NFPA Standards

and

Occupational Safety of First Responders

An Interactive Qualifying Project Report

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Abstract

This Interactive Qualifying Project has been prepared for the MIRAD Laboratory at Worcester Polytechnic Institute. The research of this project concerned the applicability of various industry standards on the occupational safety of first responders in the emergency medical services field. The focus of the research was on the National Fire Protection Association's (NFPA) codes and standards. The author of this IQP is a voting member of the NFPA Technical Committee on Fire and Emergency Services Protective Clothing and Equipment - Electronic Safety Equipment. This report identifies the role played by fire departments in delivering emergency medical service (EMS) care. Additionally, it outlines the applicability of existing NFPA standards on EMS vehicles and equipment. Finally, a literature review of codes and standards regarding personal protective equipment (PPE) for first responders was generated.

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Thanks, also, to the technical committees of the National Fire Protection Association for their ongoing efforts to develop standards to improve firefighter and EMS safety.

Thanks to John Soderberg, paramedic, Pittsburgh EMS, for his thoughtful and thorough instruction of Pennsylvania EMT-B certification.

Thanks to the First Responder; those who work tirelessly and selflessly that others may be safe. Our country would not be what it is today were it not for your sacrifice and diligence.

> *When I'm called to duty God, wherever flames may rage, give me strength to save a life, whatever be its age. . .*

CHAPTER 1: EMS and Life Saving Practices

1.1 Motivation and Significance

Many of the codes and standards in the first responder community are defined by the National Fire Protection Association (NFPA). A review of existing MIRAD Laboratory's Interactive Qualifying Projects indicated that additional research of NFPA codes and standards would be helpful. This project was conducted to supplement the existing codes and standards research work performed through and on the behalf of MIRAD.

1.2 Objectives

The first objective of this report was to identify the role played by fire departments in delivering emergency medical service (EMS) care. The second objective was to outline the applicability of existing NFPA standards on EMS vehicles. The last objective was to provide a literature review of codes and standards regarding personal protective equipment (PPE) for first responders.

1.3 Order of Report

Chapter 2 provides a background of the codes and standards process of the NFPA. The chapter is concluded with a discussion regarding the mentality of firefighter and EMS personnel. Chapter 3 provides discussion of several codes and standards. First is a discussion of the collaborative role played by fire departments in the delivery of EMS care. The role of the Insurance Services Office in providing insurance premium reductions through fire department qualification frequently leads to municipalities tasking their fire departments with EMS functions. Chapter 3 is concluded with discussions of several codes and standards applying to PPE. Chapter 4 provides concluding remarks and recommendations for future research efforts.

CHAPTER 2: Background

2.1 National Fire Protection Association

Founded in 1896, the National Fire Protection Association (NFPA) was established when representatives met to consolidate the several available electrical codes of the time. Beginning with the National Electric Code of 1897, the NFPA embarked upon creating standards. Now with close to 300 active codes and standards, the NFPA is the predominant source for codes governing first responders as well as electrical and life safety issues.[1]

It is important to note that while many of the NFPA standards are written in legal form, they are not legal instruments. All of the standards disclaim themselves as subordinate to applicable law, as can be seen by the following boilerplate:

> *Law and Regulations*
>
> *Users of NFPA Documents should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of its codes, standards, recommended practices, and guides, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.*[2]

As an international non-profit organization, the NFPA generally has no statutory authority. These documents are instead presented in a manner that can be easily adopted by law makers should they choose to do so.

There are no federal laws that dictate the usage of NFPA standards. Within the fire industry, it is exceedingly rare to find departments that willingly choose to ignore such standards. There are those who do, but frequently they are criticized for not following standards while operating as a fire department. Failure to adhere to NFPA standards further invites legal liabilities.

Another subtlety to the NFPA process is insurance. Many underwriters of fire departments require adherence to NFPA and other applicable standards. If it is discovered that the departments are not following as such, the insurers may very well deny claims. Additionally, they may increase the department's premiums or even terminate service.

2.2 First Responders

For the purposes of this report, the term First Responder represents the group of individuals that respond to and provide aid in the event of an emergency. There are many types of first responder, including firefighters, emergency medical personnel, and police to name a few. This document attempts to focus upon a specific category of first responders, namely those who work in Emergency Medical Services (EMS). This group primarily consists of Emergency Medical Technicians (EMT(s)) and Paramedics.

2.3 First Responder Priorities

For the purposes of delivery of care, it is important to understand the mentality of a first responder. To digress to a cliché, while others flee, it is the first responder who rushes towards an emergency scene. The type of individual who hears the call of civil service is one who cares for the well-being of his fellow man.

Integral to the training of higher level care is the occupational safety. While not openly documented, probably for legal reasons, the generally accepted priority list for emergency medical technicians, EMTs, can be considered "SPOVE" which follows. As morbid as it may seem, the priorities are simple and objective in their logic.[3]

1. Self
2. Partner
3. Others (Bystanders/General Public)
4. Victim(s)
5. Environment

In the following three sub-sections prioritization comparisons will be made. These comparisons will illustrate the priorities of the five points of SPOVE.[4]

2.3.1 Example: 1, 2 versus 4

As a giver of care, the EMT and his/her partner (if present) can be, and frequently are, confronted with environments where their safety may not necessarily be assured. Under these conditions, it is inacceptable to go running to the scene of the accident like a cowboy.

Consider the following two classic car accident examples used in EMS training. In the presence of (a) an unstable wreck or (b) a car surrounded by a pool of gasoline, the conditions are considered IDLH, or immediately dangerous to life or health. Prior to delivery of care, it is the responsibility of the first responder to secure the scene and render the environment safe.

In example (a) above, the first responders would first stabilize the vehicle with chocks, blocks, and cribbing lest the vehicle roll and crush a first responder. Upon securing the vehicle, a first responder would provide stabilization of the victim(s), if necessary. In example (b) above, the presence of pools of highly combustible fuels ready for an ignition source would be too dangerous to first responders. Absorptive compounds would be applied to limit the vaporization of the fuel whereupon again a first responder would stabilize the victim(s). Following these steps would be vehicle extraction and the subsequent transport of the patient.

In the above examples, the violent and traumatic nature of a vehicle accident necessitates victim immobilization before extraction. This is done to prevent spinal injuries or other permanent damage that may occur without proper stabilization. However, the *life* of the victim must still be considered. In the two examples above, one would normally render the scene safe before attempting a rescue. Modify example (a) with the vehicle teetering on the edge of a bridge and modify example (b) to include a live power line arcing near the fuel. In both of these cases, the immediate danger to the victim is no longer spinal injury, but rather imminent death. In these cases the first responder must make a judgment call between an immediate rescue and the assured tragic outcome.

2.3.2 Example: 1, 2, 3 versus 4

The classic example presented for this prioritization is that of communicable diseases. Take a victim who collapses at an airport with bleeding eyes and coughing frothy, bloody spittle. Immediately, the first responder must consider the victim to be potentially dangerous to themselves and their partner. The first responder must also consider that the victim could present a danger to the other travelers present. Prudence would dictate that the bystanders be evacuated. However, the first responder should also consider the danger presented to the surrounding populace and protect them from those potentially exposed. This particular scenario usually results in quarantines, but is an important example of a scenario that can be faced by first responders.

Additionally, this example illustrates the very real concern over domestic terrorism in post-9/11 America. Heavily populated urban environments such as New York have been repeatedly targeted by terrorists. The 2001 anthrax attacks which targeted both Washington D.C. and New York showed that terrorists were willing to use biological weapons to kill innocents.

It should be noted that this particular form of prioritization (*1, 2, 3 versus 4*) need not be limited to communicable diseases or bio-weaponry. Any form of contaminant, be it chemical, biological, radiological, or nuclear that can be spread past the emergency scene must be considered by the first responders and their incident commanders. In the event of large scale emergencies such as this, the first responder must take a macro view of the situation and address the issue of quarantine, including themselves, should the incident warrant it.

2.3.3 Example: 1 versus 2

The cold hard prioritization of 1 versus 2 could be construed that one living first responder is better than two dead ones. However, that would not be an accurate characterization. Professional first responders are a close knit group who would generally do anything for the other. The primary reason for the prioritization of 1 versus 2 is that it is a reminder to all that the most critical priority is your partner. When you have their back, they have yours.

The classic example of this is the Dayton FD airbag incident from 1995. In this incident, the rear passenger of a vehicle was entrapped with serious injury to their legs. As is common practice, the firefighters attempted to open the hood of the vehicle in order to disconnect the negative terminal of the battery rendering the electrical system open. The process of opening the hood caused considerable movement of the vehicle and excessive discomfort to the victim. Against their better judgment, the firefighters opted to forgo the battery disconnect, but did prepare for potential electrical fires with extinguishers as well as a charged fire hose. What was unexpected was the unintentional electrical short that triggered the passenger side airbag.

Compounding the situation was the fact that the vehicle had wrapped around a tree. The result was that the tree was actually inside the passenger compartment, pinning the twisted legs of the rear seat occupant. In an article written for Firehouse Magazine, Ron Moore, a noted expert in the field of vehicle extrication, documented the incident:

> *In what was a pivotal moment of the rescue operations, Chief Beach decided to accept the inherent risk of working on a damaged vehicle with the electrical system intact. Accepting this calculated risk coupled with a failure to completely*

stabilize the vehicle against unwanted movement, set the stage for the historic events yet to unfold.[5]

Dayton Firefighter Tom Trimbach was kneeling inside the passenger side of a car attempting to remove the seats to free the crushed legs of the rear seat occupant. It was at this point that the airbag accidentally deployed forcibly ejecting him from the vehicle. Trimbach recalled:

It ejected me from the car. It was a pretty violent ejection. I landed on my back. At that point I really didn't know what happened. I just told them ...make the pain go away, I can't take the pain anymore.[6]

In addition to Trimbach, an additional firefighter was injured. A paramedic observed the damage caused by a simple airbag:

Initially your first gut reaction is to go ahead and work on your own people but you have to consider all the people that are at the scene. We wanted to look around and make sure that no one we hadn't seen had gotten hurt when the bags deployed and make sure we were limited to the three patients. We triaged them and it turned out that the two firefighters were more serious than the patient that was actually in the back seat with lower extremity trauma.

We noticed that Trimbach was the more seriously injured of the two. He had chest trauma and head trauma. Fortunately he was wearing his gear. Once we got the gear stripped off him and assessed him, we noticed some red marks on

his chest and were again very concerned about a possible pnuemothorax or some other injuries to the chest. [7]

The importance of knowing that the first responder's highest priority is their partner could not have been better summed up than by Tribach's recollection after the accident:

The medics came over . . . and they gave me tremendous victim care. More than anything, it put me at ease to feel the medics there giving me the care that I probably would have done that much if not more if it had been a friend of mine. That was more comforting than anything to realize that they were giving me the care that was making me feel better even though it still hurt.[8]

News footage of the accident can be seen on YouTube at:

http://www.youtube.com/watch?v=b1Qj75pbl8o

2.4 Fire Departments and EMS

In most emergency medical situations, firefighters are involved. This is due to the fact that emergency medical services are a core competency of most fire departments. This competency is partly due to demand for such types of service, but is also recommended or required from a national level.

