M. Personal Protective Equipment

General Background: PPE

Firefighting is an inherently dangerous profession, with personnel routinely exposed to environments that pose an immediate risk to an individual's health and safety (IDLH environments). In 1970, the United States Congress enacted the Occupational Safety and Health Act to provide "for the development and promulgation of occupational safety and health standards."[92] Federal regulations regarding Personal Protective Equipment (PPE) can be found in 29 CFR § 1910.132, which outlines employer and employee obligations for providing and utilizing PPE in hazardous environments. Notably, these regulations are relatively broad, requiring that "all personal protective equipment shall be of safe design and construction for the work to be performed."[93] In other words, the federal regulations support industry standards for personal protective equipment. Additionally, 29 CFR 1910.134 covers Respiratory PPE, such as a firefighter's Self-Contained Breathing Apparatus (SCBA) This regulation requires an employer to conduct a medical evaluation to determine whether an employee is medically qualified to use a respirator and conduct a fit test.

The National Fire Protection Association (NFPA) provides national consensus standards for the firefighting industry. NFPA 1971, Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting, provides "minimum design, performance, testing, and certification requirements for proximity firefighting protective ensembles and ensemble elements that include coats, trousers, coveralls, helmets, gloves, footwear, and interface components."[94]

NFPA 1851 Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting provides a national standard for maintaining personal protective ensembles, including standards for selecting, inspecting, cleaning, and repairing protective clothing and equipment.[95] Several key provisions of NFPA 1851 include section 6.3.3, which establishes that "[a]dvanced inspections of all protective ensemble elements that are issued shall be conducted at a minimum of every 12 months, or whenever, routine inspections indicate that a problem could exist." Additionally, section 7.3.2 establishes that "[e]nsemble and ensemble elements that are soiled should receive advanced cleaning prior to reuse" and section 7.3.3 establishes that "[e]nsemble and ensemble elements shall receive advanced cleaning at the time of advanced inspection if not subjected to advanced cleaning within the preceding 12 months." Beyond cleaning, Section 10.1.2 requires that "[s]tructural firefighting ensembles and

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[92] 29 U.S.C.A. § 651 (West)

[93] 29 C.F.R. § 1910.132(c) (West)

[94] National Fire Protection Association 1971 Standard on Protective ensembles for Structural Fire Fighting and Proximity Fire Fighting 1.1.2 (2018).

[95] National Fire Protection Association 1851 Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting (2014).

ensemble elements shall be retired in accordance with 10.2.1 or 10.2.2, no more than 10 years from the date the ensembles or ensemble elements were manufactured."

Policies and Standards Applicable to Howard County Department of Fire and Rescue Services: PPE

HCDFRS General Order 530.02 Personal Protective Equipment establishes the minimum requirements for HCDFRS personnel's personal protective equipment. This order requires that "Personal Protective Equipment (PPE) shall meet NFPA guidelines as well as require DFRS approval."[96] While all of the PPE ensemble is provided by HCDFRS, individual personnel are empowered to purchase leather helmets and leather boots for use on the fireground as long as the equipment meets the applicable NFPA standard. In addition to outlining the minimum PPE personnel are to have, it establishes procedures for replacing equipment as well as general guidance for when and where PPE should be worn.

In regards to maintenance of PPE, Howard County Department of Fire and Rescue Services Special Order 2004-42, Protective Equipment Cleaning, requires that "[e]very 12 months, at a minimum, departmental issued and approved personally owned protective equipment currently in-service and soiled shall be sent for cleaning."

General Order 150.18, Carcinogen Exposure Reduction Plan addresses how to clean PPE, but it does not address a regular/mandatory schedule or period for advanced cleaning or inspection.[97] Furthermore, this is addressed strictly from the perspective of carcinogen reduction and not overall safety and performance of the gear.

[96] Howard County Department of Fire and Rescue Services General Order 530.02 Personal Protective Equipment (2009).
[97] Howard County Department of Fire and Rescue Services General Order 150.18 Carcinogen Exposure Reduction Plan (2018).

