

Initiative

7

Create a national research agenda and data collection system that relates to the 16 Firefighter Life Safety Initiatives.

Executive Summary

In response to the need to improve firefighter safety, The National Fallen Firefighters Foundation has developed a prioritized list of research needs. This list has the potential to be the foundation of a research agenda. This paper gives some background on the development of these priorities and provides an overview of the many research activities that are being conducted by federal and national fire service organizations. Challenges still exist in how to co-ordinate the activities in order to optimize the use of resources and accelerate the delivery of results. While many of these research efforts occur at a level remote from the local firehouse, they are dependent on data from the local level and the ultimate success of the research programs will be measured at the local level.

In order to encourage co-operation with both the data input and the research results implementation, communication with all fire departments in clear and concise ways is critical to improving the safety of firefighters. Acknowledging the need for research and data was an important step for the fire service to take in 2004. Now it is critical that the identified research be conducted, the results be transferred and implemented at the local levels. This is the only way that research will impact the life safety of firefighters and the communities they serve. The 7th Initiative asks us to support a national research agenda and to support all research efforts with data collection at the local and state levels—a responsibility of all fire service organizations.

Introduction

Since its inception, the fire service has been a beneficiary of research. Improvements in protective equipment, in the ability to move water, in communications, and in training are all a result of research. In a few cases, the improvements were based on research that was done specifically for the fire service. In most cases, the improvements were the result of the fire service utilizing a body of research or an advance in technology that was done for other reasons. The thermal imaging camera is an example of the application of research developed for military use and via equipment manufacturers transferred to the fire service.

What is research? Research is an organized study to solve problems, test theories or develop new technologies. Research can be accomplished in many ways and may take many different forms. Research can be something very remote from the fire service, for example the development of a new product or process that is in hands of scientists in a laboratory. Research can also be a practical means to solve an immediate need, such as studying a map book or developing a pre-plan to improve the efficiency of your emergency response. The 7th of 16 Firefighter Life Safety initiatives is, “create a national research agenda and data collection system.” While acknowledging the need for research and data was an important step for the fire service to take, it is critical that the identified research be conducted and the results transferred and implemented at the local levels for the results to have impact on life safety. Since the Firefighter Life Safety Summit in 2004, many steps have been taken toward the goals of the initiative, but many more are needed. This paper will review the advances to date and discuss potential areas for advancement on a national, state and local level.

Recommendation #1: *Support activities such as the Firefighter Life Safety Summits and all fire service research symposia by submitting ideas for presentation, reading meeting summaries, and by sending presenters whenever possible.*

Research Agenda Symposium

In June of 2005, The National Fire Service Research Agenda Symposium was conducted. The Symposium was conducted by the National Fallen Firefighters Foundation (NFFF) and funded by a grant from the National Institute of Standards and Technology (NIST). The United States Fire Administration (USFA) provided the facilities to host the symposium and was directly involved in the planning and all other aspects of the symposium.

The symposium produced a document that identified and prioritized the areas where research efforts should be directed to support improvements in firefighter life safety. The emphasis on efforts to address firefighter health and safety concerns coincides with the mission of the NFFF, as well as the goals of the USFA to reduce line-of-duty deaths by 25% within five years and 50% within ten

years. This document, an initial response to the 7th Firefighter Life Safety Initiative, is intended to be used as a guide for both research organizations and sponsoring agencies to support the goal of reducing firefighter fatalities.

The overall scope of the symposium included firefighter health and wellness; structural firefighting; wildland firefighting; firefighter training; emergency vehicle design and operations; and reduction of fire risk occurrences. The 53 symposium attendees represented several segments of the research community, including fire protection, building construction, occupational medicine and behavioral science; fire service organizations, individual fire departments and allied professionals. The complete report is available at

<http://www.everyonegoeshome.com/report.pdf> [see reference 1]

The symposium attendees identified 40 priority needs in the general areas listed below:

- 1) Firefighter Health, Wellness and Fitness
- 2) Training and Incident Management
- 3) Technology Applications
- 4) Fire Prevention, Public Education, and Data.

