2015
15

Death in the line of duty...

National Institute for Occupational Safety and Health NIOSH

A report from the NIOSH Fire Fighter Fatality Investigation and Prevention Program July 10, 2017

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

## Executive Summary

**An aerial view of the structure fire after the collapse of the wall on Side Delta. The street on the right side of the photograph is Side Alpha.**
***(Photo courtesy of the fire department.)***

On October 12, 2015, a 39-year-old fire fighter from Pumper 10 and a 43-year-old fire fighter from Truck 2 died due to a structural collapse during a fire in a multi-occupancy structure. A regular alarm was dispatched for a structure fire in a multi-occupancy building at 1927 hours. Pumper 10 was the first unit on-scene at 1929 hours and reported a "working fire" with smoke showing. A "working fire" dispatch was transmitted at 1930 hours. Pumper 10 moved into the alley on Side Delta. Pumper 10 (officer and two fire fighters) stretched a 1¾-inch handline to the 1st floor of the building on Side Charlie. The officer of Pumper 10 realized the fire was in the floor joists. ***Note:*** *The ground floor of the building contained various commercial occupancies. The 2nd and 3rd floors were apartments.* At 1931 hours, Command (Battalion 104) advised, "Heavy smoke on all three floors." ***Note:*** *The captain (district safety officer) assigned to Battalion 104 was working out of classification (WOC) as Battalion 104. Another captain was assigned as the Battalion 104 district safety officer.* Command requested a 2nd Alarm at 1944 hours. Truck 2 responded on the 2nd Alarm at 1945 hours. Truck 2 arrived on-scene at 1945 hours. A fire fighter from Truck 2 went to the roof of the fire building with Truck 10 to ventilate the roof. After the roof was vented, the fire fighters from Truck 2 and Truck 10 came off the roof. At 1949 hours, an evacuation order was sounded that ordered all fire fighters out of the building. Command conducted a personnel accountibility report to ensure all crews were accounted for and out of the building. Command announced the strategy was changing from offensive operations to defensive operations. Also, Command advised to have a collapse zone established around the entire building. Pumper 10, Pumper 23, Truck 3, Truck 6, and Rescue 1 exited the apartment building on Side Alpha and Side Charlie. Crews on Side Charlie pulled the hoselines out of the building. The captain from Pumper 10 pulled a 1¾-inch hoseline to Side Delta (the alley) behind

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

Pumper 23. A fire fighter from Truck 2 went into the alley (Side Delta) and started to take out windows. The fire fighter from Truck 2 was pulling on a ventilation fan located in a window of a vacant bar to gain acces to the fire. Crews operating on the exterior of Side Alpha and Side Charlie witnessed an interior collapse of the 2nd floor. On Side Delta, two fire fighters from Pumper 23 were in the alley. The wall collapsed into the alley trapping all four fire fighters at approximately 2006 hours. One fire fighter from Pumper 23 was pushed to his knees near the driver's side tailboard of Pumper 23. The other fire fighter from Pumper 23 was covered to his waist with debris. The fire fighters from Pumper 10 and Truck 2 were completely covered with debris. The fire fighters from Pumper 10 and Truck 2 were removed and pronounced dead at the hospital. The two fire fighters from Pumper 23 were rescued from the debris pile and admitted to the hospital for treatment.

## Contributing Factors

- *Arson fire*
- *Failure to maintain an established exclusion and collapse zone on Side Delta*
- *Tactical level management*
- *Building construction*
- *Personnel accountability system*
- *Unclear function of the district safety officer*
- *Pre-incident planning*
- *Nonsprinklered structure*

## Key Recommendations

- *Fire departments should ensure, when a collapse zone is established, that the collapse zone is properly managed and enforced by the division supervisor and/or assistant safety officer. Command should also consider designating exclusion zone(s) or no-entry zones as needed due to dangerous or hazardous conditions*
- *Fire departments should ensure that once command is established at an incident, the incident commander maintains control of situation status, resource status, and communications, plus ensures the completion of the tactical objectives.*

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## Introduction

On October 12, 2015, a 39-year-old fire fighter from Pumper 10 and a 43-year-old fire fighter from Truck 2 died due to injuries received during a structural collapse at a fire in a multi-occupancy structure. On October 13, 2015, the United States Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On October 21–31, 2015, an investigator, a general engineer, and an occupational safety and health specialist traveled to Missouri to investigate this incident.

The NIOSH investigators met with the fire chief, executive assistant to the fire chief, and the executive staff of the fire department; the fire marshal and his staff; the fire department's SCBA maintenance and repair staff; the International Association of Fire Fighters local unions (fire fighters and fire officers); the department's training academy staff; the director of the county medical examiner's office; investigators from the Bureau of Alcohol, Tobacco, Firearms, and Explosives; and the department's dispatch center. The investigators reviewed the fire department's standard operating procedures, training records from the department and the state of Missouri, dispatch and tactical channel printouts, plus audio radio transmissions. The NIOSH investigators visited and photographed the fire scene. During the investigation, witness statements were reviewed and interviews were conducted with the fire fighters, fire officers, battalion chiefs, deputy chief, and assistant chiefs who responded to the incident. The NIOSH investigators inspected and photographed the personal protective clothing (turnout gear) and SCBA of the affected fire fighters, which was under control of the city's police department.

## Fire Department

This career fire department consists of 940 uniformed members, 326 emergency medical services personnel, and 90 civilian employees. The fire department protects a population of 470,800 within 318 square miles and provides emergency medical care and transport services, fire protection, technical rescue, and hazardous material response from 34 fire stations, which are organized into 7 battalions. The fire department also staffs a fire station with three aircraft rescue and firefighting (ARFF) units at the city's international airport. The uniformed members of the department are organized into three bureaus that include the Emergency Operations Bureau, the Technical Services Bureau, and the Systems Support Bureau.

The department responds to approximately 110,000 emergency calls per year. The Operations Bureau consists of three platoons, which work a 24/48 work schedule and a 49.5-hour workweek with a Kelly Day every 9 working days. The daily staffing of each shift is 270 members. The Operations Bureau operates 10 advanced life support (ALS) pumper companies, 24 basic life support (BLS) pumper

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

companies, 12 truck companies, 3 heavy rescue companies, 2 haz-mat companies, 3 airport rescue fire-fighting (ARFF) companies, 27 dynamic ALS medic units, and 7 battalion chiefs.

**Table. The staffing for each piece of apparatus or response vehicle that was involved in this incident.**

| Apparatus | Officer | Fire Apparatus Operator | Fire Fighter(s) |
|---|---|---|---|
| Pumper | 1 | 1 | 2 |
| Truck (Tiller) | 1 | 2 (Driver and Tiller) | 1 |
| Truck (Platform) | 1 | 1 | 2 |
| Heavy Rescue | 1 | 1 | 4 |
| Medic Unit | | 1 (Medic) | 1 (Medic) |
| Battalion | 1 (Battalion Chief) | 1 (Captain) | |

The rank structure of the fire department is fire chief, assistant chief, deputy chief, division chief, battalion chief, captain, and fire fighter. The Operations Bureau assistant chief is not dispatched on incidents. The shift commander (deputy chief) is dispatched to all 2nd Alarm incidents. The shift commander works a 24/48 work schedule and a 49.5-hour workweek.

The organizational structure of the fire department's three bureaus is detailed in the fire department's organizational chart (**See Diagram 1**). An assistant chief heads each principal bureau. Deputy chiefs or division chiefs head the major divisions. A deputy chief also functions on each of the three operations shifts as a shift commander, responsible for all field activities for that shift.

- Emergency Operations Bureau
  - Fire Suppression/Emergency Medical Services
  - Technical Rescue
  - Hazardous Materials
  - Aircraft and Rescue Fire Fighting
- Technical Services Bureau
  - Communications
  - Logistics
  - Fleet
  - Facilities
  - Finance/Purchasing
- Systems Support Bureau
  - Community Risk Management (Prevention/Education)
  - Community Outreach
  - Professional Development
  - Medical Services

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

Quality Assurance/Data Management

The fire department's Professional Development Division maintains a fire training center, which is staffed with a battalion chief, captains, and fire fighters. The fire training center consists of offices, classrooms, and a burn building/training tower and is responsible for recruit training and certification, EMS training and certification, and special operations training and certification. The fire training center also houses the SCBA maintenance facility.

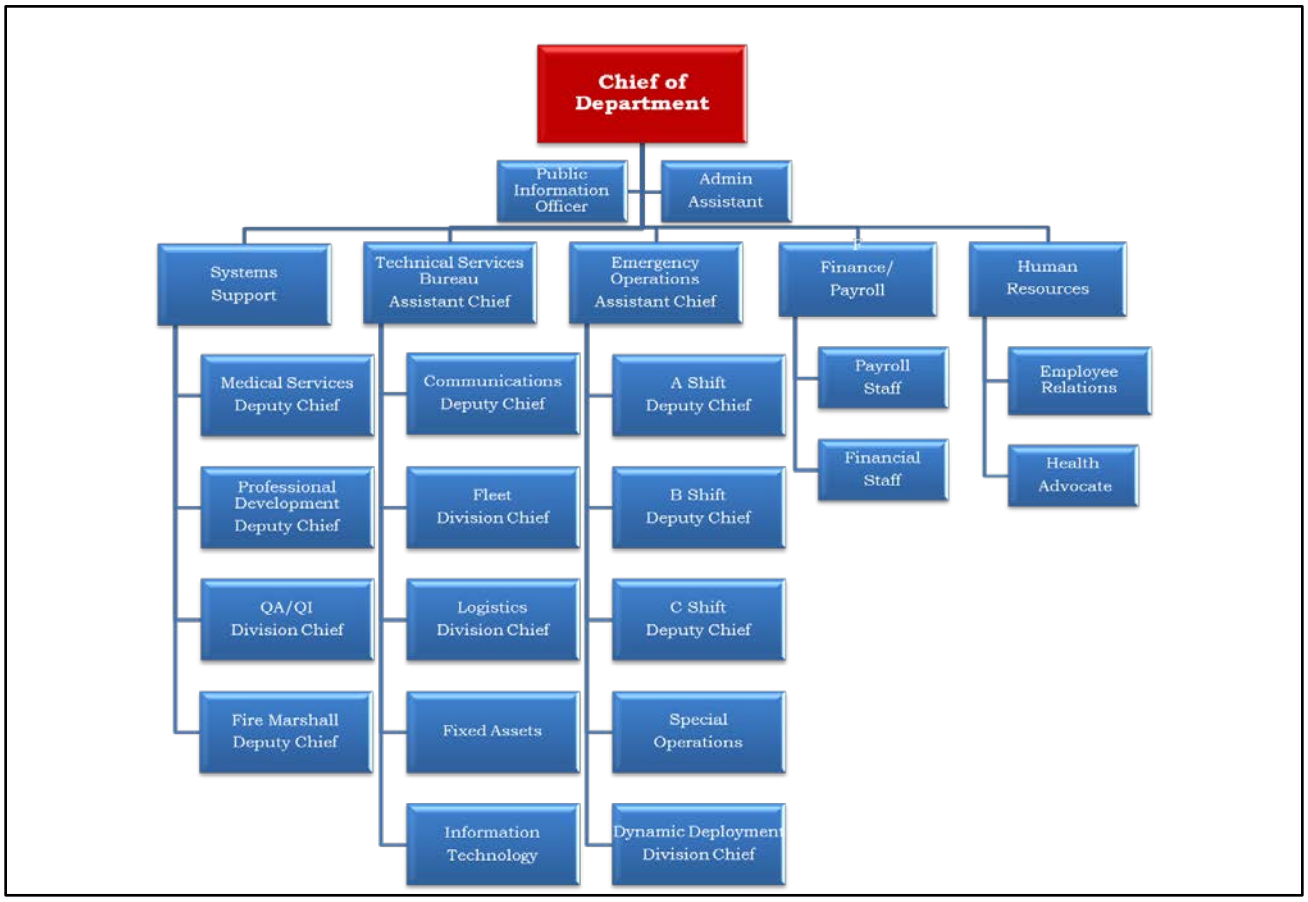


**Diagram 1. The organizational chart of the fire department. The department is organized into three operating bureaus and the Office of the Fire Chief.**

The Fire Marshal's Office is staffed with 21 personnel. The rank structure for the Fire Marshal's Office is:

- 1 fire marshal
- 2 assistant fire marshals
- 12 fire inspectors

- 2 fire education specialists
- 4 fire investigators

Fire inspectors are both uniformed and civilian (retired fire department members).

The Fire Marshal's Office uses NFPA 101, *Life Safety Code*® with the exception of county and state occupancies. In 2014, fire inspectors completed 15,500 inspections, including schools. Fire inspectors are certified to NFPA 1031, *Standard for Professional Qualifications for Fire Inspector and Plan Examiner*—Fire Inspector I (National Board on Fire Service Professional Qualifications [ProBoard] and International Fire Service Accreditation Congress [IFSAC]) [NFPA 2014a]. Fire investigators are certified to NFPA 1033, *Standard for Professional Qualifications for Fire Investigator*—Fire Investigator I (IFSAC) [NFPA 2014b]. Founded in 1990, IFSAC is a not-for-profit, peer-driven, self-governing system of both fire service certifying entities and higher education fire-related degree programs. Accreditation is accomplished through the review of certification programs of member entities to ensure they meet nationally recognized professional qualification standards in their administration of skills and knowledge exams. Because of this accreditation, Missouri shares certification reciprocity with many states and countries, as well as the U.S. Department of Defense and the Canadian Armed Forces.

## Training and Experience

The state of Missouri Department of Public Safety, Office of the State Fire Marshal, oversees fire fighter training and certification through the Division of Fire Safety's Training and Certification Unit. This unit develops, provides, and oversees the training curriculum used regionally for fire fighters, fire investigators, fire inspectors, fire officers, fire service instructors, as well as emergency responders dealing with hazardous materials. Although certification is not mandatory in the state of Missouri, the Division of Fire Safety has issued more than 71,000 certifications at various levels to more than 28,000 individuals.

The Division of Fire Safety is accredited by IFSAC and the ProBoard. The Division of Fire Safety strictly adheres to the testing requirements of both organizations. Candidates must meet the prerequisite and requisite knowledge and skills as required by the NFPA standards, such as NFPA 1001, *Standard for Fire Fighter Professional Qualifications for Fire Fighter I and Fire Fighter II* [NFPA 2013b]. Candidates must also complete and pass a required training program that meets the applicable NFPA standard. A candidate is allowed to challenge the written and practical certification examinations based upon previous education, training, and experience of the candidate. Detailed requirements are listed for each level on the Division of Fire Safety website at http://dfs.dps.mo.gov/programs/training/.

The fire department hiring process starts with accepting interest card submissions. The fire department conducts a hiring process every 2 years.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

The following are the minimum qualifications to apply for the position of fire fighter:

- Candidate must be a resident living within the city limits.
- Candidate must be 19 years of age by close of the application period.
- Candidate must not have turned 30 years of age prior to close of the application period.
- Candidate must be a high school graduate (or possess a state-issued GED/HiSET).
- Candidate must possess a valid Missouri driver's license at time of application and appointment.

Preference is given to paramedics. Minorities, women, and active military personnel are encouraged to apply.

Once an individual is selected to test, the department conducts a written examination and oral interview. After the testing is completed, a hiring list is posted and is certified for 2 years. Once the fire department announces a recruit school, candidates are selected to become a fire fighter recruit. Each recruit school is approximately 24 weeks (6 months) in length. The schedule for the recruit school is:

- Week 1: Human Resources and the Candidate Physical Ability Test (tested initially, at 4 weeks, and at 8 weeks)
- Weeks 2–10: National Registry EMT
- Weeks 11–23: Firefighting Certification
- Weeks 23–24: Emergency Vehicle Operators Course, EMS vehicle operations, hospital locations, and the city's human resource requirements.

The department's fire academy offers Fire Fighter I and Fire Fighter II classes through the state's Division of Fire Safety on a regular basis. These classes are registered with the Division of Fire Safety prior to delivery. Instructors are certified with the Division of Fire Safety. Written and practical skills certification testing is conducted upon completion of the course delivery. This includes Hazardous Materials Awareness and Hazardous Materials Operations training and certification testing.
Upon the completion of the recruit school, the recruit has the following certifications:

- NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, Fire Fighter I and Fire Fighter II (IFSAC) [NFPA 2013b]
- NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents, Awareness and Operations* (IFSAC) [NFPA 2013a]
- National Registry Emergency Medical Technician/Basic

The probationary period is 18 months. When the probationary period is completed, a fire fighter is assigned to a floating fire fighter position. A fire fighter is detailed daily to a vacant assignment to meet staffing needs.

The fire department has several methods of conducting annual continuing education and training for all members of the department. These programs are:

- Back to the Basics
- International Association of Fire Fighters *Fireground Survival* Program

- EMS hands-on skills
- Company-level hot-wash of an incident

The department has no requirements for annual live fire training.

The testing and certification for the fire department includes fire apparatus operator, captain, battalion chief, and deputy chief.

The requirements for designation for the position of fire apparatus operator are:

- Senior fire fighter
- Completion of the work out of classification (WOC) for fire apparatus operator (FAO) course
- Written examination
- Practical evolutions for pumper and/or truck (platform or tiller).

***Note:*** *The position of fire apparatus operator is a promotion done by certification and designation. A senior fire fighter can accept or decline this appointment. The senior fire fighter must be fire apparatus operator qualified by the fire academy prior to appointment to the positon.*

The requirements for testing for the position of captain are:

- 10 years on the job or fire apparatus operator
- 100-question written examination
- Assessment Center with a fire problem—three scenarios with a 4-minute presentation.

The requirements for testing for the position of battalion chief are:

- 5 years as a captain
- 3 years as a captain with a bachelor's degree
- 100-question written examination
- Assessment Center with three parts or sections: Administration, Operations, and Situational (three scenarios)

The requirements for testing for the position of deputy chief are:

- 5 years as a battalion chief
- 3 years with a Master of Arts or a Master of Science
- Portfolio Promotional Process

***Note:*** *The fire chief can rank the top five candidates.*

The fire fighter assigned to Pumper 10 was hired July 1, 2002. He successfully completed recruit training at the department's fire academy in November 2002. Upon completion of recruit school, the fire fighter received certification as NFPA 1001, *Standard for Fire Fighter Professional* Qualifications, Fire Fighter I and Fighter II [NFPA 2013b]; NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, Hazardous Materials Awareness, and Hazardous Materials Operations [NFPA 2013a]; and Emergency Medical Technician/Basic (EMT/B). He maintained his EMT/B with continuing education units through

monthly training mandates. Other training certifications included IS-100, *Introduction to the Incident Command System*. In September of 2008, the fire fighter was certified as a fire apparatus operator/pumper to act out of class as a fire apparatus operator.

The fire apparatus operator from Truck 2 was hired May 1, 1998. In August 1998, he successfully completed recruit school at the department's fire academy. Upon completion of recruit school, the fire fighter received certification as NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, Fire Fighter I and Fighter II [NFPA 2013b]; NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, Awareness and Operations, Hazardous Materials Awareness, and Hazardous Materials Operations [NFPA 2013a]; and Emergency Medical Technician/Basic (EMT/B). He maintained his EMT/B with continuing education units through monthly training mandates. On August 26, 2012, he was promoted to fire apparatus operator, having successfully completed written and practical examinations.

The incident commander was hired by the fire department on May 6, 1985. He was promoted to deputy chief in June 2015 and was assigned to "B" Shift. ***Note:*** *The incident commander was working a trade with the "C" Shift Deputy Chief on the day of this incident.* He successfully completed recruit school in August 1985 and received certification as NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, Fire Fighter I and Fighter II [NFPA 2013b]; NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, Hazardous Materials Awareness, and Hazardous Materials Operations [NFPA 2013a]; and Emergency Medical Technician/Basic. His certifications include: IS-100, *Introduction to ICS*, IS-200, *Basic ICS*, IS-300, *Intermediate ICS*, IS-700, *Introduction to NIMS*, IS-800, *Introduction to the National Response Plan*, NIMS ICS All Hazards Task Force/Strike Team Leader, NIMS ICS All Hazards Logistics Section Chief, NIMS ICS All Hazards Finance/Administration Section Chief, NIMS ICS All Hazards Safety Officer, Structural Collapse Rescue—Operations, Structural Collapse Rescue—Technician, Trench Rescue—Operations, Trench Rescue—Technician, Trench Rescue—Technician and Train-the-Trainer, Swiftwater/Flood Rescue—Technician, Structural Collapse Rescue—Operations, Structural Collapse Rescue—Technician, Structural Collapse Rescue—Technician 2, Structural Collapse Rescue—Technician Level 1, Train-the-Trainer, Rope Rescue—Technician, Introduction to Technical Rescue, Confined Space Rescue—Technician, and Boat Rescue Operations—Technician.

