FIRE TRAINING FATALITY
Milford, MI
October 25, 1987

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Fire Fighter Fatality Training Incident Fact Sheet
By Thomas J. Klem
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Fatal Live Fire Training Incident
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Investigation Report

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Prepared By

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INTRODUCTION

An investigation was conducted by the National Fire Protection Association to document and analyze significant factors that resulted in the loss of life of three fire fighters during a live fire training exercise in Milford, Michigan. Soon after learning of the incident, Thomas J. Klem, Director, Fire Investigations and Applied Research Division, traveled to the scene to conduct a study of the incident. The study was conducted in cooperation with the Fire Marshal Division, Michigan Department of State Police, Milford Police and the Oakland County Sheriff's Department.

This report is another of NFPA's studies of fire having particularly important educational or technical interest. The information presented is based on the best data available immediately after the training fire incident and that obtained during subsequent follow-up.

This report describes fire safety conditions at the live fire training exercise and presents findings on factors that contributed to the loss of life based on the NFPA analysis of collected data and observations during the investigation. NFPA codes and standards were used (except where otherwise noted) as criteria for the analysis so that conditions during the training exercise could be compared with current fire protection practice as represented by existing NFPA codes and standards at the time the report was written. It is recognized that these codes and standards were not in effect in Milford at the time of the exercise.

The objective of this report is to document and analyze a significant multiple-fire fighter fatality incident in order to prevent a recurrence of such an occurrence in the future. It is not NFPA's intention that this report pass judgment on, or fix liability for, the loss of life at the training exercise.
NFPA acknowledges the help and assistance provided by Lt. Jon Curtis and Detective Sergeant Patrick Garrity and other members of the Fire Marshal Division, Michigan Department of State Police, officers from the Milford Police Department and investigators from the Oakland County Sheriff's Department in documenting this incident.
ABSTRACT

On Sunday October 25, 1987, at approximately 8:45 a.m., three fire fighters were killed and three others were injured during a multi-department, live fire training exercise involving a vacant, two-story, wood frame farmhouse in Milford, Michigan. After the fire department had made arrangements with the owner to raze the structure, a training exercise simulating realistic fire conditions encountered by fire fighters was planned. The training exercise was also intended to improve basic fire fighting skills and to aid fire fighters in recognizing incendiary fire scenarios.

As part of the exercise, several incendiary fire "sets" were arranged in all major rooms on both floors of the house. Most of the ignition scenarios involved the use of flammable and combustible liquids (gasoline, kerosene and camp stove-type fuel). The various "sets" were joined by a "trailer" designed to propagate fire throughout the building once it was ignited from a location at the main entrance door. In addition to the flammable and combustible liquids, various combustible interior finish materials and furnishings comprised the fuel load. Although the presence of flammable and combustible liquids is thought to have been significant in this incident, other variables, such as combustible ceiling tile and wall finish materials and the extension of the fire to the attic area, also affected the rapid buildup, spread, extension, and outcome of the fire.

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After most fire fighters involved in the exercise were given a walk-through tour of the building and the incendiary fire "sets", the trailer located at the main entrance was ignited. Ignition did not proceed as planned, and two fire fighters entered the building to ignite uninvolved areas. The two fire fighters moved to the second floor, and sets on this level were ignited. Shortly afterward, four additional fire fighters were directed into the building to make observations of the exercise. Spot fires and light smoke conditions were observed by the four fire fighters as they progressed through the building to the second floor. They met the two other fire fighters, and quickly they realized that fire conditions on the first and second floors had intensified, trapping all six fire fighters on the second floor and forcing them to attempt to escape through exterior windows. Three of the fire fighters escaped through a second floor window, and they sustained various injuries before the fire completely engulfed the structure. Fire fighters positioned outside the building advanced hose lines into the interior and raised ladders to the second floor in an attempt to rescue the remaining trapped fire fighters. Once the fire was controlled, fire fighters located the remaining three fire fighters on the second floor.

Based on NFPA's investigation and analysis of this fire, the following are considered significant factors that contributed to the fire fighter fatalities in this incident:

1. The use of flammable and combustible liquids in a live fire training exercise.

2. The presence of combustible wall paneling and ceiling tiles within the training building.
3. Lack of adequate planning and of communication of the training exercise objectives to all individuals involved.

4. Lack of adequate assessment of the hazards of the training exercise and the hazards presented by the structure in such an exercise.

5. Lack of an adequate training (fire) ground command structure to ensure safe and coordinated procedures.
BACKGROUND

The Milford Township Fire Department is a 27 active member, volunteer organization that provides fire protection for Milford and adjoining areas. Milford, a community of just over 11,000 residents, is located approximately 40 miles northwest of Detroit, in Oakland County Michigan. The department responds to approximately 300 emergency calls for assistance each year (including medical and mutual aid responses). The department operates two pumpers, a tanker-pumper, a tanker, three brush (grass) units, and a rescue unit, out of one fire station. Because of Milford's rural setting, many of the department's structural fire fighting strategies involve the use of tankers, portable water tanks, and involve "shuttling" water from static sources to the fire scene. Operational control of the department is vested with the fire chief and the other line officers of the department, including a training officer. The department holds monthly training drills to maintain basic fire fighter skills. Members of the department participate in the State of Michigan's fire fighting training schools.

During the summer of 1987, members of the fire department became aware that a vacant home, located at 1975 Wixom Road, was to be razed, and another home was to be constructed on an adjacent portion of the land. Discussions ensued between the owner of the property and fire department officials regarding the use of the old farmhouse for a fire fighter training exercise that would ultimately result in the total destruction of the house by fire.
After the initial discussions, the site was visited several times by department members and assessed for the best positioning of fire apparatus, water source location and utilization, etc. A walk-through tour of the building was included. Before final arrangements could be completed, complications arose. The shell of the new home was constructed on the site adjacent to the vacant building but separated from it by approximately 100 feet. This required the development of strategies to protect the new home during the training exercise.

The Building

The training exercise was to take place in a vacant 120-year-old farmhouse. An addition was added to the original structure at some time, creating an "L" configuration. The original structure was a two-story colonial style dwelling set back approximately 30 feet from Wixom Road. An unpaved driveway from Wixom Road ran along the north side and to the rear of the building. The original structure contained the living and dining rooms and two second floor bedrooms (see Figures 1 and 2). There was no direct entrance/exit door to the outside from the two-story portion of the home. The one-story addition to the building was attached at the northeast corner of the main building (see Figure 3). The main entrance to the dwelling was through the addition, which led to a "mud" room and the kitchen.

Access to the second floor was gained from the dining room by way of the stairway, which led to an upstairs hallway, two bedrooms, and a bathroom located at the south end of the hall. All sides and each level of the building contained windows, except the east side of the original structure. All windows were reported to be intact at the time of the training exercise.
Each portion of the dwelling was of wood frame construction, and each had a peaked roof with independent attic spaces. The interior partitions of the building were constructed of wood studs. On the second floor, the studs were covered with wood lath, and finished with plaster. On the ground floor, gypsum wallboard was attached to the wood studs, and lightweight wood paneling was used as the finish material for the walls. Throughout the building, gypsum wallboard was attached to the ceiling joists to form the finished ceiling. However, throughout the ground floor, 12 X 12 inch low density fiberboard ceiling tiles were attached to wood furring strips covering the gypsum board to form the finished ceiling.

In addition to the fuel provided by the incendiary fire sets and the combustible interior finish materials, the building contained two full-length sofas, an upholstered chair (both arranged in the living room), and several other pieces of furniture.

