Running Head: FIRE DYNAMICS FOR COMPANY OFFICERS

A Company Officer Fire Dynamics Training Program for Forest Grove Fire and Rescue

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Certification Statement

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

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Abstract

The problem was that Forest Grove Fire and Rescue has personnel working at the company officer level with only minimal training in fire behavior/dynamics. This creates a situation where the company officer is expected to make critical tactical decisions without a clear understanding of the physics of fire in compartment spaces. The purpose of this Applied Research Project (ARP) was to develop a training program for company officers to better understand fire dynamics. The action research method was utilized and a copy of that program is included in the appendix. The research questions identified the need for this training within the department, the current training standards for the department and region, and a possible model for the training program. The procedures used included a literature review, collection of information and data, research into other programs available, and development of a training program. The results of the study agree with the data uncovered in the literature review regarding the importance of fire dynamics training and the creation of a training program to incorporate into the department's company officer training program. It is recommended that the training division provide fire dynamics training to all company officers, evaluate the possibility of a re-certification requirement, and develop appropriate fire dynamics training programs for all firefighters and recruit academies.

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Introduction

"If I have six hours to chop down a tree, I will spend four hours sharpening my axe."

Abraham Lincoln

One of the most dangerous environments we ask our company officers to enter is the compartment fire in a residential dwelling. They are expected to be able to adequately recognize the current conditions in the compartment when they enter and predict the fire conditions that will occur as their team advances deeper into the structure, and select appropriate strategies and tactics to safely extinguish the fire. Unfortunately, our training programs have not kept pace with the changes in building geometry, contents, and modern construction materials. Statistics show a continued loss of firefighters in residential structures, and one of the most significant contributing factors is a lack of understanding of fire dynamics in compartments.

The problem is that Forest Grove Fire and Rescue (FGFR) has company officers that have not received adequate training in fire dynamics for compartment fires. This puts the officer in the position of trying to make potentially life-threatening decisions without the appropriate foundation for their decision-making process. The purpose of this applied research project is to develop a compartment fire dynamics training program for FGFR.

The action research method was used to answer the following research questions:

1. Why is compartment fire dynamics training necessary for company officers?
2. What are the current local, state and national requirements for fire dynamic training for company officers?
3. What types of compartment fire dynamics training is currently available to fire officers?

4. What does a model fire dynamics training program consist of?

The results of this research will be used to develop a compartment fire dynamics training program for FGFR company officers.

Background and Significance

The City of Forest Grove is located on the western border of Washington County, Oregon. It has a population of 20,380 and is surrounded by the smaller communities of Banks, Cornelius,Gaston, and several unincorporated rural communities. Pacific University, with a student population of approximately 2,000, is located within the heart of a vibrant downtown complex. The university is known for its school of optometry and ophthalmology. Major industries within the city include computer chip manufacturing, service industries, and vegetable processing industries that support the surrounding farm industry (City of Forest Grove, 2011).

The City is governed by a city manager-council form of government with an elected mayor and five elected city councilors that represent geographical divisions within the City. The city is composed of an urban core surrounding the college, and a large number of suburban neighborhoods that serve as a "bedroom community" for the nearby Portland metropolitan area. There are 7,844 one and two family dwellings located within the response jurisdiction, and the true cash value of the service area is estimated to be $1.4 billion dollars. Surrounding the city is a large agricultural base of vineyards and wineries, grass seed production fields, nurseries, and orchards which extend north and west until they meet the wilderness areas of the coastal mountain range and the Tillamook State Forest. The metropolitan areas of Hillsboro, Beaverton, and Portland lie to the east of the City (City of Forest Grove, 2011).

Forest Grove Fire and Rescue (FGFR) was formed in 1884, and provides fire and rescue services for the five square miles of the City and the surrounding eighty square miles of the

Forest Grove Rural Fire Protection District (FGRFPD). FGFR provides contractual services to FGRFPD, providing all fire, rescue and emergency medical first response in the surrounding area. FGRFPD is governed by elected fire board members that live, or own property within, the boundaries of the fire district (2011).

Currently FGFR operates two stations – the main City station (Station 4) and the rural Gales Creek Station (Station 7). The main Station is staffed with 15 career personnel divided into three platoons working a west coast traditional 24/48 hour shift, providing a maximum of five career firefighters per shift. They are supervised by one shift captain and one lieutenant. All career firefighters are certified at the Oregon Emergency Medical Technician (EMT) Basic, Intermediate, or Paramedic levels, with the requirement that one paramedic be on-duty at all times to provide advanced life support care. Administrative staff is composed of the Fire Chief, the Training Chief, a Fire Marshal, and an administrative support person.

Due to its limited career staffing, FGFR depends heavily on its volunteer firefighters to provide adequate fire and rescue services to the communities we serve. Currently the department maintains a staffing of 42 volunteer firefighters, which includes community responders and firefighter-interns that are enrolled in a nearby community college fire science degree program. These intern-firefighters are assigned to a shift to increase our available response staffing. According to the 2011 Oregon Office of State Fire Marshal Annual Report (Oregon State Fire Marshal, 2011), Forest Grove Fire and Rescue responded to a total of 2,875 incidents, of which 117 were fires, 1,901 were rescue incidents, and 85 were mutual aid incidents.

The department is committed to its recently updated mission and values statements. The mission statement is an action statement, which defines the fundamental purpose and mission of

an organization by succinctly describing why it exists and what it does to achieve its vision (David, 2011). The updated mission statement of Forest Grove Fire and Rescue reads:

> "Everything we do, we do for the people and the communities we serve. With education and training, we prevent harm. With rapid and professional response, we protect lives and property. Through our desire to serve and courage to act, we are the model of a successful fire and rescue agency for the State of Oregon."

Vision statements define the desired or intended future state of an organization in terms of its fundamental objectives and/or strategic direction. The vision statement is a long-term view and it is used to set a 'picture' of the organization in the future, and answers the question "What do we want to become?" The current vision statement of Forest Grove Fire and Rescue reads: "To be the leading fire and rescue agency in Oregon by setting the standard of excellence in training, prevention, protection, and service for all people and communities who call upon us in a time of need" (City of Forest Grove, 2011).

Value statements are the core beliefs that are shared among the stakeholders of an organization. Values are the forces that drive an organization's culture and priorities, while providing a framework in which decisions are made. They are the guiding principles the department is willing to publicly proclaim and actually live by. The value statement of Forest Grove Fire and Rescue (City of Forest Grove, 2011) reads:

> "We achieve our mission and vision by building upon our core values and being loyal to our duty to serve. We work with a continued focus in the direction of leadership and excellence. Our defining core values

include Professionalism, Teamwork, Leadership, Compassion, Integrity, and Service Excellence. We hold ourselves accountable to these values."