## Equipment and Personnel

The Fire Communications Center serves as the dispatch center for fire, emergency medical services (emergency and non-emergency transport), and special operations responses. Also, the Fire Communications Center dispatches for three fire protection districts and one other municipal fire department in the county. The Fire Communications Center has 49 civilian dispatchers plus supervisors who work a 12-hour schedule (either 0600–1800 or 1800–0600) with a minimum staff of 12 dispatchers per shift. Dispatchers change work schedules every 2 weeks. The training program for the dispatchers consists of 12–16 weeks of classroom and practical training. Once this training is completed, the dispatcher functions are under the supervision of the Assistant Division Chief of Communications until their probation period is completed.

The department uses an 800-megahertz trunked digital radio system. Mobile data terminals (MDTs) are located in the three deputy chiefs' vehicles, all medic units, and all battalion chief vehicles. All apparatus and vehicles are equipped with an automatic vehicle locator.

When an incident is dispatched, the incident is dispatched on the dispatch channel. If the incident is assigned a tactical channel, all companies switch to the tactical channel with a dedicated communication specialist. Unit(s) remain on the tactical channel while responding, while on-scene, and until they are back in quarters or available.

Each fire fighter is assigned a portable radio. Each portable radio identifies the user: e.g., T10"A" (officer of Truck 10), P30"B" (right jumpseat of Pumper 30), T2"C" (left jumpseat of Truck 2), and P23"D" (fire apparatus operator of Pumper 23). Every portable radio has an emergency button. When the emergency button is pressed, this opens (keys) the microphone for 10 seconds and gives this radio priority. The radio microphone remains keyed for 60 seconds as long as the push-to-talk button is pressed.

The fire department's response matrix for structural fires is:

| | |
|---|---|
| **Regular Alarm:** | 3 pumpers, 2 trucks, 1 medic unit, and 1 battalion chief |
| **Working Fire:** | 1 truck, 1 RIT capable, 1 medic unit, 1 air unit, investigator, and 1 EMS supervisor |
| **1st Alarm:** | 2 pumpers, 1 truck, 2 medic units, 1 battalion chief, and 1 deputy chief (shift commander) |
| **2nd Alarm:** | 2 pumpers, 1 truck, 1 heavy rescue, 1 medic unit, 1 battalion chief, High-Rise Unit, 1 investigator, and 1 EMS supervisor |
| **3rd Alarm:** | 2 pumpers, 1 truck, 1 battalion chief, and 1 medic unit |
| **4th Alarm:** | 2 pumpers, 1 truck, 1 battalion chief, and 1 medic unit |
| **5th Alarm:** | 2 pumpers, 1 truck, 1 battalion chief, and 1 medic unit |
| **6th Alarm:** | 2 pumpers, 1 truck, 1 battalion chief, and 1 medic unit |
| **General Alarm:** | Additional units as needed by the incident commander. A general alarm activates off-duty recall for reserve apparatus staffing. |

## Timeline

The following timeline is a summary of events that occurred as the incident evolved. Not all incident events are included in this timeline. The times are approximate and were obtained by studying the dispatch records, audio recordings, witness statements, and other available information. This timeline also lists the changing fire behavior indicators and conditions reported, as well as fire department response and fireground operations. The timeline is not intended, nor should it be used, as a formal record of events.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

| Dispatch Communications & Fire Department Response | Time | Fireground Communications & Fireground Operations |
|---|---|---|
| **October 12, 2015** | | |
| Fire Communications Center dispatched Car 104, Pumper 10, Pumper 25, Truck 3, Truck 10, Pumper 23, and Medic 5 on a regular alarm for an apartment fire. "Unknown if occupants are out of the structure. The tac channel is A5TAC." | **19:27:37 Hours** | |
| Fire Communications Center acknowledged all units responding.<br>Fire Communications Center advised responding units, "Bottom floor is a business and the top floors are apartments." | **19:28:07 Hours** | |
| Pumper 10 arrived on-scene. Pumper 10A advised: "Smoke is showing from a 3-story brick apartment complex. Make this 'Avenue Command.' This is a working fire." | **19:29:23 Hours** | Fire Communications Center acknowledged Pumper 10: "Pumper 10 on the scene. Smoke showing 3-story complex. Making you 'Avenue Command'." |
| | **19:29:40 Hours** | Pumper 10 to Fire Communications Center, "Give me a working fire response." |
| | **19:29:49 Hours** | Pumper 23 arrived on-scene. |
| | **19:29:53 Hours** | Truck 3 arrived on-scene. |

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

| Dispatch Communications & Fire Department Response | Time | Fireground Communications & Fireground Operations |
|---|---|---|
| Fire Communications Center acknowledged the request for traffic control. | **19:30:02 Hours** | Car 104 on-scene. Car 104: "Assuming 'Avenue Command'. We need PD for traffic control." |
| | **19:30:28 Hours** | Truck 10 arrived on-scene. |
| | **19:30:38 Hours** | Pumper 10A advised, "We have smoke on all floors." |
| | **19:30:45 Hours** | Pumper 25 arrived on-scene. |
| Fire Communications Center dispatched Truck 5, Rescue 1, Medic 35, Air 1, and Car 212 on the "working fire dispatch" for the apartment fire. (Dispatched on Channel A1.) | **19:30:52 Hours** | |
| Command advised Fire Communications Center that smoke was showing from all three floors. "Prepare for a 2nd Alarm." | **19:31:52 Hours** | |
| | **19:32:12 Hours** | Rescue 1 arrived on-scene. |
| Car 105 contacted Fire Communications Center and requested to be added to the incident. Car 105 responded. | **19:32:30 Hours** | |
| | **19:32:50 Hours** | Pumper 10 made entry into the building on the 1st floor from Side Charlie on the Side Charlie/Side Delta corner. |

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

| Dispatch Communications & Fire Department Response | Time | Fireground Communications & Fireground Operations |
|---|---|---|
| | **19:32:57 Hours** | Command advised Pumper 10 to stay on the 1st floor and hold the fire. |
| The Fire Communications Center dispatched Car 105, Pumper 24, Truck 6, Car 101C, Car 120, Medic 9, and U535 on the 1st Alarm for the apartment fire. | **19:33:05 Hours** | |
| | **19:33:10 Hours** | Pumper 23 and Truck 10 were going to the 2nd floor apartments from Side Charlie. |
| Command advised Fire Communications Center that Truck 5 was going to work. Truck 5 assigned to Side Charlie. "Please dispatch another truck company." | **19:33:59 Hours** | |
| | **19:34:30 Hours** | Car 105 arrived on-scene. |
| | **19:34:53 Hours** | Pumper 10 to Command, "We found the fire." (Pumper 10 was operating in the vacant bar.) |
| | **19:35:12 Hours** | Command to Truck 5, "You are going to be making a rescue on the 2nd floor balcony when you arrive." Truck 5 acknowledged. |
| | **19:35:25 Hours** | Car 101C responding to the working fire. |
| | **19:35:34 Hours** | Rescue 1 to Command, "We have an all clear primary on the 1st floor. |
| | **19:36:34 Hours** | Truck 5 arrived on-scene. |

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

| Dispatch Communications & Fire Department Response | Time | Fireground Communications & Fireground Operations |
|---|---|---|
| | **19:36:52 Hours** | Truck 5 rescued one victim from the 2nd floor balcony. Truck 5 and Pumper 24 rescued another person from inside an apartment on the 2nd floor. |
| Command to Fire Communications Center, "We have a rescue going for two people on the 2nd floor." | **19:38:14 Hours** | |
| | **19:39:18 Hours** | Command: "To all suppression crews, fire is now showing itself from the 2nd floor rear, middle of apartment. We have fire coming through windows. Pumper 23 do you see it?" |
| | **19:39:34 Hours** | Command to Pumper 10 and Pumper 25: "The fire is above you. Pumper 23 is addressing it now." |
| | **19:39:47 Hours** | Truck 6 on-scene. Command to Truck 6, "You are my RIT for right now." |
| | **19:41:01 Hours** | Pumper 10 to Command: "We have some fire below us. We need some truckmen on the 2nd floor to open up the floor." |
| | **19:42:42 Hours** | Pumper 10 to Command: "We are trying to cut a hole in the floor now. We know the fire is below us." (Pumper 23 is still operating on the 2nd floor.) |
| Command to Fire Communications Center, "Go ahead and dispatch a 2nd Alarm for this incident." ***Note:*** *Fireground operations are now 15 minutes into the incident.* | **19:44:19 Hours** | |
| | **19:44:56 Hours** | Command to Pumper 24: "Your line is not needed there. Come into the 2nd floor apartment and back up Pumper 25. We have heavy, black smoke showing from the 2nd floor, east side (Side Delta)." |

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

| Dispatch Communications & Fire Department Response | Time | Fireground Communications & Fireground Operations |
|---|---|---|
| Fire Communications Center dispatched Car 102, High-Rise 102, Medic 40, Pumper 9, Pumper 27, Pumper 18, Rescue 31, Truck 2, Truck 12, Car 211, and Car 530 on a 2nd Alarm for an apartment fire. | **19:45:13 Hours** | |
| | **19:45:47** | Truck 2 arrived on scene. Truck 2 was requesting an assignment from Command. |
| | **19:47:13 Hours** | Command to Rescue 31: "Rescue 31 stay on Side Alpha to be my RIT. I might have to get some crews out of here in a hurry." |
| | **19:48:49 Hours** | Rescue 1 to Command, "We have heavy smoke and fire showing from the bar." |
| | **19:48:53 Hours** | Car 105 to Command: "The front of the nail salon just lit up. It looks like it is going to light up all the way down. Think about pulling them out." |
| Command to Fire Communications Center: "Give me the evacuation tones. I need everybody out of the building. Everyone get out of there." ***Note:*** *During the department's review of this incident, there were fire fighters on scene that stated they did not hear the evacuation tones or the radio communications to evacuate the building.* ***Note:*** *Fireground operations are now 20 minutes into the incident.* | **19:49:01 Hours** | |

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

| Dispatch Communications & Fire Department Response | Time | Fireground Communications & Fireground Operations |
|---|---|---|
| | **1950 Hours** | Command conducted a personnel accountability report (PAR). The following units are PAR: Car 105, Rescue 31, Pumper 24, Truck 5, Pumper 18, Pumper 25, Pumper 10, and Pumper 23. |
| | **19:51:17 Hours** | Car 101C (Deputy Chief "B" Shift Commander) arrived on-scene. ***Note:*** The Deputy Chief on "B" Shift was working a trade with the Deputy Chief on "C" Shift. |
| | **19:51:58 Hours** | Command verified all crews were PAR. ***Note:*** *Many of the crews on-scene reported their PAR face-to-face with Command.* |
| Car 600 responded as safety officer. Fire Communications Center copied. | **19:52:34 Hours** | |
| Command to Fire Communications Center, "I need the power and light company to respond to this location." Fire Communications Center acknowledged. | **19:55:42 Hours** | |
| Car 101C to Fire Communications Center: "I am assuming command of this incident. Car 104 will be Operations. I will have assignments for Car 102 and Car 105 shortly." Fire Communications Center acknowledged. | **19:58:13 Hours** | Fireground operations are now defensive. |
| Command to Fire Communications Center: "Give me emergency tones. I am going to move everyone back from the building. We are going to create a collapse zone." | **20:00:07 Hours** | |

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

| Dispatch Communications & Fire Department Response | Time | Fireground Communications & Fireground Operations |
|---|---|---|
| | **20:00:27 Hours** | Fire Communications Center to all companies: "Move back. All companies move back and create a collapse zone." |
| Command to Fire Communications Center, "The power and light company has disconnected the power from the building." Fire Communications Center acknowledged. | **20:02:56 Hours** | |
| | **2006 Hours** | Two fire fighters from Pumper 23, two fire fighters from Pumper 10, and one fire fighter from Truck 2 were operating in the alley on Side Delta. |
| | **20:06:16 Hours** | **Division Charlie (Car 105) to Command: "We have had a collapse on Side Delta. A collapse on Side Delta."** |
| | **20:06:24 Hours** | Car 102 to Command, "Respond a Mayday, we had a collapse." |
| | **20:06:37 Hours** | Car 102 to Command, "We are extricating people now." |
| | **20:06:41 Hours** | Division Charlie: "Mayday, Mayday, Mayday. This is Car 105. Go ahead and start me three more ambulances." Fire Communications Center acknowledged. |
| | **20:06:56 Hours** | Fire Communications Center to all companies: "A Mayday has been declared. A Mayday has been declared. Curtail all non-essential radio traffic. Go to Tac Channel A6. Go to Tac Channel A6." |

# *Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri*

| Dispatch Communications & Fire Department Response | Time | Fireground Communications & Fireground Operations |
|---|---|---|
| Fire Communications Center dispatched Car 106, Medic 6, Pumper 17, Pumper 28, Truck 7, 531, and 522 for a Mayday on Tac Channel A6, apartment fire. | **20:07:39 Hours** | |
| | **2008 Hours** | Car 600 on-scene and assumed safety officer function. |
| | **20:09:22 Hours** | Safety to Command, "It looks like we are going to be transporting three, transporting three." |
| | **20:09:47 Hours** | Safety to Command: "We are going to have a fourth fire fighter down at this time. We are going to need four transport units for four fire fighters." |
| | **2026 Hours** | All injured fire fighters transported. |
| **October 13, 2015** | | |
| | **0146 Hours** | Fire knocked down. |
| **October 16, 2015** | | |
| Fire Communications Center: Response for Incident 15-102152 is closed. | **2338 Hours** | |

## Building Construction and History

***Note:*** *Sections of the building construction and history including the collapse scenario was provided to NIOSH FFFIPP investigators by Christopher J. Naum. This material was developed by Christopher J. Naum based upon information obtained by NIOSH FFFIPP investigators during this investigation and from publicly available sources. Mr. Naum did not respond to this incident.*

The earliest city records show that this building was erected in 1925. The building was a three-story Type III, ordinary construction with five commercial spaces on the 1st floor. The measurements of this building were 216 feet by 64 feet (13,825 square feet per floor), which equates to 41,472 total square

feet. Eight apartments were located on the 2nd floor and eight apartments were located on the 3rd floor. This structure did not contain a sprinkler system or a centrally monitored fire alarm system. Several of the apartments on the 2nd floor and 3rd floor contained single-station smoke detectors (**See Photo 1 and Diagram 2**).

According to the deputy chief of the Fire Prevention Office, the building was constructed of Type III ordinary construction and built on-grade with a concrete floor slab. The three-story building had masonry bearing walls located on Side Bravo and Side Delta. The in-fill, non-bearing masonry walls were on the north (Side Charlie) and south (Side Alpha) of the building. The building did not have a basement or cellar. Sited on a city block, the building was accessible on all four sides and had an attached exposure structure of single use occupancy on the Side Alpha/Side Bravo corner. There was a building exposure (grocery store) across the alley on Side Delta. ***Note:*** *The rear entrance (Side Charlie - North side) to the nail salon was bricked over. Companies had no access to the rear of the nail salon, which required companies only use the Side Alpha access*.


**Photo 1. Side Alpha of the structure. The loan business on the Side Alpha/Bravo corner is only one-story. The alley on Side Delta is where the collapse occurred between the fire building and the grocery store.**
***(Google Earth Street View.)***

Type III, ordinary construction (also referred to as "Brick and Joist" construction) [NFPA 2015d] generally refers to a construction system that incorporates masonry perimeter wall construction with both fully supporting masonry bearing and non-bearing wall characteristics. Ordinary construction incorporates fully dimensioned timber wood construction for structural supporting floor joists, roof rafters, and assemblies and dimensioned wood framing for interior partitions. In this structure, a non-

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

combustible beam and column structural framing system were used for support of the subsequent two floors above. At the time of construction in 1925, this process was referred to as non-fireproof construction based on the recommended building codes [NFPA 2015d]. ***Note*****:** *The subsequent evolution of both the National Building Code (circa 1922) and the development of the NFPA 220, Standard on Types of Building Construction (circa 1961 & 1975 with the current edition being 2015) have significantly defined the parameters and specification of Type III ordinary construction* [Naum 2012a; NFPA 2015d].

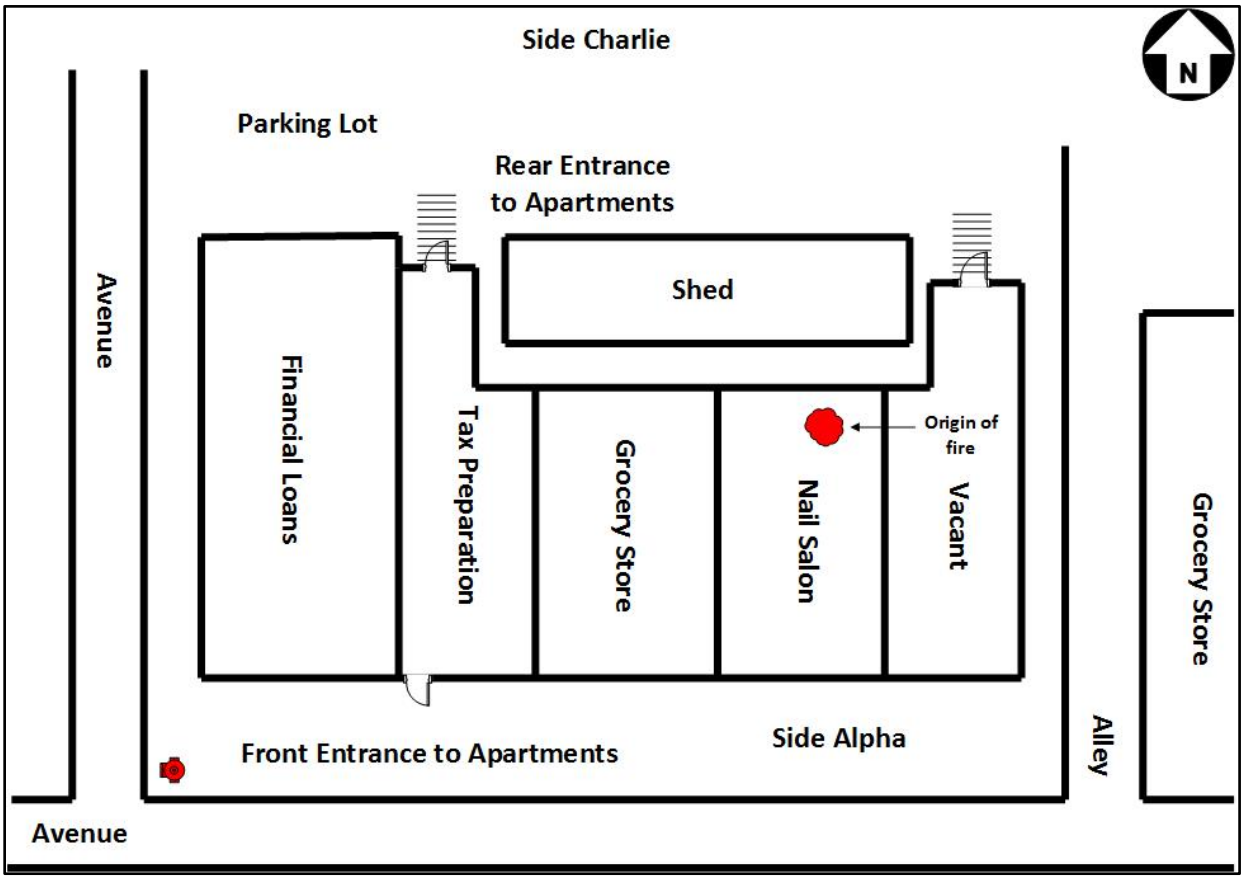


**Diagram 2. The site plan for the fire building. The financial loan business was a one-story occupancy. The apartments on the 2nd and 3rd floors extended from tax preparation business to the vacant occupancy.**

A dominate and unique feature of this building was the incorporation of hollow building tile construction with a full-face brick veneer. This feature was used in the design and assembly of the primary masonry bearing walls located on the east side (Side Delta) and west side (Side Bravo) of the building that provided primary structural support to the building enclosure (perimeter wall system). ***Note*****:** *With this type of construction, it is much more prevalent to find multiple Wythe course, full-width brick bearing walls than those incorporating hollow building tile units.*

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

The building was classified in both vintage and anatomy as legacy construction [Naum 2012a]. Legacy construction was a common building construction system and building type throughout the 1800s and into the early 1900s. The building's anatomy, methods and materials of construction, and building characteristics, have a predictability of performance under fire conditions. These factors include the manner in which systems, assemblies, components, compartments, and the overall building will perform when impacted by a fire within the structure [Naum 2012b, 2013b]. The architectural style incorporated in the building was in the Tudor style of design. This architectural style incorporated a distinctive dual gable roof design on the street façade that provided 12/12 pitch (45 degree) gables at the east end and west end of the building. This façade was connected by a sloping shed roof façade that connected the two ends but did not extend along the entire roof. Brickwork and treatment, dormers, chimney and flue design, and window treatments carried forward this architectural style and design [Naum 2012a].