The building appeared to be structurally sound; however, there were numerous holes in the walls and ceilings and several holes in the flooring at the second floor level. The holes appeared to be more extensive on the second floor where in some locations, large areas of plaster were removed exposing wood lath and studs. Although the integrity of the walls was better on the ground floor, it appeared that paneling in some locations was attached directly to the wood studs. The wall openings provided access into the combustible concealed spaces between the wood studs, which ran vertically into the wood frame attic space. During one of the walk-through tours of the building, fire fighters placed a bathroom sink over a hole between the first and second floor.

The Live Fire Training Exercise

The live fire training exercise, involving the Milford Fire Department and three neighboring fire departments, was scheduled for Sunday morning, October 8.
25, 1987. The training exercise was intended to improve fire fighter skills and to assist fire fighters in recognizing physical evidence indicative of an incendiary. At a fire department business meeting on the Wednesday before the training exercise, a discussion of the details of the exercise took place among the Fire Chief, the Assistant Fire Chief, and the department's training officer. In addition, word was spread among the members that the training exercise was scheduled for Sunday, following a breakfast to be served at the fire station. The breakfast meeting would serve as an assembly point for all participants, including those from the neighboring departments.

During the meeting on Wednesday, it was decided that the Assistant Chief would be responsible for arranging the fire "sets" for that portion of the training exercise involving incendiary fire recognition. The assignment was based in part on the fact that the Assistant Chief was associated with a sheriff department's arson investigation unit in a neighboring county. It was also decided that the Fire Chief would be responsible for "outside activities," such as hose line placement, exposure protection, apparatus placement, water supply etc.

On the day of the drill, at approximately 7:30 a.m., the Assistant Chief proceeded to the training site to begin arranging the incendiary fire sets within the building. He was soon joined and assisted by another fire fighter. A five gallon container and several one-gallon containers of flammable and combustible liquids were brought to the scene. The amount of liquid in each container was not determined. Reportedly, they contained gasoline, kerosene, and camp-type fuels. These materials along with other

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1 Flammable liquids have flashpoints below 100°F (38°C) and vapor pressures not exceeding 40 psia at 100°F (275 kPa at 38°C). Liquids with flashpoints at or above 100°F (38°C) are referred to as combustible liquids. Also see NFPA 321, Standard on Basic Classification of Flammable and Combustible Liquids.
items, such as surgical-type gloves, string, newspapers, one-gallon plastic containers, roadside flares, and candles, were used in preparing the sets. In addition, combustible materials within the building, such as discarded clothing and the remaining furniture and household appliances, were also used. Each major room of the building was arranged with a different incendiary fire scenario, each used various combinations of the items in the arrangement and some involved combinations of suspended surgical-type gloves partially filled with flammable or combustible liquid or pooling of the liquids on the floor. One set involved attaching a string to the corners of a room and draping sheets of newspaper over the string. The newspapers then had flammable or combustible liquid poured over them. The string was placed at a height of approximately 3 feet above the floor. Below this arrangement were placed discarded clothing and a large pile of crumpled newspapers. The combustible materials on the floor also included a one-gallon plastic container partially filled with a flammable or combustible liquid. Similar type arrangements were placed throughout the building.

Although each area of the building contained a different and separate set, each was connected by a waxed paper "trailer" draped through the sets, around the furniture, and through the remaining drapery. The trailer was brought to the main entrance door where it was to be ignited, thereby propagating fire to all locations.

Fire fighters began arriving at the Milford station at approximately 7:00 a.m. for the breakfast and subsequent training exercise. During the breakfast meeting, participants of the drill were informally briefed regarding the location of the drill site, apparatus and hose line placement, and exposure concerns, and the Milford fire fighters were assigned positions on their fire apparatus. Shortly after 8:00 a.m., the 36 fire fighters who were to participate in the drill began to arrive at the training site and to prepare their equipment for the exercise.

10.
Several 1 1/2-inch and 2 1/2-inch hand lines from the Milford pumpers were prepared, charged, and placed on the north and south sides of the building. It was planned that the Milford units would be the only units so positioned and committed. Portable water tanks were filled, and water was shuttled from a remote point by the neighboring fire departments' apparatus. On the south side of the home, several explorer scouts from an auxiliary unit of one of the neighboring fire departments were given instructions in operating a hose line and were told that they were to help protect the exposure presented by a 250 gallon fuel oil tank adjacent to the training building. In addition, they were told they were to help protect the exposure presented by the new home. Part of the instruction included how to flow water through the hand lines and onto the drill building.

During these and other preparations for the drill, most of the fire fighters and the four explorer scouts were given a tour of the building and shown the various materials arranged in a manner to represent methods thought used by arsonists. When interviewed later, several fire fighters told investigators that they noted a strong odor of flammable liquid "fumes" or of "gasoline" within the building during their tour.

Weather at the time of the training exercise was reported to be 29°F with no detectable winds.

The Incident

Preparations for the training exercise were being completed at approximately 8:20 a.m. While a fire fighter prepared to ignite the trailer at the main entrance to begin the exercise, a crew of four fire fighters was assembled and instructed to "gear up." The four donned protective hoods and coats, helmets, and self-contained breathing apparatus (SCBA) and wore either
protective trousers or three-quarter length boots. They stood on the north side of the building near the main entrance for an estimated 15 minutes, waiting for further instructions regarding their duties. During this time, several of the fire fighters disconnected the face piece of their SCBA from its regulator in order to conserve air and prevent the face piece from becoming fogged.

Meanwhile, the ignition was not proceeding as planned. The "trailer" that was ignited by a flare did not propagate the fire throughout the dwelling as planned and designed. A second attempt was made by the fire fighter at the main entrance, and this attempt did succeed in igniting one of the flammable liquid pools located on the kitchen floor. Once again, however, further propagation did not occur as anticipated. After an initial flare-up of the fire in the kitchen, the fire diminished, and the Assistant Chief and another fire fighter decided to enter the building to ignite additional sets and to photograph the burning process. These fire fighters were wearing protective clothing similar to that worn by the crew of four fire fighters. Several minutes passed, and no significant change in the progression of the fire was noted from the main entrance area. Reportedly, in order to help ventilate the building, two second floor windows were broken on the southern side. Also during this time, several fire fighters located on the outside of the building, noticed light smoke coming from the eaves of the two-story portion of the home during this time.

At about this time, the crew of four fire fighters received instructions to enter the building and to observe the incendiary fire sets. The four entered the building by way of the main door, entered the mud room, and proceeded into the kitchen.
The crew of four entered in single file; they did not advance a hose line with them. As they passed through the kitchen, they observed several spot fires in the area of the stove and kitchen countertop where sets had been arranged. One of the fire fighters described the area at this time as being free of any detectible amount of heat and containing only a small quantity of smoke. The crew progressed through the kitchen into the dining room and began to ascend the stairway to the second floor. Once on the second floor, they met the Assistant Chief and the other fire fighter, who were still in the process of igniting the sets in one of the second floor bedrooms. One bedroom fire was described as "going pretty good" at the time.

The Assistant Chief immediately instructed the crew of four fire fighters to "get out" of the building. About at this same instant, fire conditions within the building began to change. All six fire fighters were confronted by a sudden buildup of heat and a smoke layer descending from the second floor ceiling. The crew of four fire fighters, who were located closest to the stairway, turned and started down the stairs.² The lead fire fighter of the crew determined that they could not exit by way of the first floor due to the intensity of the fire now in that area. At least one of the fire fighters in the group began to get very anxious but was calmed by a more experienced fire fighter within the group who advised them "not to panic" and to return to the second floor. Upon reaching the second floor, the conditions were now described as extremely hot and the visibility was near zero. The six fire fighters, all now located on the second floor, began to search for a way out. Three fire fighters were in positions close to the window at the north end of the corridor. They scrambled to escape through this window. While waiting

² It could not be determined if the Assistant Chief and his assistant planned to follow the crew or if they began to search for another way out from the second floor. The time interval between these events is estimated to be less than one minute.
his turn to escape through the window, one fire fighter described fire
conditions as "unbearable," and the last fire fighter to escape said that a
portion of his face piece began to deteriorate from the heat just as he was
escaping through the window. These three fire fighters dropped to the roof of
the one-story addition just below the window and were assisted to the ground.