Providing training for the department's company officers is consistent with the goals of the department's mission, vision and values statement.

This applied research project (ARP) meets the following United States Fire Administration operational objectives, as required by the National Fire Academy Executive Fire Officer Applied Research Guidelines (National Fire Academy, 2009). This ARP directly relates to Goal 3 and Goal 4 of the United States Fire Administration 2010-2014 Strategic Plan "...to improve the fire and emergency services capability for response to and recovery from all hazards" and "...to improve the fire and emergency services professional status" (United States Fire Administration, 2010). The goal of the Executive Fire Officer Program (EFOP) "Executive Leadership" course is to "...develop the ability to conceptualize and employ key processes and interpersonal skills used by effective executive-level managers" (United States Fire Administration, 2011). Providing training to company officers under the supervision of the executive-level manager is in-line with this goal.

The significance of this applied research paper for the United States Fire Administration is three-fold. It evaluates the necessity of fire dynamics training for company officers, utilizes models from scientific research to objectively make sound tactical decisions, and provides a model for other fire departments to conduct their own company officer training.

Literature Review

"There is not one set of tactics that apply to all fires but all fires have to follow the rules of physics" (Kerber, 2010).

The purpose of this literature review is to set the foundation for this applied research project by explaining what fire dynamics is, the importance of compartment fire dynamics (CFD) training to the company officer, and to research the availability of compartment fire dynamics training programs for company officers. This literature review gathered information from books, magazine articles, lectures, formal reports and local materials in an effort to answer the research questions.

The concept of fire dynamics has only been discussed for the last 25 years, and is frequently confused with fire behavior. Fire behavior is a component of fire dynamics, although the terms are often used interchangeably. Traditional fire behavior studies concentrate on fire chemistry and usually focus on the following (Underwriter Laboratories, 2005):

- Intensity of the flame.
- Rate, or the amount of energy that is released over time.
- Spread, or the fire's movement from the initial fuel source to other fuels.
- Growth, or the physical size of the fire.

The term fire dynamics was not commonly used until the mid-1980's, and fire engineering programs were not teaching courses with this title until the 1970's. The first known use of the term was in 1978, when the Worcester Polytechnic Institute (WPI) developed a curriculum for its master of science degree program in fire protection engineering. WPI invited Douglas Drysdale, Ph.D. from the University of Edinburgh's Department of Fire Safety

Engineering, to help develop the course. In 1986 Dr. Drysdale published the textbook *An Introduction to Fire Dynamics* (a third edition was published in 2011), which has become the standard reference source for this field (United States Fire Administration, Unknown). This text was published primarily for researchers in the field of fire protection, not firefighters or fire officers. It is a very complex scientific text book.

Fire dynamics was initially more the study of the physics of fire (versus the chemistry), but over the years the definition has evolved. The complexity of fire behavior requires not only an understanding of fire chemistry, but also the study of many subjects normally associated with the engineering disciplines. Fire dynamics has become a detailed study of how chemistry, fire science, material science, and the engineering disciplines of fluid mechanics and heat transfer (thermodynamics) interact to influence fire behavior (Madrzykowski, 2011). Today, fire behavior and fire dynamics may be used interchangeably in the fire service, but the more accurate term is fire dynamics.

How does this scientific discipline apply to firefighters? The NFPA has published data that documents the problem (Ahrens, 2010). From 2003-2007, fire departments in the United States average approximately 378,000 residential fires annually, causing an annual average of 2,850 deaths and over 13,000 injuries. Over 84% of the fatal home fires occurred in one or two-family dwellings. In regards to firefighter deaths and injuries, firefighter deaths occurring inside structures has continued to climb for the past 30 years, while deaths outside the structures and from cardiac arrest have declined (Fahy, 2010). Responding to structure fires is an inherently risky business that presents significant hazards to firefighters. The direct hazards include extreme fire behavior and rapid fire development, toxic byproducts of combustion, and structural collapse. The indirect hazards include the physiological stressors of firefighting (short-term and

long-term) and the long-term exposures to toxins and carcinogens. The fire service has attempted to minimize these risks through improved fire codes, technological innovation and improved procedures.

Fahy (2010) noted that from 1977-2000 the number of firefighter deaths in structure fires dropped 59 percent, a statistic that is often attributed to improvements in protective clothing, training and procedures. He also noted that simultaneously the number of fire responses had decreased by 54 percent. He then asked the question, “Are firefighters just as likely to die today as they were 25 years ago?” (p. 2). His findings showed “The one area that is showing marked increases over the period is the rate of deaths due to traumatic injuries while operating inside structures” (p. 10).

In 2010 Underwriters Laboratories published the groundbreaking study "*Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction*" (Kerber). Two houses were constructed in a large fire facility in Northbrook, IL, and 15 full scale experiments were conducted varying the ventilation locations and the number of ventilations openings to examine this change in fire dynamics. "The results of these experiments provide knowledge for the fire service for them to examine their thought processes, standard operating procedures and training content. Several tactical considerations were developed utilizing the data from the experiments to provide specific examples of changes that can be adopted based on a departments current strategies and tactics" (Kerber, 2010, p. 5).

The National Institute for Occupational Safety and Health investigates all firefighter line-of-duty deaths and issues a report with recommendations to prevent a reoccurrence. These are available on-line, and there are multiple examples where firefighters have died because officers did not understand fire dynamics. One example is NIOSH report F2010-10. In 2009 Firefighter

Brian Carey was killed in a residential fire in Homewood, Illinois. The firefighter fatality report generated by NIOSH (2010, p. 34) states "Fire departments should ensure that fire fighters and officers have a *sound understanding of fire behavior and the ability to recognize indicators of fire development and the potential for extreme fire behavior, and, fire departments should ensure that incident commanders and fire fighters understand the influence of ventilation on fire behavior* and effectively coordinate ventilation with suppression techniques to release smoke and heat". What NIOSH is describing is fire dynamics.

In Oregon, a recent case studies demonstrates the problem. In the summer of 2007, a small Oregon fire department conducted a training burn in their jurisdiction. The author had the opportunity to discuss this training event with one of the officers on scene (G. Robards, personal communication, May 5, 2012).

The interior safety officer was an experienced career officer. This fire department serves a neighboring community to FGFR, providing fire and EMS response with approximately 45 volunteer firefighters and four paid career staff.

The acquired structure was located in a suburban area with a good water supply. It was a single story ranch house, with approximately 1500 square feet of living space, and of typical wood-frame construction for an Oregon house built in the 1970s. A morning safety briefing was held, and the training was started immediately after.