Table 1. Top 16 Research Needs from NFFF Research Agenda Symposium

Firefighter Health, Wellness and Fitness

Firefighter Candidate Selection & Assessment

Health Maintenance

Risk Factors Relating to Cardiovascular Disease in the Fire Service

Physiological & Psychological Effects of Heat Stress

Functional Capacity Evaluation Testing

Analysis of Fire Service Culture

Training and Incident Management

Identify Fire Ground Factors that Contribute to Fire Service Injuries and Fatalities

Technology to Support Incident Command

Document Failures & Lessons Learned from Live Fire Training Deaths and Close Calls

Technology Applications

Situational Awareness of Firefighter Physiological and Environmental Conditions

Fire Department Communications - Operability

PASS Failure Analysis

Firefighter Fatalities and Injuries Involving Motor Vehicle Accidents

Fire Prevention, Public Education, and Data

Capture Data to Determine Firefighter Exposure to Fire Problems

Fire Prevention and Public Education Efforts to Target Identified Problem Areas

Standardized Criteria for the Evaluation of Public Education Programs

Of the 40 priority needs, 26 needs were identified as a top priority by the individual breakout groups. The priorities were then voted on again by the collective group of attendees. This final vote resulted in 16 issues with a ranking of "1A", meaning it was considered a top priority by both the breakout groups and the entire group.

The list of the 16, “1A” issues is provided in Table 1.
The parallels between firefighter fatalities and the priorities are easy to see.

The majority of firefighter fatalities are caused by overexertion or stress, typically resulting in sudden cardiac death (54%). This is followed by “struck by or contact with object”, typically due to vehicle accidents (25%). The next largest cause of injury categories occur on the fire ground and resulted in firefighters being “caught or trapped” and “fell/ jumped” which resulted in trauma, asphyxiation or burn related fatalities (14%) [see reference 2]. Altogether these categories accounted for more than 90% of the firefighter fatalities in 2005. Fourteen of the 16 “1A” issues address the top causes of firefighter fatalities listed above.

Recommendation #2: *Become familiar with the leading causes of firefighter line-of-duty deaths in order to speaking convincingly and knowingly as you advocate for future research.*

Fire Service Needs Workshop

There have been other efforts that have attempted to develop fire service research needs lists, such as the Fire Service Needs Workshop held in 1999 [see reference 3]. The NIST/USFA sponsored workshop was not as focused on firefighter health and safety as the NFFF symposium. It resulted in 102 identified needs, 42 of the needs were identified as a “high” priority. There is significant overlap with the “high priority” issues from the 1999 workshop and the “1A” issues that were identified in the symposium. The workshop proceedings can be found at <http://fire.nist.gov/bfrlpubs/fire00/PDF/f00038.pdf>

Protecting Emergency Responders

The National Institute for Occupational Safety and Health (NIOSH), through its National Personal Protective Technology Laboratory, and the RAND Corporation has developed a series of guidance documents on protecting emergency responders [see references 4-7]. The focus of these documents is the need for research, equipment, training and incident management. The documents can be downloaded from www.cdc.gov/niosh/npptl/guidancedocs/rand.html

Fire Service Technology Needs Research Workshop

National Firefighter Technology Resource Center conducted a one day workshop on November 15, 2006. Based on a review of the Firefighter Needs Assessment [see reference 8] and considering the NFFF symposium and initiatives, the 17 participants came up with 7 technology needs:

- 1) Communications, 2) Incident management technologies, i.e. accountability and tracking, 3) Physiological monitoring, 4) Emergency vehicle safety, 5) PPE, 6) Interactive training (simulators), and 7) Enhanced building life safety systems.