As with EMS, the level of competency in emergency medicine exhibited by firefighters varies. The level of expertise is often due to demographics and the representative types of calls that are expected. While specific levels of certification vary from state to state as well as country to country, in general the levels of competency can be ranked as follows:

1. First Aid
2. First Responder
3. EMT-B basic
4. EMT-I intermediate
5. EMT-P paramedic
6. Advanced-Paramedic/Nurse

The responsibilities of the various levels of competency vary from state to state. *First Aid* is a certification that involves treatment of minor abrasions and cuts as well as identification of serious issues such as cardiac arrest and choking. *First Responder* training is more intensive with a focus on preparing victims for transport to a hospital. *EMT* levels provide the ability to administer limited medications as well as specific training for many medical emergencies, including child birth. In virtually all states, automatic external defibrillation (AED) training is

provided. Higher levels of *EMT* training allow procedures such as intubation or therapeutic hypothermia. Some states allow *EMT-P* trained technicians to use manual defibrillation. The highest levels of training are often found in individuals such as flight nurses in emergency medical aircraft, Coast Guard rescue helicopters, or combat medics.

A large number of cities across the country require that firefighters be certified to a level greater than first aid, usually First Responder. The cities of Glendale[9] and Phoenix[10], AZ, both known for being some of the more progressive fire departments in the country, specifically require that every firefighter be certified, at a minimum, as an emergency medical technician.

One of the other reasons firefighters are often involved with EMS is that they often *are* the first responders. In many situations, the first due apparatus is an engine/pumper. There are very specific requirements imposed upon fire departments across the country. Insurance classifications specifically dictate department facilities and readiness. Additionally, standards such as NFPA 1710 and NFPA 1720 specifically outline the response times expected of fire departments based upon population density.

Lastly, firefighters are often sent as they have specialized equipment for handing any complicated rescue operations. In the event of vehicular entrapment, removing the victim from the vehicle is almost always the responsibility of a fire department, which is largely due to the hazard of fire that a crashed car presents. In townships such as Swissvale, PA, it is the jurisdiction of the fire department for forceful entry into homes for medical and lock-out reasons.[11] Thus in many cases, it is often easier for dispatchers to send a fire company in conjunction with an ambulance in the event of a medical call.

2.5 Insurance Services Office

As with all things, there is a financial reason that many cities choose to focus on fire protection. The Insurance Services Office (ISO) maintains the Public Protection Classification (PPC™) Program. This program focuses on the state of readiness of a fire department as well as available facilities such as hydrants (an example map of which is included in Figure 1), apparatus, staffing, and response times. According to ISO,

> *ISO collects information on municipal fire-protection efforts in communities throughout the United States. In each of those communities, ISO analyzes the relevant data using our Fire Suppression Rating Schedule (FSRS). We then assign a Public Protection Classification from 1 to 10. Class 1 generally represents superior property fire protection, and Class 10 indicates that the area's fire-suppression program doesn't meet ISO's minimum criteria.*[12]

Having a good PPC rating financially benefits the residents and local business,

> *Virtually all U.S. insurers of homes and business property use ISO's Public Protection Classifications in calculating premiums. In general, the price of insurance in a community with a good PPC is substantially lower than in a community with a poor PPC, assuming all other factors are equal.*[13]

The prevalence of the PPC program is such that it presents a financial incentive to municipalities to better prepare their fire protection services. As virtually all home owners and businesses have the potential to realize savings in insurance, action by the municipality can benefit the entire constituency.

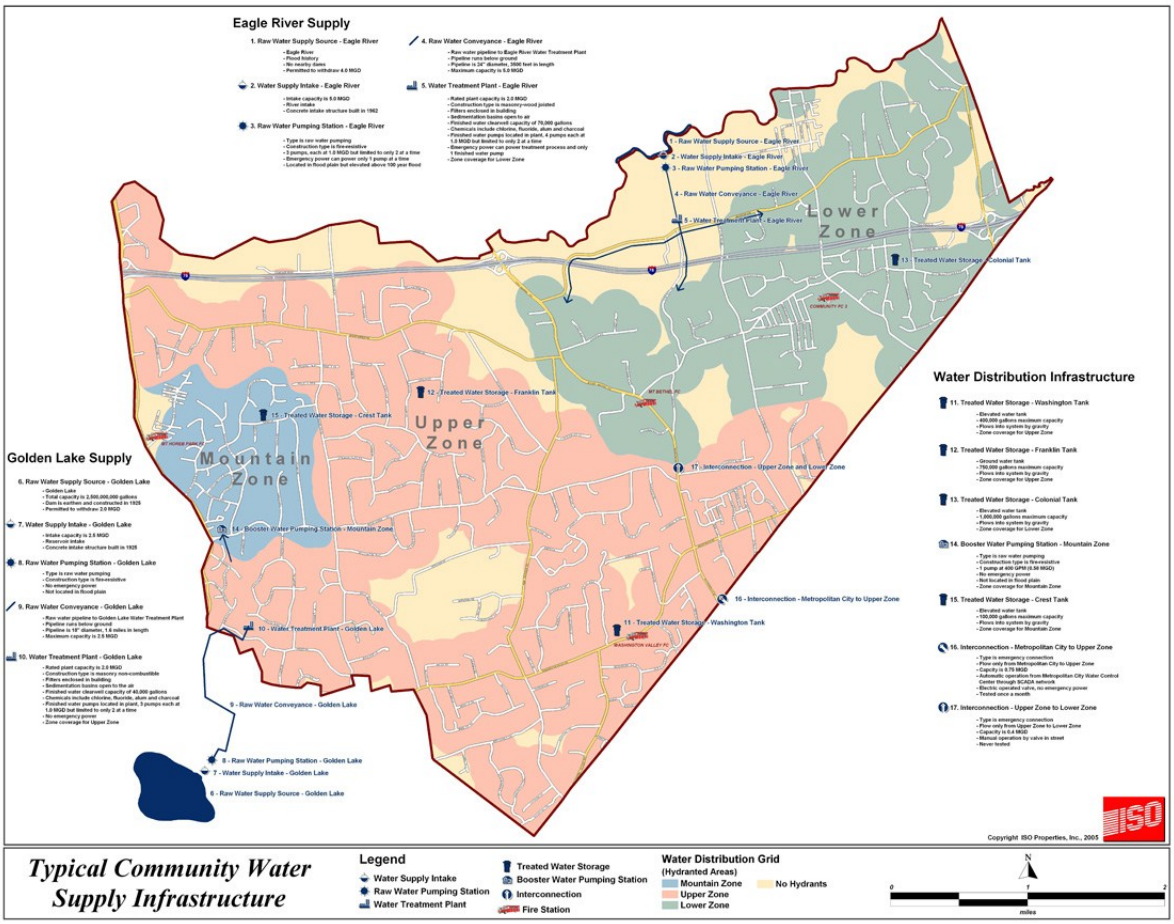

Figure 1 Example ISO water supply map for PPC rating[14]

Under most situations, firefighters are willing to provide medical support. As they are already in place to protect their municipality, minimal additional funding is required to add EMS functionality to the existing infrastructure. Take the town of Sterling, MA. According to the personnel page of the department, twenty one out of the forty firefighters have EMS training at the basic EMT level or higher.[15]

The 2000 census demographics of the town of Sterling, MA, can be seen in Table 1. The population density of Sterling was 237.75 [$^{pop}/_{sq\text{-}mi.}$]. As a comparison, the 2000 population density of Boston, MA, was 2322.6 [$^{pop}/_{sq\text{-}mi.}$] and Worcester, MA, was 1717.3 [$^{pop}/_{sq\text{-}mi.}$].[16]

Considering the significant differences in population density between Sterling and nearby urban centers, as well as the high number of EMT trained personnel on the fire department, it is not hard to understand why towns such as Sterling, MA, operate Emergency Medical Services through their fire departments.

Table 1 Demographics of Sterling, MA[17]

	Sterling	Massachusetts	U.S.
Population			
Total population	7,257		
Square miles (land)	30.52		
Population per square mile	237.75	809.83	79.56
Gender			
Male	3,612 - 49.8%	48.2%	49.1%
Female	3,645 - 50.2%	51.8%	50.9%
Age			
15 or younger	1,692 - 23.3%	19.8%	21.4%
16 - 24	714 - 9.8%	12.9%	13.9%
25 - 44	2,230 - 30.7%	31.3%	30.2%
45 - 64	1,966 - 27.1%	22.4%	22.0%
65+	655 - 9.0%	13.5%	12.4%
Average Age	36.12 years	37.4 years	36.22 years
Race and Ethnicity			
White	7,116 - 98.1%	84.5%	75.1%
Black or African American	42 - 0.6%	5.4%	12.3%
American Indian and Alaska native	7 - 0.1%	0.2%	0.9%
Asian	29 - 0.4%	3.8%	3.6%
Native Hawaiian and other Pacific Islander	1 - 0.0%	0.0%	0.1%
Some other race	20 - 0.3%	3.7%	5.5%
Two or more races	42 - 0.6%	2.3%	2.4%
Hispanic or Latino	59 - 0.8%	6.8%	12.5%

CHAPTER 3: Applicable Codes

3.1 Introduction

This chapter covers several topics associated with codes and standards. (1) The role of fire departments in delivering EMS care is discussed in Section 3.2 Organization of Fire Department EMS. (2) Discussion of applicable fire apparatus standards as they would apply to EMS vehicles is discussed in Section 3.3 NFPA 1901. (3) The applicability of OSHA and NIOSH codes on respiratory protection is outlined in Section 3.4 Respiratory Protection. Additional discussion of NFPA requirements for self-contained breathing apparatus (SCBA) is provided. Lastly, (4) Considerations for hazardous environments and potential terrorism concerns are outlined in Section 3.5 CBRN Consideration. The pages for these sections are as follows:

3.2 Organization of Fire Department EMS

3.2.2 NFPA 1710

NFPA 1710 is one of two NFPA documents specifying the general organization of (1) fire suppression operations, (2) EMS operations, and (3) special operations. NFPA 1710 specifically focuses on career departments which are generally defined as departments with full-time firefighters on staff. Two particular sections are worthy of note as they pertain to emergency medical services. Section 4.3 and section 5.3, both titled Emergency Medical Services.

Section 4.3 outlines the organizational criteria required of a career department:

> *4.3.1 The fire department organizational statement shall set forth the criteria for the various types of emergency medical incidents to which the fire department is required and/or expected to respond.*
>
> *4.3.2 The fire department organizational statement shall ensure that the fire department's emergency medical response capability includes personnel, equipment, and resources to deploy at the first responder level with AED* [automatic external defibrillator] *or higher treatment level.*
>
> *4.3.3 Where emergency medical services beyond the first responder with AED level are provided by another agency or private organization, the AHJ* [authority having jurisdiction]*, based on recommendations from the fire department, shall include the minimum staffing, deployment, and response criteria as required in Section 5.3 in the following:*

(1) The fire department organizational statement

(2) Any contract, service agreement, governmental agreement, or memorandum of understanding between the AHJ and the other agency or private organization[18]

Section 5.3, addresses specific standards for delivery of EMS by fire departments:

Section 5.3.1 requires clear documentation of the EMS role of the fire department. Additional wording is provided for documenting the number and types of apparatus that will respond to a given call. Additionally, the department is permitted to employ mutual aid provided that the aid meets the aforementioned requirements. Mutual aid is the process of calling in additional support from neighboring jurisdictions when existing units are on a call or when a call is too overwhelming and requires additional resources.

