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Death in the line of duty...

National Institute for Occupational Safety and Health NIOSH

A report from the NIOSH Fire Fighter Fatality Investigation and Prevention Program December 2019

# Firefighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Exercise - California

Revised Date: April 2, 2021

## Executive Summary

In 2017, a 33-year-old state inmate was accepted into the state's Conservation Camp Program which allows inmates to request assignments within one of the state's correctional institution fire departments. On April 21, 2018, the inmate became a trainee (trainee) of the fire program and was participating in an initial training hike. He had recently been assigned to serve the campfire station as a structural firefighter. The training exercise involved hiking in moderately steep terrain while wearing full wildland personal protective equipment (PPE), web gear, and a hose pack. As the trainee reached the top of the climb for a second and final lap, he knelt and said he needed to catch his breath. The crew told the trainee to drink some water while he rested and questioned him to see if he was alert and oriented. Less than two minutes later, the crew noticed the trainee wasn't drinking water or moving and did not respond to his name when called. The crew quickly came to his aid and notified the captain that they needed additional support. The crew started treating the trainee for heat exhaustion and loaded him into a vehicle. As they drove down the hill, he became pulseless and non-breathing at which time the crew immediately started cardiopulmonary resuscitation (CPR). The crew arrived at the fire station within two minutes and medical staff was waiting. The crew continued CPR as correction medical staff began advanced life support (ALS) efforts. Despite the efforts of fire crews, medical staff and paramedics, the trainee died. The cause of death was fatal cardiac arrhythmia due to cardiomyopathy.

## Key Recommendations

NIOSH investigators offer the following recommendations to prevent similar fatal events, and to address general health and safety issues among firefighters at this and other fire departments across the country.

- ***Provide preplacement and annual medical evaluations consistent with National Fire Protection Association (NFPA) 1582, which include a baseline electrocardiogram (EKG) in all individuals prior to engagement in any strenuous physical activity to rule out any underlying cardiac anomalies.***
- ***Ensure all firefighters are cleared for duty by a health care provider knowledgeable about the physical and psychological demands of firefighting.***
- ***Implement a mandatory wellness and fitness program for fire department members consistent with NFPA 1583 and the IAFF/IAFC Wellness-Fitness Initiative.***
- ***Perform an annual physical performance (physical ability) evaluation for all firefighters.***

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For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

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## Introduction

On April 21, 2018, a 33-year-old firefighter inmate trainee (trainee) collapsed during a physical fitness training and died. The National Institute for Occupational Safety and Health (NIOSH) contacted the affected correctional agency on July 13, 2018, to gather information and again on October 18, 2018, to initiate the investigation. On November 19, 2018, a firefighter safety specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) conducted an on-site investigation of the incident.

During the investigation, the NIOSH investigator interviewed the following agency personnel:

- Fire Chief
- Fire Captain
- Crew members
- Agency physicians

NIOSH personnel reviewed the following documents:

- Fire department standard operational procedures
- Facility incident reports
- Agency medical policies
- Emergency medical service (ambulance) report
- Autopsy and toxicology reports
- Agency physician records

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## Investigation

On April 21, 2018, the trainee began his first day of fire department training. The trainee was participating in a training exercise which involved hiking in terrain with an average 21.5-degree slope (800 feet of elevation in 0.6 miles) (see Photo 1 and Photo 2). The training program was administered by one of 27 institutional state fire departments throughout the agency. Trained agency personnel respond to medical and fire emergencies within the facility, as well as medical, fire and vehicle accident emergencies off the facility grounds.