Implementation

Action to address the issues identified in the symposium requires action at the national, state and local levels to achieve meaningful impact. This section will overview some of the activities that are happening at the national level, and discuss how state and local authorities/departments are needed to provide data, obtain research results, and implement the research findings to improve the health and safety of their firefighters. Many of the national groups have developed programs, information, safety alerts and data that local fire departments can use today to improve the health and safety for their firefighters. The websites provide an easy source for the information.

National Organizations Conducting Firefighter Researcher
National organizations include both federal and private sector organizations.

- **Department of Homeland Security, U.S, Fire Administration**

The USFA has been working with many fire service groups and government agencies to address improvements in firefighter health and safety issues. The USFA website, <http://www.usfa.dhs.gov>, is full of resource information about ongoing and completed research efforts. By following the “Fire Service” link, and then going to the “research” link, firefighters can find reports in the following areas:

Fire Fighter Wellness and Fitness

- Health and Wellness Guide for the Volunteer Fire Service

National Volunteer Fire Council (NVFC)

- Emergency Incident Rehabilitation

Emergency Vehicle Safety

- Emergency Vehicle Safety Initiative

International Association of Fire Chiefs (IAFC), International

Association of Fire Fighters (IAFF) and NVFC

- Safe Operations of Fire Tankers

- Alive Arrival: Tips for Safe Emergency Operation (Brochure)

The DHS Fire Prevention and Safety Grants program provides funding that can be used for research to improve firefighter safety. An example of a successful research project is the *Health and Safety Guidelines for Firefighter Training* conducted by the University of Maryland Center for Firefighter Research and Development [see reference 9]. The report can be downloaded from <http://mfri.org/>

The USFA oversees the **National Fire Data Center**, also, for the collection, analysis, publication, dissemination and marketing of information related to the nation's fire problem. It is the home of all USFA research efforts in fire detection, prevention, suppression and first responder health, safety and effectiveness, although USFA's funding for research has been reduced significantly during the past four years. The USFA also maintains the National Fire Information Reporting System (NFIRS) the node through which virtually all local fire data from the participating states is funneled to the federal research agencies (see

<http://nfirs.fema.gov>).

Recommendation #3: *It is very important that fire departments consistently participate in the NFIRS data collection process. If your department does not, find out why and work to correct this situation.*

• **National Institute for Occupational Safety and Health (NIOSH)** is part of the **U.S. Centers for Disease Control and Prevention (CDC)**

The NIOSH Fire Fighter Fatality Investigation and Prevention Program was started in 1998. The objectives of the program are to 1) better define the characteristics of line-of duty deaths, 2) develop recommendations for the prevention of deaths and injuries, and 3) disseminate prevention strategies to the fire service. Since the start of the program more than 350 Line of Duty Deaths (LODDS) have been documented. Each of these reports are available for download at <http://www.cdc.gov/niosh/fire/>. The site also provides links to NIOSH publications that have been compiled to analyze the trends of the fatalities and provide prevention strategies and SCBA safety notices.

NIOSH is also the home of **The National Personal Protective Technology Laboratory (NPPTL)** in Pittsburgh. The mission of NPPTL is to prevent workrelated illness and injury by ensuring the development, certification, deployment, and use of personal protective equipment and fully integrated, intelligent ensembles. This will be accomplished through the advancement and application of personal protective technology standards. Information specific to firefighters, regarding research on PPE, SCBAs and respirators can be found at <http://www.cdc.gov/niosh/npptl/default.html>.