The sudden change in fire conditions and the escaping fire fighters
alerted fire fighters positioned on the outside of the building that there was
trouble. As a result, they began to advance hose lines into the building and
raise ladders to positions to assist the escaping fire fighters. Additional
hose lines were layed, charged, and also advanced into the structure. Ground
ladders were raised to a second floor bedroom location, where it was reported
that one of the trapped fire fighters was seen attempting to escape. Since
the structure was almost fully involved at this point, a major fire fighting
task was also confronting fire fighters in their efforts to rescue the trapped
fire fighters.

After an estimated 10 minutes, the fire was "knocked down," fire fighters
positioned along the west side of the structure were able to enter a second
floor bedroom, where they located one of the fire fighters and removed him
from the building. Upon searching further, the fire fighters were able to
locate the remaining two fire fighters, who were found in the second floor
corridor just outside bedrooms, and they, too, were removed from the
building. Emergency medical treatment was administered at the scene and the
fire fighters were subsequently transported to an area hospital for further
care.

Casualties

Tragically, three fire fighters died and three were injured during this
fire training exercise. The fatalities were among the crew of four fire
fighters to enter the building. One fire fighter from the crew as well as the Assistant Chief and the fire fighter assisting in the sets, were injured during their escape. The fatalities were members of three of the four fire departments involved in the training exercise. The fire fighters were two males, ages 33 and 34, and a female, age 41. Autopsy results, as reported by the Office of the Medical Examiner, County of Oakland, show they died of "soot and smoke inhalation." Each had elevated carboxy-hemoglobin levels reported at 27.4, 48.2, and 58.4 percent, respectively. In addition, the percentage of body burns was reported at 40, 45, and 65 percent, respectively.

**Extent of Fire Spread**

Both the living and dining rooms were severely damaged by the fire. The combustible interior finish material in the living room was totally consumed, and in the dining room, it was almost totally destroyed. The furniture in the living room was also almost totally consumed. Damage in the living room was severe enough that the fire penetrated the wall stud channel, thus providing an avenue for the fire to extend into the attic area via the concealed combustible space. There was also burn through from the living room to the exterior of the building. This damage showed at the floor level at the northwest exterior of the building. Damage to the remainder of the first floor was not as extensive.

Damage on the second floor was most severe in the bathroom area, located directly above the living room. Damage in this area also showed the continued avenue of fire spread to the attic from below. The second floor ceiling collapsed in the area of the bathroom and south bedroom. Damage to the south portion of the attic and roof was severe, resulting in almost total consumption of the roof truss and roof material in this area. Damage to the remainder of the second floor and attic was less severe.
Analysis

The numerous incendiary fire sets employed in this training exercise, which involved the use of flammable and combustible liquids placed in various arrangements, are capable of producing an extremely intense fire. An intense fire would not only be a result of the use of flammable and combustible liquids used in the sets, but would also be a result of the other combustible materials and furnishings and of the positioning of the sets in close proximity to the combustible wall and ceiling materials. Fire scenarios involving various combinations of these variables can result in extremely rapid changes in the growth rate of a fire that are sudden and unexpected. This phenomenon is commonly referred to as "flashover."

In addition to the ignition of several of the incendiary fire sets close to the main entrance, it appears that the initial attempt to ignite the sets resulted in sustained ignition of a set in the living room. The set, in the southeast corner of the room, involved a sofa and an undetermined quantity of flammable or combustible liquid poured onto the sofa. This arrangement of flammable and combustible material in a corner configuration and in close proximity to combustible wall and ceiling materials resulted in a severe and significant fire that affected the outcome of this incident.

As the fire developed at this location, it penetrated the wall and extended into the combustible vertical stud channel leading to the second floor and the attic area. Because it was concealed, the severity, buildup, and spread of this fire to the attic may have gone undetected. Further, fire fighters who entered the building after ignition most likely did not observe the fire development in the living room as they progressed to the second floor, a partition would have obscured their full view of the living room and the severity of the fire.

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When the six fire fighters were on the second floor, however, a severe fire was most likely burning in the attic space above them and the living room was approaching flashover. The fire fighters on the second floor detected heat and observed a smoke layer descending from the second floor ceiling.

The fire fighters were quick to move from the area, and they attempted to exit down the stairs and through the first floor. However, flashover of the living room had likely occurred by this time, and products of combustion were extending through the opening in the partition into the dining room. The fire fighters determined that they could not exit by way of the first floor, and this resulted in their retreat back to the second floor.

Once they had returned to the second floor, they found that fire conditions there had worsened. Only a short interval of time now existed before untenable conditions were reached on the entire second floor. During this interval, three of the six fire fighters were able to locate and scramble through a window at the north end of the corridor. The last escaping fire fighter reported breathing hot products of combustion because the severe heat began to damage the breathing tube of his SCBA. Untenable conditions were reached on the second floor before the remaining three fire fighters could locate an escape route.

FIRE FIGHTER SAFETY AND LIVE FIRE TRAINING STANDARDS

NFPA statistics indicate that in 1986 (the last year for which complete data is available), there were 113 fire fighter fatalities in the United States. Although this represents a significant improvement in the number of fire fighter deaths when compared to the number killed annually in the late seventies, there appears to have been little progress in further reducing the number of fatalities since 1979.³

Included in the 1986 fire fighter fatalities were seven training related deaths. The tragic incident in Milford prompted a closer examination of such incidents. NFPA loss records over the past decade (1977 - 1986) show that there were 53 training related fire fighter deaths, illustrating that this component of a fire fighter's activities also has associated risks. As is the case with fire fighter deaths in general, the majority of the training related deaths were due to heart attacks. Nine of the training related deaths occurred during a live fire or smoke training exercise. The records show that there was a multiple fire fighter fatality incident in Boulder, Colorado in 1982 resulting in two deaths during a live fire training exercise. The Milford incident represents the worst multiple fire fighter fatality during a live fire training incident documented by the NFPA records.

Live fire training is a necessary and excellent means of training fire fighters because it provides a high level of realism they will encounter in fulfilling their duties. However, it must be recognized that many training exercises also pose many of the hazards encountered during actual emergencies. As a result, live fire training drills must be planned with great care and must be closely supervised to ensure risks are kept to a minimum. A fatal live training incident in 1982 led NFPA's Committee of Fire Service Training to develop a standard that would help prevent such tragedies. Provisions for conducting live fire training are addressed in NFPA 1403, Standard on Live Fire Training Evolutions in Structures. 4,5,6,7 These

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4 For further details, see NFPA 1403, Standard on Live Fire Training Evolutions in Structures.


7 It is recognized that NFPA 1403 was not in effect in Milford nor had it been adopted by the State of Michigan. Further, the Milford Fire Department was apparently not aware of NFPA 1403 at the time of the training exercise.
provisions of NFPA 1403, along with the application of fire ground command principles, are intended to prevent tragedies such as occurred at Milford.

Based on NFPA's analysis of this incident, the following are considered significant factors in the outcome of this fire:

1. **The use of flammable and combustible liquids in a live fire training exercise.**

Flammable and combustible liquids present an extreme danger to fire fighters if used during a live fire training exercise in a structure. Any amount of flammable liquid should be strictly prohibited, and only a small amount of combustible liquid (if any) should be allowed in a live fire training exercise. These materials along with furnishings, such as the sofas and the upholstered chair, arranged as they were, can (and did) result in a sudden and unexpected growth rate in the fire. Rapid growth rate fires are an extreme danger to occupants of buildings. Even with full protection, fire fighters positioned in close proximity to such phenomena can be severely injured or killed. Live fire training exercise should not be designed with the intent of reaching this magnitude of fire intensity. Realistic simulations can be achieved without unduly risking the safety of fire fighters.