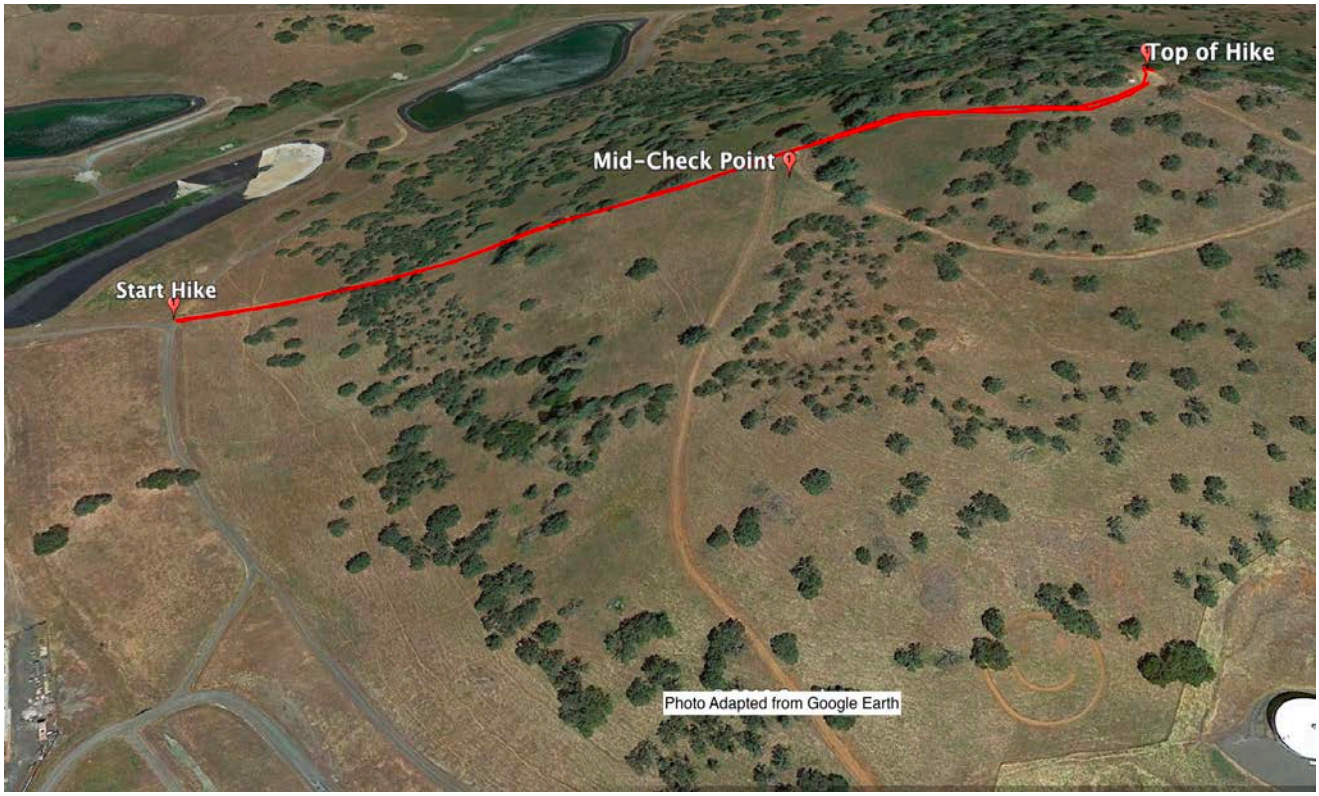


**Photo 1. The training hike (marked in red). Photo adapted from Google Earth.**

The temperature on the morning of April 21, 2018, was approximately 62 degrees Fahrenheit. At approximately 0700 hours the trainee, fire crews and the station captain began the training exercise. All wore full wildland personal protective equipment (PPE), including Nomex pants, Nomex jacket, helmet, gloves and web gear. In addition, the trainee wore a hose pack (approximately 75 pounds [lbs]).

Prior to the hike, an inmate crew member and the fire captain with a vehicle was positioned at the bottom of the hill. Additional crew members were positioned halfway, and at the top of the hill. All members had radios. An inmate safety crew member with medical pack hiked along with the trainee throughout the exercise. The safety member's medical pack consisted of oxygen, automated external defibrillator (AED), pulse oximeter and other basic first aid equipment.

