

U.S. Firefighter Disorientation Study

1979 - 2001

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Firefighter Disorientation, which is loss of direction due to the lack of vision in a structure fire, is one of fire fighting's most serious hazards and according to the National Institute of Occupational Safety and Health (NIOSH), usually precedes firefighter fatality. In an effort to stop firefighter fatalities caused by smoke inhalation, burns, and traumatic injuries attributable to disorientation, a firefighter disorientation study was conducted. The study focused on 17 incidents occurring between 1979 and 2001 in which disorientation played a major part in 23 firefighter fatalities. In addition to other data, including interviews with firefighters involved in the incidents, the study was facilitated by the detailed information provided by the Firefighter Fatality Investigation Reports of The National Institute for Occupational Safety and Health. The reports allowed for the study of specific incidents in which disorientation was known to have occurred. All incidents were closely examined with special attention given to:

1. The information about the structures involved
2. The conditions found on and after arrival
3. The strategy and tactics utilized
4. The actions that occurred in the structure

Information about the Structures Involved

Occupancy Type

The structures in which disorientation occurred involved different types of occupancies including: 1 place of assembly, 1 office building, 1 multi-family dwelling, 2 single-family dwellings, 3 warehouses, 3 high-rise apartment buildings and 6 commercial structures. At the time of the fire, 8 structures were occupied, 8 were unoccupied and 1 was vacant.

The Construction Type

The construction types varied and included: 5-Fire Resistive, 2-Heavy Timber, 7-Unprotected Non-Combustible, and 3 were Protected Wood Frame structures.

Structure Size

The size of the structures also varied widely ranging from a townhouse unit measuring 19' in width and 33' in length to a paper warehouse measuring 500' in width, 600' in length and 25' in height.

Age

The age of the structures varied and included a 20-year old single-family dwelling, a thrift store built in the 1940s and a 98-year old warehouse built in 1905.

The Fire Protection Provided

In 15 of 17 structures, there was no sprinkler system or the system failed to operate. In one case (6%), the sprinkler valve was closed. In one case (6%), the heat of the fire did not activate the sprinkler heads and the ventilation system did not operate. In two cases (12%), the sprinkler system did activate.

The Structural Feature

There was a wide range of structural features associated with the 17 buildings, including size, height and type of construction. However, in 100% of the cases the structures had an enclosed design with very few windows or doors in relation to the size of the structure. The enclosed structures in which disorientation occurred also included basements and high-rise hallways. The structure's enclosed appearance was made by architectural design or by alteration after construction. When owners altered the building, pre-existing windows or doors were often enclosed by use of different materials including plywood sheeting, cinderblock, sheetrock or brick and mortar.

Conditions Found On and After Arrival

The Smoke Condition Showing on Arrival

In the vast majority of cases, 94%, there was nothing, light, moderate, or heavy smoke showing when the first fire company arrived on the scene.

The Fire Showing on Arrival

In one case (6%) there was fire showing on arrival coming from the fifth floor of an apartment high-rise building.

The Smoke Condition After Arrival

In 100% of the cases heavy smoke developed during the course of the incident that caused Prolonged Zero Visibility Conditions to occur. Prolonged Zero Visibility Conditions are heavy smoke conditions lasting longer than 15 minutes. In one case (6%), prolonged zero visibility lasted 7 hours. In 59% of the cases, prolonged zero visibility occurred suddenly after arrival. In one case (6%) prolonged zero visibility conditions occurred 52 minutes after arrival.

The Fire Conditions After Arrival

In 59% of the cases, firefighters were exposed to rollover, flashovers or backdrafts. In four cases (24%), the episodes of flashover and backdraft were sudden and violent causing immediate disorientation. In two cases (12%) involving high-rise buildings, strong winds caused flashover with blowtorch characteristics to occur.

The Strategy and Tactics Utilized

In 100% of the cases, firefighters initially executed an aggressive interior attack to locate and extinguish the seat of the fire. In 4 cases (24%) a primary search was conducted. In two cases (12%) firefighters searched for fire extension. In three cases (18%), firefighters located and attacked the fire with handlines. In 12 cases (71%) the strategy changed from an Offensive to a Defensive operation but only after injury or fatalities had occurred.

