2013
04

Death in the line of duty...

NIOSH Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation

May 20, 2014

Two Career Lieutenants Killed and Two Career Fire Fighters Injured Following a Flashover at an Assembly Hall Fire—Texas

Executive Summary

On February 15, 2013, a 36-year-old male career lieutenant (Victim #1) and a 54-year-old male career lieutenant (Victim #2) were killed and two career fire fighters were injured (FF1 and FF2) at an assembly hall fire. At approximately 2320 hours, the fire department responded to a reported assembly hall fire with flames visible. Upon arrival, fire was observed by the fire department burning at the roof level in the area of the A/B corner. After arriving units conducted 360-degree walk-arounds, offensive interior operations were employed to stop the fire's progression. The first interior attack crew (Victim #1 and his probationary fire fighter) advanced a hoseline toward what they believed was the seat of the fire. After discovering the fire in the A/B corner and flowing water on it, Victim #1 and his probationary fire fighter both became low on air. Victim #1 told his probationary fire fighter they needed to exit. Both began following the hoseline out, with the probationary fire fighter in front. However, for an unknown reason, Victim #1 was unable to follow the hoseline and he became separated from his probationary fire fighter. Victim #1 radioed for help. The probationary fire fighter called out to Victim #1 but did not receive an answer nor did he hear any alarms. He then continued following the hoseline to the outside. At this time, an engine company (Victim #2, FF1, and FF2), which was designated as the rapid intervention team (RIT), was immediately deployed into the structure to locate Victim #1. The RIT followed the hoseline in and was able to locate Victim #1, who was responsive. While dragging Victim #1 toward the exit, the RIT was caught in a flashover. Following the flashover, all of them were quickly removed and transported to local hospitals. Unfortunately, Victim #1 did not survive his injuries. FF1, FF2 and Victim #2 were transferred to a regional burn center for extensive treatment where Victim #2 later succumbed to his injuries.

Incident scene.
(Photo courtesy of local police department.)

Contributing Factors

- *Nonsprinklered commercial building*

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- *Risk management principles not effectively used*
- *High-risk, low-frequency incident*
- *Fire ground strategy, tactics, and ventilation*
- *Rapid fire progression*
- *Fire burned and spread undetected above the ceiling*
- *Crew integrity*
- *SCBA air management*
- *Fire ground communications*
- *Flashover.*

Key Recommendations

- *Fire departments should use risk management principles at all structure fires.*
- *Fire departments should ensure that incident commanders and fire fighters understand the influence strategy and tactics (e.g., ventilation) may have on fire behavior and fire fighter safety and consider whether traditional firefighting tactics are appropriate.*
- *Fire departments should ensure that an established incident management system on a fireground is appropriate and effective as it relates to that specific incident.*
- *Fire departments should ensure that a complete situational size-up is conducted on all structure fires.*
- *Fire departments should ensure that crew integrity is properly maintained by face-to-face contact or radio contact when operating in an immediately dangerous to life and health (IDLH) atmosphere.*

Two Career Lieutenants Killed and Two Career Fire Fighters Injured Following a Flashover at an Assembly Hall Fire—Texas

Introduction

On February 15, 2013, two career lieutenants were killed and two career fire fighters were injured at an assembly hall fire following a flashover. On February 19, 2013, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On February 24 through March 1, 2013, a safety and occupational health specialist and a safety engineer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to Texas to investigate this incident. The NIOSH investigators met with the fire chief, assistant chiefs, department fire marshal, a state fire marshal's office representative, and the local union representative.

Interviews were conducted with the incident commander (IC), fire department members directly involved with the incident, and the fire department's fire marshal. The NIOSH investigators visited, documented, and photographed the fire scene and structure. The NIOSH investigators reviewed photographs and video taken by law enforcement, bystanders, and the state fire marshal's office. The NIOSH investigators also reviewed available training records for the victims, injured fire fighters and the IC; dispatch radio transcripts; autopsy reports; and departmental standard operating procedures (SOPs). The NIOSH investigators traveled with representatives of the fire department and met the representative of the state fire marshal's office at the regional burn center to interview the injured fire fighters.

The NIOSH investigators documented the condition and took photographs of the victims' and injured fire fighters' personal protective equipment (PPE) and self-contained breathing apparatus (SCBA). The victims' and injured fire fighters' SCBAs were sent to NIOSH's National Personal Protective Technology Laboratory (NPPTL) for further evaluation. The NIOSH investigators also reviewed available SCBA maintenance records.

Fire Department

At the time of this incident, the fire department was operating out of five fire stations with 110 uniformed members, serving a population of approximately 78,000 within an area of about 43 square miles. On a daily basis, the fire department would staff five engine companies (minimum staffing of 3), a truck company (minimum staffing of 3), four advanced life support ambulances (cross-trained as fire fighters), a battalion chief, and an EMS supervisor. This fire department also staffed a technical rescue team trained in confined space, trench collapse, high angle rescue, water rescue, building collapse, and wilderness search and rescue.

Field personnel currently work 24-hour shifts with 48 hours off, averaging 8,000 – 9,000 calls per year with an average response time of 6½ minutes (2011). In 2011, the department responded to 9,125 calls consisting of:[1]

- 7,150 EMS/rescue calls
- 563 Good intent calls
- 424 Service calls

- 368 Fire calls
- 293 False calls
- 290 Hazardous situations
- 25 Other calls
- 9 Explosions
- 3 Weather-related incidents

In 2012, the fire department responded to approximately 107 structure fires. The breakdown included:

- 56 Private Dwellings (1 or 2 family), including mobile homes
- 28 Apartments (3 or more families)
- 0 Hotels/Motels
- 2 Other residential (dormitories, boarding houses, tents)
- 5 Public Assembly (church, restaurant, clubs)
- 2 Schools and Colleges
- 1 Health Care and Penal Institutions
- 5 Stores and Offices
- 2 Industry, Utility, Defense, Laboratories, Manufacturing
- 4 Storage in Structures (barns, vehicle storage garages, general storage)
- 2 Other Structures (outbuildings, bridges)

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At the time of this incident, the department's annual operating budget was 9 million dollars. Also, this fire department was rated as a Class 2 fire department by the Insurance Services Organization (ISO).[a] In the ISO rating system, Class 1 represents exemplary fire protection, and Class 10 indicates that the area's fire-suppression program does not meet ISO's minimum criteria.

This department provided annual medical evaluations, a job performance standard test, and respiratory fit testing for its members. The victims' and injured fire fighters' training and medical records were reviewed for 2011 and 2012.

When vacancies occur, this fire department would hold an eligibility list for approximately 1 year for potential candidates wishing to become a fire fighter. Individuals are required to pass a written test, a fitness assessment and physical proficiency exam, a background investigation, an oral interview, a physical exam, a drug screen, and the Behavioral Personnel Assessment Device Test. The fitness assessment requires the individual to run/walk a single mile in 12 minutes or less. The department's physical proficiency examination included the following tasks:

- Task 1: With a ladder fully extended at 70 degrees, climb to the top platform without stopping.
- Task 2: Pick up the nozzle end of a 1¾-inch hoseline and drag the hose 75 feet to a pre-positioned drum. Make a 90-degree turn and continue an additional 25 feet. Place the nozzle in a box, kneel on one knee, and pull the remaining 75 feet of hoseline across the finish line.
- Task 3: Using hand-over-hand technique, raise the flies of a 35-foot extension ladder to maximum height.
- Task 4: Carry a 50-foot, rolled section of double-jacketed 3-inch hose from the base of the training tower up to the fourth floor and back down to the base.
- Task 5: Crawl through a 12-foot tubular obstacle.
- Task 6: Stand at the fourth story of the training tower, pull up a 35-pound equipment bag that is attached to a ½-inch rope to the top of the railing using a hand-under-hand method. The rope cannot touch the railing and you cannot stop upward movement of the equipment bag.
- Task 7: Walk 25 yards, pick up a 165-pound rescue mannequin, and drag it back to your starting point without stopping.

[a] The Insurances Services Organization (ISO) is an independent commercial enterprise that helps customers identify and mitigate risk. ISO can provide communities with information on fire protection, water systems, other critical infrastructure, building codes, and natural and man-made catastrophes. ISO's Public Protection Criteria program evaluates communities according to a uniform set of criteria known as the Fire Suppression Rating Schedule. More information about ISO and their Fire Suppression Rating Schedule can be found at http://www.isogov.com/about/.

- Task 8: Using an 8-pound sledgehammer, move the Keiser slide to the opposite end in 22 hits.
- Task 9: Pick up a positive pressure fan and walk 25 yards without setting it down.

Once an individual is hired they are included in the department's annual physical fitness and health and wellness program. The physical condition of all incumbent fire fighters is tested every six months by a job performance standard test that evaluates the fire fighter's ability to perform simulated tasks equivalent to job tasks on the fireground such as carrying and deploying a hoseline, raising a ladder, carrying fire fighter equipment, and crawling through an obstacle. The nine total tasks are graded as "Pass" or "Fail" with the ability to retest a failed task one additional time after completing all nine tasking consecutively without a break.

All fire fighters are required to participate in the department's annual assessment of overall fitness and well-being sponsored through the local university's exercise science lab. This evaluation includes such things as a physical exam with blood work, review of medical history, lung function test, cardiac stress, and medical fitness evaluation.

9-1-1 Dispatch Center

The county 9-1-1 dispatch center has a contract with the city to provide police and fire dispatch services. At the time of this investigation, the center employed 50 employees who worked 12-hour shifts, providing a 24-hour operation within the center. The computer-aided dispatch program used a 700-MHz radio system with the victims' department using digital radios. The center has three telephone call positions and five radio positions (two police, victims' department, volunteer fire companies, and county constables). Personnel rotate between positions every 1– 2 weeks. The center has the ability to utilize nine recorded fire channels with separate police and fire servers. Mobile data terminals are utilized within response units. At the time of this investigation, the center was not currently accredited, but all dispatchers were required by the state of Texas to obtain 40 hours of telecom training and 24 hours of crisis management training within a year of being hired as a dispatch operator. Additionally, the center required their operators to obtain cardiopulmonary resuscitation (CPR), certification as an emergency medical dispatcher, and attend ethics training.

Training and Experience

The state of Texas requires that prior to being appointed fire suppression duties with a government entity, fire protection personnel must possess:

- Valid documentation of accreditation from the International Fire Service Accreditation Congress as a Fire Fighter 1, Fire Fighter 2, and Hazardous Materials Awareness Level Personnel; and
    - Hazardous Materials Operations Level Responders
    - NFPA 472 Hazardous Materials Operations
- Complete a basic structure fire suppression program approved by the Texas Commission on Fire Protection (Commission); and,

- Successfully complete an emergency medical technician (EMT) course recognized by the Commission.

The Commission also required 18 hours of continuing education for renewal during the certification period.

The minimum requirements set forth by this department for a fire fighter position, included the following:

- United States citizenship
- Age 18-35 at time of hire
- High school diploma or GED, with ability to read and write the English language
- Texas Commission on Fire Protection Basic Fire Fighter Certification
- Texas Department of State Health Services licensed or certified Emergency Medical Technician
- Texas Commission on Fire Protection Personnel Standards and Education legal requirements
- Valid Class B Exempt Texas Operators License with a good driving record
- Honorable military discharge (if applicable)
- No felony convictions
- Good moral character, stable employment history, and no history of any conduct that may affect suitability for fire fighter work
- Ability to meet the physical standards of the position.

This fire department does not hold a recruit school for incoming fire fighters, but rather a two week fire department orientation. This orientation included a review of fire department SOPs, rapid intervention team training, and an emergency vehicle operator's course. Following the orientation, the candidate fire fighter is detailed to the field.

Monthly fire department training is coordinated by an assistant chief. Each company officer is responsible for holding five training sessions each month. The training topics for each month are set by the battalion chief and company officers. The fire department also conducts annual training for all members on rapid-intervention operations. The department's monthly training included:

- First full week of month – department-level fire training

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- Second full week of month – EMS training
- Third full week of month – company-level training
- Fourth full week of month – rescheduled, specialized, and other classes

Note: The department did not have a topic-specific agenda for training. At the time of this investigation, the fire department had received limited training on fire dynamics and fire behavior. Also, the fire department had a long-standing policy of critiquing every structure fire. The crew(s) involved would get feedback from the battalion chief and administrative chiefs. Over the past year, the fire department had developed a new process to complete a white paper report accessible to the entire fire department through the department's computer system.

Victim #1 had been with this department for approximately 12 years, holding the current rank of a lieutenant. He had completed all the certifications required of the state of Texas and the fire department. Additionally, between 2011 and 2012, he had completed continuing education training on topics such as aerial operations, hose handling and fire streams, truck company operations, and special operation rescues.

Victim #2 had been with this department for approximately 32 years, holding the current rank of a lieutenant. He had completed all the certifications required of the state of Texas and the fire department. Additionally, between 2011 and 2012, he had completed continuing education training on topics such as lost fire fighters and command response, downed fire fighter exercise, SCBA/PPE, hose and fire streams, and ladders.

The injured FF1 had been with this department for approximately 5 years, holding the current rank of a fire fighter. He had completed all the certifications required of the state of Texas and the fire department. Additionally, between 2011 and 2012, he had completed continuing education training on topics such as downed fire fighter exercise, SCBA/PPE, structural collapse equipment review, master streams and blitz fire, and suspended victim rescue techniques.

The injured FF2 had been with this department for approximately 11 months, holding the current rank of a probationary fire fighter. He had completed all the certifications required of the state of Texas and the fire department. Additionally, in 2012, he had completed continuing education training on topics such as RIT, SCBA/PPE, RIT bag familiarization, RIT practical, and hose handling and fire streams.

The fire department also had time-in-position requirements for someone to "act" in a higher position. For a fire fighter to act as a driver, an individual must have completed their probationary year. A driver must have been in their position for 6 months prior to act as a company officer. A company officer must be in their position for one year prior to acting as a battalion chief. Additionally, each of these positions had specific training requirements that must be met prior to moving up. Each individual is checked off on the required training and it is documented on a form prior to receiving official clearance to act in the next higher position.

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Equipment and Personnel

The initial dispatched assignment from the victims' department included the following units:

Fire Department

- Engine 1 (E1) with a lieutenant (Victim #1), an operator, and a probationary fire fighter
- Engine 2 (E2) with a lieutenant, an operator, and a fire fighter
- Engine 5 (E5) with a lieutenant (Victim #2), FF1 (acting operator), and FF2 (probationary fire fighter)
- Truck 1 (T1) with an operator, an acting lieutenant (normally an operator), and a fire fighter *Note: T1, an aerial platform apparatus, was out of service and members responded in a rescue truck designated for the shift as Truck 1.*
- Med 2 (M2) with two fire fighter/medics
- EMS supervisor (EMS1), a lieutenant in rank, responded in a department vehicle (designated incident safety officer (ISO) per department standard policy)
- Battalion 1 (B1), a battalion chief in rank, responded in the department's battalion vehicle

Upon his arrival to the scene, B1 assumed incident command (IC) and requested an admin page, a ladder truck, and an additional engine to assist with the incident. The requested apparatus came from the neighboring automatic aid department and arrived as the victims and injured fire fighters were being removed from the structure.

The IC also requested a second alarm, which consisted of:

- Engine 4 (E4) with a lieutenant, operator, and a fire fighter
- Med 5 with two fire fighter/medics

Water Supply

The town's municipal water supply with hydrants (located across the street) was available during this incident. The assembly hall did not have a fire sprinkler system.

