased more fans and commenced more extensive trialling. These trials proved very successful and the decision was taken to equip all apparatus (fire appliances) and allow the use of PPV in any stage including PPA. SLC has now been using PPA on all stations for nearly ten years.

### Training

All training was performed in house with crews attending a two day course at the training centre. SLCFD trained all firefighters in the use of PPV and placed PPV training on the syllabus for all recruit firefighters. In this manner the use of PPV has become as much ingrained into the fire department as any other piece of equipment.

Similar to Tyne and Wear, SLCFD has a small geographical area and has the ability to detach fire appliances to the training centre complete with the crew. The department has a far greater amount of fire appliances than a comparable UK city and takes a more holistic approach to fire cover without having specific station grounds.

Refresher training is not considered any more necessary than other pieces of equipment and as such, following initial recruit training, all training is crew/watch based. Recruit firefighters fresh from training school found it difficult to understand the controversy or debate that surrounds PPV and seemed to accept PPV in the same manner that they accepted breathing apparatus or hose.

All staff in SLCFD receive real fire training although the department has recently stopped carbonaceous fire training and changed to gas simulators, citing PPE destruction as the reason.

PPV training is supplemented by the department's training manual, which covers all aspects of a firefighters role in a similar manner to the UK Manuals of Firemanship. This manual contains a section of 30 pages on ventilation, including PPV, as well as the department providing a specific 13 page supplement dedicated to PPA.

#### Resistance to Change

There is little doubt in the minds of Kriss Garcia and Reinhard Kauffman that a general resistance to change provided the biggest barrier to PPV implementation, indeed they both admit that they initially had similar feelings. The resistance experienced in SLCFD was different to that experience in Tyne and Wear. In Tyne and Wear there appeared to be a general cynicism regarding the technique and whether it would create additional structural damage or injuries. The resistance in SLCFD was more about abandoning the traditional vertical ventilation tactics rather than a lack of faith in the technique. Ladder Companies saw their role as getting

onto the roof of buildings, and PPV would change this role to one of PPV operation on the ground. During informal discussion with operational staff the researcher formed the view that some personnel saw this removal of a traditional technique as striking at the very heart of a Ladder Company's role, regardless whether the new technique proved to be safer or more effective. Whilst discussing this matter with the researcher, Battalion Chief Kriss Garcia made a statement that caught the essence of how he and his colleague, Battalion Chief Reinhard Kauffman, managed to change attitudes; "Facts alone will not change hearts and minds. To change hearts and minds passion is required".

The two Battalion Chiefs found that by simply explaining PPV and PPA using the results of scientific and empirical research they were not convincing staff of the equipment's worth. Success, in the minds of the two Battalion Chiefs, was only achieved once they started to use emotive situations, videos and scenarios. Indeed it took this type of example, the death of a young girl, to convince the two young Lieutenants of PPV's worth in the mid 1980s. This is the method that Kriss Garcia uses to this day when he lectures throughout the USA on the subject.

## **Aachen Fire Department**

This case study has been compiled following a three day visit to Aachen Fire Department. Semi-structured interviews were conducted with Ollie Grooz and Ralf Johnen, junior officers allocated to the researcher by the host brigade. The researcher also had unstructured discussions with groups of operational personnel.

### **The Fire Department**

Aachen is a small city with a resident population of approximately 250,000, situated on the Belgian border of North West Germany. The city is known for its historical importance and its well-established university that supports a significant student population. Although slightly smaller in population than SLC, Aachen is geographically much smaller with over 50 percent of its accommodation being in three or four storey apartments.

Aachen Fire Department provides fire and primary emergency medical cover from four fully staffed stations, one in a hospital, and two volunteer stations. The department attends approximately 3,500 fire related incidents per year, of which 600 are confirmed fires. The stations are staffed by 265 professional firefighters receiving support from 300 registered volunteers. Volunteer firefighters play a significant role in Germany with one in every 60 persons being a volunteer firefighter; it not being unusual to have over 100 volunteers at a station that would be staffed by 12 retained firefighters if in the UK.

Appliances in Aachen are similar to those seen in the UK, with rescue pumps, turntable ladders, hazardous material vehicles and ambulances. The fire departments of Aachen and SLC provide the same services, the only difference being that Aachen uses dedicated ambulance vehicles for emergency medical response, although all staff are fire and ambulance trained.

### Firefighting Culture

The method of firefighting in Aachen appears to be very similar to that seen in the UK. Crews that attend incidents do not have predetermined roles like SLC's Ladder and Engine Companies; they take their lead from the incident commander and act accordingly. Again, more in common with the UK, vertical ventilation does not figure highly on an Aachen firefighter's agenda, ventilation being performed horizontally, if at all. Ventilation is at the very core of firefighting in SLC, this not being the case in Aachen. It is for these reasons that the researcher believes Aachen Fire Department and UK fire brigades' firefighting tactics have far more in common than UK brigades' tactics have with SLC.

### Chronology of Implementation

Aachen did not set an implementation strategy or timetable, with the introduction of PPV being very ad hoc in nature. Aachen's chief officer first saw PPV at the Intershultz Exhibition in 1988. Based upon the chief officer's discussions with a manufacturer at the exhibition, Aachen purchased PPV fans and placed them on the run immediately. The staff were given very minimal instruction or training and were

allowed to learn from usage and experience. Staff were given a very basic lecture on ventilation and were left with a manufacturer's manual. The department gave little guidance although staff, through their own initiative, used the fans for smoke clearance before attempting PPA.

This situation prevailed for eight years until the mid 1990s when more formal instruction was given. PPV was also placed on basic recruit courses.

Prior to attending the fire department, the researcher was given the impression that Aachen personnel used PPA extensively, however they use PPV mainly in stage 1 or 2 mode, although they can, and do, use it for PPA if they so wish.

### Building Construction

The building construction in Aachen is similar to that of the UK with houses having stone or brick walls and pitched roofs covered with slate or stone tiles. At least 50 percent of the accommodation is three or four storey apartments, which were built following the destruction of building stock during World War Two. Both these types of construction have a bearing on PPV usage.

Firstly the traditional house construction in Aachen cannot be easily vertically ventilated due to the solid roof construction and therefore vertical ventilation is rarely used. Whilst discussing this aspect of PPV usage in Aachen it was found that the department's firefighters were very reluctant to create an exhaust exit for PPV if it meant causing damage, for example breaking a window. The firefighters were happy

to use an existing exhaust opening already created by the fire but found it alien to cut openings or break windows. Upon discussion the firefighters readily agreed that the internal structure would be seriously damaged by 'bottling up' the fire and that it was best to remove the heat, smoke and other products of combustion. Their views and actions appear to contradict one another – a statement they agreed with! Perhaps this is an example of how deeply rooted an historical practice or view can be.

As stated above, many residential buildings in Aachen are in the form of three or four storey apartments. The apartments are constructed in the traditional block or stone manner but with one difference that significantly affects the potential use of PPV. The apartments have a natural ventilation system that is designed to keep the air moving throughout and between apartments. This is shown in Figure 4.

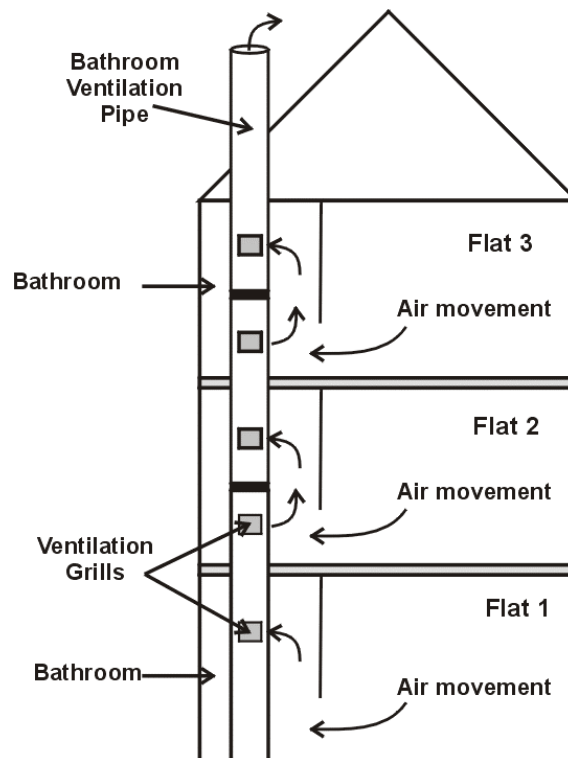


Figure 4

Figure 4 is an over-simplification of the process of air flows, but gives the basic principles.

A ventilation pipe runs vertically up through all bathrooms. The air from the bathroom in flat 1 flows into the bathroom in flat 2. It then circulates and flows into the return grill and discharges into flat 3, from flat 3 discharging to outside. As can be seen from figure 4, this means that there are open connections between all flats. Bathroom ventilation is not the primary reason for this. Flats are normally provided with a gas heating system that requires adequate ventilation. All internal doors in the flats have a grill at their base so that air can move freely around the flat and ultimately to outside. This ensures that the gas system operates correctly – unfortunately it also means that all parts of the same building have interconnections that, in the case of fire, mean rapid fire or smoke spread. Should PPV be used in this type of building, the smoke or fire could be forced to all section of the building.

