Executive Summary

On December 14, 2015, a 42-year-old male career fire fighter was critically injured after falling down an unsecured elevator shaft while searching for the seat of a smoldering fire in a two-story, Type-1, brick warehouse. The fire fighter was a member of Tower Ladder 34, the second truck company to arrive at the 25,000-square-foot vacant structure following the dispatch at 0241 hours. The arriving crews found light smoke conditions and no heat on the first floor. The incident commander, Battalion Chief 23, sized up the conditions on the first floor and directed Tower Ladder 34 and Truck 17 crews to the second floor where they encountered thick, white smoke banked down to floor level, creating almost zero visibility. The Tower Ladder 34 fire fighter advanced up the stairs on the west side of the structure with a fire fighter from Truck 17. At the top of the stairs, the two fire fighters encountered near-zero visibility but no heat. The Tower Ladder 34 fire fighter turned to the left while the Truck 17 fire fighter turned to the right to begin searching for the fire. The Tower Ladder 34 lieutenant, who had previously advanced to the second floor using the same stairway, and a fire fighter advanced straight ahead and encountered open holes in the second-story floor. He immediately radioed “Emergency, Emergency, I have openings in the second floor” over the fireground radio channel. At the same time, Battalion Chief 23 also observed a 10 foot by 10 foot hole in the floor on the first floor. He immediately acknowledged the Tower Ladder 34 lieutenant’s report and repeated the emergency alert over the radio to all companies announcing holes in the first and second floors. Approximately 90 seconds later, the Tower Ladder 34 fire fighter fell down an unsecured elevator shaft on the second floor located near Side B into the basement. The incident commander, located on the first floor near the Side B loading dock doors, saw the Tower Ladder 34 fire fighter fall and immediately radioed a Mayday. The Tower Ladder 34 fire fighter was removed from the basement at approximately 0302 hours and transported to the hospital where he was pronounced dead.
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Contributing Factors

- Vacant structure undergoing renovation
- Elevator removed during renovation work
- Inadequate shielding of flammable materials during welding operations
- Multiple unsecured openings in floors
- Unsecured floor openings not immediately broadcast to everyone on fireground
- Deep-seated fire that smoldered undetected for approximately 36 hours
- Zero visibility conditions on second floor
- Fire fighter operating alone (searching on second floor).

Key Recommendations

- Fire departments should ensure that crew integrity is properly maintained by sight, voice, or radio contact when operating in an immediately dangerous to life and health (IDLH) atmosphere.
- Fire departments should continually train on becoming proficient in search operations (residential, rope-assisted, large area, etc.) with emphasis on entering low and crawling when visibility is limited or obscured.
- Fire departments should train fire fighters on the principles of situational awareness.
- Fire departments should use risk management principles at all structure fires and emergency response incidents.

Additionally:

- Fire departments, cities, and authorities having jurisdiction should consider developing systems that allow the integration of building information into the information available to responding crews during the initial dispatch.

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH Fire Fighter Fatality Investigation and Prevention Program, which examines line-of-duty deaths or on-duty deaths of fire fighters to assist fire departments, fire fighters, the fire service, and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with state or federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department, or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

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

On December 14, 2015, a 42-year-old male career fire fighter was critically injured after falling down an unsecured elevator shaft while searching for the seat of a smoldering fire in a two-story, Type-1, brick warehouse. That same day, the United States Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of the fire fighter line-of-duty death.

On December 16, 2015, the fire department contacted NIOSH and requested an investigation of this incident. On January 4, 2016, a safety engineer and a general engineer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program traveled to Illinois to investigate the incident. The NIOSH investigators met with the fire department’s senior management staff to initiate the investigation. The NIOSH investigators also met with the International Association of Fire Fighters (IAFF) local Vice President and Health and Safety Representative. The NIOSH investigators interviewed the fire fighters and officers who responded to this incident. The NIOSH investigators obtained and reviewed copies of the fire dispatch and fireground audio records and transcripts, fire department standard operating procedures and guidelines, incident scene photographs, and training records for the deceased fire fighter. The NIOSH investigators also met with the fire department’s fire investigation bureau, logistics chief, and training chief and visited the fire department training academy and the Fire Alarm Office (dispatch and communications center). The NIOSH investigators met with Illinois-OSHA representatives investigating this incident. The NIOSH investigators were not able to enter the incident site due to ongoing criminal investigations at the time of the NIOSH investigation.

Fire Department

The career fire department involved in this incident has 98 stations with over 4,500 uniformed members that serve a population of approximately 2,851,000 within an area of about 228 square miles.

Department members assigned to the Operations Division work a 24-on/48-off shift schedule with three shift platoons. The department is organized into 5 districts, which command a total of 24 battalions and a special operations battalion.

The fire department currently operates 97 engine companies, 50 truck companies, 10 tower ladders, 1 aerial tower, 4 squads (heavy rescue companies, which are two-piece companies), 1 marine fire boat plus 1 reserve fire boat, and various support apparatus for high-rise incidents, hazardous materials incidents, airport rescue, and special operations. All fire department apparatus are maintained by the city’s fleet maintenance division. Annual testing (e.g., pumps and ladders) as recommended by the National Fire Protection Association (NFPA) is conducted by qualified vendors. In addition to fire suppression, hazardous materials mitigation, and special operations response, the fire department operates an emergency medical services (EMS) division, which consists of 75 advanced life support (ALS) ambulances, and support staff, including EMS field officers. Also, the fire department operates
an aircraft rescue fire fighting (ARFF) division at two airports within the city.

The fire department has well documented written policies and procedures consistent with the requirements of NFPA 1500 Standard on Fire Department Occupational Safety and Health Program, Section 4.1 and 8.8, which are available to all department members at each fire station and all fire department offices. Policies and procedures on the incident command system, engine company operations, truck company operations, self-contained breathing apparatus (SCBA), structural firefighting protective gear and equipment use, personal accountability report (PAR) procedures, Mayday procedures, radio use, rapid intervention team (RIT), and other topics were reviewed during the NIOSH investigation. The fire department has a training facility that is in operation from 0700 to 1600 hours, Monday through Friday. The fire department's training academy literature includes training materials related to bowstring truss construction, lightweight truss construction, and steel bar truss construction.

The fire department dispatch center (Fire Alarm Office) is part of the city's Office of Emergency Management and Communication (OEMC). The Fire Alarm Office operates with six dispatchers plus a supervisor on each 8-hour shift. The Fire Alarm Office processes approximately 1,800 calls per 24 hours or approximately 600 calls per shift. The department receives over 500,000 emergency calls annually. Fireground audio is not recorded.

The fire department is rated as a Class 1 department by ISO as of February 1, 2017. 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.

Training and Experience
Beginning in August 2010, the Illinois Office of the State Fire Marshal (OSFM) implemented new minimum certification standards for all fire fighters in the state, and these standards meet or exceed the requirements of NFPA 1001 Standard on Fire Fighter Professional Qualifications, Fire Fighter I and Fire Fighter II [NFPA 2013a]. As of December 2015, the Illinois Firefighter Requirements for Basic Operations included:

- 180 course hours with written and practical exams
- FSVO – Fire Service Vehicle Operator Course completion
- Hazmat Awareness
- Hazmat Operations
- TRA – Technical Rescue Awareness
- CPR/Basic First Aid

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 (FSRS). More information about ISO and their Fire Suppression Rating Schedule can be found at the website http://www.isogov.com/about/. 
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- National Incident Management System (NIMS) 100 and 700
- National Fallen Firefighters Foundation (NFFF) “Courage to Be Safe” course completion.

This career fire department enacted requirements that exceed the state’s requirements.

The fire department hires candidates through the city career service process. The fire department gives recruitment tests for both single-role paramedics and fire fighter positions. Candidates are selected from a list using a random-number process. Candidates must pass a background check. Once a candidate is selected by the city, the candidate is sent to the fire department for a candidate physical ability test (CPAT).

Fire fighter recruits must complete a probationary period which is considered nine months of continuous employment from the date of initial hire. The fire department operates its own recruit training academy, which recruits attend for at least 6 months, exceeding the state requirement. In addition to completing Basic Operations Firefighter certification requirements, recruits receive approximately 150 additional hours of fire-fighting training at the academy. Each recruit must also complete instruction in emergency medical services and be certified as a state of Illinois EMT-Basic (EMT-B). After completing the recruit training, candidates are further reviewed during the Candidate Field Evaluation Period which is a period of twelve months of post-fire academy assignment on a company (engine or truck).

Fire fighters are required to participate in 2 hours of training per work shift, which is documented by the company officer. All fire fighters complete a 30-minute mask drill (self-contained breathing apparatus or SCBA) at the beginning of each work shift that includes monitoring the air pressure in the SCBA cylinder. During the mask drill, each fire fighter adds their personal accountability system identification tag to the personal accountability report (PAR) apparatus collection ring located on the apparatus they are assigned to.

All pump operators on the fire department hold the career service rank of Fire Engineer for which they must pass competitive written and practical examinations. Engineers also go through a 5-week class at the fire academy. Ladder/Truck apparatus do not have pumps. Ladder/Truck operators are referred to as a driver. The fire department’s engineer and driver training requirements exceed the requirements of NFPA 1002 Standard for Fire Apparatus Driver/Operator Professional Qualifications [NFPA 2014a].