Section 5.3.2 places a requirement for all firefighters to be certified to a first responder level with training to use an AED. The section further classifies the types of treatment that can be administered. They are as follows:

1. First Responder with AED
2. Basic Life Support (BLS)
3. Advanced Life Support (ALS)

Section 5.3.3 identifies and specifies the functions that the EMS system of the fire department will perform. Response and transport are identified. It is permissible for a department to only respond with the three previously mentioned levels. However, if transport is desired, the

department must guarantee that the same level of treatment remains uninterrupted throughout the entire period of transport. Lastly, there must be documentation assuring the quality of care for every step taken.

Regardless of the level of EMS chosen, specification 5.3.3.3.2 requires that the fire department must provide first responder level medical care with an AED with a 240 second response time (*see Section 3.2.2.1 Total Response Time*) to 90% of the incidents within its coverage area. If an ALS level is chosen, 5.3.3.3.3 sets the response time of an ALS unit to 480 seconds to 90% of the incidents within its coverage area. However, 5.3.3.3.2 must still be maintained. [19]

Finally, section 5.3.4 specifies the Quality Management of the EMS functionality of the fire department. A well documented process of quality review is mandated. If the fire department chooses first responder or BLS levels of care, quality car review may be performed by fire department medical personnel. If ALS level of care is employed, quality of care can only be reviewed by a named medical director. Additionally, the fire department is required to provide a "mechanism for immediate communications with EMS supervision and medical oversight." Commonly called medical command, this enables the insertion of a medical doctor into the communications system.[20]

3.2.2.1 Total Response Time

Section 3.3.53 defined total response time. The definition of total response time is presented in graphical form as an annex to the requirements. This figure can be seen in Figure 2. It should be

noted however, that in all NFPA documents, annexes are not official requirements. The specific wording of the standard always takes precedent. Accordingly, the specifics follow.

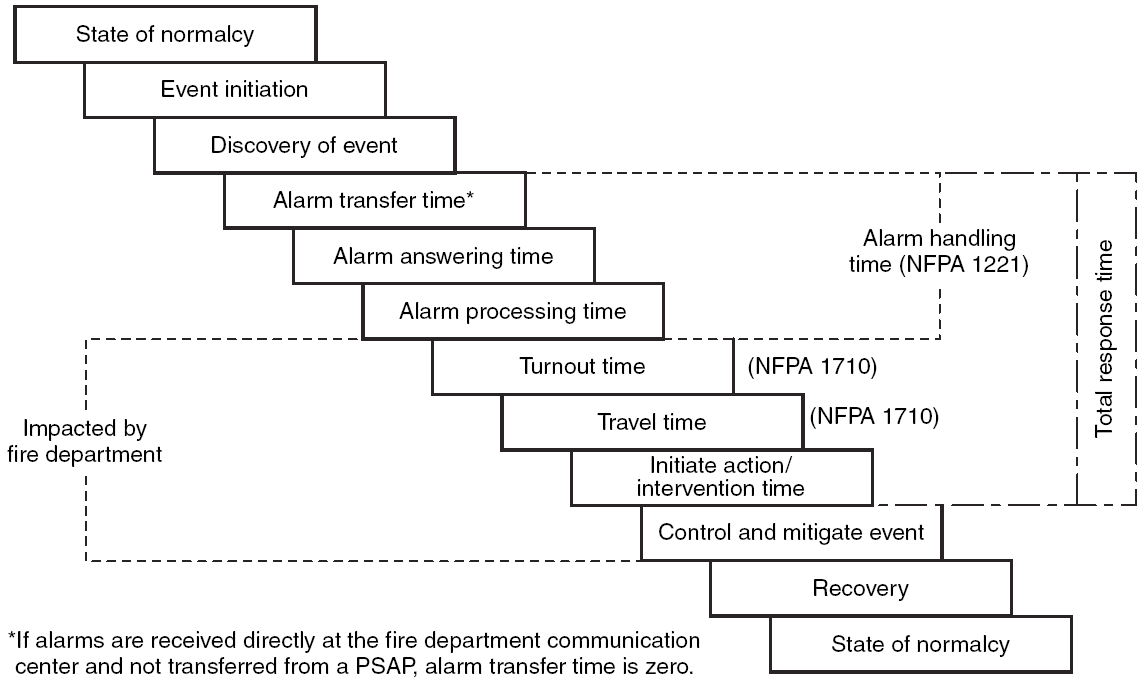

Figure 2 NFPA 1710 Cascade of Events Chart[21]

The terms outside of the total response time portion of Figure 2 are not defined in the text of NFPA 1710. These terms are, however, relatively straight forward.

Prior to the *total response time*, the definitions of terms are as follows. A *state of normalcy* exists where there is no emergency or other threat to life or property. The *event initiation* is the start of an emergency. In the case of NFPA 1710, this event can be any form of emergency, be it medical, fire or other. It should be noted that the event does not necessarily need to be of a medical nature in order to still require EMS. The *discovery of event* is the time where someone

is made aware of the event. This is analogous to the time whereby a bystander may notice an emergency and make the decision to call 9-1-1.

Subsequent to the *total response time*, the definitions of terms are as follows. The *recovery* period is the time during which the first responders return to service. This period can include, but is not limited to, such activities as returning vehicles and personnel to station, cleaning vehicles (e.g. blood in an ambulance), re-stocking supplies (medical or other), refueling vehicles, re-filling water tanks, and/or re-filling air cylinders. Following the *recovery* period, the *state of normalcy* returns as defined above.

The specifics of the various periods of the *total response time* are quoted here verbatim.

> *3.3.53.1 Alarm Answering Time. The time interval that begins when the alarm is received at the communication center and ends when the alarm is acknowledged at the communication center.*
>
> *3.3.53.2 Alarm Handling Time. The time interval from the receipt of the alarm at the primary PSAP* [Public Safety Answering Point] *until the beginning of the transmittal of the response information via voice or electronic means to emergency response facilities (ERFs) or the emergency response units (ERUs) in the field.*
>
> *3.3.53.3 Alarm Processing Time. The time interval from when the alarm is acknowledged at the communication center until response information begins to*

be transmitted via voice or electronic means to emergency response facilities (ERFs) and emergency response units (ERUs).

3.3.53.4 Alarm Transfer Time. The time interval from the receipt of the emergency alarm at the PSAP until the alarm is first received at the communication center.

3.3.53.5 Initiating Action/Intervention Time. The time interval from when a unit arrives on the scene to the initiation of emergency mitigation.*

3.3.53.6 Total Response Time. The time interval from the receipt of the alarm at the primary PSAP to when the first emergency response unit is initiating action or intervening to control the incident.*

3.3.53.7 Travel Time. The time interval that begins when a unit is en route to the emergency incident and ends when the unit arrives at the scene.

3.3.53.8 Turnout Time. The time interval that begins when the emergency response facilities (ERFs) and emergency response units (ERUs) notification process begins by either an audible alarm or visual annunciation or both and ends at the beginning point of travel time.

3.2.3 NFPA 1720

Like its sister document NFPA 1710, NFPA 1720 specifies the general organization of (1) fire suppression operations, (2) EMS operations, and (3) special operations. NFPA 1720 specifically focuses on volunteer departments.

A small portion of NFPA 1720 covers the application of emergency medical services by a volunteer fire department. As with NFPA 1710, the volunteer fire department has the choice of delivering emergency medical services in the categories of first responder, basic life support (BLS), and advanced life support (ALS).

As with NFPA 1710, a volunteer department must clearly document its role in the delivery of services. Critical to this documentation is a quality management program. This quality management program is reviewed by the fire department medical personnel for first responder and BLS activities. For ALS activities, the department must have a named medical director. Additionally, the departments providing ALS services must have a means for immediate communication with EMS supervision and medical oversight.

One slightly different requirement for NFPA 1720 versus NFPA 1710 is the requirement of first due apparatus. In particular:

> *4.9.3 EMS operations shall be organized to ensure the fire department's emergency medical capability includes personnel, equipment, and resources to deploy the initial arriving company and additional alarm assignments.*[22]

NFPA 1720 offers greater leeway in response times in general. The requirements for standard response and medical response are the same. Table 2, below, is the staffing and response time requirements from the standard. The response times are based upon demographics. The only notation is section 4.9.3 above which requires EMS functioning fire departments to ensure EMS personnel are part of the first due units.

Table 2 Staffing and response time for structural firefighting[23]

Staffing and Response Time				
Demand Zone [a]	Demographics people/mi^2	Minimum Staff to Respond [b]	Response Time (minutes) [c]	Meets Objective (%)
Urban area	> 1000	15	9	90
Suburban area	500 - 1000	10	10	80
Rural area	< 500	6	14	80
Remote area	Travel distance ≥ 8 mi	4	Directly dependent on travel distance	90
Special risks	Determined by AHJ	Determined by AHJ based on risk	Determined by AHJ	90

[a] A jurisdiction can have more than one demand zone.
[b] Minimum staffing includes members responding from the AHJs department and automatic aid
[c] Response time begins upon completion of the dispatch notification and ends at the time interval shown in the table.

3.3 NFPA 1901

Should it be the desire of MIRAD to develop an ambulance that is operated by a fire department, NFPA 1901, *Standard for Automotive Fire Apparatus* will be applicable. EMS functions, such as those noted in the preceding sections, when performed by a fire department will arguably require NFPA oversight. This section is an attempt to simplify and identify the applicable portions of this 204 page standard.

NFPA 1901 provides specifications for seven types of apparatus as follows:

- Pumper Apparatus
- Initial Attack Apparatus “Mini Pumper”
- Mobile Water Supply Apparatus
- Aerial Apparatus
- Quint Apparatus
- Special Service Fire Apparatus
- Mobile Foam Fire Apparatus

For the purposes of this project, the most likely candidate vehicles for first responder EMS delivery will be chosen. These apparatus are the Pumper Apparatus, Initial Attack Apparatus, and Special Service Apparatus. In most fire departments, first due apparatus are usually pumpers or initial attack apparatus. These vehicles are generally lighter than their aerial and quint apparatus, reducing the wear and tear of their more expensive cousins.

3.3.1 Pumper "Engine"

The most common fire apparatus in use today is the pumper. Commonly referred to as an engine, this vehicle is used to transport firefighters to and from the scene of the fire. More importantly, the apparatus provides the crucial role of pumping water, allowing the firefighters to live up to their moniker and fight the fire. Internal to these machines are high-capacity pumps that are fed by large, on-board water storage tank(s). Large bays are available for the storage of various size hoses, some of which are pre-connected to the pump. Lastly, additional compartments are provided around the apparatus for storage of critical equipment.

The minimum requirements for a pumper are defined in the fifth chapter of NFPA 1901, *Pumper Fire Apparatus*. An example pumper can be seen in Figure 3.