It must be stated that this type of construction is not now permitted, with the vast majority of buildings of this type being built in the post-war rapid rebuilding period.

### Training

Aachen firefighters have had very little training in PPV, but the training they have had can easily be provided either at stations or centrally. This is the one common aspect of the three case study fire brigades; they are all compact in nature and can easily facilitate training using on duty personnel. The only exception to this are the volunteer Aachen firefighters who receive no centrally based training. Aachen

appears to have a different attitude for the provision of training, which would perhaps require further research to establish if it has an effect on PPV usage.

The prevailing training culture in Aachen appears to believe that firefighters are practically minded, intelligent individuals who by nature of the profession they perform, have good common sense. Using these traits it is expected that firefighters can almost train themselves on the job, based upon the fact that they would always want to do their best. The watch and station commanders who oversee their activities are all long serving and experienced personnel, and by cascading their experience personnel build up expertise.

With such a brief time in Aachen Fire Department it is difficult for the researcher to offer comment on this training culture, with the exception of saying that the staff appear professional in their approach and application of fire fighting tactics, including PPV.

Real fire training has been introduced into Aachen Fire Department in the previous two years with all professional firefighters receiving the training, but this has not been specifically linked to any PPV training.

#### Resistance to change

Resistance to change did have an impact in Aachen, but not to such an extent as has happened with SLC and Tyne and Wear. It appears that staff have a very open mind to PPA, but through the predominant type of building construction it has a limited use.

SLC had some entrenched views, both for and against PPA. Tyne and Wear had some entrenched views, both for and against PPA; but Aachen personnel seemed to have a more relaxed attitude to the subject and simply accepted that it could be used if necessary.

## **4.5 Case Study Conclusions**

The three brigades in these case studies have similarities; geographically compact, staffed predominantly by wholetime professional firefighters, involved with PPV for eight years or more, and using PPV in PPA mode. However there are also important differences; culture, training regimes, building construction and operational activities. These similarities and differences have all had an impact on the implementation of PPV in the respective brigades.

Aspects of the organisation and prevailing internal and external environments influence the implementation of any new procedure or process. As a general overview, all three organisations had very different implementation methods. Tyne and Wear controlled their implementation quite tightly with defined and identifiable milestones throughout; trialling, post fire use, PPA use in specific circumstances, and finally full adoption of PPA. The opposite was found in Aachen with procurement immediately followed by full use of PPV in any stage as the incident commander decided necessary. SLCFD sat between these two styles of implementation in that they did trial the equipment, but initially without specific managerial direction.

The UK Fire Service now has an advantage over those in the USA and Germany. In 1997 the UK Fire Service received detailed guidance on PPV procedures in the fire service (Home Office 1997), and DCOL 14/1999 (Home Office 1999), which gave detailed guidance on PPV implementation. This type of national guidance or framework is not available in either the USA or Germany. The USA does have a very informal network of PPV contacts but no evidence for this could be found in Germany. Although this guidance is now available, Tyne and Wear adopted a full implementation programme without it, in fact it was Tyne and Wear's investigation and pro-active stance on PPV that drove the production of this guidance.

Perhaps the starkest finding in the case studies was the difference in training that personnel of the three organisations received. In common with implementation styles, Tyne and Wear were very much different to Aachen, with SLCFD sitting somewhere between. Aachen did not devise or introduce any significant training prior to full implementation, whereas Tyne and Wear had a training programme before post fire and PPA use. Tyne and Wear's training ensured that all personnel were fully trained before progressing to each stage. SLCFD did train personnel, but a formal PPA training regime was not introduced until after implementation of this stage of use. Initial training was given in SLCFD with the two Battalion Chiefs personally delivering the programme, this training being considered adequate for full implementation of all stages of use.

A common theme in Tyne and Wear and SLCFD was that of 'champions' forcing their respective organisations to progress towards implementation. David Turpin and Graham Bowser in Tyne and Wear, and Kriss Garcia and Reinhard Kauffman in

SLCFD acted as PPV advocates, and through personal endeavour beyond their normal brigade roles, they persuaded and convinced senior management of the value of PPV, and ultimately PPA. Although difficult to evidence, the researcher gained the impression that neither fire brigade would have implemented PPA or even PPV in the stated time frames, without these individuals acting in the manner they did. A significant commonality between all four individuals is that they have remained as their respective brigade's PPV 'gurus', regardless of promotion through the ranks or transfers through various brigade departments. Initially Aachen did not have a 'champion', the brigade's chief officer identifying the equipment and its worth, but not personally following its introduction with the same personal vigour as seen within the other two brigades. This may be another contributory factor as to why personnel in Aachen seem to hold less positive views than in the other two brigades.

Another reason for this difference in strength of views may be attributable to the level of use of PPA, which is affected by the prevalent building construction within the three brigades. Tyne and Wear has a lot of low socio-economic building stock, and during the early and mid 1990s much of this was derelict and prone to arson. This gave Tyne and Wear personnel many opportunities to use PPV and ultimately gain valuable knowledge and experience to progress in full confidence to PPA. The personnel in Aachen are very much restricted in the application of PPA; firstly the brigade's level of fire calls is low in comparison to Tyne and Wear and to a lesser extent SLCFD; but more significant, the type of apartment accommodation is not suitable for PPV use. SLCFD has fewer calls than Tyne and Wear but its building stock is very suitable for PPA use in that it is mainly two storey detached housing.

This demonstrates that the type of building stock encountered in an area can dictate PPA usage and perhaps even whether PPA should be adopted.

Resistance to change was very much evident in SLCFD and Tyne and Wear, but less so in Aachen. The resistance in SLCFD and Tyne and Wear was for different reasons, but both reasons could be attributable to the historic cultures of the brigades. Some resistance remains in SLCFD and Tyne and Wear, but this is very much in the minority. Aachen encountered much less resistance to this change and could be cited as a reason why a 'champion' did not appear - perhaps a 'champion' is only required when cultural resistance is encountered.

All three brigades have implemented PPA in different ways; indeed they had different environments in which to introduce this equipment. These case studies have exposed the difficulties that may be encountered in PPA implementation and some of the restrictions in the use of PPA. The results of the Firefighter Opinion Survey should help to identify how successfully the implementation, training and cultural changes have been received.

## **4.6 Firefighter Opinion Survey**

### **Introduction**

The stated hypothesis for this research has three elements; UK PPV usage, potential PPV usage, and the potential for PPV to enhance firefighter safety. The UK Brigade Survey has established the UK usage of PPV and the literature review has established the theoretical potential for PPV usage and its ability to enhance firefighter safety. The literature review demonstrated some robust research, especially from the FRDG, but is this theoretical view backed up by actual experience within brigades?

This questionnaire was devised and used by the researcher to establish the perceptions and views of firefighters regarding PPV. Three brigades were selected that use PPV to its considered full potential – that of PPA. The three brigades selected, Tyne and Wear, SLC and Aachen, give a perspective from the UK, the USA, and Germany. The researcher felt that by selecting brigades from separate countries it would give him the opportunity to obtain views from brigades with no connection and that may have different cultural and historic backgrounds.

This survey also gave the researcher the ability to explore any barriers to PPV implementation from the viewpoint of firefighters that use PPV defensively (stage 1) or not at all (non-user). Two brigades were selected in each of these categories from the UK Brigade Survey. It is not considered necessary to identify these brigades and

therefore their results have been combined under two headings – ‘Stage 1’ and ‘Non-Users’.

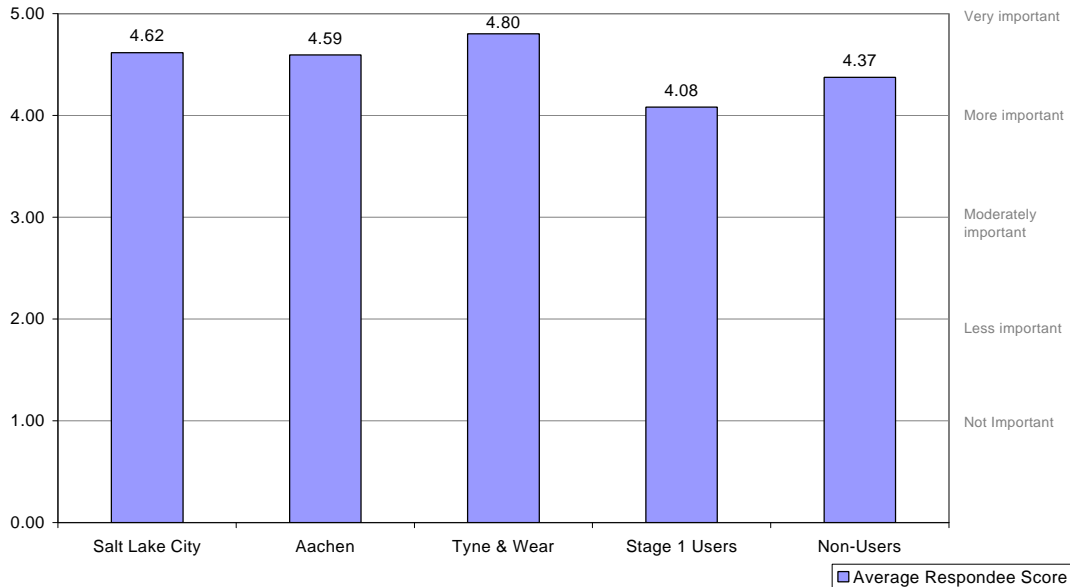
The questionnaires were sent by post to the selected UK brigades, with the contact identified in the UK Brigade Survey distributing, collating and returning the completed questionnaires. The researcher had lengthy telephone discussions with the contact in each UK brigade to ensure correct instructions were given to all personnel who completed the questionnaire.