The training officer, in an attempt to provide a more realistic training scenario, had placed furniture is a room to demonstrate fire behavior to new recruits in the final burn. This room was reserved for the last fire set and was to be observed from outside the house. The day's training continued with seven different fire sets ignited. During the fire sets, department members received training in fire behavior, suppression tactics and advancing hose lines.

Throughout the day, the interior safety officer would ignite the fire and call for the interior attacks. Only Class A combustible materials (hay, pallets and cardboard) were utilized in each of the room sets. In one of the final sets, the heat and smoke intensity levels rapidly increased at the ceiling. The smoke level was well above him and the interior safety officer called for the attack crew to enter. There was a delay at the door as the crews prepared, and unknown to the interior safety officer, heat and the byproducts of combustion had accumulated in the ceiling above him and extended into the room set aside for the final burn. The furniture reached its ignition temperature rapidly and the room flashed. The smoke levels instantly dropped to the ground and he could not see the front door (his nearest exit) that was six feet in front of him. The resulting flash and increase in fire and heat intensity drove the interior safety officer to his knees. He started to move to where he thought the front doorway was. He found the door, but could not exit the building due to the incoming attack crew. He struggled to communicate to the crews that he needed to get out and was finally able to do so. The incident commander, aware that the interior safety officer was in trouble, immediately called for hose teams to knock down the fire, but they were hesitant to apply water out of fear of "steaming" the interior safety officer. The incident commander observed him coming out the front door, emerging from the fully involved room, completely surrounded by flames. Fortunately, the interior safety officer only received minor second degree burns, and was quoted as saying “We are lucky we didn’t kill one or two people that day.”

The interior safety officer of this event was a career officer with over 10 years of experience working for the department. Multiple company and chief officers at this fire failed to adequately understand the concepts of fire dynamics and accurately predict the potential compartment fire behavior in this single family residence during a planned training drill. All of

these officers had participated in multiple live fire training evolutions and have responded to multiple real-world fire suppression events in the past. Despite this experience, they were caught by surprise by the rapid heat release rates, the potential energy of the fuel load in the furnished room, the heat transfer that occurred to the uninvolved room through radiative and convective fluid dynamics, and the rapid evolution of flashover.

The next subject of the literature review was to determine what level of fire dynamics and fire behavior training was currently being done through the firefighter and officer development programs in the region.

In Oregon, the Department of Public Safety Standards and Training established minimum training levels and certification for firefighters and fire officers utilizing the National Fire Protection Association standards as a guideline. The NFPA 1001 "Firefighter Professional Qualifications" (NFPA, 2008) states that the requisite knowledge of a firefighter should include "... on the principles, advantages, limitations and effects of horizontal, mechanical, and hydraulic ventilation; safety considerations when venting a structure, fire behavior in structure, the products of combustion found in a structure fire, the signs, causes, effects, and prevention of backdrafts; and the relationship of oxygen concentration to life safety and fire growth."

NFPA 1021 "Fire Officer Professional Qualifications" (NFPA, 2009, p. 12) states "The requisite knowledge of a fire officer shall include: Develop an initial action plan, given size up information for an incident and assigned emergency response sources, so that resources are deployed to control the size up. The requisite knowledge includes elements of a size up, standard procedures for emergency operations, and fire behavior."

To determine to what levels these standards are being met, the author reviewed the training programs currently provided to firefighters both internally and externally, through the

Washington County (Oregon) Training Association (WCTA). The 2012 NFPA Firefighter I Academy (syllabus) conducted by WCTA is approximately 102 hours in length. A three hour lecture in fire behavior, based on IFSTA 5th edition Essentials is included (2008). The 2012 WCTA NFPA Firefighter II academy was reviewed. This is a 60 hour class, which included no fire behavior training (WCTA, 2011). Finally, the requirements for Oregon DPSST NFPA Fire Officer I and DPSST NFPA Fire Officer II were reviewed. The estimated hours to complete these certifications levels is approximately 108, and again, no fire behavior classes are required to successfully complete these programs (DPSST, 2009). While these programs establish minimums, and firefighter and fire officer candidates often exceed these minimums, this does give some idea of the lack of emphasis on fire behavior and fire dynamics. When measured against the total amount of training required to obtain these certifications, less than 1% of the training is focused on fire behavior.

In Oregon there are two higher education programs available to firefighters. Through the local community colleges one can obtain an associates of applied science in fire protection technology, which requires 105 credits to complete. There is one 5 credit course required in this program, Physical Science for Fire Science and EMS that has a pre-requisite of Elementary Algebra (MTH070). A review of the on-line syllabus shows this class deals with basic physics and has no fire behavior or fire dynamics components (Fire Protection Technology, 2013).

Oregon also has a baccalaureate degree in Fire Services Administration available through Eastern Oregon University and Western Oregon University. This program requires 180 total credits, none of which require any type of fire behavior or fire dynamics training (EOU, 2012). The final phase of the literature review was to determine if there were any existing training programs that could be adopted or adapted to provide training for fire officers in fire dynamics,

or serve as a model for the development of a training program. The author conducted research at the National Fire Academy Learning Resource Center (LRC). Three primary reference textbooks were identified as potential source material. The Federal Emergency Management Agency National Fire Academy developed a course "Fire Dynamics" through the Open Learning Fire Service Program in the 1990's (the exact date of development is unknown). The course guide is currently stored in the basement at the LRC and is not available for checkout or interlibrary loan (United States Fire Administration, Unknown). This course guide does not appeared to have been used in recent years, and appears to be out-of-date with the latest advances in research.

In 1986 Dr. Drysdale published the textbook *An Introduction to Fire Dynamics* (a third edition was published in 2011), which has become the standard reference source for this field. This text was published primarily for researches in the field of fire protection, not firefighters. It is a very complex scientific text book written for those pursuing postgraduate studies in fire protection engineering. The third book reviewed was "Enclosure Fire Dynamics," written by Bjorn Karlsson and James Quintiere. This book is also written for fire safety engineers and those pursuing postgraduate studies in fire protection engineering (Karlsson & Quintiere, 2000).

Kerber (2010, p. 16) noted that "As a general rule firefighters are taught practical knowledge with little scientific foundation to support their training." This literature review has demonstrated that there is a definitive requirement for fire officers to understand fire behavior and fire dynamics. Reviews of national and state standards for firefighter training, recent scientific studies, and reviews of NIOSH line-of-duty death reports, all recommend that fire officers understand the chemistry and physics of compartment fire dynamics. In order for

company officers to make sound tactical decisions in potentially life-threatening situations, they need to understand compartment fire dynamics.