Figure 3 Sterling FD Engine 4, example of a pumper/engine

3.3.1.1 Pumping and Hose Specifications

An NFPA approved pumper must have a pump that has a minimum rated capacity of 750 gallons per minute (gpm). The on-board tank(s) must have a minimum capacity of 300 gallons. While this is the minimum, it is quite common for pumpers to exceed this minimum. Many have tanks sized at 500 gallons or even higher. With respect to fire hoses, the engine must accommodate the following in order to be NFPA certified:[24]

1. Storage requirements
    a. A minimum hose storage area of 30 ft^3 for 2½ in. diameter or larger hose, and
    b. A minimum of two bays to store pre-connected "hand lines"
        i. Hand lines must be 1½ in. diameter hose or larger
        ii. Each bay must have a volume of 3.5 ft^3 or larger
2. Supply hose requirements
    a. A minimum of 20 ft of "hard-walled" suction hose with strainer, or
    b. A minimum of 15 ft of "flexible" supply hose
3. Minimum hose requirements
    a. 800 ft (240 m) of 2½ in. (65 mm) or larger fire hose
    b. 400 ft (120 m) of 1½ in. (38 mm), 1¾ in. (45 mm), or 2 in. (52 mm) fire hose
4. Nozzle requirements
    a. One hand line nozzle, 200 gpm (750 L/min) minimum
    b. Two hand line nozzles, 95 gpm (360 L/min) minimum
    c. One play pipe with shutoff and 1 in. (25 mm), $1^1/_8$ in. (29 mm), and 1¼ in. (32 mm) tips

It is important to note that all of the hoses referenced above must conform to the applicable portions of NFPA 1961, *Standard on Fire Hose*.[25] Additionally, the nozzle requirements referenced above must conform to the applicable portions of NFPA 1964, *Standard for Spray Nozzles*.[26]

3.3.1.2 Equipment Specifications

Storage and quick accessibility to equipment is critical to the efficient usage of a pumper. An NFPA approved pumper must have a minimum 40 ft^3 of storage space for miscellaneous equipment. Required miscellaneous equipment is quoted verbatim as follows:[27]

> *(1) One 6 lb (2.7 kg) flathead axe mounted in a bracket fastened to the apparatus*
>
> *(2) One 6 lb (2.7 kg) pick-head axe mounted in a bracket fastened to the apparatus*
>
> *(3) One 6 ft (2 m) pike pole or plaster hook mounted in a bracket fastened to the apparatus*
>
> *(4) One 8 ft (2.4 m) or longer pike pole mounted in a bracket fastened to the apparatus*
>
> *(5) Two portable hand lights mounted in brackets fastened to the apparatus*

(6) One approved dry chemical portable fire extinguisher with a minimum 80-B:C rating mounted in a bracket fastened to the apparatus

(7) One 2½ gal (9.5 L) or larger water extinguisher mounted in a bracket fastened to the apparatus

(8) One self-contained breathing apparatus (SCBA) complying with NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, for each assigned seating position, but not fewer than four, mounted in brackets fastened to the apparatus or stored in containers supplied by the SCBA manufacturer

(9) One spare SCBA cylinder for each SCBA carried, each mounted in a bracket fastened to the apparatus or stored in a specially designed storage space

(10) One first aid kit

(11) Four combination spanner wrenches mounted in brackets fastened to the apparatus

(12) Two hydrant wrenches mounted in brackets fastened to the apparatus

(13) One double female 2½ in. (65 mm) adapter with National Hose (NH) threads, mounted in a bracket fastened to the apparatus

(14) One double male 2½ in. (65 mm) adapter with NH threads, mounted in a bracket fastened to the apparatus

(15) One rubber mallet, suitable for use on suction hose connections, mounted in a bracket fastened to the apparatus

(16) Two salvage covers each a minimum size of 12 ft × 14 ft (3.7 m × 4.3 m)

(17) Two or more wheel chocks, mounted in readily accessible locations, that together will hold the apparatus, when loaded to its GVWR or GCWR, on a hard surface with a 20 percent grade with the transmission in neutral and the parking brake released

(18) One traffic vest for each seating position, each vest to comply with ANSI/ISEA 207, Standard for High-Visibility Public Safety Vests, and have a five-point breakaway feature that includes two at the shoulders, two at the sides, and one at the front

(19) Five fluorescent orange traffic cones not less than 28 in. (711 mm) in height, each equipped with a 6 in. (152 mm) retro-reflective white band no more than 4 in. (102 mm) from the top of the cone, and an additional 4 in. (102 mm) retro-reflective white band 2 in. (51 mm) below the 6 in. (152 mm) band

(20) Five illuminated warning devices such as highway flares, unless the five fluorescent orange traffic cones have illuminating capabilities

(21) One automatic external defibrillator (AED)

In addition to the required miscellaneous equipment, an NFPA approved pumper must carry a minimum of three types of ladders, including:[28]

- One straight ladder equipped with roof hooks
- One extension ladder
- One folding ladder

A roof ladder has specifically designed hooks that, when placed over the ridge of a roof, prevent the ladder from slipping. Stepladders and other types of multipurpose ladders can be substituted for the folder ladder provided that the replacement meets ANSI A14.2, *Ladders - Portable Metal - Safety Requirements*, or ANSI A14.5, *Ladders - Portable Reinforced Plastic - Safety Requirements*. In all cases, duty ratings of Type 1A or 1AA are required. Additional ladders are permitted provided that the meet the aforementioned ANSI criteria.

3.3.2 Initial Attack "Mini Pumper"

An initial attack fire apparatus is a reduced performance pumper. As the name suggests, it is specifically designed for initial response. This type of fire apparatus is routinely used by departments whose typical response is medical rather than structural (read fire). This type of vehicle offers fire suppression capabilities for environments that do not require high volume water application, such as car or dumpster fires. Thus the initial attack fire apparatus is generally used to reduce general wear and tear of the more expensive pumpers.

The minimum requirements for a pumper are defined in the sixth chapter of NFPA 1901, *Initial Attack Fire Apparatus*. An example initial attack fire apparatus can be seen in Figure 4.

Figure 4 Initial attack fire apparatus[29]

3.3.2.1 Pumping and Hose Specifications

An NFPA approved initial attack apparatus must have a pump that has a minimum rated capacity of 250 gpm. The on-board tank(s) must have a minimum capacity of 200 gallons. Additionally, the following must be accommodated:[30]

1. Storage requirements
    a. A minimum hose storage area of 10 ft^3 for 2½ in. diameter or larger hose, and
    b. A minimum of two bays to store pre-connected "hand lines"
        i. Hand lines must be 1½ in. diameter hose or larger
        ii. Each bay must have a volume of 3.5 ft^3 or larger
2. Supply hose requirements
    a. A minimum of 20 ft of "hard-walled" suction hose with strainer, or
    b. A minimum of 15 ft of "flexible" supply hose
3. Minimum hose requirements
    a. 300 ft (240 m) of 2½ in. (65 mm) or larger fire hose
    b. 400 ft (120 m) of 1½ in. (38 mm), 1¾ in. (45 mm), or 2 in. (52 mm) fire hose
4. Nozzle requirements
    a. Two hand line nozzles, 95 gpm (360 L/min) minimum

As with the pumper, all of the hoses referenced above must conform to the applicable portions of NFPA 1961, *Standard on Fire Hose*. Additionally, the nozzle requirements referenced above must conform to the applicable portions of NFPA 1964, *Standard for Spray Nozzles*.

3.3.2.2 Equipment Specifications

As with the pumper, storage and quick accessibility to equipment is critical to the efficient usage of an initial attack apparatus. An NFPA approval requires a minimum 22 ft^3 of storage space for miscellaneous equipment. Required miscellaneous equipment is quoted verbatim as follows:[31]

> *(1) One 6 lb (2.7 kg) pick-head axe mounted in a bracket fastened to the apparatus*
>
> *(2) One 6 ft (2 m) pike pole or plaster hook mounted in a bracket fastened to the apparatus*
>
> *(3) Two portable hand lights mounted in brackets fastened to the apparatus*
>
> *(4) One approved dry chemical portable fire extinguisher with a minimum 80-B:C rating mounted in a bracket fastened to the apparatus*
>
> *(5) One 2½ gal (9.5 L) or larger water extinguisher mounted in a bracket fastened to the apparatus*
>
> *(6) One SCBA complying with NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, for each assigned seating position, but not fewer than two, mounted in brackets fastened to the apparatus or stored in containers supplied by the SCBA manufacturer*

(7) One spare SCBA cylinder for each SCBA carried, each mounted in a bracket fastened to the apparatus or stored in a specially designed storage space(s)

(8) One first aid kit

(9) Two combination spanner wrenches mounted in a bracket(s) fastened to the apparatus

(10) One hydrant wrench mounted in a bracket fastened to the apparatus

(11) One double female adapter, sized to fit 2½ in. (65 mm) or larger fire hose, mounted in a bracket fastened to the apparatus

(12) One double male adapter, sized to fit 2½ in. (65 mm) or larger fire hose, mounted in a bracket fastened to the apparatus

(13) One rubber mallet, for use on suction hose connections, mounted in a bracket fastened to the apparatus

(14) Two or more wheel chocks, mounted in readily accessible locations, that together will hold the apparatus, when loaded to its GVWR or GCWR, on a hard surface with a 20 percent grade with the transmission in neutral and the parking brake released

(15) One traffic vest for each seating position, each vest to comply with ANSI/ISEA 207, Standard for High-Visibility Public Safety Vests, and have a

five-point breakaway feature that includes two at the shoulders, two at the sides, and one at the front

(16) Five fluorescent orange traffic cones not less than 28 in. (711 mm) in height, each equipped with a 6 in. (152 mm) retro-reflective white band no more than 4 in. (102 mm) from the top of the cone, and an additional 4 in. (102 mm) retro-reflective white band 2 in. (51 mm) below the 6 in. (152 mm) band

(17) Five illuminated warning devices such as highway flares, unless the five fluorescent orange traffic cones have illuminating capabilities

(18) One automatic external defibrillator (AED)

Lastly, an NFPA approved initial attack apparatus must carry a 12 ft or longer ground ladder. This ladder may be combination-type or an extension-type as required by the fire department. Additional ladders with duty ratings of Type 1A or 1AA under ANSI A14.2 or ANSI A14.5 are permitted.

3.3.3 Special Service Fire Apparatus

The Special Service Fire Apparatus can be considered the "other" category of fire apparatus. This can include such activities as vehicle extraction, hazardous materials operations, dive/water rescue, or even collapse rescue (for FEMA Teams).

For the purposes of this investigation, the particulars of this category will be curtailed towards the classic "rescue" vehicle. A specific definition of a rescue apparatus will differ between various fire departments; however, the main idea is that it serves as a platform to supply the equipment necessary for "rescue" operations.

As with the aerial apparatus, there are no general requirements for water tanks and/or pumps. Some fire departments co-habit pumpers with vehicle rescue operations, as a small amount of water may be necessary to quench a vehicle fire, or at least guard against the potential. In these cases a minimum capacity of 250 gpm is required. For the most part, rescue vehicles do not have pumps or tanks. An example of a rescue apparatus without a pump or a water tank can be found in Figure 5.

These vehicles do have the tendency to have very heavy equipment installed. Additional generators are present for hydraulic tools. Many vehicle-rescue units also carry large amount of wooden cribbing to stabilize vehicles during extraction. The vibration dynamics of these types of apparatus may vary from that of pumping operations, but these vehicles can still be exceedingly heavy and prone to road vibration.

Governing NFPA language can be found in Chapter 10 of NFPA 1901.

