An Independent Review of Incident #6053780
257 Elm Street, Atlanta, Georgia
Occurring
Thursday, November 23, 2006

Commissioned by:

Dennis L. Rubin, Fire Chief

Submitted to:

Atlanta Fire-Rescue Department
675 Ponce de Leon Avenue, Northeast
Atlanta, Georgia 30308-1807

January, 2008

Developed by an independent review committee consisting of Georgia Fire Service professionals

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Editorial note:

In 1992, Vincent Dunn noted in his book, *Safety and Survival On the Fireground*,
"There are no new lessons to be learned from a firefighter's death or injury. The cause and tragedy is usually an old lesson we have not learned or have forgotten along the way." (p.364)
The following report concurs with Chief Dunn's finding.

Introduction:

On Thursday, November 23, 2006, Thanksgiving evening, Atlanta Firefighter Steven Solomon was fatally burned while conducting firefighting operations in an abandoned dwelling at 257 Elm Street Northwest. On November 24, while Firefighter Solomon was in critical condition at Grady Memorial Hospital Burn Center, Chief Rubin requested the assistance of an independent review committee to fully examine the causes of this incident and determine the actions that should be taken to prevent any similar occurrences in the future. Firefighter Solomon died on November 29, 2006 as a result of his injuries.

On Saturday, November 26, 2006, Chief Rubin convened a special meeting at Atlanta Fire Rescue Station 4 to begin a detailed review and analysis of the incident that fatally injured Firefighter Solomon. Chief Rubin invited several representatives from Atlanta Fire-Rescue and the Georgia Fire Service as well as local community members to the meeting. Georgia Fire Academy Director David M. Wall was asked to chair a special panel to review the facts regarding the incident and prepare a written report. The fact-finding process used by the panel required many hours of research and discussion. This report includes information and recommendations and the conclusions represent a consensus by the panel participants.

Background Information:

The City of Atlanta is the "Heart of the South" and is an international center for trade and commerce as well as tourism. The incorporated city covers a land area of 132.6 square miles and has a resident population of over 450,000. The City of Atlanta also owns and operates Hartsfield –Jackson Atlanta International Airport, the busiest airport in the world, which occupies an additional 7.35 square miles.

The Atlanta Fire-Rescue Department employs over 1,100 members and has an annual operating budget that exceeds $81.5 million dollars. Annual expenditures provide both fire protection and emergency responder medical services. The Fire-Rescue Department operates 31 fire stations within the urban area of Atlanta and 5 additional stations at the airport. In 2005, Atlanta Fire-Rescue responded to 58,388 alarms of which 5,749 were fire calls.

The Operations Division operates 31 engine companies, 13 truck companies and one squad company from the fire stations that are located within the city itself. These companies operate on a 3-platoon system, under the supervision of 5 Battalion Chiefs. Each platoon is commanded by a Division Chief/Shift Commander. The Department also operates an air truck and a customer service unit on each shift.

The minimum daily staffing level for the Operations Division requires 152 personnel to be on-duty. The minimum staffing level provides three (3) crew members for engine and truck companies and 6 crew members on the squad company; however the Department strives to provide 4 person crews on engines and trucks whenever possible. On November 23, 2006, a total of 193 personnel were on duty, which provided 4 person crews on all of the 31 engine companies and on 9 of the 13 truck companies. Squad 4 was operating with 7 crew members.

All Battalion Chiefs and officers of higher rank, are required to be Fire Department Safety Officers Association (FDSOA) certified as Incident Safety Officers. A majority of Atlanta Fire-Rescue captains and lieutenants also hold this certification.

The squad company, Squad 4, functions as both a hazardous materials team and a technical rescue team. Three of the double companies (engine and truck in the same station) provide decontamination support for the hazardous materials team. Companies 8 and 14, along with Squad 4, make up Georgia Search and Rescue (GSAR) Metro Task Force 6.

The City of Sandy Springs staffs an additional fire station with an engine company and 4 personnel operating under a mutual response agreement. (At the time of the Elm Street fire, this station was staffed by the Fulton County Fire Department).

The Airport Division operates the 5 fire stations on the property of Hartsfield-Jackson Atlanta International Airport. A total of 70 staff persons are assigned to the airport on each shift, with a minimum of 57 personnel on duty each day. Battalion 7 includes 4 engine companies and 2 truck companies for structural fire protection and operates 9 crash trucks, one mini-pumper, a hazardous materials unit and 3 Advanced Life Support transport units. Supervision is provided by a paramedic supervisor, and a Battalion Chief.

Fire Station 16

Firefighter Solomon was assigned to Fire Station 16 in North West Atlanta, which is part of the 2nd Battalion. Engine and Truck 16 responds on first alarm assignments in the western part of downtown Atlanta, which includes the Georgia Dome, the Georgia World Congress Center and the new Georgia Aquarium.