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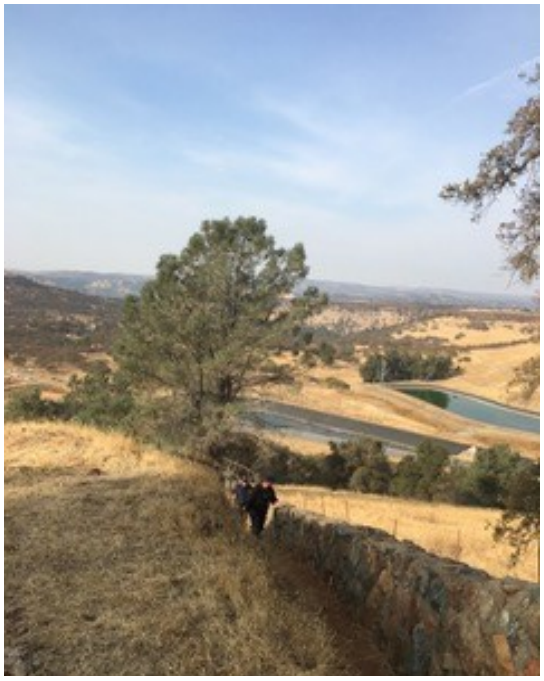

**Photo 2. Firefighters hiking up a portion of the trail (NIOSH photo).**

The trainee made the first of two trips up the hill at approximately 0711 without issue. Upon completion of the first trip at approximately 0720, the trainee was asked by the fire captain how he was doing, and the trainee replied, "I'm good." At approximately 0734, as the trainee neared the top of the climb for a second and final trip, he took a knee and said he needed to catch his breath. The crew members told the trainee he was only 25 feet from the top and it would be better to stand because it would be difficult to get back up. The trainee decided to take a knee anyway and as he took a knee, the crew assisted him taking his pack off to help him cool down. After a five-minute rest, the crew helped the trainee back to his feet, put his gear back on and he completed the climb to the top at 0750.

Once at the top, the trainee once again stated he needed to catch his breath. The crew told the trainee to drink some water while he rested and asked him if he wanted them to call for medical help, which he stated he did not, and just needed to catch his breath. The crew asked him questions to see if he was alert and oriented, which the trainee answered appropriately. Less than three minutes later, the crew noticed the trainee was not drinking water or moving and called out to him. He did not respond to their calls, so the crew immediately radioed the captain about the situation and that they needed medical help as they started a patient assessment. One crew member checked his pulse and breathing, as the second crew member rubbed his sternum. His pulse and breathing were slow, his pupils were unresponsive to light and he responded slightly to a sternum rub. The crew immediately started treating for heat exhaustion by removing the trainee's PPE, web gear and hose pack as the captain brought the vehicle to the top of the hill.

The trainee's condition continued to deteriorate as the support vehicle arrived. At approximately 0800 the crew loaded the trainee in the vehicle and began to drive down the hill to the fire station where an agency physician and staff would be waiting. As the crew responded down the hill, the trainee became pulseless and non-breathing and the crew immediately started cardiopulmonary resuscitation (CPR). The crew arrived at the fire station within two minutes of being loaded in the vehicle. The crew continued CPR as agency medical staff began advanced life support (ALS). The transporting ambulance arrived with paramedics at approximately 0825 and took over primary care as crews took turns performing CPR. Despite the efforts of fire crews, medical staff and paramedics the trainee died, and was pronounced at 0841 hours.

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## Medical Findings

The autopsy report, completed by the coroner's office, listed fatal cardiac arrhythmia due to cardiomyopathy as the cause of death. Contributing factors included intramural coronary disease, acute ischemia of the left ventricular myocardium and hypertrophy of the left ventricular myocardium. The trainee was 72 inches tall and weighed 220 pounds, with a body mass index (BMI) of 29 kilograms per metered squared ($kg/m^2$). A BMI of 25–29.9 $kg/m^2$ is considered overweight [CDC 2020]. The toxicology report identified no significant findings.

During the trainee's medical classification with an agency physician in June 2017, he met the criteria to be classified as low medical risk and he was assessed as having functional capacity for vigorous duty. The medical classification included a medical survey and range of motion exam. The trainee had no prior history of heart or respiratory problems, hypertension, no known family history of cardiomyopathy and was not taking any medications at the time of the incident.

## Fire Department

At the time of the NIOSH investigation, the agency maintained eight structural inmate firefighters in one fire station, as well as four paid shift captains and a full-time fire chief. The fire department provides fire and emergency medical response to the correctional facility, which includes ten structures with approximately 1 million square feet of housing and approximately 4,260 inmates. In addition, firefighters respond mutual aid to fires, vehicle accidents and medical emergencies to approximately 100 square miles surrounding the corrections facility.