Recommendation #4: *Fire departments should actively review the NIOSH LODD reports and the related safety information and incorporate them into their training programs.*

• **The National Institute of Standards and Technology (NIST), Building and Fire Research Laboratory**

NIST is the federal government's only national laboratory with a comprehensive fire research program, focused on "the reduction of life and property loss due to unwanted fire." NIST has a balance of basic and applied research that investigates topics ranging from the impact of nano-composites on the heat transfer in materials, such as PPE, to the development of a technically based, performance standard for thermal imaging cameras. NIST also has a program dedicated to advances in fire fighting technology for the purpose of improved fire fighter safety and effectiveness. NIST works with Federal agencies with an interest in firefighter safety including DHS/USFA and NIOSH. NIST provides grants or assistance in kind to academic institutions or organizations that are focused on advancing fire research and improved fire fighter safety, such as the

University of Maryland, Department of Fire Protection Engineering and the Maryland Fire and Rescue Institute (MFRI), the International Fire Service Training Association (IFSTA), the National Fire Protection Association (NFPA), National Association of State Fire Marshals (NASFM), University of Texas, Austin, National Fallen Firefighters Foundation (NFFF), National Fire Academy, International Association of Arson Investigators (IAAI), and many others.

Perhaps the most important relationships that NIST has are the collaborations with fire departments across the country. NIST conducts fire investigations, fire experiments, training, and “reality checks” with a wide variety of fire departments. These field experiments and investigations could never be accomplished without the co-operation of the local fire department. The key benefit for the fire service is that the increased interaction between the firefighters and the researchers has enhanced the quality and usability of the research and will promote the rapid adoption of the technology or tactic being studied.

NIST has released many reports in multimedia format with the fire training officer in mind. For example, the Structural Collapse DVD that was produced in conjunction with the Phoenix Fire Department [see reference 10], the LODD fire simulations that were developed with the support of the local fire departments involved and NIOSH [see references 11-13]. These CDs and DVDs and other NIST reports are available from NIST at <http://www.fire.nist.gov>, as well as from the USFA Publications Center; <http://www.usfa.dhs.gov/applications/publications/>

- **fire.gov**

NIST and USFA also support the website www.fire.gov which is means of providing the fire service information on fire fighting research that is occurring in the U.S. and around the world. An example of the information available is the article on the forcible entry training website that has been developed by the U.S. General Services Administration (GSA). Many buildings have new window technology designed to protect occupants from high winds, explosions and other threats. The training website, <http://www.oca.gsa.gov/firefighter/index.php>, presents background information on blast, hurricane, and ballistic resistant windows, along with methods and issues associated with clearing such windows. The website includes videos of firefighters using hand tools and power tools to vent and clear a wide variety of windows. In addition the full report and a training manual are downloadable.

- **U.S. Department of Defense**

The Department of Defense research laboratories are many and given classification issues etc, it is hard to find information on going research projects. This problem has been recognized and an organization, the **Federal Laboratory Consortium for Technology Transfer** (FLCTT) has been set-up to assist in technology transfer from the federal labs to the private sector. FLCTT has a fire

fighting taskforce initiative. The initiative consists of a variety of projects, which are outlined at <http://www.federallabs.org/home/about/fftf/>.

- **The International Association of Fire Chiefs (IAFC)**

The IAFC is very active in collaborating with other organizations on a variety of research efforts aimed at improving the health and safety of firefighters. One of the principle research efforts for IAFC in 2006 and 2007 is the National Firefighter Near-Miss Reporting System. The system which can be accessed at www.firefighternearmiss.com is based on reports that are submitted by fire departments around the country. The reports are reviewed and all identifying characteristics of the report are removed. The report is categorized and posted on the website to provide a “lessons learned” educational experience. The National Fire Fighter Near-Miss Reporting System has three main goals:

1. To give firefighters the opportunity to learn from each other through real life experiences,
2. To help formulate strategies to reduce firefighter injuries and fatalities
3. To enhance the safety culture of the fire service.

- **The International Association of Fire Fighters (IAFF)**

The IAFF works with the IAFC on the Fire Service Joint Labor Management Wellness/Fitness Initiative. On their website, www.iaff.org, the IAFF maintains a “Stay Safe” section which includes: fire fighter equipment recalls, government agency warnings, health and safety fact sheets, and information on the “Fit to Survive” program on health and nutrition. In addition, there is an occupational medicine section which is composed of downloadable sections on hazards that are encountered by fire fighters and paramedics. The sections are developed by medical residents from Johns Hopkins University who spend a two month rotation in the IAFF Department of Occupational Health and Safety.