Secondly, this literature review has documented that current training standards and curriculum are lacking any significant fire behavior or fire dynamics training for FGFR company officers. This lack of training extends to regional and state training programs in Oregon, and the fire service higher education programs available to FGFR company officers.

Finally, this literature review has not been able to identify a current comprehensive fire dynamics training program designed for company officers that provides practical knowledge with a scientific foundation.

Procedures

This applied research paper was written and formatted based on the 5th edition of the American Psychological Association *Publication Manual*. This study utilized an action method of research.

To answer questions 1, 2 and 3, the author performed a literature review of scientific studies, texts, and reports related to the role and importance of fire dynamics training for company officers, and a review of regional, state and national standards. In addition to the author's personal library, a physical visit was conducted at the Learning Resource Center (LRC) located at the National Fire Academy in Emmitsburg, Maryland, where electronic searches of its database were conducted. Additionally, library resources of George Fox University (Newberg, Oregon) EBSCO host online databases were utilized to perform additional searches and the online resources of the LRC. Electronic research was conducted via the internet utilizing the Google search engine www.google.com.

The following search strategies were used for this review: fire behavior OR fire dynamics AND company officer. The scope of the search was limited to peer-reviewed journals in the EBSCO database. Within the LRC database the scope of the search was limited to peer-reviewed journals, texts, and the Executive Fire Office (EFO) published Applied Research Projects. Results were limited to publication dates between January 1, 1980 and December 1, 2012. The next step involved a three-step process:

1. Identification of studies: Abstracts, articles, books, reference lists and journals were retrieved by the author and reviewed for applicability to the research questions and purpose of this research paper.
2. The full text version of all of the articles that could be retrieved were retrieved and evaluated for currency (within the last 30 years) and applicability to the research topic and questions. Several texts that were not available on-line were requested via intra-library loan or purchased.
3. Each text was analyzed in a structured review to determine its applicability to the research topic.

From this review the author selected the most pertinent materials to the research question to help define the need for and concepts of fire dynamic training.

In 2012 the author also attended classes in "The Art of Reading Smoke" taught by David Dodson and classes from the engineering laboratory at the National Institute of Standards and Technology taught by Daniel Madrzykowski. Training and reference materials were gathered at each of these classes, and informal discussions were held with each of the instructors.

The next phase involved research into a draft model of a training program for company officers in fire dynamics. Utilizing text identified in the literature review, a draft model was

developed (Appendix A) with help from a focus group of three senior chief officers affiliated with the Oregon Fire Instructors Association with experience in fire dynamics and curriculum design (Peterson, Crowder, & Phillips, 2011). Mind-mapping software was used to capture the thoughts and ideas of this focus group. From this model a sixteen-hour training program was developed, which was then presented in a train-the-trainer course to 24 senior training officers at the 2012 Oregon Fire Instructors Association Firefighter Safety Symposium (OFIA, 2012). This course was designed to elicit feedback on the course content and design from the participants. Based on this input, the course was modified and a second model generated (Appendix B).

This applied research project has several limitations. First and foremost is the lack of experience the author has in conducting and writing scientific research papers. Personal bias, inexperience, and subjectivity could have affected the findings stated in this paper.

The methods used to select appropriate studies for this research could be considered subjective, as it was difficult to establish objective criteria to select papers to include in this literature review. In addition, there is a large amount of available research literature on this subject. The author does not present this as an exhaustive literature review on the subject matter.

The research was limited to compartment fire dynamics in residential structures. The research does not include wildland fire dynamics, fire dynamics for chemical, liquid or gas-fed fires, large-building fire behavior (although there may be some application), or wind-driven structure fires. Our knowledge of fire dynamics is continuously evolving and expanding, which may limit the future usefulness of this research.

The research did not discover any terms requiring additional explanation of their definition (that have not already been defined in this APR) in this section of the research process.

Results

The purpose of this Applied Research Project (ARP) was to develop a training program for company officers to better understand fire dynamics. This section will report the results of the information collected for the study.

Research question 1. Why is compartment fire dynamics training necessary for company officers? The literature review provided the information to answer this question. Statistics from the NFPA demonstrated that the vast majority of fires are residential one and two story fires. The vast majority of traumatic civilian and fire deaths occur in these circumstances. NFPA statistics also demonstrated that while overall firefighter deaths have been declining, so have fire responses, and traumatic firefighter deaths in fires have been increasing. It was identified that NIOSH line-of-duty death reports have recognized and called for more fire dynamic training for firefighters and officers. A case study from a neighboring department was presented that demonstrated a recent incident where a company officer's lack of understanding of fire dynamics almost led to tragedy. Compartment fire dynamics training is clearly necessary for company officers to make knowledgeable and timely tactical decisions in a rapidly changing hazardous environment.

Research question 2. What are the current local, state and national requirements for fire dynamics training for company officers? The research indicated that the nationally accepted standard is NFPA 1021, Standard for Fire Officer Professional Qualifications. The Oregon Department of Public Safety Standards and Training (DPSST) has responsibility for certification of fire officers based on the NFPA 1021 standard. NFPA 1021 requires training in fire behavior. Two other NFPA standards, 1500 and 1561, provide additional guidelines on the training needs of company officers.

Research question 3. What types of compartment fire dynamics training is currently available to fire officers? The literature review provided the answer to this question. DPSST has responsibility for certification of fire officers based on the NFPA 1021 standard, and makes curriculum recommendations to meet the training requirements of the standard. None of the curriculum requirements for NFPA Fire I, II, III or IV require any type of fire behavior or fire dynamic training. The Oregon Associates of Applied Science degree in Fire Protection Technology, offered by many of the community colleges in Oregon, provides little fire behavior or fire dynamics training in the curriculum. The baccalaureate degree programs offered in Fire Science Administration in the Oregon university system have no fire behavior or fire dynamics programs. The regional fire training association does provide a brief 3 hour lecture in fire behavior in their NFPA Firefighter I academy. Currently, fire behavior training comprises less than 1% of the FGFR company officer's total fire service training.

Research question 4. What does a model fire dynamics training program consist of? The literature review identified several sources that were utilized to develop a draft training program model to provide company officers of FGFR with knowledge in fire dynamics. The draft training program was presented to a senior group of fire instructors at a regional conference, and recommendations were made for enhancement and improvement. The final draft model is presented in Appendix C (note that the entire program is over 275 slides, so the attachment only includes the first nine slides. A full electronic version is included with this ARP). Pre-test and post-tests were developed to measure student retention of the provided material (Appendix E).