Promotion to the lieutenant rank involves both a written test and oral interview process (Seniority is 30-percent of the examination). Newly promoted lieutenants go through a 5-week training program at the fire academy that covers subjects including fire officer, fire dynamics, water rescue, high-rise operations, medical form documentation, and employee-assistance program classes. The training program includes 3 days of live fire burns including flashover simulation. The 5-week class covers the entire curriculum of the NFPA 1021 Standard on Fire Officer Professional Qualifications [NFPA 2014b].

Promotion to the captain rank involves both a written examination and oral interview process (Seniority is 30-percent of the examination). Selected officers attend a 2-week training program that covers subjects including incident safety officer (ISO) training, fire dynamics, motor vehicle accidents,
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personal protective equipment, employee-assistance program, and fire officer.

The battalion chief position is the highest tested rank. The 4-week training program for battalion chief officers includes incident safety officer (ISO), Fire Instructor 1, Fire Officer 1, and employee assistance programs.

All officer training classes involve tactical hands-on training involving simulators and tactical boards.

Officers at the deputy district chief rank and above are appointed by the fire commissioner.

In compliance with the National Incident Management System (NIMS) training requirement, the fire department requires all fire fighters to complete NIMS training commensurate with their rank. The fire department’s NIMS training requirements for fire fighters, fire engineers, and battalion chiefs are greater than the federally mandated minimum requirements. Company officers are provided with opportunities to complete advanced NIMS training (ICS 300, ICS 400, All-Hazards Incident Management Team Training) that exceed the federal minimum requirements for their rank.

The Tower Ladder 34 fire fighter was hired as a paramedic in 2000. He transitioned over to a fire fighter / paramedic position within the department in 2005, approximately 10 years prior to the incident. He completed 3 months at the department’s fire academy. At the time that he was hired, the fire department used a modified CPAT test. In 2014, the fire department adopted the full CPAT test.


The 23rd Battalion Chief (incident commander) had 29 years of experience with the fire department. He received certificates of training in Fire Fighter II, Technical Rescue Awareness, Trench Operations, Hazardous Materials Technician A, Hazardous Materials First Responder – Operations, Introduction to the Incident Command System (ICS 100) IS-00100, ICS for Single Resources and Initial Action Incidents IS-00200, National Incident Management System (NIMS) an Introduction, NIMS Multiagency Coordination System (MACS) IS-00701.a, NIMS Resource Management IS-00703.a, NIMS Communications and Information Management IS-00704, National Response Plan (NRP) –
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Equipment and Personnel
The fire department involved in this investigation has several levels of alarm responses for reports of structure fires. The Fire Alarm Office will dispatch a Still Alarm assignment to initial reports of a possible structure fire. The Still Alarm dispatch sends two engine companies, two truck companies, and a battalion chief. If the Fire Alarm Office receives additional reports of a fire or a company arrives on-scene and reports a “working fire,” then a rescue squad company, a command van, and a rapid intervention team (RIT) will be dispatched. If the report of a fire is located in a rescue squad company’s first due area (approximately 40 blocks), then the rescue squad company will be sent automatically. The on-scene incident commander can elevate the alarm (Still and Box alarm, 2-11, 3-11, etc.) depending on the resources needed. There are situations where the Fire Alarm Office can transmit a Still and Box Alarm. These situations can include a person trapped in the fire building, multiple structures on fire, a large commercial building on fire, a building collapse, a train derailment, an airport alert (aircraft in distress), or smoke in a building with a high life hazard (e.g., hospital, nursing home, theater).

Extra alarms are designated as 2-11, 3-11, 4-11, and 5-11 with defined response protocols for each.

Any equipment needed above a fifth alarm (5-11) will be considered a “Special Call” and is requested by the incident commander.

In 2002, the department implemented procedures for a RIT response in which a truck company and a battalion chief are dispatched to and designated as a RIT on every working fire. A RIT response is comprised of 1 truck company, 1 ALS engine company (RIT engine) for high-rise fires only, 1 battalion chief, 1 advanced life support (ALS) ambulance, and 1 emergency medical services (EMS) field officer. Additionally, the department has procedures for a Mayday response that follows closely with the RIT response. In the event a Mayday is transmitted, protocol requires a Still Alarm to be upgraded to a Still and Box Alarm, or if a Mayday is transmitted at a Still and Box Alarm, the incident is upgraded to a 2-11 alarm. If the incident is already a 2-11 alarm, the alarm level is upgraded at the discretion of the incident commander. The RIT chief is also the designated incident safety officer (ISO) at a structure fire unless the incident is upgraded to a 2-11 or higher alarm and additional chief officers are dispatched, at which time a separate ISO will be designated.

This incident was initially dispatched for a report of smoke in a commercial warehouse structure. Per normal standard operating procedures, the following apparatus and personnel were dispatched for the Still Alarm assignment:

- Engine 46 with an officer, engineer, and two fire fighters (1 fire fighter short due to a staffing variance)
- Engine 81 with an officer, engineer, and three fire fighters
- Truck 17 with an officer, driver, and three fire fighters
- Tower Ladder 34 with an officer, driver, and three fire fighters (including the victim)
- Battalion Chief 23
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- Ambulance 22 with two paramedics

After the arriving crews confirmed the presence of smoke, the incident was upgraded to a Full Still Alarm, which included the dispatch of 1 rescue squad company, 1 stand-by ambulance for fire victims, a RIT Task Force consisting of a truck company, a battalion chief, an ALS ambulance, and a field paramedic chief.
- Truck 49 with an officer, driver, and three fire fighters (designated as RIT)
- Battalion Chief 24 (designated as RIT chief and safety officer)
- Squad 5 with an officer, driver, and four fire fighters
- ALS Field Chief 458
- Ambulance 37 with two paramedics
- Ambulance 9 with two paramedics

Timeline
An approximate timeline for this incident summarizing the sentinel events up to the time the Tower Ladder 34 fire fighter fell through the opening in the second floor and was transported to the hospital on December 14, 2015, is listed below. The times are approximate and were obtained by studying the available dispatch channel records, witness statements, interviews, run sheets, and fire department records. This timeline is not intended, nor should it be used, as a formal record of events. Only those events directly related to the fall are included.

- **0236:41 Hours**
  911 phone call reporting smoke in commercial warehouse structure.

- **0241:08 Hours**
  Still Alarm: Engine 46, Engine 81, Truck 17, Tower Ladder 34, Battalion Chief 23, Ambulance 22 are dispatched.

- **0241:57 Hours**
  Engine 46 and Truck 17 arrive at dispatched address. They determine address is an empty lot.

- **0242: 39 Hours**
  Engine 46 locates fire building and confirms smoke showing.

- **0242:57 Hours**
  Truck 17 on-scene and confirms smoke showing on Side A.

- **0244:31 Hours**
  Battalion Chief 23 on-scene and assumes command.

- **0245:00 Hours (approximate)**
  Truck 49, Battalion Chief 24, Squad 5, ALS Field Chief 458, Ambulance 37, Ambulance 9 dispatched for a working fire alarm.
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- **0246:11 Hours**
  Truck 49 confirms RIT assignment.

- **0247:44 Hours**
  Battalion Chief 23 radios dispatch that crews are making entry into two-story, 150 X 150 warehouse.

- **0251-0255 Hours (time approximate)**
  Tower Ladder 34 lieutenant searching on second floor encounters unguarded floor openings and radios “emergency traffic” for holes in second floor.

- **0255 Hours (time approximate)**
  Battalion Chief 23 radios additional emergency traffic about floor openings and advises all companies.

- **0255:26 Hours**
  Battalion Chief 23 radios Mayday and reports fire fighter fell through hole in floor and elevates the alarm to a still and box alarm with an EMS Plan 1.

- **0300:25 Hours**
  Battalion Chief 23 radios Dispatch and gives progress report on rescue operation and scene size-up.

- **0302:01 Hours**
  Battalion Chief 23 radios fire fighter is out.

- **0309:31 Hours**
  Ambulance 22 enroute to hospital with Tower Ladder 34 fire fighter.

**Personal Protective Equipment**
At the time of the incident, the Tower Ladder 34 fire fighter was wearing his structural firefighting protective gear (coat and pants), helmet, Nomex® hood, gloves, boots, and a self-contained breathing apparatus (SCBA) with an integrated personal alert safety system (PASS). He also carried a portable radio and flashlight. The NIOSH investigators inspected and photographed the structural firefighting protective gear and equipment at a fire department facility on January 5, 2016. The fire fighter’s turnout gear and equipment were not considered to be a contributing factor in this incident.

**Weather and Road Conditions**
On December 14, 2015 at 0243 hours (approximate time of incident), the temperature was 61 degrees Fahrenheit (61°F), the humidity was at 81%, the barometric pressure was 29.31 inches, visibility was 10 miles, the wind was from the South-east at20.7 miles per hour, and it was overcast. Light rain and drizzle was also reported in the area. Approximately 0.2 inches of rain had been recorded in the past two hours [Weather Underground 2015].
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Structure
The structure was originally built in 1903 for use as a slaughterhouse and cold storage facility. Animals were slaughtered on the first floor. Meat was stored on the second floor and in the basement. The structure was used as a cold storage facility until 1963 when it was sold. From 1963 to 2007, the structure housed a wholesale food business. The structure was vacant but maintained from 2007 to 2011. The city building department had inspection records for the structure through 2014.