Timeline

This timeline is provided to set out, to the extent possible, the sequence of events according to recorded and intelligible radio transmissions. Times are approximate and were obtained from review of the dispatch records, witness interviews, and other available information. Times have been rounded to the nearest minute. NIOSH investigators have attempted to include all intelligible radio transmissions, but some may be missing. This timeline is not intended, nor should it be used, as a formal record of events.

- **2319 Hours**
  Dispatch received a cell phone call for a reported fire at an assembly hall. Additional information from the call taker included:

- Unknown if anyone was in side
- No cars are in parking lot
- Flames coming from the building

Dispatch assigned E1, E2, E5, T1, M2, B1, EMS1, and law enforcement to the reported assembly hall fire. Dispatch assigned TAC 3 as the incident channel.
Dispatch advised the responding units that all calls had come from a passersby, it was unknown if anyone was in the building, and no cars were in the parking lot.

- **2324 Hours**
  E1 on scene with fire showing, going offensive mode, Victim #1 passed command.
  T1 on scene and began assisting the E1 crew.
  EMS1 provided the location of the closest hydrant.
  B1 arrived on scene and reported he had a single-story commercial building with fire showing from the roof on B/C corner. B1 took command and advised that operations were in offensive mode.
  T1 officer requested a "k-tool" (forcible entry tool) to the front door from the T1 operator.
  EMS1 arrived on scene

- **2326 Hours**
  IC requested a ladder truck from the automatic aid department, an additional engine, and an admin page (notifying department admin) to respond.
  Victim #1 radioed the IC and stated, "…bring me a 200-foot to the front door."
  IC transmitted, "say again."
  Victim #1 transmitted, "200-foot to the front door."
  IC acknowledged and stated, "Ok, I hear E1 at the front door."
  T1 officer advised that they forced a door on D-side of the structure and were working on forcing a door on C-side of the structure.

- **2327 Hours**
  M2 arrived on scene and was setting up standby.
  E2 arrived on scene and began setting up a water supply.
  EMS1 setting up safety command at the rear of the building (positioned himself on C-side of the structure).
  T1 officer advised doors on C- and D-side had been forced opened and remained closed.

- **2328 Hours**
  E2 advised the IC they were on scene setting up water supply and laying a line around M2 and B1.
  E5 on scene and setting up as RIT.
  IC requested set-up for large water flow.
  E2 officer advised they were conducting a walk-around and grabbing another line; acknowledged by IC.

IC transmitted, "Confirming E1 and T1 inside."
A unit transmits, "Negative, T1 on the C-side opening up a ventilation hole for the engine."
IC transmitted, "Confirming E1 on the inside."
Victim #1 advised the IC that his crew was on the inside making fire attack.

- **2329 Hours**
  IC advised the ISO and RIT to do a walk-around.
  ISO advised the IC over the radio that RIT is completing their walk-around and that he was ¾ done with his and looking for the electrical box.
  IC advised E2 to pull a second line and assist E1; E2 acknowledged.
  IC asked E1 for UCAN (unit, conditions, actions, needs) report.

- **2330 Hours**
  IC reported a lot of fire on the A/B roof.
  Victim #1 over the radio stated, "…there was a door, on the bravo side I could not get opened, that a, if we could get it opened we could…unintelligible…get that door opened we can get all that smoke outta of here, I tried to get it opened on the walk-around but couldn't."
  IC requested T1 to open door on B-side.
  T1 advised door is open and would be making entry with a crew of 3.
  IC advised T1 to repeat and T1 advised the IC that they got the door to the B-side opened and were making entry with a crew of 3.
  IC acknowledged over the radio that T1 was inside with 3 and that the B-side door was opened.

- **2331 Hours**
  Victim #1 requested additional hose.
  E2 crew makes entry; acknowledged by IC and dispatch.
  E1 operator advised the IC that he was at half a tank.
  IC advised E2 to charge the hydrant.

- **2332 Hours**
  ISO cut off air handler units and believed the main breaker box too.
  Automatic aid ladder truck and engine en route.

- **2333 Hours**
  E2 operator established water to E1.
  T1 officer advised they exited with three and will be re-entering with only two; acknowledged by the IC.
  IC confirmed with dispatch that he had an additional engine company responding.
  Dispatch confirmed automatic aid units were responding and provided a 10-minute notification to the IC; acknowledged by the IC.
  E2 officer asked for somebody at the door to pull more hose.

- **2334 Hours**
  IC advised Victim #1 that they still had fire through the roof on the A/B corner.
  E1 operator advised water supply was established.
  IC requested "BTU" to respond. (BTU is acronym for local utilities)
  Dispatch asked IC to reset his emergency status on his radio; IC acknowledged.

- **2336 Hours**
  IC assigned ISO to the C/D corner to "maintain a size up."
  E2 operator advised IC that he was set up for "big water."
  T1 officer advised Victim #1 that all the hose had been pulled.
  E2 officer asked IC if they were making any progress; IC replied, "I think so, I think so, it looks like the fire is diminishing."

- **2337 Hours**
  T1 officer advised IC they were exiting the structure with a crew of two to get more air.

- **2338 Hours**
  IC requested E1 or T1 operator to stack fans in the front door; E5 advised they would take care of the second fan.
  IC advised crews inside that it looked like some improvement, not a lot of visible fire just a lot of smoke, and fans were being stacked at the front door.
  E2 officer advised they were in the second room (believed to be the dance hall) with heavy heat conditions and everything above them (fire conditions), and making progress.

- **2339 Hours**
  IC replied, "I think you are, the only fire above the roof we see is still on that B, A/B roof side, still a lot of smoke, we're going try and stack some fans at the front door." *Note: The fan(s) were turned on after placement.*
  T1 entered the structure with a crew of 3; acknowledged by IC and dispatch.

- **2340 Hours**
  Victim #1 advised the IC that he had a low-air alarm, was separated from his fire fighter, and was on the red hoseline; transmission repeated to IC.
  E1 probationary fire fighter advised he is on the red hoseline and low on air.

- **2341 Hours**
  IC requested dispatch to sound the emergency evacuation alert tone, and the IC advised all units to evacuate the building. The tone was given and the IC repeated "evacuate the building."
  E2 officer advised they were out with two; acknowledged by the IC.
  ISO advised the IC to go into rescue mode and request a second alarm.

- **2342 Hours**
  T1 officer advised the IC over the radio that he can hear a personal alert safety system (PASS)

device alarming.
A second alarm was requested by the IC but an emergency alert tone was set off. IC gave the order to evacuate the building again after tone.
Automatic aid units on scene requesting an assignment.

- **2343 Hours**
  IC advised all units to evacuate the building.
  ISO advised heavy flames through the roof toward the C-side.
  IC requested the automatic aid ladder to be set up.
  IC advised all units to evacuate the building.
  IC asked E5 if they were accounted for.
  Victim #1 advised low-air alarm is off, to please give him air and he is still on the red hoseline.

- **2344 Hours**
  IC replied, "Follow the red hoseline out, follow the red hoseline out." Victim #1 advised, "Negative, command, I can't do it, cause I had stuff fall on the hoseline and I'm disoriented on it. Please send help." IC replied, "Follow the red hoseline out."
  T1 officer advised the IC they had a fire fighter down on the red hoseline (approximately 25 feet away).
  IC advised all units to evacuate.
  E1 operator advised the IC that he had his deck gun up and asked if he wanted him to flow.
  IC ordered T1 to exit the building.

- **2346 Hours**
  IC asked E5 officer (RIT) for a status report.
  IC asked dispatch for an evacuation tone.
  IC advised all units to evacuate the building and asked for a status report from E5.
  IC asked for all units to evacuate the building.

- **2348 Hours**
  Open mic.
  Dispatch asked over the radio if "E1 lieutenant" had emergency traffic (Victim #1's radio).
  E4 en route.
  IC requested two additional ambulances.

- **2350 Hours**
  Automatic aid ladder truck advised the IC they were in place and ready to flow water when he was ready. IC advised them to flow water as soon as they could.
  ISO advised the IC that one fire fighter was out.
  IC asked dispatch for an aeromedical helicopter.

- **2351 Hours**
  M2 requested additional ambulances; IC advised dispatch that he needed four ambulances.

- **2352 Hours**
  ISO advised that a third fire fighter was out of the structure and launch a second aeromedical helicopter.

- **2353 Hours**
  T1 radioed they needed help removing fire fighters from the doorway.

- **2355 Hours**
  Automatic aid ladder truck advised the IC that the roof was beginning to collapse; the IC confirmed.
  E4 on scene.

- **2359 Hours**
  T1 officer advised that Victim #1 was 10 feet from him and needed help getting him out.

- **0002 Hours**
  E4 officer advised the IC of heavy fire and that they heard a PASS device going off.

- **0004 Hours**
  IC asked for a third alarm.

- **0008 Hours**
  ISO advised the IC that Victim #1 was at the door.

- **0009 Hours**
  All fire fighters accounted for.
  IC advised the ISO to get everyone out of building after removing Victim #1.

- **0010 Hours**
  All personnel out of structure.

Personal Protective Equipment

It was reported to NIOSH investigators that Victim #1, Victim #2, FF1, and FF2 entered the structure wearing a full array of personal protective clothing and equipment, consisting of turnout gear (coat and pants), gloves, boots, hand-held radios with extended mics, SCBA with an integrated PASS device, Nomex® hoods, and helmets. All facepieces were reported to be properly donned and connected prior to entering the structure. The last flow tests on the SCBAs were conducted in 2012, and all hydrostatic cylinder testing was within date.

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The SCBAs of the victims and injured fire fighters were secured and retained by the local police department. NIOSH investigators were able to photograph and document all the SCBAs. All of the SCBA cylinders were 30-minute, 4500-psi units. Victim #1's SCBA was certified under the 2007 edition of the National Fire Protection Association (NFPA) 1981 *Standard on Open-circuit Self-contained Breathing Apparatus (SCBA) for Emergency Services* and NFPA 1982 *Standard on Personal Alert Safety Systems.* The other three SCBAs—used by Victim #2, FF1, and FF2—were certified under the 2002 edition of NFPA 1981.[2, 3]

NIOSH NPPTL evaluated all four SCBAs to determine conformity to the NIOSH-approved configuration (see Appendix I). Information that could be retrieved from the four PASS device data loggers were also downloaded with assistance from the SCBA manufacturer. NIOSH investigators noted that all four facepieces showed signs of thermal degradation (see Photos 1-4).

The fire department maintains their SCBA equipment and compressed breathing air refill system. The SCBA maintenance shop had manufacturer-certified technicians who worked on the SCBAs. In January 2013, the fire department's stationary and mobile air refill system was evaluated by a third party and found to be in compliance with NFPA 1989 *Standard on Breathing Air Quality for Emergency Services Respiratory Protection*, 2008 edition,[4] and Compressed Gas Association G-7.1-2004 Grade E standards and regulations. This fire department is also approved as a cylinder requalification facility under 49 CFR Section 107.805.[5]

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Photo 1. Victim #1's facepiece showing thermal degradation.
(NIOSH photo.)

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Photo 2. Victim #2's facepiece showing thermal degradation.
(NIOSH photo.)

Two Career Lieutenants Killed and Two Career Fire Fighters Injured Following a Flashover at an Assembly Hall Fire—Texas

Photo 3. FF1's facepiece showing thermal degradation.
(NIOSH photo).

Two Career Lieutenants Killed and Two Career Fire Fighters Injured Following a Flashover at an Assembly Hall Fire—Texas

Photo 4. FF2's facepiece showing thermal degradation.
(NIOSH photo.)

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Structure

The assembly hall was built in 1945 and contained approximately 7,400 square feet of interior space at the time of the incident (see Photo 5, Diagram 1, and Photo 6). The structure was classified as a commercial occupancy when constructed and local building codes did not require fire sprinklers at that time. The last known interior renovation was believed to have been in 1960, but available records showed that permits were issued in 2011 to replace mechanical equipment within the structure and to replace vinyl siding with fiber-cement lap siding. The structure included gas and electrical utilities. The interior walls were covered with laminated wood paneling, and the interior floor was vinyl on a concrete pad. A gabled roof covered the dance hall, and a flat roof supported by wooden dimensional lumber covered the bingo hall. The kitchen entrance on the B-side was covered by an awning. The fire department involved in this incident last inspected the structure in 2005 without noting any problems. Pre-planning of this structure had not been conducted.

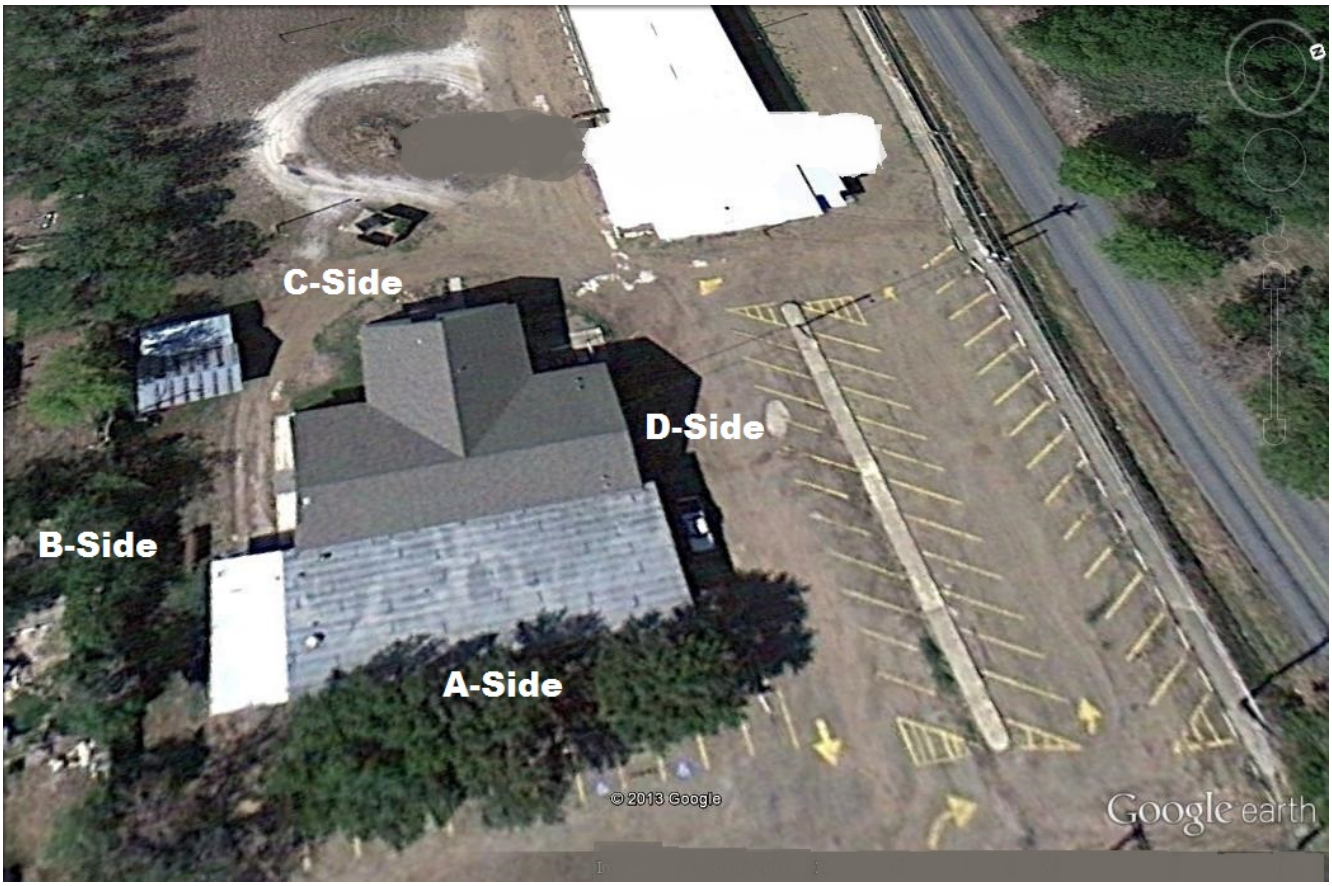

Photo 5. Aerial view of the structure prior to the fire.
(Adapted from Google Earth® satellite image.)