The Action That Occurred in the Structure

In 100% of the cases, firefighters became separated from the handline or became confused when they encountered loops of hose or tangled handlines. In four cases (24%), firefighters did not advance a handline into the structure when conducting a primary search or when searching for the seat of the fire. In three cases (18%), firefighters were knocked off their handline by the pressure created from flashovers and backdrafts. In one case (6%), a firefighter had the nozzle pulled from his hands during an evacuation. In one case (6%), a firefighter became separated from the handline after falling through a floor and into an involved basement. In one case (6%), a firefighter released the handline while evacuating, possibly to investigate a personal alert safety system device that was activating. In (51%) of the cases firefighters became confused when encountering tangled handlines in zero visibility as they attempted to evacuate the structure.

In 100% of the cases, company integrity was lost. In one case (6%) a fire officer was not with a crew or a buddy while inside the structure. In one case (6%), company integrity was lost as a company anxiously walked up a stairwell. In one case (6%), the crew did not enter the structure together. In one case (6%), company members became separated during the course of firefighting. In three cases (18%), company integrity was lost due to the force of flashovers or backdrafts. In 10 cases (51%), companies lost integrity during the evacuation from the building.

In 100% of the cases, firefighters became disoriented.

In 11 cases (65 %), firefighters exceeded their air supply while attempting to evacuate. In four cases (24%), firefighters were trapped due to collapsing floors or collapsing truss roofs. In three cases (18%), firefighters became disoriented secondary to flashover or backdrafts. Disorientation occurred in distances of as little as 10 feet, 10-20 feet, 25 feet and 30 to 40 feet from the point of entry. In two overly aggressive attacks, advances were made over distances of as much as approximately 80 and 200 feet resulting in disorientation.

Findings /Analysis:

The disorientation fires occurred in several different occupancy types, construction types and structures of different ages and sizes. About half of them were occupied during the fire, half unoccupied and one was vacant. However, there were many similarities in other areas.

To provide a clear understanding of the findings, the following terms are defined and utilized.

Opened Structure- An Opened Structure has windows or doors of sufficient number and size to provide for prompt ventilation and emergency evacuation. An Opened structure may or may not have a basement.

Enclosed Structure- An Enclosed Structure is one in which there is an absence of windows or doors of sufficient number and size to provide for prompt ventilation and emergency evacuation. An Enclosed structure may or may not have a basement.

Prolonged Zero Visibility Conditions- Prolonged zero visibility conditions are heavy smoke conditions lasting longer than 15 minutes.

Since these prolonged zero visibility conditions exceed the approximate breathing-time of a working firefighters' self-contained breathing apparatus, (30-minute rated), these conditions should be considered extremely dangerous should disorientation occur.

There were nine major similarities involving each of the structures and fireground operations. These areas of similarities appear in the graph in figure 1. Of the 17 national incidents studied:

1. 100% occurred in an enclosed structure.
2. 94% had nothing, light, moderate or heavy smoke showing on arrival
3. 100% utilized an aggressive interior attack
4. 100% developed prolonged zero visibility conditions
5. 100% experienced handline separation or tangled handlines
6. 100% experienced loss of company integrity
7. 100% experienced disorientation
8. 88% lacked a functioning sprinkler system
9. 100% involved a disorientation sequence

The Disorientation Sequence

A sequence of events that caused firefighters to become disoriented occurred in each of the 17 incidents studied. In general, the sequence unfolds as follows:

A fire in *an enclosed structure* with *smoke showing* occurs. The arriving fire company immediately initiates *an aggressive interior attack* to search for the seat of the fire. During the search, the seat of the fire cannot be located and conditions deteriorate with the production of heat, smoke and *prolonged zero visibility*. As companies perform an emergency evacuation due to deteriorating conditions, *handline separation occurs or tangled handlines are encountered*. *Disorientation then occurs* as firefighters exceed their air supply, are caught in flashovers or backdrafts, or are trapped by the collapsing floor or roof. When the firefighters are not located quickly enough, the outcome is *fatalities or serious injuries*. The disorientation sequence usually plays out in a structure that does not have a sprinkler system or one that is inoperable.