The questionnaires for the two international brigades were given to firefighters personally by the researcher whilst visiting their fire departments. To eliminate any potential bias that may be inherent in the host for these visits, the researcher was given opportunity to randomly select the stations and crews that were given the questionnaire.

The primary intent of this survey was to identify the views of PPA users, stage 1 PPV users and non-PPV users. For this purpose the three PPA users; Tyne and Wear, SLC and Aachen, have been grouped together for statistical analysis. Each PPA brigade is however given its own entry on the charts so that any potential differences between these brigades may be seen. For analytical purposes, on occasions, the stage 1 PPV users and non-PPV users have been grouped together as ‘non-PPA users’.

The original data from this survey can be found in appendix 5.

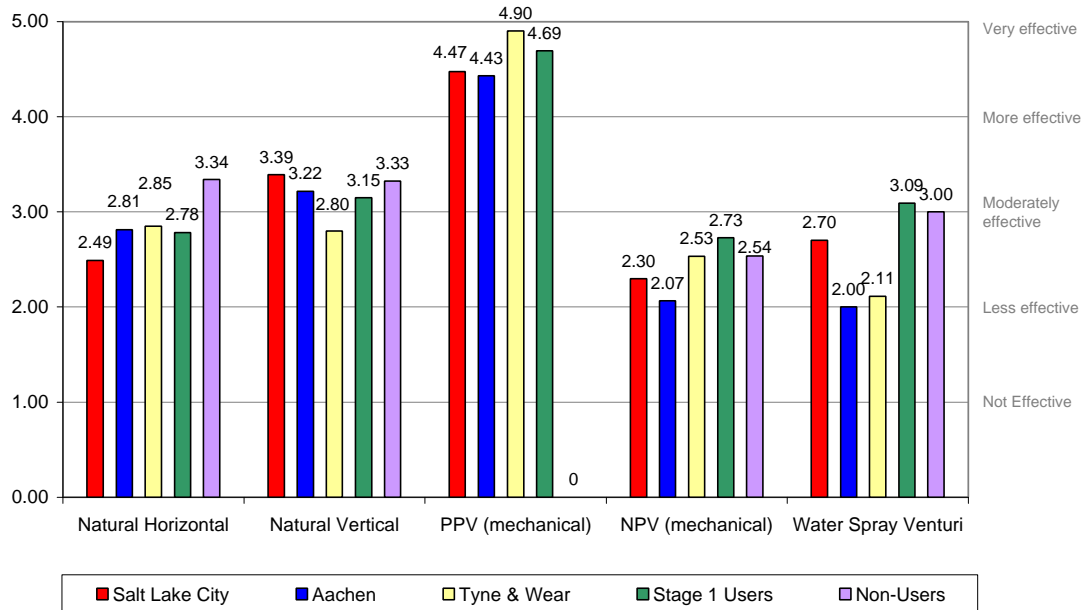
**Question 1. How important is the use of ventilation in fighting fires in compartments (single rooms, domestic properties, industrial units etc.)?**



ANOVA	p=0.000	demonstrating a high statistical significance.
t test comparing non user data set with stage 1 user data set	p=0.164	indicating no significant difference between the two data sets
t test comparing stage 1 data set with PPA data set	p=0.000	indicating a highly significant difference between the two data sets
t test comparing non-user data set with PPA data set	p=0.146	indicating no significant difference between the two data sets

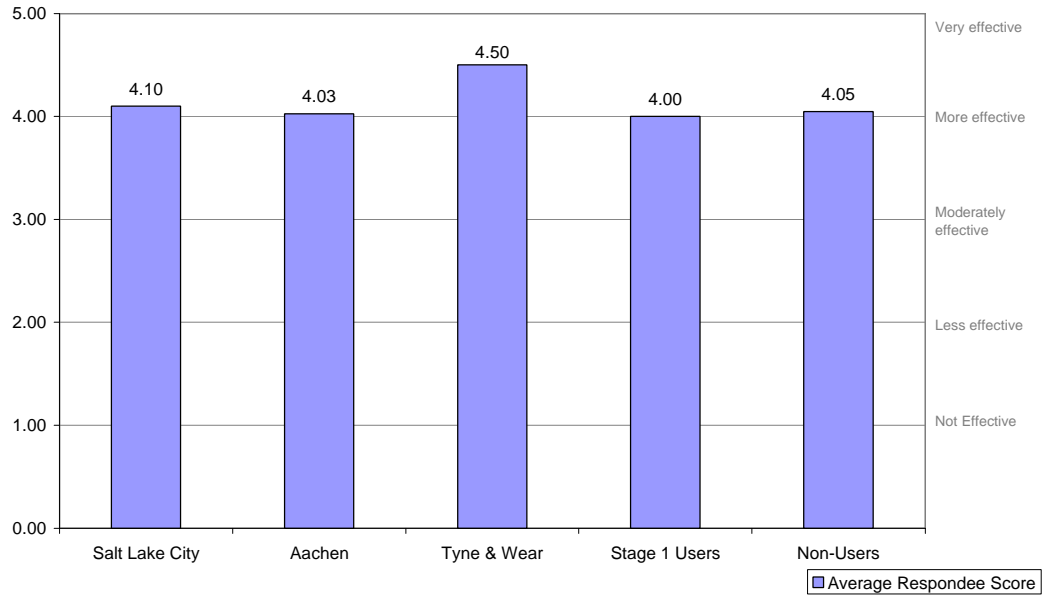
The ANOVA test demonstrated a high significance, which was further explored using t tests. These tests showed no significance between non-users and stage 1, but high significance between stage 1 and PPA, this is shown in the chart with PPA users rating the importance of ventilation higher than non-PPA users. These statistical tests indicate that if firefighters use PPA they rate the importance of ventilation higher than firefighters that do not use PPA. The results also show that on average all firefighters rate the importance of ventilation 'more important' or higher.

**Question 2. Please indicate and rate the effectiveness of the different types of ventilation you use as a standard operational procedure within your Fire Brigade/Department**



This question sought to explore the effectiveness of the ventilation techniques that may be used by the brigades questioned. It can be seen that those brigades utilising PPV rate its effectiveness higher than any other type of ventilation. Both types of natural ventilation are rated by all brigades as being more effective than either negative pressure or water spray venturi. The three UK brigades rate both types of natural ventilation similarly, in contrast to SLC and Aachen who each rate natural vertical as more effective than natural horizontal.

**Question 3. Please indicate how effective P.P.V. is in reducing fire compartment temperature when used for P.P.A.**

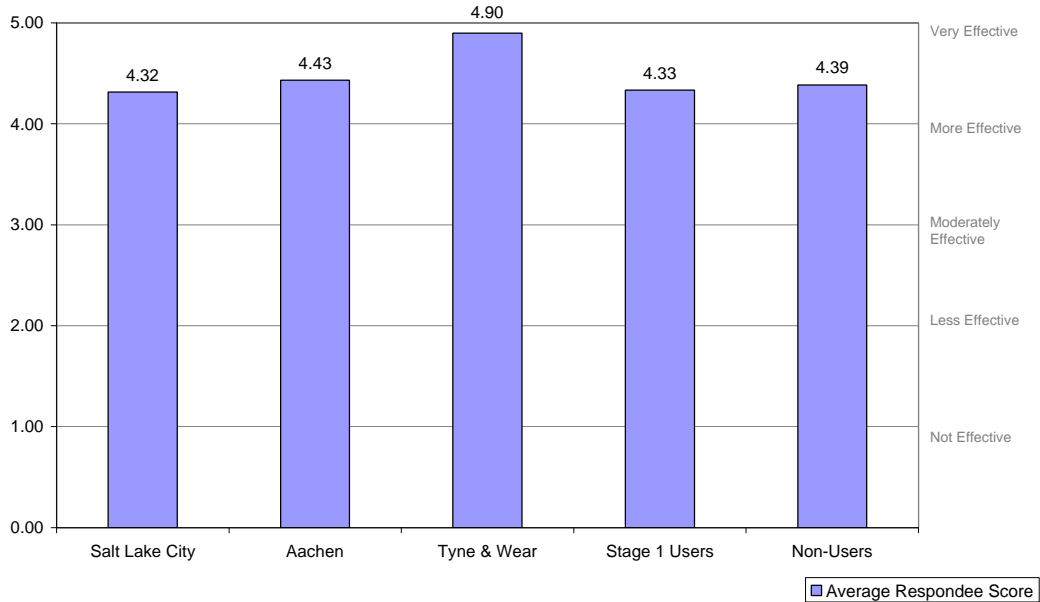


ANOVA  $p=0.070$  Demonstrating no statistical significance.