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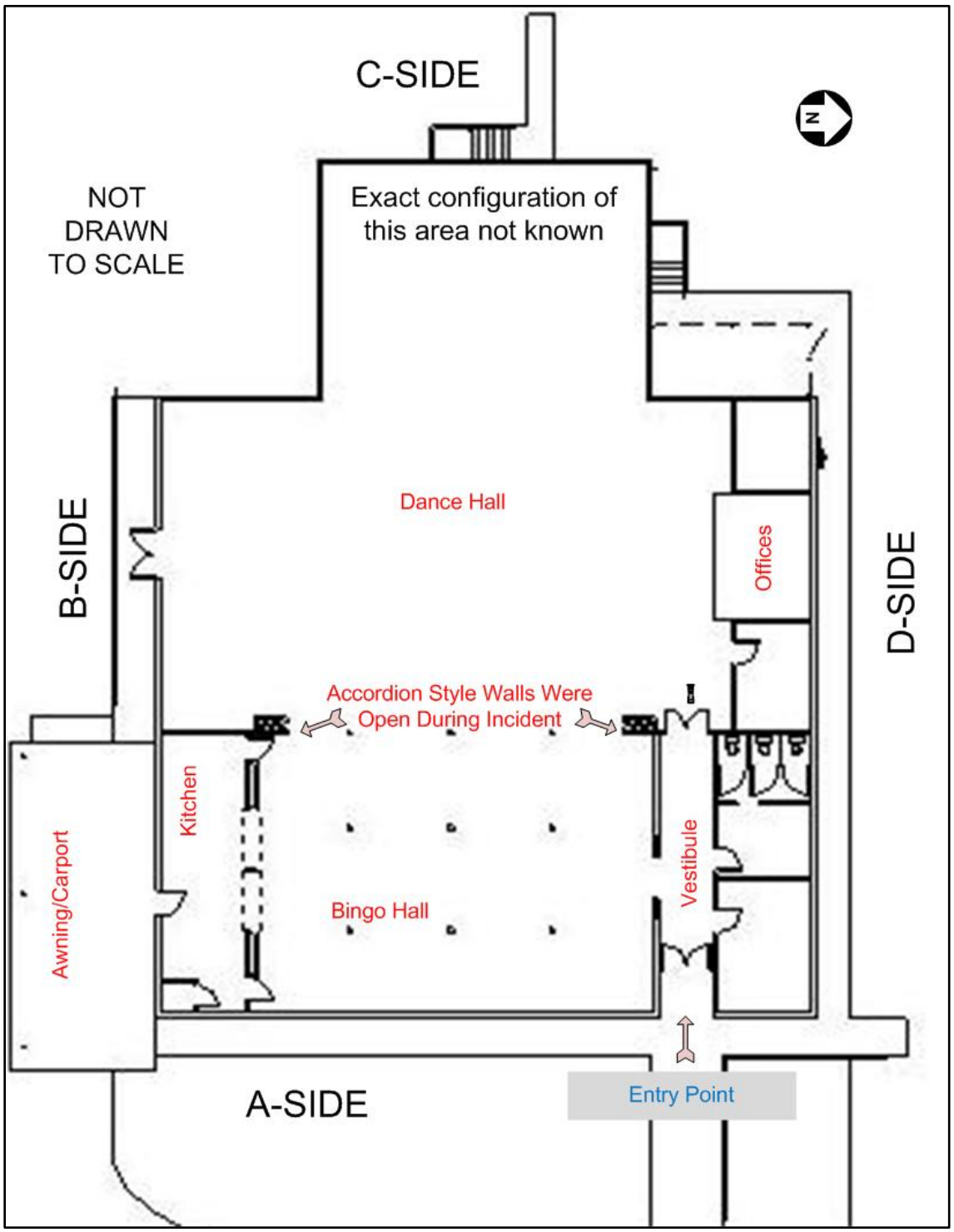

Diagram 1. Computerized layout of structure.
(Diagram courtesy of fire department.)

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Photo 6. Looking toward the C/D corner, aerial photo of structure after being brought under control.
(Photo courtesy of local aerial photographer.)

Weather

The incident occurred during the late evening hours with an approximate temperature of 45°F and winds between 5.0 – 7.0 miles per hour.

Investigation

On February 15, 2013, a motorist passing by the assembly hall at approximately 2319 hours noticed fire coming from the roof and immediately placed a cellular 9-1-1 call. Fire and police units were dispatched for a structure fire. Police units arrived on scene at the same time as the fire department. Police units observed a 3- to 4-foot flame with smoke coming from the A/B corner roof and thick, black smoke emitting from an attic vent on the D-side. *Note: Arriving fire department units could not confirm thick, black smoke emitting from the attic vent on the D-side.* Additionally upon their arrival,

police observed that no vehicles were in the parking lot and the building appeared secured and empty of people.

The first fire department apparatus to arrive on scene was E1. Over the radio from E1, Victim #1 advised incoming units that fire was showing through the roof and they were in an offensive fire mode. Victim #1 then passed command to the next arriving officer. Victim #1 directed his probationary fire fighter to place a positive-pressure ventilation (PPV) fan (see Photo 7) at the A-side front door and pull the 1¾-inch hoseline (200 feet of red hose) off the rear of E1. While these tasks were being performed, Victim #1 conducted a 360-degree walk-around of the structure. T1, EMS1, and B1 arrived shortly after E1. B1 took over as the IC and advised dispatch and responding units that they were in an offensive mode for a single-story commercial structure with fire showing from the B/C corner roof. Following departmental procedures, the IC directed EMS1 to become the ISO and to position himself at C-side after he finished his walk-around of the structure. The ISO also shut off the main electrical breaker, which was located on the D-side. He noticed fire coming from the A/B corner roof and smoke pushing from the eves on C-side.

Photo 7. Photo of a PPV fan used during the incident.
(Photo courtesy of fire department.)

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Upon exiting their apparatus, T1 personnel heard and saw E1 personnel breaking the glass on the A-side door. T1 personnel began gathering their tools and the acting lieutenant and fire fighter started a 360-degree walk-around, walking counterclockwise around the structure. After donning his turnout gear and SCBA, the T1 operator walked around the structure to meet the rest of the T1 crew. E2 arrived on scene, took the hydrant and fed E1 with a 5-inch supply line. Additionally, E5 arrived on scene and was designated as the RIT by the IC. Victim #2 and FF2 did a walk-around of the structure while FF1 donned his protective gear. Victim #1 and his probationary fire fighter then advanced the 1¾-inch red hoseline through the A-side door into the vestibule with his probationary fire fighter on the nozzle. Prior to their entry, the PPV fan had been turned on high and placed just outside the A-side door, blowing into the vestibule. The E1 probationary fire fighter stated to NIOSH investigators that smoke was initially a few feet off the ground with approximately 10 feet of visibility. Once inside the vestibule, the E1 crew went left (see Photo 8) into the bingo hall, which was filled with what appeared to be tables and chairs. Smoke was moderate and just off the floor, but the probationary fire fighter said he was able to see a "yellow glow" in the distance (B-side wall). Roughly in the middle of this room, Victim #1 told his probationary fire fighter to open the hoseline and hit the fire that was rolling over them. Penciling with a straight stream pattern initially knocked down the "yellow glow." The IC advised Victim #1 over the radio that whatever he was doing was having a good effect on the fire conditions observed from the outside.

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Photo 8. Shows vestibule and red hoseline on left leading into bingo hall. Yellow hoseline on right leads straight ahead into the dance hall. Photo taken after incident scene cleared of fire debris.
(Photo courtesy of state fire marshal.)

While the E1 crew operated in the bingo room, two members from T1 began breaching exterior doors. T1 first breached an office door on D-side, which contained no smoke or fire. They then closed the door and repeated this procedure for a single door on C-side; light smoke was visible but no fire was observed. T1 then bypassed a double door on the B-side close to the B/C corner and breached the door on B-side close to where the fire was believed to have originated (doorway to kitchen area). When the T1 crew breached the door and pushed it in, fire was observed coming around this door and the entire room (kitchen) was engulfed with heavy fire. At this point, all three members of the T1 crew were together and they had gone on air while breaching the door, due to the amount of fire and smoke in the immediate area. The T1 crew blocked the door open for ventilation, and fire began rolling out the door.

Passing the T1 crew, personnel from E2 were completing their walk-around at this time and were heading back to A-side where they observed that the E1 operator had pulled a second 1¾-inch hoseline off the rear of E1 (200 feet of yellow hose). The IC tasked the E2 crew with backing up E1 so they grabbed the yellow hoseline and walked with it into the vestibule (see Photo 9). They then turned left

into the bingo hall where they had to crawl due to conditions. They followed the red hoseline until they came upon Victim #1. A brief face-to-face discussion occurred about finding the seat of the fire. The E2 crews then backed out of the bingo hall and back into the vestibule where they then decided to proceed into the dance hall area (see Diagram 2). They entered the dance hall, advancing approximately 25 feet. The E2 crew observed fire over their heads so they immediately flowed water into the ceiling above them, knocking down acoustic tiles.

Photo 9. Looking toward the A-side entry door, red and yellow hoselines are stretched into the structure and a PPV fan is in position.
(Photo courtesy of law enforcement.)

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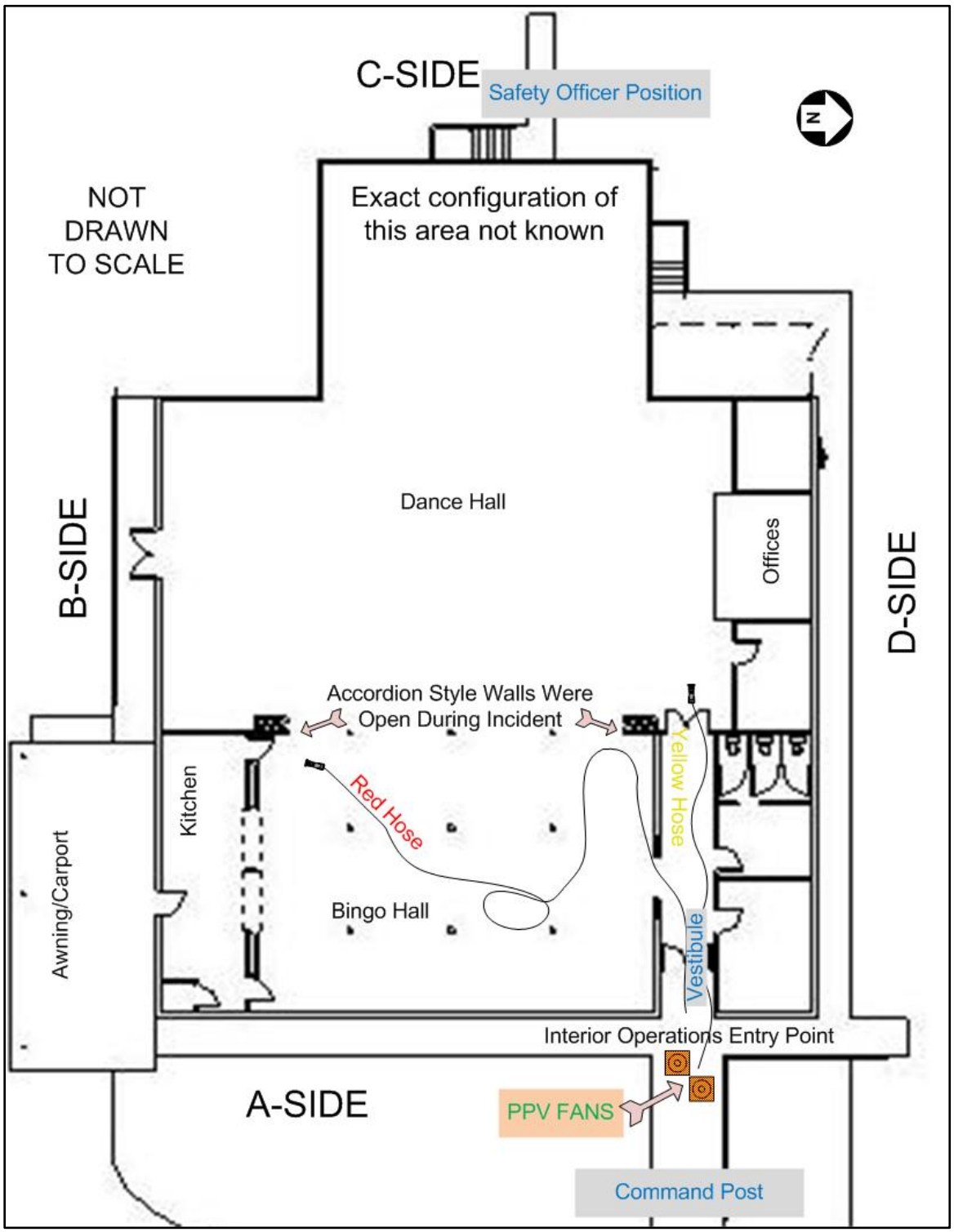

Diagram 2. Depicts layout of fireground when Victim #1 and his probationary fire fighter began to move toward the exit of the structure.

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After completing their walk-around and opening doors at all four sides, the T1 crew returned to A-side. The T1 crew (acting lieutenant, the operator, and a fire fighter) then entered through the A-side door carrying their hand tools. Standing up, they began a left-handed search into the bingo hall. Upon entering this room, the smoke was dark and thick but not a lot of heat. After a few minutes, they had to exit the structure because the T1 operator had a seal issue with his facepiece. While the T1 operator attended to his facepiece issue on the exterior, the T1 acting lieutenant and his fire fighter re-entered the structure through the A-side door and crawled in following the red hoseline further into the bingo hall to locate the E1 crew. T1 came upon Victim #1 who requested them to feed him additional hoseline. The E1 probationary fire fighter stated that he and Victim #1 then crawled deeper with the hoseline, eventually making it over to a large amount of fire from floor to ceiling that was rolling over them at times (B-side). The E1 probationary fire fighter stated they sat there flowing water on the fire for a few minutes and conditions then got really dark and hot. The T1 crew (two members) exited the structure to change bottles.

While the E1 probationary fire fighter was flowing water, Victim #1 asked him to check his remote pressure gauge. *Note: The lieutenant who worked the night before advised NIOSH investigators that the heads-up display (HUD) on the same SCBA used by Victim #1 wasn't working during a structure fire that extended through shift change. This lieutenant advised NIOSH investigators that he immediately advised Victim #1 of the SCBA issue when he changed shifts the morning of the incident.* Victim #1's tank was at ¼ full and the E1 probationary fire fighter's HUD was reading amber. Victim #1 then advised his probationary fire fighter that they needed to leave. The E1 probationary fire fighter dropped the nozzle where they had been spraying down the fire and began to follow their hoseline (red hoseline) out first. Victim #1 followed behind him but soon became separated from his probationary fire fighter. The E1 probationary fire fighter reported hearing Victim #1 over the radio say he was lost and also hearing the IC tell Victim #1 to follow the red hoseline out. *Note: Prior to Victim #1's radio transmission and at the request of the IC, a second PPV fan was placed near the first PPV fan at the A-side door by RIT personnel (see Diagram 2).* The E1 probationary fire fighter then stopped, called out to Victim #1, but heard no response or a PASS alarm. The E1 probationary fire fighter continued to crawl out because his Vibralert® was sounding. The E1 probationary fire fighter stated he briefly got turned around on the hoseline because there was a loop in it (see Diagram 2, Photo 10 and Photo 11). He was able to use his stream light to find the hose direction leading out. He eventually came upon all three members of the T1 crew (in the bingo room just before the vestibule) who directed him to the exit. The E1 probationary fire fighter advised the T1 crew that Victim #1 was following him out on the hoseline and that they had gotten separated.

