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NIOSH Fire Fighter Fatality Investigation and Prevention Program
Death in the line of duty...
A summary of a NIOSH fire fighter fatality investigation July 15, 2005

A Career Fire Fighter was Killed and a Career Captain was Severely Injured During a Wildland/Urban Interface Operation - California

SUMMARY

On October 29, 2003, a 38-year-old male career fire fighter (the victim) was killed and a 48-year-old male career Captain was severely injured when fire overran their position. The incident occurred during the protection of a residential structure during a wildland fire operation that eventually consumed more than 280,000 acres. The victim and his crew were part of a task force assigned to protect a number of residential structures located along a ridge on the flank of the fire. The victim's crew was in the process of preparing to defend the structure when the fire made a slope and wind-driven run through heavy brush directly toward their position. The crew retreated to the residential structure to seek refuge from the oncoming fire. Two of the four crew members were able to get into the structure while the Captain was attempting to assist the victim as the fire reached their position. The victim died near the structure and the Captain, who was seriously burned, had to be assisted into the structure by the other crew members.

NIOSH investigators concluded that, to minimize the risk of similar occurrences, fire departments and fire service agencies should:

- ***ensure that the authority to conduct firing out or burning out operations is clearly defined in the standard operating procedure (SOP) or incident action plan (IAP) and is closely coordinated with all supervisors, command staff and adjacent ground forces***
- ***ensure that all resources, especially those operating at or near the head of the fire, are provided with current and anticipated weather information***
- ***stress the importance of utilizing LCES (Lookouts, Communications, Escape Routes and Safety Zones) to help identify specific trigger points (e.g., extreme fire behavior, changes in weather, location of fire on the ground, etc) that indicate the need for a crew to use their escape route(s), and/or seek refuge in a designated safety zone***
- ***ensure that, at a minimum, high-risk geographic areas are identified (e.g.; topography, fuels, property, etc.) as part of the pre-planning process and provide this information to assigned crews***
- ***ensure that incident command system (ICS) span-of-control recommendations are maintained***

- ***consider the implementation of a carbon monoxide-based monitoring program for wildland fire fighters***

Additionally,

- ***State agencies, local municipalities and community organizations should consider developing statewide guidelines and local community plans for managing fuels in the wildland/urban interface***

- ***Fire departments and fire service agencies should provide members with annual medical evaluations consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments***

- ***Standard setting bodies (e.g., NFPA, NWCG, etc.) should consider developing a national standard that fire fighters can utilize during wildfire incidents for identifying and marking wildland/urban interface properties based on the ability to defend the structure(s) located on that property***

Incident Scene

INTRODUCTION

On October 29, 2003, a 38-year-old male career fire fighter (the victim) was killed and a 48-year-old male career Captain was severely injured when fire overran their position while protecting a residential structure during a wildland fire operation. The National Institute for Occupational Safety and Health (NIOSH) was notified of this incident on October 30, 2003 by the U.S. Fire Administration (USFA). On November 18, 2003, a Safety and Occupational Health Specialist and the Senior Investigator from the NIOSH Fire Fighter Fatality Investigation and Prevention Program conducted a site visit where photographs of the incident scene were taken. A meeting was held with an Assistant Chief and Unit Forester from the California Department of Forestry and Fire Protection (CDF). On November 19, 2003, a phone interview was conducted with the home owner of the incident site.

On February 3, 2004, a meeting was conducted with a Deputy Chief from the victim's fire department. On February 3-5, 2004 and March 17-19, 2004, interviews were conducted with the officers and fire fighters from the Task Force involved in this

incident. On March 19, 2004, a meeting was held with the Chief Deputy Director and Departmental Safety Officer of the CDF. The NIOSH investigators reviewed copies of the Incident Action Plan (IAP) distributed on the day of the incident, the Sheriff department's incident report, the CDF Green Sheet, the county medical examiner's report, the report produced by the victim's fire department, and the report produced by the CDF.

On September 2, 2004, an occupational medicine physician with the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to California to meet with and interview the Deputy Chief from the victim's fire department and the victim's widow. During this visit, the victim's medical records were accessed and subsequently reviewed.

Victim's Fire Department

The victim's fire department serves a population of approximately 60,000 in an area of approximately 71 square miles. The department has five fire stations and 70 uniformed fire fighters. The victim's fire department is approximately 500 miles from the incident site.

Training and Experience

The victim was a California State Board certified Fire Fighter Level I and II, Fire Officer, Fire Instructor, Driver/Operator, First Responder, and Emergency Medical Technician (EMT)/Paramedic. The victim's wildland fire fighter training consisted of National Wildfire Coordinating Group (NWCG) certified S-130/131/190 (Fire Fighter Training/Advanced Fire Fighter Training/Introduction to Wildland Fire Behavior), S-212 (Wildfire Power Saws), S-234 (Ignition Operations), S-270 (Basic air operations), S-290 (Intermediate Wildland Fire Behavior), ICS I-200 (Basic Incident Command System), and ICS I-300 (Advanced Incident Command System). The victim had 18 years of structural and wildland fire fighting experience.

Equipment and Personnel

There were approximately 3,662 fire fighters assigned to this fire at the time of the incident. Crews and equipment resources were assigned as follows: 35 single resource and 6 strike team hand crews; 48 single resource engines; 97 strike teams/task forces; 12 single resource dozers; 27 water tenders; and 605 overhead (managers, supervisors, etc).