2. **The presence of combustible wall paneling and ceiling tiles within the training building.**

The lightweight wood paneling and low density ceiling tiles on the first floor contributed to the rapid growth and extension of the fire. Combustible ceiling tiles were identified as a contributing
factor in a similar live fire training incident in Boulder, Colorado in 1982. Once ignited, in certain geometric arrangements inside a training building, these combustible interior finish materials contribute to a sudden change in the intensity of a fire (i.e., flashover) that is life threatening and can trap fire fighters. Such materials should be identified during preinspections of training buildings and removed before training begins.

3. Lack of adequate planning and of communication of the training exercise objectives to all individuals involved.

There were several conflicting objectives for the training exercise. They reportedly included: "nozzle work," "observe arson sets," "mask work," and "fire fighter skill development." It appears that most of the information conveyed to the fire fighters at the early morning breakfast meeting concerned water supply during the exercise. Further, fire fighters were told where fire apparatus would be positioned, and the briefing dealt with the exposure concerns. It did not appear that fire fighters had a clear understanding of other objectives of the exercise, such as involvement of fire fighters in interior fire suppression training. One of the fire fighters who was able to escape from the building told investigators that he did not know that he would be part of interior training until he was instructed to "gear up", and then he was unsure of his specific assignment. More explicit objectives and procedures for the exercise might have prevented the crew of four fire fighters from being directed into the interior of the building after ignition had occurred.

20.
4. Lack of adequate assessment of the hazards of the training exercise and the hazards presented by the structure in such an exercise.

The arranged sets that included the use of flammable and combustible liquids presented a hazard to the fire fighters who entered the training building once ignition occurred. In addition, there were numerous other high-heat release materials, including combustible interior finish and furnishings present in the training building. These variables, when combined with the construction method of the building and the deteriorated condition of the structure, such as holes in walls and ceilings, created a condition conducive to rapid propagation and to a concealed fire. The preinspection of the structure apparently did not identify the hazards presented by the interior finish materials and penetrations in walls and ceilings, and it also appears that the fire fighters were not fully aware of the danger of using flammable liquids in such arrangements.

Further, it does not appear that there was a designated safety officer with full authority and sole responsibility to intervene and control any aspect of the exercise when, in his or her judgement, a potential danger, such as these, existed. An individual so assigned may have been able to assess developing dangers.

5. Lack of an adequate training (fire) ground command structure to ensure safe and coordinated procedures.

A fire ground command structure is designed to ensure that the numerous simultaneous actions that are occurring are coordinated with
the incident commander. These same principles also apply at live fire training exercises. NFPA 1403, *Standard on Live Fire Training Evolutions in Structures*, specifically states: "Live fire training evolutions conducted in accordance with this standard shall be managed by means of a documented fire ground command system. The line of authority shall be made clear to all participants in order that both expected and unforeseen situations will be managed with the most efficiency and that reasonable margins of safety will be provided." To ensure a coordinated effort, many fire departments establish clear, defined, standard operating procedures (SOP's) that help the fire ground commander to streamline operations, reduce confusion, and promote accountability and safety on the fire ground. 8 Further, fire ground commanders assign sector fire officers, who are responsible for a specific area of the fire ground, to report back to the incident commander on the dynamics of events that may affect his decision making. Included are changes in fire conditions, deployment of fire fighters to specific tasks, and other actions that affect the suppression effort or fire fighter safety.

Had key events, which occurred early in this incident, been communicated through a training ground commander, subsequent decisions and actions might have changed its outcome. These events included:

1. Ignition was sustained, and fire fighters were in the building without hose lines; and
2. smoke was coming from the second floor eaves, an indication of fire growth and spread.

When live fire training operations are conducted without such a command structure, fire fighter safety may not be ensured.

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FIGURE 1: FLOOR PLAN OF GROUND LEVEL
SECOND FLOOR

REAR

CORRIDOR

< ESCAPE WINDOW

BATHROOM

BEDROOM 1

DRESSER

BEDROOM 2

FRONT

FIGURE 2: FLOOR PLAN OF UPPER LEVEL
FIGURE 3: NORTHSIDE VIEW OF FARMHOUSE ILLUSTRATING ESCAPE WINDOW USED BY FIRE FIGHTERS
The National Fire Protection Association is conducting a study of the fatal fire fighter training incident that occurred in Milford, Michigan on October 25, 1987. Three fire fighters were killed and three others injured when fire engulfed a two-story wood frame dwelling during a live fire training exercise. (See the attached fact sheet for further information.) This incident followed another fatal live fire training incident in Hollandale, Minnesota on October 20, in which one fire fighter was killed.

Over the past decade, NFPA records show that 53 fire fighters have died in training accidents involving a range of activities, such as live fire training, smoke drills, physical fitness, or hose and ladder evolutions. A primary cause of death in many of the incidents was heart attack. During this period, there were nine deaths attributed to live fire or smoke training, and these incidents point toward the need for adherence to fire fighter health and safety policies and related standards.

A fatal live training incident in 1982 led NFPA's Committee on Fire Service Training to develop a standard that would help prevent such
tragedies. The Committee's efforts led to the adoption, in May 1986, of NFPA 1403, Standard on Live Fire Training Evolutions in Structures.

Ongoing training for fire fighters is the cornerstone of good fire protection in today's world. However, the benefits derived from live fire training are negated by the injuries and deaths suffered by fire fighters under unsafe and poorly supervised training conditions. It is therefore essential that all fire departments focus renewed attention on NFPA 1403. Like all NFPA consensus standards, NFPA 1403 was developed by a committee of experts who represent the nation's fire community. The document was open to public examination and comment, and it is the result of the best thinking available.

Above all, NFPA 1403 stresses safety, and proposes a basic system that can be adapted to local conditions to serve as a standard mechanism for live fire training evolutions. The standard deals with the training of fire fighters under live fire conditions and focuses on training for coordinated interior fire suppression operations.

Live fire training in a suitable acquired building is an accepted means of training fire fighters, because it provides high levels of realism. It can simulate most of the hazards of interior fire fighting in an actual emergency. Evolutions must be planned with great care, and they have to be supervised closely by instruction personnel. NFPA 1403 contains information that is designed to ensure adequate levels of safety while allowing local fire departments some flexibility to use independent judgement based on local situations and the level of training to be achieved.

The following guidelines for live fire training in acquired buildings are among the several requirements contained in NFPA 1403 (see the standard for complete requirements):

24.
- Inspect the structure for anticipated load bearing capacities.
- Remove hazardous storage and correct hazardous conditions.
- Provide protection for spectators and exposed structures.
- Provide adequate water supply to handle the anticipated fire with a reserve supply equal to an additional 50 percent; provide separate water sources for attack lines and backup lines.
- Provide a pre-burn briefing plan to discuss each evolution and to make specific assignments; all participants must be familiar with the building configuration.
- Do not use flammable liquids.
- Appoint a safety officer to prevent unsafe acts, eliminate unsafe conditions, provide for the safety of all participants; the safety officer shall have no other duties that interfere with these responsibilities.
- Establish a building evacuation plan.
- Provide on-site emergency medical services.
- Designate one person to control the materials being burned and to ignite the fire in the presence of and under the direct supervision of the safety officer.
- Equip all participants with full protective clothing and self-contained breathing apparatus that meets the appropriate NFPA standards.
- Provide qualified instructors; one per five trainees.
- Establish a method of fire ground communications to allow coordination among the incident commander, the interior and exterior sectors, the safety officer, and those making external requests for assistance.
The tragic deaths occurred when a sudden, unexpected buildup of fire forced six fire fighters to try to escape through windows. Three escaped with injuries. Then fire engulfed the building.