The T1 fire fighter advised the T1 officer he could hear a PASS alarm sounding in the room that the E1 probationary fire fighter had just exited from. The T1 crew then followed the red hoseline in, following the sound of the PASS device. They stated that it seemed like the sound of the PASS alarm was moving away from them as they advanced. The T1 crew advanced as far as the loop in the hoseline that the E1 probationary fire fighter had described when he was exiting the structure. The T1 fire fighter was low on air again so the T1 crew had to turn around and exit. The T1 crew met the E2 crew who were also exiting due to low air in the vestibule. The T1 acting lieutenant asked the E2 crew if they had heard a PASS alarm; they hadn't heard a PASS alarm. During this time, an evacuation tone

was requested by the IC as the T1 crew was exiting the bingo hall. The T1 officer stated he thought he heard two pops right before exiting the structure that came from the bingo hall.

Photo 10. Close up of loop in hoseline. Photo taken after incident scene cleared of fire debris. ***(Photo courtesy of state fire marshal.)***

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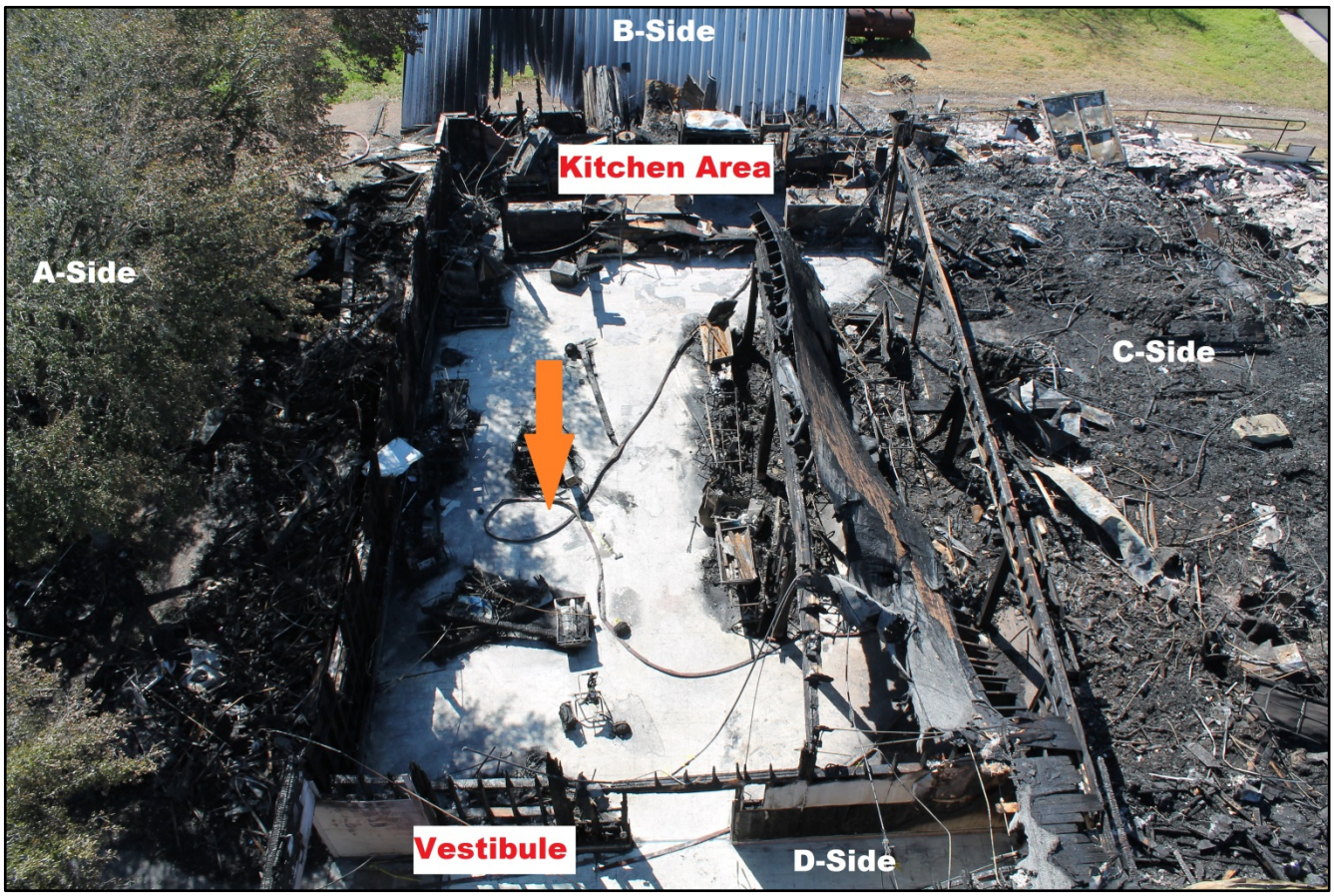

Photo 11. Aerial view of structure, after floor was cleared of fire debris, showing stretch of hoseline used by Victim #1 and his probationary fire fighter. Orange arrow shows location of loop in relationship to size of structure.
(Photo courtesy of state fire marshal.)

When Victim #1 got separated from his probationary fire fighter, he immediately made a radio transmission indicating he was lost, running out of air, and needed someone to come get him on the red hoseline. The IC advised Victim #1 to follow the red hoseline out, but Victim #1 stated he could not. Victim #1 had also pressed his emergency activation button on his hand-held radio which was never reset by him. The dispatch supervisor advised NIOSH investigators that Victim #1's radio mic was keyed up and opened for the duration of the fire. The fire department believed that the radio continued to activate due to thermal damage from the fire. This would interrupt communications on the fireground. The IC had to do face-to-face communications to assign tasks at times. The IC also noticed that the fire was now intensifying and spreading across the roof line toward C-side.

After the evacuation call from the IC, the ISO advised the IC to go to rescue mode and request a second alarm, which was done. The ISO stated he now observed fire through the roof from the center peak line and back toward C-side, which he relayed to the IC. The ISO also placed a flash light in the opened door way on C-side as a signal to help anyone inside the structure locate the door. The ISO

then made his way to A-side where he was tasked by the IC to count fire fighters as they exited the structure and handle EMS. The RIT (E5 crew) was also ordered by the IC to make entry into the structure to look for Victim #1. *Note: The T1 acting lieutenant did speak with Victim #2 on where he thought they had heard Victim #1's PASS device earlier, approximately 25 to 30 feet inside the bingo room.* Victim #2 advised FF1 and FF2 to follow the red hoseline in to search for Victim #1; they did not take a hoseline with them. They had to crawl inside the bingo hall, which was dark with zero visibility and extremely hot. FF1 and FF2 recalled hearing Victim #1 yelling for help and a PASS alarm was sounding toward the rear of the room. FF1 was leading the RIT, followed by Victim #2 and then FF2. According to FF2, Victim #2 stopped the RIT and took a reading from his thermal imager before entering the bingo hall. FF1 came upon Victim #1 after following the red hoseline in about 40 or 50 feet.

While changing bottles, the E2 officer noticed heavy fire conditions in the dance hall area while looking down the vestibule from the outside. *Note: The E2 crew heard the call for the evacuation while they were exiting the structure.* E2 re-entered with the yellow hoseline into the vestibule to flow water into the dance hall area from the dance hall threshold. While advancing the hoseline through the vestibule, the E2 officer noticed extremely dark conditions within the bingo hall with no fire, but the dance hall was fully engulfed with fire.

FF1, FF2, and Victim #2 grabbed Victim #1 and began dragging him toward the vestibule. FF1 had the red hoseline under one arm. FF1, FF2, and Victim #2 were dragging Victim #1 when the room flashed over. The RIT continued to drag Victim #1 until FF1 had no choice but to drop Victim #1 in an attempt to shield himself from the fire.

After positioning his nozzle man at the dance hall threshold the E2 officer briefly came off the yellow hoseline to look into the bingo hall again. He now observed what appeared to be fire fighters off to the right enveloped in fire and dragging Victim #1 (see Diagram 3). During the investigation, the E2 fire fighter reported to NIOSH that while advancing the hoseline past the bingo hall doorway, he heard the sound of a PASS alarm in the bingo hall and assumed his officer heard it too.

The E2 officer attempted to radio the IC without a response. The E2 officer quickly went back to his nozzle man on the yellow hoseline and told him to reposition and flow water into the bingo hall area to protect the fire fighters inside the bingo room. The E2 officer believed that a flashover may have occurred while E2 was flowing water for the second time into the dance hall area. The T1 crew re-entered the structure and observed E2 spraying water with the yellow hoseline into the bingo hall. The E2 officer noticed what appeared to be a fire fighter on the ground just inside the bingo hall, so he grabbed him and pushed him toward the vestibule and T1 personnel quickly grabbed the fire fighter and took him to the front door of the structure. No fire was visible in the bingo hall at this time; however, the dance hall (C-side) was engulfed with fire. The automatic aid ladder company observed what appeared to be the roof collapsing into the dance hall once their ladder was in position. E2 was assisted by T1 with removing two additional downed fire fighters from the same area (a second fire fighter and then Victim #2). The yellow hoseline was being operated toward the dance hall area and also as protection for those removing downed fire fighters from the bingo hall. The last fire fighter to be found and removed was Victim #1 by T1, E2, and E4 personnel. He was discovered approximately

10 to 15 feet on the right just inside the bingo hall. He was removed to the exterior and found to be pulseless with apnea. Victim #2 later died at a regional burn center from his injuries. FF1 and FF2 were removed from the scene suffering extensive burn injuries that required extensive rehab at a regional burn center.

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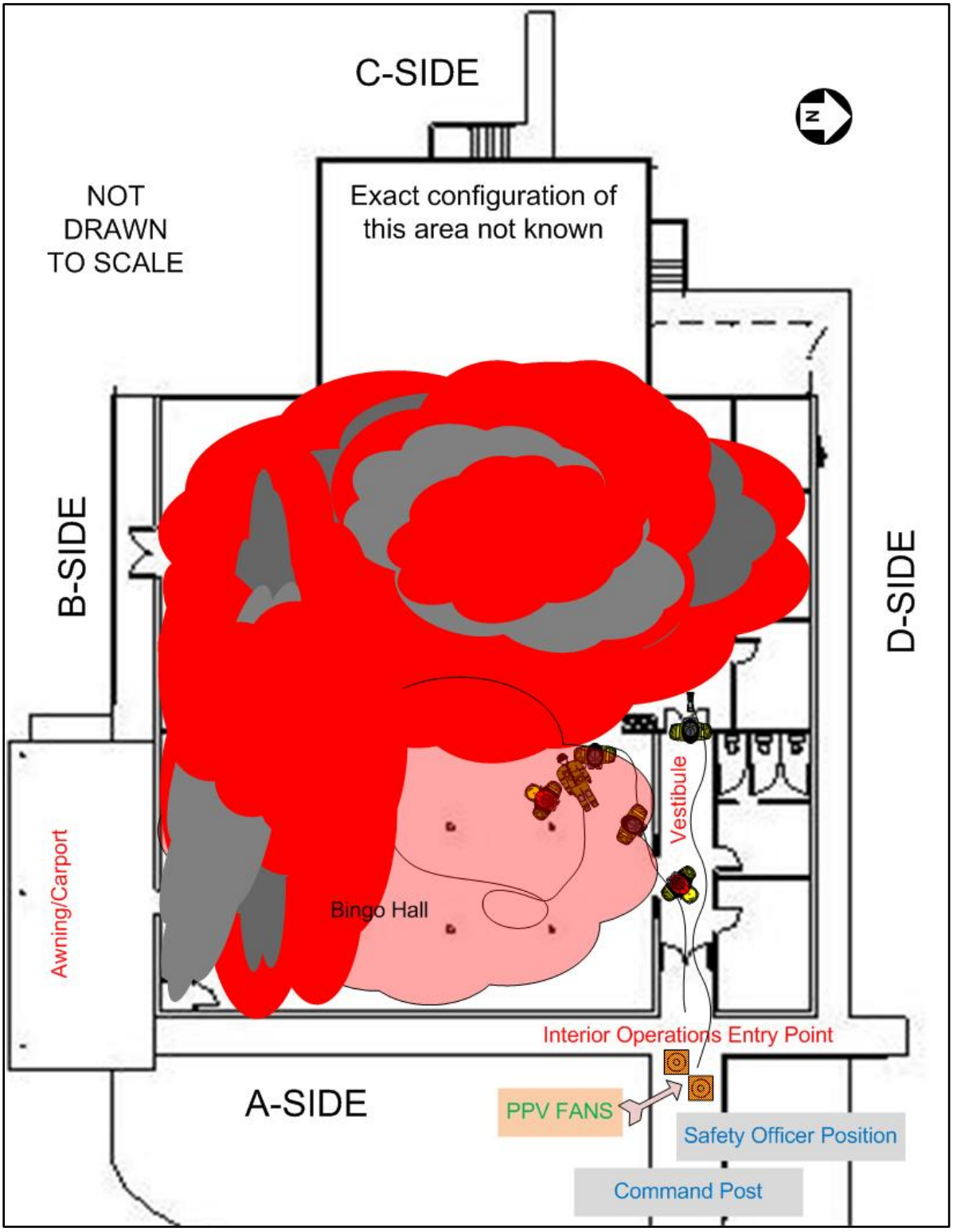

Diagram 3. Rendering of what was observed by E2 officer.

Dispatch and Fireground Communications

On the night of the incident, eight personnel were working in the dispatch center. The fire dispatch position was manned by an operator that had been with the center for the past 7 months. This operator had been working the different floor positions for the past 2 months, rotating to the fire dispatch position about once every 2 weeks. According to dispatch personnel, this incident ran smoothly, and the new dispatch operator was closely monitored to ensure the incident continued this way. The operator worked the entire the incident. According to dispatch center procedures, a 10-minute bench mark notification was provided to fire units during the incident, except that the clock was started upon dispatch and not upon the first unit's arrival. Additionally, on the night of the incident, dispatch was not initially made aware of a fire fighter being down.

Following the emergency activation of Victim #1's hand-held, the dispatch supervisor advised NIOSH investigators that his radio mic was keyed up and open for the duration of the fire. The fire department believed that the radio continued to activate due to thermal damage from the fire. This would interrupt communications on the fireground. Every dispatch position was alerted of the emergency activation, and it was silenced within the dispatch center. However, the emergency activation can only be reset if the radio that initiated the emergency activation is turned off or its emergency button is depressed. When an emergency button is activated on a hand-held radio, dispatch will know which radio was activated but will only know the location if that fire unit checked in. Dispatch personnel stated they reset the emergency activation within the dispatch center approximately 12 times prior to Victim #1 being removed. At the time of this incident, if an emergency button was activated on a hand-held radio, dispatch would immediately contact the IC and give the radio identification number. The IC would then be responsible for advising dispatch of any additional unit requirements. If no contact could be made, dispatch would respond police code 3 (lights and siren) to the location.

Fire Behavior and Origin/Cause

Local and state fire/arson investigators investigated the origin and cause of the fire. These investigators determined that the fire was accidental and originated in the kitchen area of the assembly hall before free burning above the ceiling level. Just hours prior to the incident, the assembly hall had been decorated for a party that was scheduled to occur the following day. Plastic tables, chairs and decorations were also set up and organized throughout the bingo hall.