The victim's crew was assigned to a Task Force that consisted of:

Task Force Leader and Aide – Battalion Chief and Battalion Chief Aide Engine 6162 (Type III) – Captain (second- and third-degree burns affecting approximately 28% of his body and respiratory burns to 30% of his lungs and upper airway), Driver/Operator (some first- and second-degree burns on face, hands and back), fire fighter (minor inhalation injuries and some first-degree burns on face and back), and an Engineer (the victim)

Engine 5214 (Type I) – Captain, Driver/Operator, and two fire fighters

Engine 24 (Type I) – Captain, Driver/Operator, and two fire fighters

Engine 334 (Type III) – Captain, Driver/Operator, and two fire fighters

Federal FD (Type I) – Captain, Driver/Operator, and two fire fighters

The fire was under Unified Command with the United States Forest Service, the California Department of Forestry and Fire Protection (CDF), and local government.

Weather Conditions

At the time of the incident a strong onshore pressure gradient had developed with sustained winds of 17 miles per hour (mph), and gusts of up to 31 mph out of the west. At approximately 1430 hours, the temperature was 70 degrees Fahrenheit with a relative humidity (RH) of 30%.

Incident Site Description

Size – The incident site was a privately owned home situated along a ridge top that runs in a north-northeast direction. The incident site was a small segment of a much larger wildland fire that consumed approximately 280,278 acres and destroyed 2,232 residential structures, 22 commercial buildings, and 566 outbuildings, damaging another 53 structures and 10 outbuildings.

Topography – The incident site was located on a ridge at an elevation of 3,800 feet, 400 feet above the bottom of the drainage, with west facing slopes ranging between 12-20% (Map 1).

Vegetation – The fuel models in the immediate area of the incident site were Fuel Model 4-brush (with at least 90% crown closure) and Fuel Model 1-grass (Glossary of Terms). Live fuel moisture values were below critical levels.

Fire Behavior – There was a sustained run from the west/southwest directly to the incident site, as the flanking fire established on the west facing slope below the incident site. Flame lengths were calculated to be in excess of 78 feet, fire line intensities in excess of 73,989 BTU/ft/sec, and rates of spread in excess of 16 miles per hour (for the maximum wind speed recorded at 31 mph). The fire took a little under 2 minutes to travel from the bottom of the slope to the top, a distance of .46 miles. All fuels, both dead and live, were totally consumed below the incident site.

Sequence of Firing Operations (Map 2)

Residence #1 – CDF FAE (fire apparatus engineer) began firing out around the structure while the CDF Captain drove down the dirt road where he met up with Engine 334. He then instructed them to proceed to Residence #1 to support the firing operation.

Two dozers and a Hotshot crew arrived at the north end of the dirt road. One dozer and part of the Hotshot crew started working near Residence #1 and began direct perimeter control in that area.

Engine 6162 crew began clearing brush along the driveway to Residence #2 while the Captain assessed the area around the structure. Although the Captain had concerns, after further assessment, the crew determined that the structure is defendable and decides to stay.

Residence #3 – CDF Captain and FAE arrived and began firing out operations approximately 100-150 feet to the west of the structure. The FAE laid fire on the ground, from south to north, in the shape of an arc. He continued in a straight line from the top of the arc toward the structure at Residence #2. Fire quickly spread to the east but was knocked down by a bucket drop from Helo 523EH. The FAE discontinued his firing operation at Residence #3.

Residence #2 – The CDF Captain and FAE drove their vehicle to Residence #2 and parked near the garage. The Captain instructed the FAE to begin firing out from the garage toward the driveway and to continue in a northerly direction toward the unimproved lot to the south of Residence #1.

THE CDF Captain and Captain of Engine 6162 did not make contact with each other.

The Superintendent of the Hotshot crew, while standing in the meadow (safety zone), observed unexplained fire along the ridge between Residence #3 and Residence #2 and then between Residence #2 and Residence #1. He radioed his crew who informed him that they were not conducting firing operations. He ordered them to retreat to the meadow.

Residence #4 – The CDF Captain and FAE drove south on the dirt road to Residence #4 where they began firing operations around the structures. Fire spread to the brush and ignited an outbuilding. The fire intensified and cut off the egress of Engine 24. Engine 24 had been assigned by the Task Force Leader to protect the structure.

INVESTIGATION

The fire was reported on Saturday, October 25, 2003, at about 1737 hours. Under the State's mutual-aid system, a Task Force was established two days later to help combat the fire which included the victim's Engine, four other Engines, and a Task Force Leader. The victim was assigned to Engine 6162 of the Task Force. Engine 6162 was dispatched at 2130 hours on October 27, 2003 and headed for a rendezvous site with the Task Force Leader and two other engine crews. The Task Force Leader and three engines left the rendezvous site at approximately 2359 hours. A third engine crew was met en route. The crews drove the 500 miles to the incident base site where they arrived at approximately 1100 hours on the morning of October 28, 2003.

The task force was in the staging area approximately three hours before receiving an assignment (at 1400 hours) to provide structure protection. A fifth engine (Type I) crew

was assigned to them at this time. The task force worked with a number of crews providing structure protection until they were relieved to return to the incident base at approximately 2130 hours.

On October 29, 2003, the Task Force leader attended the morning briefing at 0700 hours. The crew was assigned to a Branch and Division on a flank of the fire. The Task Force Leader met with the Division Supervisor at this time for any additional instructions and information. The Task Force Leader then met with his crews and briefed them on their assignment before proceeding to the rendezvous point (approximately 40 miles from the staging area) where they would meet with the rest of the Division (Photo 1). The task force arrived at the rendezvous site and was assigned to provide structure protection. The Task Force Leader then received a map and debriefing from a Strike Team Leader that had been working in the area. Fire fighters reported to NIOSH investigators that the fire at this time was moving slowly with spot fires on both sides of the state road. The crews began mopping up operations in a small subdivision on the south side of the road before receiving a new assignment at 1100 hours (Photo 1).