**Building Anatomy and Profile**

- **Constructed:** Circa 1925
- **Occupancy:** Mixed use: commercial retail with multiple residential.
- **Condition:** Occupied and in-use: Degree of apartment occupancy, undetermined. 1st floor tenant space was 75% occupied; one space vacant and unused. Generally building condition was good shape.
- **Construction System:** Type III *Ordinary Construction* (based on National Building Code, circa 1922 edition.)
    - **Floor Joists:** 2-inch x 10-inch or 2-inch x 12-inch (assumed based on distance spans and National Building Code, circa 1922.) Resting upon load carrying steel I-profile beams. Floor joists were pocketed/diagonal bevel (fire-cut) into the masonry bearing walls. The presence of internal joint strap anchors, with tieback to the masonry bearing walls, could not be determined (no external spreader plates were used.) Bridging would have been expected to be present between floor joists.
    - **Columns:** Tubular design-cast iron or rolled steel (material type and dimension not determined) with either riveted or bolted connections at flanges and caps to steel I-beams.
        - Smaller-sized columns were noted along the storefront; assumed either cast iron or rolled steel, size undetermined. Presumed to carry load from presumed steel beam and lintel that would be present along the entire length of the storefronts (Side Alpha), providing structural support of the span, transom, and wall area above (façade face).
        - The tubular vertical support columns were fully exposed on the 1st floor within the commercial tenant spaces and extended into the concealed ceiling area above the 1st floor space.
    - **Structural Supporting Beams:** I-profile steel beams, size undermined, with either riveted or bolted connections at flanges and caps.

        - The steel I-beams were positioned in a north-south orientation and located in the transom-ceiling (concealed) void on the 1st floor and within the ceiling (concealed) voids on the 2nd floor and 3rd floor.
    - **Flooring:** 2-inch or 3-inch composite wood plank flooring is common for this building type and vintage consisting of a rough underfloor planking attached to the wood floor joist and a finished upper flooring treatment.
        - 1st floor: Slab-on grade concrete floor.
- **Size:** Three stories with no basement.
    - Height: Curb line to cornice was approximately 35 feet.
- **Floor Area:** 216 feet x 64 feet (13,825 square feet per floor).
    - Total floor area: 41,472 square feet (estimated).
- **Interior Compartments:**
    - Compartment framing, wood timber construction, likelihood for original plaster and lath wall treatment (fully, partial, or removed) with or without possible renovations or addition of gypsum wallboard over existing legacy surfaces. Partitions likely fabricated on top of floor diaphragms (floor-fire separation). It is very unlikely full balloon frame construction was present in the structure based on typical design and construction features for Type III structures.
    - The high probability of single or multiple concealed spaces and voids being present was highly plausible and referenced in department's internal investigation report.
    - The presence of a defined vent shaft with interior connectivity was noted in the department's internal investigation report.
    - The presence of a transom above the Side Alpha storefronts is indicative of at the least a single if not highly probable multiple ceiling spaces, voids, and travel paths.
    - Recommended practices and code ordinances at the time of the building's construction (1922 and 1925) required.
        - Requirements in non-fireproof buildings used for business and residence. All ordinary construction non-fireproof buildings of Classes C and D over two stories or 35 feet high, where the lower stories or portions thereof are used for business, and the stories above for residence purposes shall have all partitions and ceilings separating the business portions from the residence portions, covered with metal lath, or ½-inch fiber plaster board and plastered with cement or gypsum plaster to a total thickness of ¾-inch; or plaster board may be covered with sheet metal.
        - Other equivalent fireproofing may be used. There shall be no windows in such partitions, and all other openings shall be protected by fire doors. Stairway, elevator, and other shafts in such buildings shall be constructed in conformity with requirements of Section 93 of the National Building Code (circa 1922).
        - Fire-stops shall also be provided at the line of the ceilings to completely cut off all communication to floors above through hollow stud partitions or side walls, as required by Section 97, Paragraphs 1, 2, and 3 of the National Building Code (circa 1922).

        - Sheet metal, unless backed by an unbroken layer of at least ½-inch of plaster or plasterboard, is not considered equivalent to either of the above-mentioned methods of protection.
        - It could not be fully ascertained as to the number of concealed spaces present, the type(s) or presence of original ceiling treatment, or the addition, alteration, or modification of such over the decades of building use and the condition or assembly features present at the time of the fire.
        - ***Note*****:** *Incident commanders must assume and prepare for the following issues regarding most buildings of this vintage, age, and continued use:*
            - *A high probability that multiple concealed spaces will be present from original construction.*
            - *Concealed spaces and void areas from multiple additions and renovations.*
            - *Firefighting operations may not readily locate the seat of a fire.*
            - *Fire or smoke evidence from concurrent locations.*
            - *Fire may be traveling or seated in single or multiple concealed spaces.*
- **Perimeter Walls:** Masonry wall construction.
    - Hollow clay block wall construction with full-face brick veneer construction.
    - Floor heights (approximate): 1st floor, 2nd floor, and 3rd floor, 12 feet each.
    - Wall thickness: 1st floor, 2nd floor and 3rd floor, 12-inch multi-wythe wall. ***Note:*** *A Wythe is a continuous vertical section of masonry, one unit in thickness.*
    - Pilaster wall construction: Side Charlie interior wall for beam support.
    - Window treatments: Extensive and dominate for residential and commercial retail use; conventional window treatment and sizing for residential occupancy spaces on the 2nd floor and the 3rd floor. Typical storefront framing and glazing on Side Alpha, with dominate transom treatment above the street side storefronts.
    - Side Delta perimeter wall treatment: 18 active windows; 240-square-feet window area (approximately 11% of the total wall area).
    - Side Delta masonry bearing perimeter wall:
        - Masonry wall material: 2,200 square feet of surface area
        - Approximately 135,400 lbs. gross weight (non-inclusive of interior wall materials and treatment), which represented 89% of wall area.
    - Decorative brick cornice and roof edge: Large parapets along the primary bearing (east and west) walls.
    - No clear delineation that the 1st floor tenant spaces had any qualified fire resistant fire separation of spaces. The fire department's internal investigation report states the presence of both the horizontal full building length concealed ceiling spaces and the presence of a vertical chase area in the vicinity of two tenant spaces.
- **Roof:** Timber rafters with wood deck and covering.
- **Protective Systems**: No fixed sprinkler system. No centrally monitored fire alarm system. Several of the apartments on the 2nd floor and 3rd floor contained single station smoke detectors. Passive fire doors or fire-rated separations within the interior could not be ascertained.

**Masonry Perimeter Walls**

Unreinforced masonry walls are typically several Wythes thick. This can be determined by viewing bricks laid with the butt end on the exterior face of the wall; this ties the Wythes of bricks together. ***Note:*** *A Wythe is a continuous vertical section of masonry one unit in thickness. A Wythe may be independent of, or interlocked with, the adjoining wythe(s). A single Wythe of brick that is not structural in nature is referred to as a veneer* (**See Diagram 3**) [Wikipedia 2016].

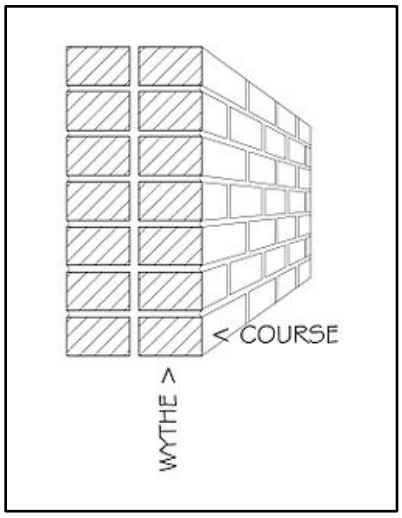


**Diagram 3. A Wythe is a continuous vertical section of masonry one unit in thickness.**
***(Diagram from Wikipedia.com.)***

Brick header courses typically occurring every six or seven courses were found in the construction of the building's walls. Sometimes, unreinforced masonry infill walls will not have header bricks, and the Wythes of brick are held together only by mortar. Floor joists were pocketed with diagonal bevel (fire-cut) into the masonry bearing walls (Side Bravo and Side Delta). The presence of internal joint strap anchors, with tieback to the masonry bearing walls, could not be determined and no external spreader plates were used.

**Perimeter Walls: Construction Features**

The exterior walls were constructed as outlined below:

- **Side Alpha.** The three-story front of the structure was an unreinforced masonry non-load-bearing wall constructed with full-face brick veneer construction. The entire façade incorporated a combination steel (single or dual) beam and steel lintel assembly to allow for the transfer of structural loads from the building face across the expansive horizontal storefront openings. Also incorporated were a series of smaller tubular or round design cast iron or rolled steel columns evident in the storefront windows. The lower street level exhibited typical

storefront framing and glazing with dominate transom treatment above the street side storefronts.

- **Side Bravo.** The Side Bravo wall was shared on the 1st floor with an additional building (financial loans). This building was not part of this report. The Side Bravo wall was masonry bearing, hollow clay block with unreinforced construction with full-face brick veneer construction (**See Diagram 4**).

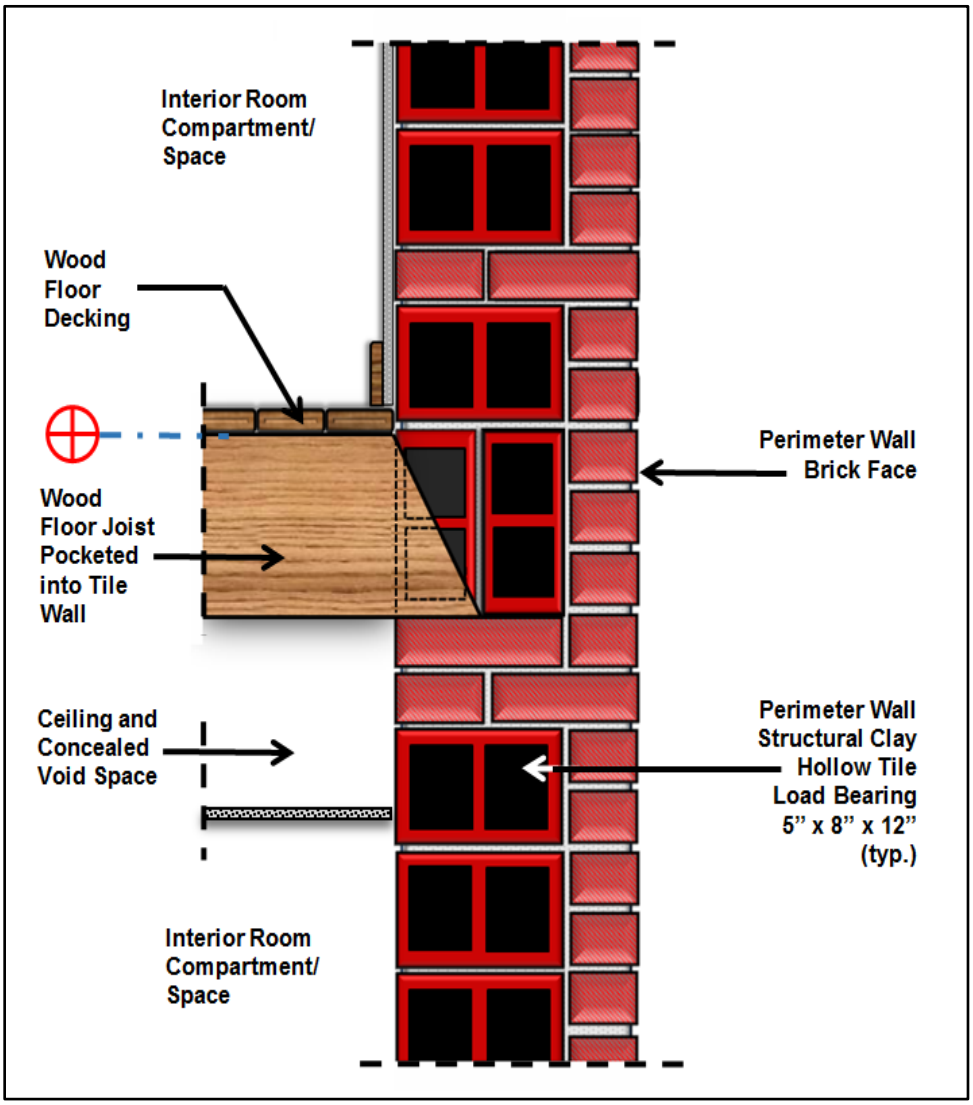


**Diagram 4. Typical masonry perimeter wall with clay hollow tile and floor joist.**
***(Graphic courtesy of Buildingsonfire.com | C.J. Naum.)***

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

- **Side Charlie.** This wall had several characteristics. Visually, this side of the structure looked like two stories due to the grade of the lot. However, this building contained a below-grade walkway that opened up to the rear of the commercial occupancies on the 1st floor. This wall was constructed of masonry non-bearing, hollow, clay block with unreinforced masonry construction with full-face brick veneer construction. The 2nd floor and 3rd floor incorporated an attached wood siding treatment for the entire rear façade. Two large covered porches and access areas were present at the Side Bravo/Side Charlie corner and Side Charlie/Side Delta corner of the façade.
- S**ide Delta.** This wall was constructed masonry bearing wall with hollow clay block wall unreinforced masonry construction with full-face brick veneer construction. There were no entrances to the building from this side of the structure. There were several apartment window openings and 3 openings to the unoccupied occupancy on the 1st floor. The facade had extensive window treatments and openings on the upper floor apartments (**See Diagram 5**).

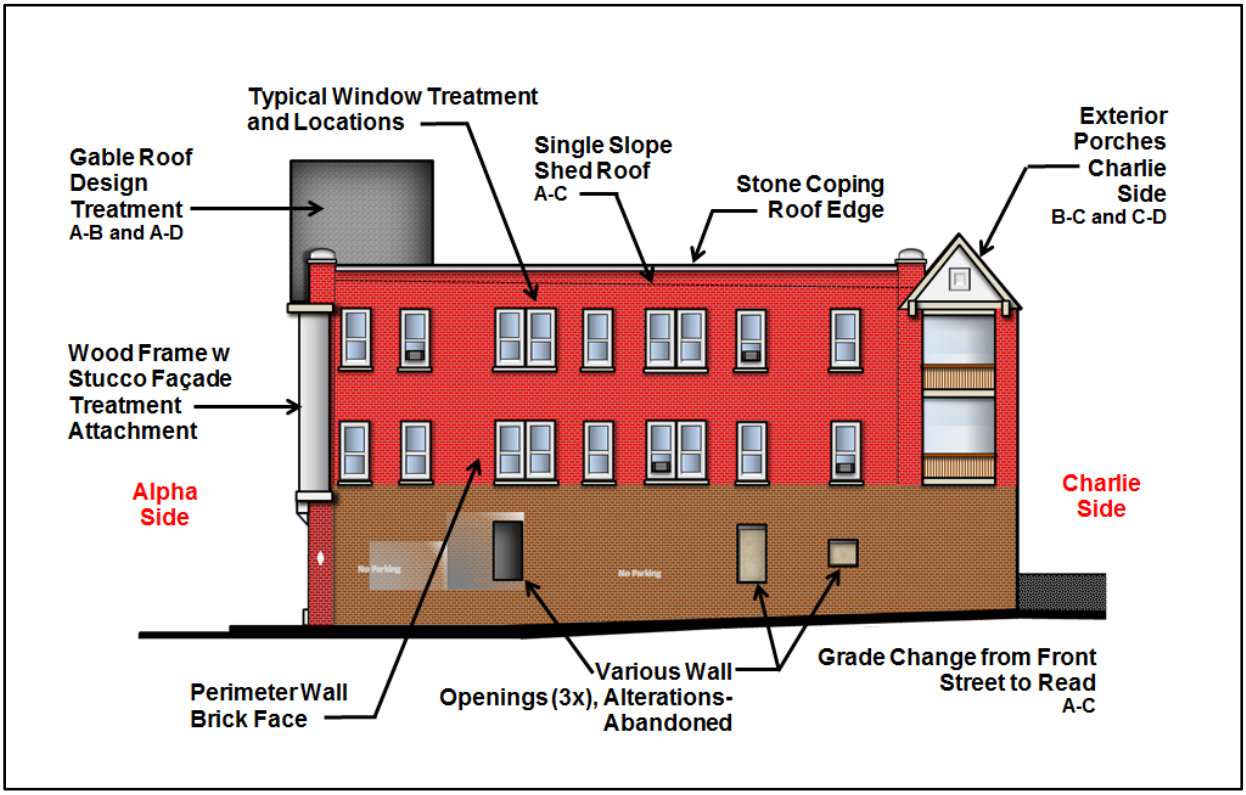


**Diagram 5. Side Delta Elevations and Masonry Perimeter Wall Features**
***(Graphic courtesy of Buildingsonfire.com | C.J. Naum.)***

The occupancy risk of a building of unreinforced masonry or reinforced masonry construction must anticipate and expect collapse or compromise to occur during fireground operations. This is especially

true when dealing with large-scale or fast-progressing fires in large square footage building, complexes, or sets of closely situated structures. The operational probability of a collapse event is likely too frequent in these building types. A structural collapse should be planned for and expected in the development and execution of the strategy and tactics (incident action plan) for these occupancies.

## Personal Protective Equipment

The NIOSH investigators inspected the personal protective equipment from the fire fighters assigned to Pumper 10 and Truck 2 at the city's police department evidence facility.

The personal protective equipment suffered no damage other than the turnout pants and turnout coat from the fire fighter from Pumper 10, which were cut off in the hospital. The personal protective equipment (turnout gear) was not considered a contributing factor in this incident. NIOSH investigators conducted no further evaluation or testing of the turnout gear.

NIOSH investigators inspected and photographed the self-contained breathing apparatus (SCBA) worn by the fire fighters from Truck 2 and Pumper 10. Also, the SCBA worn by the two injured fire fighters from Pumper 23 were inspected and photographed. This process was conducted at the city's police department evidence facility.

An additional SCBA was sent to NIOSH for testing at the request of the fire department. This SCBA had been missing and considered lost. This SCBA was worn by a fire fighter at the incident and was located at the fire scene. This SCBA had not had its annual evaluation and testing. A total of five SCBA units were shipped to the NIOSH National Personal Protection Technology Laboratory (NPPTL) in Morgantown, West Virginia, for evaluation and testing (**See Appendix One**).

## Weather Conditions

At 1927 hours on October 12, 2015, the following weather conditions were reported. The temperature was 71 degrees Fahrenheit, the dew point was 30.9 degrees Fahrenheit, the relative humidity was 23%, the winds were calm, the sky was clear with 10 miles visibility, and there had been no precipitation in the past 24 hours [Weather Underground 2015].

## Investigation

On October 12, 2015, at 1926 hours, the fire department's Fire Communications Center received a 9-1-1 call reporting smoke in an apartment building. At 1927 hours, the Fire Communications Center dispatched a regular alarm for an apartment fire. The Fire Communications Center dispatched Car 104, Pumper 10, Pumper 25, Rescue 1, Truck 3, Truck 10, Pumper 23, and Medic 5 on tactical channel A5. ***Note:*** *The captain (district safety officer) assigned to Battalion 104 was working out of classification (WOC) as Battalion 104. Another captain was assigned as the Battalion 104 district safety officer.*

Car 104, Pumper 10, and Pumper 23 arrived on the scene at 1929 hours. Car 104 parked on Side Alpha on the avenue across from the alley. Pumper 23 laid a 4-inch supply line to Pumper 10 from the east.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

The acting battalion chief left the vehicle and walked to Side Charlie. On Side Charlie, he met several occupants from the apartment building. The acting battalion chief assumed command of the incident and then made the following assignments:

- Pumper 10 was assigned to the 1st floor of the apartment building.
- Pumper 23 was assigned to the 2nd floor of the apartment building.
- Truck 3 was assigned to work with Pumper 10.
- Pumper 25 was assigned to take hoseline into the 1st floor.
- Truck 10 (split crew) was assigned to search the 2nd floor and roof operations.