Police units initially arriving on scene observed a 3- to 4-foot flame with smoke coming from the A/B corner roof and thick, black smoke emitting from an attic vent on the D-side. Arriving fire department units could not confirm thick, black smoke emitting from the attic vent on the D-side. Arriving fire department units observed smoke and fire emitting at the roof line on the A/B corner (kitchen area). NIOSH investigators believe that once the fire got going in the kitchen area it quickly spread upwards into the attic area. The attic area contained a large span of trusses over an open dance hall. E1 (in the bingo hall) and E2 (in the dance hall) both reported fire and/or rollover conditions above their heads while operating interiorly prior to Victim #1's distress call. Additionally, two PPV fans were placed at the A-side front door to create better visibility within the large and relatively open structure.

Conditions did change within the structure leading to the eventual flashover.

Contributing Factors

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. NIOSH investigators identified the following items as key contributing factors in this incident that led to the fatalities and injuries:

- Nonsprinklered commercial building
- Risk management principles not effectively used
- High-risk, low-frequency incident
- Fire ground strategy, tactics, and ventilation
- Rapid fire progression
- Fire burned and spread undetected above the ceiling
- Crew integrity
- SCBA air management
- Fire ground communications
- Flashover.

Cause of Death and Injuries

According to the autopsy report, the medical examiner listed Victim #1's cause of death due to conflagration injuries and Victim #2's cause of death due to thermal injuries and smoke inhalation. Victim #1 also had a carboxyhemoglobin (COHb) level of 34% and Victim #2 had a COHb level of 19%. FF1 and FF2 sustained third-degree burns over their bodies.

Recommendations

Recommendation #1: Fire departments should use risk management principles at all structure fires.

Discussion: While it is recognized that firefighting is an inherently hazardous occupation, risk management principles established by the fire service are based on the philosophy that greater risks will be assumed when there are lives to be saved and the level of acceptable risk to fire fighters is much lower when only property is at stake. Interior offensive firefighting or fast-attack operations can increase the risk of traumatic injury and death to fire fighters from structural collapse, a flashover, and potential asphyxiation. When it is confirmed that there are no lives to save, the IC must then decide what risks they are willing to expose their personnel to based on risk-versus-gain.

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Established risk management principles suggest that more caution should be exercised in abandoned, vacant, and unoccupied structures and in situations where there is no clear evidence indicating that people are trapped inside a structure and can be saved.[2] In this incident, no vehicles were observed within the parking lot for the structure, the time was late evening, and all doors were secured. From this information, a determination may have been made that the structure was unoccupied.

The IC, with input from the assigned ISO and/or division/group supervisors, is responsible for evaluating conditions at a structure fire and determining safe tactics for fighting the fire. To accomplish this, the IC should use a standardized strategic decision-making model. First, the IC should size up the critical fireground factors.[3] Before ordering an offensive attack, the IC must make a determination that offensive (interior) operations may be conducted without exceeding a reasonable degree of risk to fire fighters and must be prepared to discontinue the offensive attack if the risk evaluation changes during the firefighting operation. A full range of factors must be considered in making the risk evaluation, including but not limited to the following:

- Presence of occupants in the building
- A realistic evaluation of occupant survivability and rescue potential
- Size, construction, and use of the building
- Age and condition of the building
- Nature and value of building contents
- Location and extent of the fire within the building
- Adjacent exposures (structures)
- Fire involvement or compromise of the building's structural components
- Residential or commercial structure
- Delayed discovery/reporting and its effect on burn time and structural stability
- Considerations of fire loading and fire behavior
- A realistic evaluation of the ability to execute a successful offensive fire attack with the resources that are available.[2-3]

These fireground factors must be weighed against the risk management plan. Fire fighters are routinely exposed to certain known and predictable risks while conducting operations that are directed toward saving property. The IC is responsible for recognizing and evaluating those risks and determining whether the level of risk is acceptable or unacceptable. However, risks taken to save property should always be less than those to save lives.[2, 4] Risks to fire fighters versus gains in saving lives and property must always be considered when deciding whether to use an offensive or defensive attack. The IC should routinely evaluate and re-evaluate conditions and radio progress reports in reaching objectives to dispatch and on scene fire fighters. This process allows the IC to determine whether to continue or revise the strategy and attack plans. Failure to revise an inappropriate or outdated attack strategy is likely to result in an elevated risk of death or injury to fire fighters.[3, 5]

NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*, section 4.2, provides detailed information regarding the risk management plan.[5] Incident demands on the modern fireground, unlike those of the past, require ICs and commanding officers to have increased technical

knowledge of building construction with a heightened sensitivity to fire behavior, a focus on operational structural stability, and considerations related to occupancy risk versus the occupancy type. Strategies and tactics must be based on occupancy risk, not occupancy type, and must orchestrate sufficient staffing, fire flow, and tactical patience in a manner that identifies with the fire profiling and the predictability of the occupancy profile and accounts for presumptive fire behavior.[6] The first-arriving officer, as well as the IC, must make an informed judgment before and ongoing as to what is at risk—people or property. This judgment will determine the risk profile for the incident. Many fire fighters stand by the notion that all incidents are "people" events until proven otherwise. Historically, the fire service has a poor history of changing risk-taking strategies based upon the people/property issue.[7]

Arriving officers and incident commanders need to consider all information gathered during their initial risk assessment when determining their incident action plan (IAP).

Recommendation #2: Fire departments should ensure that incident commanders and fire fighters understand the influence strategy and tactics (e.g., fireground ventilation) may have on fire behavior and fire fighter safety and consider whether traditional firefighting tactics are appropriate.

Discussion: Ventilation is the systematic removal of heated air, smoke, and fire gases from a burning building and replacing them with cooler air.[8] The two types of ventilation are vertical and horizontal. During vertical ventilation the natural convection of the heated gases creates upward currents, which draw the fire and heat in the direction of the vertical opening. Horizontal ventilation allows for heat, smoke, and gases to escape by means of a doorway or window but is highly influenced by the location and extent of the fire, and special caution should be taken if the fire is in the attic or above a ceiling.[8]

Ventilation may begin as early as opening a door to a structure that is on fire.[9] For this reason ventilation should be closely coordinated with hoseline placement and offensive fire suppression tactics. Close coordination means the hoseline is in place and ready to operate, so that when ventilation occurs, the hoseline can overcome the likely increase in combustion. In other words, if air is added without the addition of water, then the fire gets larger and fire fighter safety decreases.[9]

Properly coordinated ventilation can decrease the rate the fire spreads, increase visibility, and lower the potential for flashover or backdraft. Proper ventilation reduces the threat of flashover by removing heat before combustibles in a room or an enclosed area reach their ignition temperatures. Proper ventilation can reduce the risk of a backdraft by reducing the potential for superheated fire gases and smoke to accumulate in an enclosed area. Properly ventilating a structure fire will reduce the tendency for rising heat, smoke, and fire gases, trapped by the roof or ceiling, to accumulate, bank down, and spread laterally to other areas within the structure. The ventilation opening may produce a chimney effect, causing air movement from within a structure toward the opening. These air movements help facilitate the venting of smoke, hot gases, and products of combustion but may also cause the fire to grow in intensity and may endanger fire fighters who are between the fire and the ventilation opening.

Fire development in a compartment may be described in several stages, although the boundaries between these stages may not be clearly defined.[8] The incipient stage starts with ignition, followed by growth, fully developed, and decay stages. The available fuel largely controls the growth of the fire

during the early stages. This is known as a fuel-controlled fire, and ventilation during this time may initially slow the spread of the fire as smoke, hot gases, and products of incomplete combustion are removed. As noted above, increased ventilation can also cause the fire to grow in intensity as additional air is introduced. Effective application of water during this time can suppress the fire, but if the fire is not quickly knocked down, it may continue to grow.

If the fire grows until the compartment approaches a fully developed state, the fire is likely to become ventilation controlled. Further fire growth is limited by the available air supply as the fire consumes the oxygen in the compartment. Ventilating the compartment at this point will allow a fresh air supply with oxygen to support combustion, which may accelerate the fire growth, resulting in an increased heat-release rate. If coordinated fire suppression activities do not quickly decrease the heat-release rate, ventilation-induced flashover can occur.[8] Considering that most fires beyond the incipient stage are or will quickly become ventilation-controlled, increasing ventilation is likely to be one of the most significant factors in changing fire behavior and can result in rapidly accelerating the fire.

Underwriters Laboratories (UL) Fire Research Division has recently conducted research that suggests traditional firefighting tactics should be reconsidered and suggests a more innovative fire attack tactic is more effective in making the fireground safer for fire fighters and occupants.[10] For over 250 years, traditional tactics used by the American fire service to mitigate and control hazards of fire have worked—and these tactics have been passed down from individual fire fighter experiences through the generations.[11] However, structure fires have decreased by 53% over the past 30 years, which in turn has limited the opportunities for today's fire service to gain necessary experience to understand the increasingly complex fires they are now up against.[12]

UL experiments showed that applying water into a burning room through an exterior door or window before making an interior attack will lower temperatures within the structure and cool the unburned fuel, thereby increasing the potential survival time for building occupants and providing safer conditions for fire fighters to enter. Additionally, UL experiments demonstrated that the traditional practice of increasing ventilation to a ventilation-limited structure fire by opening doors, clearing windows, or cutting the roof increased fire hazards and the potential for a rapid transition to flashover.[13]

Units arriving at this incident observed fire coming from the roof at the A/B corner. The truck company "popped" the door located at the A/B corner on the B-side and observed heavy fire in this area but did not have a hoseline to attack the fire. Victim #1 and his probationary fire fighter advanced a hoseline through the bingo hall to this same area to attack the fire from the inside. They had not pulled any ceiling tiles and did not have a thermal imager to see if the fire was advancing above them. Additionally, PPV fans were placed at the front door on A-side, which allowed better visibility within the vestibule but in turn pushed fresh air into the structure. A better strategy may have been to attack the fire through the B-side door in a defensive manner, committing to an interior attack only when confirmed lives were at risk, or the conditions improved sufficiently to make such actions low-risk.

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Recommendation #3: Fire departments should ensure that an established incident management system on a fireground is appropriate and effective as it relates to that specific incident.

Discussion: Most incidents are considered routine and involve a small commitment of resources (high-frequency/low-risk events), while fewer incidents involve large structures, large commitments of resources, and complex situations (low-frequency/high-risk events). An incident management system is intended to provide a standard approach to the management of emergency incidents. NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*[5] and NFPA 1561 *Standard on Emergency Services Incident Management System*[14] both state an incident management system shall be utilized at all emergency incidents. Most often, this system is commonly known as, or referred to as, the Incident Command System, or ICS. The many different and complex situations encountered by fire fighters require a considerable amount of judgment in the application of ICS. The primary objective is always to manage the incident. The IC should be able to apply ICS in a manner that supports effective and efficient management of the incident. The use of ICS should not create additional challenges for the IC, but rather provide a systems approach to ensuring a successful outcome of the incident.[14]

NFPA 1561, Chapter 3.3.30 defines an incident management system as "A system that defines the roles and responsibilities to be assumed by responders and the standard operating procedures to be used in the management and direction of emergency incidents and other functions."[14] Chapter 4.1 states, "The incident management system shall provide structure and coordination to the management of emergency incident operations to provide for the safety and health of emergency services organization responders and other persons involved in those activities."[14] Chapter 4.2.1 states, "The incident management system shall integrate risk management into the regular functions of incident command."[14]

The incident management system covers more than just fireground operations. The incident management system must ensure for command/control and fire fighter safety, which includes situational evaluation, strategy and the IAP, personnel accountability, risk assessment and continuous evaluation, communications, rapid intervention teams, roles and responsibilities of the incident safety officer, and interoperability between multiple agencies (e.g., mutual aid departments, law enforcement, emergency medical services, state and federal government agencies and officials) and surrounding jurisdictions (i.e., automatic aid or mutual aid responders).

One of the most critical components of this system is the development and implementation of an IAP.[14] For the fire service, the IAP is communicated verbally a majority of times. The IAP is based on the resources immediately available and those responding. The goal is determined in accordance with the incident priority from which a strategy must emerge; tactical objectives aimed at meeting the strategy are determined, and specific assignments made. A personnel accountability system should be established as assignments are made. The important point is that the overall IC communicates the IAP to tactical- and task-level supervisors.

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During this incident, this fire department responded to a high-risk/low-frequency incident in which they were faced with a nonsprinklered 7,400 square foot assembly hall versus the routine room-and-contents residential fire. This fire had vented through the roof, which was observed by cellular 9-1-1 callers before the first emergency unit ever arrived on scene. ICs and front line officers need to take this information into account and be aware that the fire may be free-burning—potentially above an interior operation—as it was in this incident. In addition, the assessment indicated that there likely were no civilian lives in jeopardy from this fire. All officers arriving at this incident performed a walk-around of the structure, giving them a better feel for the structure. This walk-around should empower the officers to express their thoughts on the structure and potential strategies and tactics before ever committing their personnel to an interior attack, especially when only property loss is at risk. Today's fire departments need to consider that performing the same strategies and tactics on every fire may make the fireground personnel complacent and not allow for situational awareness and an assessment of risk.

Recommendation #4: Fire departments should ensure that a complete situational size-up is conducted on all structure fires.

Discussion: Among the most important duties of the first officer on the scene is conducting an initial 360-degree situational size-up of the incident and transmitting this information to units on the fireground or responding to the incident. NFPA 1561, 8.9.1.1 states the incident commander shall conduct an initial and ongoing situational assessment of the incident.[14] In order to accomplish this, the first officer on scene needs to have the requisite knowledge of the elements of a proper size-up.[15] A proper size-up begins from the moment the alarm is received, and it continues until the fire is brought under control either offensively or defensively. The size-up should include an evaluation of factors such as the following:

- Location and volume of the fire
- Required fire flow
- Building construction
- Commercial versus residential structure
- Water supply
- Initial arriving engine laying in from a hydrant versus waiting for another engine to supply them upon their arrival.
- Length of time the fire has been burning, recognizing burn time may have affected structural stability
- Conditions on arrival
- Occupancy
- Fuel load
- Presence of combustible or hazardous materials
- Exposures
- Roof and wall loads
- Time of day
- Available staffing on scene or en route

- Weather conditions
- A realistic evaluation of the ability to conduct an offensive attack with available resources.[2-3]

Even before ICs take command of an incident, they will be faced with having to determine which critical tasks must be performed (simultaneously or as required) to bring the incident under control, and whether they can delegate these tasks before becoming overwhelmed. ICs may need to consider assigning an individual to be an aide or operations sector leader so that critical tasks can be delegated, carried through, and effectively supervised. ICs will use current knowledge and previous experience to formulate a plan for arriving apparatus and personnel. When the IC arrives, as much information as possible must be ascertained to determine whether the IAP will still work. The IC may be faced with several priorities, such as an entrapped civilian, an incident of a scale larger than previously determined, and the fire environment itself, which are additionally part of the initial situational size-up. Items such as these will constantly change as the incident progresses until it is brought under control. ICs should be willing to prioritize and change their strategy and plan based on these assessments. Most importantly, the initial size-up provides a starting point for all fireground operations, especially when deciding on how to safely control and extinguish the fire.

During this incident, all arriving officers performed a 360-degree walk-around of the structure. The IC did not perform a walk-around. A decision was made to stretch a hoseline interiorly, find the seat of the fire, and extinguish it. ICs should consider factors such as whether civilian lives are at stake, size and type of the building, fire progression, fire behavior and extension, available man power, and ventilation tactics before placing fire fighters interiorly.