At approximately 1150 hours, the pilot of Helicopter 523EH noticed spot fires near Residence #1. The helicopter operation was then moved to the ridge on the east side of the drainage where they are assigned to protect structures. The Task Force Leader arrived at the ridge and begins to size-up the structures, beginning with Residence #1. At approximately the same time, a California Department of Forestry (CDF) Captain and a Fire Apparatus Engineer (FAE) arrived on the ridge in a pickup truck (Utility 3334) and drive to Residence #1.

At approximately 1200 hours, most of the crews arrived at the ridge where they would provide structure protection (Map 1). The single lane dirt road runs along the east side of, and parallel to, the ridge top. There is a large open field to the east (designated as the safety zone). There were four separate residences (Residence #1, #2, #3 and #4), a water tower near Residence #1, and a storage barn along the east side of the road (Map 1). The Task Force Leader determined that he was going to red flag[a] Residence #1 and Residence #3 as he deemed them "not saveable." Engine 334 was not with the Task Force at this time as they had headed into the nearest community searching for a hydrant to refill their Engine's water tank. The Task Force Leader drove to the end of the single lane dirt road to conduct his size-up in determining where to deploy his crews. The CDF FAE begins firing out around Residence #1 while the Captain proceeds in Utility 3444 down the dirt road.

At approximately 1215 hours, Engine 6162 was assigned to protect Residence #2 (the incident site) and Engine 24 to protect Residence #4. Engine 5214 was staged at the storage barn along the east side of the road.

A Hotshot crew and two bulldozers arrived at Residence #1 with part of the Hotshot crew and one of the bulldozers beginning direct perimeter control in that area. Engine 6162 crew proceeded up the driveway of Residence #2 while the victim and a fellow crew

member cleared overhanging brush near the driveway. The driver positioned Engine 6162 approximately 60 feet to the south of the structure (Photo 2).

The Engine 334 crew was staged at the storage barn when a CDF Captain (the same captain that had met with the Task Force Leader) approached the Captain from Engine 334. The CDF Captain informed him that he had already begun burnout operations near Residence #1 and that if they didn't get up there soon they would lose the structure. The Engine 334 Captain radioed the Task Force Leader for further instructions. The Task Force Leader ordered them to head up to Residence #1 to see what they could do. The Task Force Leader proceeded down the driveway to the dirt road heading toward the storage barn where he saw bulldozers heading toward the north end of the ridge and Residence #1.

The Captain of Engine 6162 determined that the site was defensible due to the large cleared area (approximately 150 feet of brush) around the west side of the residence (Photo 2). The Engine 6162 crew had a clear view of the west and northwest. Tall brush and drifting smoke obscured their view to the southwest. They observed smoke from the fire to the north which was flanking towards them and posed the greatest threat to their position. Small runs of fire were taking place across the canyon on the west side of the drainage (Map 1 and Photo 1). The crew also noted an up-canyon and up-slope wind, at about 7-10 miles per hour. The crew decided to clear the grass and brush (manually and with fire) below the house. Two fire fighters from Engine 6162's crew were now using drip torches to burnout the grass below Residence #2 (Photo 3). The victim manned a 1 ½-inch handline while burning a brush pile near the Engine while the Captain used a drip torch to burnout the vegetation near the driveway. Fire could be seen to the north and west of their position where three helicopters were making bucket drops.

At approximately 1225 hours, the CDF Captain and FAE arrived in a pickup truck and began lighting fire near the garage without speaking with the Captain from Engine 6162 (Photo 2 and Map 2). The Captain from Engine 6162 saw the CDF Captain and fire fighter and believed that they had seen him near the house. Approximately 15 minutes later, the crew noticed that the fire activity below them was beginning to increase.

The Task Force Leader was coming down the driveway after red flagging Residence #3 when he ran into the CDF Captain and fire fighter that had been seen earlier at Residence #2 by the Captain from Engine 6162. The CDF Captain told the Task Force Leader that "they need to put some fire on the ground or they're going to lose the houses." The CDF Captain and fire fighter, carrying a drip torch, headed into the brush just to the north of Residence #3. The Task Force Leader reported to NIOSH investigators that flames, 10-15 foot tall, could be seen in the brush just minutes after the CDF Captain and fire fighter entered the brush. The CDF Captain and fire fighter then came out of the brush, got into their truck, and drove away without any further conversation with the Task Force Leader.

The Engine 6162 crew began to observe an increase in fire activity down slope from their location as fire was now making an up-canyon, up-slope run in the heavy brush and oak fuels (Photo 4). The fire was wind driven and was making a continuous run toward

Residence #2, covering a distance of approximately one-half mile in about two minutes. The Engine 6162 crew gathered behind their Engine as the fire intensity increased. The victim manned a 1 ½-inch handline at the rear of the apparatus while another fire fighter manned a handline at the front. The fire fighter on the handline at the front of the apparatus had to extinguish the juniper bushes on the patio behind them as hot embers began blowing into the brush near the residential structure. Conditions were beginning to deteriorate quickly as the smoke began reducing visibility and the heat intensified. The crew members reported to NIOSH investigators that the sky began to glow orange and that the heat appeared to be coming from the south or southwest (behind them). There was a significant increase in the wind as the flame front blew across the driveway near the garage cutting off their escape route (Photo 2). The ornamental bushes between Engine 6162 and the house began to burst into flames.