Discussion

"The evolution of our tactical capability will only be enhanced by the evolution of our mental agility." These are the words of Chief Bobby Halton in his description of a NIST

presentation on fire dynamics (2008). Analysis of the literature reviewed indicates that understanding fire dynamics is a critical function of the company officer. Understanding the construction and the materials in modern residential structures prepares the company officer for making critical decisions, such as when to ventilate, when to aggressively attack, and when to withdraw from a structure (Kerber, 2010).

Fire dynamics is more than just fire behavior. It is a detailed study of how chemistry, fire science, material science and the engineering disciplines of fluid mechanics and heat transfer interact to influence fire behavior (Madrzykowski, 2011). Gorbett and Hopkins (2007, pp. 1-2) presented a paper where they reviewed many of the current fire service training materials and determined that "many in the fire safety profession do not understand these very important enclosure fire progression phenomena...fire safety professionals must achieve a solid theoretical knowledge of fire behavior, more specifically enclosure fire behavior." The question for how much science is necessary to teach firefighters is a good one, and expanding our training to accommodate more theoretical physics will require a fundamental shift in how we train firefighters. Within FGFR there will be some resistance to this training, as it involves advanced theoretical concepts, physics and some math, and it will take time to relate the academic aspects of this research to the practical, hands-on approach FGFR firefighters generally prefer. "It is vital that we spread the word on fire dynamics and new firefighting techniques to the firefighting community," said Principal Investigator Sunil Kumar, Professor of Mechanical Engineering at NYU-Poly. "Before the FDNY started using research-based techniques for high-rise fires, such fires most often ended with significant firefighter injuries or death. Now, through new tactics and associated training, similar fires are most likely to end in a whimper" (NYU-Poly Press Room, 2012).

The national standards, specifically NFPA 1021, Standard for Fire Officer Professional Qualifications (NFPA, 2009) provide a strong argument in favor of developing a fire dynamics training program for company officers. The certification program of Oregon's DPSST is equally important as a benchmark for professional fire officer development within FGFR (DPSST, 2009). By expanding the company officers understanding of fire dynamics we increase firefighter safety, increase the effectiveness of our tactics, and limit the damage to our community. "An organized application of strategy and tactics in the fire hazard zone, enhanced by personal discipline, a well-rounded understanding of fire dynamics and building construction, and strong command presence, creates the perfect formula for fighting fire smarter and living to fight again" (Tippett, 2013).

The author's interpretation of the research is that there are many reasons for providing fire officers with fire dynamics training. The national and state standards, increasing traumatic injuries to firefighters in residential fires (despite decreasing occurrence of fires) (Fahy, 2010), and the case studies within our own region all point to the need for more understanding and awareness. The knowledge is critical to our safety, and it must be presented in a manner that is understandable to a non-scientific audience and has useful field applications for FGFR firefighters. The author strongly believes that while there will be challenges to providing this training program, the long-term gains in safety and effectiveness for both the firefighter and the public makes it worth the effort. Someone once told me "A good firefighter knows how, but a great firefighter knows why".

Recommendations

This applied research project provides a draft fire dynamics training program for FGFR company officers. There are several recommendations for FGFR:

1. The training division of Forest Grove Fire and Rescue should provide training to all company officers in fire dynamics utilizing the proposed program in the next 12 months.
2. Create a committee from the operations and training division to examine our current fire behavior training and tactics to determine if they are compatible with the latest fire dynamics research.
3. The FGFR training division should continue research, improvements and updates to the company officer fire dynamics training program.
4. The FGFR training division, working with the Washington County Training Association, should evaluate a requirement that all future company officers complete a fire dynamics training program.
5. The FGFR training division should evaluate a re-certification requirement for all company officers in fire dynamics.
6. The FGFR training division should evaluate providing expanded fire dynamics training for all current firefighters.
7. The FGFR training division, working with the Washington County Training Association, should evaluate offering a lower level of fire dynamics training in the recruit academy.

References

Ahrens, M. (2010). *Home structure fires.* Quincy, MA: National Fire Protection Association.

City of Forest Grove. (2011). *City of Forest Grove 2011-2012 Budget Document.* Forest Grove, OR: City of Forest Grove Finance Department.

City of Forest Grove. (2011). Forest grove fire & rescue annual report. City of Forest Grove.

David, F. R. (2011). *Strategic Management: Concepts and Cases.* Upper Saddle River, NJ: Prentice Hall.

DPSST. (2009). *Fire Officer Guide 2009.* Retrieved June 30, 2012, from Oregon Department of Public Safety Standards and Training: www.oregon.gov/dpsst/FC/docs/SuggestedCourseGuides/FireOfficerGuide2009edition.pdf

EOU. (2012). *FSA Degree Requirements*. Retrieved 12 10, 2012, from Eastern Oregon University Fire Services Administration: http://www.eou.edu/fsa/degree-requirements/

Fahy, R. (2010). *U.S. fire service fatalities in structure fires, 1977-2009.* Quincy, MA: National Fire Protection Research Foundation.

Fire Protection Technology. (2013). Retrieved January 28, 2013, from Chemeketa Community College: http://www.chemeketa.edu/programs/fireprotection/documents/Fire%20Info%20Fall%202013.pdf

Gorbert, G., & Hopkins, R. (2007). *The current knowledge and training requirements regarding backdraft, flashover, and other rapid fire progression phenomena.* Boston, MA: NFPA.

Halton, B. (2008, September 5). *Fire Engineering*. Retrieved December 2, 2012, from NIST Fire Dynamics Seminar: http://community.fireengineering.com/profiles/blog/show?id=1219672%3ABlogPost%3A78161

IFSTA. (2008). *Essentials of firefighting. 5th ed.* Stillwater, OK: Fire Protection Publications, International Fire Service Training Association.

Karlsson, B., & Quintiere, J. (2000). *Enclosure Fire Dynamics.* Boca Raton, FL: CRC Press.

Kerber, S. (2010). *Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction.* Northbrook, IL: Underwriter Laboratories.

Madrzykowski, D. (2011). Hazard assessment of fire service training fires. *Fire Protection Research Foundation* (p. 45). Portland: NIST.

National Fire Academy. (2009). *Executive fire officer program operational policy and procedures applied research guidelines.* Emmitsburg, MD: Department of Homeland Security.

NFPA. (2008). *NFPA 1001: Firefighter professional qualifications.* Quincy, MA: National Fire Protection Association.

NFPA. (2009). *NFPA 1021: Standard for fire officer professional qualifications.* Quincy, MA: National Fire Protection Association.

NIOSH. (2010). *One career firefighter/paramedic dies and a part-time firefighter/paramedic is injured when caught in a residential structure flashover-Illinois NIOSH report no. 2010-10.* National Institute for Occupational Safety and Health.