The ANOVA test did not demonstrate significance, however the result is important as it does show that all brigade types rate PPA as 'more effective' or higher in reducing fire compartment temperatures. The average scores of Tyne and Wear users are higher, but using the groupings and the tests applied, this does not indicate any significance.

The results do show that the perceptions of the non-PPA user brigades match the reality as PPA users believe it to be.

**Question 4. Please indicate how effective P.P.V. is in improving fire compartment visibility when P.P.V. is used for P.P.A.**

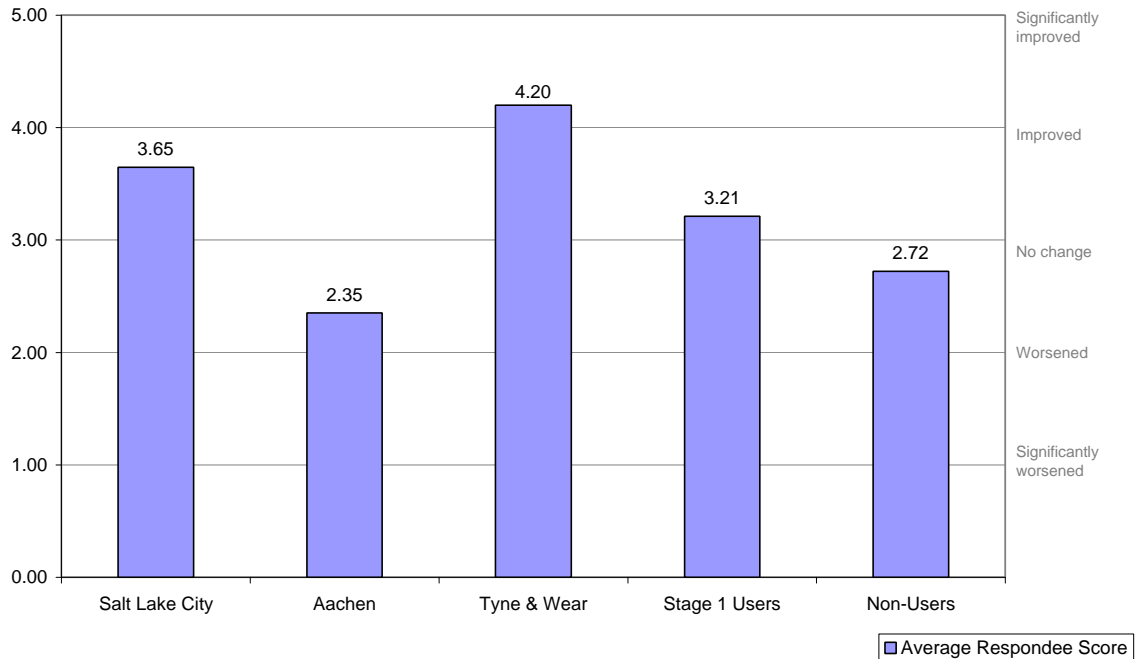


ANOVA	p=0.027	demonstrating a statistical significance.
t test comparing non user data set with stage 1 user data set	p=0.707	indicating no significant difference between the two data sets
t test comparing stage 1 data set with PPA data set	p=0.275	indicating no significant difference between the two data sets

Although the ANOVA detected significance, the generic groupings of PPA brigades and the t tests applied did not find significance. The ANOVA significance detected would probably be found if Tyne and Wear was singled out for analysis; this however did not fit the selected pattern of analysis.

The data does show that all brigades rate PPA as 'more effective' or higher for improving compartment visibility and in common with question 3 the perception of non-PPA users is broadly in line with the reality of PPA users.

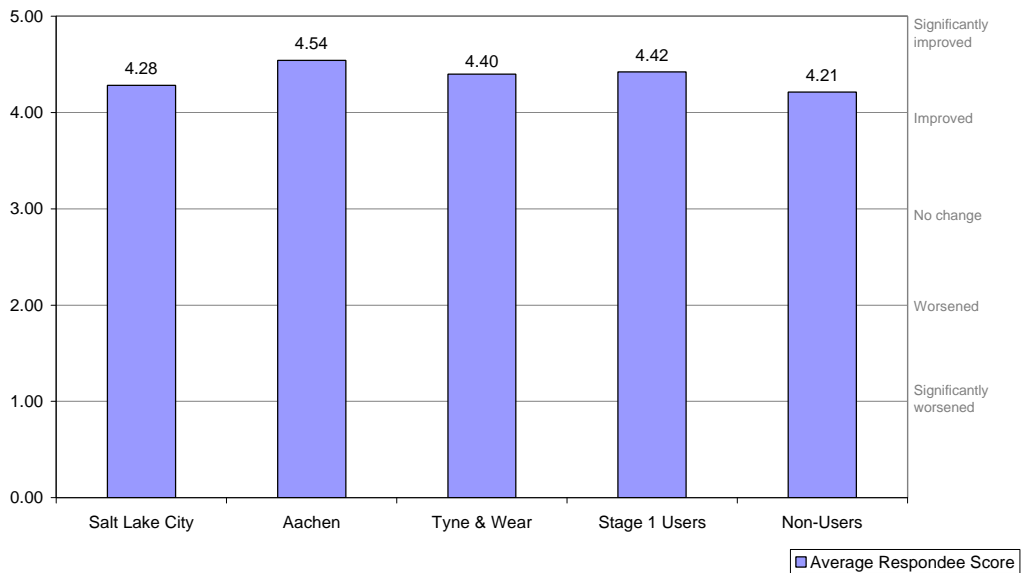
**Question 5. Please indicate the effect of P.P.V. on the condition of casualties located between the fire and the compartment outlet when P.P.V. is used for P.P.A.**



ANOVA	p=0.000	demonstrating a high statistical significance.
t test comparing non user data set with stage 1 user data set	p=0.106	indicating no significant difference between the two data sets
t test comparing stage 1 data set with PPA data set	p=0.780	indicating no significant difference between the two data sets

The results of this question showed obvious differences that are demonstrated by the highly significant ANOVA result. However using the selected groupings and applied tests, significance was not found. This could be due to the three PPA brigades achieving an average score of 3.32, being relatively close to the average scores of stage 1 (3.21) and non-users (2.72). This is the only question regarding PPV and the fire compartment's environment in which there is a large difference between the three PPA brigades.

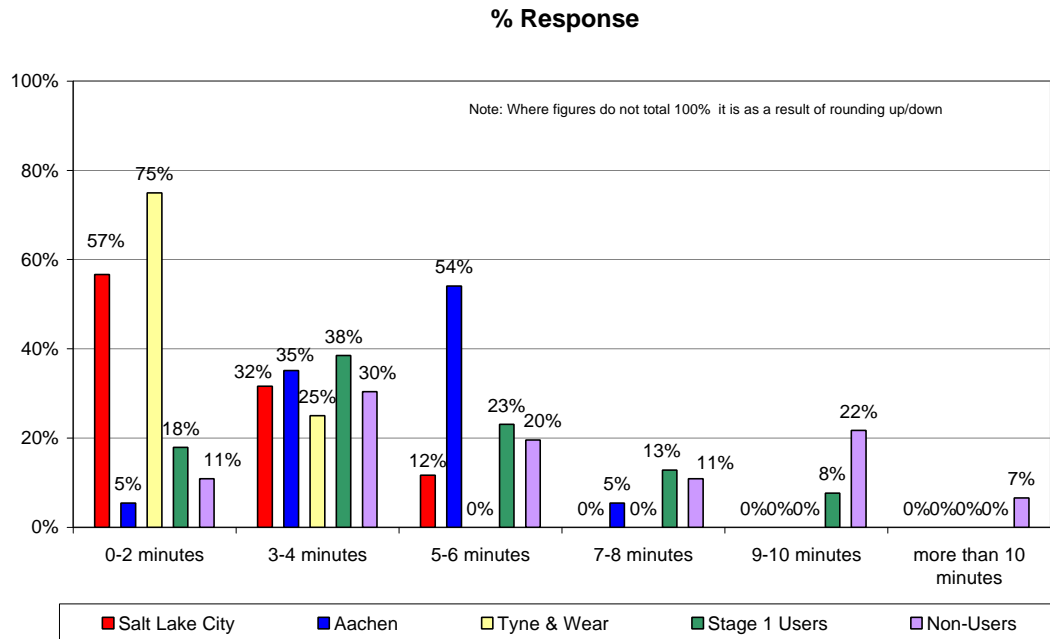
**Question 6. Please indicate the effect of P.P.V. on the condition of casualties located between the P.P.V. inlet and the fire when P.P.V. is used for P.P.A.**



ANOVA  $p=0.093$  demonstrating no statistical significance.