Why Are Firefighters Repeating the Disorientation Sequence?

Established Standard Operating Procedures in United States Fire Departments call for firefighters to utilize a quick and aggressive interior attack; also referred to as an Offensive Strategy, at any structure fire safe to enter. One fireground condition included in an officers' initial size up, is the amount of smoke showing from the structure on arrival. Light, moderate, or heavy smoke are common smoke conditions in which an officer would initiate a quick interior attack, to locate and extinguish the seat of the fire or to conduct a primary search. Based on study results however, these were the same smoke conditions that were found on arrival at 94% of the enclosed structure fires that ultimately resulted in disorientation. The root of the disorientation problem in the fire service is the lack of knowledge about the extreme danger posed by enclosed structures and the disorientation sequence.

It is clear that the cause of firefighter fatality in the categories of smoke inhalation, burns, or trauma attributable to disorientation is directly linked to specific types of structures. These structures include: Enclosed Structures, Enclosed Structures with basements, Opened Structures with basements and High-Rise hallways (Enclosed Hallways). Enclosed Structure fires will also occur in any structure in spite of the occupancy type, construction type, size, or age of the structure or whether or not it is occupied or vacant. It must be noted however, that disorientation has occurred in Opened Structures, but they seem to occur only occasionally. In one case found, disorientation secondary to flashover occurred in an Opened Structure. (NIOSH Report F2000-44)

Proposed Solutions

- A. Firefighters must be warned of the extreme dangers associated with enclosed structures and be informed that an aggressive interior attack immediately on arrival may be ineffective and unsafe in many cases. In order to avoid the disorientation sequence that leads to fatalities, Standard Operating Procedures must be rewritten adopting new strategy and tactics. These new strategy and tactics may include use of an Enclosed Structure SOP that calls for utilization of a Cautious Interior Assessment instead of a quick interior attack at the outset of the incident. A Cautious Interior Assessment is a process whereby the first engine company may enter the structure with a Thermal Imaging Camera and charged handline, established water supply and back up companies with thermal imaging cameras, to look into the structure to locate the seat of the fire. After the seat of the fire is located the Officer will decide, based on interior conditions, whether to make an aggressive interior attack and ask for back up, decide to make a Short Interior Attack from a different part of the structure or to conduct a defensive operation. An interior attack from the unburned side, which is one widely used strategy in the fire service today, has proven to be a safe and effective strategy for use in Opened Structures and should continue to be utilized. However, when distances are excessive, arrangement or amount of contents hazardous and life safety is not an issue, it may be safer to initiate a Short Interior Attack in hazardous Enclosed Structures. A Short Interior Attack involves advancing handlines to the seat of the fire using the shortest distance from the exterior. This may involve using existing windows or doors or using breaching techniques if needed. Initiating a short interior attack increases safety by minimizing the distance between the exterior and the seat of the fire to maximize efficiency of air supply, prevent handline separation, disorientation, and avoid exposure to flashover, backdraft or collapse. If breaching is not safe or cannot be accomplished in a timely manner, a defensive attack should be made.
- B. In addition, a disorientation prevention course must be provided for all firefighters. With background information provided about the recognition and identification of Enclosed Structures, Officers would then be able to identify an Enclosed Structure on arrival and be able to implement an Enclosed Structure Standard Operating Procedure that will prevent disorientation. To obtain a well-rounded understanding of the hazards associated with Enclosed Structures, in addition to National Fire Protection Association and Occupational Safety and Health Administration Standards, areas to be covered in the course should include:
1. Recognition and Identification of Opened and Enclosed Structures
 2. Hazards of Construction (Truss and Unprotected Steel)
 3. Hazards of Prolonged Zero Visibility Conditions
 4. Identification of Pre-flashover and Pre-backdraft conditions
 5. The Disorientation Sequence
 6. Instruction in an Enclosed Structure Standard Operating Procedure or Guideline
 7. Safety Equipment Required
 8. Safe Breaching Techniques
 9. Review of past Disorientation Fires
- C. Fire Departments must be advised that live burn Interior Attack and Search and Rescue practice in acquired structures, which are identified as Enclosed Structures, should be avoided.
- D. Fire Departments should ensure that sprinkler systems and other fire protection systems

at Enclosed Structures are functioning properly.