The Captain ordered the crew to seek refuge inside the residential structure. The fire fighter and driver/operator ran for the patio that led to the rear of the structure, broke out a window of the back door and reached inside to unlock it. The Captain noticed that the victim was not following them. He turned back to look for the victim, who was still standing near the rear of the apparatus, and noticed that the victim appeared to be disoriented. The Captain yelled for the victim to move to the structure. The victim was slow to respond to the Captain's order and actually appeared to begin walking in the opposite direction. The Captain continued to yell to the victim before the victim turned and began walking toward the Captain. The victim had only taken a couple of steps before he fell to the ground. The victim was able to stand back up under his own power before he turned and walked toward the tailboard of the apparatus. The victim then turned and fell into the burning bushes (ornamental shrubs planted by the homeowner) near the patio. The Captain grabbed the victim and assisted him toward the structure. The victim was moving under his own power but appeared to the Captain to be slightly hunched over at the waist. The Captain heard the victim reply that he was "burning up" but the Captain did not see any visible fire on the victim. The victim fell for the final time as he and the Captain reached the patio along the south wall of the residential structure. The victim fell to his knees and landed face down without any attempt on his part to brace his fall. The victim was unresponsive as the Captain attempted to move him. The Captain made a radio transmission stating that he had a "fire fighter down." It was at this time that the Captain began receiving the majority of his burn injuries. The Captain dropped his portable radio as it became too hot to hold and was forced to retreat to the rear of the structure where he was met by his fire fighter and driver/operator. Fire was now reportedly blowing over the patio with such intensity that no further attempts to find and assist the victim were feasible. The Captain, fire fighter, and the driver/operator sought refuge in the house.

Additional attempts were made to look for the victim but the intense heat forced the crew members back inside the structure. The driver/operator was eventually able to make it to the Engine where he grabbed the handline and attempted to extinguish the fire on the patio where he could see the victim lying face down (Photo 2). He quickly ran out of water as the hose at the rear of the engine had burned through and the tank had been pumped dry. The driver/operator went back inside the structure that was now burning

with the interior filling with smoke. They decided to make a run for the Engine where they were able to escape as the driver/operator drove Engine 6162 down the driveway to the single lane dirt road. They proceeded south along the dirt road where they met up with a Hotshot crew. At approximately 1310 hours, advanced life support ambulances and medical helicopters were requested. The Captain, fire fighter, and driver/operator were transported, via various helicopters to the county burn center for treatment. The victim's body was recovered from the scene the same day.

Crews from the Task Force operating to the south and north of the incident site reported that they too had experienced extreme fire behavior at approximately the same time as the fatal event.

The Engine 334's crew assigned to Residence #1, and Engine 24's crew, assigned to Residence #4, also reported experiencing a very similar situation to that of the Engine 6162's crew. Their escape routes had been temporarily cut off as the intensity of the fire from the firing out operation increased. Engine 334's crew reported to the Task Force Leader that their visibility was extremely limited and that there were numerous spot fires in their area. The Engine 334 crew was able to use handlines to protect themselves while CDF helicopters made bucket drops on the fire and a dozer cut a line increasing their defensible space. They were eventually able to escape without any serious injuries.

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[a] An agency practice identifying those structures requiring too many resources (e.g., manpower, equipment, time, etc.) to safely and effectively mitigate prior to the fire's arrival.

MEDICAL FINDINGS

The death certificate and autopsy report were completed by the County's Office of the Medical Examiner. The report listed "thermal injuries" as the cause of death on October 29, 2003. Significant findings from the autopsy included extensive burns over the entire body, no evidence of underlying cardiovascular or pulmonary disease, and a carboxyhemoglobin level of 27% (confirming significant exposure to carbon monoxide prior to his death).

The victim had a history of "allergen induced asthma" that seemed to have seasonal exacerbations. The condition was first diagnosed in 1999 by his personal physician and subsequently shared with the physicians providing occupational medicine services to the Fire Department. He was prescribed bronchodilators and steroid inhalers for his asthma which could be considered mild because he never required any of the following: hospitalizations, emergency medical care (e.g. a hospital emergency department), oral corticosteroids, or work restrictions. In August, 2003 the victim had his lungs tested as part of the fire department's annual medical evaluation. Off medication, his pulmonary

function tests were completely normal (FEV_1 was 99% and his FVC was 96% of predicted values for someone of his age, height, and gender).

RECOMMENDATIONS/DISCUSSIONS

Recommendation #1: Fire departments and fire service agencies should ensure that the authority to conduct firing out or burning out operations is clearly defined in the standard operating procedure (SOP) or incident action plan (IAP) and is closely coordinated with all supervisors, command staff and adjacent ground forces.

Discussion: It may be advantageous or necessary to conduct firing or burn-out operations in certain areas during a fire. Each and every fire fighter must be assigned to a team of two or more and be given specific assignments when conducting such an operation.[1] Firing out operations is a way of attacking a very intense fire. Burning out is used to widen a control line by eliminating unburned fuels between the control line and an advancing fire front.[2] Any firing out or burning-out operation requires considerable preparation, organization and coordination. Safety must be given first priority. No operation, regardless of strategic importance or other critical factors, is worth risking human life.[3] Overall fire strategy and authorities must be clear to all personnel employing firing out or burning-out, since fire behavior or fire control operations on adjacent divisions are likely to be affected.[4]

Regardless of the purpose and which tactic is chosen, certain basic safety procedures should be followed when conducting firing out or burning-out operations because any additional fire may increase the risk to life and property.

The following are examples of safety guidelines pertinent to this incident:

- Firing operations should be supervised by qualified personnel
- Firing operations should be coordinated with incident command and crews operating in the area
- Firing operations should be done by trained personnel that have authorization from their supervisor and the command staff
- Constant radio communications must be maintained so firing operations can be coordinated with other fireline operations
- Escape routes and safety zones should be identified and clearly marked before starting firing or burn-out operations
- If firing out becomes too intense for the crews to control, it should be stopped until control is regained and the firing operation is modified to reduce the intensity
- Firing operations should be initiated from and terminated at an anchor point.[2]

Recommendation #2: Fire departments and fire service agencies should ensure that all resources, especially those operating at or near the head of the fire, are provided with current and anticipated weather information.