Figure 5 Broomall Rescue 53, example of a rescue apparatus without pump or tank

3.3.3.1 Equipment Specifications

An NFPA approved special service fire apparatus must have a minimum 120 ft^3 of storage space for miscellaneous equipment. Required miscellaneous equipment is quoted verbatim as follows:[32]

> *(1) Two portable hand lights mounted in brackets fastened to the apparatus*
>
> *(2) One approved dry chemical portable fire extinguisher with a minimum 80-B:C rating mounted in a bracket fastened to the apparatus*
>
> *(3) One 2½ gal (9.5 L) or larger water extinguisher mounted in a bracket fastened to the apparatus*

(4) One SCBA complying with NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, for each assigned seating position, but not fewer than two, mounted in brackets fastened to the apparatus or stored in containers supplied by the SCBA manufacturer

(5) One spare SCBA cylinder for each SCBA carried, each mounted in a bracket fastened to the apparatus or stored in a specially designed storage space(s)

(6) One first aid kit

(7) Two or more wheel chocks, mounted in readily accessible locations, that together will hold the apparatus, when loaded to its GVWR or GCWR, on a hard surface with a 20 percent grade with the transmission in neutral and the parking brake released

(8) One traffic vest for each seating position, each vest to comply with ANSI/ISEA 207, Standard for High-Visibility Public Safety Vests, and have a five-point breakaway feature that includes two at the shoulders, two at the sides, and one at the front

(9) Five fluorescent orange traffic cones not less than 28 in. (711 mm) in height, each equipped with a 6 in. (152 mm) retro-reflective white band no more than 4 in. (102 mm) from the top of the cone, and an additional 4 in. (102

mm) retro-reflective white band 2 in. (51 mm) below the 6 in. (152 mm) band

(10) Five illuminated warning devices such as highway flares, unless the five fluorescent orange traffic cones have illuminating capabilities

(11) One automatic external defibrillator (AED)

There is no particular requirement for ladders in a special service apparatus. If ladders are supplied they must meet NFPA 1931, *Standard for Manufacturer's Design of Fire Department Ground Ladders*, ANSI A14.2, or ANSI A14.5. In cases using ANSI certifications, duty ratings of Type 1A or 1AA are required.

3.3.4 Driving and Crew Areas

Chapter 14 of NFPA 1901 provides specifications regarding the safety of occupants while operating an NFPA approved fire apparatus. Required federal and regulatory standards of crash worthiness are specified. Requirements for the securing of equipment are defined. Finally, escape and means of egress are defined with respect to the survivability of the occupants.

Specification 14.1.10, titled "SCBA Mounting" specifically defines the mounting of a self-contained breathing apparatus (SCBA). An SCBA is the source of fresh breathing air for a firefighter inside a burning structure.

The secure method of mounting an SCBA in a pumper generally leads to good conduction of vibrations. Two particular sections are worthy of note,

> *14.1.10.1 Where SCBA units are mounted within a driving or crew compartment, a positive latching mechanical means of holding the SCBA device in its stowed position shall be provided such that the SCBA unit cannot be retained in the mount unless the positive latch is engaged.*
>
> *14.1.10.2 The bracket holding device and its mounting shall retain the SCBA unit when subjected to a 9 G force and shall be installed in accordance with the bracket manufacturer's requirements.*

Independent research is ongoing at WPI concerning the damaging effects of vehicle vibration in fire apparatus upon delicate electronics stored within equipment cabinets. A preliminary analysis suggests that the rigid mounting of SCBAs is a potential source of vibration conduction.

A tentative recommendation from this research suggests that it would be helpful to design brackets such that they cushion the SCBAs to suppress vibrations up to 0.5 g. After this level, it is acceptable for the brackets to rigidly prevent movement of the units. This way, crash worthiness is not affected; however, the vibration coupling for normal day-to-day operations is greatly reduced.

3.3.5 Command and Communications

Information presented in Chapter 23 outlines requirements for command and communications requirements of a vehicle. This section should be referred to if it is the intent of MIRAD to create a medical command ambulance. The types of operation expected of such a vehicle would be management and incident command. This would be of use if the vehicle was used to control the operations of multiple ambulances or to take control of a mass casualty scene.

Within this chapter are discussions of noise and lighting levels. Climate control requirements are provided such that the compartment is heated to a minimum temperature of 60°F. If air conditioning is provided, the vehicle must be able to maintain 20°F below ambient down to a temperature of 72°F.

3.3.6 Equipment Mounting

As mentioned at the beginning of Section 3.3 NFPA 1901, the most likely candidate vehicles for first responder EMS delivery are the Pumper Apparatus, Initial Attack Apparatus, and Special Service Apparatus. In addition to the required equipment and equipment storage outlined above, many fire apparatus carry additional equipment. Typical fire-rescue trucks tend to have very heavy equipment installed. Sometimes additional generators are present for hydraulic tools.

3.3.6.1 General Equipment Mounting

The various apparatus-specific chapters of NFPA 1901 specifically identify the mounting and organization of equipment in the apparatus. The pertinent sections of the document are 5.8.1.1, 6.7.1.1, and 10.5.1.1. The specific wording in each case is:

> *Brackets or compartments shall be furnished so as to organize and mount the specified equipment.*

Examples of NFPA approved mounting assemblies can be found in Figure 6 and Figure 7. Note how individual brackets are provided for each piece of equipment installed in the apparatus. Figure 6 shows the placement of an auxiliary electrical generator with additional electrical "pigtail" converters mounted to the left of the breaker panel. Figure 6 also shows pikes, shovels and bolt cutters in the compartment over the wheel. Figure 7 shows fire extinguishers as well as hose couplings mounted in a similar fashion.

Figure 6 Officer's side compartment of example fire engine

Figure 7 Driver's side compartments of example fire engine

3.3.6.2 SCBA Mounting

It is an every day, common practice for fire departments to utilize apparatus seats that retain an SCBA (refer to Figure 8). The logic is simple; it allows a firefighter to don his/her gear while en route to a scene. For the purposes of emergency medical services, the every-day requirement for an SCBA is not the same as for a fire department. Should SCBAs be desired in a MIRAD designed ambulance, crew compartment mounting can be achieved in a manner similar to Figure 8.

Figure 8 Typical seat-mounted SCBA brackets[33]

The Chassis Subcommittee of the Fire Apparatus Manufacturer's Association Technical Committee conducted an anthropometric study of firefighter physiology and equipment statistics. A condensed version of the data pertaining to SCBAs can be found below.

Table 3 Statistical weight data for SCBAs[34]

	5th Pct.	50th Pct.	95th Pct.	Avg.	Std. Dev.	Median	Min	Max
SCBA Weight (lb)	17	27	30	26	4	27	13	47

Recall that section 14.1.10.2 requires any SCBA contained within a crew compartment to be secured in such a manner as to withstand a 9g loading. Given a maximum possible weight of 47 pounds, any given bracket may be required to withstand a minimum of 423 pounds of force.

Given the level of these clamping forces and the independent research that suggests vibratory damage is due to clamping, it is recommended to MIRAD that SCBAs be mounted with a vibration cushion of 0.5 g or that the SCBAs be mounted in a side or rear compartment.

Changes in the crash worthiness of fire apparatus, through the course of revisions to NFPA 1901, have resulted in increasingly complex SCBA retention methods. An example of such a trend is shown in Figure 9. The vibration damping afforded by the thin, dipped urethane scratch-guards is minimal at best. These all metal brackets come in direct contact with not only the SCBA, but more importantly it's more fragile electronics, effectively conducting vibration energy into the components. Thus it should come as no surprise that vibration damage is occurring to SCBA electronics.

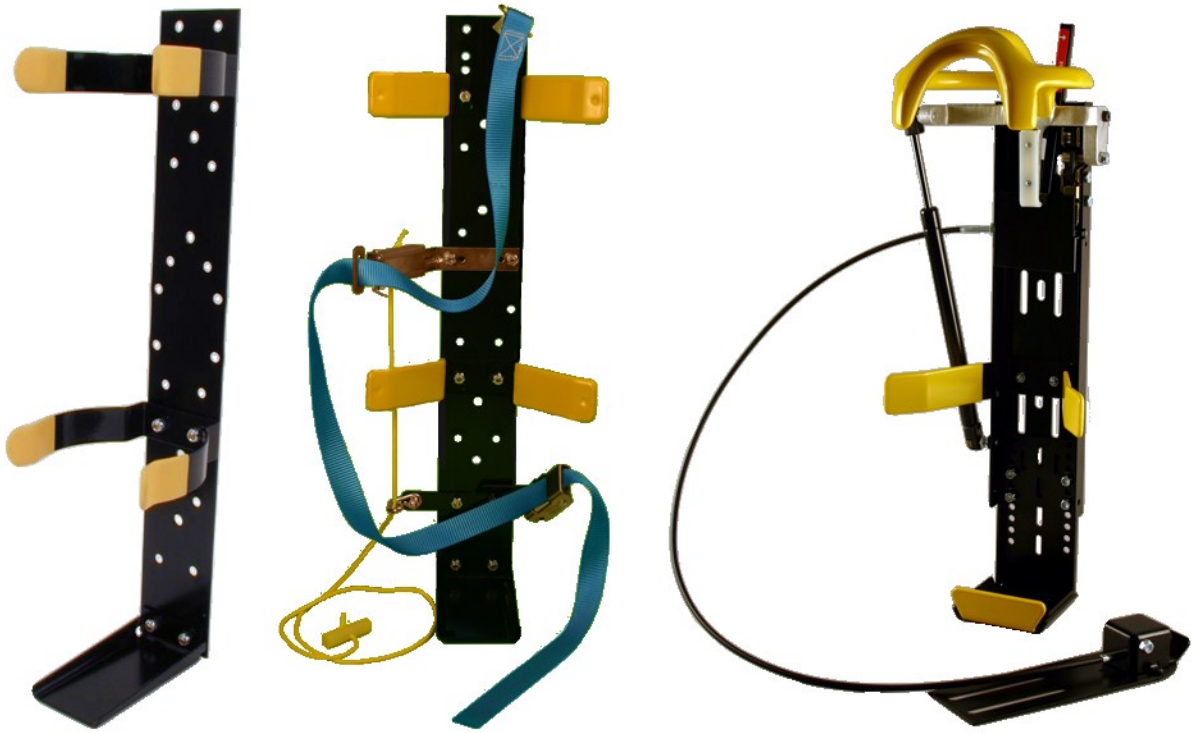

Figure 9 Examples of SCBA brackets showing increasing complexity left to right[35]

This discussion raises the question of potential Major Qualifying Project research in the area of bracket design. Such work would be useful to the non-profit NFPA in development of future standards. A proposed framework has been included in the Section “4.5 Proposal for Future MQP Research” found on page 70.

3.3.7 Breathing Air Systems

Chapter 24 is a lengthy section that provides information regarding air systems. Unlike federal requirements regarding medical oxygen, these systems are for the use of delivering breathing air. Furthermore, this portion of the standard should not be confused with compressed air foam systems, which is a particular type of fire suppression system. Specifically, firefighting and SCUBA diving activities use normal atmospheric concentrations of nitrogen and oxygen. These are done for separate reasons.

In firefighting, it is exceedingly dangerous to be breathing 100% oxygen as it only increases combustion. Human beings breathing 100% oxygen will exhale air with significantly high concentrations, which can be deadly in a combustive environment.

In SCUBA diving, breathing partial pressures on the order of 1.6 ATM or higher can result in oxygen toxicity. When breathing pure oxygen, divers would face life threatening conditions at depths of 53 feet or greater. For reference, normal recreational diving is safe up to a depth of 130 feet.

This section dictates the proper requirements for air compressors and storage tanks. Caution should be exercised such that the intake of a compressor is located away from engine exhausts. If air filtration systems are installed, these sections dictate the requirements of such.