It is unclear how large the disorientation problem is as narrow escapes or injuries are not routinely investigated by NIOSH, however, the available documented evidence pertaining to firefighter disorientation is substantial, as indicated in the *April 2002 Firefighter Fatality Retrospective Study prepared by the Tridata Corporation for The Federal Emergency Management Agency, U.S. Fire Administration*. Although not part of this study, a review of the document with an eye on events involving the disorientation sequence will reveal approximately 27 additional past cases of firefighter disorientation occurring in enclosed structures.

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SIMILARITIES IN DISORIENTATION FIRES

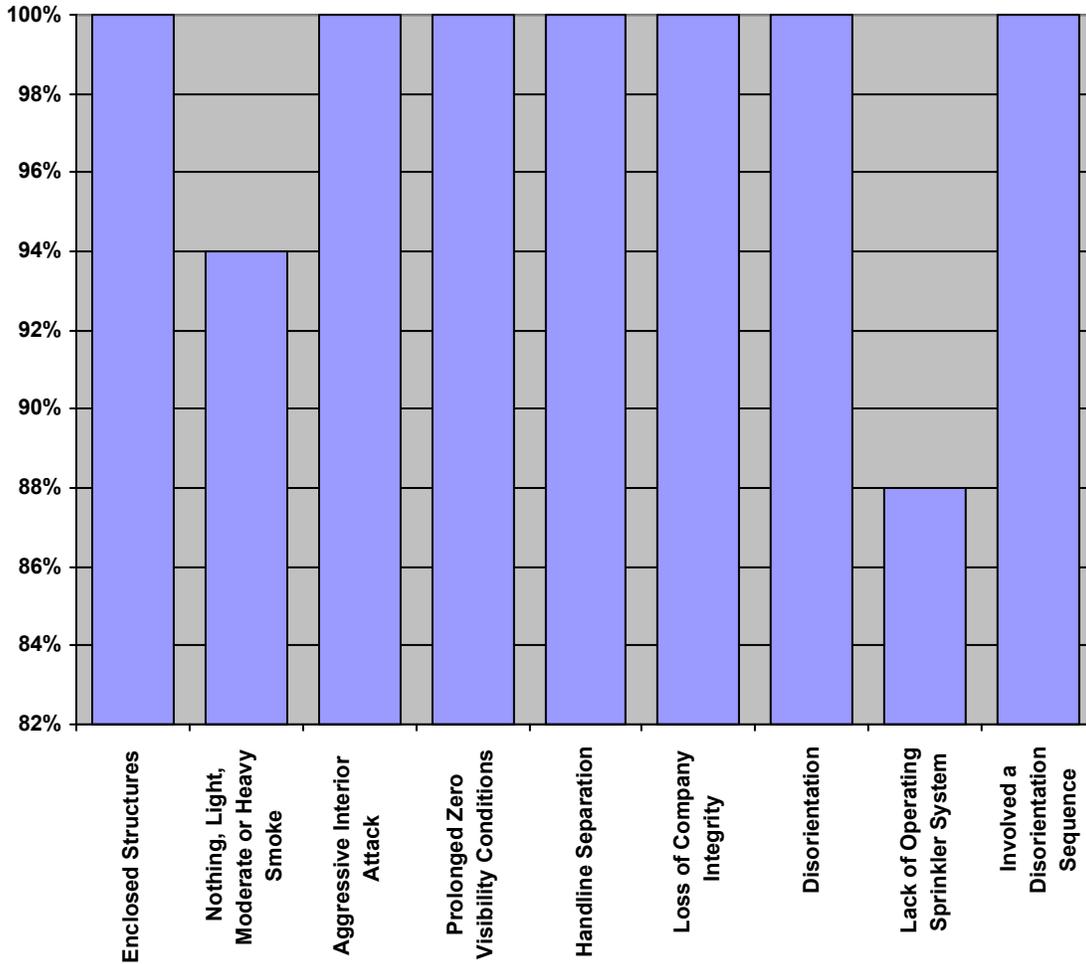


Figure 1