Woodscape Drive Incident Overview: Personal Protective Equipment: PPE

During the fire incident at 7005 Woodscape Drive, personnel operating within the hazard zone donned the appropriate personal protective equipment. This included FF Flynn, who donned his entire PPE ensemble prior to making entry into the structure. Part of FF Flynn's ensemble included personally purchased leather helmet. Additionally, FF Flynn was outfitted with and using HCDFRS MSA G1 self-contained breathing apparatus (SCBA).

From the review of FF Flynn's PPE, there were some minor variances from proper PPE donning, such as securing the protective hood with snaps between his coat's inner lining and outer shell. All components of FF Flynn's SCBA, while some were damaged, were intact and in place at the time of his rescue.

Findings and Recommendations: PPE

Personal Protective Clothing

An independent, third-party examination of FF Flynn's personal protective clothing and equipment established that FF Flynn's protective clothing and equipment operated as designed and there were no issues that could be considered as contributing factors to FF Flynn's injuries. The report verified that most of FF Flynn's personal protective clothing met the relevant NFPA 1971 standard at the time of manufacture. Although the report found no issues in FF Flynn's personal protective equipment to have contributed to his injuries, the report did include findings that could benefit the overall safety of personnel in future incidents. The examination report is attached as Appendix D. Additionally, the Internal Safety Review Board (ISRB) identified several best practices to enhance personnel safety in regard to Personal Protective Equipment that should be incorporated into HCDFRS practices.

First, FF Flynn's personal protective clothing had not received advanced inspection or cleaning within the twelve (12) months prior to the incident at 7005 Woodscape Drive. Under the current HCDFRS Special Order 2004-42 Protective Equipment Cleaning, personal protective clothing is to be cleaned at minimum every twelve (12) months if it is soiled. Because the Special Order specifically states that "soiled" equipment must be cleaned every twelve (12) months, non-soiled gear is not mandated to be inspected or cleaned every twelve (12) months. For example, a member's gear that has been stored, but not used, would not be sent out for periodic advanced inspection since it is not soiled. Additionally, the special order allows for the interpretation of "soiled" as an indicator for PPE to receive advanced cleaning, thereby negating advanced inspection if not considered to be "soiled."

Attached to Special Order 2004-42 is the DFRS Inspection/Repair/Decon Checklist form, also referred to as the DFRS Protective Ensemble Check List.[98] This form is the only Howard County Department of Fire & Rescue Services (HCDFRS) document that identifies this ten (10) year period as a condition of removal from service as established in NFPA 1851. It was also noted that, while Special Order 2004-42, issued July 6, 2004, is still in effect, the first provision within this order states, "[t]his special order is a temporary order . . ." and that "[a] General Order will be issued to identify the inspection, cleaning, repair and decon procedures of all protective equipment in the near future." At the time of the Woodscape incident, no General Order existed pertaining to advanced inspection of PPE.

Second, although FF Flynn's turnout coat had his name displayed on the rear tail, some personnel on the fireground did not have their names displayed on the rear of their coats. When wearing the appropriate personal protective clothing and equipment on the fireground, personnel appear similar and it is difficult to readily identify individuals. Names clearly displayed on the tails of turnout coats provides a quick visual identification of personnel, which enhances

[98] Howard County Department of Fire and Rescue Services Special Order 2004-42 Protective Equipment Cleaning (2004).

Figure 31 FF Flynn's Personal Helmet

personnel accountability. During this particular incident, there was a period immediately following the MAYDAY call in which the whereabouts and wellbeing of several personnel were unknown. The ability to readily identify personnel was important to determine if additional personnel were in need of rescue. Providing and assuring standardized name identification on the tail of turnout coats is one component that will enhance personnel safety and accountability on the fireground.

Third, FF Flynn's firefighting boots and personally owned helmet were greater than ten (10) years from manufacture date. Additionally, it was not possible to verify whether FF Flynn's protective hood was within ten (10) years of its manufacture date since there was no manufacture label. Under the NFPA Standard 1971, firefighter personal protective ensembles should be no more than ten (10) years past the manufacture date. While FF Flynn's helmet and firefighting boots should have been retired and replaced, there is no indication that the age of his equipment contributed to his injuries.