**Pumper 10**
While enroute, the officer on Pumper 10 advised smoke was showing from approximately three blocks away. At 1929 hours, Pumper 10 stopped at the Side Alpha/Side Delta corner of the fire building. A female civilian told the officer of Pumper 10 that the fire was in the back of the building. The officer of Pumper 10 advised the Fire Communications Center that Pumper 10 was on-scene and that smoke was showing from a three-story complex. Pumper 10A advised the Fire Communications Center this was a "working fire". The officer of Pumper 10 assumed Command. The time was approximately 1931 hours. Pumper 10 turned into the alley and parked at the Side Charlie/Side Delta corner of the fire building in the alley. Pumper 10 stretched a 1¾-inch hoseline approximately 10 feet into the 1st floor of the vacant occupancy.

**Pumper 23**
Pumper 23 approached the fire building from the east. Pumper 23 arrived on-scene at 1930 hours. Pumper 23 laid a 4-inch supply line to Pumper 10 in the alley and parked behind Pumper 10. Black smoke was coming out of the vacant bar on Side Alpha. Pumper 23 (PAR 2) went to the 2nd floor of the apartment building at approximately 1934 hours. Pumper 23 encountered heavy smoke on the 2nd floor. Pumper 23 went across the hallway above the nail salon, due to the increase of heat and smoke. Pumper 23 opened up the walls. Pumper 23 operated a 1¾-inch hoseline from Pumper 10 to cool the room down. Pumper 23 was PAR 2 (the officer of Pumper 23 and one fire fighter).

The other fire fighter from Pumper 23 met up with the crew from Pumper 23. The fire fighter got the officer and fire fighter from Pumper 23 out of the apartment at approximately 1947 hours. The officer of Pumper 23 advised Command that the building needed to be evacuated. Less than 2 minutes later, Command requested the evacuation tones be sounded. The crew of Pumper 23 left the building. The officer of Pumper 23 met with Command. The two fire fighters went back to Pumper 23 to change cylinders. The officer of Pumper 23 said the 2nd floor was completely evolved in fire about 4–5 minutes later (**See Diagram 6**).

**Truck 3**
Truck 3 arrived on-scene at approximately 1930 hours and parked at Side Alpha just west of the nail salon of the fire building. The officer of Truck 3 and a fire fighter went into the alley and then to Side Charlie. Truck 3 forced the front doors of the vacant occupancy on the 1st floor. Then Truck 3 met Pumper 10 inside the vacant occupancy. A fire fighter from Truck 3 had a thermal imager. The thermal

imager indicated that the fire was next to them in the nail salon. ***Note:*** *The rear entrance (Side Charlie - North side) to the nail salon was bricked over. Companies had no access to the rear of the nail salon, which required companies only use the Side Alpha access.*

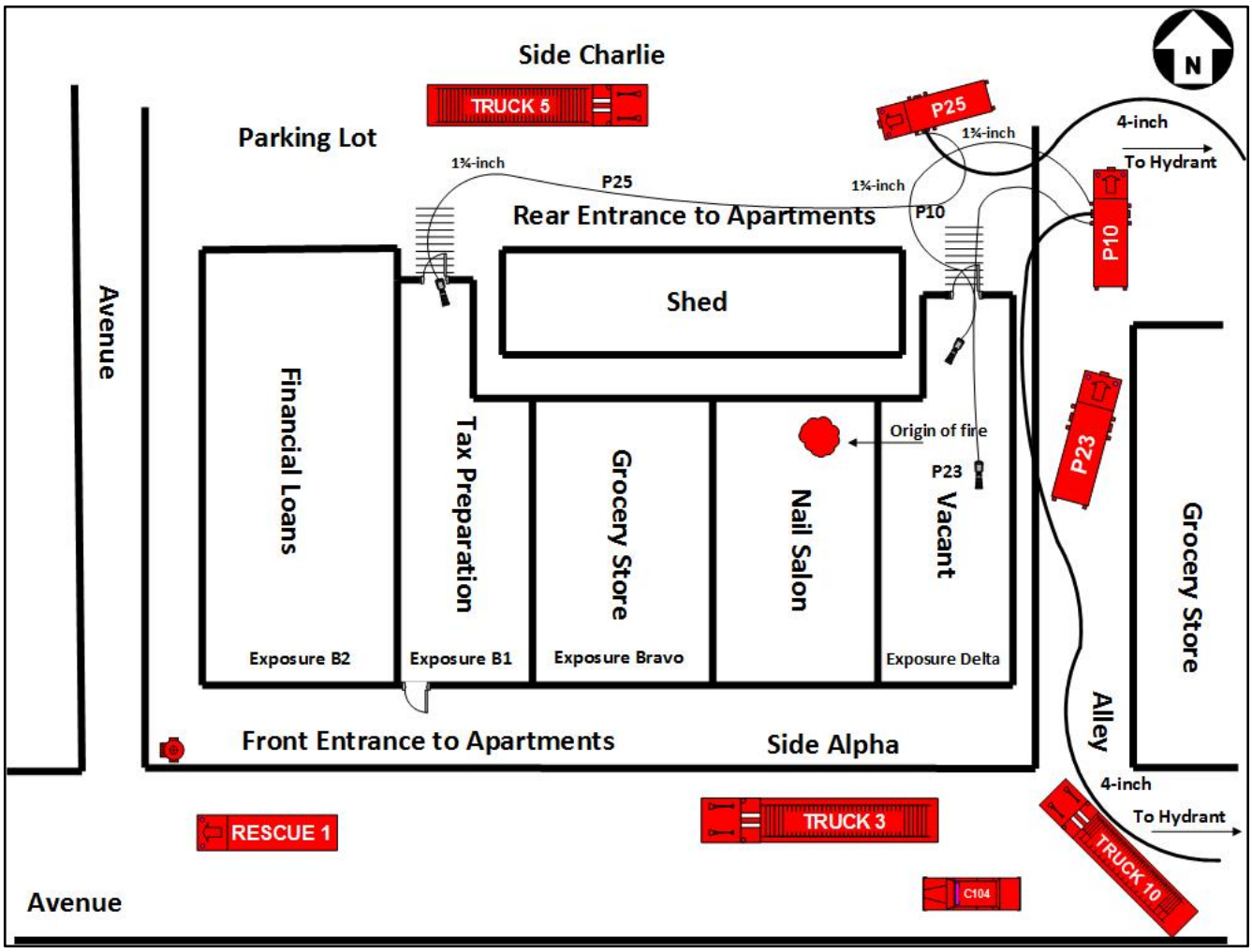


**Diagram 6. The apparatus placement of the "Regular" Alarm assignment initiated on Side Charlie with Pumper 10, Pumper 23, Pumper 25, Truck 10, and Truck 5. The time was approximately 1935 hours.**

Truck 3 and Pumper 10 continued trying to locate the fire but kept being stopped by walls. Pumper 10 went outside but could not see any indication of fire. Pumper 10 went back into the building and then went to the 2nd floor. Pumper 10 found a gap in the wall and could see the fire. The fire fighters were operating above the nail salon. A fire fighter from Pumper 10 had a 1¾-inch hoseline and was hitting the fire. Pumper 10 and Truck 3 tried to make the opening bigger to get to the fire but were unsuccessful. The heat continued to increase and crews realized the fire was now below them. The room had gotten very hot, and Pumper 10 and Truck 3 left the building.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

**Truck 10**
Truck 10 was dispatched to an apartment fire and arrived on-scene at 1930 hours. The fire apparatus operator parked Truck 10 on the Side Alpha/Side Delta corner of the building in the middle of the street. The fire apparatus operator then put the aerial ladder up to the roof. The officer and a fire fighter from Truck 10 went to Side Charlie. They entered the apartment building on the 2nd floor and started to search for occupants. They met occupants from the building exiting the structure. The officer and fire fighter from Truck 10 continued to search the 2nd floor and 3rd floor of the apartment building until the evacuation order was sounded at 1949 hours.

The fire apparatus operator (FAO) from Truck 10 climbed the aerial ladder and went to the tip. He took out 2nd floor windows on Side Delta. He stated that he could see into the apartments. He took out four rows of windows, which was as far as he could get before the evacuation order was sounded. The other fire fighter from Truck 10 climbed the aerial ladder and met the fire apparatus operator.

**Pumper 25**
Pumper 25 was dispatched on the regular alarm for an apartment fire. Pumper 25 arrived on-scene at 1930 hours. The officer of Pumper 25 stated they could see smoke showing from the east. Pumper 25 laid in and parked on Side Charlie in the rear parking lot. Pumper 25 had laid the supply line for Pumper 10, but Pumper 23 had already laid Pumper 10 a supply line. The Pumper 25 crew connected the supply line to Pumper 25.

The crew pulled 300 feet of 1¾-inch hoseline off Pumper 25. Pumper 25 went into the bar (vacant structure) but couldn't find the fire. Pumper 25 moved outside and went west down Side Alpha, which was very smoky. Pumper 25 made entry into another business, which was the grocery store. Pumper 25 went inside and started tripping over merchandize in the store. Pumper 25 was unable to determine how long they operated in the grocery store. The officer of Pumper 25 asked for a thermal imager, which came from Truck 6. Pumper 25 could see the fire and knocked it down. The officer of Pumper 25 heard on the radio that fire was blowing out of the windows on the 2nd floor. The evacuation tones were sounded at 1949 hours. The crew from Pumper 25 went back to Pumper 25 and hit the fire with a deck gun.

**Car 104 (Battalion 104)**
Car 104 arrived on the scene at 1929 hours. ***Note:*** *The captain (district safety officer) assigned to Battalion 104 was working out of classification (WOC) as Battalion 104. Another captain was assigned as the Battalion 104 district safety officer.* Car 104 and the district safety officer left the vehicle on Side Alpha and proceeded to Side Charlie. Car 104 assumed Command and the district safety officer went interior with Pumper 10. The district safety officer was carrying a halligan and a thermal imager.

The officer of Pumper 10 advised the fire was in the basement, which was actually the ground floor. ***Note:*** *The building did not have a basement*. Command advised the Fire Communications Center to prepare for a 2nd Alarm (actually the 1st Alarm for this incident) incident at 1931 hours due to the size

of the building. Pumper 24 was currently on Side Alpha. Command ordered Truck 5 and Pumper 24 to Side Charlie for the rescue of occupants from the apartment building. Truck 5 and Pumper 24 rescued one female and one male from the 3rd floor of the apartment building.

Command was still operating on Side Charlie. Car 105 advised companies to make entry into the building on Side Alpha. At this time, there was no fire showing on Side Alpha. Pumper 23 came out of the building and advised it was too hot to stay inside. Command called Pumper 10 about their position and the conditions. Pumper 10 wanted to go through a wall to get to the fire. Suddenly, the conditions worsened on the 3rd floor. Command then requested that the Fire Communications Center sound the evacuation tones to get everyone out of the building. All companies were ordered to move back from the building to create a collapse zone. ***Note:*** *The evacuation tones are variable wobble sound transmitted on the tactical channel by the Fire Communication Center. Also, all fire apparatus operators are to activate apparatus air horns. During the department's review of this incident, there were fire fighters on scene that stated they did not hear the evacuation tones or the radio communications to evacuate the building.*

**Rescue 1**
Rescue 1 responded to the apartment fire and arrived on-scene at 1932 hours with heavy smoke showing on Side Alpha. Rescue 1 parked on the Side Alpha/Side Bravo corner of the structure. Rescue 1 was divided into three teams of two with the primary function being search and rescue. Rescue 1 proceeded to the grocery store next to the nail salon, which was very difficult to search due to the clutter. The ceilings were 8 feet with a drop ceiling. Rescue 1 pulled the ceilings and found nothing. Rescue 1 went in about 30 feet and visibility was good. Rescue 1 checked the ceiling tiles in the grocery store. Rescue 1 operated in the grocery store for 10–15 minutes.

Rescue 1 moved to Side Charlie of the building and saw a panel of electrical meters on the building (Exposure B-2, **See Diagram 7**). Rescue 1 went into the next building with red double doors, which took them to the 2nd floor of the apartment building. While on the 2nd floor, they met Pumper 24 who had a 1¾-inch hoseline. It was very hot on the 2nd floor and Rescue 1 stayed on the 2nd floor for 5–10 minutes. Rescue 1 backed out, went down the stairs to Side Alpha, went outside, and met Car 105. The officer of Rescue 1 told Car 105 that the conditions were deteriorating quickly. Car 105 went to Command to get everyone out of the building. Heavy, black smoke was pouring out of the building on Side Charlie. Rescue 1 conducted a 360-degree search of the building. Rescue 1 staged at Truck 10 when the evacuation order was sounded at 1949 hours.

**Additional Alarm Assignments**
At 1930 hours, the Fire Communications Center dispatched the following units on the *Working Fire Dispatch*: Air 1, Car 212, Medic 35, and Truck 5 for a working apartment fire.

At 1933 hours, a *1st Alarm assignment* was dispatched for the apartment fire. Units dispatched were Car 105, Car 101C, Car 120, Pumper 24, Truck 6, Medic 9, and Unit 535.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

At 1945 hours, Command requested a 2nd Alarm for this incident. The Fire Communications Center dispatched Car 102, High Rise 102, Medic 40, Pumper 9, Pumper 27, Pumper 18, Rescue 31, Truck 2, and Truck 12 for an apartment fire operating on Tac Channel A5.

The following table shows the locations of the companies operating at the apartment building fire at the time of the evacuation tones at 1949 hours.

| Side Alpha | Side Charlie | Roof Operations | RIC | Medical Group |
|---|---|---|---|---|
| Rescue 1 (6) | Pumper 10 (4) | Truck 2 (4) | Truck 6 (4) | Medic 35 (2) |
| Pumper 9 (4) | Pumper 23 (4) | Truck 3***** (4) | Rescue 31(6) | Medic 40 (2) |
| Pumper 27 (4) | Pumper 25 (4) | Truck 10*****(4) | | Medic 5 (2) |
| Pumper 18 (4) | Truck 5 (4) | | | Medic 9 (2) |
| Truck 6 (4) | Truck 12 (4) | | | |
| Car 105 (1) | Car 104 (2) | | | |
| Car 102 (2) | | | | |
| Car 101C (1) | | | | |

**Table. The companies by location or function prior to the structural collapse on Side Delta at 2006 hours. The asterisk (*) indicates that Truck 3 and Truck 10 split their crews between Side Charlie and roof operations. The number in parentheses indicates the staffing level.**

Car 101C arrived on-scene at 1951 hours. Command was preparing to change strategies (offensive to defensive) and start ladder pipe operations. A personnel accountability report (PAR) was conducted and completed. Car 101C ordered Command (Car 104) to Side Alpha. Car 101C assumed Command and assigned Car 104 as Operations Section Chief.

**Structural Collapse**

Car 101C assumed Command at 1958 hours. A collapse zone had been established on all sides of the structure by Command at 2000 hours. Companies on Side Charlie started bringing hoselines out of the building. Crews from Pumper 10 and Pumper 23 moved the two 1¾-inch hoselines back toward Pumper 10.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

Ladder pipe operations for Truck 5, Truck 12, Truck 6, Truck 3, and Truck 10 were initiated. A water supply issue caused the master stream operations to be delayed until adequate water supply sources could be established.

At approximately 2005 hours, crews operating on Side Alpha witnessed an interior collapse. The district safety officer from Car 104 witnessed a collapse on Side Charlie when the balcony and walls of the 2nd floor apartment collapsed. Then the wall on Side Delta collapsed into the alley, trapping four fire fighters. The trapped fire fighters were from Pumper 10, Truck 2, and Pumper 23 (**See Diagram 7 and Photo 3**).

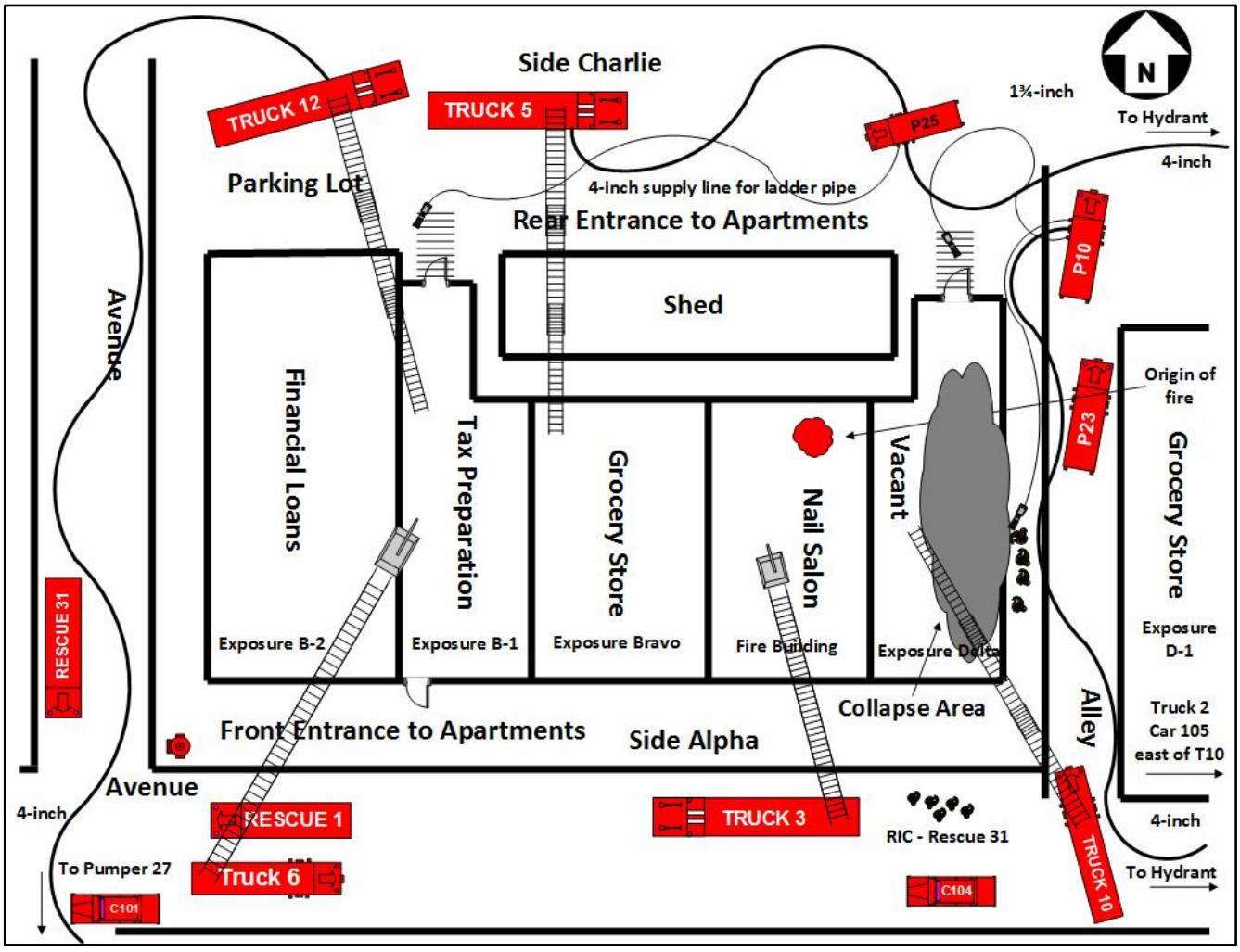


**Diagram 7. The location of the fire fighters from Pumper 23, Pumper 10, and Truck 2 on Side Delta when the structural collapse occurred at 2006 hours. The crew from Truck 2 parked on the avenue east of Truck 10**

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri


**Photo 3. Side Delta (east alley) where the collapse occurred, trapping the fire fighters from Pumper 23, Pumper 10, and Truck 2. Pumper 23 has been moved from its original location behind Pumper 10. This picture was taken the morning of October 13, 2015.**
***(Photo courtesy of the Bureau of Alcohol, Tobacco, Firearms and Explosives.)***

At the time of the collapse, which was approximately 2006 hours, two fire fighters from Pumper 23, two fire fighters from Pumper 10, and one fire fighter from Truck 2 were operating in the alley on Side Delta. The tactical decision to place resources within the collapse zone was communicated over the radio by the Side Delta division supervisor. This message was not confirmed by the Incident Commander. The task consisted of stretching and directing a hose line from the corner of the Side Delta of the structure and to place a hose stream into two openings that were showing aggressive fire. The crews on Side Delta reported that fire was impinging upon a pumper that was spotted in the alley.