The two-story commercial structure measured approximately 100 X 100 feet with a basement under the front half. The structure contained approximately 25,000 square feet of total floor space.

The structure was constructed of brick and masonry exterior walls, with concrete floors in the basement and first and second floors. The interior dividing walls were also constructed of noncombustible materials. The structure was classified as Type I per NFPA 220 Standard on Types of Building Construction [NFPA 2015]. The flat roof was covered in built-up layers of asphalt and gravel (see Google Earth view Photo 1).

Photo 1. Overhead view of the incident site. This structure was originally built in 1903 as a slaughterhouse and cold storage facility. Structure is seen in center of photo and highlighted within red box.
(Source: Google Earth.)
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The building was sold again in 2014 and was undergoing extensive renovation work at the time of the incident. Three building permits were in place for the construction and renovation work. All utilities within the structure had been disconnected. All electrical wiring within the structure was de-energized and locked out. The only electricity within the structure was temporary wiring used by the construction crews for lighting and power tools. See Diagrams 1, 2, and 3 for approximate floor plans and layout of the building interior.

Diagram 1. Approximate basement floor plan.
(Adapted by NIOSH from diagram provided by fire department.)
Not to scale
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Diagram 2. Approximate first-floor floor plan.
(Adapted by NIOSH from diagram provided by fire department.)
Not to scale
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Diagram 3. Approximate second-floor floor plan. (Adapted by NIOSH from diagram provided by fire department.)
Not to scale
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Over the years, multiple layers of cork, foam, and insulating materials were added to the walls to facilitate the cooling process.

The cause of the fire was determined to be accidental in nature and was caused by sparks and hot slag from welding operations igniting combustible materials within the insulated wall along the Side C exterior wall. The welder was working alone on Sunday, December 13, 2015, until approximately 1:00 p.m. when he left the building. The welder had extinguished a number of small fires in the area where he was working on the second floor after welding sparks and slag ignited construction debris in the area but did not recognize that fire was smoldering within the wall along Side C. The welder reported expending a portable fire extinguisher to control the small debris fires in his work area. This resulted in a thin film of powder, covering the floor in the area around the open elevator shaft on the second floor. The fire department was able to track the movement of fire fighters by visible tracks in this powder on the second floor.

The fire smoldered within the wall for over 12 hours until a pedestrian noticed smoke and called 911 at approximately 0236 hours on December 14, 2015. During the NIOSH investigation in January 2016, on-going criminal investigations prevented the NIOSH investigators from gaining access to the building’s interior.

Investigation

On December 14, 2015, at 0241 hours, Engine 46, Engine 81, Truck 17, Tower Ladder 34, Battalion Chief 23, and Ambulance 22 were dispatched for a Still Alarm.

The original dispatch directed companies to respond to an incorrect address. The closest responding company, Engine 46, quickly arrived at the address at 0241:57 hours and realized that the given address was incorrect. Truck 17 arrived within seconds and reported to Dispatch that the address was a vacant lot. Truck 17 observed smoke coming from the vacant two-story warehouse structure and advised Dispatch of the correct address. Engine 46 and Truck 17 quickly responded to the warehouse, confirmed the Still Alarm, and set up in the street on the west side of the structure (Side A).

Battalion 23 arrived on-scene at 0244:31 hours and assumed incident command. He parked west of the structure and directed Truck 17 to come to the loading dock doors on Side B and make entry. Battalion 23 directed Tower Ladder 34 to set up in the vacant parking lot located across the street from Side B so that they would have good access to the roof using their aerial platform. Battalion 23 then donned his structural firefighting protective gear and SCBA and proceeded to the loading dock doors. When he arrived at the loading dock, the Truck 17 crew had already forced open the loading dock door on Side B.

The Engine 46 crew established water supply from a hydrant and pulled 200 feet of 2½-inch preconnected hose fitted with a gated wye and 100 feet of 1¾-inch handline to the loading dock door on Side B. When Truck 17 forced open the security gate and loading dock doors, the Engine 46 lieutenant followed the Truck 17 crew (lieutenant and two fire fighters) into the first floor. Battalion Chief 23 also walked inside the first floor. The two Engine 46 fire fighters remained at the loading dock door with the hoseline. The fire fighters observed light smoke and no heat on the first floor.
The Battalion Chief 23 (incident commander) followed the Truck 17 crew inside and observed light gray-white smoke on the first floor with visibility of about 10 feet. He observed the stairway located near the front door (Side A) and walked to the center of the building where a second set of stairs was located. He walked up the steps in the center of the building and observed white smoke banked down to the floor level at the top of the stairs (second floor). He observed that there was no movement to the smoke and did not feel any heat. He walked back down to the first floor and radioed on the fireground channel that the fire appeared to be on the second floor. He walked back toward the loading dock doors where the Engine 46 crew was stretching their hoseline to the door.

The incident commander talked face-to-face with the Engine 46 lieutenant as the Engine 46 crew was pulling their hoseline through the loading dock door. The incident commander pointed out the elevator shaft opening in the first floor to the Engine 46 lieutenant and told him to be careful because of the openings in the floor. The Engine 46 lieutenant told the incident commander that he was going to the second floor for a quick look while the Engine 46 hoseline crew waited at the loading dock. The Engine 46 lieutenant walked down the east stairs adjacent to the loading dock doors to the basement and did not observe any smoke in the basement at this time. He then proceeded up the steps to the second floor where he observed heavy, thick smoke and had to don his facepiece and go on air (see Diagram 2 and Diagram 4). The Engine 46 lieutenant advanced about 10 feet onto the second floor. He reported heavy, white (optically dense) smoke with near-zero visibility but no heat. He quickly scanned the second floor using a thermal imager but did not observe any fire, and the thermal imager did not register elevated heat conditions. Due to the limited visibility, he retreated back to the first floor. While the Engine 46 lieutenant was advancing to the second floor, the incident commander (still located on the first floor) observed glowing embers falling along the Side C wall.

The Engine 46 lieutenant returned from sizing up the second floor and reported to the incident commander who was standing near the open elevator shaft on the first floor.

The Tower Ladder 34 lieutenant reported seeing three large dumpsters in the parking lot where Tower Ladder 34 was set up, so he assumed that the building was undergoing some renovation work. The incident commander directed Tower Ladder 34 to help Truck 17 open the loading dock doors. Per standard procedures, the Tower Ladder 34 driver and roof fire fighter went to the roof to help with ventilation. The Tower Ladder 34 roof crew accessed the roof via the aerial ladder on Truck 17. The Tower Ladder 34 lieutenant and the remaining two fire fighters proceeded to the loading dock area. The Tower Ladder 34 fire fighters each carried a power saw (metal saw and wood saw) and hand tools. When the Tower Ladder 34 lieutenant and two fire fighters reached the loading dock, they observed that the door was already open. The Tower Ladder 34 lieutenant carried a thermal imager and a halligan bar. The Tower Ladder 34 crew entered the first floor and proceeded toward the west stairway. The Tower Ladder 34 lieutenant and fire fighter did a quick search on the first floor. They walked clear back to the Side C wall then over to the Side A wall (see Diagram 4.)

The Tower Ladder 34 lieutenant and fire fighter met the other Tower Ladder 34 fire fighter and the two fire fighters from Truck 17 near the bottom of the west stairway. They heard the incident commander radio that the fire appeared to be on the second floor. The incident commander instructed the Tower Ladder 34 lieutenant to search the second floor. The Tower Ladder 34 lieutenant yelled out to the
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Diagram 4. Approximate paths fire fighters used to search on second floor.
(Adapted by NIOSH from diagram provided by fire department.)
Not to scale
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Tower Ladder 34 fire fighters that they were going to the second floor. The crews donned their facepieces and went on air before ascending the stairs.

The Tower Ladder 34 lieutenant was the first to ascend the stairs. When he got to the top of the stairs, he observed heavy, white smoke and near-zero visibility. He reported that he did not feel any heat and could stand upright. He scanned the area with his thermal imager and realized that a wall was located about 3 feet away directly in front of him. He knew that a fire fighter was behind him and assumed that both Tower Ladder 34 fire fighters were following him. The Tower Ladder 34 lieutenant crawled forward to the nearby wall and quickly realized that there was an opening in the wall. He also noticed that there was an opening in the floor about 2 feet wide, directly behind the wall (see Diagram 3). When the Tower Ladder 34 lieutenant came to the second-floor opening, he immediately radioed “emergency traffic” on the fireground channel and reported the floor openings on the second floor. Note: This fire department does not record the fireground radio traffic, so the exact wording of the emergency radio traffic could not be verified.

The Tower Ladder 34 lieutenant proceeded through the opening in the wall and started a right-hand search. He used his halligan bar to search for openings in the floor as he advanced. The Tower Ladder 34 fire fighter was directly behind him. They continued along the interior wall until they came to the Side A wall and then continued along the Side A wall until they came to another floor opening.

The Tower Ladder 34 fire fighter (victim) and two Truck 17 fire fighters advanced up the stairs. When they reached the top of the stairs, the Tower Ladder 34 fire fighter (victim) turned to the left, and one of the Truck 17 fire fighters turned right. The second Truck 17 fire fighter decided to stay at the top of the stairs so that they would not lose the location of the stairwell in the zero-visibility conditions.