- **The National Fallen Firefighters Foundation (NFFF)**

The NFFF started the Everyone Goes Home, Firefighter Life Safety Initiatives Program in 2004. This effort is focused on the prevention of LODDs. The website contains a rich set of tools for research and training as part of the Firefighter Life Safety Resource Tool Box, <http://www.everyonegoeshome.org/resources/>. One of the components of the tool box that is fundamental to fire training is the section on “Understanding Fire Research.”

- **The National Fire Protection Association (NFPA)**

The NFPA provides the fire community with data on fire incidents, as well as firefighter fatalities and injuries. The NFPA has reports available at www.nfpa.org. Reports analyzing firefighter deaths related to training, to structural fires, and to sudden cardiac arrest to name a few are available for no cost [see references 14-16].

• The National Volunteer Fire Council (NVFC)

The NVFC is using medical research results to encourage and provide guidance on a healthier lifestyle. The NVFC Heart Healthy Firefighter Program available at www.healthy-firefighter.org provides information the benefits of quitting smoking, a healthy diet, and exercise. Through this program and a DHS grant, NVFC has conducted mass health screenings of fire fighters at several fire conferences. The private sector also has a large selection of web-based sites which include incident data, incident analysis, a wide range of training aids and fire service news. Below are a few examples of the many useful sites:

<http://www.firefighterclosecalls.com>

<http://www.firehouse.com>

<http://fe.pennnet.com/> (fire engineering)

<http://firechief.com/>

Recommendation #5: *Incorporate the health related and motor vehicle safety programs into the culture of your fire department. Incorporate the new resources of training information from the national groups into your training and tactics to improve fire ground safety.*

Discussion

Many fire service research priorities, as they stand now, are in direct response to firefighter fatalities. As more data on firefighter injuries is collected, the agenda may need to be modified. At this time it is not clear that the prevention strategies for injuries are the same as those for preventing fatalities. A more focused set of needs may come out of the near miss reporting system that has been recently started. This will only work if fire departments take the time to participate.

Recommendation #6: *In light of the fact that LODD-reduction research may not be the same research for injury prevention, it is imperative that all firefighter injury data be collected and analyzed, to the extent possible, as LODD data. NFIRS reports and near miss reports must be filed in a timely manner.*

In general, it is great news that there is so much research and data-gathering going on by a broad spectrum of federal agencies, national organizations, and academic institutions. However, gathering all this information and making it useful within the context of average fire department is something else again. Clearly, organizing information pertinent at the local level, for instance, to be used in a training drill, can be a daunting experience.

This point was well made by a fire chief at a NIOSH stakeholders' meeting, who after sitting and listening to all of the firefighting research activities, offered a realistic perspective on the needs of the fire service. An edited portion of his comments are given below, the full transcript is given in reference 17.

I thought when I got here today that I had a pretty good understanding of safety systems and safety organizations within the fire service, but I'm probably more confused now than ever, there are a ton of outstanding programs going on in the United States...I think we're to the point that we're right on the edge of making a difference for firefighter safety in the United States. If you look at the programs that are going on, we're close. But I think we need a little bit of leadership...somebody to gather these groups, put together some sort of collaborative effort where we don't have redundant programs going on in certain areas...from the local guy's perspective I don't know who to call when. It would be nice if you could help us with that because we're simply trying to make our fire departments run. And if you talk to the average fire chief or the average operations chief, I'm worried about putting trucks on the street. And second is some of the stuff (safety and research) that we're talking about today. But this is truly the most critical topic in the American fire service. So I think that's a big deal for us.