When the collapse occurred one fire fighter from Pumper 23 was pushed to his knees near the driver's side tailboard of Pumper 23. The other fire fighter from Pumper 23 was covered to his waist with debris. The fire fighters from Pumper 10 and Truck 2 were completely covered with debris. The fire fighters from Pumper 10 and Truck 2 were removed and pronounced dead at the hospital. The two fire fighters from Pumper 23 were removed and admitted to the hospital for treatment.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

## Fire Behavior and Extension

***Note:*** *The description of fire behavior and extension was provided to NIOSH FFFIPP investigators by Christopher J. Naum. This material was developed by Christopher J. Naum based upon information obtained by NIOSH FFFIPP investigators during this investigation and from publicly available sources. Mr. Naum did not respond to this incident.*

Each building material and component is affected differently over time based on their material characteristics and fire resistance. This includes such factors as applied structural load intensity, material and component type, component dimensions, heat flux from the fire on the assembly, type of construction, and effects of temperature rise within the structural member. The mechanism and sequence of collapse of the Side Delta wall highly suggests a probability that the wall collapse was precipitated and triggered by the compromise and collapse of interior supporting assemblies. The subsequent concurrent succession of collapse of the 1st and upper floors was due to fire degradation of supporting systems from both flame impingement and exposure. This led to an interior floor collapse and the succession to the masonry wall collapse in a curtain-fall collapse configuration.

A building of Type III construction with similar vintage, occupancy use, and tenant space configuration indicates that fire conditions have either impinged or transmitted within or along concealed spaces and voids. It is highly probable and predictable that the structural integrity of the various assembly, supports, structural floor joists, and wall systems will be compromised and subject to varying degrees of degradation. Rapid or prolonged fire extension or exposure will result in probable building component and assembly compromise, deterioration, failure, and collapse [Naum 2014, 2016; NIOSH 2013b, 2015].

The performance characteristics of wood when exposed to fire are readily known. Thermal degradation of structural wood components and the effects of fire impingement on wood members and assemblies responding to heating decompose or pyrolyze into volatiles and char. As wood burns and chars, the loss of wood cross-section (mass) of single or multiple structural wood members, such as dimensioned wood floor joists, continues in direct fire growth phases. The complete loss of wood cross-section of wood floor joists due to flame impingement results in structural compromise of the component to perform as designed to carry and transfer loads or to carry attached loads present within this structure at the time of the fire [American Wood Council 2014; NFPA 1997; NIOSH 2015].

Uneven deterioration or burn-through of wood floor joists, wall/floor connections, and steel beam bearing, plus the possible loss of column, beam, and joist stability, would lead to structural compromise. This could result in the collapse of the ceiling joists. The effects of fire and heat exposure and impingement on non-protected tubular steel columns, structural steel I-beams, dimensioned wood floor joists, and their assemblies compromise these building components. The result is structural steel deformation, rotation and twisting, elongation, movement, and buckling, or the loss of load sustainability components can reach critical temperatures at which a fully loaded structural member's integrity becomes questionable. ASTM E119 assumes a critical temperature of 1000°F (538°C) for steel columns and 1100°F (593°C) for steel beams. If steel attains a temperature exposure of 1,022°F

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

(550°C), the remaining strength of the steel component is approximately 50% of the value at ambient temperature [NFPA 1997; SFPE 1995]. Steel beams will elongate and soften when exposed to temperatures at 1000°F (538°C) at a rate of 9.5 inches per 100 linear feet. This also equates to a 0.06% to 0.07% elongation for each increase in 100°F (38°C). Structural steel failure and collapse will typically occur at 1300°F (704°C) [SFPE 1995] (**See Diagram 8**).

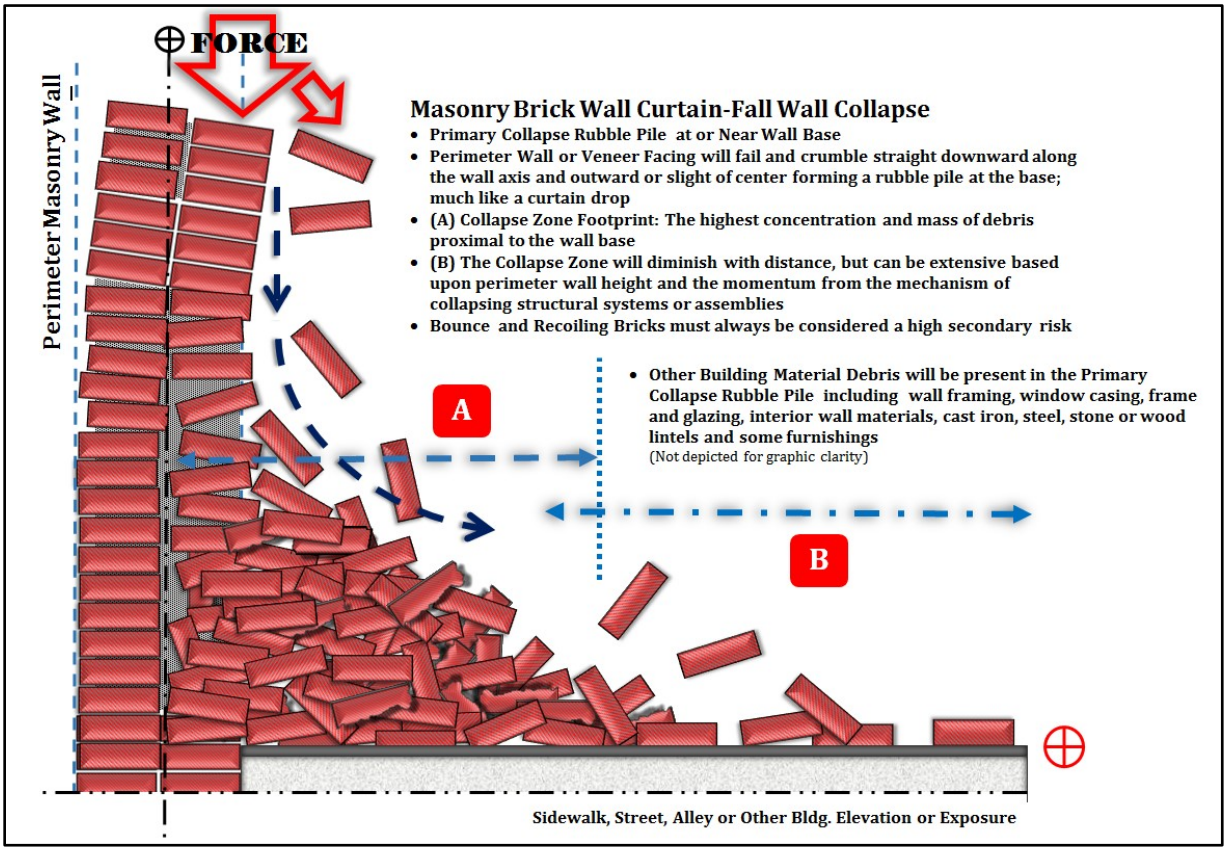


**Diagram 8. Typical masonry wall curtain-fall collapse characteristics of a masonry brick curtain-fall collapse zone**
***(Graphic courtesy of Buildingsonfire.com | C.J. Naum.)***

Operational safety concerns should be considered during fireground operations when confronted with concealed ceiling or floor space fire impingement including extension and structural stability. These are very fluid situations that require the incident commander to maintain a continuous size-up and risk assessment and to document when benchmarks are met. In this incident, the incident commander (Car 104) recognized the need to evacuate the building due to deteriorating conditions. The incident commander requested the Fire Communications Center sound the evacuation tones at 1949 hours. The

decision was made based upon continuous size-up, risk assessment, and communications from interior operating companies.

## Fire Origin and Cause

The Bureau of Alcohol, Tobacco, Firearms and Explosives determined the cause and the United States Department of Justice filed the charges of arson. Based upon the investigation, the fire was started in the nail salon.

## 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 the fatalities:

- Arson fire
- Failure to maintain an established exclusion and collapse zone on Side Delta
- Tactical level management
- Building construction
- Personnel accountability system
- Unclear functions of the district safety officer
- Pre-incident planning
- Nonsprinklered building

## Injuries

According to the death certificate, the medical examiner listed the cause of death for both fire fighters as blunt force trauma. The manner of death was homicide.

## Recommendations

***Recommendation #1: Fire departments should ensure that when a collapse zone is established, the collapse zone is properly managed and enforced by the division supervisor and/or assistant safety officer. Command should also consider designating exclusion zone(s) or no-entry zones as needed due to dangerous or hazardous conditions.***

Discussion: In most fireground situations involving a structure fire, the probability of and anticipation for structural collapse or compromise are minimized, overlooked, or at times disregarded until the catastrophic conditions present themselves with little to no time to react accordingly. The loss of situational awareness, coupled with distracted attention to subtle or obvious pre-collapse building indicators and knowledge gaps in building and construction systems combine to elevate operational risks to fire fighters on the fireground. [Naum 2012a].

Understanding the influence that building design and construction have on structural collapse has a direct correlation to safe fire-fighting operations and fire fighter survivability. In virtually every case,

structural collapse results from damage to the structural system of the building caused by the fire or by firefighting operations. The longer a fire burns in a building, the more likely the building will collapse. Older buildings that have been exposed to weather and that have been poorly maintained are more likely to collapse than newer, well-maintained buildings. The walls of buildings especially curtain walls, false fronts, marquees, and parapet walls, and heavy signs can all come falling down [NIOSH 2014].

Today's evolving fireground demands a greater understanding of buildings, occupancy risk profiling, and building anatomy by all operating companies. The identification, assessment, probability, predictability, and intrinsic characteristics of building performance under fire conditions must not only be comprehended, but also postulated into an adaptive fire-management model with flexible and fluid incident operational parameters.

Structural collapse is a significant cause of injury and death to fire fighters, the potential for a structural collapse is one of the most difficult situations to predict. The predictability of a building's performance and risk of structural collapse, compromise, or failure must be foremost in the development and execution of the incident action plan (IAP). The collapse precursors or indicators must be identified, monitored, and managed on the strategic-, tactical-, and task levels [Naum 2013a]. A collapse zone is defined as the area around the perimeter of a structure that could contain debris if the building collapsed. This area is often defined by establishing a perimeter at a distance from the building that is equal to 1½ times the height of the structure.

As noted in the document *Preventing Deaths and Injuries to Fire Fighters by Establishing Collapse Zones at Structure Fires*, determining when to establish a collapse zone starts with a community risk assessment program. Community risk assessments satisfy many fire department objectives, but one of the most important aspects is to evaluate the fire risk associated with occupancy and construction classifications. A community risk assessment program, coupled with a pre-incident planning initiative that evaluates building construction, structural integrity, fire load, and fire protection systems, is a vital tool for safely fighting fires. Fire departments should ensure all members are trained in the organization's rules of engagement, risk assessment, and situational awareness procedures [NIOSH 2014].

When conditions warrant that an area becomes an exclusion zone or no-entry zone [NFPA 2013c], Command needs to take appropriate actions to designate these areas. An exclusion zone or no-entry zone may be needed for an area where a collapse zone is not sufficient. The incident commander and the safety officer have a responsibility to establish and enforce the collapse zones plus the exclusion or no-entry zones. Also, if a division supervisor is assigned to a side (division) of a structure, they must have the responsibility to determine the conditions as they relate to the safety of fire fighters. Everyone has a responsibility to abide by the decisions made for the established collapse zones and exclusion/no-entry zones. If the fire is not contained and an exterior (defensive) attack becomes necessary, the collapse zone is moved far enough away from the structure to place the fire fighters outside the

collapse zone. The collapse zone then becomes an exclusion/no-entry zone [Klaene and Sanders 2007; NFPA 2013b, c].

At this incident, the evacuation tones were sounded at 19:49:16 hours per Command (Car 104), followed by the orders for everyone to evacuate the structure. At 19:49:56 hours, Command ordered operations changed from offensive to defensive. At 20:00:07 hours, Command (now Car 101C) ordered the Fire Communications Center to sound the emergency tones. All companies were ordered to move back from the building to create a collapse zone. Crews were operating in the alley (Side Delta) when the collapse occurred at 2006 hours.

***Recommendation #2: Fire departments should ensure that once command is established at an incident, the incident commander maintains control of situation status, resource status, and communications, plus ensures the completion of the tactical objectives.***

Discussion: Based upon the design of the Incident Command System, the standard assumption of command establishes the organizational authority to perform the command functions starting at the very beginning of the incident. When the first officer arrives on-scene, this officer has the responsibility to evaluate incident conditions, identify a strategy, develop an incident action plan, determine how to progress toward the completion of the tactical objectives, address any safety consideration, deploy and assign operating companies, and determine if there is a need for additional resources [Brunacini 2002].

It is the responsibility of the incident commander to develop an organizational structure to effectively manage the incident scene. The development of the organizational structure should begin with deployment of the first arriving fire department unit and continue through a number of phases, depending on the size and complexity of the incident. The command structure must develop at a pace that stays ahead of the tactical deployment of personnel and resources. The incident commander must be able to direct, control, and track the position and function of all operating companies. Building a command structure is the best support mechanism the incident commander can use to achieve a balance between managing personnel and the needs of the incident [NFPA 2014c].

The eight basic functions of command define standard activities that are performed by the incident commander to achieve the tactical objectives. The responsibilities of an incident commander include the following:

- The first arriving fire department resource has responsibility for the incident and assumes command of the incident.
- The incident commander conducts an initial and on-going situational assessment of the incident.
- The incident commander establishes an effective communications plan.
- The incident commander develops the incident objectives from the situational assessment and forms appropriate strategy and tactics.

- The incident commander deploys available resources and requests additional resources based upon the needs of the incident.
- The incident commander develops an incident organization for the management of the incident.
- The incident commander reviews, evaluates, and revises the strategy and tactics based upon the needs of the incident.
- The incident commander provides for the continuity, transfer, or termination of command [Brunacini 2002].

As command is transferred, so is the responsibility for these functions. The first six functions must be addressed immediately from the initial assumption of command [Brunacini 2002].

At most incidents, the initial incident commander will be a company officer. The company officer of the first arriving unit shall formally establish command and give an arrival report. The company officer should remain in command until properly relieved by a member of higher rank who is on-scene.
The initial incident commander remains in command until command is transferred, the incident is stabilized, or command is terminated. The first arriving fire department unit initiates the command process by giving an initial radio report. A standard initial radio report (arrival report) includes the following:

- Location of the incident
- Location of the command post
- Title of the incident
- Brief report (e.g., building size, construction type, and occupancy)

Other information that must be transmitted to the dispatcher and on the tactical channel are the following:

- Obvious problem/conditions
  - Nothing showing (indicates checking or investigating)
  - Smoke showing (amount and location)
  - Fire showing (amount and location)
  - Working fire
  - Fully involved
- Actions taken
  - Assuming command
  - Laying a line, attacking with …, and so forth
  - Declaration of strategy—offensive or defensive
  - Assigns the next 1 or 2 responding companies
  - Maintains accountability until a higher ranking officer (battalion chief) arrives who then assumes command (transfer of command)
- Command confirmation with name
- Follow-up radio report
  - Any immediate safety concerns
  - Accountability started (announce the initial accountability location)

Disposition of resources (situational status)

- Define initial rapid intervention crew [FIRESCOPE 2015; NFPA 2014c; VBFD 2011].

All this information gathering is essential, especially when a battalion chief or district chief arrives on-scene, and the transfer of command must occur. When the transfer of command occurs, the optimum scenario is a face-to-face exchange of information. In this situation, the company officer has the responsibility to provide an update of:

- Incident conditions
- Incident action plan
- Status of tactical objectives
- Any safety consideration
- Deployment and assignment of operating companies (situational status)
- Personnel accountability (resource status) [Brunacini 2002; NFPA 2014c]

If the arrival of the battalion chief or district chief is more than a few minutes, the second-due resource may need to assume command. This officer operates in a standard position (outside the hazard zone), monitoring communications; updating, reviewing, and reinforcing the initial size-up; backing up the initial attack; and verifying the safety, welfare, and accountability of crews.

At this incident, Car 104 arrived on-scene and assumed Command. Car 104 walked to Side Charlie and operated at this location until Car 101C arrived on-scene. The driver of Car 104 (district safety officer) separated from Command and worked with companies conducting firefighting operations on Side Charlie.

In order to provide effective command and control of an incident, the incident commander must use a tactical worksheet and an accountability board. This ensures that the incident action plan is followed and benchmarks that are met/not met are documented.

***Recommendation #3: Fire departments need to consider the impact of a structural fire on building construction and the potential for structural collapse. This process must be incorporated into the strategic-, tactical-, and task-level operations of an incident.***

Discussion: Fire fighters are at significant risk for injury or death due to structural collapse during fire-fighting operations. The United States Fire Administration and the National Fire Protection Association report that 984 fire fighters died between 2000 and 2010. Structural collapse caused 134 (13.7%) of these fire fighter line-of-duty deaths [NIOSH 2014]. Structural collapse often results in multiple fire fighter injuries and fatalities. While structural collapse is a significant cause of injury and death to fire fighters, the potential for a structural collapse is one of the most difficult circumstances to predict.

During initial size-up and ongoing fire-fighting operations, the incident commander must consider numerous variables to determine the integrity of a burning structure. Understanding the influence of

building design and construction on structural collapse has a direct correlation to safe firefighting operations and fire fighter survivability. In virtually every case, structural collapse results from damage to the structural system of the building caused by the fire or by firefighting operations. The longer a fire burns in a building, the more likely that the building will collapse [NIOSH 2014]. The walls of buildings especially curtain walls, false fronts, marquees, parapet walls, and heavy signs can all come crashing down.

Understanding the influence that building design, construction, and conditions have on structural collapse potential has a direct correlation to safe fireground operations and fire fighter survivability. A collapse zone should be established whenever the risk of structural collapse is identified as a potential occurrence.

Fire departments should not rely solely on the amount of time a fire has been burning as a collapse predictor. External loads, such as a parapet wall, steeple, overhanging porch roof, awning, sign, or large electrical service connections, may also cause structural collapse. Other factors to consider include:

- Construction type
- Age and condition of the building
- Pre-existing structural damage/deterioration
- Structural weakness caused by explosion or impact
- Presence of free-standing parapets
- Presence of wall anchor plates or stars
- Engineered load systems/lightweight construction
- Types of doors and windows
- Roof design and covering including HVAC units on fast food occupancies
- Renovation/modifications to structure
- Height of the building
- Fire duration, size, and location
- Fuel loads
- Fire behavior
- Fire protection features such as sprinkler systems and fire walls
- Weight of fire fighters and water used for extinguishment [NFPA 2015c]

Based upon continuous risk assessments being conducted, coupled with pre-incident planning information, a collapse zone should be established when factors indicate the potential for a building collapse.

Construction features, combined with fire factors, indicate the most probable type of structural failure [Klaene and Sanders 2007]. Given the fact that the incident commander is always working with incomplete and imperfect information, it is impossible to accurately predict the type of collapse and resultant collapse zone. A safe collapse zone is one that is equal to the height of the building plus an allowance for scattering debris. A good rule of thumb for setting a collapse zone for most buildings is

to establish an area 1½ times the height of the fire building. This sometimes presents a dilemma—for example, when the safe zone is beyond the street width and therefore the effective defensive positions are within the collapse zone. A risk-versus-benefit analysis is essential. The crucial question that any company officer or incident commander must ask is "What could I potentially save in relation to the risk being taken?" Obviously, no building is worth a fire fighter's life; therefore, imminent risk to a fire fighter's life to save a building is unacceptable. When a defensive operation represents a reasonable risk, positions at the corners of the buildings are normally safer than those on the flat side of a wall. Consideration should also be given to using unstaffed ground monitors to reduce the risk of placing personnel in exposed positions. When total collapse is imminent, collapse zones represent exclusion zones that no one is permitted to enter regardless of the level of protective clothing [Klaene and Sanders 2007].

At this incident, the incident commander requested evacuation tones at 1949 hours, which was 20 minutes into the incident. The strategy was to get all fire fighters out of the building and initiate defensive fire-fighting operations. At 2000 hours, the Fire Communications Center announced for all crews to move away from the structure and establish a collapse zone. During the interviews, some fire fighters stated that they never heard this communication. On Side Delta, companies continued to operate in the collapse zone until the structural collapse occurred at 2006 hours. The incident commander must initiate a personnel accountability report to ensure that all companies are operating outside the collapse zone.