Figure 32 FF Flynn's Boot

Fourth, the examination of FF Flynn's protective hood revealed holes in the rear bib that matched the size and spacing of the snaps used to attach the coat liner to the outer shell of the turnout coat and collar. Based on this observation, it is likely that FF Flynn had fastened the liner of his coat to the coat shell through the hood, a practice that has been noted among some HCDFRS personnel. Securing the hood in such a way is not recommended because it restricts the hood from effectively moving in concert with the head of the wearer. When a portion of the hood is stationary, wearer movement can result in gapping that compromises encapsulation and thermal protection. Additionally, this practice creates holes in the hood, voiding the NFPA certification of the garment.

Fifth, the independent examiner indicated that FF Flynn's turnout coat collar was not in a raised and secured position. A raised turnout coat collar provides protection for the neck area, closing the gap between the ear flaps and the coat. This item was not a contributing factor to FF Flynn's injuries. However, proper donning of the ensemble does include raising the turnout coat collar, which could affect personnel safety during structural firefighting.

Figure 33 FF Flynn's Protective Hood

Lastly, it was noted that FF Flynn was wearing reissued personal protective equipment and not gear that had been manufactured to his specifications. Although individually tailored personal protective equipment is best to ensure maximum safety for a firefighter, the quartermaster may reissue gear that is still serviceable to a department member that has a similar build and fit.
Whenever serviceable gear is reissued, it is checked against the individual's measurements to assure it matches the individual. The quartermaster also has the individual try on the gear to insure proper fit and proper overlap. There is no indication that FF Flynn's use of re-issued gear had any impact on its effectiveness.

Findings	**Recommendations**
M.1 FF Flynn's personal protective clothing had not received advanced inspection or cleaning within the twelve (12) months prior to the incident.	M.1.1 The Howard County Department of Fire and Rescue Services should consider incorporating guidance from Special Order 2004-42 into a newly issued General Order that aligns with NFPA 1851. This order should mandate yearly advanced inspection and cleaning of all personal protective equipment, regardless of soiled condition, to assure that this equipment is in safe and serviceable condition.
M.2 Although FF Flynn's turnout coat had his name displayed on the	M.2.1 General Order 530.02 should be revised to require all turnout coats

Findings	Recommendations
rear tail, some personnel on the fireground did not have their names displayed on the rear of their coats.	to have the member's last name affixed to the rear tail of the coat. Should multiple members have the same last name, additional lettering would be used to further differentiate those individuals. M.2.2 HCDFRS should assure all personnel have their name affixed to the rear tail of their turnout coats and request name panels for personnel, as necessary.
M.3 FF Flynn's firefighting boots and helmet were older than ten (10) years from manufacture date.	M.3.1 General Order 530.02, Personal Protective Equipment, should be revised to align with NFPA Standard 1971. These revisions should include: o An explicit prohibition of any modifications to equipment that would compromise or void its NFPA 1971 certification. o Allowable length of service parameters for all personal protective clothing and equipment items.
M.4 The examination of FF Flynn's protective hood revealed holes in the rear bib that matched the size and spacing of the snaps used to attach the coat liner to the outer shell of the turnout coat and collar.	See Recommendation M.3.1

Findings	Recommendations
M.5 The independent examiner indicated that FF Flynn's turnout coat collar was not in a raised and secured position.	M.5.1 Instruction and training for personal protective equipment should focus on proper donning of the entire safety ensemble, including the importance of utilizing and securing all components for maximum safety and protection (i.e. collars up, snaps fastened, etc.). M.5.2 Personnel should ensure that all clothing is fully and properly donned during any structural firefighting event for their safety.
M.6 It was noted that FF Flynn was wearing reissued personal protective equipment and not gear that had been manufactured to his specifications.	M.6.1 HCDFRS Quartermaster should continue their existing process of assuring gear is properly sized when re-issuing serviceable gear.

Self-Contained Breathing Apparatus

HCDFRS outfitted all apparatus with MSA G1 self-contained breathing apparatus (SCBA) in November 2016. FF Flynn's SCBA and facepiece were evaluated at the NIOSH National Personal Protective Technology Laboratory (NPPTL) in Morgantown, WV. In addition to the NIOSH evaluation, department SCBA practices and SCBA monitoring software were reviewed. The findings from that evaluation are detailed below.