As would be suggested by the average scores of all groups there was no significance found within the results. All brigades consider a casualty's condition to be 'improved' or better, although non-users do allocate slightly lower marks on average. Although not statistically significant, the result is important in demonstrating that all surveyed firefighters hold a similar viewpoint.

**Question 7. In your experience (or estimate), how quickly can P.P.A. be used at an incident following the attendance of the first appliance?**



ANOVA	p=0.000	demonstrating a high statistical significance.
t test comparing non user data set with stage 1 user data set	p=0.025	indicating a significant difference between the two data sets
t test comparing stage 1 data set with PPA data set	p=0.000	indicating a highly significant difference between the two data sets

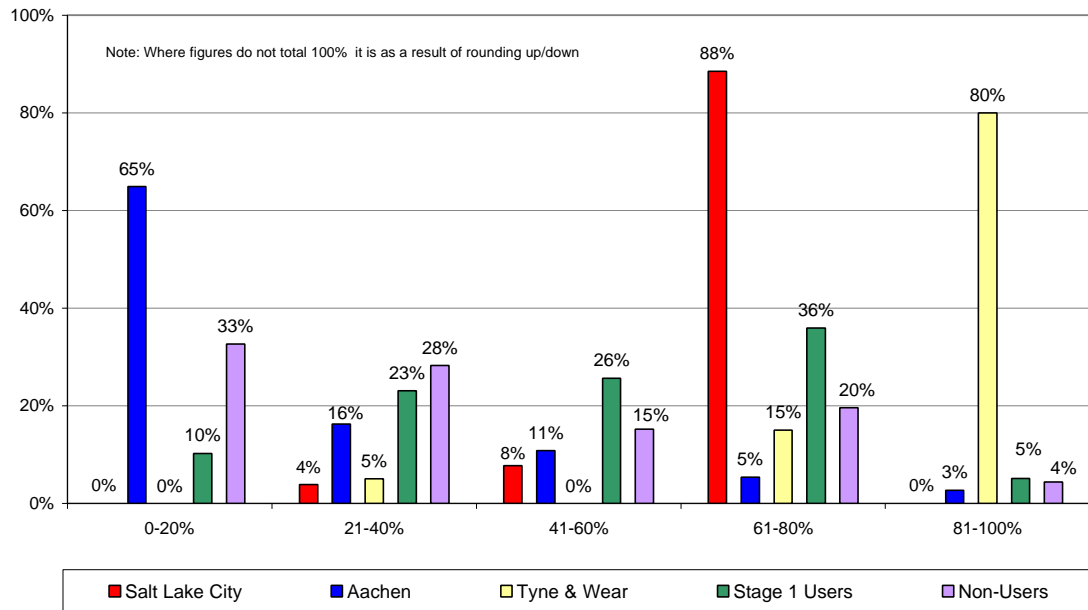
This question explored the reality of PPA users and perceptions of non-PPA user firefighters as to how quickly PPA can be used at an incident.

The charted results show that brigades which use PPA believe it can be deployed in the quickest time. As will be seen from question 8, Tyne and Wear use PPA most, as a percentage of compartment fires attended, with 75% of this brigade's respondees indicating they deploy PPA in under three minutes following attendance

of the first appliance. All remaining Tyne and Wear respondees (25%) indicate deployment in less than five minutes. The non-PPA user respondees hold a different perception; with only 11% and 30% believing PPA could be deployed in 0-2 minutes and 3-4 minutes respectively. Tyne and Wear and non-users represent the extremities of response with the other brigades falling in between.

These differences are shown when the statistical tests are applied, the ANOVA being highly significant. When explored using the t tests the results also show significance (non-users/stage 1) and highly significance (stage 1/PPA). These results do show a difference between the perception of non-PPA brigades and PPA brigades in relation to the speed of deployment.

**Question 8. At what percentage of incidents do you use (or could you use) P.P.V. for P.P.A. in relation to the amount of compartment fires you attend?**



ANOVA	p=0.000	demonstrating a high statistical significance.
t test comparing non user data set with stage 1 user data set	p=0.010	indicating a significant difference between the two data sets.
t test comparing stage 1 data set with PPA data set	p=0.027	indicating a significant difference between the two data sets

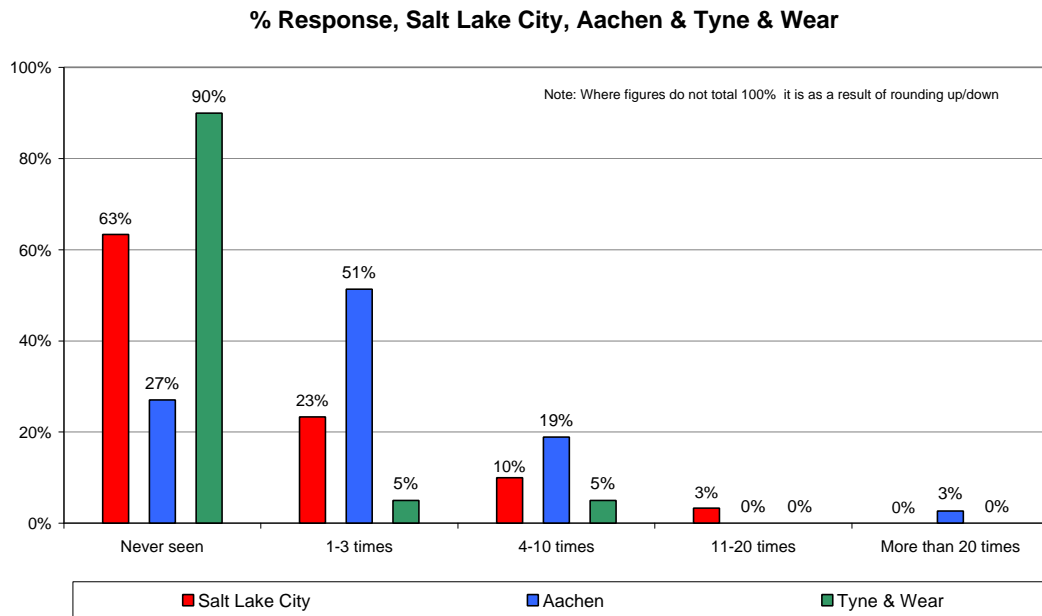
This question perhaps strikes at the very heart of firefighter perceptions – how often can PPA be used? This question gives the researcher a good indication of the potential for use, an important aspect of the research hypothesis.

The question revealed very stark results with differences between the three PPA brigades. The majority (80%) of Tyne and Wear respondees indicating PPA usage at over 80% of compartment fires, and the majority (88%) of SLC respondees indicating

over 60% usage. This contrasts with the majority (65%) of Aachen respondees who indicate usage at less than 21% of incidents, this confirming the information found during the case study. The range of the three PPA user brigades indicates differences of opinion, with Aachen having responses in all categories, Tyne and Wear and SLC in only three. The ANOVA test reflects these differences with a highly significant result. The t tests both demonstrate significance showing that the PPA users' views are very different from that of stage 1 users, and stage 1 users are very different from the views of non-users.

The perceptions of the PPA non-users are very much spread across the range of potential responses, although the stage 1 brigades show a trend towards higher usage.

**Question 9a. How many times have you seen P.P.A. contribute to increased fire damage by its use?**

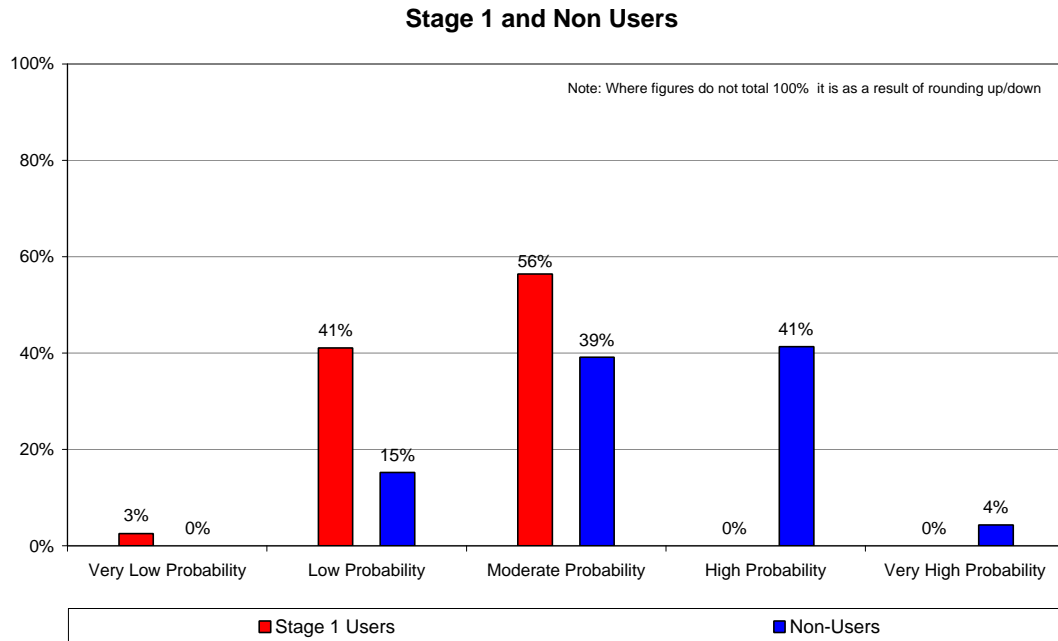


ANOVA  $p=0.000$  demonstrating a high statistical significance.