***Recommendation #4: Code-setting organizations and municipalities should consider requiring the use of sprinkler systems in multi-occupancy structures.***

Discussion: This recommendation focuses on fire prevention and minimizing the impact of a fire if one does occur. The National Fire Protection Association (NFPA) *Fire Protection Handbook* states: Throughout history, there have been building regulations for preventing fire and restricting its spread. Over the years, these regulations have evolved into the codes and standards developed by committees concerned with fire protection. The requirements contained in building codes are generally based upon the known properties of materials, the hazards presented by various occupancies, and the lessons learned from previous experiences, such as fire and natural disasters [NFPA 2008].

Although municipalities have adopted specific codes and standards for the design and construction of buildings, structures erected prior to the enactment of these building codes may not be compliant. Such new and improved codes can improve the safety of existing structures [NFPA 2008]. Sprinkler systems are one example of a safety feature that can be retrofitted into older structures. Sprinkler systems can reduce fire fighter and civilian fatalities since such systems can contain and may even extinguish fires prior to the arrival of the fire department.

Fire development beyond the incipient stage presents one of the greatest risks fire fighters are exposed to during fireground operations. This risk exposure to fire fighters can be dramatically reduced when

fires are controlled or extinguished by automatic sprinkler systems. NFPA statistics show that most fires in sprinklered buildings are controlled by the activation of one or two sprinkler heads prior to fire department arrival. An automatic fire sprinkler system also reduces the exposure risk to fire fighters during all phases of fireground operation and allows the safe egress of building occupants before the fire department arrives on-scene. Finally, by controlling fire development, the risks associated with the potential for structural collapse and during overhaul operations are greatly reduced, if not eliminated.

***Recommendation #5: Fire departments should consider implementing a pre-incident planning program that complies with NFPA 1620, Standard for Pre-Incident Planning.***

Discussion: Pre-incident planning is the process of gathering and documenting information that could be critical for making life-saving decisions at an incident such as a structure fire. Pre-incident planning is essential, no matter the size of a fire department. Even the smallest towns contain buildings or sites that require pre-incident plans based upon a community risk assessment. These occupancies can include, but are not limited to schools, high-rise occupancies, hospitals, nursing homes, medical clinics, hazardous materials manufacturer or shipper, transportation agencies (e.g., a railroad), or any other businesses that is deemed by the fire department to be a high-risk occupancy or target hazard.

NFPA 1620, *Standard for Pre-Incident Planning* serves as the foundation for this process. The purpose of NFPA 1620 is to develop pre-incident plans to assist responding personnel in effectively managing emergencies for the protection of occupants, responding personnel, property, and the environment. Moreover, NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program* requires fire departments to develop pre-incident plans as determined by the authority having jurisdiction, which complies with NFPA 1620 [NFPA 2015c].

The pre-incident plan is designed based upon an emergency occurring in the occupancy and can assist the incident commander in developing a strategy and incident action plan [NFPA 2015c].

A detailed pre-incident plan highlights all aspects of the structure including the following:

- Site plan
- Floor plans
- Construction type
- Age and condition of the building
- Ingress and egress
- Pre-existing structural damage/deterioration
- Presence of wall anchor plates or stars
- Engineered load systems/lightweight construction
- Types of doors and windows
- Roof construction and covering including HVAC units
- Renovation/modifications to structure
- Height of the building
- Fuel loads

- Fire protection features such as sprinkler systems, standpipe system, fire alarm system, and hydrant locations
- Stairwells
- Utility shut-offs
- Occupant contact information
- Other pertinent information [NIOSH 2014]

Also, a pre-incident plan identifies deviations from normal operations; it can be complex and include a formal notation about a particular problem, such as the storage of flammable liquids, explosive hazards, lack of hydrants, or modifications to structural building components.

Another consideration of the pre-incident planning process is the strategy and tactics that need to be used for a target hazard occupancy. Based upon the potential risks encountered at target hazard occupancies, the pre-incident plan should outline the deployment of resources (front-loading the incident), the type of strategy to be considered, and how to deploy resources once fire-fighting operations are initiated.

Another benefit of the pre-incident plan is the ability to provide information to company officers and chief officers responding from other battalions or from different jurisdictions that may not be familiar with a specific occupancy. Moreover, a jurisdiction's building and permit office or department may have information that the fire department does not have. Information should be routed to the department's dispatch center to ensure vital information about a structure is available. For example, a target hazard is included in the comments of the computer-aided dispatch (CAD) system. Information should also include the number and type of code violations and whether the building has been abandoned or vacant or is undergoing extensive renovation. Additionally, the CAD system can provide a real-time view of an occupancy from mapping programs that are available on the internet [NFPA 2015c].

At the time of this incident, the department did not have a program in place to provide pre-incident plans for identified hazards throughout the city.

***Recommendation #6: Fire departments should consider implementing a critical building information system that is available to responding units to enhance situational awareness.***

Discussion: Coupled with the pre-incident planning program, the critical incident dispatch system (CIDS) program provides critical building information that may not be readily apparent to responding companies upon arrival. This program also provides accurate and consistent information for required radio progress reports and indicates where variations in standard operating procedures would be necessary due to previously known features found at this location.

The process starts with input from the company officers who must consider all buildings in their first-due area as potential CIDS buildings. In considering a building, the company officer must look for

conditions that would not be immediately apparent to arriving companies assigned to the initial alarm assignment. Additionally, key building factors should automatically be included in CIDS; for example, bowstring truss, major alterations, or if a pre-incident plan exists for the building. Other examples that should be considered for inclusion in the CIDS program are:

- Hazardous chemicals, liquids, and substances and always indicate floor and location.
- High voltage equipment, including transformers containing PCBs, and always indicate floor and location of such equipment.
- Interconnected odd or unusually shaped buildings and indicate which floors are interconnected.
- Buildings with structural hazards or heavy fire loading.
- Renovated buildings with hidden voids, or duplex apartments. Indicate which floors give access to duplex apartments.
- Truss buildings (describe type of truss).
- Metal bar joist and other lightweight construction materials.
- Q-deck roofs or floors, steel plated buildings.
- Handicapped, bedridden, or incapacitated individuals. Where possible, specify the location.
- Schools with handicapped students.
- Special extinguishing systems, and the location of related controls.
- Siamese locations, if not in a normal location or readily visible.
- The location of outside screw and yoke (OS&Y) valves or alarm panels, if not located in an easily found location.
- Sub-cellar levels and access locations.
- Location of guard dogs.
- Telephone numbers of knowledgeable persons, such as the owner, building engineer, or superintendent.
- Vacant buildings.

This list is not intended to be all-inclusive. Company officers should be encouraged to include other items if they feel that the condition or hazard should be identified [FDNY 2011].

Fire departments can use a variety of methods to ensure critical building information is available during response to an incident. Mobile data terminals or mobile computer terminals, hand-held computers or tablets, information from station response printers, or printed pre-incident plans can provide location-specific data triggered by place, address, and/or name. This information can be a valuable tool for the fire officers and command officers, especially when the jurisdiction has a large number of defined target hazard occupancies [NVRC 2013].

The fire department in this incident had responded to this location for numerous emergency medical services incidents and at least three prior working fires. Individual companies had developed informal procedures for responding to this structure in the event of a structure fire. These procedures were never put into a formal format to be used by initial responding companies.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

***Recommendation #7: Fire departments should ensure incident commanders incorporate the principles of Command Safety into the incident management system.***

Discussion: The purpose of Command Safety is to provide the incident commander with the necessary resources on how to use, follow, and incorporate safety into the incident management system at all incidents. Command is used as part of the eight functions of command developed by Fire Chief Alan V. Brunacini (retired). Command Safety defines how the incident commander must use the regular, everyday command functions to complete the strategic-level safety responsibilities during incident operations. Using the command functions creates an effective way and a close connection between the safety officer and the incident command. The eight functions of command are:

- Assumption/confirmation/positioning
- Situation evaluation, which includes risk management
- Communications
- Deployment
- Strategy/incident action planning
- Organization
- Review/revision
- Transfer/continuation/termination [Brunacini 2002; Brunacini and Brunacini 2004].

A major objective of the incident management system is to create, support, and integrate an incident commander into this process. The incident commander will direct the geographical and functional needs of the entire incident on the task, tactical, and strategic level. Issues develop for the incident commander when these three standard levels are not in place, operating, and effectively connected. One of the most important components is to ensure the incident commander operates on the strategic level from the very beginning of the incident and stays on the strategic level as long as fire fighters are operating in an immediately dangerous-to-life-and-health (IDLH) environment [Brunacini 2002; Brunacini and Brunacini 2004].

The incident commander uses the incident management system as the foundation for managing the strategic-level safety function. Command Safety ensures the highest level of safety for fire department members operating at emergency incidents. The incident commander completes the operational and safety responsibility to the fire fighters by performing the eight command functions.

The incident commander must follow each of these functions in order without skipping or missing any function. Each function does its own part for both the command and safety processes. Automatically connecting and integrating safety with command becomes a simple and essential way that the incident management system protects assigned resources at an incident. These functions serve as a practical performance foundation for how the incident commander completes his/her responsibility as the strategic-level incident manager and the overall incident safety manager.

A major command function involves the incident commander using the initial scene size-up, consideration of critical factors (building type, occupancy, life safety, fire conditions, and available

resources), the standard risk management plan, and the forecast of incident conditions to develop a standardized decision-making process. Overall, operational strategy is divided into only two categories: offensive or defensive.

- Offensive operations are conducted inside a hazard zone.
- Defensive operations are conducted outside the hazard zone—in safe locations.

The two separate strategies create a simple, *understandable* plan that describes how close the emergency responders will get to the incident's hazards. The incident's overall strategic decision is based on the incident's critical factors weighed against the risk management plan. The incident commander should avoid taking unnecessary risks to save property when members are the only life safety threat in the hazard zone. Declaring the incident strategy up front, as part of the initial radio report, will announce to everybody the overall incident strategy and eliminates any question on where fire fighters will be operating on the incident scene (inside or outside the hazard zone) [MABAS 2015].

The incident commander should **re-state** the strategy when benchmarks are met, when a personnel accountability report (PAR) is completed, or as needed. An example that the incident commander would communicate would be "this is still an offensive fire." This ensures that all resources on-scene are reminded of the strategy that all members are operating in at this time. It is even more important to communicate on the radio to all members on-scene that a strategy change is being made. An alert tone should be sounded prior to the message by the dispatch center. This is similar to the procedures used by the fire department involved in this incident.

Once the overall incident strategy has been determined and the incident action plan developed, the incident commander should manage the completion of the tactical priorities for the chosen strategy. Each strategy has a different set of tactical priorities to complete. Tactical priorities provide the incident commander with a simple, short list of major categories that are designed to act as a practical guideline during the difficult initial stages of fireground planning. The incident action plan must be short and simple. A complicated incident action plan tends to break down during this critical time. The incident commander should **revise** the incident action plan when benchmarks are met, when a personnel accountability report (PAR) is completed, or as needed.

Generally, the incident commander tries to achieve the same basic objectives from one incident to the next. Tactical priorities offer a regular set of tools on which the incident commander can use for tactical activities in order to develop a standard approach to solving incident problems. With this standard approach, the incident commander can manage the basic work sequence at every incident, in the same manner (**See Diagram 9**).

# *Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri*

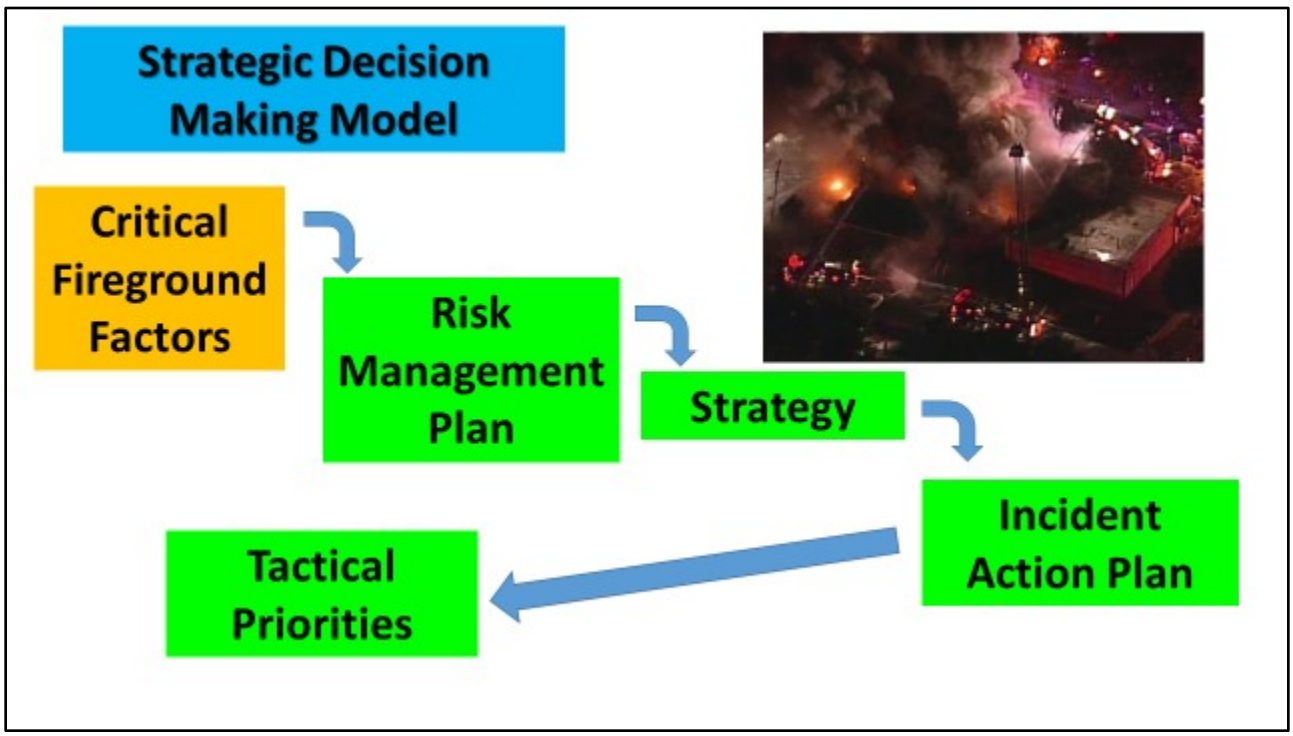


**Diagram 9: This model drives the strategic decision-making process into a standard sequence: The incident commander identifies the incident's significant critical factors and risk management plan. The incident commander then bases the strategy and incident action plan on the evaluation of those factors. This leads to the tactical priorities for the incident.**
***(Diagram courtesy of MABAS Division 201.)***

Another important part of the Command Safety process is that fire departments should consider developing and implementing a *tactical withdraw* procedure as well as an *emergency evacuation* or *abandon the building* procedure. These are two very distinct responses by crews operating in the interior of the structure. As part of the fireground survival process, all members need to be trained in these two procedures, including command officers.

- *Tactical withdraw.* The incident commander determines interior crews need to be brought out of the structure. Interior crews exit the structure bringing out hoselines and any other tools or equipment. The incident commander is constantly forecasting the integrity of the building and operating conditions from division/group supervisors, company officers, and the safety officer. Based upon the continuous size-up, risk management plan, and fire conditions, the incident commander should be able to make a confident decision on when to order interior crews out of the structure. Also, this will change the strategy from offensive to defensive operations.
- *Emergency evacuation or "abandon the building."* The incident commander will declare the emergency evacuation or "abandon the building" when a catastrophic event occurs, that places interior crews in immediate danger (structural collapse, flashover, etc.). All members

immediately stop operations and follow the hoseline out of the structure. The officer on the hoseline, who is behind the nozzleman, puts the nozzleman in front and all members follow the line out. The last member out of the building should be the officer and a PAR is immediately conducted.

Following this incident, several command safety issues were addressed by the fire department as part of their recovery process (**See Appendix Three**). These issues included fireground communications, personnel accountability, use of a tactical worksheet (which compliments personnel accountability and crew integrity), and a continuous scene size-up and evaluation.

***Recommendation #8: Fire departments should develop and consistently use a system to maintain accountability for all resources assigned to the incident.***

Discussion: The personnel accountability system is designed to track fire fighters by location and function. An integral part of the accountability system is to make sure that the fire fighters who are assigned and operating in the hazard zone are accounted for, starting with the initial operations through the entire incident. Also, a process must be in place to periodically check to make sure that all members operating in the hazard zone are accounted for throughout the incident.

A personnel accountability system is a system that readily identifies both the location and function of all members operating at an incident scene [NFPA 2013c, 2014c]. The philosophy of the personnel accountability system starts with the same principles of an incident management system—company unity and unity of command. Unity can be fulfilled initially and maintained throughout the incident by documenting the situation status and resource status on a tactical worksheet.

One of the most important functions of Command Safety is for the incident commander to initiate an accountability system that includes the functional and geographical assignments of members at the beginning of incident operations. This process continues throughout the incident and until the termination of the incident. It is very important for the first on-scene resource to initiate an accountability system. This initial system allows the passing or transfer of information to the next officer who assumes command upon his/her arrival [NFPA 2014c].

A functional personnel accountability system requires the following:

- Development and implementation of a departmental SOP
- Necessary components and hardware
- Training all members on the operation of the system
- Strict enforcement during emergency incidents

There are many different methods and tools for resource accountability. Some examples are:

- Tactical worksheets
- Command boards
- Apparatus riding lists

- Company responding boards
- Electronic bar-coding systems
- Accountability tags or keys (e.g., PASSPORT System) [NFPA 2014c]

Resource accountability should be assigned to a member who is responsible for maintaining the location and status of all assigned resources at an incident. As the incident escalates, resource status would be placed under the Planning Section. This function 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, resource status should be assigned to a dedicated member as the size and complexity of the incident dictates. A number of positions could function in this role including an incident command technician, staff assistant, chief officer, or other defined member. As the incident escalates and tactical-level management components (e.g., divisions or groups) are assigned, the resource status officer (accountability officer) works with the division or group supervisors to maintain an on-going tracking and accountability of members [FIRESCOPE 2012]. A properly initiated and enforced personnel accountability system enhances fire fighter safety and survival. It is vital that resources can be identified and located in a timely manner.

An important aspect of a personnel accountability system is the personnel accountability report (PAR). A PAR is an organized on-scene roll call in which each supervisor reports the status of their crew when requested by the incident commander [NFPA 2014c]. The PAR should be conducted every 15–20 minutes or when benchmarks are met.

In order for the personnel accountability system to properly function, the process should include a standard operating procedure that defines each function's responsibility in making this process successful on the fireground. Also a training component—both classroom and practical—should occur to ensure this process operates properly during emergency incidents.

At this incident, a formal personnel accountability process was not used. Though numerous PARs were conducted, the accountability tags were not picked up from each apparatus and taken to the command post. This is a requirement of the department's General Operational Guidelines (GOG), 11-9, *Department Accountability*. Command must have a means to track all resources on-scene whether it be an accountability board or tactical worksheet. Also, when a PAR is conducted, the company officer or division/group supervisor has to report a PAR with an actual number of members being accounted for. This ensures that the number provided to Command matches the number Command has for each apparatus. At the time of the structural collapse, there were more than 110 fire fighters, fire officers, and EMS personnel on-scene.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

***Recommendation #9: Fire departments should ensure incident commanders establish a stationary command post that is tied to a vehicle for effective incident management. The command post should be staffed with the incident commander and a staff assistant. The incident commander and staff assistant should maintain the tactical worksheet, fireground communications, and resource status.***

Discussion: In order to effectively command an incident, the incident commander needs to be in the most advantageous position possible. NFPA 1561 *Standard on Emergency Services Incident Management System and Command Safety* states the following on establishing a command post at an incident scene:

**5.3.7.1** In establishing a command post, the incident commander shall ensure the following:
- (1) The command post is located in or tied to a vehicle to establish presence and visibility.
- (2) The command post includes radio capability to monitor and communicate with assigned tactical, command, and designated emergency traffic channels for that incident.
- (3) The location of the command post is communicated to the communications center.
- (4) The incident commander, or his or her designee, is present at the command post.
- (5) The command post is located in the cold zone of an incident.

**5.3.8** The incident commander shall be responsible for controlling communications on the tactical, command, and designated emergency traffic channels for that incident.