Discussion: A "Fire Weather Watch" indicates a possible critical fire weather pattern (i.e., strong wind, dry lightning, dry cold front, low relative humidity.) A "Spot Weather Forecast" should be requested for fires that have potential for extreme fire behavior, exceed the initial attack, or are located in areas for which a "Fire Weather Watch" or "Red Flag Warning" has been issued.[5]

A "Fire Weather Watch" had been issued at 0900 hours for this fire on the day of the incident. The victim's crew was not aware of the "Fire Weather Watch" issued earlier that day and not provided with a "Spot Weather Forecast."

Recommendation #3: Fire departments and fire service agencies should stress the importance of utilizing LCES (Lookouts, Communications, Escape Routes and Safety Zones) to help identify specific trigger points (e.g., extreme fire behavior, changes in weather, location of fire on the ground, etc) that indicate the need for a crew to use their escape route(s), and/or seek refuge in a designated safety zone.

Discussion: In the wildland fire environment, Lookouts, Communications, Escape Routes, Safety Zones (LCES) are key to safe procedures for fire fighters. The elements of LCES form a safety system used by fire fighters to protect themselves. LCES is a self-triggering mechanism that allows the lookout to continuously assess and reassess the fire environment and to communicate those threats to fellow crew members.[5] Being on the alert to the indicators of extreme fire behavior will help fire fighters identify established trigger points (e.g., increased spotting, approaching weather front or change in wind direction, etc). Trigger points allow crews the necessary time to utilize escape routes to reach safety zones. Seeking refuge in an apparatus or permanent structure should not be considered a safety zone but rather a survival site. Key points regarding shelter deployment, building refuge and vehicle refuge can be found in the Fireline Handbook and the Incident Response Pocket Guide.[5, 6]

Radio communications allow lookouts, supervisors, crew members and air resources to warn crews of any situational changes in weather and fire behavior. Ample warning of changing conditions would provide fire fighters with the necessary time to utilize escape routes to the designated safety zone(s).

Individual crews observed the fire from their individual vantage points. There were no assigned or designated lookouts for the Task Force or adjacent ground forces operating on or near the ridge to observe and communicate their observations of the fire's progress up the drainage.

There are numerous examples of where communication was effective among individual crews but not between crews. One example of a successful outcome involved the Hotshot crew operating at the north end of the ridge. Their supervisor, standing in the safety zone, ordered his crew to his location after he observed an increase in fire activity along the ridge. Unfortunately, this radio transmission was made on the Hotshot crew's tactical channel and was not heard by the victim's crew or other crews operating on the ridge.

Recommendation #4: Fire departments and fire service agencies should ensure that, at a minimum, high-risk geographic areas are identified (e.g.; topography, fuels, property, etc.) as part of the pre-planning process and that that information is provided to assigned crews.

Discussion: Pre-incident plans are guidelines intended to assist fire officers in establishing priorities and making fireground decisions. The pre-incident plans should be reviewed at least annually and updated as needed.[2] Copies of pre-incident plans should be made available to all assigned crews. The pre-incident plans should contain, at a minimum; **maps** (showing topography, possible staging areas, target hazards, access routes, water sources, and possible facilities such as base camps, helibases, and helispots), **list of special concerns/needs** (special hazards, fuels, expected fire behavior, etc.) and **history of previous fires**, an invaluable resource for out-of-area crews providing mutual-aid.

In this incident, none of the officers or fire fighters assigned to the Task Force had ever fought a wildland fire in this region of California. Fire history, fuels, weather, topography and crew training/experience varies throughout the state. This creates a situation where crews may be unfamiliar with local factors affecting fire behavior and is listed as one of the eighteen "Watch-Out" situations taught to all wildland fire fighters - "Unfamiliar with weather and local factors influencing fire behavior"[5] that have been identified as a contributing factor in wildland fire fighter fatalities.

The CDF Green Sheet and the report produced by the victim's fire department both pointed out that an incident involving the deaths of 11 fire fighters, occurred less than 1.5 miles southwest of the entrapment site under very similar weather conditions in November of 1957. This information was not made available to the victim and his crew.

Recommendation #5: Fire departments and fire service agencies should ensure that incident command system (ICS) span-of-control recommendations are maintained.

Discussion: Span-of-control refers to the number of personnel reporting to any given individual. Optimum span-of-control in the incident command system (ICS) is five, with an acceptable spread of two to seven. On a situation that is not yet under control, no one operating under ICS should have more than five personnel reporting to him or her. Span-of-control ratios can be driven by a number of factors such as the training and experience of the fire fighters, complexity of the incident, or the type or timeframe of the incident.[7]

This incident can best be described as a fast moving complex incident that would have required a tight span-of-control. The span-of-control at the Division level on this incident was 27 to 1 and exceeded the acceptable ratios as outlined by the ICS.

Recommendation #6: Fire departments and fire service agencies should consider the implementation of a carbon monoxide-based monitoring program for wildland fire fighters.

Discussion: Crew members reported that the victim reacted in a confused or disoriented manner during the critical minutes as the fire approached. Hypoxia, the reduction of oxygen in blood or tissues, can cause an altered mental status and the victim had two potential reasons for hypoxia: carbon monoxide poisoning and/or a severe asthma attack.[8] An asthma attack of sufficient severity to cause hypoxia typically is preceded by symptoms of respiratory distress such as shortness of breath, difficulty breathing, wheezing, or chest tightness.[9] According to his crew members, the victim never displayed any of these symptoms. The NIOSH medical investigator considers asthma an unlikely cause due to the lack of symptoms, coupled with the victim's relatively mild underlying asthma.