If compressed air breathing lines are employed, Section 24.13 should be referenced. The applications for remote breathing air systems are typically environments where high heat and/or hot surfaces are not present. This can include hazardous materials situations where EMS personnel are in Level A or Level B protective ensembles. This also applies for confined space or

low oxygen environments. Generally these systems are used in situations where prolonged operation exceeds the duration of an air cylinder or where there may be size limitations. Systems can either be designed by individual vehicle manufacturers or can be purchased in modular designs such as the one shown in Figure 10.

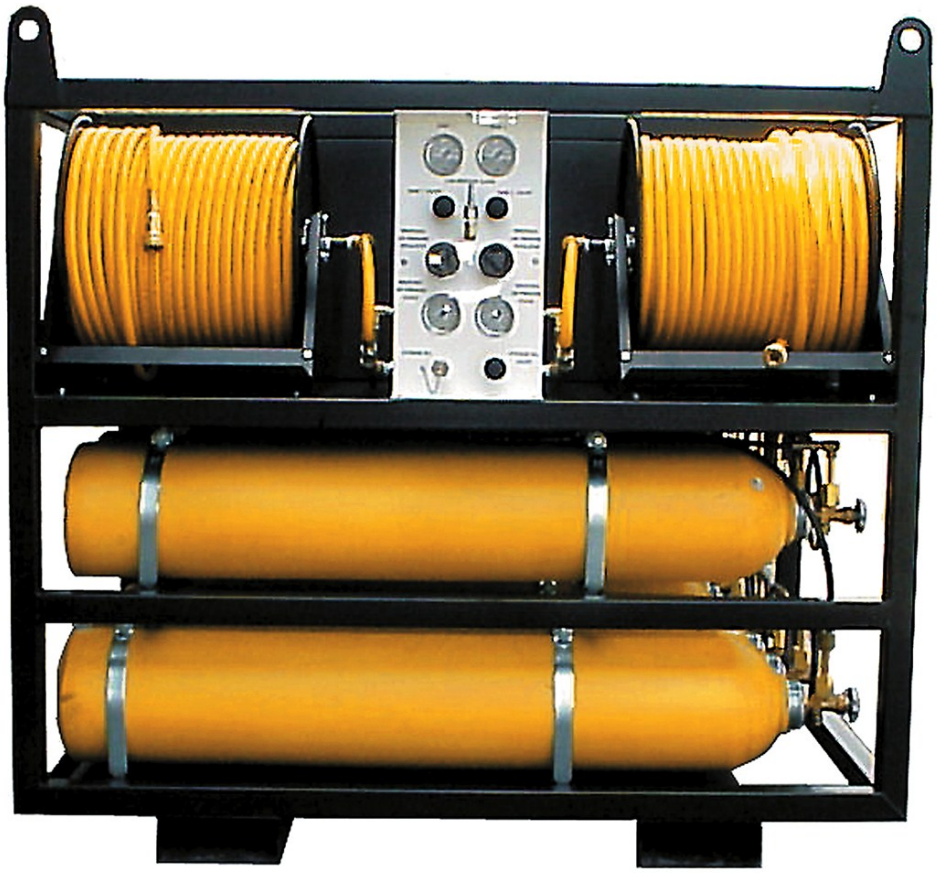

Figure 10 Remote breathing air system with storage tanks and air lines on reels[36]

3.3.8 NFPA 1901 Approved Apparatus in Use with EMS

Many EMS departments across the country use NFPA-approved fire apparatus. These vehicles are operated in either direct or supporting roles with the normal, day-to-day EMS operations. Examples from Pittsburgh, PA, EMS and Boston, MA, EMS are provided below.

3.3.8.1 Pittsburgh EMS

The Pittsburgh Emergency Medical Services in Pittsburgh, PA, operate two heavy rescue units. Operated under the Rescue Division, these two vehicles are both 2007 Pierce Arrow XT apparatus. A picture of Rescue 1 can be seen in Figure 11. These units are in active duty 24 hours a day, seven days a week, and are staffed with two paramedics. The vehicles are used for all types of EMS rescue that might, in other cities, be the purview of the fire department. These rescue operations include:[37]

- Low-angle rescue
- High-angle rescue
- Vehicle
- Confined space
- Trench
- People trapped in elevators

According to the department's website, responses for the Rescue apparatus "range from a child locked in a vehicle, carbon monoxide alarms, vehicle accidents, a person trapped on a hillside to assisting ALS ambulances for medical back up."

Figure 11 Pittsburg EMS Rescue 1, heavy rescue apparatus[38]

The equipment carried by these apparatus includes the same medical equipment carried on medic units. These units carry additional rescue equipment as follows:[39]

> *They carry three pre-connected Hurst hydraulic rescue tools. A model 32B spreader, Maverick spreader and a model O cutter are connected off the back of the truck. Rescue 1 and Rescue 2 also have a 9000-watt 20-foot extendable light tower and a 35000-watt Onan PTO generator. Advanced Life Support gear includes a Philips MRx defibrillator, intubation equipment, intravenous needles and solutions and medications.*

Further specifics of the rescue equipment carried are defined on the "rescue inventory" sheet from the Pittsburgh EMS website. The equipment is as follows:[40]

Table 4 Rescue equipment inventory from Pittsburgh EMS Rescue 1 and Rescue 2

Rescue 1	Rescue 2
• Ajax 911 air chisel-pre connect • Cribbing 2x4 • Cribbing 4x4 • Cribbing Wedges • Draeger SCBA • Elevator Pole • Jib Pole Head • Light box, Streamlight • Long back boards, plastic: 5 • Misc straps • Peds immobalizer board • Reeves Stretcher • Sked, Adult • Sked, Peds • Step chocks: 4 • Stokes basket, wire • Stokes basket, plastic • Stokes Gear Bag • Stokes bridle • PMI 50' Lashing Rope:2 • Water rescue throw bag	• Auto Vent • Ballistic vests: 6 (4) • Body bags • Cool-It Decon Spray • Drug Box • Infectious Disease Kits:2 • LifePak-12 • Mast Suit, Adult • Mast Suit, Peds • Nitrous oxide/Oxygen set up • O2 bag w/ D cyl & masks • OB kit • Padded Board Splints, S, M, L • Peds Kit • Salvage covers: 3 • Smith Cot: 2 • Spare BVM • Spare D cylinders: 3 • Spare Drug Box • Suction unit • Trauma Bag • Vac Splints • XP-1

3.3.8.2 Boston EMS

The EMS department of Boston, MA, employs similar specialized EMS vehicles. An example of one of Boston EMS' heavy ambulances can be seen in Figure 12. This vehicle, ambulance A1, is based off of a GMC chassis. A similar, but extended GMC vehicle is shown in Figure 13 and Figure 14. This apparatus is the Special Operations Homeland Security vehicle.

Figure 12 Boston EMS heavy ambulance[41]

The Special Operations division of Boston EMS focuses on special events within the city. Planned events, such as the 4th of July celebration on the Esplanade as well as unexpected disasters are within the purview of the Special Operations Division. It is not known if the Special Operations Homeland Security vehicle is an NFPA approved apparatus. It is instead being described here to illustrate the applicability of NFPA 1901 equipment requirements.[42]

Figure 13 Boston EMS Special Operations Homeland Security Vehicle[43]

Figure 14 Equipment cabinets of Boston EMS special Operations Homeland Security vehicle[44]

Specific equipment carried on the Homeland Security vehicle is not published. A partial list of the items can be ascertained from Figure 14. These items include:

- Auxiliary power generator
- Collapsible, low profile wheel chairs
- Assorted equipment in hardened Pelican Cases
- Multiple back-boards
- Drinkable water

Additional items are likely to be:

- Assorted lighting products
- Kendrick Extrication Devices
- Mass casualty identifications tags
- Body bags
- Hazardous materials protective equipment
- Decontamination spray and equipment

3.4 Respiratory Protection

3.4.1 OSHA 1910 Sub-Part I

The Occupational Safety and Health Administration (OSHA) is a government administration that sets requirements for safe work environments. The section of requirements detailing Personal Protective Equipment is OSHA 29 CFR, Part 1910, Sub-Part I. Sub-Part I includes standards 1910.132 through 1910.138, as well as reference appendices A and B.

In a strict sense, these requirements are established for employer compliance. That is, these are the requirements for safe working conditions that every employer must provide their employees. In a general sense, these requirements are used by manufacturers to design products for use in these environments. These are the same standards that can be found printed on eyewear or gloves at Home Depot or Lowes or found on SCBAs worn by firefighters.

The breakdown of 1910 Sub-Part I is as follows:

1910.132 - General requirements

1910.133 - Eye and face protection

1910.134 - Respiratory Protection

1910.135 - Head protection

1910.136 - Foot protection

1910.137 - Electrical protective devices

1910.138 - Hand Protection

3.4.2 OSHA 1910.134: Respiratory Protection

Respiratory protection is a serious part of first responder safety throughout the country. For firefighters, the most common form of respiratory protection is that of the SCBA. Within the day-to-day operations of EMS first responders, this will likely be the medical/surgical mask or similar protection when working on patients when facial protection is necessary (for example infectious patients, elderly patients, or bleeding cases).

Should greater protection than that of a medical/surgical mask be required of an EMS first responder, the next levels of protection are, in ascending order:

Air-Purifying Respirator (APR)

Powered Air-Purifying Respirator (PAPR)

Supplied-Air Respirator (SAR)

Self-Contained Breathing Apparatus (SCBA)

The term Assigned Protection Factor (APF) is defined in 1910.134. This term effectively classifies the level of protection afforded by a form of respiratory protection. A higher APF value indicates an increasing level of protection. Table 5 identifies configuration APF values.

A fit test is mandated by OSHA for ensuring that a mask is properly protecting an individual. The general specifications for the fit test are defined in 1910.134 App A. It should be noted that the only conditions where a loosely fitting face piece is given an APF occurs when the device is in continuous flow. Under these conditions, the best achievable level is an APF 25.

Table 5 Assigned Protection Factors for various forms of respiratory protection[45]

Type of respirator	Half mask	Full Facepiece	Helmet/Hood	Loose-fitting Facepiece
Air-Purifying Respirator	10	50	xxx	xxx
Powered Air-Purifying Respirator	50	1,000	25/1,000	25
Supplied-Air Respirator • Demand mode • Continuous flow mode • Pressure-demand or other positive-pressure mode	 10 50 50	 50 1,000 1,000	 xxx 25/1,000 xxx	 xxx 25 xxx
4. Self-Contained Breathing Apparatus • Demand mode • Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	 10 xxx	 50 10,000	 50 10,000	 xxx xxx

3.4.3 IDLH

The term IDLH is an acronym that stands for Immediately Dangerous to Life or Health. It is defined under several standards and regulatory agencies including OSHA and the National Institute for Occupational Safety and Health (NIOSH) which is part of the Centers for Disease Control (CDC). The OSHA definition is:

> *An atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere.*[46]

3.4.4 Self-Contained Breathing Apparatus

The Self-Contained Breathing Apparatus is first responder's supply of fresh breathing air while operating in an environment that is IDLH. An example of an SCBA may be found in Figure 15. The circled portions of the image show a standard version of the Pathfinder locator system co-invented by this author that has been installed in the Sperian/Honeywell Warrior SCBA. Specifics on the SCBA can be found in NFPA 1981: Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services.

Figure 15 Example of an SCBA with author's firefighter locator transmitter installed (circled)[47]

3.5 CBRN Consideration

3.5.1 Purpose

The regular duties of a First Responder involve exposure to a wide range of occupational safety hazards. With the ever present threat of domestic terrorism, preparedness is important. Chemical, Biological, Radiological and Nuclear ("CBRN" pronounced '*see-burn*') agents require different levels and techniques of protection.