THOMAS J. KLEM
Director
NFPA Fire Investigations and Applied Research Division

On Sunday, October 25, 1987, at approximately 8:45 a.m., three fire fighters were killed and three others were injured during a multi-department training exercise involving an abandoned two-story, wood frame farmhouse in Milford, Mich. The training exercise was being conducted to familiarize fire personnel in the use of self-contained breathing apparatus (SCBA) and to assist them in detecting indicators of incendiary fires. The NFPA is conducting a study of this incident in cooperation with the Michigan State Police Fire Marshal’s Division. A final report will be available from the NFPA upon completion of the on-site documentation and an analysis of the assembled data.

As part of the live fire training, several fires were arranged in all major rooms on both floors of the house. The fires involved various incendiary fire ignition scenarios. Most of them involved the use of flammable liquids (gasoline and camp stove fuel). The set fire areas were joined by trailers designed to spread fire from one location to another. In addition to the flammable liquids, various combustible furnishings, such as sofas and chairs, contributed to the fuel load. Although the presence of flammable liquids is thought to have been significant in this incident, other fire spread variables, such as combustible ceiling tile and wall finish materials, are thought to have affected the rapid buildup of the fire and to have led to a concealed fire in the walls and ceiling.

At the beginning of the fire fighting exercises, fire fighters entered the building to ignite the simulated incendiary fires. The fire fighters were wearing protective coats, helmets, SCBA, and either protective trousers or three-quarter-length boots. Fires were ignited on the first floor, and the fire fighters went to the second floor. The rapid buildup of the fire was sudden and unexpected, and the sudden change of conditions on the first and second floors forced six fire fighters to attempt to escape through exterior windows. Three fire fighters who did escape sustained various injuries before the fire completely engulfed the structure. Fire fighters positioned on the exterior of the building advanced hose lines into the interior and raised ladders to the second floor in an attempt to rescue trapped fire fighters. The fire was extinguished, and the bodies of the three fire fighters were found on the second floor. The cause of death was reported to be smoke inhalation.

This fact sheet is based on preliminary information. A final report will be available from the NFPA Fire Investigations Division when this study is completed.
Fatal Live Fire Training Incident

The use of flammable and combustible liquids and the presence of combustible wall paneling and ceiling tiles contributed to the triple tragedy.

THOMAS J. KLEM
Director
Fire Investigations and Applied Research Division
National Fire Protection Association

On Sunday October 25, 1987, at approximately 8:45 a.m., three fire fighters were killed and three others were injured during a multi-department, live fire training exercise involving a vacant, two-story, wood frame farmhouse in Milford, Mich. After the fire department had made arrangements with the owner to raze the structure, a training exercise simulating realistic fire conditions encountered by fire fighters was planned. The training exercise also was intended to improve basic fire fighting skills and to aid fire fighters in recognizing incendiary fire scenarios.

As part of the exercise, several incendiary fire “sets” were arranged in all major rooms on both floors of the house. Most of the ignition scenarios involved the use of flammable and combustible liquids (gasoline, kerosene and camp stove-type fuel). The various “sets” were joined by a “trailer” designed to propagate fire throughout the building once it was ignited from a location at the main entrance door. In addition to the flammable and combustible liquids, various combustible interior finish materials and furnishings comprised the fuel load. Although the presence of flammable and combustible liquids is thought to have been significant in this incident, other variables, such as combustible ceiling tile and wall finish materials and the extension of the fire to the attic area, also affected the rapid buildup, spread, extension, and outcome of the fire.

After most fire fighters involved in the exercise were given a walk-through tour of the building and observed the incendiary fire “sets,” the trailer located at the main entrance was ignited. Ignition did not proceed as planned, and two fire fighters entered the building to ignite uninhibited areas. The two fire fighters moved to the second floor, and set fires on this level were ignited. Shortly afterward, four additional fire fighters were directed into the building to make observations of the exercise. Spot fires and light smoke conditions were observed by the four fire fighters as they progressed through the building to the second floor. They met the other two fire fighters, and quickly realized that fire conditions on the first and second floors had intensified, trapping all six fire fighters on the second floor and forcing them to attempt to escape through exterior windows. Three of the fire fighters escaped through a second floor window, and they sustained various injuries before the fire completely engulfed the

Introduction

An investigation was conducted by the National Fire Protection Association to document and analyze significant factors that resulted in the loss of life of three fire fighters during a live fire training exercise in Milford, Michigan. Soon after learning of the incident, Thomas J. Klem, Director, Fire Investigations and Applied Research Division, traveled to the scene to conduct a study of the incident. The study was conducted in cooperation with the Fire Marshal Division, Michigan Department of State Police, Milford Police and the Oakland County Sheriff’s Department.

This report is another of NFPA’s studies of fires having particularly important educational or technical interest. The information presented is based on the best data available immediately after the training fire incident and that obtained during subsequent follow-up.

This report describes fire safety conditions at the live fire training exercise and presents findings on factors that contributed to the loss of life based on the NFPA analysis of collected data and observations during the investigation. NFPA codes and standards were used (except where otherwise noted) as criteria for the analysis so that conditions during the training exercise could be compared with current fire protection practice as represented by existing NFPA codes and standards at the time the report was written. It is recognized that these codes and standards were not in effect in Milford at the time of the exercise.

The objective of this report is to document and analyze a significant multiple fire fighter fatality incident in order to prevent a recurrence of such an event in the future. It is not NFPA’s intention that this report pass judgment on, or fix liability for, the loss of life at the training exercise.

NFPA acknowledges the help and assistance provided by Lieutenant Jon Curtis and Detective Sergeant Patrick Garity and other members of the Fire Marshal Division, Michigan Department of State Police, officers from the Milford Police Department, and investigators from the Oakland County Sheriff’s Department in documenting this incident.
structure. Fire fighters positioned outside the building advanced hose lines into the interior and raised ladders to the second floor in an attempt to rescue the remaining trapped fire fighters. Once the fire was controlled, fire fighters located the remaining three fire fighters on the second floor.

Based on NFPA’s investigation and analysis of this fire, the following are considered significant factors that contributed to the fire fighter fatalities in this incident:
1. The use of flammable and combustible liquids in a live fire training exercise.
2. The presence of combustible wall paneling and ceiling tiles within the training building.
3. Lack of adequate planning and communication of the training exercise objectives to all individuals involved.
4. Lack of adequate assessment of the hazard of the training exercise and the hazards presented by the structure in such an exercise.
5. Lack of an adequate training (fire) ground command structure to ensure safe and coordinated procedures.

Background
The Milford Township Fire Department is a 27 active member, volunteer organization that provides fire protection for Milford and adjoining areas. Milford is a community of just over 11,000 residents located approximately 40 miles northwest of Detroit, in Oakland County, Mich. The department responds to approximately 300 emergency calls for assistance each year (including medical and mutual aid responses). The department operates two pumpers, a tanker-pumper, a tanker, three brush (grass) units, and a rescue unit out of one fire station. Because of Milford’s rural setting, many of the department’s structural fire fighting strategies involve the use of tankers, portable water tanks, and the shutting of water from static sources to the fire scene. Operational control of the department is vested with the fire chief and the other line officers of the department, including a training officer. The department holds monthly training drills to maintain basic fire fighter skills. Members of the department participate in the state of Michigan’s fire fighting training schools.

During the summer of 1987, members of the fire depart-

ment became aware that a vacant home at 1975 Wixom Road was to be razed, and a new home was to be constructed on an adjacent portion of the land. Discussions ensued between the owner of the property and fire department officials regarding the use of the old farmhouse for a fire fighter training exercise that ultimately would result in the total destruction of the house by fire.