Fire departments should be aware of the International Association of Fire Chiefs' (IAFC) *Rules of Engagement (ROE) of Structural Firefighting.*[16] These guidelines recommend that ICs conduct or obtain a 360-degree situational incident size-up, determine the occupant survival profile, and conduct an initial risk assessment.

Recommendation #5: Fire departments should ensure that crew integrity is properly maintained by face-to-face contact or radio contact when operating in an immediately dangerous to life and health (IDLH) atmosphere.

Discussion: When an engine company enters a structure, the members must remain in contact by visual (eye-to-eye contact), verbal (by radio or by face-to-face), or direct (by touch) contact. NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*, 8.5.5 states, "Crew members operating in a hazardous area shall be in communication with each other through visual, audible, or physical means or safety guide rope, in order to coordinate their activities," 8.5.4 states, "Members operating in hazardous areas at emergency incidents shall operate in crews of two or more.[5] Additionally, NFPA 1500 8.5.6 states, "Crew members shall be in proximity to each other to provide assistance in case of an emergency."[5]

The International Association of Fire Chiefs, Safety, Health, and Survival Section has redefined the *Rules of Engagement for Structural Firefighting*. One of its objectives is to ensure that fire fighters always enter a burning building as a team of two or more members and no fire fighter is allowed to be

alone at any time while entering, operating in, or exiting a building. A critical element for fire fighter survival is crew integrity. Crew integrity means fire fighters stay together as a team of two or more. They must enter a structure together and remain together at all times while in the interior, and all members come out together**.** Crew integrity starts with the company officer ensuring that all members of the company understand their riding assignment, have the proper PPE, and have the proper tools and equipment. Upon arrival at the incident, the company is given a task to perform by the IC. The company officer communicates to the members of the company what their assignment is and how they will accomplish their assignment. To ensure that crew integrity is maintained, all the members of a company should enter a hazardous environment together and leave together. If one member has to leave, the whole company leaves.[16]

It is the responsibility of every fire fighter to stay connected with crew members at all times. All fire fighters must maintain the unity of command by operating at all times under the direction of the IC, division/group supervisor, or their company officer. The ultimate responsibility for crew integrity and ensuring no members get separated or lost rests with the company officer. While operating in a hazard zone they must maintain constant contact with their assigned members by visual observation, voice, or touch. They must ensure they stay together as a company or crew. If any of these elements are not adhered to, crew integrity is lost and fire fighters are placed at great risk.

NFPA 1500, 8.4.4 – 8.4.6 states:

- The incident commander shall maintain an awareness of the location and function of all companies or crews at the scene of the incident.
- Officers assigned the responsibility for a specific tactical level management component at an incident shall directly supervise and account for the companies and/or crews operating in their specific area of responsibility.
- Company officers shall maintain an ongoing awareness of the location and condition of all company members.[5]

If a fire fighter becomes separated and cannot immediately get reconnected with his/her crew, the fire fighter must attempt to communicate via portable radio with the company officer. If reconnection is not accomplished after three radio attempts or reconnection does not take place within one minute, a mayday should be declared. If conditions are rapidly deteriorating, the mayday must be declared immediately. As part of a mayday declaration, the fire fighter must next activate the radio's emergency alert button (where provided), followed by manually turning on the PASS alarm. Similarly, if the company officer or the fire fighter's partner recognizes they have a separated member, they must immediately attempt to locate the member by using their radio or by voice. If contact is not established after three attempts or within one minute, a Mayday must be declared immediately.[16]

During this incident, Victim #1 and his probationary fire fighter somehow became separated after leaving together. The probationary fire fighter was unaware that Victim #1 was having trouble in exiting until after he heard a radio transmission over the radio. By this time, the two were out of reach and contact from each other. Victim #1 immediately began radioing for assistance and alerted others by depressing his emergency button on his hand-held radio.

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Recommendation #6: Fire departments should ensure that fire fighters are properly trained in "out of air" and "low air" SCBA emergencies and SCBA repetitive-skills training.

Discussion: Repetitive-skills training on an SCBA is a vital necessity for fire fighters working in an immediately dangerous to life and health (IDLH) atmosphere. Repetitive-skills training can increase the ability to operate SCBA functions and controls in a high-anxiety moment or an emergency. Many times, these skills must be performed with gloved hands, limited vision, and reduced ability to hear commands or information from other fire fighters or fire officers. Repetitive-skills training allows fire fighters to engage buttons such as the don/doff button, bypass, cylinder wheel or main line valve, and buddy breathing connection in training conditions that are non-IDLH. This helps build the fire fighters muscle memory skills so their hands will be able to activate the controls with gloves on and the operation will be a second-nature response.

Fire fighters need to be trained to use their equipment and the repetitive-skills training reinforces the muscle memory to properly activate the correct controls. Overcoming out-of-air emergencies is an important goal of repetitive-skills training. Fire fighters also need to understand the psychological and physiological effects of the extreme level of stress encountered when they run low on air, become lost, disoriented, injured, or become trapped during rapid fire progression. Most fire training curricula does not include discussion of the psychological and physiological effects of extreme stress, such as encountered in an imminently life-threatening situation, nor do they address key survival skills necessary for effective response. Understanding the psychology and physiology involved is an essential step in developing appropriate responses to life-threatening situations. Reaction to the extreme stress of a life-threatening situation, such as being trapped, can result in sensory distortions and decreased cognitive processing capability. [17] In the book *Stress and Performance in Diving*[18] the author notes that while all training is important, "we know that under conditions of stress, particularly when rapid problem-solving is crucial, over-learning responses is essential. The properly trained individual should have learned coping behavior so well that responses become virtually automatic requiring less stop and think performance." Fire fighters should never hesitate to declare a mayday. There is a very narrow window of survivability in a burning, highly toxic building. Any delay declaring a mayday reduces the chance for a successful rescue.[19]

Air management is the responsibility of the fire fighters using the SCBA as well as those commanding the incident. Fire departments and fire fighters need to understand what it means to manage their SCBA air (especially with a 1,200 liter bottle), the importance of leaving an IDLH environment prior to a low air alarm sounding, and the need to treat low-air alarms as an emergency or mayday situation to promote immediate planned actions.

In this incident, several fire fighters on the fire ground expended their air supply simultaneously which may have led to fire attack positions not being manned. The International Association of Fire Chiefs, Safety, Health, and Survival Section *Rules of Engagement for Structural Firefighting* states all fire fighters should maintain continuous awareness of their air supply, situation, location and fire conditions.[16] Fire departments should also consider retiring 1,200 liter volume SCBA bottles and replace with 1,800 liter volume bottles or higher. Additional information on what should be evaluated

when looking at one's ability to use an SCBA and air management can be found in NFPA 1404 *Standard for Fire Service Respiratory Protection Training*.

Fire fighters must frequently check their air supply while in a structure. Major benchmarks include prior to entering the structure, labor demanding tasks (e.g., pulling ceiling/charged hoselines, ascending stairs), before/after entering an interior room to search, and before entering large open spaces or long corridors.

In this incident, Victim #1 asked his probationary fire fighter to check his remote pressure gauge for him to see how much air he had remaining. According to information provided to NIOSH from the lieutenant coming off shift, there might have been an issue with Victim #1's HUD. After determining how much air he had left, approximately ¼ or 25%, Victim #1 made the decision for him and his probationary fire fighter to exit the building. Victim #1 became separated from his probationary fire fighter and then had difficulty in following the hoseline to the exit. The remaining air in his bottle was not sufficient for Victim #1 to attempt to follow the hoseline out before becoming disoriented. Victim #1 most likely suffered an SCBA out-of-air emergency and may have been out of air when the RIT found him. It is not known whether he removed his own facepiece but it was not on when he was brought out of the structure.

Recommendation #7: Fire departments should use thermal imagers (TIs) during firefighting operations.

Discussion: Thermal imagers, (TI), also known as a thermal imaging camera or "TIC", provide a technology with potential to enhance fire fighter safety and improve the ability to perform tasks such as size-up, search and rescue, fire attack, and ventilation. TIs should be used in a timely manner, fire fighters should be properly trained in the use of a thermal imager and be aware of their limitations.[19, 20]

The application of thermal imaging on the fireground may help fire departments accomplish their primary mission, which is saving lives. This mission can be accomplished in many ways. First and foremost, in near zero visibility conditions, primary searches may be completed quickly and with an added degree of safety. The use of thermal imaging technology may also be invaluable when a fire department is confronted with larger floor areas or unusual floor plans.[20] Searching for trapped civilians is part of a fire department's primary mission. At times, the search may be for a member who has become separated from the company or crew. TIs may also provide a method for fire fighters to track and locate other fire fighters in very limited visibility conditions. The TI may provide invaluable assistance in locating a missing member of the company or crew. This process can enhance fire fighter accountability before an issue arises.[21]

At a structure fire, the TI may help identify the location of the fire or the extent of fire involvement prior to fire fighters being deployed into a structure. Knowing the location and extension of the fire may help fire fighters determine the best approach to attack the fire. The TI may provide additional information for a crew(s) making the fire attack that they would not previously have due to poor visibility and building construction. Using this information, fire fighters may be able to locate the fire

more quickly and may also ensure that the water application is effective. One of the most important aspects of the TI is that when used properly and understood it may provide the potential to detect a fire that is isolated or hidden within parts of a structure.[22] While the use of a TI is important, research by UL has shown that there are significant limitations in the ability of these devices to detect temperature differences behind structural materials, such as the exterior finish of a building or outside compartment linings (i.e., walls, ceilings, and floors).[23] It is important that fire fighters understand these limitations.

Of all the operations in which the TI can improve a fire fighter's efforts, search and rescue has been impacted the most. Fire fighters using thermal imagers can see the room, which enables them to quickly navigate and identify victims. Without a TI, fire fighters search burning buildings by crawling through smoke to try and locate possible victims. From a ventilation perspective, fire fighters can use the TI to identify areas of heat accumulation, possible ventilation points, and significant building construction features. This helps ensure proper and effective ventilation and fire attack that successfully removes smoke and heat from a building.

In this incident, thermal imagers were not used by initial engine companies searching for the seat of the fire. A TI was used by RIT when initially entering the structure to locate Victim #1.

Recommendation #8: Fire departments should conduct pre-incident planning inspections of buildings within their jurisdictions to facilitate development of safe fireground strategies and tactics.

Discussion: NFPA 1620 *Standard for Pre-incident Planning* states, "The purpose of this document shall be to develop pre-incident plans to assist responding personnel in effectively managing emergencies for the protection of occupants, responding personnel, property, and the environment." A pre-incident plan identifies deviations from normal operations and can be complex and formal or simply a notation about a particular problem, such as the presence of flammable liquids, explosive hazards, lack of hydrants, modifications to structural building components, or structural damage from a previous fire.[24-26]

Building characteristics including type (or more importantly risk) of construction, materials used, occupancy, fuel load, roof and floor design, and unusual or distinguishing characteristics should be recorded, shared with other departments who provide mutual aid, and, if possible, entered into the dispatcher's computer so that the information is readily available if an incident is reported at the noted address.[26] NFPA 1021, 4.5.2, states "Identify construction, alarm, detection, and suppression features that contribute to or prevent the spread of fire, heat, and smoke throughout the building or from one building to another."[15] These pre-incident plans can help determine safety hazards within or around a structure, length of response times, and locations of closest hydrants. Since many fire departments have tens/hundreds of thousands of structures within their jurisdiction, it is a challenge to establish an effective preplanning system. Priority should be given to structures that have elevated or unusual fire hazards, have high occupancy loads (e.g., schools, malls, hospitals, meeting halls), represent a high-risk and low-frequency type incident, and have life safety considerations.

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According to the fire department, this structure had a pre-plan but it was outdated and not available the night of the incident.

Recommendation #9: Fire departments and dispatch centers should ensure that emergency traffic over a radio, such as a Mayday, is effectively monitored, receiving the highest priority during an incident.

Discussion: NFPA 1221 *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems* recommends the communication center have the ability to monitor tactical fireground radio traffic. Fireground communications can become very hectic and confusing when a fire fighter is in distress, becomes lost, or is trapped. Fire departments and dispatch centers must be able to effectively monitor radio transmissions (e.g., maydays) while on the fireground and within a dispatch center. A mayday procedure can outline the fireground response plan and duties of fire fighters, officers, the dispatch center, and the IC. Procedures can include establishing separate radio channels for fireground operations, search and rescue operations, and/or water supply. Fire departments and dispatch centers should understand and be trained on what should happen and what individuals' roles are in the event of a mayday or emergency button activation. This will help reduce any confusion during the mayday.

The term mayday is the international distress signal. Fire fighters must act promptly when they become lost, disoriented, injured, low on air, or trapped.[19, 27-31] They should announce, "Mayday-Mayday-Mayday" over the radio and manually activate their PASS device. A transmission of the mayday situation should be followed by the last known location of the fire fighter and, if able, the individual's identifier. A crew member who suspects a fire fighter(s) is in trouble or missing should quickly try to communicate with the fire fighter(s) via radio and, if unsuccessful, initiate a mayday providing relevant information.

An emergency radio transmission reporting a mayday is the highest priority transmission that may occur at any incident and should receive precedence from dispatch, the IC, and other units operating at the incident. When this emergency traffic is initiated, all other radio traffic should stop to clear the channel and allow the message to be heard. Mayday transmissions must always be acknowledged and immediate action taken. The IC must either personally handle the situation or designate another officer to do so. Part of handling a mayday is to communicate with the fire fighter(s) in distress and with other fire fighters or officers involved. The sooner the IC is notified and a RIT is activated, the greater the chance of the fire fighter being rescued. If there is any question that a mayday may have been transmitted and heard by someone (not all), priority should be given in verifying if it were a mayday transmission. The IC should be made aware of this immediately, so that he can attempt to contact the individual who potentially transmitted the mayday or contact dispatch to verify the transmission. A possible mayday transmission should never be overlooked. Additionally, fireground communications should immediately be transferred to an additional tactical channel so that the mayday or emergency activation can have a dedicated channel so that RIT operations or communications with a distressed fire fighter can be managed.

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Fire departments should be aware of the International Association of Fire Chiefs' (IAFC) *Rules of Engagement (ROE) of Structural Firefighting*.[16] These guidelines recommend that fire fighters constantly monitor fireground communications for critical radio reports and declare a mayday as soon as they are in danger. Although not addressed by the IAFC ROE, ICs and dispatch centers should also be constantly monitoring fireground communications for critical radio reports. The value of a dispatch center monitoring fireground channels cannot be understated. Quite often, due to normal fireground activities, it is possible for the IC to miss a critical radio transmission. The dispatch center, in a different environment than the fireground and with a dispatcher dedicated to the incident, may be able to hear that transmission, potentially making a measurable difference in the outcome of the incident.

During this incident, Victim #1 did not declare a mayday but did radio the IC that he needed assistance and he did activate the emergency button on his hand-held radio, alerting all listening of his emergency. However, he was unable to reset it, which may have caused communication problems at times on the fireground between responders on this channel. Dispatch or the IC should request an additional tactical channel when a fire fighter issues a mayday or is in trouble to handle the fireground operations.

Also, the IAFF Fire Ground Survival program which is available to all fire departments was developed to ensure that training for mayday prevention and mayday operations is consistent between all fire fighters, company officers, and chief officers.[19]

Recommendation #10: Fire departments should ensure that Mayday training program(s) are developed and implemented so that they adequately prepare fire fighters to call a Mayday.