This question explored the experiences of PPA users in SLC, Aachen and Tyne and Wear regarding the fire damage that PPA may cause and gave a highly significant result. The concerns over this perception of increased damage were explored in the UK Brigade Survey, whereas this question sought the actual experiences of PPA users.

A large majority (90%) of Tyne and Wear personnel had never seen any increased damage, this percentage lowering to 63% in SLC. In contrast to this, a majority (51%), albeit a small one, of Aachen personnel had witnessed increased damage on 1-3 occasions. These figures do show Aachen to have experienced more damage, as a percentage of respondees, than the other two PPA users.

**Question 9b. What probability do you believe Positive Pressure Attack has to contribute to increased fire damage by its use?**



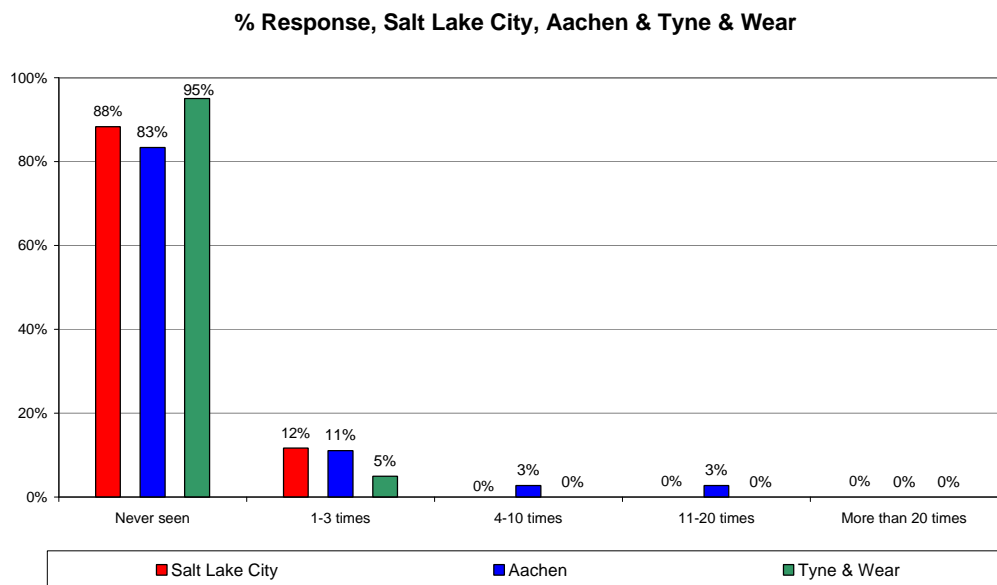
ANOVA  $p=0.000$  demonstrating a high statistical significance.

The perceptions of users could be either a help or hindrance in introducing any new procedure or item of equipment. This question explored the perception of non-PPA users.

It can be seen from the chart that non-users thought that there was a higher probability for damage than perhaps suggested by their PPA colleagues. The chart shows a difference between stage 1 and non-user; the latter believing there is a higher probability of damage than stage 1 users.

The non-users belief of a higher probability of damage is not reflected by the results of question 9a, which shows a small amount of damage seen by their UK colleagues that use PPA. It is perhaps reflected somewhat by the experiences found in Aachen.

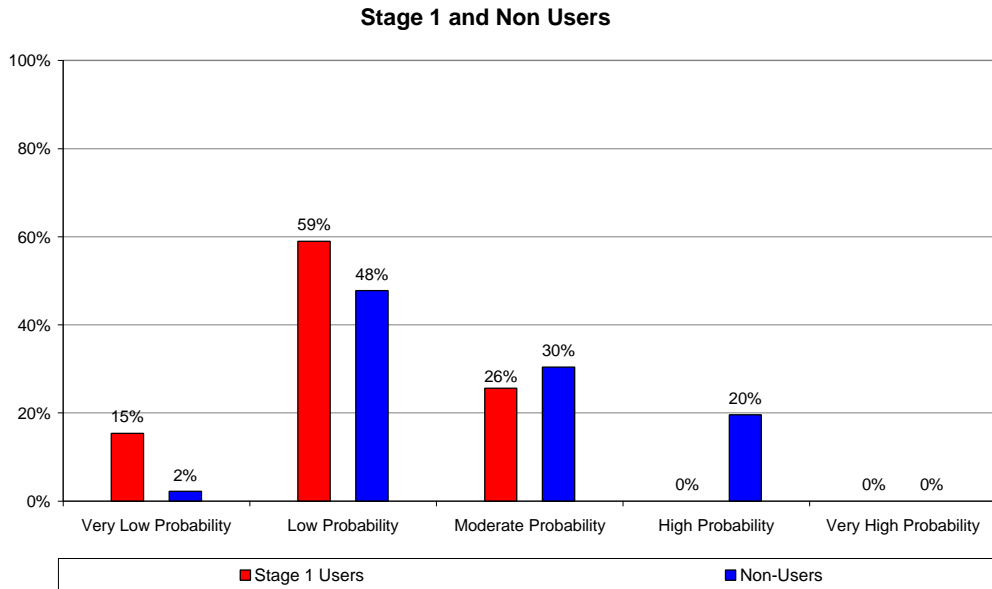
**Question 10a. How many times have you seen P.P.A. contribute to casualty injuries?**



ANOVA  $p=0.000$  demonstrating a high statistical significance.

This question explored the experience of PPA users in relation to PPA contributing to casualty injuries. The vast majority of the respondees had never seen PPA contribute to casualty injuries, but a small proportion had, this being more prevalent in Aachen.

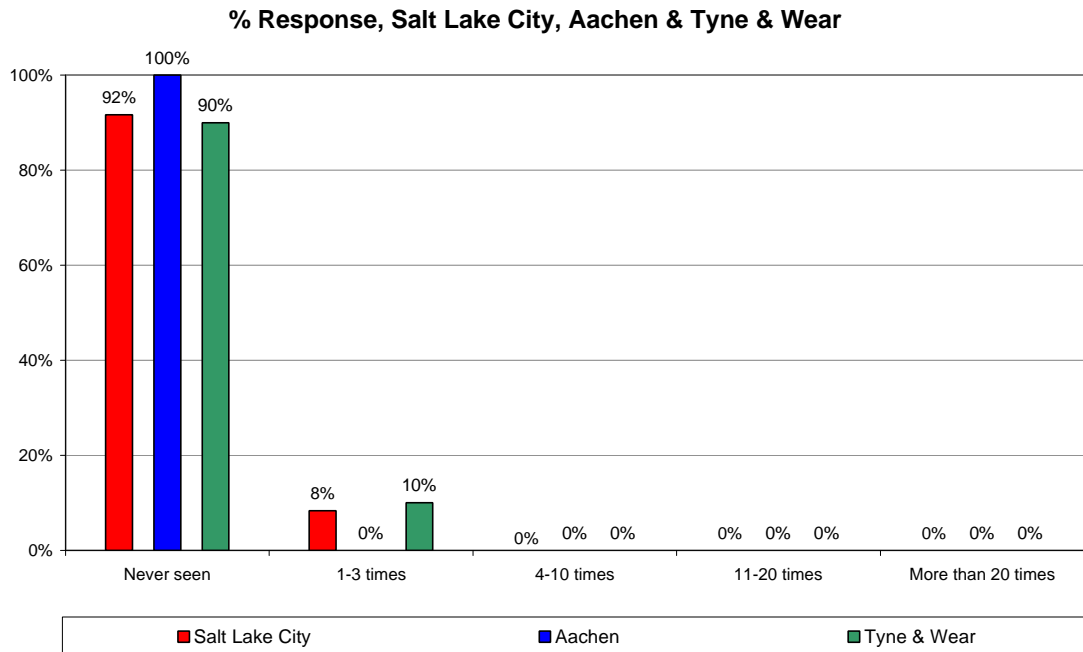
**Question 10b. What probability do you believe Positive Pressure Attack has to contribute to casualty injuries?**



ANOVA  $p=0.000$  demonstrating a high statistical significance.