After the initial discussions, the site was visited several times by department members and assessed for the best positioning of fire apparatus, water source location and utilization, etc. A walk-through tour of the building was included. Before final arrangements could be completed, complications arose. The shell of the new home was constructed on the site adjacent to the vacant building but separated from it by approximately 100 feet. This required the development of strategies to protect the new home during the training exercise.

The building
The training exercise was to take place in a vacant 120-year-old farmhouse. An addition was added to the original structure at some time, creating an “L” configuration. The original structure was a two-story colonial style dwelling set back approximately 30 feet from Wixom Road. An unpaved driveway from Wixom Road ran along the north side and to the rear of the building. The original structure contained the living and dining rooms and two second floor bedrooms (see Figures 1 and 2). There was no direct entrance/exit door to the outside from the two-story portion of the home. The one-story addition to the building was attached at the northeast corner of the main building (see Figure 3). The main entrance to the dwelling was through the addition, which led to a “mud” room and the kitchen.

Access to the second floor was gained from the dining room by way of the stairway, which led to an upstairs hallway, two bedrooms, and a bathroom located at the south end of the hall. All sides and each level of the building contained windows, except the east side of the original structure. All windows were reported to be intact at the time of the training exercise.

Each portion of the dwelling was of wood frame construc-
tion, and each had a peaked roof with independent attic spaces. The interior partitions of the building were constructed of wood studs. On the second floor, the studs were covered with wood lath and finished with plaster. On the ground floor, gypsum wallboard was attached to the wood studs, and lightweight wood paneling was used as the finish material for the walls. Throughout the building, gypsum wallboard was attached to the ceiling joists to form the finished ceiling. However, throughout the ground floor, 12-by-12-inch low density fiberboard ceiling tiles were attached to wood furring strips covering the gypsum board to form the finished ceiling. In addition to the fuel provided by the incendiary fire sets and the combustible interior finish materials, the building contained two full-length sofas, an upholstered chair (both arranged in the living room), and several other pieces of furniture.

The building appeared to be structurally sound; however, there were numerous holes in the walls and ceilings and several holes in the flooring at the second floor level. The holes appeared to be more extensive on the second floor where, in some locations, large areas of plaster were removed exposing wood lath and studs. Although the integrity of the walls was better on the ground floor, it appeared that paneling in some locations was attached directly to the wood studs. The wall openings provided access into the combustible concealed spaces between the wood studs, which ran vertically into the wood frame attic space. During one of the walk-through tours, fire fighters placed a bathroom sink over a hole between the first and second floor.

The live fire training exercise

The live fire training exercise involving the Milford Fire Department and three neighboring fire departments was scheduled for Sunday morning, October 25, 1987. The training exercise was intended to improve fire fighter skills and to assist fire fighters in recognizing physical evidence indicative of an incendiary fire. At a fire department business meeting on the Wednesday before the training exercise, a discussion of the details of the exercise took place among the fire chief, the assistant fire chief, and the department’s training officer. In addition, word was spread among the members that the training exercise was scheduled for Sunday, following a breakfast to be served at the fire station. The breakfast meeting would serve as an assembly point for all participants, including those from the neighboring departments.

During the meeting on Wednesday, it was decided that the assistant chief would be responsible for arranging the fire sets for that portion of the training exercise involving incendiary fire recognition. The assignment was based in part on the fact that the assistant chief was associated with a sheriff department’s arson investigation unit in a neighboring county. It was also decided that the fire chief would be responsible for “outside activities,” such as hose line placement, exposure protection, apparatus placement, water supply, etc.

On the day of the drill, at approximately 7:30 a.m., the assistant chief proceeded to the training site to begin arranging the incendiary fire sets within the building. He was soon joined and assisted by another fire fighter. A five-gallon container and several one-gallon containers of flammable and combustible liquids were brought to the scene.2 Reportedly, they contained gasoline, kerosene, and camp-type fuels. The amount of liquid in each container was not determined. These materials along with other items, such as surgical-type gloves, string, newspapers, one-gallon plastic containers, roadside flares, and candles, were used in preparing the sets.

In addition, combustible materials within the building, such as discarded clothing and the remaining furniture and household appliances, also were used. Each major room of the building was arranged with a different incendiary fire scenario, each used various combinations of the items in the arrangement, and some involved combinations of suspended surgical-type gloves partially filled with flammable or combustible liquid or pooling of the liquids on the floor. One set involved attaching a string to the corners of a room and draping sheets of newspaper over the string, then pouring flammable or combustible liquid over them. The string was placed at a height of approximately 3 feet above the floor. Below this arrangement were placed discarded clothing and a large pile of crumpled newspapers. The combustible materials on the floor also included a one-gallon plastic container partially filled with a flammable or combustible liquid. Similar type arrangements were placed throughout the building.

Although each area of the building contained a different and separate set, each was connected by a waxed paper “trailer” draped through the sets, around the furniture, and through the remaining drapery. The trailer was brought to

When interviewed later, several fire fighters told investigators that they noted a strong odor of flammable liquid “fumes” or of “gasoline” within the building during their tour.

the main entrance door where it was to be ignited, thereby propagating fire to all locations.

Fire fighters began arriving at the Milford station at approximately 7:00 a.m. for the breakfast and subsequent training exercise. During the breakfast meeting, participants of the drill were briefed informally regarding the location of the drill site, apparatus and hose line placement, and exposure concerns, and the Milford fire fighters were assigned positions on their fire apparatus. Shortly after 8:00 a.m., the 36 fire fighters who were to participate in the drill began to arrive at the training site and to prepare their equipment for the exercise.

Several 1¾-inch and 2½-inch handlines from the Milford pumpers were prepared, charged, and placed on the north and south sides of the building. It was planned that the Milford units would be the only units so positioned and committed. Portable water tanks were filled, and water was shuttled from a remote point by the neighboring fire department’s apparatus. On the south side of the home, several explorer scouts from an auxiliary unit of one of the neighboring fire departments were given instructions in operating a hose line and were told that they were to help protect the exposure presented by a 250-gallon fuel oil tank adjacent to the training building. In addition, they were told they were to help protect the exposure presented by the new home. Part of the instruction included how to flow water through the handlines and onto the drill building.

During these and other preparations for the drill, most of the fire fighters and the four explorer scouts were given a tour of the building and shown the various materials arranged in a manner to represent methods thought used by arsonists. When interviewed later, several fire fighters told
investigators that they noted a strong odor of flammable liquid "fumes" or of "gasoline" within the building during their tour.

Weather at the time of the training exercise was reported to be 29°F with no detectable winds.

The incident

Preparations for the training exercise were being completed at approximately 6:20 a.m. While a fire fighter prepared to ignite the trailer at the main entrance to begin the exercise, a crew of four fire fighters was assembled and instructed to "gear up." The four donned protective hoods and coats, helmets, and self-contained breathing apparatus (SCBA) and wore either protective trousers or three-quarter-length boots. They stood on the north side of the building near the main entrance for an estimated 15 minutes, waiting for further instructions regarding their duties. During this time, several of the fire fighters disconnected the facepieces of their SCBA from the regulators in order to conserve air and prevent the facepieces from becoming fogged.

Meanwhile, the ignition was not proceeding as planned. The trailer that was ignited by a flare did not propagate the fire throughout the dwelling as planned and designed. A second attempt was made by the fire fighter at the main entrance, and this attempt did succeed in igniting one of the flammable liquid pools located on the kitchen floor. Once again, however, further propagation did not occur as anticipated. After an initial flare-up of the fire in the kitchen, the fire diminished, and the assistant chief and another fire fighter decided to enter the building to ignite additional sets and to photograph the burning process. These fire fighters were wearing protective clothing similar to that worn by the crew of four fire fighters. Several minutes passed, and no significant change in the progression of the fire was noted from the main entrance area. Reportedly, in order to help ventilate the building, two second-floor windows were broken on the south side. Also during this time, several fire fighters outside the building noticed light smoke coming from the eaves of the two-story portion of the home.