Given that his impression of being overwhelmed with research may be common, how do we transfer meaningful, useful results in bite size pieces to the fire service? What message can be given to the agencies and organizations working to assist the fire service toward this “user friendly” goal? This begs the issue of how fast can the research agencies respond to the identified needs of the fire service? PASS devices are a good example. More than a year ago, a safety alert indicated that PASS devices may fail at high temperatures, see reference 18. That is good information, but what is a fire chief or a firefighter supposed to do about it? Who is focused on finding a solution? Who is providing the leadership?

Recommendation #7: *Leadership on research issues is not confined to laboratories or creating elaborate research projects. Rather, leadership occurs when chiefs and other officers set an example for respecting and using research in their departments to make critical decisions, such as in making purchasing decisions based on reputable data, reporting data when queried, and by being familiar with developing research through reading periodicals, trade journals, and websites and participating in conferences and the codes and standards process. Given that we have the basis of an agenda do we change the 7th initiative? Does the agenda need to become generalized and reduced to five focal points or less? Do we need to make the agenda more specific? If so how should that be done? More importantly how do we get the needed research conducted? Again leadership is needed. There appears to be little if any co-ordination between DHS, USFA, NIST, NIOSH with regard to fire fighter research issues. Are we as a group serious about our 5 year and 10 year goals? If so, the federal funding set aside for firefighter health and safety needs to increase if changes are to occur within intervals of five years.*

Recommendation #8: *The fire service needs to generate a focused, goal driven*

research agenda.

Recommendation #9: *The fire service needs to provide the leadership to ensure that the research agenda is addressed by the Federal, State and local governments and private organizations in a partnership that is well-coordinated, efficient and funded to reflect the urgency of the need. This effort must include the conduct of the research and a means of transferring the research results to the fire service in a useful and understandable manner.*

Conclusion

A foundation for a research agenda has been developed and a number of new data collection activities have begun. Leadership on a national level is needed to focus the efforts of many agencies on the firefighter's research agenda. While many of these research efforts occur at a national level, they are all dependent on data from the local level. The ultimate success of the research programs will be measured at the local level. Therefore communication with all fire departments to encourage co-operation is critical. It is important for fire departments to provide data to the process, for example filing complete NFIRS reports and participating in near miss reporting. With effective communication the research results can be implemented by fire departments. Implementation can take the form of offering state of the art training, encouraging health and fitness programs, using new and proven technologies, and developing and training to SOGs.

Recommendations

Recommendation #1: Support activities such as the Firefighter Life Safety Summits and all fire service research symposia by submitting ideas for presentation, reading meeting summaries, and by sending presenters whenever possible.

Recommendation #2: Become familiar with the leading causes of firefighter line-of-duty deaths in order to speaking convincingly and knowingly as you advocate for future research.

Recommendation #3: It is very important that fire departments consistently participate in the NFIRS data collection process. If your department does not, find out why and work to correct this situation.

Recommendation #4: Fire departments should actively review the NIOSH LODD reports and the related safety information and incorporate them into their training programs.

Recommendation #5: Incorporate the health related and motor vehicle safety

programs into the culture of your fire department. Incorporate the new resources of training information from the national groups into your training and tactics to improve fire ground safety.

Recommendation #6: In light of the fact that LODD-reduction research may not be the same research for injury prevention, it is imperative that all firefighter injury data be collected and analyzed, to the extent possible, as LODD data. NFIRS reports and near miss reports must be filed in a timely manner.

Recommendation #7: Leadership on research issues is not confined to laboratories or creating elaborate research projects. Rather, leadership occurs when chiefs and other officers set an example for respecting and using research in their departments to make critical decisions, such as in making purchasing decisions based on reputable data, reporting data when queried, and by being familiar with developing research through reading periodicals, trade journals, and websites and participating in conferences and the codes and standards process.

Recommendation #8: The fire service needs to generate a focused, goal driven research agenda.

Recommendation #9: The fire service needs to provide the leadership to ensure that the research agenda is addressed by the Federal, State and local governments and private organizations in a partnership that is well-coordinated, efficient and funded to reflect the urgency of the need. This effort must include the conduct of the research and a means of transferring the research results to the fire service in a useful and understandable manner.