NYU-Poly Press Room. (2012, October 16). Retrieved November 25, 2012, from NYU-Poly: www.poly.edu/news/2012/10/16/learning-fight-modern-fire-modern-way

OFIA. (2012). *Oregon Fire Instructors Association.* Retrieved March 22, 2012, from 2012 Firefighter Safety Symposium: https://0bd856df-a-62cb3a1a-s-sites.googlegroups.com/site/ofianet/general-information/2012OregonFireServiceSymposium-RegOnline.pdf?attachauth=ANoY7cpZ8e4J5iFlfcftVFBNw_bQokShVxO7pC5mOUND3O88jbgMhljqs_BuNTwKalPKvEzON30UsV6SGB93PH5BQl1y8_Sg23oCu6mMmcvj1196Q

Oregon State Fire Marshal. (2011). *Oregon Office of State Fire Marshal Annual Report.* Salem, OR: State of Oregon.

Peterson, D., Crowder, T., & Phillips, S. (2011, February). Developing a fire dyanamics training program for Oregon fire officers. (M. Kinkade, Interviewer)

Tippett, J. B. (2013, February 16). *The Fire Attack Holy Grail*. Retrieved March 18, 2013, from FirefighterNation: www.firefighternation.com/article/firefighting-operations/fire-attack-holy-grail

Underwriter Laboratories. (2005). *Fire behavior is a single family occupancy*. Retrieved February 2, 2012, from Underwriter Laboratories: http://www.ul.com/global/eng/pages/offerings/industries/buildingmaterials/fire/courses/behavior/

United States Fire Administration. (2011). *Executive leadership.* Emmitsburg, MA: United States Fire Administration.

United States Fire Administration. (Unknown). *Fire Dynamics.* Emmittsburg, Md: United States Fire Administration.

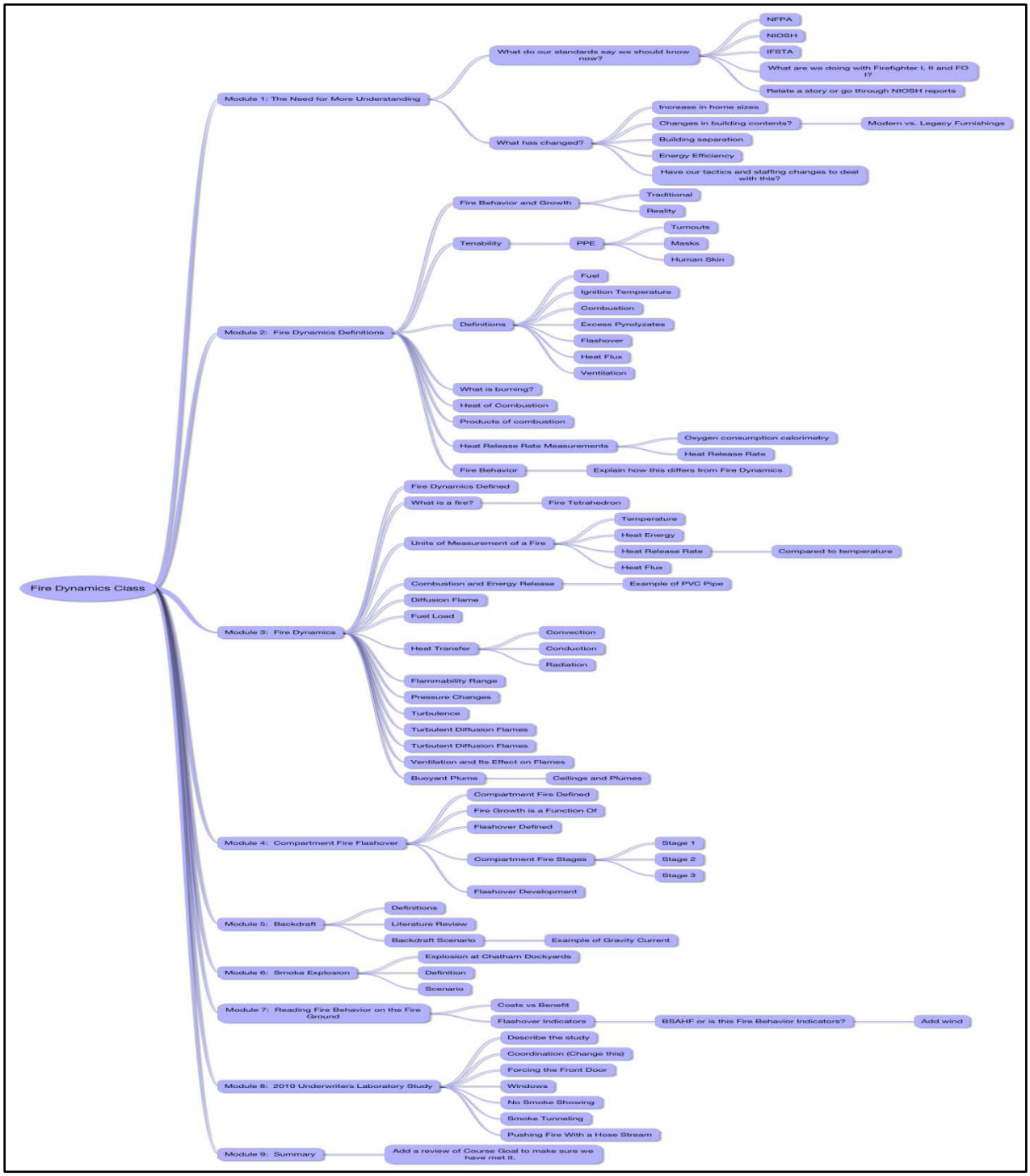
United States Fire Administration. (2010). *Strategic plan: fiscal years 2010-2014.* Emmitsburg, MA: United States Fire Administration.