The Tower Ladder 34 lieutenant told the Tower Ladder 34 fire fighter that they were going directly back to the top of the stairs. He used his thermal imager to scan the area for the stairway, and he observed a number of fire fighters at the top of the stairs.

During this same time, the Truck 17 captain climbed up the east stairwell near the loading dock doors. When the Truck 17 captain came to the interior wall, he turned right and then saw the lights of the second Truck 17 fire fighter who had remained at the top of the west stairs. The Truck 17 captain proceeded to the west stairway and met the Truck 17 fire fighter. The remaining Tower Ladder 34 and Truck 17 fire fighters also returned to this point.

The Engine 46 lieutenant had just returned from sizing up the second floor and reported to the incident commander who was still inside the structure. The incident commander observed a 10-foot by 10-foot hole in the floor on the first floor and radioed on the fireground channel additional “emergency traffic” reporting floor openings on the first and second floors. He advised all companies to “watch where they are walking.” Very shortly thereafter, the Tower Ladder 34 fire fighter (victim) fell down the elevator shaft from the second floor to the basement.

Immediately after completing his radio transmission, the incident commander observed something falling from overhead through the elevator shaft opening. He asked the Engine 46 lieutenant what had fallen, and they proceeded to the elevator shaft opening in the first floor and looked down into the
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basement. They immediately saw the injured fire fighter lying on the basement floor. The incident commander immediately radioed a Mayday for a fire fighter down. They observed that an aluminum ladder was in place in the floor opening. The Engine 46 lieutenant immediately climbed down the ladder to reach the injured fire fighter. The incident commander ran outside and met the RIT Company (Truck 49). They directed the Truck 49 captain to get a Stokes basket and ropes to reach the fire fighter in the basement. The incident commander radioed Dispatch and told the dispatcher to send the RIT ambulance crew to Side B. Squad 5 was just arriving on-scene. The incident commander told Squad 5 that they would need to bring ropes inside to the first floor. Photo 2 shows conditions in the basement.

Photo 2. Photo taken shortly after the Tower Ladder 34 fire fighter was removed from the basement. Photo shows smoke conditions in basement. Bottom of elevator shaft where the fire fighter landed is in center of photo.

(Photo courtesy of fire department.)

When the incident commander returned to the loading dock, he met fire fighters carrying the Stokes basket with the injured fire fighter outside. Emergency advanced life support measures were immediately begun on the Tower 34 fire fighter. He was placed into Ambulance 22 and transported to
a hospital where he was pronounced dead.

After the Tower Ladder 34 fire fighter was removed from the basement, crews resumed work to extinguish the fire. Ventilation fans were set up by the Truck 17 roof crew to ventilate and remove the smoke from the second floor. The Engine 81 crew worked on fire suppression. Crews worked to pull the thick layers of cork and foam insulated walls along Side C on the second floor to reach the deep-seated smoldering fire. Crews had to return to the location the following day to pull more walls to reach the fire that continued to smolder inside the thick walls (see Photo 3 and Photo 4).

Photo 3. Photo taken looking toward Side C at the rear of the second floor. The exterior walls were covered with five layers of tile, 2-inch-thick cork, plaster and lathe, 2-inch-thick foam insulation, and 2x4 framing lumber covered by luan sheeting. The fire smoldered in the thick foam and cork insulation material from Saturday till Monday.

(Photo courtesy of fire department.)
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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 ultimately led to this fatality:

- Vacant structure undergoing renovation
- Elevator removed during renovation work

See Appendix One for a list of proactive measures taken by the fire department soon after the incident to help prevent the occurrence of similar incidents.

Photo 4. Another view of the exterior walls on the second floor after the thick layers of insulating materials had been pulled down to reach the deep-seated fire. Note the foam insulation attached to the wall at the lower right corner of the photo.

(Photo courtesy of fire department.)
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- Inadequate shielding of flammable materials during welding operations
- Multiple unsecured openings in floors
- Unsecured floor openings not immediately broadcast to everyone on fireground
- Deep-seated smoldering fire that smoldered undetected for over 12 hours
- Zero-visibility conditions on second floor
- Fire fighter operating alone (searching on second floor)

Cause of Death
According to the Medical Examiner’s Office report, the Tower Ladder 34 fire fighter “died of multiple blunt force injuries received in a fall from a height.”

Recommendations
Recommendation #1: Fire departments should ensure that crew integrity is properly maintained by sight, voice, or radio contact when operating in an immediately dangerous to life and health (IDLH) atmosphere.

Discussion: Crews of fire fighters should operate as cohesive teams of at least two and remain in contact by visual (eye-to-eye contact), verbal (by radio or by person-to-person), or direct (by touch) contact when entering a structure or potentially hazardous area. NFPA 1500 Standard on Fire Department Occupational Safety and Health Program states in Paragraph 8.5.5, “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” [NFPA 2013b]. Additionally, NFPA 1500 Paragraph 8.5.6 states, “Crew members shall be in proximity to each other to provide assistance in case of an emergency” [NFPA 2013b].

The International Association of Fire Chiefs, Safety, Health, and Survival Section has redefined the Rules of Engagement for Structural Fire Fighting. One of the 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 personal protective equipment and structural firefighting gear, and have the proper tools. Crew integrity continues upon arrival at the incident, where the incident commander assigns tasks. The company officer communicates to the members of the company what their assignment is and how they will accomplish the assignment. Members of a company enter a hazardous environment together and should leave together to ensure that crew integrity is maintained. If one member has to leave, the whole company leaves together [IAFC 2012].

Every fire fighter is responsible for staying in communication with other crew members at all times. All fire fighters must maintain the unity of command by operating under the direction of the incident commander, division/group supervisor, or their company officer at all times. The ultimate responsibility for crew integrity (functioning as a team, ensuring no members get separated or lost) at
the company level rests with the company officer. They must maintain constant contact with their assigned members by visual observation, voice, or touch while operating in a hazard zone. 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. If a fire fighter becomes separated and cannot re-connect with his/her crew immediately, 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 1 minute, a Mayday should be declared. The Mayday must be declared immediately if conditions are rapidly deteriorating. The fire fighter must next activate the radio’s emergency alert button (where provided), followed by manually turning on the PASS alarm as part of a Mayday declaration. 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. A Mayday must be declared immediately if contact is not established after three attempts or within 1 minute [IAFC 2012].

In this incident, the victim was reported to have climbed the stairs to the second floor with another fire fighter. They had previously received the assignment to search the second floor for the seat of the fire. Once they reached the top of the stairs, the victim moved to the left while the other fire fighter began to search to the right. Soon after separating, the victim fell through the unsecured elevator shaft opening and received fatal injuries. Near-zero visibility caused by the smoldering fire contributed to the fatality.

**Recommendation #2: Fire departments should continually train on becoming proficient in search operations (residential, rope-assisted, large area, etc.) with emphasis on entering low and crawling when visibility is limited or obscured.**

Discussion: All fire fighters should be proficient in conducting search operations at structure fires. Searches within or around a structure are for two main reasons: to locate potential victims and to locate the seat of the fire. Different types of structures will require different search techniques so fire fighters should be trained on the various techniques for searching residential structures, commercial buildings, high rise structures, big-box department stores, places of worship, and other types of structures. There are generally two search types – the primary search and the secondary search.

The primary search is a rapid but thorough search that is performed either before or during fire suppression operations. The secondary search is conducted after the fire has been brought under control and the greatest hazards have been reduced. Fire fighters should always use the buddy system and work in teams of two or more. By working together, two rescuers can conduct a search quickly while maintaining their own safety. Fire fighters working as a team should always remain in physical, voice or visual contact at all times [IFSTA 2008].

**Recommendation #3: Fire departments should train fire fighters on the principles of situational awareness.**

Discussion: All fire fighters operating at an incident should maintain situational awareness and conduct a continuous risk assessment throughout the incident, reporting unsafe or changing conditions to the incident commander. Fire fighters need to understand the importance of situational awareness and personal safety on the fireground. *Essentials of Fire Fighting and Fire Department Operations* defines
situational awareness as an awareness of the immediate surroundings. On the fireground, every fire
fighter should be trained to be constantly alert for changing and unsafe conditions. This applies not
only to the conditions found within a burning structure, but to exposure buildings and the exterior
fireground as well. Even though a safety officer may have been designated for an incident, all
personnel are obligated to remain alert to their immediate surroundings.

The ability to maintain situational awareness is reliant on a fire fighter’s training, judgment, and
personal condition. These factors must come together every time a fire fighter goes to an emergency
incident, especially those involving a low-frequency, high-risk event, such as structural fire-fighting,
wildland fire-fighting, trench rescue, high-angle rescue, or any of the wide arrays of emergencies fire
fighters are called upon to mitigate. A lack of competency, or even a temporary lack of focus, can lead
to a chain of events that may be catastrophic or even fatal [Brennan 2009, Gasaway 2013].

To properly train personnel to maintain situational awareness on the fireground or at any emergency
incident, a fire department has to develop and utilize effective scenario-based training. Training fire
fighters to maintain situational awareness on the fireground needs to include building construction, fire
behavior, fireground tactics and strategy, ventilation, and other fireground operations. This is a
continuous process that is initiated in recruit school and continues throughout a fire fighter’s entire fire
service career.