Discussion: The first and foremost priority for fire fighter safety is not getting oneself into a situation that could potentially cause injury or death. The fire fighter must maintain situational awareness at all times while operating on the fireground. Knowledge and skill training on how to prevent a mayday situation and how to call a mayday should begin and be mastered before a fire fighter engages in fireground activities or other immediately dangerous to life and health environments. Beginner fire fighter training programs should include training on such topics as air management; familiarity with an SCBA, a radio, or PPE; crew integrity; reading smoke, fire dynamics, and fire behavior; entanglement hazards; building construction; and signs of pending structural collapse. Fire fighters must be able to recognize when they find themselves in a questionable position (dangerous or not) and be trained on procedures for when and how a mayday should be called. A fire fighter's knowledge, skill, and ability to declare a mayday must be at the mastery level of performance. This performance level should be maintained throughout their career through training offered more frequently than annually.[19]

Fire departments must understand that each fire fighter may have a different interpretation of what is life-threatening. The ability of a fire fighter to call a mayday is a complicated behavior that includes the affective, cognitive, and psychomotor domains of learning and performance.[32] Any delay in calling a mayday reduces the chance of survival and increases the risk to other fire fighters trying to rescue the downed fire fighter. This incident illustrates the need for fire fighters to be given specific mayday procedures for determining when a mayday must be called.

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No rules are established for determining when a mayday must be called, and mayday training is not included in the NFPA standard for fire fighter qualifications. It is up to the authority having jurisdiction to train members for emergency operations[5, 33] and to develop rules and performance standards for a fire fighter to call a mayday. The National Fire Academy (NFA) has two courses addressing the fire fighter mayday doctrine: Q133 Firefighter Safety, Calling the Mayday, a 2-hour program covering the cognitive and affective learning domain of the fire fighter Mayday doctrine; and H134 Calling the Mayday: Hands-on Training, an 8-hour course covering the psychomotor learning domain of the fire fighter Mayday doctrine. These courses are based on the military methodology used to develop and teach ejection doctrine to fighter pilots. A training CD is available to fire departments free of charge from the U.S. Fire Administration Publications Office.[32,34] The NFA Mayday courses present specific mayday parameters or rules for determining when a fire fighter must call a mayday. The courses may help fire departments in developing and teaching mayday procedures for fire fighters. Also, NFPA 1001 *Standard for Fire Fighter Professional Qualifications,* includes job performance requirements related to the fire fighter calling for assistance (such as a mayday situation).[33]

The IAFF Fire Ground Survival program is another resource fire departments can use and was developed to ensure that training for mayday prevention and mayday operations are consistent between all fire fighters, company officers, and chief officers.[19]

Following this incident, the fire department implemented a "Mayday" mode of operation which focuses on enhancing SOPs to ensure critical tasks are accomplished.

Recommendation #11: Fire departments should ensure that policies and procedures for proper inspection, use, and maintenance of self-contained breathing apparatus (SCBA) are enforced to ensure they function properly when needed.

Discussion: NFPA 1981 *Standard on Open-Circuit Self-Contained Breathing Apparatus for Emergency Services* and NFPA 1852 *Standard on Selection, Care, and Maintenance of Open-Circuit Self-Contained Breathing Apparatus* speak directly to the maintenance and use of self-contained breathing apparatus.[35,36] Daily, weekly, and or monthly inspections of a SCBA needs to be documented to include items like air bottle and remote pressure gauge readings, general state of SCBA components and facepiece, PASS device actuation, and regulator flow test and hydrostatic tests. A documented inspection can catch minor issues before they result in a SCBA malfunction or failure. Additionally, annual maintenance, testing, and repairs require an individual to receive specialized training from factory-certified technicians and to perform required tasks as outlined by the manufacturer. This requires special tools, equipment, and knowledge to take apart the components of a SCBA. A fire department should consider adopting a policy that states all SCBA are thoroughly inspected prior to each shift and after each use.

Prior to the incident, Victim #1 was advised by the lieutenant coming off shift that the HUD on the officer's SCBA was not functioning. It is believed that Victim #1 used this same SCBA during the incident. Victim #1's HUD wasn't working so he was not able to determine how much air was remaining in his SCBA bottle. When Victim #1 asked his probationary fire fighter to look at his

remote pressure gauge it was discovered that Victim #1 was only at ¼ of his bottle, or about 25% of air remaining. This proved not to be enough air for Victim #1 to follow the hoseline out before getting separated and disorientated. Over 15 minutes passed after he made his final transmission and he was brought out of the structure.

Recommendation #12: Fire departments should ensure that appropriate staffing levels are available on scene to accomplish fireground tasks and be available for unexpected emergencies.

Discussion: Adequate resources are needed at incident scenes to ensure incident stabilization and fire fighter safety and health. Prior to any response, a department should pre-plan the tasks that may be performed at any structural fire. From determining the required fire flow, to stretching hoselines, forcing entry, search, rescue, extinguishment and much more—fire departments should consider what the staffing need will have to be in order to simultaneously perform these tasks. Additionally, the planning for the first alarm assignment needs to include additional unassigned fire fighters to be on scene, staged and ready to assist with fireground operations in the event of an emergency or to allow for fire fighter rehab. An IC must recognize the limits of their desired action plan based on available resources to fight a fire.

NFPA 1710 *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* identifies the minimum resources for an effective firefighting force to perform critical tasks. These tasks include establishing water supply, deploying an initial attack line, ventilating, performing search and rescue, and establishing a RIT. NFPA 1710 recommends that the minimum staffing levels for an engine company to perform effective and efficient fire suppression tasks is four.[37] However, NFPA 1710 also recommends that large jurisdictions with tactical hazards, high hazard occupancies, high incident frequencies, or other pertinent factors, should staff companies with a minimum of five or six on-duty members.[37]

In addition, a study released by the National Institute for Standards and Technology (NIST), *Report on Residential Fireground Field Experiments*, concluded that a three-person crew started and completed a primary search and rescue 25% faster than a two-person crew and that a four or five-person crew started and completed a primary search and rescue 6% faster than a three-person crew.[38]

In this incident, the fire department responded with three-person engine crews and a three-person truck company.

Recommendation #13: Fire departments should ensure that incident commanders are provided chief's aides to help manage information and communication.

Discussion: A chief's aide, staff assistant, or field incident technician (FIT) is a position designed to assist an IC with various operational duties during emergency incidents. The chief's aide is an

essential element for effective incident management and for a successful outcome of the incident. The importance of having a chief's aide assigned to a battalion chief is to insure that the tasks associated with incident management can be initiated even before arrival on scene. The benefit of having a chief's aide is that the battalion chief can focus on radio communications, initiate the development of the strategy and tactics for the incident, and began to develop an incident action plan. The battalion chief is able to focus on the critical incident management tasks versus trying to operate the vehicle and locate the incident scene under emergency response conditions. If a chief's aide is not provided for a battalion chief, the tasks are delayed until a fire fighter or fire officer is appointed to this position. At an emergency incident, the staff assistant can assist with key functions, such as managing the tactical worksheet; maintaining personnel accountability of all members operating at the incident (resource status and situation status); monitoring radio communications on dispatch, command, and fireground channels; control information flow by computer, fax, or telephone; and access reference material and pre-incident plans.

The personnel accountability system is a vital component of the fire fighter safety process. The system is designed to account and track personnel as they perform their fireground tasks. In the event of an emergency or mayday, the personnel accountability system must be able to provide the rapid accounting of all responders at the incident. This is one of the chief's aide's essential responsibilities.

Another important chief's aide function is the role of a driver in addition to their role as part of the command team. Chief officers are required to respond quickly to emergency incidents. In their response, they have to be fully aware of heavy traffic conditions, construction detours, traffic signals, and other conditions. More importantly, the chief officer must also monitor and comprehend radio traffic to assess which companies are responding, develop a strategy for the incident based upon input from first-arriving officers, and develop and communicate an incident action plan that defines the strategy of the incident. A chief's aide can assist the battalion chief or chief officer in processing information without distraction and complete the necessary tasks en route to the scene.[14]

Departments should consider the aide to be an individual who has the experience and authority to conduct the required tasks. Other potential functions for the chief's aide include serving as group or division supervisor, training position to facilitate officer development, and non-emergency functions that are vital to the daily operations of the department (e.g., daily staffing and leave management).

In this incident, the IC was managing arriving units from the automatic aid department and current operations on the fireground when Victim #1 gave his distress call. The IC juggled the RIT operations, deteriorating fire conditions, and fireground operations. A chief's aide would have been valuable in managing the tactical worksheet; maintaining personnel accountability of all members operating at the incident; and monitoring radio communications on the multiple channels.

Recommendation #14: Fire departments should ensure that backup hoselines are deployed, staffed, and appropriately utilized to protect the means of egress for interior operating crews.

Discussion: A backup hoseline is known as the "safety line" for the interior suppression crew. The primary responsibility of the backup hoseline is to protect interior fire suppression crews if they become overrun with fire, have a failure with the primary hoseline or appliance, and protect a fire fighter's egress point(s). A backup hoseline should be advanced through the same entry point as the primary attack line(s) and should not be advanced past the primary suppression crew. Additionally, the staffed backup line should not crowd the fire suppression crew. The backup line should not be used as the primary attack line for a fire in another area or for exposure control. The backup hoseline crew and suppression crews need to stay in constant communication so that each hoseline is advanced appropriately.

During this incident, a second hoseline was initially advanced into the structure by E2 to support the E1 crew. When it was determined that the E1 crew was fine, the E2 crew repositioned the second hoseline for suppression support from the vestibule into the dance hall. At this point, both hoselines were now being used for primary suppression in two different locations and the crews and the primary egress point were not protected by a backup hoseline.

Recommendation #15: State and local government should adopt and enforce requirements for sprinkler protection in all commercial buildings.

Discussion: Fire development beyond the incipient stage is one of the greatest hazards that fire fighters are exposed to. This exposure and risk to fire fighters can be dramatically reduced when fires are controlled or extinguished by automatic sprinkler systems. NFPA statistics show that most fires in sprinklered buildings are controlled prior to fire department arrival by the activation of one or two sprinkler heads. The presence of automatic fire sprinklers also reduces the exposure risk to fire fighters in rescue situations by allowing the safe egress of building occupants before the fire department arrives on scene. Finally, by controlling fire development, the exposure to hazards such as building collapse and overhaul operations are greatly reduced, if not eliminated.

In this incident, having a sprinkler system possibly could have contained the fire to the room of origin and prevented extension of the fire to the ceiling. Containing or extinguishing the fire would have significantly reduced the risk to all emergency responders and likely would have prevented these injuries and fatalities.

Fire Department Actions Taken Since the Incident

During the course of the investigation, the fire department advised NIOSH that they had implemented a number of changes in department structure and procedures. A description of these efforts can be found in Appendix II.

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Investigator Information

This incident was investigated by Stacy C. Wertman, Safety and Occupational Health Specialist, and Tim Merinar, Safety Engineer with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, WV. This report was authored by Stacy C. Wertman. An expert technical review was provided by Deputy Chief Billy Goldfeder, EFO, of the Loveland-Symmes Fire Department (OH). An expert review was also provided by Chief Gary Morris (Retired). A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

Additional Information

IAFC Rules of Engagement for Firefighter Survival

The International Association of Fire Chiefs (IAFC) is committed to reducing fire fighter fatalities and injuries. As part of that effort, the nearly 1,000 – member Safety, Health and Survival Section of the IAFC has developed DRAFT "Rules of Engagement for Structural Firefighting" to provide guidance to individual fire fighters and incident commanders, regarding risk and safety issues when operating on the fireground. The intent is to provide a set of model procedures for structural fire fighting to be made available by the IAFC to fire departments as a guide for developing their own standard operating procedure. http://www.iafcsafety.org/downloads/Rules_of_Engagement

IAFF Fire Ground Survival Program

The purpose of the International Association of Fire Fighters (IAFF) Fire Ground Survival Program is to ensure that training for Mayday prevention and Mayday operations are consistent between all fire fighters, company officers, and chief officers. Fire fighters must be trained to perform potentially life-saving actions if they become lost, disoriented, injured, low on air, or trapped. Funded by the IAFF and assisted by a grant from the U.S. Department of Homeland Security through the Assistance to Firefighters (FIRE Act) grant program, this comprehensive fire ground survival training program applies the lessons learned from fire fighter fatality investigations conducted by the National Institute for Occupational Safety and Health (NIOSH) and has been developed by a committee of subject matter

experts from the IAFF, the International Association of Fire Chiefs (IAFC), and NIOSH. http://www.iaff.org/HS/FGS/FGSIndex.htm

NFPA Safety Alert on SCBA Facepiece Lenses

On July 2, 2012, NFPA issued a safety alert on SCBA facepiece lenses when investigations and additional research found SCBA facepiece lenses may undergo thermal degradation when exposed to intense heat. Investigations conducted by the NIOSH FFFIPP from 2002 – 2011 found evidence of thermal degradation of facepiece lenses that may have been a contributing factor in three fatalities. NIOSH also reported on the investigation of three SCBAs from a state training academy where the SCBA facepiece lens showed evidence of thermal degradation after being used in live fire training. Additionally, in four other NIOSH line-of-duty death investigations, the evidence, while not conclusive was suggestive of possible SCBA degradation or failure. Additional information on the alert including a full notice can be found at www.nfpa.org/scba.

In addition, in 2010 the National Institute for Standards and Technology (NIST), NIOSH, the Fire Protection Research Foundation (FPRF) and the NFPA jointly hosted a research planning workshop on evaluating and addressing the concerns regarding the thermal impact of SCBA facepiece lenses.[52] Subsequently, the United States Fire Administration (USFA) funded and participated with NIST in research[53] that validated the adverse consequences to firefighters when lens degradation occurs in extreme thermal conditions and developed and provided new testing and performance methodologies to the NFPA Technical Committee on Respiratory Protection Equipment.[54] Based on the information learned from the NIOSH investigations and NIST research, this Technical Committee is in the process of incorporating new test methods and performance criteria for facepiece lenses into the proposed 2013 edition of NFPA 1981.[13] Information on the continuing development of this new edition is available at http://www.nfpa.org/1981next.

Underwriters Laboratories Firefighter Safety Research Institute

http://ulfirefightersafety.com/

NIST Building and Fire Research Laboratory's Fire Research Division

http://fire.nist.gov/

Two Career Lieutenants Killed and Two Career Fire Fighters Injured Following a Flashover at an Assembly Hall Fire—Texas

Appendix I

Status Investigation Report of Four
Self-Contained Breathing Apparatus
Submitted by the
NIOSH Division of Safety Research on behalf of the this Texas Fire Department
NIOSH Task Number 18986
(Note: The full report is available upon request.)

Background

As part of the ***National Institute for Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention Program***, the Technology Evaluation Branch agreed to examine and evaluate four SCBA identified as Scott Health and Safety model AirPak 4.5, 4500 psi, 30-minute, self-contained breathing apparatus (SCBA).

This SCBA status investigation was assigned NIOSH Task Number 18986. The NIOSH Division of Safety Research (NIOSH/DSR) and this Texas Fire Department was advised that NIOSH would provide a written report of the inspections and any applicable test results. The SCBA units, contained within cardboard boxes, were delivered to the NIOSH facility in Bruceton, Pennsylvania on March 12, 2013. After their arrival, the packages were taken to building 20 and stored under lock until the time of the evaluations.

SCBA Inspection

The packages were opened initially in the General Respirator Inspection Area (building 20) on March 27, 2013 and an initial visual inspection was conducted by Tom Pouchot, General Engineering NPPTL. The SCBAs were inspected extensively on successive dates of April 2, 3, 4 and 5, 2013. The SCBA identified as FF#1 was labeled by NPPTL as SCBA Unit #1. The SCBA identified as Victim #1 was labeled by NPPTL as SCBA Unit #2. The SCBA identified as FF#2 was labeled by NPPTL as SCBA Unit #3. The SCBA identified as Victim #2 was labeled by NPPTL as SCBA Unit #4. These SCBA units were extensively examined, component by component, in the condition received to determine the conformance of the unit to the NIOSH-approved configuration. The units were identified as the Scott Health and Safety Company model AirPak 4.5, 30 minute, 4500 psi units, NIOSH approval numbers TC-13F-0076 for Unit # 3, TC-13F-0076CBRN for Unit #2 and unknown for Units #1 (label shows TC-13F-0080, a 2216 PSIG unit, but the unit is a 4500 PSIG SCBA) and #4 as the NIOSH label was covered. The visual inspection process was documented photographically.