At about this time, the crew of four fire fighters received instructions to enter the building and to observe the incendiary fire sets. The four entered the building by way of the main door to the mud room, and proceeded into the kitchen.

The crew of four entered in single file; they did not advance a hose line with them. As they passed through the kitchen, they observed several spot fires in the area of the stove and kitchen countertop where sets had been arranged. One of the fire fighters described the area at this time as being free of any detectable amount of heat and containing only a small quantity of smoke. The crew progressed through the kitchen into the dining room and began to ascend the stairway to the second floor. Once on the second floor, they met the assistant chief and the other fire fighter, who were still in the process of igniting the sets in one of the second floor bedrooms. One bedroom fire was described as "going pretty good" at the time.

Soon after the crew of four fire fighters met the assistant chief and the other fire fighter, fire conditions within the building began to change.

The assistant chief immediately instructed the crew of four fire fighters to "get out" of the building. At about this same instant, fire conditions within the building began to change. All six fire fighters were confronted by a sudden buildup of heat and a smoke layer descending from the second floor ceiling. The crew of fire fighters who were located closest to the stairway turned and started down the stairs. The lead fire fighter of the crew determined that they could not exit by way of the first floor due to the intensity of the fire now in that area. At least one of the fire fighters in the group began to get very anxious but was calmed by a more experienced fire fighter within the group who advised them "not to panic" and to return to the second floor. Upon reaching the second floor, the conditions were described as extremely hot with visibility near zero. The six fire fighters, all now located on the second floor, began to search for a way out. Three fire fighters were in positions close to the window at the north end of the corridor. They scrambled to escape through this window. While waiting his turn to escape through the window, one fire fighter described fire conditions as "unbearable," and the last fire fighter to escape said that a portion of his facepiece began to deterio-
rate from the heat just as he was going through the window. These three fire fighters dropped to the roof of the one-story addition just below the window and were assisted to the ground.

The sudden change in fire conditions and the escaping fire fighters alerted fire fighters positioned on the outside of the building that there was trouble. As a result, they began to advance hose lines into the building and raise ladders to positions to assist the escaping fire fighters. Additional hose lines were laid, charged, and advanced into the structure. Ground ladders were raised to a second floor bedroom location, where it was reported that one of the trapped fire fighters was seen attempting to escape. Since the structure was almost fully involved at this point, a major fire fighting task was also confronting fire fighters in their efforts to rescue the trapped fire fighters.

After an estimated 10 minutes, the fire was "knocked down" and fire fighters positioned along the west side of the structure were able to enter a second floor bedroom, where they found one of the fire fighters and removed him from the building. Upon searching further, the fire fighters were able to locate the remaining two fire fighters, who were found in the second floor corridor just outside bedrooms. They, too, were removed from the building. Emergency medical treatment was administered at the scene, and the fire fighters were subsequently transported to an area hospital for further care.

Casualties
Tragically, three fire fighters died and three were injured during this fire training exercise. The fatalities were among the crew of four fire fighters to enter the building. One fire fighter from the crew, as well as the assistant chief and the fire fighter assisting in the sets, were injured during their escape. The fatalities were members of three of the four fire departments involved in the training exercise. The fire fighters were two males, ages 33 and 34, and a female, age 41. Autopsy results, as reported by the Office of the Medical Examiner, County of Oakland, show they died of "soot and smoke inhalation." Each had elevated carboxy-hemoglobin levels reported at 27.4, 48.2, and 58.4 percent, respectively. In addition, the percentage of body burns was reported at 40, 45, and 65 percent, respectively.

Extent of fire spread
Both the living and dining rooms were severely damaged by the fire. The combustible interior finish material in the living room was totally consumed, and in the dining room it was almost totally destroyed. The furniture in the living room was also almost totally consumed. Damage in the living room was severe enough that the fire penetrated the wall stud channel, thus providing an avenue for the fire to extend into the attic area via the concealed combustible space. There was also burn-through from the living room to the exterior of the building. This damage showed at the floor level at the northwest exterior of the building. Damage to the remainder of the first floor was not as extensive.

Damage on the second floor was most severe in the bathroom area, directly above the living room. Damage in this area also showed the continued avenue of fire spread to the attic from below. The second floor ceiling collapsed in the area of the bathroom and south bedroom. Damage to the south portion of the attic and roof was severe, resulting in almost total consumption of the roof truss and roof material in this area. Damage to the remainder of the second floor and attic was less severe.

Analysis
The numerous incendiary fire sets employed in this training exercise, which involved the use of flammable and combustible liquids placed in various arrangements, are capable of producing an extremely intense fire. An intense fire not only would be a result of the use of flammable and combustible liquids used in the sets, but also would be a result of the other combustible materials and furnishings and of the positioning of the sets in close proximity to the combustible wall and ceiling materials. Fire scenarios involving various combinations of these variables can result in extremely rapid changes in the growth rate of a fire, changes that are sudden and unexpected. This phenomenon is commonly referred to as "flashover."

In addition to the ignition of several of the incendiary fire sets close to the main entrance, it appears that the initial attempt to ignite the sets resulted in sustained ignition of a set in the living room. This set, in the southeast corner of the room, involved a sofa and an undetermined quantity of flammable or combustible liquid poured onto the sofa. This arrangement of flammable and combustible material in a corner configuration and in close proximity to combustible wall and ceiling materials resulted in a severe and significant fire that affected the outcome of this incident.

As the fire developed at this location, it penetrated the wall and extended into the combustible vertical stud channel leading to the second floor and the attic area. Because it was concealed, the severity, build up, and spread of this fire to the attic may have gone undetected. Further, fire fighters who entered the building after ignition most likely did not observe the fire development in the living room. As they progressed to the second floor, a partition would have obstructed their full view of the living room and the severity of the fire.

When the six fire fighters were on the second floor, however, a severe fire was most likely burning in the attic space above them and the living room was approaching flashover. The fire fighters on the second floor detected heat and observed a smoke layer descending from the second floor ceiling.

The fire fighters were quick to move from the area, and they attempted to exit down the stairs and through the first floor. However, flashover of the living room had likely occurred by this time, and products of combustion were extending through the opening in the partition into the dining room. The fire fighters determined that they could not exit by way of the first floor, and this resulted in their retreat back to the second floor.

Once they had returned to the second floor, they found that fire conditions there had worsened. Only a short interval
Fire fighter safety and live fire training standards

NFPA statistics indicate that in 1986 (the last year for which complete data is available), there were 113 fire fighter fatalities in the United States. Although this represents a significant improvement in the number of fire fighter deaths when compared to the number killed annually in the late seventies, there appears to have been little progress in further reducing the number of fatalities since 1979. 2

Included in the 1986 fire fighter fatalities were seven training-related deaths. The tragic incident in Milford prompted a closer examination of such incidents. NFPA loss records over the past decade (1977—1996) show that there were 53 training-related fire fighter deaths, illustrating that this component of a fire fighter’s activities also has associated risks. As is the case with fire fighter deaths in general, the majority of the training-related deaths were due to heat attacks. Nine of the training-related deaths occurred during a live fire or smoke training exercise. The records show that there was a multiple fire fighter fatality incident in Boulder, Colo., in 1982 resulting in two deaths during a live fire training exercise. The Milford incident represents the worst multiple fire fighter fatality during a live fire training incident documented by the NFPA records.