Fire fighters need to understand the importance of situational awareness, personal safety, and
company/crew accountability on the fireground. The fireground dangers and hazards can and do
change as an incident evolves and the event duration increases. Situational awareness is defined as
recognition of the immediate surroundings. On the fireground, every fire fighter should be trained to be
constantly alert for changing and unsafe conditions related to their immediate surroundings. Each and
every fire fighter needs to be responsible and accountable for their own safety, as well as team
members and others working in the immediate area. This applies not only to the conditions found
within a burning structure, but to the exterior fireground as well.

The United States Coast Guard says that "situational awareness is the ability to identify, process, and
comprehend the critical elements of information about what is happening to the team with regards to
the mission." In other words, in order to have “situational awareness” you must constantly know what
is happening around you and where you are in relation to threats.

The need for fire fighters to maintain situational awareness is paramount. A loss of situational
awareness can lead directly to disorientation. Disorientation far too often leads to a fire fighter line-of-
duty death. In addition, a perceived lack of a threat can lead directly to complacency or an unrealistic
feeling of comfort in one’s environment. Situational awareness is a cognitive skill; it can be taught. In
order to have situational awareness, you must be able to perceive the threat, comprehend the threat,
and predict what effect that threat may have on you. These elements—Perceive, Comprehend, and
Predict—form the cornerstone of maintaining complete situational awareness [Brennan 2009, Gasaway
2013].

In this incident, the building was undergoing renovation work that produced a number of openings in
the first and second floors. Fire fighters reported to NIOSH investigators that they observed dumpsters
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with construction debris as they arrived on-scene. Tools and construction materials were present on the first floor when fire fighters entered the building to begin their search. The Tower Ladder 34 lieutenant observed openings in the second floor as he searched from the top of the stairway toward Side C. The Tower Ladder 34 lieutenant correctly radioed his observations to Incident Command. Soon after, the Tower Ladder 34 fire fighter fell through the unsecured elevator shaft and received fatal injuries. The various holes in the floors were not properly secured by the construction crews.

Recommendation #4: Fire departments should use risk management principles at all structure fires and emergency response incidents.

Discussion: While it is recognized that fire fighting is an inherently hazardous occupation, established fire service risk management principles 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 (inside a structure) offensive fire-fighting operations can increase the risk of traumatic injury and death to fire fighters from structural collapse, burns, asphyxiation, falls, and many other fireground hazards. 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 [NIOSH 2010].

The incident commander, with input from the assigned incident safety officer 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 incident commander should use a standardized strategic decision-making model. First, the incident commander should size up the critical fireground factors [Phoenix Fire Department 2009]. The incident commander must make a determination that offensive (interior) operations may be conducted without exceeding a reasonable degree of risk to fire fighters before ordering an offensive attack and must be prepared to discontinue the offensive attack if the risk evaluation changes during the fire-fighting operation. A full range of factors must be considered in making the risk evaluation, including (but not limited to):

- 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
- 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 [NIOSH 2010; Phoenix Fire Department 2009].

These fireground factors must be weighed against the risk management plan. There is absolute recognition of the fact that fire fighters are routinely exposed to certain known and predictable risks while conducting operations that are directed toward saving property. The incident commander is responsible for recognizing and evaluating those risks and determining whether the level of risk is
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acceptable or unacceptable. However, risks taken to save property should always be lesser than those to save lives [NIOSH 2010; Grorud 2009]. 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 incident commander should routinely evaluate and reevaluate conditions and radio progress reports in reaching objectives to Dispatch and on-scene fire fighters. This process allows the incident commander 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 [NFPA 2013b; NIOSH 2010].

This incident began at approximately 0243 hours when fire companies began arriving at a locked commercial structure. Arriving fire fighters reported observing dumpsters containing construction debris at the exterior of the structure, which may indicate that the structure was under renovation. As the fire companies entered the structure, they encountered low visibility but little or no heat. Fire departments and fire fighters should anticipate the possibility of floor openings and other hazards whenever they enter buildings that may be under construction, renovation or otherwise unsafe.

Recommendation #5: Fire departments should consider ways to block open shafts and fall hazard areas when they are identified.

Discussion: Fall hazards identified during emergency operations need to be immediately reported to other fire fighters working in the area and the incident commander. The hazard area should be blocked off to reduce the possibility of a fall. Pieces of furniture can be used to cover or block a hole in a floor, open shaft, or stairway. A door can be removed from its hinges and used to cover a hole or block access to an open shaft. If sufficient staffing is present and the immediate area is safe, a fire fighter can be stationed at the fall hazard area to ensure that other fire fighters do not fall.

In this incident, holes in the second floor were observed by the Tower Ladder 34 lieutenant as he searched the second floor. The Tower Ladder 34 lieutenant correctly radioed his emergency alert to Incident Command. As the incident commander received the emergency alert radio transmission from the Tower Ladder 34 lieutenant, the incident commander also observed a 10 foot by 10 foot hole in the first floor and announced an emergency alert over the radio to all companies announcing holes in the floor on the first and second floors. Moments later, the victim fell through the unsecured elevator shaft from the second floor to the basement and received fatal injuries. It is unknown whether the victim heard the radio transmissions about the presence of floor openings within the structure.

Recommendation #6: Fire departments should ensure that interior attack crews always enter a hazardous environment with a charged hoseline, especially in one- or two-story structures.

Discussion: The modern fire environment can change very rapidly. Fire fighters entering the hazardous atmosphere must be prepared to rapidly apply water when interior temperatures increase, often without warning. Many fire fighters have advocated this tactical method based on previous years of experiencing successful results. Modern fuel loads have changed and industry standards do not permit entry into this environment unless fire crews are properly protected except in life-saving situations.

Today’s fire service has the ability to evaluate tactics based on research. As an industry, the fire service needs to reevaluate current standard operating procedures based on research and the modern
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fire environment. The risks of altering actions from accepted safety procedures has been identified in the Normalization of Deviance by Colonel Mike Mullane, Retired USAF, presentation series [Mullane 2009]. Just because fire crews have been successful in the practice does not solidify the safety of the practice.

Engine companies should stretch sufficient hoseline to reach the seat of the fire and ensure that the hoseline is charged, the nozzle bled, and proper nozzle pressure flowing prior to entry into a structure while always being cognizant of the warning signs of flashover or rapid fire progression: pressurized, dark smoke; high heat; roll-over; a lowering thermal layer; and superheated air. A charged hoseline also protects the search team and allows the search team to utilize the charged hoseline as a search line.

In this incident, search teams made entry into the two-story vacant commercial structure under renovation and observed moderate smoke on the first floor but no heat. Search teams advanced to the second floor and found dense, white smoke with near-zero visibility but no heat. A charged hoseline was advanced to the roll-up overhead door on Side B, but no hoseline was advanced to the second floor until after the fatality occurred.

Recommendation #7: Fire departments should consider providing battalion chiefs with a staff assistant or chief’s aide to help manage information and communication.

Discussion: A chief’s aide, staff assistant, or field incident technician is a position designed to assist an incident commander with various operational duties during emergency incidents. The chief’s aide is an essential element for effective incident management. 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 deployment location); monitoring radio communications on the 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 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.

The fire department involved in this incident does not assign aides to battalion chiefs. The fire department dispatches a Command Van to all working structure fires in lieu of chief’s aides. The Command Van aide duties are to document personnel accountability (PAR Sheets), monitor radio frequencies, use the PDT computer, document times, set up and update the tactical command board, provide periodic updates from the fire scene to the Office of Emergency Management and
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Communications (OEMC), liaison with other departments/agencies and other duties as needed. In this incident, the incident commander was managing fire tactics when the Mayday occurred. His priority then focused on the fallen Tower Ladder 34 fire fighter. An aide could have provided valuable assistance managing the tactical worksheet, maintaining personnel accountability and monitoring radio communications.

Recommendation #8: 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 rapid incident stabilization and to promote fire fighter safety and health. A department should pre-plan the tasks that may be performed at any structural fire prior to response and develop response packages to address the tasks. 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 are in order to simultaneously perform these tasks. The planning for the first-alarm assignment needs to include sufficient 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 on-scene fire fighter rehabilitation. Incident commanders should recognize the limits of available resources to complete fireground tasks and adjust their desired action plan to coincide with resources on hand.

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 rapid intervention team or RIT. NFPA 1710 recommends that the minimum staffing level for an engine company to perform effective and efficient fire suppression tasks is four fire fighters. 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 [NFPA 2016].

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 [NIST 2010].

In this incident, Engine 46 was riding with one position short. A full complement of personnel would have provided additional fire fighters to aid in the ongoing size-up and search. This would have also provided additional personnel for a more efficient rapid intervention and to aid in removing the Tower Ladder 34 fire fighter from the basement after he fell through the floor opening.
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Recommendation #9: Fire departments should ensure critical benchmarks are communicated to the incident commander.

Discussion: The size-up of interior conditions is just as important as exterior size-up. The incident commander monitors exterior conditions while the company officers monitor interior conditions and communicate these conditions to the incident commander as soon as possible. Knowing the location and the size of the fire inside the building lays the foundation for all subsequent operations. Interior conditions could change the incident commander’s initial strategy [Klaene and Sanders 2000].

Also, when operating inside the structure, company officers should communicate to the incident commander when making initial entry, while searching and clearing areas, during fire attack, while progressing between floors, and when exiting the structure.