WCTA. (2011). *WCTA Training*. Retrieved June 23, 2012, from Washington County Training Association: www.wwcta.net/index.cfm/training/

APPENDIX A

Initial Draft Model for Company Officer Fire Dynamics Training

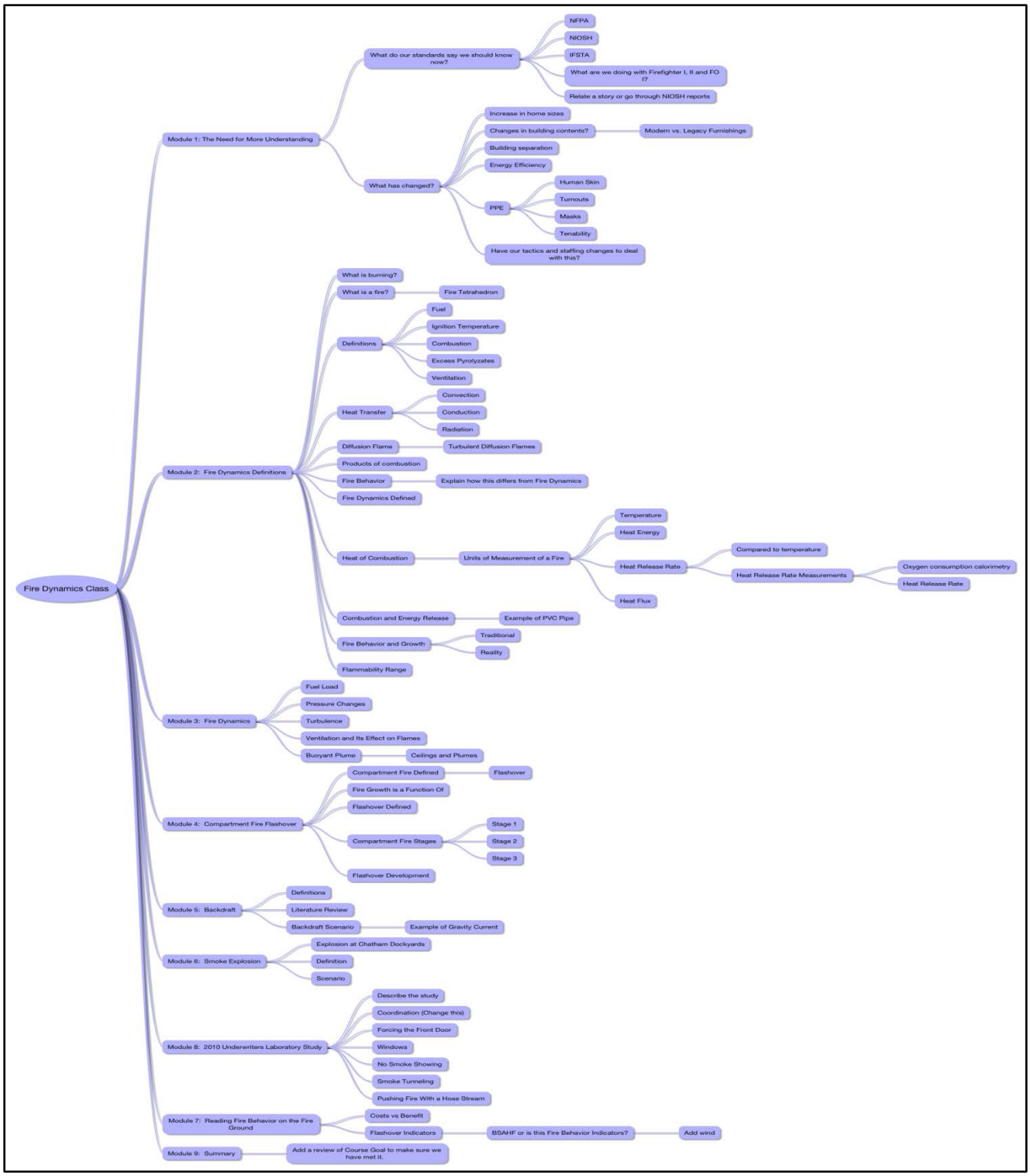
Mind Map (best viewed electronically)



APPENDIX B

Revised Draft Model for Company Officer Fire Dynamics Training

Mind Map (best viewed electronically to allow zooming)

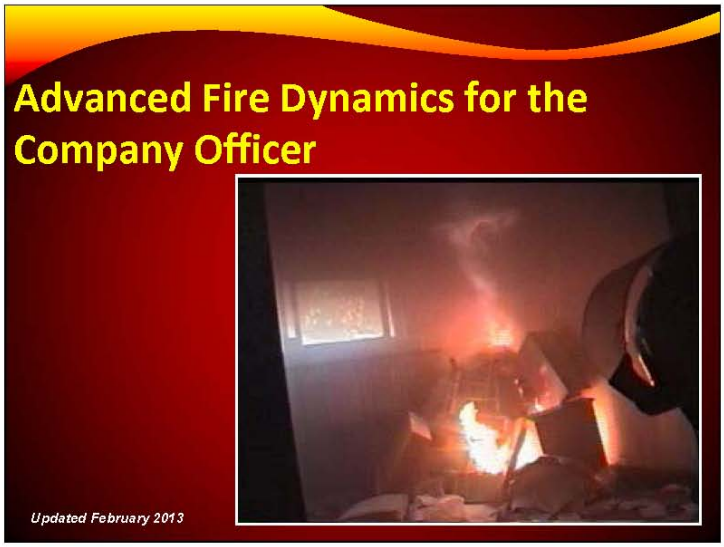


APPENDIX C

Advanced Fire Dynamics for the Company Officer

Training Program

(Note: Only the first nine slides of the instructor manual are included in the attachments, as the program is over 275 slides long. An electronic copy is included with the full training program).



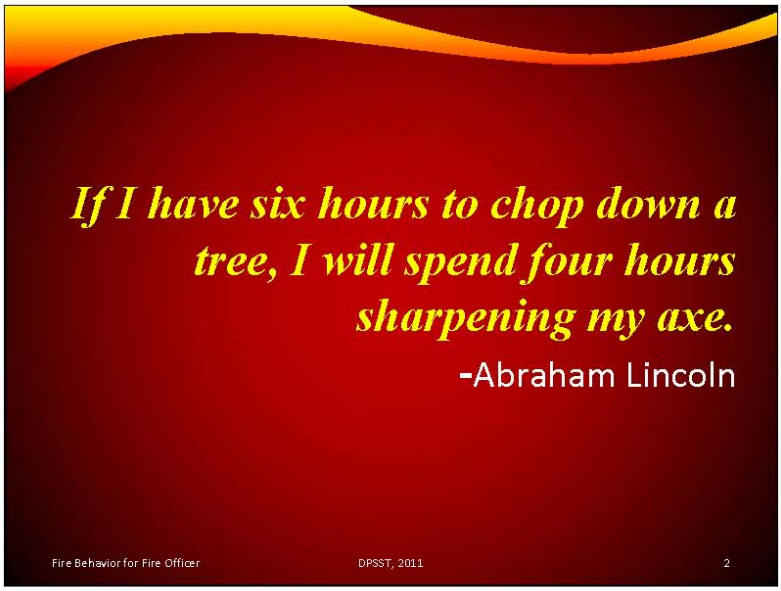
Source: Kinkade, M. W. (Director). (1997). *Flashover: Acquired Structure Fire, Corvallis, Oregon* [Motion Picture]. *Used with permission*

Notes on Video: This video was shot in the late 1990's at an acquired structure fire in Corvallis, Oregon. The instructors were attempting to provide a video document of fire behavior during a live fire training exercise where new recruits were being taught fire behavior and fire suppression techniques. Towards the end of the video a recruit firefighter misunderstood the instructor and started to crawl into the room as flashover was occurring – this was not intended by the instructors. The recruit was uninjured and no equipment was damaged despite the dramatic nature of this footage.