Station 16's territory includes an area traditionally known as Vine City, a primarily residential area close to downtown Atlanta. The fire occurred at 257 Elm Street, which was one of many vacant and abandoned structures in the area. The Vine City area also includes many vacant lots where structures have been demolished in anticipation of urban redevelopment.

The firefighters at Station 16 were very active in their community and have hosted a Christmas party for underprivileged children in their district for the past 36 years. The most recent children's Christmas party had over 300 in attendance.

Committee Participants:

The interviews of Atlanta Fire-Rescue personnel were conducted at sites away from their normal workplaces, this to provide more neutral, relaxed settings that would be most conducive to the firefighters "telling their story in their own words." Several days of interviews were conducted using space at the Georgia World Congress Center. Additional interviews with members who were unavailable for the initial sessions were conducted a few weeks later and at other locations.

The interviews were conducted over a period of several days by Dr. Vic Pentz, J. Gordon Routley, and Chief Chris James. Committee Chair David Wall was also present during the interviews. Each interview began with an introduction of the committee members and an explanation of the committee's charge and process. The interviewees were informed that the process was intended to gather information and analyze the situation that occurred so that the lessons learned could be used to prevent future tragedies. They were assured that the process was non-punitive and that nothing that was stated to the interview panel would be used for disciplinary purposes. All of the interviewees were cooperative in relating their observations and recollections and open to questions from the interview committee.

Each interviewee was asked to describe the incident and their actions to the best of their recollection. The critical activities occurred in a small area within a very short time frame and involved a large group of firefighters. The interview panel attempted to trace the actions of each firefighter and correlate their observations to fully analyze the situation and the sequence of events.

Building Description:

The fire occurred in an abandoned structure at 257 Elm Street Northwest, approximately one half mile west of the Georgia World Conference Center and the Georgia Dome Complex. The neighborhood included a mixture of occupied and abandoned residential structures as well as numerous vacant lots where structures had been demolished.

The structure was one story high, with brick exterior walls and a wood gable roof covered with asphalt shingles. The exterior dimensions were approximately 36 feet wide by 34 feet in depth. The interior dimensions were 35 feet wide by 32.5 feet deep, for a total floor area of 1,137.5 square feet. The house was constructed on a concrete slab and the exterior walls were assembled with two wythes of brick, covered by plaster on the inside surfaces. The property had been abandoned and boarded-up for an unknown period of time. All of the exterior windows and doors had been covered with plywood.

Exposure A was the street. The lot to the north (Exposure B) was a vacant lot where a similar structure had been demolished. There was a large vacant property to the east (Exposure C) and a separation of approximately 25 feet to an occupied structure on the south side (Exposure D). Two other vacant structures of similar construction occupied the properties north of Exposure B and records indicate that there were originally six similar structures in a row along the east side of the street. The property sloped downward from front to rear, so that the front entrance was approximately 6 inches above grade level and the two rear doors were approximately 7.5 feet above grade level. The rear doors were accessible via a pair of steep exterior concrete block stairways.

The interior was configured to provide two small dwelling units. The front door (Side A) opened into a small vestibule that provided access to the dwelling units on the left and right sides. Each unit had access to one of the rear doors on Side C.

The interior vestibule wall was the only remaining solid wall inside the structure.
All of the interior doors had been removed and the interior walls and ceilings had been stripped of their gypsum and plaster coverings, leaving the wood studs and rafters exposed. Several sections of the wood studs had also been removed, along with most of the plumbing fixtures and electrical wiring. There were no utilities connected to the structure.

A homeless couple had illegally taken up residence in the house. The covering (plywood sheeting) over the rear doorway at the northeast (B/C) corner had been removed to provide access. A few belongings including two mattresses were inside the house. The occupants were using candles for illumination. Investigators determined the origin of the fire was at or near the mattresses, and the cause of the fire was one or more burning candles.