This section is included to inform MIRAD of some of the more complicated and technical aspects of hazardous material and terrorist related situations. It is not the intent of this section to suggest that all ambulances provide these types of protection. In fact, EMS services may not be necessary for situations requiring level A and Class 1 protection. The morbid reality is that victims would already likely be deceased.

Instead, this section is intended to illustrate that hazardous situations, where victims may be dead, may still require first responder operations (such as structural firefighting or incident containment). In these cases, back-up medical services would be desired to protect those first responders working. Effective operation in these types of conditions may require the use of supplied air respiratory systems. In addition to the truck-mounted solutions shown in Figure 10, there are portable versions that can be carried on apparatus and then wheeled around on scene. An example is Figure 16.

In these types of environments, protection of first responders is paramount. Efforts such as decontamination require long periods of protection in which supplied air reduces the need to decontaminate prior to changing air cylinders. Figure 17 shows an example training exercise.

Figure 16 Example of an "air cart" used for supplied air respiratory protection[48]

Figure 17 Hazmat decontamination where supplied air respiratory protection is desired[49]

3.5.2 NFPA 1994

Critical to wellbeing of innocent bystanders caught in a terrorist attack is the availability of first responders to provide aid. The insidious threat of CBRN agents presents a serious challenge to the application of emergency medical services.

Started in 1998, the NFPA Technical Committee on Hazardous Materials Protective Clothing and Equipment began work on what would become NFPA 1994. Titled the Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents, it is currently in the 2012 edition. This document addresses the need for standards that define personal protective equipment (PPE) for fire and emergency services personnel operating at domestic terrorism incidents.

In particular, the section 1.2.1.2 states that the standard is established to

> *. . . provide emergency first responder personnel with three levels of CBRN protective ensembles and ensemble elements that could be selected for minimum protection of emergency first responder personnel based on what the incident risk analysis indicates is necessary protection for the intended operations.*[50]

As a CBRN incident is clearly an IDLH environment, it goes without saying that first responder activity would cease once an incident command learned of the situation. All first responders would immediately be evacuated. This would be a first responder or an incident commander's worst nightmare: the decision of holding back care in the face of a CBRN incident.

This is not to say that victims would not receive aid. National Guard units might likely deploy, but they would take time to arrive and would most likely make taking command of the scene a

priority. Thus NFPA 1994 was developed to help protect, amongst other reasons, the very first responders that would be needed in the immediate hours following a terrorist attack.

NFPA 1994 uses the term protective ensemble to define a full set of clothing and respiratory protection. Three levels of protection are specified based upon the threat level of the particular agents employed. In addition to different levels of protection against agents, some levels are designed for practical first responder activities. For example, NFPA Class 2 ensembles are specified such that the garments can be designed to withstand fire suppression activities (refer to Figure 18).

Originally written with three classifications, Class 1, Class 2, and Class 3 (*in descending order of protection*), NFPA 1994 now specifies Class 2, Class 3, and Class 4 levels of protection. The original Class 1 specification is now contained in NFPA 1991. The levels of protection can be seen in Table 6. A comparison to OSHA and EPA performance-based specifications commonly referred to as the "level" specifications, can be found in Table 7.

The likelihood of conducting emergency medical operations in a level A environment would be limited at best. As previously mentioned, in these situations, most everyone would be deceased. However, cities with high risk levels for terrorist attacks do prepare for the worst. Fire departments and police departments in cities such as New York have contingencies for operations as such. Performing fire and police operations in Class 2 protective ensembles does in fact happen. This can be both for drill, but also in heightened sates of readiness. The point to take from this is that operation in Class 2 environments is common for certain cities these days.

Table 6 Levels of protection afforded by NFPA 1994[51] and NFPA 1991

	Level of Protection
Class 4	Provides limited protection against incidents involving biological hazards or radiological particulate hazards where concentrations are below IDLH. Permits the use of air-purifying respirators (APR).
Class 3	Provides limited protection against incidents with low levels of vapor or liquid chemical hazards where the concentrations are below IDLH. Permits use of APR.
Class 2	Provides limited protection against incidents involving vapor or liquid chemical hazards where the concentrations at or above IDLH. Requires use of SCBA.
NFPA 1991	Provides 60 minute minimum protection against specified chemicals in hazardous materials emergencies with vapor and liquid splash hazards. Complete and total encapsulation; requires SCBA or remote air source.[52]

Table 7 Comparison of NFPA requirements with OSHA/EPA performance standards[53]

Ensemble Description Using Performance-Based Standard(s)	OSHA/EPA Level
NFPA 1991, 2005 edition [CBR(N) protection now included in mandatory requirements], worn with NIOSH CBRN SCBA	A
NFPA 1991, 2000 edition with C/B optional requirements, worn with NIOSH CBRN SCBA	A
NFPA 1994 Class 1 worn with NIOSH CBRN SCBA	A
NFPA 1994 Class 2 worn with NIOSH CBRN SCBA	B
NFPA 1994 Class 2 worn with NIOSH CBRN APR	C
NFPA 1994 Class 3 worn with NIOSH CBRN SCBA	C
NFPA 1994 Class 3 worn with NIOSH CBRN APR	C

An additional note of interest for MIRAD would be the consideration of offering breathing air to personnel inside the vehicle. This form of protection would allow operators to drive in contaminated areas. Conversely, this type of supplied air could be used to protect EMS personnel while administering aid to an infectious or contaminated victim. Consider the situation of treating a victim exposed to anthrax. Treatment can be provided and aid administered to save their life, but the exposure to the medic is unacceptable.

Figure 18 NFPA 1994 Class 2 protective ensembles for police[54] and fire[55] applications

3.5.3 NFPA 1991

NFPA 1991, Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies, focuses on suit design for the highest level of protection in a wide range of environments. Similar in scope to NFPA 1994, NFPA 1991 differs in that it requires full encapsulation.

The system ultimately becomes a positive pressure containment system. Restrictions are placed upon the maximum ventilation rate of the suit. As the operator exhales air from their open-circuit SCBA, the exhaust generally will be more than the ventilation rate. Thus the occupant's own breathing helps mitigate permeability infiltration.

A significant battery of twenty-six different tests helps to ensure the quality of both design and manufacturing of an NFPA 1991 compliant suit.

Table 8 List of compliance tests for NFPA 1991 certified ensembles

1. Gastight Integrity
2. Liquid-tight Integrity
3. Overall Ensemble Function and Integrity
4. Maximum Suit Ventilation Rate
5. Chemical Permeation Resistance
6. Flammability Resistance
7. Overall Ensemble Inward Leakage
8. Exhaust Valve Mounting Strength
9. Burst Strength
10. Puncture Propagation Tear Resistance
11. Cold Temperature Performance Test One
12. Fitting Pull Out Strength
13. Cold Temperature Performance Test Two
14. Cut Resistance
15. Puncture Resistance Test One
16. Glove Hand Function
17. Thermal Protective Performance (TPP)
18. Puncture Resistance Test Two
19. Abrasion Resistance
20. Impact and Compression
21. Ladder Shank Bend Resistance
22. Slip Resistance
23. Seam/Closure Breaking Strength
24. Closure Penetration Resistance
25. Exhaust Valve Inward Leakage
26. Overall Ensemble Flash

Some particular distinctions between NFPA 1991 and other similar style encapsulation suit standards are the "over-all ensemble flash test" and flammability tests. The chemical flash test is designed to verify that the integrity of the suit will remain intact when subjected to a 7 second fireball. The specifics of this rather aggressive test are:

> *Propane gas, at 99 percent purity or better, shall be metered into the chamber at a delivery pressure of 172.3 kPa, ±13.8 kPa (25 psi, ±2 psi) and rate of 0.16m^3/min, ±0.01m^3/min (51⁄2 ft^3/min, ±1⁄2 ft^3/min). The concentration of propane within the chamber shall be sufficient to produce a visible chemical flash fire lasting 7 seconds, ±1 second.* [56]

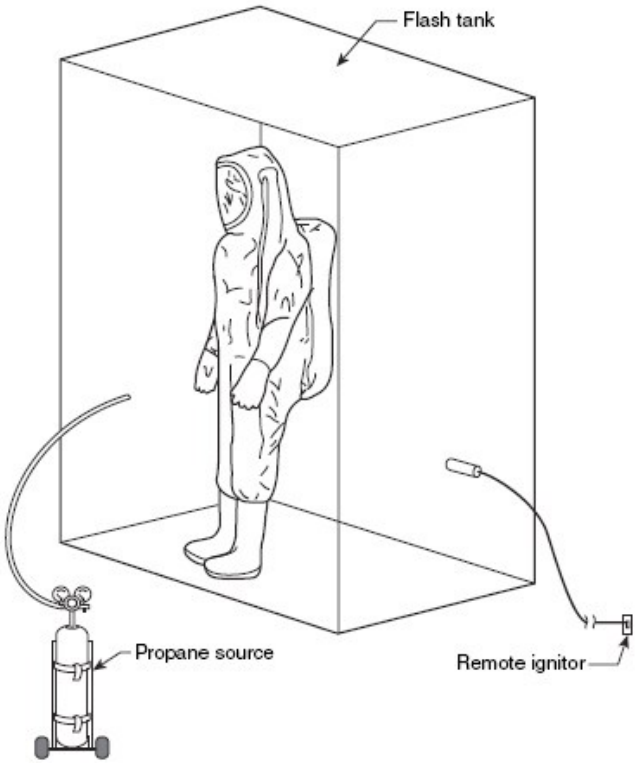

Figure 19 Diagram of NFPA 1991 flash test assembly[57]

A flammability resistance test is conducted using the standard test methods defined in ASTM F 1358, Standard Test Method for Resistance of Protective Clothing Materials to Flame Impingement. In a simplistic description, this type of test is the equivalent of holding a propane blow torch to the suit and ensuring that the material self-extinguishes and does not drip.

An informative video on the Saint-Gobain OneSuit Pro NFPA 1991 certified ensemble can be found on YouTube at the following address: http://www.youtube.com/watch?v=NnrdW2HvxbA

Figure 20 Saint-Gobain OneSuit NFPA 1991 protective ensemble[58]

CHAPTER 4: Concluding Remarks

The first objective of this report was to identify the role played by fire departments in delivering emergency medical service (EMS) care. The second objective was to outline the applicability of existing NFPA standards on EMS vehicles. The last objective was to provide a literature review of codes and standards regarding personal protective equipment (PPE) for first responders.

4.1 Fire Departments and EMS

Despite its namesake, the National Fire Protection Agency creates codes and standards for much more than the fire industry. Several standards apply to the emergency medical services field of the first responder community. In addition, the Insurance Services Office provides incentives to municipalities to focus on improved quality of service of fire departments. This in turn leads to increased application of EMS by fire departments across the United States.

4.2 Fire and EMS Apparatus

Several sections of NFPA 1901, *Standard for Automotive Fire Apparatus* apply to fire departments that deliver EMS care in the capacity of first responders. Consideration of pumper apparatus and special service apparatus should be made when defining requirements for vehicles utilized by fire departments.

4.3 Personal Protective Equipment

Several regulatory agencies as well as the NFPA establish requirements for the protection of first responders. Respiratory and body protection are important considerations to be made for first responders operating in hazardous environments. Respiratory protection requires multiple levels of testing with different organizations in order to be certified for use.