## Employment and Training

The agency requires new inmate firefighter applicants to pass a medical evaluation, a candidate physical ability test and a personal interview. Structural firefighters are assigned to the fire department to begin First Responder, Firefighter 1 and Firefighter 2 training. Once the training is completed, the firefighter is allowed to respond on fire apparatus.

## Preplacement/Periodic/Return to Work Medical Evaluation

The agency requires medical evaluations for all firefighter applicants. Components of the medical evaluation include:

- Medical history survey
- Medical risk assessment
- Functional capacity assessment

Inmates arrive at one of six corrections reception facilities (five reception centers for men and one for women), and a medical evaluation is performed by a correctional health care services physician. After the inmate completes a medical history survey, the physician will then classify the inmate according to medical risk and functional capacity. Medical risk is classified into three categories: low risk, medium risk and high risk. The risk level is based on medical history and range of motion examination. Once the inmate has been evaluated for medical risk, the physician then determines the inmate's fitness for

duty. Work in a fire camp or work at the corrections fire department is open to inmates classified as low or medium medical risk and determined to be qualified functionally for vigorous duty.

## Wellness/Fitness Programs

Once approved by the physician and placed at a camp, new firefighter candidates begin with a four-week physical fitness conditioning program. Trainees start the conditioning program on the first day with a hill climb exercise that is timed to establish a baseline of fitness. After the four-week physical fitness conditioning program, all trainees once again participate in the same timed hill climb exercise to compare their improvement from the first day. A physical ability test is not conducted.

The trainee was participating in the initial hill climb to establish his baseline fitness level when he suffered sudden cardiac death. The trainee had no previous firefighting experience.

All firefighter trainees and members must participate in a physical fitness program. The fire department had some weightlifting equipment that they have acquired for strength training. The fire department did not have equipment for cardio training, such as treadmill, stair climber, or exercise bikes. In place of using cardio equipment, the trainees and members run, stair climb in the training tower, or pull tires while running when weather permits.

Members injured on duty are evaluated by an agency physician who determines the members' ability to work. The agency physician establishes the members' functional capacity level (vigorous duty, full duty, limited duty, totally disabled) and forwards their medical clearance opinion to the fire department. Members who are ill may be examined by a physician depending on the level of illness.

## Discussion

Cardiomyopathy is a broad term referring to an abnormal heart muscle that is not explained by coronary artery disease or conditions that overload the ventricles, such as high blood pressure or having to pump through a tight valve (aortic stenosis). One of the types of cardiomyopathy is called Hypertrophic Cardiomyopathy (HCM), a genetic condition that is caused by changes in the muscular components of the heart, leading to an abnormal thickening of the left side of the heart and making it harder to pump blood. The thickened heart muscle, along with the absence of other heart disease, suggest that HCM was the most likely condition of the trainee.

On a global scale, it is estimated that 1 in 500 people suffer from HCM. Oftentimes, patients with HCM go undiagnosed for years due to absence of clinical symptoms; however, in a small portion of people with HCM, the thickened heart muscle can cause shortness of breath, chest pain or problems in the heart's electrical system, resulting in life-threatening abnormal heart rhythms and sudden death. When diagnosing someone with HCM, a doctor must conduct a thorough family history and physical exam. In addition, an electrocardiogram (EKG – wires attached to skin over heart to measure electrical impulses) and echocardiogram (imaging study that allows a doctor to look for an abnormal thickening of the heart muscle and determine if the blood flow is obstructed) are two tests that should be

considered. Lastly, a goal of medical treatment of HCM is to relax the heart muscle and to slow the heart rate so that the heart can pump efficiently (beta blockers and calcium channel blockers).

In line with this particular case and the sudden death of an otherwise healthy male, a thorough review of the current literature was conducted to determine the best screening tool for this fatal and silent medical condition. Several studies have indicated that the utilization of a five-minute, non-conventional 12-lead EKG in determining HCM is extremely sensitive (93%) and specific (95.5%).

In those individuals with an abnormal EKG, it is recommended that a detailed imaging study of the heart (echocardiogram) is completed. The goal of an echocardiogram is to visualize the different structures of the heart and to determine if there is in fact thickness of the left side of the heart. In reading EKGs, there are no differences in accuracy between general practitioners as compared to specialists trained in this field, such as cardiologists.