This question again explored non PPA users' perceptions of PPA's potential to cause harm to casualties, and produced similar results to those seen in question 9b. As can be seen, the stage 1 brigades see the probability of casualty injury as being lower than the non-users perception of it. The reality as expressed by PPA-users in question 10a is not fully replicated by the non-users, again indicating a difference between the perception and expressed reality.

**Question 11a. How many times have you seen P.P.A. contribute to firefighter injuries?**



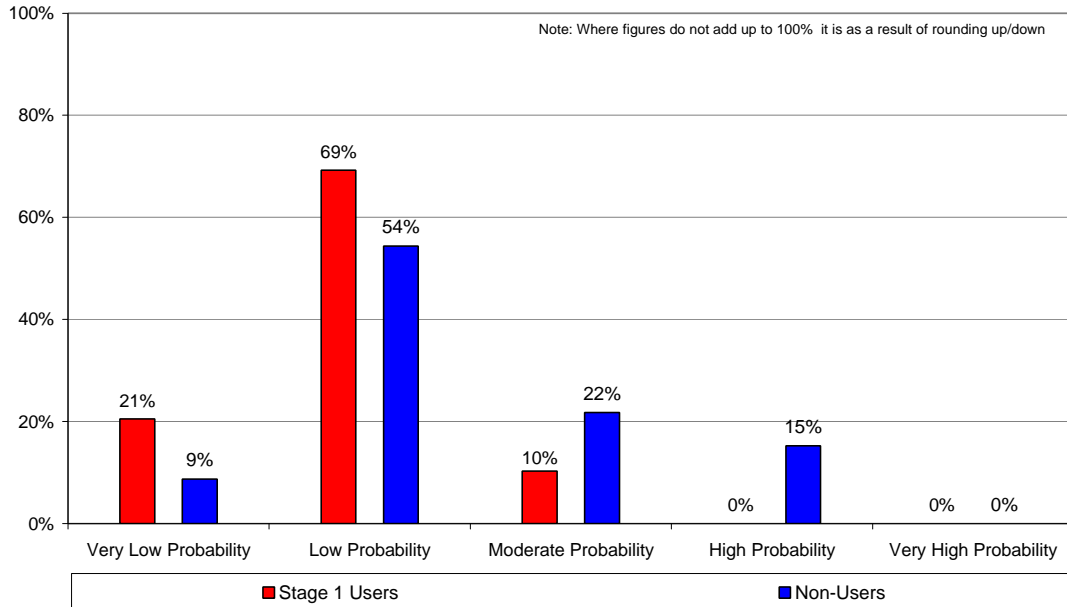
ANOVA p=0.072 demonstrating no statistical significance.

This question is key to this research project in that it explores PPA’s potential to cause injury to firefighters. The results are quite stark with a high percentage of all respondees indicating that they had ‘never seen’ PPA contribute to firefighter injuries. Aachen respondees were unanimous in that no injuries had been sustained. Although only 8% and 10% of SLC and Tyne and Wear firefighters had seen injuries, this nevertheless means that some firefighter injuries had been sustained.

This question does not demonstrate any significance, but is important in that the vast majority of firefighters have not seen PPA contribute to firefighter injuries.

**Question 11b. What probability do you believe Positive Pressure Attack has to contribute to firefighter injuries?**

**Stage 1 and Non Users**

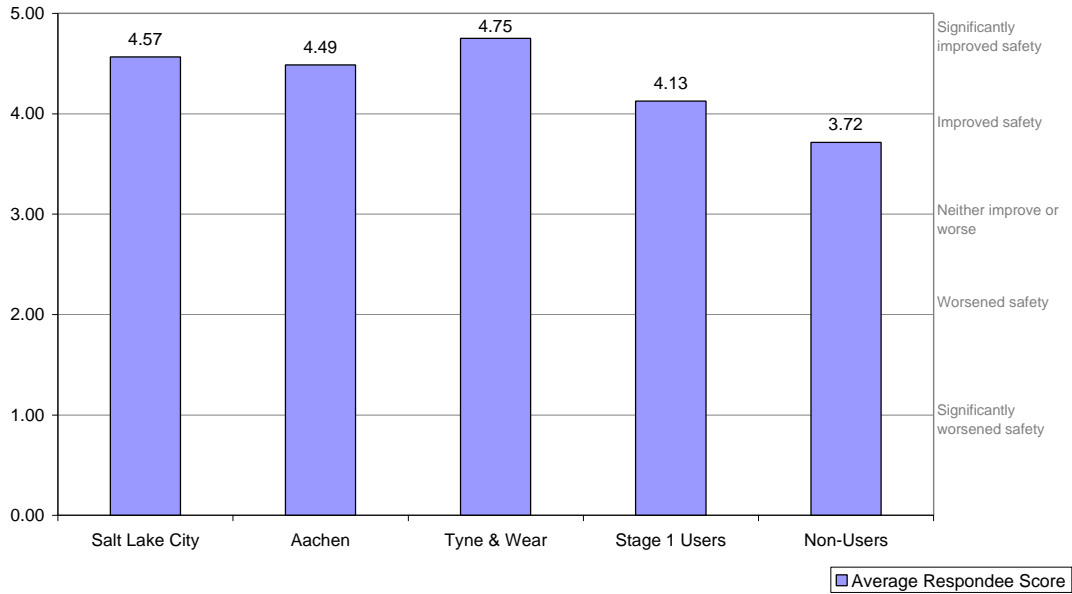


ANOVA  $p=0.000$  demonstrating a high statistical significance.

The results of this question, which explores the perceptions of non PPA users, very much follows the trends set in question 9a and 10a and achieved a high significance.

The majority of stage 1 (90%) and non-users (63%) believe there to be a low or very low probability of PPA contributing to firefighter injuries. Although not a high proportion, 15% of non-users believe there to be a high probability of injury and 22% consider there to be a moderate probability. The chart shows the continuing trend set in questions 9a and 10a with non-users' perceptions tending to be more negative than stage 1 respondees. The majority of respondees' perceptions are that of a low probability of injury, this equating to the reality demonstrated in question 11a.

**Question 12. When using P.P.A. as a fire fighting tactic, do you believe that firefighter safety can be improved or worsened?**



ANOVA

p=0.000

demonstrating a high statistical significance.

t test comparing non user data set with stage 1 user data set

p=0.023

indicating a significant difference between the two data sets

t test comparing stage 1 data set with PPA data set

p=0.000

indicating a highly significant difference between the two data sets

This question is key to this research in that it obtained firefighters' views regarding PPA enhancing firefighter safety. The relationships between PPA users, stage 1 users and non-PPV users are clear, with PPA users believing firefighter safety to be

enhanced more than stage 1 users believe it to be. In turn stage 1 users believe this safety to be more enhanced than non-users. However it is shown that on average all respondees believe PPA, as a firefighting tactic, enhances firefighter safety.

This question follows the general trends set throughout the survey with Tyne and Wear giving the most 'positive' responses, followed by SLC, Aachen and then the two non PPA user brigades, firstly stage 1 and then non-users.

## **4.7 Firefighter Opinion Survey Conclusions**

This survey has identified some differences of opinion between PPA and non-PPA brigades; it also identifies some differences between the three PPA brigades. Importantly it also identifies some areas of agreement, the first being the importance of ventilation. All brigades agree that ventilation is important although this first area sets a trend for many questions in that PPA users have a more 'positive' opinion than non-PPA users. All brigades also agree that PPV is the most effective method of ventilation, including the brigades that do not have the equipment.

Another area of agreement is that PPA has the ability to reduce compartment temperature and improve visibility, this confirming the findings of the literature review.

The first area of disagreement is that of casualty condition when PPA is used. There is no disagreement when the casualty is situated between the fan and the fire - the

casualty's condition is improved, but there is much disagreement when situated between the fan and the exhaust opening.

Tyne and Wear and SLC see casualty condition improving slightly, but all other brigades, including Aachen, believe casualty condition to be worsened. Tyne and Wear were directly involved in testing for casualty survivability in 1998 when they commissioned their own tests and assisted Thomas (1998) in his work. This first hand experience of testing of casualty survivability, which demonstrated no reduction in survivability, may have influenced Tyne and Wear personnel who score casualty 'improvement' higher than other brigades.

The speed and amount of use is another area where PPA brigades disagree. SLC and Tyne and Wear are high percentage and relatively quick users, whereas Aachen appears to have a far lower rate and speed of use. It would appear that the more PPA is used the quicker the firefighters believe it can be brought into use.

The perception of stage 1 and non-users is different from the reality as indicated by PPA users, especially SLC and Tyne and Wear. The perception of non-users is quite marked with them perceiving far lower usage and in a greater time following attendance.

The potential for PPA to cause property damage, and firefighter and casualty injury, is an area for disagreement. Firstly, PPA users have seen less damage to property and injuries to casualties and firefighters, than the perception of non-users would suggest. Non-PPV users rate the probability for these areas of concern higher than

all other users, which again demonstrates a difference between PPV non-users' perceptions and PPA users' reality. There is however a noticeable difference between Aachen and the other two PPA users, Aachen personnel having seen more damage than their UK and USA colleagues.