Live fire training is a necessary and excellent means of training fire fighters because it provides a high level of realism they will encounter in fulfilling their duties. However, it must be recognized that many training exercises also pose many of the hazards encountered during actual emergencies. As a result, live fire training drills must be planned with great care and must be closely supervised to ensure risks are kept to a minimum. A fatal live training incident in 1982 led NFPA’s Committee on Fire Service Training to develop a standard that would help prevent such tragedies. Provisions for conducting live fire training are addressed in NFPA 1403, Standard on Live Fire Training in Structures.5 These provisions of NFPA 1403, along with the application of fire ground command principles, are intended to prevent tragedies such as occurred at Milford.

In addition to the information conveyed to the fire fighters at the early morning breakfast meeting concerned water supply during the exercise. Further, fire fighters were told where fire apparatus would be positioned, and the briefing dealt with the exposure concerns. It did not appear that fire fighters had a clear understanding of other objectives of the exercise, such as the involvement of fire fighters in interior fire suppression training. One of the fire fighters who was able to escape from the building told investigators that he did not know that he would be part of interior training until he was instructed to “gear up,” and then he was unsure of his specific assignment. More explicit objectives and procedures for the exercise might have prevented the crew of four fire fighters from being directed into the interior of the building after ignition had occurred.

4. Lack of adequate assessment of the hazards of the training exercise and the hazards presented by the structure in such an exercise.

The arranged sets that included the use of flammable and combustible liquids presented a hazard to the fire fighters

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who entered the training building once ignition occurred. In addition, there were numerous other high-heat release materials, including combustible interior finish and furnishings present in the training building. These variables, when combined with the construction method of the building and the deteriorated condition of the structure, such as holes in walls and ceilings, created a condition conducive to rapid fire propagation and to a concealed fire. The pre-inspection of the structure apparently did not identify the hazards presented by the interior finish materials and penetrations in walls and ceilings, and it also appears that the fire fighters were not fully aware of the danger of using flammable liquids in such arrangements.

Further, it does not appear that there was a designated safety officer with full authority and sole responsibility to intervene and control any aspect of the exercise, when, in his or her judgment, potential dangers such as these existed. An individual so assigned may have been able to assess developing dangers.

5. Lack of an adequate training (fire) ground command structure to ensure safe and coordinated procedures.

A fire ground command structure is designed to ensure that the numerous simultaneous actions that are occurring are coordinated with an incident commander. These same principles apply at live fire training exercises. NFPA 1403, Standard on Live Fire Training Evolutions in Structures, specifically states: “Live fire training evolutions conducted in accordance with this standard shall be managed by means of a documented fire ground command system. The line of authority shall be made clear to all participants in order that both expected and unforeseen situations will be managed with the most efficiency and that reasonable margins of safety will be provided.” To ensure a coordinated effort, many fire departments establish clear, defined, standard operating procedures (SOP’s) that help the fire ground commander to streamline operations, reduce confusion, and promote accountability and safety on the fire ground. Further, fire ground commanders assign sector fire officers, who are responsible for a specific area of the fire ground, to report back to the incident commander on the dynamics of events that may affect his decision making. Included are changes in fire conditions, deployment of fire fighters to specific tasks, and other actions that affect the suppression effort or firefighter safety.

Had key events . . . been communicated through a training ground commander, subsequent decisions and actions might have changed the outcome.

Had key events that occurred early in this incident been communicated through a training ground commander, subsequent decisions and actions might have changed the outcome. These events included:
1. Ignition was sustained, and fire fighters were in the building without hose lines; and
2. Smoke was coming from the second floor eaves—an indication of fire growth and spread.

When live fire training operations are conducted without such a command structure, fire fighter safety may not be ensured.

1Flammable liquids have flashpoints below 100°F (38°C) and vapor pressures not exceeding 40 psia at 100°F (275 kPa at 38°C). Liquids with flashpoints at or above 100°F (38°C) are referred to as combustible liquids. Also see NFPA 321, Standard on Basic Classification of Flammable and Combustible Liquids.

2It could not be determined if the assistant chief and his assistant planned to follow the crew or if they began to search for another way out from the second floor. The time interval between these events is estimated to be less than one minute.


4For further details, see NFPA 1403, Standard on Live Fire Training Evolutions in Structures.


7It is recognized that NFPA 1403 was not in effect in Milford, nor had it been adopted by the state of Michigan. Further, the Milford Fire Department apparently was not aware of NFPA 1403 at the time of the training exercise.

Alert bulletin

TO: State and Provincial Fire Marshals, State Training Directors, and Metro Fire Chiefs
FROM: Martin F. Henry, Director, Public Protection Division
DATE: October 20, 1987
SUBJECT: Recent Multiple Fire Fighter Fatality Training Incident, Milford, Michigan

The National Fire Protection Association is conducting a study of the fatal fire fighter training incident that occurred in Milford, Michigan, on October 25, 1987. Three fire fighters were killed and three others injured when fire engulfed a two-story wood frame dwelling during a live fire training exercise. This incident followed another fatal live fire training incident in Hollandale, Minnesota, on October 20, in which one fire fighter was killed.

Over the past decade, NFPA records show that 53 fire fighters have died in training accidents involving a range of activities, such as live fire training, smoke drills, physical fitness, or hose and ladder evolutions. A primary cause of death in many of the incidents was heat attack. During this period, there were nine deaths attributed to live fire or smoke training, and these incidents point toward the need for adherence to fire fighter health and safety policies and related standards.

A fatal live training incident in 1982 led NFPA's Committee on Fire Service Training to develop a standard that would help prevent such tragedies. The committee's efforts led to the adoption, in May 1986, of NFPA 1403, Standard on Live Fire Training Evolutions in Structures.

Ongoing training for fire fighters is the cornerstone of good fire protection in today's world. However, the benefits derived from live fire training are negated by the injuries and deaths suffered by fire fighters under unsafe and poorly supervised training conditions. It is therefore essential that all fire departments focus renewed attention on NFPA 1403. Like all NFPA consensus standards, NFPA 1403 was developed by a committee of experts who represent the nation's fire community. The document was open to public examination and comment, and it is the result of the best thinking available.

Above all, NFPA 1403 stresses safety and proposes a basic system that can be adapted to local conditions to serve as a standard mechanism for live fire training evolutions. The standard deals with the training of fire fighters under live fire conditions and focuses on training for coordinated interior fire suppression operations.

Live fire training in a suitable, acquired building is an accepted means of training fire fighters, because it provides high levels of realism. It can simulate most of the hazards of interior fire fighting in an actual emergency. Evolutions must be planned with great care, and they have to be supervised closely by instruction personnel. NFPA 1403 contains information that is designed to ensure adequate levels of safety while allowing local fire departments some flexibility to use independent judgment based on local situations and the level of training to be achieved.

The following guidelines for live fire training in acquired buildings are among the several requirements contained in NFPA 1403 (see the standard for complete requirements):

- Inspect the structure for anticipated load bearing capacities.
- Remove hazardous storage and correct hazardous conditions.
- Provide protection for spectators and exposed structures.
- Provide adequate water supply to handle the anticipated fire with a reserve supply equal to an additional 50 percent; provide separate water sources for attack lines and backup lines.
- Provide a pre-burn briefing plan to discuss each evolution and to make specific assignments: all participants must be familiar with the building configuration.
- Do not use flammable liquids.
- Appoint a safety officer to prevent unsafe acts, eliminate unsafe conditions, and provide for the safety of all participants: the safety officer shall have no other duties that interfere with these responsibilities.
- Establish a building evacuation plan.
- Provide on-site emergency medical services.
- Designate one person to control the materials being burned and to ignite the fire in the presence of and under the direct supervision of the safety officer.
- Equip all participants with full protective clothing and self-contained breathing apparatus that meets the appropriate NFPA standards.
- Provide qualified instructors, one per fire trainees.
- Establish a method of fire ground communications to allow coordination among the incident commander, the interior and exterior sectors, the safety officer, and those making external requests for assistance.