Instructor Note: This video should be playing as the students enter the room and left on an endless loop until the instructor is ready to begin the class. This is intended to set the stage for understanding fire dynamics and fire behavior. This same video will be used in Module 4, Compartment Fire Flashover.

Module 0: Introductions
Time: 45 minutes (includes pre-test)

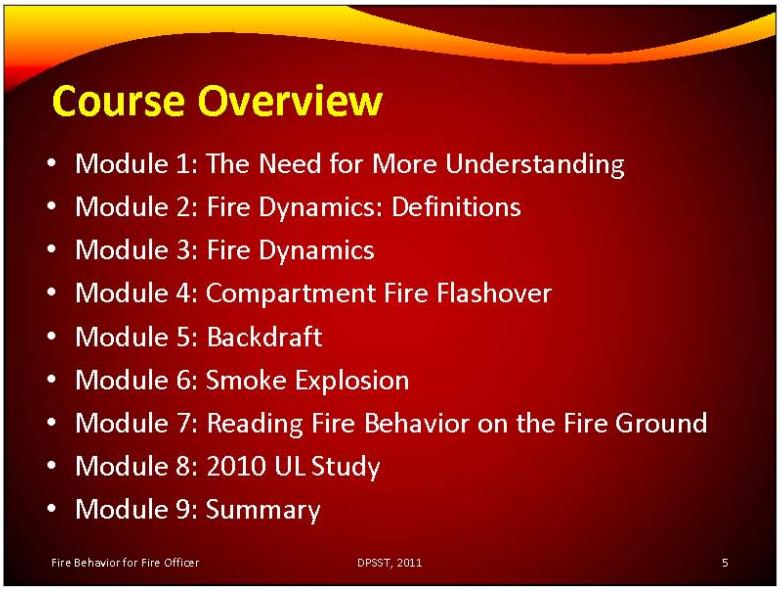
1



Instructor note: This quote from Abraham Lincoln can be used to start the discussion on why the student is here.

Preparation for the fire officer is key, and in an environment of decreasing fires and subsequently decreasing experience in fire behavior, the fire officer has to commit themselves to an on-going preparation for the safety of the men and women they lead into harm's way.

Instructor Note: Distribute the pre-test for this course and allow the students 15 minutes to take the test.



Instructor Notes:

Total Class Length is approximately 8.5 hours – 16 hours. The 16-hour class involves expansion of the provided videos and PowerPoint presentation for an experienced instructor to use props and dollhouses to demonstrate some of the fire dynamic and fire behavior concepts.

Module 0: Introductions: Time: 30 minutes

Module 1: The Need for More Understanding: Time: 30 minutes

Module 2: Fire Dynamics: Definitions: Time: 1 hour

Module 3: Fire Dynamics: Time: 1 hour

Module 4: Compartment Fire Flashover: Time: 1.5 hour

Module 5: Backdraft: Time: 1 hour

Module 6: Smoke Explosion: Time: 30 min

Module 7: Reading Fire Behavior on the Fire Ground: Time: 1.5 hour

Module 8: 2010 UL Study: Time: 30 minutes

Module 9: Summary: Time 15 min

5

Instructor Notes:

Target Audience: Students for this course are current fire officers and those seeking to become fire officers.

Deliver Method: Course delivery method consists of:

- Lecture with PowerPoint presentations
- Case studies
- Video reviews
- Participant discussion

Note: Instructors should strive to add experiments, videos and hands-on skills to reinforce some of the difficult concepts necessary. Recommendations are made throughout the instructor guide.

Course Prerequisites: Students of this course should have obtained at a minimum the Department of Public Safety Standards and Training certification for Firefighter II. This course is not designed as a basic fire behavior class for entry-level firefighters.

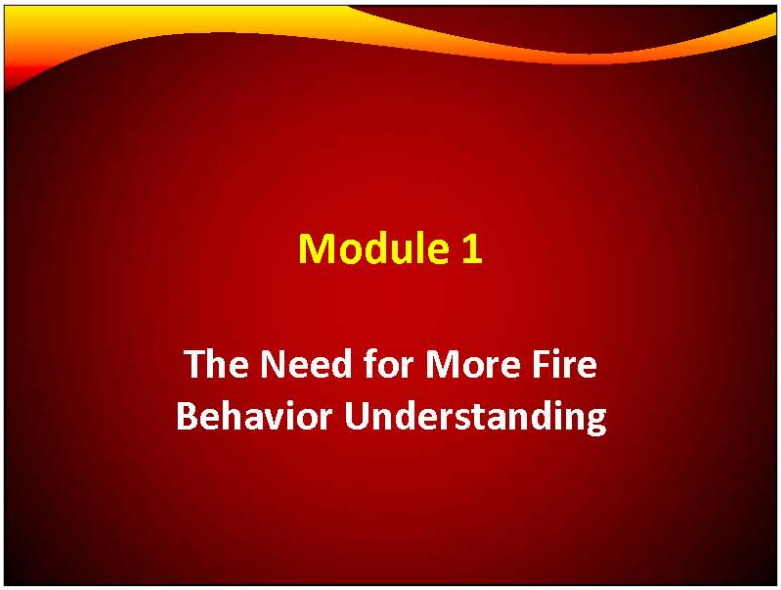
Instructor Notes:

NFPA 1021 (2009), 1.3.4 states:

"The fire officer at all levels of progression shall remain current with the general requirement for fire officers, human resource management, community and government relations, administration, inspections and investigations, ***emergency service delivery****, and health and safety."*

Source: National Fire Protection Association. (2009). *NFPA 1021: Standard for Fire Officer Professional Qualifications*. Quincy, MA: NFPA.

Instructor Notes: In the student manual each slide is annotated with the source information, and a bibliography is included on the final slide for additional research.



Terminal Objective

Upon the successful completion of this module, participants will be able to describe the need for more understanding of fire behavior and combustion for the fire officer and fire officer candidates.

Enabling Objectives

1.Describe the differences between legacy buildings and modern construction.

2.Discuss the excerpts from the National Near-Miss Reporting system and relate to personal experiences of the instructor and students.

3.Contrast the difference in flashover rates between legacy and modern compartments.

Module Time: 1 hour

9