Hypoxia due to carbon monoxide poisoning is a more likely scenario. Although wildland fires generally do not expose fire fighters to high levels of carbon monoxide averaged over an entire work shift, they can expose fire fighters to dangerous concentrations for short periods of time during specific activities.[10-12] In addition, carbon monoxide exposures were found to be higher during prescribed burns, presumably because fire fighters feel compelled to keep the fire within prescribed boundaries at all costs.[13] "The increasing problem of residential influx to wildland areas may cause more overexposure to smoke as firefighters feel compelled to protect structures despite heavy smoke situations."[13]

At approximately 1100 hours, the victim was exposed to carbon monoxide during mop-up operations for about 50 minutes. At approximately 1215 hours, the victim was protecting a residential structure by supervising a "burn pile;" a small "prescribed burn" to reduce fuel load around the home. To control the pile, water was applied to the ground around, and onto, the pile. The latter activity probably increased the pile's generation of carbon monoxide due to incomplete combustion. He did this for approximately 25 minutes before the fire conditions dramatically deteriorated. In addition, the victim encountered conditions that may have increased the severity of the exposure: exertion related increase in minute ventilation (how fast and deep the individual was breathing), long duration of exposure (approximately 30 minutes at the scene, about 50 minutes of mop-up in the late morning, and at least 12-hours during the previous shift), altitude (3800 feet), simultaneous exposure to airborne irritants (wildland fire smoke), and proximity to engine tailpipe exhaust.[14, 15] During the autopsy, a carboxyhemoglobin level of 27% was found, demonstrating his significant exposure to carbon monoxide. Although carboxyhemoglobin levels do not correlate well with clinical findings, profound unconsciousness has been reported with levels less than 20%.[16, 17]

While these findings can explain the victim's confused behavior, it is unclear why his Captain and other crew members, working under similar conditions, did not experience symptoms or signs of carbon monoxide poisoning. Upon hospital admission, the Captain had a carboxyhemoglobin level of 4.6%. Prior to hospital admission, the Captain's resuscitation efforts included intubation and administration of 100% oxygen; measures that speed the elimination of carboxyhemoglobin. Assuming he was intubated and receiving 100% oxygen for about one hour prior to his carboxyhemoglobin level being drawn, the Captain's estimated peak carboxyhemoglobin level would have been

approximately 9.2%.[18, 19] Possible explanations for the discrepancy between the Captain's and the victim's carboxyhemoglobin levels include: 1) the victim had higher exposures to carbon monoxide due to any of the factors listed in the previous paragraph, or 2) individual variation.

Fire management and safety officers responsible for health and safety of fire fighting personnel should consider using CO monitors to manage fire fighter's acute overexposure to components of smoke. To monitor acute exposures, field personnel need to calibrate and activate a CO monitor during wildland fire fighting operations. The monitors are already set to alarm at certain levels, and can be used as an "early warning device" to trigger actions to reduce exposures. Managers should also develop a written smoke exposure plan. This plan should focus on responding to CO monitor warning alarms, and include health surveillance, training, and tactics to minimize exposure.[5, 20] Since smoking increases CO levels, encourage smokers to quit and non-smokers to not start. The victim and the Captain of E-6162 were non-smokers.

Additionally,

Recommendation #7: State agencies, local municipalities and community organizations should consider developing statewide guidelines and local community plans for managing fuels in the wildland/urban interface.

Discussion: A number of organizations at the state and national levels provide community leaders and citizens with guidelines that can be utilized in identifying specific threats to life and property (i.e., wildfires), best practices and available resources.

The following are links that provide information regarding the wildland/urban interface:

- http://www.cafirealliance.org/default.php
- http://www.fire.ca.gov/php/
- http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/FirePlan.asp
- http://www.firewise.org/

The incident site occurred in a community that was identified and designated by the California Fire Alliance as having a Hazard Level Code of 3, indicating the highest fire threat level. The surrounding communities also had a Hazard Level Code of 3.

These communities were in the process of establishing a committee to deal with the threat of a wildfire when the incident occurred. The homeowners of Residence #2 had cleared a large portion of the wildland brush in all directions surrounding the house.

Approximately 70 feet of brush had been cleared to the east, 180 feet to the west, 100 feet to the south, and 115 feet to the north of the house. There was extensive management of the landscape vegetation and grounds surrounding the incident site that consisted of a mix of herbaceous plantings, a juniper hedge (near patio where victim was found), small woody shrubs, a few small fruit trees and larger diameter oak trees.

Recommendation #8: Fire departments and fire service agencies should provide members with annual medical evaluations consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Discussion: The affected fire department had already implemented a comprehensive annual medical evaluation program. In addition, the victim's personal physician appropriately shared medical information (i.e. his asthma diagnosis) with the fire department physician, but not other fire department or city officials. The fire department physician (employed by a Health Maintenance Organization under contract with the fire department) assessed whether this condition could affect the victim's ability to safely perform the job. Specifically, they noted the victim never required any of the following for this asthma: hospitalizations, emergency medical care (e.g. a hospital emergency department), oral corticosteroids, or work restrictions. In addition, the victim had normal PFTs as described in the above medical findings section.

According to NFPA 1582, asthma compromises a member's ability to perform several essential job tasks of structural fire fighter.[21] However, the NIOSH occupational medicine physician and investigators believe the fire department physician appropriately evaluated the fire fighter's underlying lung condition off his asthma medications. Since 1) these PFTs and chest X-rays were normal, 2) his condition was easily controlled with intermittent use of inhalers, and 3) in four years his condition never affected his ability to perform the duties of a structural fire fighter, NIOSH investigators agree with the fire department physician's decision to clear this fire fighter for unrestricted duty.