**5.3.9** The incident commander shall maintain an awareness of the location and function of all companies or units at the scene of the incident.

**5.3.10** The incident commander shall be responsible for overall responder accountability for the incident [NFPA 2014c].

The best position for a stationary command post is a fixed, visible, and accessible location. This can be accomplished 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 with a radio communication headset. This will enable the incident commander to be in the best position possible to hear critical radio transmissions [NFPA 2014c].

NFPA 1561 *Standard on Emergency Services Incident Management System and Command* Safety states the following regarding additional requirements for a stationary command post:

**8.12.1** The incident commander shall maintain an awareness of the location and function of all companies or units at the scene of the incident.

**8.12.2** The incident commander shall be responsible for overall responder accountability for the incident.

**8.12.3** The incident commander shall initiate an accountability system that includes functional and geographical assignments at the beginning of operations and that system shall be maintained throughout operations.

**8.12.4** The incident commander and members who are assigned a supervisory responsibility that involves three or more companies or crews under their command shall have an additional member(s) (staff aide) assigned to facilitate the tracking and accountability of the assigned companies or crews.
**8.12.5** The incident commander shall keep the safety officer informed of strategic and tactical plans and any changing conditions.
**8.12.6** The incident commander shall evaluate the risk to responders with respect to the purpose and potential results of the responders' actions.
**8.12.7** In situations where the risk to emergency service responders is excessive, as defined in 8.12.8, activities shall be limited to defensive operations [NFPA 2014c].

The fire service responds to a wide range of emergency incidents on a daily basis. In order to effectively manage personnel and resources and to provide for the safety and welfare of personnel, departments will always operate within an incident command system. This annex material identifies standard fire department operations for a *Type V* or *Type IV* incident. These requirements are essential components of Command Safety, which is discussed in the next recommendation.

At this incident, the incident commander operated on Side Charlie without the benefit of a command vehicle. Without the benefit of a tactical worksheet, the incident commander was depending completely on memory of the location of all companies operating in or around the building. With at least three alarms operating on-scene, crews operating interior on Sides Alpha and Charlie, roof operations, and several companies splitting crews, this goes beyond the ability to effectively manage resources by memory.

***Recommendation #10: Fire departments should ensure that a tactical worksheet is used by the incident commander during initial fireground operations and maintained throughout the incident.***

Discussion: The tactical worksheet is a vital piece of equipment because it helps the incident commander organize the incident from the initial onset of the incident. The benefit of using a tactical worksheet is that critical information is documented as well as providing reminders, prompts, and a convenient workspace for tracking companies and apparatus. For fire departments that provide a staff assistant or incident command technician, the district chief or battalion chief has the ability of starting the tactical worksheet enroute to the incident. The incident commander has the ability to record vital information that may help them make future operational decisions. By documenting the assignments of division/group supervisors and division/group resources, the incident commander creates a visual reference of the overall fireground organization and deployment [NFPA 2014c].

The use of a tactical worksheet can assist the incident commander in tracking various task assignments on the fireground. It can be used along with preplan information and other relevant data to integrate information management, fire evaluation, and decision-making. The tactical worksheet should record unit status and benchmark times and include a diagram of the fireground, occupancy information, activities checklist(s), and other relevant information. The tactical worksheet can also help the incident

commander in continually conducting a situation evaluation and maintaining personnel accountability. The tactical worksheet can serve as a reminder for the incident commander to ensure critical benchmarks occur on the fireground. Without a tactical worksheet, the incident commander can overlook or forget these benchmarks. The tactical worksheet is a tool to help the incident commander to stay several steps ahead of the fire [Brunacini 2002; NFPA 2014c; VBFD 2011].

The advantages of using a tactical worksheet are:

- 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 responsibilities.
- Expedites passing of command or support for the incident commander.
- Maintains and documents resource status [NFPA 2014c].

The tactical worksheet is also an excellent tool when the "passing of command" must occur. On the fireground, the officer assuming command can quickly check the worksheet and obtain a complete understanding of the initial deployment of resources, the need for additional apparatus and equipment, and the status of units in the staging area.

At this incident, the incident commander (Car 104) operated from Side Charlie during the initial stages of this incident without the benefit of a vehicle or tactical worksheet. Fire departments should ensure a stationary command post is established at working incidents or any time that command is established. This process includes initiating strategy and the incident action plan (tactics), initiating the tactical worksheet, and starting the personnel accountability system process.

***Recommendation #11: Fire departments should provide a checklist for the incident commander regarding procedures in the event of a Mayday.***

Discussion: When a Mayday is transmitted for whatever reason, the incident commander has a very narrow window of opportunity to locate the lost, trapped, or injured member(s). The incident commander must restructure the strategy and incident action plan (tactics) to include a priority rescue [NFPA 2014c].

Some departments have adopted the term “LUNAR” —location, unit assigned, name, assistance needed, and resources needed—to gain additional information in identifying a fire fighter who is in trouble and needs assistance. The incident commander, division/group supervisors, company officers, and fire fighters need to understand the seriousness of the situation. It is important to have the available resources on-scene and to have a plan established prior to the Mayday [Brunacini and Brunacini 2004; NFPA 2014a].

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

A checklist is provided in **Appendix Two: Incident Commander's Tactical Worksheet for Mayday.** This checklist can assist the incident commander to ensure the necessary steps are taken to clear the Mayday as quickly and safely possible. This checklist serves as a guide and can be tailored to any fire department's Mayday procedure. The intent of the checklist is to provide the incident commander with the essential actions to be taken in the event of Mayday. This format allows the incident commander to follow a structured worksheet. This process is too important to operate from memory and risk missing a vital step that could jeopardize the outcome of the rescue of a fire fighter who is missing, trapped, or injured.

At this incident, Car 101C arrived on-scene at 1958 hours had assumed Command from Car 104. Car 104 was assigned as Operations Section Chief. At 2000 hours, Command asked for emergency tones to create a collapse zone around the structure. At 2001 hours, Command asked for Operations to meet him on Side Alpha at the command post. As Command and Operations were meeting, the collapse occurred on Side Delta in the alley at 2006 hours. Command immediately requested a Mayday response plus additional medic units. The Fire Communications Center also assigned Tac Chanel A-6 for fireground operations not involved in the Mayday. Also, Command requested a hoseline on the fire while RIC operations were being conducted in the alley.

The intent of this Mayday worksheet, like the tactical worksheet, is to assist the incident commander during a very difficult and stressful time on the fireground. The Mayday worksheet provides the incident commander with a checklist to ensure no critical actions are missed. Also, the incident commander should ensure that fire-fighting operations continue.

***Recommendation #12: Fire departments need to ensure incident commanders assign a safety officer as early in the incident as possible. Consideration should be given to the appointment of assistant safety officer(s) if the incident escalates or the situation dictates.***

Discussion: With the advent of the Incident Command System, the goal is to ensure that the incident commander is responsible for the safety and welfare of all members and other first responders who are on-scene at an incident [NIMSC 2008].

The following items shall be considered regarding the appointment of a safety officer:

- The safety officer must be assigned as early in the incident as possible.
- The safety officer reports directly to the incident commander.
- The safety officer recons the incident to identify existing or potential hazards or risks and informs the incident commander.
- The safety officer recommends to the incident commander any changes to the incident action plan as a result of the ongoing surveys.
- At an emergency incident where the safety officer judges activities unsafe or an imminent hazard, the safety officer shall have the authority to alter, suspend, or terminate those activities. The safety officer shall immediately inform the incident commander of any actions taken to correct imminent hazards at the emergency scene.

- At an emergency incident where a safety officer identifies unsafe conditions, operations, or hazards that do not present an imminent danger, the safety officer should take appropriate action through the incident commander to mitigate or eliminate the unsafe condition, operations, or hazard at the incident scene.
- When operating in forward or otherwise hazardous positions, the safety officer must be attired in appropriate personal protective equipment—including self-contained breathing apparatus and radio communication equipment—and be accompanied by another responder [NFPA 2014c; NIOSH 2012b].

Upon arrival at the incident, the designated safety officer should meet with the incident commander to confirm the safety officer assignment and to be integrated into the personnel accountability system. Upon confirmation, the safety officer should obtain the following information:

- Overall situation status and resource status.
- Incident action plan.
- Identification of known hazards and concerns, plus the establishment of control zones, especially collapse zone(s).
- Status and location of rapid intervention crews.

Additionally, the safety officer should:

- Ensure the establishment of the rehabilitation group.
- Confirm that radio communication channels have been established (command channel, tactical channels) [NFPA 2014c, 2015b; NIMSC 2008].

Based upon the size and complexity of the incident, such as a commercial structure with accessibility problems, the incident commander should consider the appointment of assistant safety officers. Types of incidents that might require expansion of the safety officer role include the following:

- Incidents covering a large geographical area (e.g., commercial structure fire) that include numerous divisions or groups.
- Incidents where significant acute or chronic responder health concerns require coordination and input to the Planning Section (responsible for accounting for the organizational structure, availability of resources, deployment of resources, and the situation status reports).
- Incidents requiring interface with local, state, federal, or other health and safety representatives.
- Multi-agency incidents where Unified Command is established.
- Incidents where Area Command is established [FIRESCOPE 2012; NFPA 2015b; NIMSC 2008; NIOSH 2012a].

Assistant safety officers assigned to branches, divisions, or groups can be addressed according to their area of responsibility. For example, an assistant safety officer assigned to Alpha Division can be addressed as "Alpha Division assistant safety officer." The assistant safety officers assigned to divisions or groups report to and follow direction from the safety officer who is part of the command staff. The assistant safety officer works with the supervisory person in the assigned division or group to ensure safety conditions are being met [FIRESCOPE 2012; NFPA 2015b; NIMSC 2008; NIOSH

2012a]. Another consideration is to form a safety group by utilizing an engine company or truck company. This would help supplement the need for assistant safety officers on or at a multi-alarm incident or an incident with a large geographical area.

The fire department in this incident utilizes the concept of district safety officers assigned to each battalion chief. At an incident, the district safety officer can function as a safety officer or a chief's aide. At this incident, the first arriving district safety officer entered the fire building with companies from the 1st Alarm assignment. The safety officer function was not initiated until the arrival of Car 600 at 2008 hours.

***Recommendation #13: Fire departments should develop a training program for staff assistants or incident command technicians.***

Discussion: The function of a staff aide (e.g., chief's aide, incident command technician, emergency incident technician, field incident technician, or staff assistant) is an essential component of the incident management system [Brunacini 2002]. Functions of the staff aide include maintaining the tactical worksheet; maintaining personnel accountability of all members operating at the incident (resource status and situation status); monitoring radio communications on the dispatch, command, and fireground channels; controlling information flow by computer, fax, or telephone; and accessing reference material and pre-incident plans [Ciarrocca and Harms 2011; LAFD 2011; Phoenix Fire Department 2010]. NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety* states in Chapter 8, "Command Safety," that the staff aide is assigned to facilitate the tracking and accountability (resource status) of the assigned companies or crews [NFPA 2014c].

Some fire departments use fire fighters as staff aides and other fire departments use fire officers to serve as a staff aide for the incident commander. Regardless of the rank of the staff aide, the staff aide has to be trained in the duties and responsibilities in order to proficiently function and meet the expectations of the incident commander. These job functions include:

- Size-up of the incident
  - Address of incident
  - Type of incident
  - Name of incident
  - Resources assigned and responding to the incident
  - Life hazard
  - Additional resources needed
  - Exposure problems
  - Location of the command post
- Communications with the dispatch center or fire department communications center
  - Dispatch channel
  - Command channel
  - Tactical channels
- Situation status (What is the incident doing?)

Are we making progress on this incident?
- Resource status (What are they doing?)
  - Personnel accountability system (e.g. PASSPORT System)—accountability board or tactical worksheet
  - How, what, and where are companies operating?
  - Who is in staging?
- Staging
  - Staging area manager(s)
  - Separate tactical channel
- Tactical worksheet
  - Printout of an *Incident Briefing* (ICS Form 201) form to gather basic information.
  - Upon arrival, transfer information immediately to the department's tactical worksheet and document companies by assignment or location (personnel accountability system).
  - Diagram the incident starting with Side Alpha.
  - Document divisions and groups with assigned supervisor.
  - Document response of other resources on-scene (e.g., law enforcement, other fire departments).

As the incident expands, an officer could be assigned as a division supervisor or group supervisor. The assigned officer will proceed to the division or group, evaluate conditions, and report these conditions to the incident commander. If directed by the incident commander, the assigned officer will assume responsibility for directing resources and operations within their assigned area of responsibility. Division/group supervisors assigned to operate within the hazard zone must be with a second individual, which would be the staff aide. The staff aide can assist the division/group supervisor by maintaining accountability of the resources assigned that particular division/group. The division/group supervisor and the staff assistant should be equipped with the appropriate protective clothing and equipment for their area of responsibility [LAFD 2011].

In order to ensure that the personnel accountability is functioning during initial fireground operations, the staff aide should assist the incident commander with the tactical worksheet as needed. Then the staff aide starts the personnel accountability system process.

At this incident, due to the immediate issues of life safety, the staff aide (district safety officer) assisted with the rescue of the building occupants. The staff aide (district safety officer) separated from the incident commander and went interior with companies on Side Charlie to assist with fire-fighting operations. The incident commander operated by himself on Side Charlie until Car 101C arrived on-scene. Car 104 (acting battalion chief) operated on Side Charlie without the benefit of a tactical worksheet and accountability board.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

***Recommendation #14: Fire departments should ensure all operating engine, truck, and rescue companies have a thermal imager.***

Discussion: Another valuable tool that enhances situational awareness is the thermal imager. The thermal imager provides a technology with potential to enhance fire fighter safety and improve the ability to perform tasks such as size-up, search and rescue, fire attack, and ventilation. Thermal imagers should be used in a timely manner. Fire fighters should be properly trained in the use of a thermal imager and be aware of their limitations [NIOSH 2015; SAFE-IR 2013].

The application of thermal imaging on the fireground may help fire departments accomplish their primary mission, which is saving lives. This mission can be accomplished in many ways. First and foremost, in near zero visibility conditions, primary searches may be completed quickly and with an added degree of safety. The use of thermal imaging technology may also be invaluable when fire fighters are confronted with larger floor areas or unusual floor plans [SAFE-IR 2013]. Searching for trapped civilians is part of a fire department's primary mission. Thermal imagers may provide a method for fire fighters to track and locate other fire fighters in very limited visibility conditions. This process can enhance fire fighter accountability before an issue arises [SAFE-IR 2013].

One of the most important aspects of the thermal imager is that when used properly and understood it may provide the potential to detect a fire that is isolated or hidden within parts of a structure [NIOSH 2013a]. While the use of a thermal imager is important, research by Underwriters Laboratories has shown that there are significant limitations in the ability of these devices to detect temperature differences behind structural materials, such as the exterior finish of a building or outside compartment linings (i.e., walls, ceilings, and floors) [NIOSH 2009]. The most common misconception about temperature measurement is that it estimates air temperatures. Thermal imagers do not read air temperatures; they read surface temperatures. Thermal imagers operate solely on differences in surface temperatures. Although occasionally a thermal imager may show superheated or cryogenic gases, in general, thermal imagers do not "see" or measure gases. Fire fighters should not be lulled into a mistaken sense of security because the temperature measurement on the thermal imager seems relatively low or has not reached its scale maximum [Corbin 2000].

At a structure fire, the thermal imager may help identify the location of the fire or the extent of fire involvement prior to fire fighters being deployed into a structure. Knowing the location of the fire may help fire fighters determine the best approach to the fire. For a crew(s) making the fire attack, the thermal imager may provide additional information that they would not previously have had due to poor visibility and building construction. Using this information, fire fighters may be able to locate the fire more quickly and may also ensure that the water application is effective. From a ventilation perspective, fire fighters can use the thermal imager to identify areas of heat accumulation, possible ventilation points, and significant building construction features. This helps ensure proper and effective ventilation that successfully removes smoke and heat from a building [Bastain 2003; SAFE-IR 2013].

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

At this incident, members of Truck 3 and Truck 6 provided a thermal imager to use while operating in the grocery store and vacant occupancy on Side Alpha. The department equips all truck companies and the rescue companies with thermal imagers. All engine companies should also be equipped with a thermal imager as well.

***Recommendation #15: Fire departments should ensure that all members engaged in emergency operations receive annual proficiency training and evaluation on fireground operations.***

Discussion: In order to ensure for the proficiency and competency of fire department members, the fire department should conduct annual skills evaluation to verify minimum professional qualifications. This annual evaluation should address the qualifications specific to the member's assignment and job description. This process should be structured in a manner where skills are evaluated on a recurring cycle with the goal of preventing the degradation of skills and abilities and ensuring for the safety of members. Proficiency evaluation and training provide an opportunity to ensure that all fire officers and fire fighters are competent in the knowledge, skills, and abilities in fireground operations. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program* requires a fire department to establish and maintain a training, education, and professional development program with the goal of preventing occupational deaths, injuries, and illnesses. This ensures members are trained and competencies are maintained in order to effectively, efficiently, and safely execute all responsibilities [NFPA 2013c].

This process is consistent with the organizational statement that establishes the existence of the fire department. The services the fire department is authorized and expected to perform, the organizational structure, and the job descriptions and functions of fire department members are essential in formulating a structured training program [NFPA 2013c]. The primary goal of all training, education, and professional development programs is the reduction of occupational injuries, illnesses, and fatalities. As members progress through various job duties and responsibilities, the department should ensure the introduction of necessary knowledge, skills, and abilities to members who are new in their job titles as well as ongoing development of existing skills [NFPA 2013c].

NFPA 1410, *Standard on Training for Emergency Scene Operations* defines basic evolutions that can be adapted to local conditions and serves as a method for the evaluation of minimum acceptable performance during initial fireground operations [NFPA 2015a]. Proficiency training for fireground operations and emergency incidents should be conducted annually. This training should include, but not be limited to, scene size-up, situational awareness, use of the incident management system, personnel accountability system, strategy and tactics, search and rescue, hoseline operations, ladder operations, ventilation, thermal imaging cameras, fireground communications, use of rapid intervention teams, and Mayday operations.

At the time of this incident, the department was not conducting annual proficiency training for fireground operations.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

***Recommendation #16: Fire departments should establish a water supply group when the lack of water supply affects fire-fighting operations.***

Discussion: As incidents dictate the need for additional water supply due to heavy volumes of fire, the incident commander must be able to forecast the need for additional water. This is regardless of whether the incident is served by fire hydrants or requires a rural water supply. Though this is not a function used during urban fire-fighting operations as much as rural fire-fighting operations, this function remains vital to ensuring that adequate water supply is maintained throughout the incident. The incident commander should assess incident water supply needs. When requirements exceed the amount available from nearby hydrants or exceed the amount of water carried by the 1st Alarm apparatus, a water supply group and water supply officer shall be designated as soon as practical. All units in the water supply group will be under the management of the water supply officer. The water supply officer is the individual responsible for the development of adequate water supplies required to implement the tactics outlined by the incident commander [FCFCA 2015].

The water supply officer has the responsibility for the following:

- Identify available water supplies.
- Establish requirements of the necessary water needed for fire-fighting operations, compare the incident action plan to available water resources, and report inadequacies to the operations section chief or incident commander.
- Handle requests for information about water supply.
- Develop and monitor water supply operations.
- Obtain a separate radio channel for the water supply group through Command.
- Keep a written record of assignments for water supply group tactical units.
- The water supply officer communicates with the incident commander on the Command channel.
- Keep Command appraised of the amount of water available upon request.
- Notify Command when the amount of water is inadequate for completion of tactical objectives and recommend the need for additional apparatus or specialized equipment (e.g., large-diameter hose, portable pumps, portable tanks, high GPM capacity engines) to maintain the required fire flow [FCFCA 2015; Mechanicsville Fire Department 2003].

At this incident, the incident commander evacuated the structure and ordered a change to defensive operations. The defensive operations ordered Truck 5, Truck 12, Truck 6, Truck 3, Truck 10, and several master streams into operation. Due to the lack of available water, the ladder pipes did not have enough water to be effective. Several pumpers were ordered to lay supply lines down various streets in order to establish an effective water supply. Also, a private hydrant across the street from the fire building on Side Alpha was used to bolster the water supply. This process took a considerable amount of time to establish a water supply that was needed for fire extinguishment.