Proper size-up and risk-versus-gain analysis require that the incident commander gather a number of key pieces of information and be kept informed of the constantly changing conditions on the fireground. The incident commander must develop and utilize a system that captures pertinent incident information to allow continuous situational evaluation, effective decision making, and development of an incident management structure. Decisions can be no better than the information on which they are based. The incident commander must use an evaluation system that considers and accounts for changing fireground conditions in order to stay ahead of the fire. If this is not done, the incident action plan will be out of sequence with the phase of the fire and the incident commander will be constantly surprised by changing conditions [Brunacini 2002; NIOSH 2010; Smith 2002].

Interior size-up is just as important as exterior size-up. Since the incident commander is located at the command post (outside), the interior conditions should be communicated by interior crews as soon as possible to the incident commander. Interior conditions could change the incident commander’s strategy. Interior crews can aid the incident commander in this process by providing reports of the interior conditions as soon as they enter the fire building and by providing regular updates, especially when benchmarks are met (e.g., “primary search complete is all clear” and “the fire has been brought under control”).

Benchmarks are a critical part of the incident commander’s incident action plan. If benchmarks are being met, this information must be communicated to Command, as this ensures that Command knows that tactical objectives are being met. This information then allows Command to update the incident action plan. Also, if benchmarks are not being met and not communicated to Command, this creates issues with tactical objectives being met. This may have Command duplicating assignments.

Retired Fire Chief Alan Brunacini states that critical fireground factors, including interior and exterior conditions, are among the many items that the incident commander must consider when evaluating tactical situations. These items provide a checklist of the major issues involved in size-up, decision making, initiating operations, and review and revision. The incident commander deals with these critical factors through a systematic management process that creates a rapid, overall evaluation; sorts out the critical factors in priority order; and then seeks out more information about each factor [Brunacini 2002].
The incident commander should train and prepare through practice to engage in conscious information management. Incident factors and their possible consequences offer the basis for a standard incident management approach. A standard information approach is the launching pad for effective incident decision making and successful operational performance. The incident commander should develop the habit of using the critical factors in their order of importance as the basis for assigning the specific assignments that make up the incident action plan. The incident commander should create a standard information system and use effective techniques to keep informed at the incident. The incident commander can never assume the action-oriented responder engaged in operational activities will stop what they are doing so they can feed the incident commander with a continuous supply of top-grade objective information. It is the incident commander’s responsibility to do whatever is required to stay effectively informed [NIOSH 2010].

For all members operating at an incident scene, in addition to general discipline on the fireground, radio discipline is essential. Fire fighters and fire officers should follow a standard operating procedure/guideline used by all responding departments. All members on the fireground should use the thought process of (and be trained on) "is my transmission necessary" as a part of fireground behavior. All radio transmissions should be reserved for relevant messages such as benchmarks, personnel accountability reports, safety issues or concerns, needed resources, changing conditions, and emergency traffic and Mayday, as opposed to transmissions that add little to the incident action plan.

At this incident, operational benchmark information was not transmitted in a consistent basis over the fireground radio channel. Holes in the second floor were observed by the Tower Ladder 34 lieutenant as he searched the second floor. The Tower Ladder 34 lieutenant correctly radioed his emergency alert to Incident Command. As the incident commander received the emergency alert radio transmission from the Tower Ladder 34 lieutenant, the incident commander also observed a 10 foot by 10 foot hole in the first floor and announced an emergency alert over the radio to all companies announcing holes in the floor on the first and second floors. Note: This fire department does not record the fireground radio traffic, so the exact wording of the emergency radio traffic could not be verified. Search operations to locate the seat of the fire continued. Moments later, the Tower Ladder 34 fire fighter fell through the unsecured elevator shaft.

**Recommendation #10:** Fire departments should ensure that the incident commander establishes a stationary command post for visibility and effective incident management, which includes the use of a tactical worksheet, efficient fireground communications, and a personnel accountability system.

**Discussion:** Although there is no clear evidence that this recommendation would have prevented this fatality, the recommendation is presented as good fireground safety practice. NFPA 1561 *Standard on Emergency Services Incident Management System and Command Safety* §5.3.1 states, “The incident commander shall have overall authority for management of the incident.” The incident commander must establish and maintain a command post outside of the structure in order to assign companies, delegate functions, and continually evaluate the risk versus gain of continued fire-fighting efforts [NFPA 2014c].
Command safety principles provide the incident commander a foundation for effective and efficient management of Type IV and Type V incidents and ensures the highest level of safety for fire department members at emergency incident scenes. This system defines requirements that the incident commander must meet during an incident, including the establishment of a stationary command post and utilization of a tactical worksheet, effective fireground communications, and a personnel accountability system.

When a chief officer (e.g., battalion chief, district chief) arrives on scene, the first steps are to assume command, announce the name of the incident (e.g., Main Street Command), and establish a stationary, exterior, and remote command position. Once command is established and an initial size-up has been done, the incident commander should continue command and control functions inside or at the rear of the vehicle, which should have a command board [Ciarrocca and Harms 2011].

In establishing a command post, the incident commander shall ensure the following (NFPA 1561, Chapter 8—Command Safety):

- The command post is located in or tied to a vehicle to establish presence and visibility.
- The command post includes radio capability to monitor and communicate with assigned dispatch, tactical command, and other designated emergency traffic channels for that incident.
- The location of the command post is communicated to the communications center.
- The incident commander, or designee, is always present at the command post.
- The command post should be located in the incident cold zone [NFPA 2014c].

In order to effectively command an incident, the incident commander should be in the most advantageous position possible. The best position is a fixed, visible, and accessible location at the command post. This can be accomplished by utilizing the incident commander’s staff vehicle, a designated command vehicle, or fire apparatus. An acceptable alternative is utilizing the rear area of a sport utility vehicle or van-style vehicle. This method will provide the incident commander with an area that is quiet and free of distractions from which to command an incident. It is also vital for the incident commander to be able to hear all radio transmissions, especially from those operating on scene. The best way to accomplish this is through the use of a radio communication headset. This will enable the incident commander to be in the best position possible to hear critical radio transmissions. The incident command post also should be visible and recognizable. This can be accomplished by displaying a colored light, flag, banner, or other symbol to mark the location. Where special command post vehicles are used, such vehicles are usually marked with distinctive identification to make the command post recognizable [NFPA 2014c].

The tactical worksheet is a critical piece of equipment because it helps the incident commander organize tasks by providing reminders, prompts, and a convenient workspace for tracking companies and apparatus. It allows them to slow down during what could be a large, multi-alarm incident, although the worksheet can be used for fires big and small, as well as EMS incidents, to help develop proficiency and to record vital information that may help them make future operational decisions. By documenting the assignments of division/group officers and division/group resources, the incident
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The tactical worksheet is also an excellent tool when the passing of command occurs. On the fireground, the officer taking over command can quickly check the worksheet and obtain a strong understanding of the initial deployment of resources, the need for additional apparatus and equipment, and the status of units in the staging area. The advantages of using a tactical worksheet are that it:

- Includes a location to quickly note individual assignments
- Provides prompts for the incident commander, such as time, air management, and strategy
- Provides tactical benchmarks, such as primary search complete, fire under control, and loss stopped
- Facilitates consistent, organized information
- Documents assignments and responsibility
- Expedites passing of command or support for the incident commander
- Provides resource status. [NFPA 2014c]

Fire departments should have a communications standard operating procedure (SOP) coupled with an effective training program. These procedures include the use of clear text (specifically, no 10 codes, or other terms that may be unfamiliar to other responders), a separate radio channel for dispatch, and a separate tactical channel to be used during the incident. When a tactical-level management unit is implemented (division or group), a fire department should provide a dispatch channel, a command channel, and a tactical channel. A fire department should provide the necessary number of radio channels with multiple tactical channels, depending on the type of incident and the complexity of the incident.

Effective fireground and incident scene communications are also essential to the success of the personnel accountability system. The function of resource accountability should be assigned to a member such as a chief’s aide who is responsible for maintaining the location and status of all assigned resources at an incident. This is separate from the role of the incident commander. The incident commander is responsible for the overall command and control of the incident. Due to the importance of responder safety, this function should be assigned to an accountability officer or resource status officer. A number of members could function in this role including a staff assistant, chief officer, apparatus driver/operator, or other responder. There are many means of accounting for resources. Components can include tactical worksheets, command boards, apparatus riding lists, company responder boards, electronic bar-coding systems, and so forth depending on whether equipment or personnel are being tracked. These components can be used in conjunction with one another to facilitate the tracking of responders by both location and function. The components of any resource accountability system should be modular and expand with the size and complexity of the incident [NFPA 2014c].

An incident commander cannot successfully manage all of these functions without the benefit of a tactical worksheet, personnel accountability system, and adequate communications. The intent of command safety is to provide the incident commander with a system that allows the systematic
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development of an incident and in an environment without distractions. Also, managing all these systems can quickly become overwhelming and create task saturation for the incident commander. A staff assistant or chief’s aide is another essential element of this process.

The fire department dispatches a Command Van to all working structure fires in lieu of chief’s aides. The Command Van aide duties are to document personnel accountability (PAR Sheets), monitor radio frequencies, use the PDT computer, document times, set up and update the tactical command board, provide periodic updates from the fire scene to the Office of Emergency Management and Communications (OEMC), liaison with other departments/agencies and other duties as needed.