4.4 Hazardous Environment Protection

As time progresses, first responder training in terrorism response and weapons of mass destruction identification is increasing. This can be evidenced by the adoption of new standards and codes such as NFPA 1994 and NFPA 1991. Additionally, proper training of emergency personnel in high-risk locations, such as New York, is increasing.[59] Off the record conversations with members of the NFPA Technical Committee on Electronic Safety Equipment further corroborates the growing need of training in this area.

It was the intent of this document to help broaden the research base of the MIRAD Laboratory. As many of the codes and standards in the first responder community are defined by the NFPA, this project was conducted to supplement the existing codes and standards research work performed through and on the behalf of MIRAD.

An additional outcome of this research has led to the development of a Major Qualifying Project proposal. Future research by WPI students may help address issues facing the performance of existing fire apparatus.

4.5 Proposal for Future MQP Research

The development of a bracket that both cushions and retains and SCBA over different ranges of acceleration loading may well be of the extent worthy of an MQP. Should this be of interest, the following list is provided as a framework for the proposed work:

1. Literature review of applicable standards (such as NFPA 1901 and NFPA 1981)
2. Review and characterization of the existing bracket designs and methodology
3. Review and characterization of the six major US brands of SCBAs
    a. Draeger
    b. Honeywell/Sperian
    c. International Safety Instruments (ISI)
    d. Interspiro
    e. Mine Safety Appliances (MSA)
    f. Scott Safety
4. Design of a universal bracket
    a. 0.0 to 0.5 g: Vibration Isolation
    b. 0.5 to 9.0 g: Rigid restraint of SCBA
5. Reporting
    a. Write up of lessons learned
    b. Presentation to NFPA in Quincy, MA, or to a TC meeting of NFPA 1901
    c. Potential presentations to TCs of NFPA 1981 and NFPA 1982

REFERENCES

[1] 911 Safety Equipment, LLC. *Air Systems International.* 2012. http://www.gsafire.com/Air%20Systems.html (accessed April 25, 2012).

[2] Acclaim Images. "U.S. Air Force Airmen Go Through Decontamination Procedures." *Stock Photograph by Department of Defense Public Domain .* October 18, 2006. http://www.acclaimimages.com/_gallery/_pages/0420-0904-1311-1201.html (accessed April 26, 2012).

[3] Bay Fire. "Fire Trucks." 2008. http://www.bayfireproducts.com/ (accessed May 16, 2012).

[4] Calolympic Safety. "MULTI-PAK CYLINDER AIR CARTS." http://www.caloly-safety.com/detail/respiratory/multi-pak-cylinder-air-carts-190.cfm (accessed April 26, 2012).

[5] City of Boston. "Special Operations." *Emergency Medical Services.* 2012. http://www.cityofboston.gov/ems/divisions/specialoperations.asp (accessed May 30, 2012).

[6] dugdogmaster. "Moving to Pittsburgh...anyone know about EMS?" *Citi-Data.com.* January 4, 2009. http://www.city-data.com/forum/pittsburgh/527750-moving-pittsburgh-anyone-know-about-ems.html (accessed May 31, 2012).

[7] Fire Rescue Safety Australia. "ONESuit Pro (NFPA)." 2012. http://www.frsa.com.au/index.php/onesuitr-pro-nfpa.html (accessed April 24, 2012).

[8] Flame Fighter. *SCBA Brackets and Straps.* http://www.flamefighter.com/SCBABracketsStraps.html (accessed April 24, 2012).

[9] Glendale Fire Department. "Fire - Personnel Information and Resources." 2012. http://www.glendaleaz.com/fire/recruitment.cfm (accessed April 24, 2012).

[10] Grant, Casey Cavanaugh. "The Birth of NFPA." *National Fire Protection Association.* 1996. http://www.nfpa.org/itemDetail.asp?categoryID=500&itemID=18020&URL=About%20NFPA/Overview/History&cookie%5Ftest=1 (accessed April 26, 2012).

[11] Haase, Zachary S. "Warrior Integrated Beacon." *Pathfinder Product Website.* May 1, 2009. http://www.summitsafetyinc.com/products/sperian/warrior.html (accessed April 20, 2012).

[12] Insurance Services Office, Inc. "How the PPC™ Program Works." *ISO Mitigation Online.* 2012. http://www.isomitigation.com/ppc/0000/ppc0004.html (accessed April 25, 2012).

[13] —. "ISO's Public Protection Classification (PPC™) Program." *ISO Mitigation Online.* 2012. http://www.isomitigation.com/ppc/0000/ppc0001.html (accessed April 25, 2012).

[14] —. "Water-Supply Information." *ISO Government Solutions.* 2012. http://www.isogov.com/services/infrastructure/water-supply-information.html (accessed April 25, 2012).

[15] KarasCorner's photostream. "Boston Emergency Medical Services, EMS Special Operations, Homeland Security vehicle." *flikr.* March 14, 2010. http://www.flickr.com/photos/karascorner/4436806496/ (accessed May 30, 2012).

[16] Lackore, Roger. *Firefighter Anthropometric Data White Paper.* Fire Apparatus Manufacturer's Association, 2007.

[17] Lion Apparel, Inc. "MT94™ Fire." 2012. http://www.lionprotects.com/firefighter-cbrn-mt94 (accessed April 25, 2012).

[18] —. "MT94™ Law Enforcement." 2012. MT94™ (accessed April 25, 2012).

[19] Moore, Ron. *The Dayton Airbag Incident.* Firehouse Magazine.

[20] New York Division of Homeland Security and Emergency Services. "Office of Emergency Management." *Training Calendar.* April 2012. http://www.dhses.ny.gov/oem/training/ (accessed April 26, 2012).

[21] NFPA 101. *Life Safety Code.* National Fire Protection Association, 2012.

[22] NFPA 1710. *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments.* National Fire Protection Association, 2010.

[23] NFPA 1720. *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments.* National Fire Protection Association, 2010.

[24] NFPA 1901. *Standard for Automotive Fire Apparatus.* National Fire Protection Association, 2009.

[25] NFPA 1961. *Standard on Fire Hose.* National Fire Protection Association, 2007.

[26] NFPA 1964. *Standard for Spray Nozzles.* National Fire Protection Association, 2008.

[27] NFPA 1991. *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies.* National Fire Protection Association, 2005.

[28] NFPA 1994. *Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents.* National Fire Protection Association, 2012.

[29] Occupational Safety and Health Administration. "29 CFR 1910.120." December 27, 2011.

[30] —. "29 CFR 1910.134." June 8, 2011.

[31] Parise, John. "FireNews.org." http://firenews.org/mass/BostonEMSA1-07.jpg (accessed April 20, 2012).

[32] Phoenix Fire Department. "EMT/CPAT Information." *Recruitment web site.* April 7, 2011. http://www.phoenix.gov/joinpfd/index.html (accessed April 24, 2012).

[33] Pittsburgh Emergency Medical Services. "Heavy Rescue Unit." *Rescue Division.* http://www.city.pittsburgh.pa.us/ems/html/heavy_rescue_unit.html (accessed May 31, 2012).

[34] —. "Inventory List for Rescue Trucks." *Rescue Division.* http://www.city.pittsburgh.pa.us/ems/assets/Rescue_Inventory.doc (accessed May 31, 2012).

[35] Public Surplus. *Auction #503061 - 1995 Spartan Pumper Fire Truck.* November 12, 2010. http://www.publicsurplus.com/sms/auction/view?auc=503061 (accessed April 24, 2012).

[36] Town of Sterling. "About Sterling." *Demographics.* 2000. http://www.sterling-ma.gov/Pages/SterlingMA_Webdocs/demographics (accessed May 31, 2012).

[37] —. "Personnel." *Fire Department.* 2011. http://www.sterlingfd.net/personnel.php (accessed April 24, 2012).

[38] United States Census Bureau. *Geography @ Census Bureau.* 2000. http://www.census.gov/geo/www/ua/ua2k.txt (accessed May 31, 2012).

ENDNOTES

[1] [10] (Grant 1996)
[2] [21] (NFPA 101 2012)
[3] Author's personal experience with Pennsylvania State EMT-B certification.
[4] Pittsburgh EMS paramedic John Soderberg.
[5] [19, pp. 2] (Moore n.d., 2)
[6] [19, pp. 1] (Moore n.d., 1)
[7] [19, pp. 4] (Moore n.d., 4)
[8] [19, pp. 4] (Moore n.d., 4)
[9] [9] (Glendale Fire Department 2012)
[10] [32] (Phoenix Fire Department 2011)
[11] Author's personal experience as a firefighter in Pennsylvania
[12] [13] (Insurance Services Office, Inc. 2012)
[13] [12] (Insurance Services Office, Inc. 2012)
[14] [14] (Insurance Services Office, Inc. 2012)
[15] [37] (Town of Sterling 2011)
[16] [38] (United States Census Bureau 2000)
[17] [36] (Town of Sterling 2000)
[18] [22, pp. 8] (NFPA 1710 2010, 8)
[19] [22, pp. 10] (NFPA 1710 2010, 10)
[20] [22, pp. 10] (NFPA 1710 2010, 10)
[21] [22, pp. 15] (NFPA 1710 2010, 15)
[22] [23, pp. 8] (NFPA 1720 2010, 8)
[23] [23, pp. 7] (NFPA 1720 2010, 7)
[24] [24, pp. 22-3] (NFPA 1901 2009, 22-3)
[25] [25] (NFPA 1961 2007)
[26] [26] (NFPA 1964 2008)
[27] [24, pp. 23] (NFPA 1901 2009, 23)
[28] [24, pp. 22] (NFPA 1901 2009, 22)
[29] [3] (Bay Fire 2008)
[30] [24, pp. 24] (NFPA 1901 2009, 24)
[31] [24, pp. 24-5] (NFPA 1901 2009, 24-5)
[32] [24, pp. 29-30] (NFPA 1901 2009, 29-30)
[33] [35] (Public Surplus 2010)
[34] [16] (Lackore 2007, 10)
[35] [8] (Flame Fighter n.d.)
[36] [1] (911 Safety Equipment, LLC 2012)
[37] [33] (Pittsburgh Emergency Medical Services n.d.)
[38] [6] (dugdogmaster 2009)
[39] [33] (Pittsburgh Emergency Medical Services n.d.)
[40] [34] (Pittsburgh Emergency Medical Services n.d.)
[41] [31] (Parise n.d.)
[42] [5] (City of Boston 2012)
[43] [15] (KarasCorner's photostream 2010)
[44] [5] (City of Boston 2012)
[45] [30] (Occupational Safety and Health Administration 2011, 134)
[46] [29] (Occupational Safety and Health Administration 2011, 120)
[47] [11] (Haase 2009)
[48] [4] (Calolympic Safety n.d.)
[49] [2] (Acclaim Images 2006)

[50] [28] (NFPA 1994 2012)
[51] [28] (NFPA 1994 2012)
[52] [27, pp. 1] (NFPA 1991 2005, 1)
[53] [27, pp. 38] (NFPA 1991 2005, 38)
[54] [18] (Lion Apparel, Inc. 2012)
[55] [17] (Lion Apparel, Inc. 2012)
[56] [27, pp. 36] (NFPA 1991 2005, 36)
[57] [27, pp. 36] (NFPA 1991 2005, 36)
[58] [7] (Fire Rescue Safety Australia 2012)
[59] [20] (New York Division of Homeland Security and Emergency Services 2012)