In summary, a baseline EKG should be ordered and completed in all individuals interested in becoming a firefighter, and those with abnormal results should be assessed by a cardiologist where an echocardiogram will be ordered to rule out the possibility of HCM.

## Recommendations

NIOSH investigators offer the following recommendations to prevent similar fatal events, and to address general health and safety issues among firefighters at this and other fire departments across the country.

***Recommendation #1: Provide preplacement and annual medical evaluations consistent with National Fire Protection Association (NFPA) 1582, which include a baseline EKG in all individuals prior to engagement in any strenuous physical activity to rule out any underlying cardiac anomalies.***

In this incident, the physician conducted a medical evaluation and deemed him eligible for vigorous activity. As the fire department assumed the victim was medically fit for duty by the agency physician, the victim was asked to perform hill climbing as part of a baseline assessment for a four-week physical conditioning program. This hill climbing increased the cardiac demand on the victim and thereby his risk of sudden death from cardiac arrhythmia due to HCM.

After the victim was selected for firefighter duties, he did not undergo the comprehensive examination as recommended by NFPA 1582. The scope of the examination as recommended in NFPA 1582 is designed to evaluate symptoms of heart disease, as well as heart murmurs and abnormal rhythms that could suggest HCM. As part of the recommendations in NFPA 1582, a resting EKG and aerobic capacity assessment (stepmill or treadmill) should be performed at baseline, and annually over 40 years of age, to assess any cardiac abnormalities that could increase the risk of cardiac problems – including sudden death due to HCM – that could occur as a result of strenuous activity during firefighting. This is described in more detail in NFPA 1583 Standard on Health-Related Fitness Programs for Firefighters [NFPA 2015]. An abnormal EKG and aerobic capacity assessment can detect arrhythmias, presence of conduction defects, ischemic heart disease or cardiac enlargement, leading to

a further evaluation performed by a cardiologist that may include echocardiography. Had the trainee undergone the examination as advised by NFPA 1582, his HCM may have been detected and he would not have been medically cleared to become a firefighter.

***Recommendation #2: Ensure all firefighters are cleared for duty by a health care provider knowledgeable about the physical and psychological demands of firefighting.***

In accordance with NFPA 1582 [NFPA 2018a], the agency should require that health care providers be familiar with the physical demands of firefighting and the hazards firefighters encounter and should guide, direct and advise members with regard to their health, fitness and suitability for duty. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among firefighters, the NFPA developed NFPA 1582 Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2018a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The trainee did not have any known medical conditions that would have required restrictions; however, he did not have a baseline EKG. NFPA 1051 Standard for Wildland Firefighting Personnel Professional Qualifications sets forth the requirements to become a wildland firefighter including physical fitness and medical considerations. NFPA 1051 refers to NFPA 1582 Standard on Comprehensive Occupational Medical Program for [Structural] Fire Departments to use as a base process for medical clearance that should be adapted for specific wildland firefighter functions. [NFPA 2018a, 2020].

The health care provider should understand the physiological and psychological demands of firefighting and the environmental conditions under which firefighters perform, as well as the personal protective equipment they must use during various types of emergency operations. *(Refer to Appendix A for a list of essential job duties listed in NFPA 1582.)*

***Recommendation #3: Implement a mandatory wellness and fitness program for fire department members consistent with NFPA 1583 and the IAFF/IAFC Wellness-Fitness Initiative.***

Although health and fitness levels have not been shown to reduce the risk for sudden death due to HCM, health promotion programs for firefighters can reduce modifiable coronary heart disease risk factors and improve fitness levels, with mandatory programs producing the greatest benefit. Guidance for fire department wellness/fitness programs to reduce cardiovascular risk factors and improve aerobic capacity can be found in NFPA 1583 Standard on Health-Related Fitness Programs for Firefighters [NFPA 2015] and the Fire Service Joint Labor Management Wellness-Fitness Initiative (WFI) [IAFF-IAFC 2018]. In a joint letter [April 8, 2009], the California Chiefs Association, California Professionals Firefighters and California Governor's Office of Emergency Services have all recognized the International Association of Firefighters/International Association of Fire Chiefs Wellness-Fitness Initiative as a standard for California fire departments to determine fitness for duty [Zagaris et al. 2009]. Under this guidance, an annual EKG and aerobic capacity assessment stress test is recommended as part of a fitness for duty evaluation.