Casualty injury is an area where all PPA users agree, with the vast majority of PPA user respondees never having seen any. It is interesting to note that 83% of Aachen personnel have never seen casualty injuries but Aachen personnel indicate the lowest score for all brigades when relating to the potential for PPA to worsen casualty condition, if the casualty is located between the fan and the exhaust outlet. All PPA users agree that firefighter injuries as a result of PPA are seldom seen, with Aachen personnel never having witnessed a single injury. In contrast, non-users seem to have a concern with 37% of respondees indicating a moderate to high probability of injury. Stage 1 users have fewer concerns with 90% indicating low probability or less. This indicates that non-users' perceptions are again different to the reality of PPA users, with stage 1 users being closer to this reality.

This research is closely related to firefighter safety, with the findings demonstrating that all brigades believe that PPA enhances firefighter safety - a crucial statement in the context of the stated hypothesis. Although all brigades agree on improved safety, that level of safety varies. The specific question of safety is indicative of the general response of the five brigades. Tyne and Wear personnel have the most positive viewpoint regarding PPA, with SLC personnel having a similar point of view. The third PPA brigade, Aachen, are slightly less positive in outlook than SLC, but more so than stage 1 brigades. Non-users have the most negative view of PPA as a technique,

but on the important issue of firefighter safety they agree with the others - PPA does improve firefighter safety.

## 5. FINAL CONCLUSIONS

This section will draw together the conclusions from each area of investigation and relate them to the stated research objectives of the investigation to test the hypothesis. The objectives are:

- (a) To identify previous PPV research, its extent and findings.**
- (b) To establish the extent of PPV use in the UK Fire Service.**
- (c) To establish the reasons why brigades have or have not implemented PPV.**
- (d) To compare a UK brigade's implementation process with that of a selected European and a selected United States of America Fire Department that are using PPV extensively.**
- (e) To obtain the views of firefighters as to the benefits and problems associated with the use of PPV.**
- (f) To establish any barriers to PPV implementation within the UK.**

Objective (a) has been achieved with the literature review identifying previous research along with its extent and findings. These findings have given a very strong indication towards the potential application of PPV, with the FRDG series of research identifying PPA as an acceptable and desirable tactic to complement compartment firefighting. Indeed Hay (1996) sets out his conclusions explicitly, indicating that firefighter safety can be improved. DCOL 14/1999 (Home Office, 1999) complements Hay's views, stating that the benefits of PPV far outweigh the perceived disadvantages. These views on crew safety are in agreement with the

results of the Firefighter Opinion Survey in which all brigades agree that PPA improves firefighter safety, thereby addressing one of the three aspects of the stated hypothesis.

This potential use, to enhance firefighter safety, has to be viewed with the full implications in mind. The main implication is that of training, this being the main concern of brigade implementing PPV. Objective (f) seeks to identify the barriers to implementation, training being at the head of this list. This concern is a reflection of the literature, which advocates training as part of any implementation of PPV (Robertson, 1989a), (Hay 1996, p.40). Fraser (1994, p.28) links the wider aspects of fire development, flashover and backdraught training to the advancement of ventilation as a firefighting tactic, something that seems appropriate considering all respondees to the Firefighter Opinion Survey consider ventilation to be important.

Analysis of the case studies suggests that in two brigades, Tyne and Wear and SLC, resistance to change was a significant barrier to implementation of PPV, albeit for different reasons. The Aachen case study indicated another barrier to successful implementation and usage - local building construction. It was apparent from the three case studies that acceptance of PPV and its eventual level of usage will be dependent on the local prevailing conditions and cultures.

Perhaps limited to the training concerns of brigades are the amount of retained firefighters a brigade employs. The UK Brigade Survey suggested that the more retained firefighters employed, the less chance there is of a brigade using PPV. It appears that Aachen, who has a significant amount of volunteers, do not give any training to their volunteer personnel.

The lack of training given to Aachen personnel is an interesting aspect of the case studies. It is to Aachen's credit that personnel appeared fully confident in using PPV, but the Aachen personnel do indicate a higher level of damage and casualty injury in their questionnaire returns than the other two PPA brigades. It is worth considering whether Aachen's higher level of casualty injuries and property damage, and the lesser usage of PPA, is attributable to the significantly lower levels of training they receive. The time constraints did not allow the researcher to fully explore this aspect of Aachen's culture and therefore it would be incorrect to draw definitive conclusions on this issue, but rather leave it as an as yet unanswered question.

The Firefighter Opinion Survey showed non-users as having a more negative view of PPV and PPA than their PPA user or stage 1 PPV user colleagues. To successfully introduce any new procedure, personnel must fully embrace the new concept. This can only be achieved through proper and meaningful communication. The three types of investigation show that the greater the knowledge and use of PPV or PPA, the more positive the views of the brigade and its members. The lack of knowledge of PPV was stated by Tyne and Wear as a barrier to implementation. Tyne and Wear overcame this by carrying out their own research over a period of years, something that should assist all UK brigades now, and in the future. It would appear that Tyne and Wear's proactive and lengthy investigations, coupled with the FRDG research series, have effectively reduced, or even removed the barrier of 'lack of knowledge' from the UK fire service.

From the discussion above it can be seen that research objective (f) has been met with training, resistance to change, the level of retained firefighters, and the lack of available knowledge being the primary barriers to PPV implementation. These

reasons also assist in achieving research objective (c) in that they are the main reasons why UK brigades have not yet implemented PPV. In addition to the above reasons, financial implications are a stated reason why brigades have not yet implemented PPV

Objective (b) is an aspect of PPV in which many fire service personnel have shown an interest. There appears to be much interest in the level of use, with the UK Brigade Survey giving figures for usage. The survey also gives an indication for future usage and demonstrates the growth in PPV usage since Fraser's work in 1994. The case studies in SLC and Tyne and Wear suggest that firefighters' desire to introduce PPV fully can become a driver to implementation, this desire being created through involvement and knowledge acquisition as the process develops.

The above conclusions have been drawn following an extensive firefighter survey and visits to two international brigades. These visits and the survey have allowed the researcher to compare the implementation strategies and views of firefighters, in doing so, objectives (d) and (e) have been met.

The above conclusions need to be applied to the stated hypothesis:

***Fire brigades in the UK are not using PPV to its fullest potential to enhance the ability of firefighters to carry out their fire fighting and rescue duties in safety.***

It has been demonstrated in the literature review and indicated in the Firefighter Opinion Survey that PPV can enhance firefighter safety, especially when used for PPA. The UK Brigade Survey has indicated that only a small minority of brigades are using PPA, this being the perceived full potential for PPV. Therefore the hypothesis has been proved. However, with the researcher being able to apply hindsight, it could be considered that the hypothesis could never be met, as 'full potential', is a very subjective judgement. This research has established the potential for PPV and also the gathering momentum within the UK for the implementation of PPV. The researcher has found that PPV and PPA are acceptable firefighting tactics, but to progress the issue a 'champion' may be desirable.

## **6. RECOMMENDATIONS**

In the light of the investigation, analysis and subsequent conclusions that have been reached, the researcher makes the following recommendations to UK fire brigades:

1. Considering the explicit research that is available to suggest that PPV can have many benefits, especially to firefighter safety, brigades that have not investigated PPV implementation should seriously consider doing so.
2. Any investigations that are carried out need not focus on the viability of PPV or PPA as an operational tactic. The investigations should focus on the financing, training and local environment, which may influence PPV usage, as it has been shown that PPA is not appropriate for all types of building construction.
3. Further research should be carried out in brigades that have a high level of retained or volunteer personnel to establish any specific problems relating to the implementation of PPV to crews of this type, particularly in respect of training.
4. Implementation of PPV should follow the guidance set out in DCOL 14/1999, with appropriate training given before each stage of use.

5. To overcome any potential resistance to implementation, brigades should effectively communicate the rationale for introduction before and during training.
  
6. Training in the use of PPV should be seen as an integral, not isolated, part of basic and maintenance firefighting training.
  
7. Further research should be carried out to explore the views of the senior managerial level of brigades to identify any potential barriers to implementation at that level.

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## **LIST OF APPENDICES**

1. UK Brigade Survey and Covering Letter.
2. Firefighter Opinion Questionnaire and Covering Letter (PPA User).
3. Firefighter Opinion Questionnaire (Non-PPA Users).
4. UK Brigade Survey Data.
5. Firefighter Opinion Survey Data.

***Appendix 1 - UK Brigade Questionnaire and Covering Letter***

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*Appendix 2 - Firefighter Opinion Questionnaire and Covering Letter  
(PPA User)*

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Appendix 3 - Firefighter Opinion Questionnaire (Non-PPA Users)



*Appendix 5 - Firefighter Opinion Questionnaire Data*

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