Recommendation #9: Standard setting bodies (e.g., NFPA, NWCG, etc.) should consider developing a national standard that fire fighters can utilize during wildfire incidents for identifying and marking wildland/urban interface properties based on the ability to defend the structure(s) located on that property.

Discussion: A structure triage checklist or assessment sheet is an invaluable tool when evaluating and identifying structures that can be successfully protected during a wildland fire incident. The evaluation (triage) of a structure by an officer (preferably a wildland/urban interface protection specialist[b]) is but one part of the size-up process when determining if a structure can be protected from an approaching wildland fire. The safety of fire fighters must be the primary consideration when evaluating whether a structure can be successfully protected. There are three categories of structures: those that are **not threatened**, those that are **hopeless** or too dangerous to protect, and those that will be **threatened** and have the potential of being saved.[4] Determining which category a structure will fall into should be based upon a logical process of determining anticipated fire behavior, estimating the capabilities and availability of resources, and analyzing the defensible space around the structures.

The ability to identify structures that are or are not saveable must be communicated to other fire fighters in the area. A national standard, utilizing alpha-numeric characters or symbols, is needed to provide the wildland/urban interface protection specialist with a means to communicate his findings to other emergency service personnel. Examples

include: a large A or 1 spray painted in fluorescent orange on the driveway near the road would indicate that the structure on that particular property is saveable, whereas a large X or 3 would indicate that the structure is not saveable. Symbols such as an X (not saveable), a large circle (not threatened), or a square (threatened but saveable) could also be utilized as a means to communicate the triage findings of the officer (urban interface specialist). A national standard would provide a system that would allow all fire fighters, who may have responded from various regions of the state or country, to understand which structures have been identified as not saveable, not threatened or threatened but saveable.

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[b] A wildland/urban interface protection specialist is an individual that meets or exceeds the minimum requirements outlined in Chapter 9 of NFPA 1051, Standard for Wildland Fire Fighter Professional Qualifications, 2002 edition.

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Additional safety resources for fire fighters who operate in the wildland/urban interface:

1. The **Wildland Fire Lessons Learned Center** web site http://www.wildfirelessons.net/

2. **Firewise - Guide to the wildland/urban interface firefighter safety series** and the **Wildland/urban interface hazard assessment training**. These and other resources are available at http://www.firewise.org/

3. **The Federal Fire and Aviation Safety Team (FFAST)** and the **National Interagency Fire Center (NIFC)** present the ***6 Minutes for Safety*** at the following web site http://www.nifc.gov/sixminutes/dsp_sixminutes.php The web site covers a variety of wildland fire related safety issues that include ***wildland/urban interface-structure protection and wildland/urban interface watchouts.***

4. **Wildland fire safety & health reporting network (SAFENET)** allows front line firefighters a way to be heard and get unsafe situations resolved. **SAFENET** is a form, and process, that has been in demand by firefighters themselves. It's a method for reporting and resolving safety concerns encountered in wildland fire, prescribed fire or all risk operations. The information provided on the form will also help collect important, safety-related data at the National Interagency Fire Center, to determine long-term trends and problem areas. **SAFENET** submissions can be made and read at the following web site http://safenet.nifc.gov/

INVESTIGATOR INFORMATION

This incident was investigated by Mark McFall, Safety and Occupational Health Specialist, and Richard Braddee, Senior Investigator with the Fire Fighter Fatality and Prevention Team, Trauma Investigations Section, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH. A review of the victim's medical history was conducted by Thomas Hales, MD, MPH. Dr. Hales is a senior medical epidemiologist with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. He is board certified in internal and occupational medicine.

EXPERT REVIEW

Expert review was provided by Dick Mangan, Blackbull Wildfire Services, LLC.

GLOSSARY OF TERMS*

Crown Closure: Is the percentage of ground covered by a vertical projection of the outermost perimeter of the crowns in a stand. Only the crowns that form part of the upper canopy level (dominant/co-dominant stratum) are used to determine closure in uneven-aged or stands with multiple canopy layers.

Crown Fire: A fire that advances from top to top of trees or shrubs more or less independent of a surface fire. Crown fires are sometimes classed as running or dependent to distinguish the degree of independence from the surface fire.

Firing Out: Act of lighting fire with a torch, fusee, etc., to accomplish burning out or backfiring.

Fuel Model: Simulated fuel complex for which all fuel descriptors required for the solution of a mathematical rate-of-spread model have been specified.

Green Sheet: An informational summary report issued by CDF following a serious accident or fatality to assist with accident prevention and training by providing a brief narrative of the conditions and sequence of events leading to a serious accident. It is subject to revision as more findings are discovered. It is usually completed within 72 hours of the accident, and is therefore necessarily preliminary in nature and subject to potential inaccuracies.

Hotshot Crew: Intensively trained fire crew used primarily in hand line construction. (Type 1)

Resources: (1) Personnel, equipment, services and supplies available, or potentially available, for assignment to incidents. Personnel and equipment are described by kind and type, e.g., ground, water, air, etc., and may be used in tactical, support or overhead capacities at an incident. (2) The natural resources of an area, such as timber, grass, watershed values, recreation values, and wildlife habitat.

Spot Fires: Fire ignited outside the perimeter of the main fire by a firebrand.

Spotting: Behavior of a fire producing sparks or embers that are carried by the wind and which start new fires beyond the zone of direct ignition by the main fire.

Strike Team: Specified combinations of the same kind and type of resources, with common communications, and a leader.

Structural Triage: Process of inspecting and classifying structures according to their *defensibility/indefensibility* based on their situation, their construction, and the immediately adjacent fuels.

Task Force: Any combination of single resources assembled for a particular tactical need, with common communications and a leader. A Task Force may be pre-established and sent to an incident, or formed at an incident.