First, at the time of this incident, FF Flynn was wearing and using department provided MSA G1 SCBA. All components of FF Flynn's SCBA were intact and in place at the time of his rescue. There was air remaining in FF Flynn's SCBA air cylinder when he was rescued and the SCBA that was utilized by FF Flynn did not contribute to his death. Data downloaded from FF Flynn's SCBA indicated that the pressure in his SCBA was 2705 psi at 02:43:39 hours, at which time he had been rescued and was outside of the structure. FF Flynn's SCBA and facepiece were evaluated by NIOSH and per the associated report, "[n]o evidence was identified to suggest that the SCBA unit inspected and evaluated contributed to the fatality." The details of this evaluation are contained in the NIOSH PPE Case report found in Appendix D.

Second, data downloaded from FF Flynn's SCBA integrated motion sensor component indicated that motion stopped at 02:28 hours, was reinitiated at 02:39 hours, and continued until the SCBA was shut-down at 02:45 hours. Based on the information available, FF Flynn's motion stopped at 02:28 hours and the reinitiated motion at 02:39 hours was when the RIC located FF Flynn and initiated his rescue.

Third, FF Flynn used an SCBA with the identifier (E101C) that did not correspond with his riding position and assignment (E101B). This mismatch could lead to confusion on the fireground if the Battalion Chief and Medical Duty Officers are using software available to them that receives signals from SCBA equipment, including distress signals. FF Flynn was assigned to the "B" position at the time of this incident and was seated in the "B" seat of Engine 101 (behind officer) while responding to this incident. SCBA on field apparatus are identified by a visible label on the backplate and digitally within the control module with an identifier that corresponds with the SCBA's position on the apparatus.

The SCBA can transmit various statuses to the MSA A2 software, which is available on the Mobile Data Terminal (MDT) installed in the Battalion Chief and Medical Duty Officer vehicles. These statuses include PASS (Personal Alert Safety System) device activation, air supply, and temperature alarms. The MSA A2 software displays the SCBA's apparatus position identification (i.e. E101A, E101B, etc.) as the means to identify the unit to the individual monitoring the A2 software. Additionally, the "B" SCBA on fire engines has an integrated thermal imaging camera (TIC) in the control module. If the MSA A2 software was used, it would have indicated E101C's PASS device activation instead of FF Flynn's assigned position E101B. Because of this mismatch, personnel may have either not realized that the "B" position firefighter was in trouble or interpreted that there was an additional firefighter in trouble.

This situation also creates confusion when the identifier on a firefighter's SCBA does not match the identifier they transmit verbally or electronically via their portable radio. A transmission received with one identifier and SCBA data received with a different identifier would make it difficult for a monitoring individual to appropriately identify the information as coming from a single firefighter. Through interviews, it was determined that the E101B SCBA had been sent out for maintenance and had not been placed back on the apparatus. When the E101B SCBA was sent out, SCBA on E101 was rearranged, instead of placing a reserve SCBA in the "B" seat of E101.

Fourth, although the Howard County Department of Fire and Rescue Services owns MSA A2 SCBA monitoring software, the software has not been adopted for use on the fireground. The ability to monitor SCBA data on the fireground is a critical asset to the safety of personnel operating on incidents. When HCDFRS obtained MSA G1 SCBA in 2015, they also obtained MSA A2 software. This software provides the ability to remotely and wirelessly monitor individual SCBA statuses, to include PASS device activation and air supply. The MSA A2 software product key was obtained in December 2016. As of May 30, 2017, this software had been installed on the MDTs in the Battalion Chief, Medical Duty Officer, and Safety Officer Vehicles, however, the use of the software has not been adopted by the department.