References

1. Report of the National Fire Service Research Agenda Symposium, June 1-3, 2005, Emmitsburg, MD. National Fallen Firefighters Foundation, Emmitsburg, MD.
2. Fahy, R.F. and Leblanc, P.R., U.S. Firefighter Fatalities for 2005, NFPA Journal, National Fire Protection Association, Quincy, MA., Vol. 100, No. 4, July/August 2006, p 50- 63.
3. Walton, W.D., Bryner, N., Madrzykowski, D., Lawson, J.R., Jason, N.H., eds, Fire Service Needs Workshop Proceedings, NISTIR 6538, National Institute of Standards and Technology, Gaithersburg, MD, July 2000.
4. Jackson, B.A., Peterson, D.J., Bartis, J.T., LaTourrette, T., Brakmakulam, I., Houser, A., and Sollinger, J. Protecting Emergency Responders: Lessons Learned From Terrorist Attacks. RAND, Santa Monica, CA., 2002.
5. LaTourrette, T., Peterson, D.J., Bartis, J.T., Jackson, B.A., and Houser, A. Protecting Emergency Responders : Community Views of Safety and Health Risks and Personal Protection Needs. RAND, Santa Monica, CA., 2003.
6. Jackson, B.A., Baker, J.C., Ridgely, M.S., Bartis, J.T., and Linn, H.I. Protecting Emergency Responders: Safety Management in Disaster and Terrorism Response. RAND, Santa Monica, CA., 2004.

7. Willis, H.H., Castle, N.G., Sloss, E.M., and Bartis, J.T. Protecting Emergency Responders: Personal Protective Equipment Guidelines for Structural Collapse Events. RAND, Santa Monica, CA., 2006.
8. Kennedy, T.J., Firefighter Needs Assessment: Final Report. Public Safety Technology Center, Westborough, MA., March 2005.
9. Health and Safety Guidelines for Firefighter Training, University of Maryland, Center for Firefighter Safety Research and Development, Maryland Fire and Rescue Institute, College Park, MD., 2006.
10. Stroup, D.W., Structural Collapse DVD Videos and Reports. National Institute of Standards and Technology, Gaithersburg, MD 2004.
11. Madrzykowski, D. and Vettori, R. Simulation of the Dynamics of the Fire at 3146 Cherry Road NE, Washington D.C., May 30, 1999. National Institute of Standards and Technology, Gaithersburg, MD, NISTIR 6510, April 2000.
12. Madrzykowski, D., Forney, G.P., and Walton, W.D. Simulation of the Dynamics of a Fire in a Two-Story Duplex-Iowa, December 22, 1999. National Institute of Standards and Technology, Gaithersburg, MD, NISTIR 6854, January 2002.
13. Vettori, R., Madrzykowski, D., and Walton, W.D. Simulation of the Dynamics of a Fire in a One-Story Restaurant – Texas, February 14, 2000. National Institute of Standards and Technology, Gaithersburg, MD, NISTIR 6923, Oct. 2002.
14. Fahy, R.F., U.S. Firefighter Deaths Related to Training, 1996-2005. National Fire Protection Association, Quincy, MA., June 2006.
15. Fahy, R.F., U.S. Fire Service Fatalities in Structures. National Fire Protection Association, Quincy, MA., July 2002.
16. Fahy, R.F., U.S. Firefighter Fatalities Due to Sudden Cardiac Death, 1995-2004. National Fire Protection Association, Quincy, MA., June 2005.
17. The National Institute for Occupational Safety and Health Stakeholder's Meeting to Seek Input on the Fire Fighter Fatality Investigation and Prevention Program Wednesday, March 22, 2006. National Institute for Occupational Safety and Health, Morgantown, WV.
18. "PASS alarm signals can fail at high temperature", NFPA Alert Notice, National Fire Protection Association, Quincy, MA. December 2005.
Feb 16, 2007