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***Recommendation #4: Perform an annual physical performance (physical ability) evaluation for all firefighters.***

NFPA 1500 recommends fire department members who engage in emergency operations be annually evaluated and certified by the fire department as having met the physical performance requirements identified in paragraph 10.2.3 of the standard [NFPA 2018b]. This is recommended to ensure firefighters are physically capable of performing the essential job tasks of structural firefighting. The physical ability test could be incorporated into the fire department's annual training program.

## References

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## Investigator Team Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiac/Medical Team, in Cincinnati, Ohio led by Dr. Wendi Dick. TJ Welch is a Firefighter Safety Specialist and co-authored the report with Dr. Dick. Mr. Welch is a State Certified Fire Officer, founding member of the California Incident Command Certifications System (CICCS), chaired the CICCS committee on Physical Fitness Standards, former Emergency Medical Technician and Chief Officer. Dr. Robert Harrison MD, MPH (California Department of Public Health) and Dr. Michael Shabaz, MD, MPH (University of California, San Francisco) provided medical consultation, and Laura Styles, MPH (Public Health Institute) also contributed to this report.

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## Appendix A

### NFPA 1582-Appendix C: Essential Job Tasks and Descriptions (NFPA 1582 Guidelines, 2018)

The fire department shall evaluate the following 14 essential job tasks against the types and levels of emergency services provided to the local community by the fire department, the types of structures and occupancies in the community, and the configuration of the fire department to determine which tasks apply to their department members and candidates:

1. While wearing personal protective ensembles and self-contained breathing apparatus (SCBA), performing firefighting tasks (e.g., hoseline operations, extensive crawling, lifting and carrying heavy objects, ventilating roofs or walls using power or hand tools, forcible entry), rescue operations, and other emergency response actions under stressful conditions, including working in extremely hot or cold environments for prolonged time periods.
2. Wearing an SCBA, which includes a demand valve-type positive-pressure face-piece or HEPA filter mask, which requires the ability to tolerate increased respiratory workloads.
3. Exposure to toxic fumes, irritants, particulates, biological (infectious) and non-biological hazards, and heated gases, despite the use of personal protective ensembles and SCBA.
4. Depending on the local jurisdiction, climbing six or more flights of stairs while wearing a fire protective ensemble, including SCBA, weighing at least 50 lb. or more and carrying equipment/tools weighing an additional 20 to 40 lbs.
5. Wearing a fire protective ensemble, including SCBA, that is encapsulating and insulated, which will result in significant fluid loss that frequently progresses to clinical dehydration and can elevate core temperature to levels exceeding 102.2°F.
6. While wearing personal protective ensembles and SCBA, searching, finding, and rescue-dragging or carrying victims ranging from newborns to adults weighing over 200 lbs. to safety despite hazardous conditions and low visibility.
7. While wearing personal protective ensembles and SCBA, advancing water-filled hoselines up to 2.5 in diameter from fire apparatus to occupancy [approximately 150 ft], which can involve negotiating multiple flights of stairs, ladders, and other obstacles.
8. While wearing personal protective ensembles and SCBA, climbing ladders, operating from heights, walking or crawling in the dark along narrow and uneven surfaces that might be wet or icy, and operating in proximity to electrical power lines or other hazards.
9. Unpredictable emergency requirements for prolonged periods of extreme physical exertion without benefit of warm-up, scheduled rest periods, meals, access to medication(s), or hydration.
10. Operating fire apparatus or other vehicles in an emergency mode with emergency lights and sirens.
11. Critical, time-sensitive, complex problem solving during physical exertion in stressful, hazardous environments, including hot, dark, tightly enclosed spaces, that is further aggravated by fatigue, flashing lights, sirens, and other distractions.

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12. Ability to communicate (give and comprehend verbal orders) while wearing personal protective ensembles and SCBA under conditions of high background noise, poor visibility, and drenching from hoselines and/or fixed protection systems (sprinklers).
13. Functioning as an integral component of a team, where sudden incapacitation of a member can result in mission failure or in risk of injury or death to civilians or other team members.
14. Working in shifts, including during nighttime, which can extend beyond 12 hours.