There is no written plan for implementing and monitoring the software and use of the MSA A2 software on the fireground is voluntary. Based on user interviews, distance and physical objects (i.e. some building construction components) may interfere with the wireless data transmissions from the SCBA, however, there were no identified factors or issues indicating that monitoring the software would be detrimental to personnel operating on the fireground. It was identified that an implementation plan would need to designate who should be responsible for monitoring the software during incidents. The monitoring software requires an individual's focused attention and would likely overextend the Incident Commander if this task were added to their responsibilities. While this is a safety related item, the Safety Officer position is not conducive for monitoring the MSA A2 software because the Safety Officer needs to be mobile on the scene and must be focused on crew operations and actively evolving hazards. One consideration would be to assign this task to the accountability officer, as it is closely related to the accountability officer's responsibilities.

Fifth, some SCBA unit control modules do not have an accurate date and time saved. In the process of downloading data from the control modules of SCBA that were utilized on this incident, it was realized that some units did not have accurate date and time data. FF Flynn's SCBA and E101A's SCBA were accurate while some other units were not. For example, some units were saving current event data as dates in the years 1969 and 1970. The department Breathing Apparatus Technician advised that date inaccuracy is likely related to extremely low or dead internal clock batteries in the power module of the affected SCBA. The SCBA internal clock battery maintains the date and time during periods when the main battery module is removed.

As with any battery, the internal battery has a life span and at some time the battery will be depleted. Because of the low or dead internal clock batteries, there were multiple SCBA that did not have accurate date and time information. This presents difficulty in determining when an event occurred and impedes the ability to accurately obtain valuable data. The process to determine the correct date and time from the affected units is cumbersome, requiring calculating the date from a known or controlled event date and time. While this internal battery issue does not present a safety issue to the wearer, it does affect the ability to track data that, as in this case, is valuable in analyzing events and breathing apparatus operation that are related to firefighter safety.

It was also identified through this process that the limited staff assigned to the Breathing Apparatus Shop ("BA Shop") is a contributing factor in prioritizing SCBA maintenance tasks and how quickly tasks can be completed. There is only one full-time employee assigned to the BA Shop which limits the number of tasks that can be accomplished over any given period of time.

Sixth, FF Flynn's SCBA PASS alarm activated at full alarm at 02:28 hours, which assisted the rapid intervention crew (RIC) in locating FF Flynn. Data downloaded from FF Flynn's SCBA (E101C) indicated that an activation of the manual initiating component of the PASS occurred at 02:28 hours. The sound of FF Flynn's PASS alarm was heard by RIC personnel when they arrived at the area of the steps that lead into the basement crawlspace. The PASS alarm sound assisted the RIC personnel in locating FF Flynn and it was still activating when the RIC contacted Flynn.

Seventh, FF Flynn was wearing his assigned SCBA facepiece, which passed his most recent SCBA facepiece fit test on March 27, 2018. In accordance with 29 CFR 1910.134 and NFPA 1500, section 7.13, HCDFRS personnel are fit tested annually to assure they are utilizing the proper size SCBA facepiece to achieve an effective seal.

Findings	**Recommendations**
M.7 FF Flynn used an SCBA with the identifier (E101C) that did not correspond with his riding position and assignment (E101B).	M.7.1 Create or update a General Order to institutionalize cultural practice of associating SCBA with riding positions. M.7.2 Educate personnel on the important current practice of keeping SCBA in the riding position for which it is identified. Whenever an SCBA is removed from apparatus for maintenance, a spare SCBA is to be placed in the vacant position. M.7.3 Make available a spare SCBA with the same functional capabilities (i.e. thermal imaging camera) as the SCBA removed from service.

Findings	Recommendations
	M.7.4 Remind personnel to assure that their SCBA and portable radio identifiers match. (The only exception being when utilizing a spare SCBA due to SCBA being out for maintenance.)
M.8 Although the Howard County Department of Fire and Rescue Services owns MSA A2 SCBA monitoring software, the software has not been adopted for use on the fireground.	M.8.1 Develop a plan for the use of MSA A2 SCBA monitoring software, to include identifying who is responsible for monitoring the software on an incident and begin utilizing this software on incidents.
M.9 Some SCBA unit control modules do not have an accurate date and time saved.	M.9.1 Evaluate all department SCBA for low or dead internal clock batteries and replace affected power modules, utilizing warranty provisions whenever possible. M.9.2 Evaluate BA Shop staffing options to provide for more efficient and timelier SCBA maintenance.