At this incident, the incident commander moved between the loading dock and the interior of the first floor. Fireground communications were generally effective, however hazardous and unsafe conditions such as the unsecured floor openings were not immediately broadcast over the radio as soon as they were identified. It is noted that radio traffic announcing presence of floor openings was broadcast over the fireground radio channel shortly before the fire fighter fell through the opening on the second floor. Note: This fire department does not record the fireground radio traffic, so the exact wording of the emergency radio traffic could not be verified.

**Recommendation #11: Fire departments should ensure all fireground ventilation is coordinated with fire-fighting operations.**

Discussion: Although there is no clear evidence that this recommendation would have prevented this fatality, the recommendation is presented as good fireground safety practice. Fire departments should manage and control the openings to the structure to limit fire growth and spread and to control the flow path of inlet air and fire gases during tactical operations. All ventilation must be coordinated with suppression activities. Uncontrolled ventilation allows additional oxygen into the structure, which may result in a rapid increase in the fire development and increased risk to fire fighters due to increased heat release rates within the flow path. Underwriters Laboratories (UL) released a report on the *Impact of Ventilation on Fire Behavior in Legacy and Residential Construction*. This report addressed multiple ventilation locations and the possibility of creating fuel-limited fires. The research indicated it was not possible to create fuel-limited fires with multiple ventilation openings. The report stated, “It is more likely that the fire will respond faster because the already open ventilation location is allowing the fire to maintain a higher temperature than if everything was closed” [Underwriters Laboratories 2010].

The flow path of a fire is how a fire moves through the structure as determined by incoming and outgoing vents for air, since air allows fire to sustain or grow [Underwriters Laboratories 2010]. Identifying and controlling the flow path is about knowing where the air comes from and where it’s headed, and its importance cannot be underestimated. The identification of flow path is an item that should find its way into every after-action review. The intent is to locate the fire, cool the heated space from a safe location, and ensure for the safety of the fire fighters. Once the fire is under control, the fire can be completely extinguished. The rescue and salvage operations are self-explanatory—if anything can be saved, save it. These two actions are always active, right from sizing up to extinguishing [ISFSI 2013].
The UL research was conducted on one-story and two-story houses. The data collected from this research project provides valuable insight into the impact of ventilation on fire behavior in both legacy and contemporary residential construction [Underwriters Laboratories 2010]. Based upon the UL research, the following are tactical considerations that should be considered during fireground operations:

- **Stages of fire development**: The stages of fire development change when a fire becomes ventilation limited. It is common with today’s fire environment to have a decay period prior to flashover, which emphasizes the importance of a ventilation strategy.

- **Forcing the front door is ventilation**: Forcing entry has to be thought of as ventilation as well. While forcing entry is necessary to fighting a fire, it also adds another vent that feeds air to the fire. When this happens, the clock is ticking before either the fire gets extinguished or it grows until an untenable condition exists, jeopardizing the safety of everyone in the structure.

- **Flow paths**: Every new ventilation opening provides a new flow path for the fire. This could create very dangerous conditions when there is a ventilation-limited fire.

- **No smoke showing**: During the UL experiments, a common event was that once the fire became ventilation-limited, the smoke being forced out of the gaps of the houses greatly diminished or stopped all together. No smoke showing during size-up should increase awareness of the potential conditions inside.

- **Coordination**: If you add air to the fire and don’t apply water in the appropriate time frame, the fire gets larger and safety decreases. A clear and direct communication between companies or crews assigned to ventilation, fire attack, and other tactical functions that take place inside the structure are required.

- **Smoke tunneling and rapid air movement through the front door**: Once the front door is opened, attention should be given to the flow of air through the front door. A rapid inrush of air, or tunneling effect, could indicate a ventilation-limited fire.

- **Vent Enter Search (VES)**: During a VES operation, primary importance should be given to closing the door to the room. This eliminates the impact of the open vent and increases tenability for potential occupants and firefighters while the smoke ventilates from the now isolated room [Underwriters Laboratories 2010].

Command should conduct a complete and thorough size-up at all structure fires to attempt to determine the location of the fire and communicate the results of the size-up to all fire fighters on the scene. Once the fire location has been determined, the strategy and tactics can be addressed and communicated in order to control the incident in a safe and effective manner.
At this incident, the deep-seated fire had been smoldering within the wall for over 12 hours before fire department companies were dispatched, resulting in the second floor becoming full of thick smoke that severely limited visibility. Fire fighters were sent to the roof for vertical ventilation but the Tower Ladder 34 fire fighter fell through the floor on the second floor before ventilation work could improve visibility.

**Recommendation #12: Fire departments should consider using search lines when conducting primary and secondary searches in large or smoke-filled areas.**

Discussion: Although there is no evidence that following this recommendation would have prevented this fatality, it is being provided as a reminder of a good safety practice. Regardless of how large or small a building may be, fire fighters almost always search the building if it is safe and reasonable to do so. Search teams should carry a radio, thermal imager, flashlights, and forcible entry tools whenever they enter a burning building and throughout the search. Some departments also require search teams to take a search rope with them when they enter the hazard zone [IFSTA 2008].

There are many types and variations of search lines and many different variations on procedures to using the search line in large or smoke-filled areas. The search line is anchored to a fixed object about 10 feet outside the entry point. A company identifier, such as a flag, metal tag, or other identifier, should also be attached to the end of the search line. An example of a search line is one consisting of 200 feet of 3/8-inch rope with abrasion and heat resistant sheathing to protect the rope. A series of knots and 2-inch metal rings are placed at equal intervals along the length of the search line, usually about every 50 feet. The ring is attached into the rope in a manner so that the ring will not slip or come loose from the rope. Immediately after the ring, one or more knots are tied in the rope to indicate the distance from the beginning point. The knots are placed after the ring to indicate direction. In this example, the knots indicate direction to the fire and the rings indicate direction to the exit. The rings are used as anchor points for lateral tether lines that allow fire fighters to search away from the main search line while having the tether as an aid in returning to the main search line [IFSTA 2008]. Using this example, a team of two or three fire fighters can quickly search a large area while maintaining some level of safety in being able to locate the location where they entered.

Search lines were not used during this incident.

**Recommendation #13: Fire departments should train and empower all fire fighters to report unsafe conditions to Incident Command.**

Discussion: Although there is no clear evidence that this recommendation would have prevented this fatality, the recommendation is presented as good fireground safety practice. The International Association of Fire Chiefs (IAFC), Safety, Health and Survival section developed the Rules of Engagement for Structural Fire Fighting. The rules of engagement have been developed to assist both the fire fighter and the incident commander (as well as command team officers) in risk assessment and “Go or No-Go” decisions. The fireground creates a significant risk to fire fighters, and it is the responsibility of the incident commander and command organization officers to minimize fire fighter exposure to unsafe conditions and stop unsafe practices [IAFC 2012].

The IAFC Rules of Engagement can assist the incident commander, company officers, and fire fighters
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(who are at the highest level of risk) in assessing their situational awareness. One principle applied in the rules of engagement is that fire fighters and the company officers are the members most at risk for injury or death and will be the first to identify unsafe conditions and practices. The rules integrate the fire fighter into the risk assessment decision-making process. These members should be the ultimate decision makers as to whether it’s safe to proceed with assigned objectives. Where it is not safe to proceed, the rules allow a process for that decision to be made while still maintaining command unity and discipline.

One of the IAFC Rules of Engagement for Firefighter Survival states: “You Are Required to Report Unsafe Practices or Conditions That Can Harm You. Stop, Evaluate, and Decide.” This Rule applies the principles of crew resource management by encouraging all fire fighters to apply situational awareness and be responsible for their own safety and that of other fire fighters. In a sense, all fire fighters become the additional eyes and ears of the incident commander and should alert the incident commander (or the immediate supervisor) to unacceptable situations. No fire attack or building is worth the life of a fire fighter or a preventable (sometimes career-ending) injury. The intent of this Rule is to allow any member to report a safety concern through a structured process without fear of penalty.

One of the key tenants of the National Fallen Firefighter Foundation is their 16 Life Safety Initiatives. The 16 Firefighter Life Safety Initiatives (FLSI) were jointly developed by representatives of the major fire service constituencies in 2004 at a Firefighter Safety Summit in Tampa, Florida. At that time, the National Fallen Firefighters Foundation was tasked with promulgating the Initiatives throughout the fire service and developing material to support their implementation [NFFF 2004a].

Live Safety Initiative number 4 is “Empowerment: All fire fighters must be empowered to stop unsafe practices.” While this may appear to be a challenging or even controversial statement, it simply means that every organization should provide an environment that allows its members to speak up regarding personal and organizational safety, without negative consequences for doing so (within a prescribed context) and without decentralizing the authority of the formal leader. The goal is to have every member fully engaged during an emergency incident with a focus on doing the work in a proficient manner and looking out for one another to avoid injuries and potential line-of-duty death [NFFF 2004b].

Every fire fighter is responsible for their individual safety and the safety of other fire fighters. Each fire fighter is responsible for identifying risks and hazards and reporting them. Supervisors are responsible for accepting reports regarding safety concerns without penalizing the fire fighter and properly acting on the report to ensure the safety of fire fighters.