## Fire Department Actions Taken Since the Incident

The department undertook a number of actions to prevent the occurrence of a similar incident. The Fire Chief initiated a recovery process from all ranks to review this incident, to develop recommendations, and to move the department forward. Soon after, the department's Investigation Committee was established to begin looking into several areas directly related to this fire and attempt to understand just how such a tragic loss could occur. A description of these efforts can be found in **Appendix Three: Fire Department Update**.

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## Investigator Information

This incident was investigated by Murrey Loflin, Investigator, Matt Bowyer, General Engineer, and Stephen Miles, Investigator, with the Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH located in Morgantown, West Virginia. Information in the "Building Construction and History" section and "Fire Behavior and Extension" section was provided by Christopher J. Naum, SFPE (Command Institute). An expert technical review was provided by District Chief Edward Llewellyn, Operations District Chief, Houston Fire Department and Deputy Chief Harry Bannon, Operations Deputy Chief, Philadelphia Fire Department. The NFPA Division of Public Fire Protection also provided a technical review of this report.

## Additional Information

**Modern Fire Behavior**

This site 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/

**National Institute for Standards and Technology (NIST) and Underwriters Laboratories (UL)**

These two agencies provide information including training videos showing the findings from NIST and UL research conducted in cooperation with the Fire Department of New York on Governor's Island in 2012. http://www.firecompanies.com/modernfirebehavior/governorsislandonlinecourse/story.html

Flashover TV, sponsored by FireRescue.com, includes a series of training presentations by NIST researcher Dan Madrzykowski. http://flashovertv.firerescue1.com/videos/1875870-nist-and-ul-research-on-fire-dynamic-case-studies-part-4/

Information on completed fire-fighting research studies is available at the NIST website at http://www.nist.gov/el/fire_research/firetech/index.cfm.

The information on completed fire-fighting research studies is available at the UL Firefighter Safety Research Institute website at www.ULfirefightersafety.com.

**International Association of Fire Fighters (IAFF) Fire Ground Survival Program**

The purpose of the 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 (IAFC), and NIOSH. http://www.iaff.org/HS/FGS/FGSIndex.htm

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

**NFPA 1561, Standard on Emergency Services Incident Management System and Command Safety (2014 edition)**
The primary focus of the revision to NFPA 1561 in the 2014 edition is to develop requirements directly aimed at reducing and eliminating fireground injuries and fireground deaths of fire department members. The most apparent change to this edition is the inclusion of "Command Safety" in the document title and the creation of a new chapter, "Command Safety." This chapter is intended to provide a foundation on how to incorporate the incident management system at all emergency incidents, especially *Type V* and *Type IV* incidents.

The chapter on Command Safety clearly defines the requirements for the incident commander to meet, including establishing a fixed command post, personnel accountability, the use of staff aides, rapid intervention crews, and the appointment of a safety officer and assistant safety officer(s)(as needed), plus the expectations and authority of the safety officer. Annexes cover *Functional Assignments for High-Rise Building Incidents, Development of Subordinate Officers or Implementing a More Efficient Management System, Incident Management for the Fire Service on Type V or Type IV Incidents,* and *Structural Fire-Fighting—Risk Assessment and Operational Expectation.*

NFPA 1561, *Standard on Emergency Services Incident Management System and Command Safety (2014 edition)* can be purchased from the National Fire Protection Association at http://www.nfpa.org.

## Disclaimer

Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH). In addition, citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these websites. All web addresses referenced in this document were accessible as of the publication date.

# *Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri*

## Appendix One
## Summary of Personal Protective Equipment Evaluation
**Status Investigation Report of five**
**Self-Contained Breathing Apparatus**
**Submitted by the**
**Fire Department**

## *NIOSH Task Number TN-20619*

(***Note:*** *Full report is available upon request*)

### Background

As part of the ***National Institute for Occupational Safety and Health (NIOSH), Fire Fighter Fatality Investigation and Prevention Program (FFFIPP)***, the National Personal Protective Technology Laboratory (NPPTL) agreed to examine and evaluate five self-contained breathing apparatus (SCBA) units identified as Mine Safety Appliances (MSA) model Firehawk M7, 4500 psi. Four units are identified as 45-minute and one as 30-minute SCBA. All of the units were labeled by the fire department with the identifiers that were on each pressure reducer assembly. The units will be referred to by that system throughout the report.

This SCBA status investigation was assigned the NIOSH Task Number 20619. The NIOSH Division of Safety Research (NIOSH/DSR) and the fire department were advised that NIOSH/NPPTL would provide a written report of the inspections and any applicable test results.

All SCBA units, contained in cardboard shipping boxes, were delivered to the NIOSH facility in Morgantown, West Virginia on October 30, 2015. Once the cardboard boxes containing the units arrived, the units were taken to the H Building and locked in the evidence cage located in Room 1513. The inspection was conducted on LAE318676 on January 6, 2016, LAE312422 and LAE313526 on January 11, 2016, and LAE318722 and LAE320911 on January 12, 2016. The units remained locked in the evidence cage until the testing evaluations.

### SCBA Inspection

The units were removed from their packaging in the Testing Lab, Room 1513 and inspected on January 6, 11, and 12, 2016 by Jay Tarley (Physical Scientist), and Karis Kline (contractor), NPPTL. The five SCBAs were identified as the fire department SCBA Units LAE 312422, LAE313526, LAE318676, LAE318722, and LAE320911. These SCBA units were extensively examined, component by component, in the condition received to determine the conformance of each unit to the NIOSH-approved configuration. The units were identified Mine Safety Appliances (MSA) model Firehawk M7, 4500 psi. Four units are identified as 45-minute, NIOSH approval numbers TC-13F-550CBRN and one as 30-minute SCBA, NIOSH approval numbers TC-13F-549CBRN. The visual inspection process was documented photographically. Once all the

inspections were completed, the SCBA units were repackaged and placed back in the evidence cage in Room 1513.

During the inspection of cylinders and facepieces, the following units were deemed untestable: LAE320911 (outside of the hydrostatic test date range); LAE312422 (level-two damage to wrapping on bottle); LAE313526 (level-two damage to fiber wrapping); and LAE318676 (damage to fiber wrapping and facepiece was also untestable). The cylinder from LAE318722 was good to test.

### SCBA Testing

The purpose of the testing was to determine the conformance of each SCBA to the approval performance requirements of Title 42, *Code of Federal Regulations*, Part 84 (42 CFR 84). Further testing was conducted to provide an indication of the conformance of each SCBA to the National Fire Protection Association (NFPA) Air Flow Performance requirements of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service*, 2013 Edition.

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

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

**National Fire Protection Association (NFPA) Tests** (in accordance with NFPA 1981, 2013 Edition):

7. Airflow Performance Test [Chapter 7, 7-1.1]

### *Summary and Conclusions*

Five SCBA units were submitted to NIOSH/NPPTL by the NIOSH/DSR for the fire department for evaluation. The SCBA units were delivered to NIOSH on October 30, 2015 and extensively inspected on January 6, 11, and 12, 2016. The five units were identified as Mine Safety Appliances (MSA) model Firehawk M7, 4500 psi. Four units were identified as 45-minute, NIOSH approval number TC-13F-550CBRN and one unit was a 30-minute NIOSH approval number TC-13F-549CBRN. The unit worn by the victim, Unit LAE318676, suffered damage to the unit, the low pressure hose had a slit in it making the unit not testable. The corresponding cylinder to this unit suffered extensive damage to the fiber wrapping and also was deemed not testable. The overall conditions of the other four units were fair to good and exhibited normal signs of wear and tear. All 45-minute units were tested with the cylinder corresponding to unit LAE318722.

All SCBAs delivered included a cylinder. During the inspection of the SCBA cylinders, the air cylinder on Unit LAE320911 had a manufactured date of 06/05. Under the applicable Department of transportation (DOT) exemption, the air cylinders are required to be hydrostatically tested every five

years. For the air cylinder on this unit, the last hydrostatic testing date is 03/2011; therefore, a retest would need to take place before the last day of 03/2016. Due to the cylinder being out of date for hydrostatic testing, it was determined that it was not safe to pressurize during the tests run on 06/2016. The cylinder on LAE312422, 313526, 318676 were deemed not safe to pressurize due to damage to the cylinder. The tests were run with an appropriate cylinder from unit LAE318722.

Unit LAE313526 did not come with a specified corresponding facepiece. Overall condition was fair to good with some dirt and debris. The rib of the backframe was broken just above the connection to the Personal Alert Safety System (PASS) control assembly. The cylinder with the unit had level two damage with gouges and dents throughout the bottle. Level two damage affects the fiberglass composite layer of the cylinder. This damage exposes the fiberglass composite layer and may further exhibit fraying of the exposed fiberglass composite. The cylinder was received closed with roughly 3800 psi in the bottle. This unit passed the NIOSH tests and NFPA airflow test.

Unit LAE312422 had a corresponding facepiece and cylinder. The facepiece was used for all NIOSH tests, but switched for the NFPA airflow test with a facepiece of the same model number. The submitted facepiece was scratched and dirty with a ripped head harness near the crown area. Overall condition was poor and dirty. There was damage to the interior side of the reducer. High pressure lines were very dirty with dirt on the threads and a ripped cover at the attachment point of the quick fill. Gauge lenses on the PASS were dirty with debris inside under the screen. The lower left corner of the backframe was broken off at the lumbar attachment, and the cylinder had debris in the threads. This unit passed the NFPA airflow test and NIOSH rated service time tests. However, this unit failed the positive pressure test and gas flow test for the 500 psig.

Unit LAE318676 could not be run through the testing since there was a hole in the low pressure line just past the high pressure reducer.

Unit LAE318722 had a corresponding cylinder, but did not have a facepiece. An equivalent facepiece was used for all tests on this unit. The overall condition of this unit was good with some minimal dye sublimation on the right shoulder strap. The cylinder was received closed with 4000 psig showing in the bottle. The cylinder showed normal wear, but the overall condition was good and testable. This unit passed all NIOSH tests and NFPA airflow test.

Unit LAE320911 was received with a corresponding facepiece and cylinder, but both were replaced with an equivalent cylinder and facepiece for all testing on this unit. The overall condition of the unit was fair. The temple strap was broken at the attachment points, the mask mounted regulator (MMR) had many scratches. The unit turned on, but the PASS did not. The PASS control module operated with new batteries. The frame was broken at the first stage regulator and was broken at the bottom right side by the PASS control module. The cylinder provided was closed with 3000 psi left in the bottle. The cylinder hydrostatic test date was out of the acceptable range to test. The bottle was deemed unsafe to be pressurized.

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

In light of the information obtained during this investigation, NIOSH has proposed no further action on its part at this time. The SCBA units remained locked in the evidence cage until ordered to return to the fire department.

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

# *Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri*

## Appendix Two
## Incident Commander's Tactical Worksheet for Mayday

**INCIDENT COMMANDER'S TACTICAL WORKSHEET FOR "MAYDAY"**

- ☐ **MAYDAY - MAYDAY - MAYDAY Message is Transmitted;**
- ☐ **Announce *EMERGENCY RADIO TRAFFIC* only;**
- ☐ **Acknowledge Company/Member transmitting the Mayday – Obtain LUNAR information:**

**LOCATION** _____
**UNIT** _____
**NAME** _____
**ASSIGMENT AND AIR SUPPLY** _____
**RESOURCES NEEDED** _____

- ☐ **If no answer after two attempts conduct a PAR of all operating companies on the fire ground to isolate company/member;**
- ☐ **Deploy RIC to reported or last known location/assignment;**
- ☐ **Request an additional alarm;**
- ☐ **Request an additional TAC channel for fire operations TAC___**
- ☐ **Assure that companies not assigned to the rescue or near the rescue change to the new fire operations channel and conduct a PAR;**
- ☐ **Maintain fire-fighting positions. Withdraw only if necessary;**
- ☐ **Establish a Rescue Group with a Safety Officer;**
- ☐ **Review the Building Pre-Plan if available;**
- ☐ **Establish a Backup RIC to replace the deployed RIC;**
- ☐ **Establish a forward staging area for the Rescue Group and provide support with adequate staffing and equipment;**
- ☐ **Request additional EMS Resources/ALS Ambulances;**
- ☐ **Request Specialized Resources if needed – Technical Rescue;**
- ☐ **Conduct a PAR if an emergency evacuation is ordered (due to structural stability or fire conditions);**
- ☐ **Conduct a PAR after the rescue operation is completed;**
- ☐ **Announce the end of the Mayday;**

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

## Appendix Three
## Fire Department Update

The department undertook a number of actions to prevent the occurrence of similar injuries. The Fire Chief initiated a recovery process from all ranks to review this incident and to develop recommendations and to move the department forward. Soon after, the department's Investigation Committee was established to begin looking into several areas directly related to this fire and attempt to understand just how such a tragic loss could occur. The findings in the investigative report were derived from applying a multi-dimensional team approach. The scope of this investigation represents the construction of a final report that will be presented to the fire chief, which outlines the facts of the incident, the identification of any causal factors and recommend appropriate corrective actions. The following bullets represent the investigation objectives:

- Identify factors which resulted in the Line-of-Duty-Deaths (LODD).
- Identify situations that involve unacceptable risk.
- Identify previous unknown hazards.
- Identify inadequacies in training, policy or performance.
- Ensure lessons learned are communicated to effectively prevent future accidents and injuries.
- Identify professional standards used/applied in the construction of departmental policy.

The fire department issued an internal investigation report (https://data.kcmo.org/dataset/KCFD-Internal-Investigation-Into-The-Line-Of-Duty-/i4x2-s2s) which identified 14 recommendations that were identified as key areas that the department needs to focus.

**Recommendation #1:** *The department should develop a Collapse Zone policy.* This policy should be developed utilizing NFPA, NIOSH, IFSTA and other industry recognized standards and recommendations as a reference. Currently the fire department does not have a specific policy addressing collapse zones. Contained within this policy should include the visual identification of establishing collapse zones such as lighted beacons or colored incident scene tape.

**Recommendation #2:** *The department should update the department's current communication policies as they apply to emergency incidents.* Currently, the department does not employ a uniformed methodology as it applies to radio communications. The policies addressing critical information exchange should be updated. The investigative team also identified the need to establish departmental procedures regarding the confirmation of critical emergency incident communications. Much in the same manner we conducted PAR procedures, the confirmation steps should be employed for every major benchmark within an incident. The investigation team has concluded that GAG 3-4 Radio Communication's should contain updated information regarding radio call procedures.

**Recommendation #3:** *The department should develop an inclusive training program that revolves around the merits of Situational Awareness.* Firefighters and fire officers should be trained and a system should be implemented to outline clear rules of engagement and initial scene size-up. The risk vs reward methodology should be employed. The Incident Commander is specifically responsible for

managing risk at the incident; however, one person cannot be expected to apply these principles to an incident if the organization has not integrated a standard approach to risk management into its policies and its organizational culture. This recommendation coincides with Goal 5 of the department's strategic plan (2014): Provide Comprehensive training and professional development to ensure personnel are fully prepared to effectively perform their duties and responsibilities.

**Recommendation #4:** *The departments current Incident Management System manual needs updated to included current practices and new standards.* The following bullets identify the elements of this policy that should be included or updated: When, where, and how IMS should be employed.

- Clear instruction on how emergency incidents should be organized at the tactical level.
- The incident commander should have a dedicated safety officer on all incidents.
- The incident commander should develop a survivability profile when determining offensive or defensive operations.
- The initial size-up should consider the type and condition of structure to determine possible structural weakness.
- The creation of major incident benchmarks and the announcement and verification of these benchmarks such as the department's current PAR procedures.
- The establishment and verbal announcement by the Communications Center as it pertains to the construction of a 20-minute clock that is communicated to the Incident Commander.

The review and changes to the departments IMS manual should refer to: National Fire Protection Association (NFPA) 1500, *Standard on Fire Department Occupational Safety and Health Program*, 2007 Edition and NFPA 1561, *Standard on Emergency Services Incident Management System*, 2008 Edition, and the National Incident Management System (NIMS).

**Recommendation #5:** *Train all department officers regarding the certification of Safety Officer.* One critical characteristics of the Safety Officer function is the understanding that this incident function is not task oriented. The responsibility of this IMS function is overall scene safety. This recommendation coincides with Objective 3K of the department's strategic plan (2014): Define the role and function of the Safety Officers.

**Recommendation #6:** *Train all emergency personnel on building construction.* Building construction has drastically changed of the last two decades. It is imperative that this organization recognize critical structural weaknesses and signs of collapse. The knowledge gained through this department training should be incorporated into all scene Size-ups given by the first arriving officer. This recommendation coincides with Goal 5 of the department's strategic plan (2014): Provide comprehensive training and professional development to ensure personnel are fully prepared to effectively perform their duties and responsibilities.

**Recommendation #7:** *Ensure all personnel properly wear all assigned Personal Protective Equipment when required by policy.* The organizational culture that allows for various interpretations regarding when and where PPE should be donned must be terminated. This recommendation coincides

with Objective 3G of the department's strategic plan (2014): Develop an organizational strategy to promote consistent use of personal protective equipment (PPE) to reduce potential for injury.

**Recommendation #8:** *Develop, train and employ an Incident Accountability System for use in all emergency incidents.* The department currently has a general operating guiding establishing a departmental accountability system (GOG 11-9). The details of this policy deal with the administration of an accountability system at emergency and non-emergency scenes. Impractical, outdated, and inefficient for emergency scene use, the policy has lacked consistent utilization from the implementation. This recommendation coincides with Goal 7 of the department's strategic plan (2014): Develop an updated department's incident management accountability system.

**Recommendation #9:** *The fire department should consider preparing, training, and implementing new policies and procedures in a different format.* Currently the department has over 200 policies, directives, GAG's and GOG's. In order to update and re-organize our current system, we must identify operational polices that should not be deviated from. Calling our operational procedures "General Operating Guidelines" (GOGs) vs. Standard Operating Procedures (SOPs) may imply that there is flexibility in complying with any given policy. When in reality, there is no legal difference between GOG vs SOP. All policies and procedures must comply with state and federal regulations such as OSHA, NFPA and the Code of Federal Regulations and should be cross-referenced to these standards. A procedure for an annual review of all policies and procedures should be implemented.

**Recommendation #10:** *The department should develop a policy that addresses the formation of an investigation team concept that is employed to serious injury incidents.* The following resources are recommended for utilization and construction of this policy; LODD or Injury Investigation guides published by IAFF/IAFC, NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program,* and NFPA1521, *Standard on Fire Department Safety Officer Professional Qualifications.* By preparing in advance, the department will ensure that they are able to handle at least some of the myriad of items that must be dealt with after a serious incident such as the incident on October 12, 2015. Other organizations have developed Health and Safety Units that hold the responsibilities mentioned in this recommendation.

**Recommendation #11:** *The Department should develop and implement a behavioral health training, referral and educational program that also addresses peer counseling, suicide prevention and intervention.* Not all firefighters will need this service or take advantage of it. The construction of this team is crucial to ensuring the emotional health and recuperation of department members. Although not a contributing factor to the collapse, the department experienced many challenges that were a direct result from this incident. The construction of this program is crucial to ensuring the behavioral and emotional health and recuperation of the members of the fire department. Recommended resources include the IAFF/IAFC Wellness Fitness Initiative, and the NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.*

# Two Fire Fighters Die and Two Fire Fighters are Injured at Multi-occupancy Fire with Structural Collapse—Missouri

**Recommendation #12:** *The Department should review the current Mayday GOG and update to include new communication considerations.* The investigation team identified a possible element of confusion within the application of procedures outlined in the policy. After many years of successful implementation, this policy has provided a foundation for signaling of firefighters in distress. The review of this policy is recommended that also includes a regional perspective.

**Recommendation #13:** *The Department should further develop leadership and foster management capabilities as part of an Officer Development program.* This should include elements of supervision at both emergency incidents and non-emergency situations. Achieving this recommendation will position the department to be better prepared in the area of succession planning. The following resources are recommended for building the framework for this program; the IAFC Officer Development Handbook, NFPA 1021, *Standard for Fire Officer Professional Qualifications*, NFPA 1026, *Standard on Incident Management Personnel Professional Qua*lifications, and the Kansas City, Missouri Human Resources Academy coursework.

**Recommendation #14:** *The Department should enhance its current building data collection methods utilized by emergency operations and facilitate high hazard risk identification with Fire Prevention records*. Pre-fire tactical preplanning should be considered in all areas of the city. Inspection records should be interchangeable between divisions within the department. Identification and visiting target hazards that have multiple violations will give primary response companies knowledge that may impact interior firefighting tactics and strategy. This policy should be developed utilizing the standards presented in NFPA 1620, *Standard of Pre-Incident Planning* as a reference.