Type: Refers to resource capability. A Type 1 resource provides a greater overall capability due to power, size, capacity, etc., than would be found in a Type 2 resource. Resource typing provides managers with additional information in selecting the best resource for the task.

Unified Command: In ICS, unified command is a unified team effort which allows all agencies with jurisdictional responsibility for the incident, either geographical or functional, to manage an incident by establishing a common set of incident objectives and strategies. This is accomplished without losing or abdicating authority, responsibility, or accountability.

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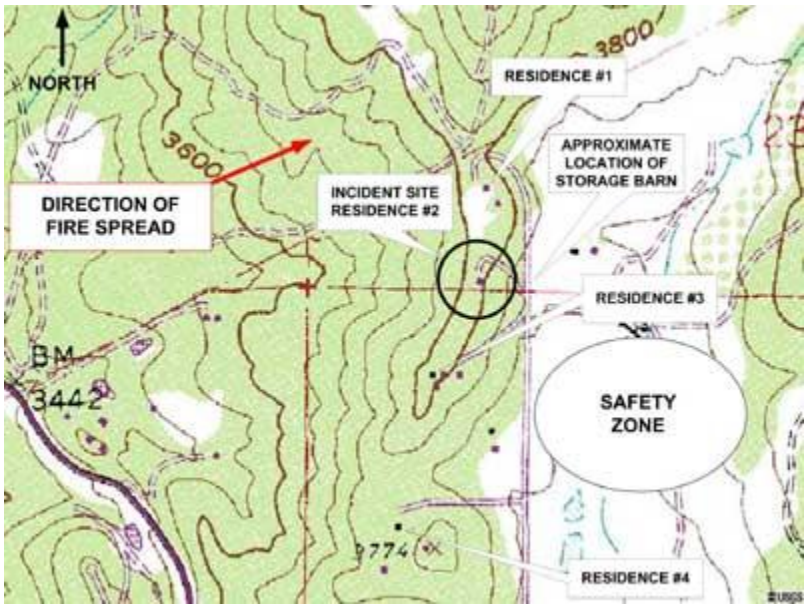
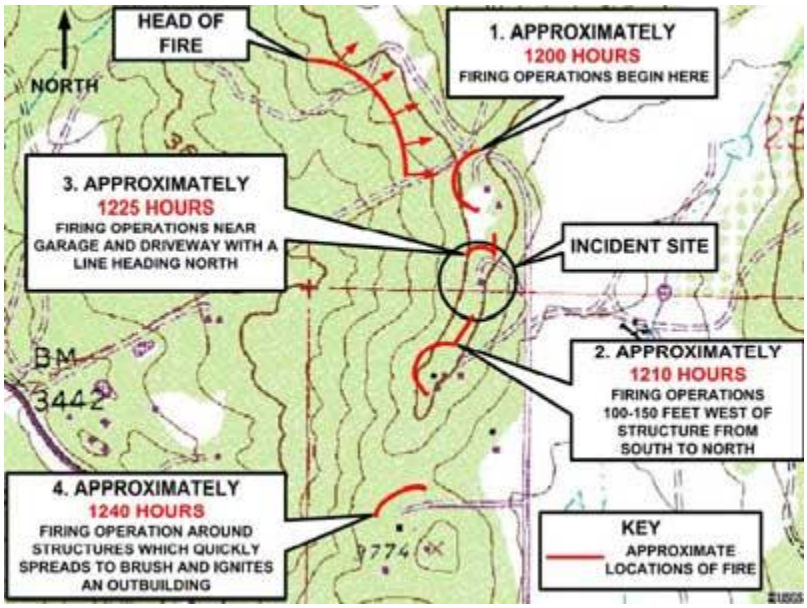
*A complete glossary of terms can be found in the **National Wildfire Coordinating Group's Fireline Handbook**[5] and IFSTA's **Wildland fire fighting for structural firefighters**, 4th ed.[2]

MAPS AND PHOTOGRAPHS



Map 1. Aerial view of drainage and incident scene.



Map 2. Sequence of firing operations

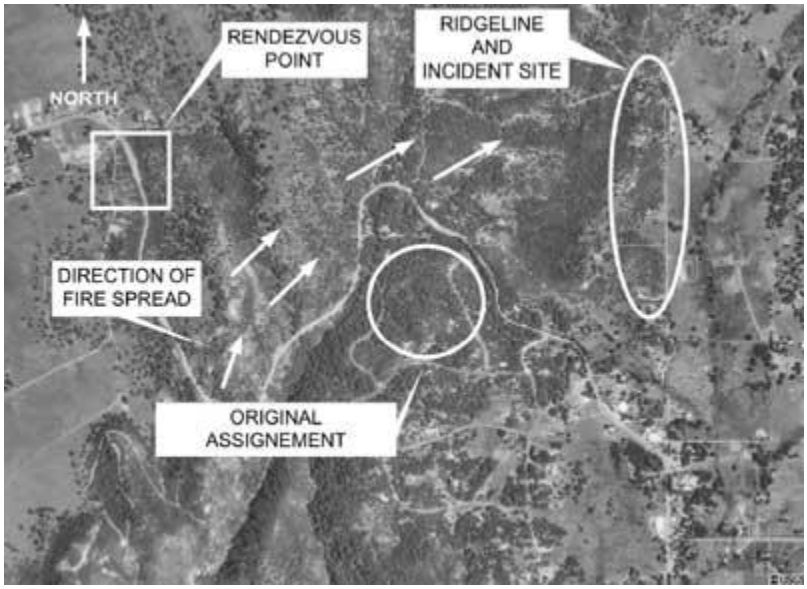


Photo 1 Aerial view of spread of fire and incident site

Photo 2. Aerial view of incident site

Photo 3. View of fuels below incident site

Photo 4. Fire observed by victim's crew prior to burnover

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