In this incident, the Tower Ladder 34 lieutenant observed openings in the second floor as he searched from the top of the stairway toward Side C. The Tower Ladder 34 lieutenant correctly radioed his observations to Incident Command. It is unknown whether the victim heard the radio transmissions about the floor openings. Unsafe fireground conditions should be reported to Incident Command and to other fire fighters on the fireground as soon as possible.
Additionally,

**Recommendation #14:** Fire departments, cities, and authorities having jurisdiction should consider developing systems that allow the integration of building information into the information available to responding crews during the initial dispatch.

Discussion: Fire departments should work with city and local authorities to develop and implement a strategy to share information about known and possible unsafe conditions within or around buildings. This information is very useful to emergency responders and can be used by incident commanders, company officers, and individual fire fighters to help ensure fire fighter safety. Known hazards should be readily identified and their locations made aware to all emergency responders. Information such as construction or renovation work, utility issues, lightweight construction, truss construction, and other construction features can be used to help formulate a safe incident action plan. This information can be made available to fire fighters and emergency responders through a number of ways, such as integrating the information into computer-aided dispatch systems, making the information available through mobile data terminals within apparatus, adding the information to pre-incident planning information, and other methods.

At the time of this incident, the fire department did not have building inspection and pre-plan information in its computer-aided dispatch system.

**Recommendation #15:** Authorities having jurisdiction should consider implementing a marking system for commercial structures undergoing renovation and demolition work to identify the presence of floor openings and other hazardous areas.

Discussion: The need for hazardous building marking systems has been highlighted in a number of NIOSH fire fighter fatality investigation reports and publications [NIOSH 2010, 2011, 2012, 2013]. A number of cities across the country have implemented hazardous building marking programs. While many of these marking programs are targeted to vacant and abandoned structures, marking programs could be extended to commercial structures undergoing renovation and demolition work. The building and construction permitting system could be used as a means to identify high-hazard areas, such as the open elevator shaft and floor openings found in this incident. Having this type of information available to fire fighters and emergency responders during the initial stages of an event can help formulate a safer approach to the emergency event.

**Recommendation #16:** Fire and Building Code officials should consider modifying building and fire codes to require fall protection for any temporary hole in a floor while a building is under renovation.

Discussion: Currently, building and fire codes do not contain requirements to provide fall protection for openings in vacant structures or buildings under renovation. Opening protections can be provided with a number of strategies such as solid coverings over the opening, barriers or high visibility protective netting.
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Workers in General Industry are protected by OSHA 1910 provisions [OSHA 2017]. This Standard requires employers to provide fall protection for their employees when operating on the job site. (Workers in the Construction Trades are protected by similar requirements in OSHA 1926.)

1910.23 Guarding Floor and Wall Openings and Holes lists general requirements to guarding floor and wall openings and holes.

In this incident, the building was undergoing renovation work. A number of opening were cut into the second floor as part of the renovation work. The existing elevator that provided service from the basement to the second floor was completely removed. The resulting floor openings were not guarded, including the elevator shaft where the Tower Ladder 34 fire fighter fell.

Communication #17: Authorities having jurisdiction should consider establishing policies and procedures to require building departments to notify fire departments of all major renovation permits issued in the fire department's response area.

Discussion: Authorities having jurisdiction should consider establishing policies and procedures that require information sharing between building and fire departments. When a renovation project is submitted and approved by the building department, information concerning the project should be shared with the fire department. Typically in the United States property and business owners must submit a request for a permit to initiate a major renovation project. In the vast majority of instances this permit, and supporting renovation details, are submitted to the local building department for review. Unless local policy establishes a requirement for information sharing, this information is kept with the Building Department and not shared with the local Fire Department.

Fire Departments should implement policies and procedures to utilize this information by requiring fire department follow-up and a familiarity inspection by the first-due response units. This process can be duplicated when major alterations have been started and completed. Information should include, but not limited to, building location, building name, type of structure and proposed renovations and proposed timelines for the work to be performed. This information should be included in computer-aided dispatch systems so that the information is readily available to emergency responders. The information can be verbally transmitted to responders and also displayed on mobile data terminals within the responding apparatus.

The Fire Department also has a responsibility to utilize this information appropriately. When information of a renovation project is received the fire department should, at the least, schedule a familiarity inspection or walk through by the first due companies. This will permit the responding fire fighters to conduct an informed size-up based on the alterations proposed for the structure. These inspections should occur regularly or when major alterations have been initiated.

In this incident, there was no system in place requiring information on major renovation work to be shared between building department and the fire department.
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Recommendation # 18: Fire Departments and authorities having jurisdiction should consider a twenty-four hour fire watch policy when hot work is being performed in vacant buildings and locations where fires can smolder undetected such as vacant cold storage facilities and similar structures.

Discussion: Unfortunately the United States has experienced major fire in cold storage facilities that were vacant or under renovation. The cold storage fire in Worcester Massachusetts on December 3, 1999 that claimed the lives of six fire fighters is one example [NIOSH 2000]. The unique hazard is the combustible fuel package that is attached to the walls of the interior structure. These cold storage structures tend to be well built Type I: Fire Resistant Construction making them attractive for renovation projects.

In some cases welding and additional “hot work” may be required during the renovation project. This work may produce hot embers as a by-product of the work. These embers can become imbedded in the foam insulation or cork wall board. Once imbedded, it can take hours until the hot ember produces ignition. This can occur when the building is unoccupied after the construction crew has left for the day. Due to the lack of occupants and the probability that automatic fire suppression systems are not in place, these smoldering fires can grow unnoticed into open flaming fires or fires that produce a ventilation limited fire. These smoldering fires can produced limited visibility conditions placing the responding fire fighters at risk of falls or other hazards.

Ventilation-limited fires can also produce serious risks to responding fire fighters when they create openings for entry. In either situation fire fighters must operate with great care. Requiring a twenty-four hour fire watch should identify a smoldering condition early in the event providing the fire fighters the ability to respond early in the event and commence extinguishment prior to deteriorating conditions.

In this incident, sparks and hot slag from welding operations ignited combustible materials within the thick insulated wall along Side C. The fire smoldered for several hours producing thick dense smoke that limited visibility on the second floor to near zero conditions.

References


Grorud LJ [2009]. Written comment to NIOSH Docket #141. March 3.
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Phoenix Fire Department [2009]. Written comment to NIOSH Docket #141. March 9.


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Investigator Information
This incident was investigated by Timothy R. Merinar, Safety Engineer, and Matt E. Bowyer, General Engineer, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research (DSR), NIOSH located in Morgantown West Virginia.

An expert technical review was provided by Sean DeCrane, Battalion Chief, Cleveland Division of Fire (ret.). A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division.

Additional Information
Modern Fire Behavior
This website is meant to serve as a clearinghouse of news and training information related to Modern Fire Behavior and Modern Building Construction Research, Tactics, and Practices, along with actual street experiences (http://modernfirebehavior.com/). ModernFireBehavior.com is a joint effort between www.FirefighterCloseCalls.com and the Underwriters Laboratories Fire Safety Research Institute.

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 IAFC Safety, Health and Survival Section has developed the 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 “modern procedures” for structural firefighting to be made available by the IAFC to fire departments as a guide for their own standard operating procedure development process. 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 is consistent among 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 fireground 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, and NIOSH. http://www.iaff.org/HS/FGS/FGSIndex.htm.
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National Institute for Standards and Technology (NIST)—Fire on the Web
Fire on the Web is a collection of resources from the Building and Fire Research Laboratory's Fire Research Division at NIST. These webpages provide links to fire-related software, experimental fire data, and mpeg/quick time movies of fire tests, which can be downloaded and/or viewed with a Web browser. [http://www.nist.gov/el/fire_research/firesafety/fireontheweb.cfm](http://www.nist.gov/el/fire_research/firesafety/fireontheweb.cfm)

Underwriters Laboratories (UL) Firefighter Safety Research Institute
An online course offered by the UL Firefighter Safety Research Institute (FSRI) highlights the tactical application of nearly two decades of research at the National Institute of Standards and Technology (NIST) and UL on how best to fight modern fires. In 2012, The New York City Fire Department (FDNY), NIST, and UL FSRI set fire to abandoned townhouses on Governors Island, New York, in a series of experiments to examine tactics for controlling fires and rescuing occupants inside burning homes. [http://www.firecompanies.com/modernfirebehavior/governors%20island%20online%20course/story.html](http://www.firecompanies.com/modernfirebehavior/governors%20island%20online%20course/story.html)

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Appendix One

Fire Department Update

The department involved in this incident has taken the following proactive measures to prevent the occurrence of similar injuries prior to the issuance of this NIOSH report:

- Currently, the entire fire department is going through search refresher training contracted through the Illinois Fire Service Institute on residential search, rope assisted search and company officer lead oriented search.

- Updated the current fire department’s standard operating procedure for fires in structures which contain a First Responder Warning Placard (“Red-X”) to include “Dangerous Buildings” that are abandoned, vacant, boarded up, under construction, rehabbed, under demolition or secured with security systems such as Vacant Property Security (VPS) or Door and Window Guard Systems (DAWGS).

- Implemented safety alert messages that are broadcasted on a daily basis to every firehouse to draw attention to the hazards encountered when responding to both fire and EMS incidents.

- Updates and posts fire related research studies (UL, NIST, NIOSH/CDC, NFFF, etc.) to SharePoint for all department members to view and discuss.