Also on June 14, 2013 Scott Health and Safety conducted a down loading of the data logger for SCBA #2. Once all inspections were completed, the SCBA units were repackaged and placed back in building 20 under lock. The complete SCBA inspections are summarized in **Appendix I of the NPPTL report**. *The condition of each major component of each of the SCBA's that were photographed with a digital camera is contained in* ***Appendix III of the NPPTL report****.*

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It was judged that only Unit #3 of the 4 SCBA units could be safely pressurized and tested using a substitute cylinder provided by the Texas Fire Department and a substitute facepiece from NIOSH. Unit #3 was tested on April 18, 2013.

SCBA Testing

The purpose of the testing was to determine the conformance of the SCBA to the approval performance requirements of Title 42, *Code of Federal Regulations*, Part 84 (42 CFR 84). Further testing was conducted to provide an indication of the conformance of each SCBA to the National Fire Protection Association (NFPA) Air Flow Performance requirements of NFPA 1981, *Standard on Open-circuit Self-contained Breathing Apparatus for the Fire Service*, 1997 Edition.

NIOSH SCBA Certification Tests (in accordance with the performance requirements of 42 CFR 84):

1. Positive Pressure Test [§ 84.70(a)(2)(ii)]
2. Rated Service Time Test (duration) [§ 84.95]
3. Static Pressure Test [§ 84.91(d)]
4. Gas Flow Test [§ 84.93]
5. Exhalation Resistance Test [§ 84.91(c)]
6. Remaining Service Life Indicator Test (low-air alarm) [§ 84.83(f)]

National Fire Protection Association (NFPA) Tests (in accordance with NFPA 1981, 1997 Edition):

7. Air Flow Performance Test [Chapter 5, 5-1.1]

Unit #3 was the only unit in a condition to be tested. This unit was tested on April 18, 2013 using a substitute cylinder and facepiece. NIOSH was unable to perform the NFPA test as the test set up was inoperable.

Appendix II of the NPPTL report contains the complete NIOSH test reports for the SCBA. **Tables One and Two** summarize the NIOSH and NFPA test results.

Summary and Conclusions

Four SCBA units were submitted to NIOSH by the NIOSH Division of Safety Research for this Texas Fire Department for evaluation. The SCBA units were delivered to NIOSH on March 12, 2013 and initially inspected on March 27, 2013. The units were identified as a Scott Health and Safety model AirPak 4.5, 4500 psi, 30-minute, SCBA (NIOSH approval numbers TC-13F-0076, Unit #3 and TC-13F-0076CBRN, Unit #2). Scott Health and Safety performed a downloading of the Unit #2 data logger on June 14, 2013. The complete inspections of the SCBA units were conducted on April 2, 3, 4 and 5, 2013. The units suffered varying levels of heat damage, exhibited other signs of wear and tear and the units were covered generally with dirt, grime, some foreign material and soot. The cylinder valves as received on Unit #1, #2, #3 and #4 were in the closed position. *The cylinder gauge could not be read on Unit #1 from the front.* The cylinder gauge on Unit #2 read 0 psig. The cylinder gauges on Unit #3 and #4 could not be read due to heat damage. The cylinder valve hand-wheels could be

turned. The regulator and facepiece mating and sealing areas on Units #1, #2, #3 and #4 were relatively clean and there was minimal debris on the inside of the facepieces. All the units had varying degrees of lens damaged due to heat. The lens on Units #2 and #4 had holes. The facepiece head harness webbing on the Units #1, #2 and #3 were in fair condition with dirt present and only some evidence of wear or damage. Unit #4 had the left side straps not attached to the facepiece as the attachment hardware was damaged and the hairnet was black. Only the PASS on Unit #3 functioned. The NFPA approval labels on Units #2, #3 and #4 were present and readable. Unit #1 did not have a NFPA label visible. Visibility through all the facepiece lenses was poor as the lenses had heat damage.

The air cylinder on Unit #2 had a manufactured date of 01/04. The air cylinder on Unit #1 had a partial date visible of 2003. Under the applicable DOT-E-10945-4500 exemption, the air cylinder is required to be hydro tested every 5 years. For the air cylinder on Unit #2, a retest date before the last day of 01/09 is required. No retest labels were readable on Unit #2, therefore it is not possible to determine if the cylinder was within the hydro certification when last used. The Unit #1 cylinder also could not be determined if the cylinder was within hydro certification when last used. The Unit #3 and Unit #4 cylinders could not determine a manufacturer date or re-hydro date. Therefore, it could not be determined if the cylinders were within hydro certification when last used. All the cylinders were mostly black. The fiber wrap on the cylinder of Unit #4 was exposed and damaged. No air was remaining in any of the cylinders.

A replacement air cylinder with a current hydrostatic re-test qualification was supplied by the Texas Fire Department. This cylinder was substituted for all Unit #3 tests. In addition, the facepiece on Unit #3 was damaged and this facepiece was replaced by a facepiece supplied by NIOSH. No other maintenance or repair work was performed on the units at any time.

SCBA Unit #3 met the requirements of the NIOSH Positive Pressure Test, with a minimum pressure of 0.05 inches of water. Unit #3 **met** the requirements of all of the other NIOSH tests.

In light of the information obtained during this investigation, NIOSH has proposed no further action on its part at this time. Following inspection and testing, the SCBAs were returned to storage pending return to the Texas Fire Department.

If some of the units are to be placed back in service, the SCBA's must be extensively repaired, tested, cleaned, damaged components replaced and inspected by a qualified service technician, including such testing and other maintenance activities as prescribed by the schedule from the SCBA manufacturer. Typically a flow test is required on at least an annual basis.

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Appendix II

The department undertook a number of actions to prevent the occurrence of similar injuries. An Operations Committee of fire department personnel from all ranks was formed. The committee was charged with thoroughly reviewing all firefighting standard operating procedures (SOPs) to determine any changes needed to increase the level of safety of the department personnel. The Operations Committee met numerous times over the months following the fire and spent many hours in this endeavor. The department advised NIOSH that they have implemented a number of changes based on Committee recommendations. The following is a summary of the changes reported to NIOSH:

Staffing Increase and Resolution

On June 25, 2013, the city council unanimously resolved to increase department staffing over a ten-year period to a minimum of four firefighters on all fire apparatus. On the day of the incident, each fire company had been staffed with three firefighters. While this fire department has had success at delivering efficient firefighting services in the past, staffing was many times stretched to accomplish required fireground tasks. Several national staffing studies reviewed by the fire department showed that fire companies with four fighters can accomplish 22 required fire ground tasks 25% faster than a three-person crew.

In addition, this staffing increase would include the assignment of a full-time chief's aide. The department noted that it is a very demanding task to monitor and direct a working incident, especially on larger incidents involving larger structures. When a fire fighter mayday situation develops, the abilities of the incident commander can be quickly overwhelmed. Assigning an aide to the battalion chief will provide better management during firefighting operations and most importantly, during mayday situations. The duties of the chief's aide would include operating the battalion chief vehicle, which would allow the battalion chief to focus on evolving details of the emergency event while en route, assist in incident management, track personnel accountability, perform radio communications (especially during mayday operations), operate the command board, act as a scribe to document all activities and operate the mobile data terminal.

Six firefighters were hired in November 2013 increasing daily staffing levels and in December 2013, the truck company minimum staffing was raised to four fire fighters.

An additional fire inspector was assigned to the fire marshal's office increasing the ability to inspect commercial structures. The department noted that inspecting commercial structures on a more frequent basis will increase chances of finding potential fire risks.

Increase of Staffing on Initial Response to a Structure Fire

Another engine company has been added to the initial alarm bringing, the total response to four engines, one truck company, a battalion chief, an EMS supervisor and an ambulance. The company

officer and fire fighter(s) on the fourth arriving engine company will deploy a hand line and will be in a stand-by role in the event of a fire fighter mayday. This "blocking line" will deploy alongside the Rapid Intervention Team (RIT) solely to provide protection from heat or flashover while the RIT is locating and extracting the downed fire fighter. The apparatus operator of the fourth engine will immediately report to the incident commander and serve in the role of a chief's aide and scribe. The chief's aide will track and document all pertinent information relating to fireground operations.

Implementation of "Mayday" Mode of Operation

Standard operating procedures for mayday situations were enhanced to ensure critical tasks are accomplished. In the event of a reported fire fighter mayday, each company operating at the scene will know their role in rescuing the trapped fire fighter. During a mayday mode, the EMS Supervisor who typically serves as incident safety officer will report to command as the rescue division officer when mayday mode is declared by command. The incident commander will monitor safety until someone else is assigned to the safety officer's position. The trapped/lost fire fighter(s) and the company members with them will remain on the assigned radio talk group as will the RIT and the blocking line crew. The rescue division officer will monitor the radio traffic, direct the rescue effort and report progress face-to-face with command. All other companies engaged in firefighting operations will move to a pre-determined tactical channel to communicate firefighting operations. When a mayday mode is confirmed and declared by command, RIT and the blocking line will deploy to begin rescue operations. In addition, command will request an additional alarm for more resources and will have administrative officers immediately paged to respond to the scene.

Coordinated Hoseline Rotations Providing Relief for Attack Crew and Reducing Fire Fighter Fatigue

With the addition of a blocking line, crews who have been actively involved in firefighting will come out when necessary and report to rehab. Once the crew has replenished their air supply and are rested, they will report to the blocking line and assume those duties. The crew that was previously assigned to the blocking line will now engage in the remaining firefighting tasks. The rotation of crews will continue until no longer needed. The blocking line will remain in place as long as the RIT is standing by.

Thermal Imager Use

During the incident, it was noted that not all company officers had a thermal imager (TI) with them during firefighting efforts. TIs are carried on all fire companies for use by the company officer. Standard operating procedures now mandate that all company officers have a TI with them at all times while performing fireground activities.

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All Pre-connected Hoselines will be 200 Feet in Length and Different Colors

Previously, all engine companies carried two 150-foot hoselines midsection of the truck (one red in color, one yellow in color, and two 200-foot hoselines on the rear of the truck, one red one yellow. While these hose configurations did not cause any issues at this incident, the need to make all hoselines the same length became apparent with the change of staffing a blocking line. This will ensure that regardless of which hose is deployed initially by the attack crews, the other hoselines will have adequate length to reach those areas.

The different color hoselines will help fire fighters to distinguish a hoseline they may be following out of a building so not confuse it with another. The department noted that this had proved helpful during the incident as the downed lieutenant was able to identify that he was on the red hoseline when calling for assistance. The RIT was able to follow the red hoseline directly to him as a result. With the addition of the blocking line, the need to separately identify all four different hoselines would be very helpful in a similar situation involving the deployment of multiple hoselines.

Communications

Based on factors at the incident, several changes in fireground communications were made. The department noted that during the rescue operation of Victim #1 it was very difficult at times to communicate due to the number of personnel on scene and the intensity of radio traffic during the rescue. During a typical structure fire, radio communication on one talk group is manageable among fire companies operating at the scene. However, it became apparent that when the rescue effort began, radio communications, at times, became overwhelming. The fire scene was divided between the ongoing firefighting effort and the rescue. The incident commander had to manage both efforts while monitoring all radio communications.

Communication changes have included separating radio talk groups when a mayday situation is declared, establishing a designated rescue division officer to monitor rescue operations, and reprogramming portable radios to have voice-announced talk groups. Previously, when a structure fire call was received, a tactical talk group was assigned to the incident by the fire department dispatcher at the time of alarm. All fire companies assigned operated on the designated talk group throughout the incident. Under the new procedure, when a mayday is declared by command the RIT, the blocking line crew, and the rescue division officer will remain on the originally assigned tactical talk group (now known as the rescue talk group) while all other crews will move to a pre-determined tactical talk group (Tact 6) and continue firefighting operations. The incident commander monitors Tact 6 and the rescue division officer directs and monitors the rescue talk group at the command post next to the incident commander. The rescue division officer and the incident commander will monitor accountability and communicate progress and needs in a face-to-face.

Due to firefighting crews having to change radio talk groups during a declared mayday, all portable radios have been reprogrammed so each time a radio is turned on, or a change is made in the selection of a talk group, the radio operator will hear a voice announcing the selected talk group to help ensure

the proper talk group has been selected. In addition, the radios were previously programmed with talk groups in descending order (Talk group 1, Talk group 2, etc.). The last talk group on the radio dial is now also programmed to Tact 6 so if any confusion remains as to which talk group is which, the radio operator can roll the talk group selection clockwise until it stops and they will be on Tact 6 as well.

Upgrades to Personal Protective Equipment (PPE)

The fire department has been specifying and purchasing high quality firefighting coats and pants for many years. The specifications included Globe brand G-Xtreme gear with Millenia XT outer shell, 3 layer crosstech moisture barrier, and Quantum 3d 2i thermal liner. Although the gear worn during the fire sustained heavy damage, the department believes it performed well. In an effort to make the gear even better, another layer of Quantum 3D SL2i was added to the complete thermal cape of the coat.

The PPE committee researched firefighting hoods that are currently available to determine if a higher level of protection is available. After much research, the committee recommended the Majestic C6FYR-Hawk which is a four layer hood with a steam resisting layer of Melange. The department has ordered enough hoods to provide one to everyone in the department along with extras for replacement.

The fire department decided to move to 45-minute cylinders in lieu of their current 30-minute cylinders. The 30-minute cylinders have been completely phased out and the department is now using 45-minute cylinders.

New Hose Load and High-rise Packs

A new hose load, called a combination roundabout load, was introduced and implemented. The new hose load provides easier deployment and requires less manpower for deployment into structures. All high-rise hose packs were replaced with two-inch hose with combination fog/breakaway nozzles. These hose packs will be used in high-rise firefighting situations but can also be used in commercial settings where a higher flow is required.

Identification of Probationary Fire Fighters

In order to better recognize probationary fire fighters at fire scenes, the tetrahedrons on a probationary fire fighter's helmet and the leather helmet front are now green.

Additional Training

Since the incident, much training has occurred for all personnel concerning the following topics related to this incident:

- Annual SCBA/PPE requirement
- Critique of this incident
- RIT drill practical exercises

- Basic Structural Tactical Initiative (BSTI) with a fourth engine added; classroom and practical exercises
- BSTI with mayday practical exercises
- New roundabout hose load and breakaway nozzles
- Training was conducted with all dispatchers concerning new procedures and SOPs

Several companies also had training in:

- Strategy and Tactics
- Thermal Imaging Cameras
- Building Construction

Command Staff Training/Discussion

- Transitional fire attack
- Risk management during structure fires
- Truck company operations
- Parameters for offensive operations in commercial structures

Technology

The fire department PPE committee evaluated the Scott pack trackers and the SEMS II products in October 2013. The committee members had mixed opinions and decided more research was needed, and is planning to interview departments currently using the products being considered.

Current Considerations

The operations committee has been tasked with evaluating the recent research performed by the National Institute of Standards and Technology (NIST). After adequate time for all committee members to review data, decisions will be made regarding any potential strategy and tactic changes. Additionally, the committee has determined the need to draft a commercial occupancy standard operating procedure, similar to the basic structural tactical initiative currently in place.

Disclaimer

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