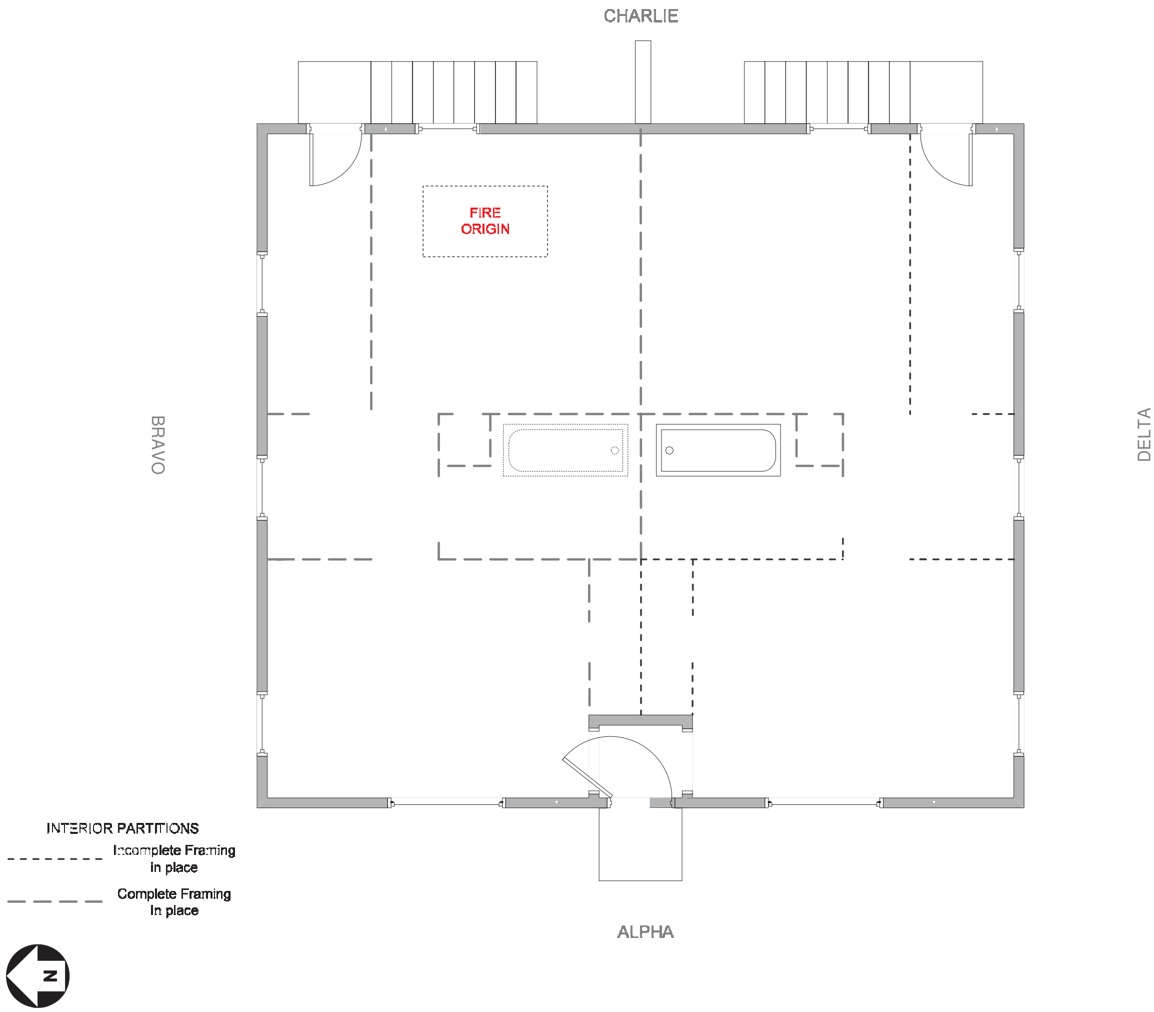


Figure 1

Sequence of Events

Atlanta Fire-Rescue received one telephone call from a neighbor and transmitted a first alarm for a reported fire "in an abandoned house across the street from 260 Elm Street" at 20:02 hours. The first alarm assignment consisted of Engines 16, 1 and 7 (Paramedic Engine), Trucks 16, 1 and 11, Squad 4, Battalion Chiefs 2 and 3 and Customer Service 5. The total response included 37 on-duty personnel; the engine and truck companies each had 4 crew members assigned (Engine 1 only had 3 members assigned while Truck 1 responded with 5 people due to members being detailed to other stations for the shift), while Squad 4 was operating with 7 crew members. Each Battalion Chief is assigned a Command Technician (Aide), while Customer Service 5 is a one-person unit.

Due to the location of the fire, which was close to the central part of the city, five companies arrived in rapid succession, between 20:05 and 20:06 hours. First due Engine and Truck16 arrived from the north, just ahead of Engine 1, which was coming in from the south. Truck 1 and Engine 7 were close behind, also arriving from the south.

On approach to the scene, smoke was visible from a distance of two or three blocks. The initial radio report was “Engine 16 on the scene at Elm and Thurmond. We have a working fire in a one story brick. Engine 16 is assuming command and accountability and pulling two attack lines.” Engine 16 stopped in front of the house and the crew deployed one pre-connected 1-3/4 inch hose line toward the front door.

The recorded radio traffic did not include any communications between Engine 16 and the other companies that arrived almost simultaneously. The second and third arriving engine companies and the first and second arriving truck companies all initiated actions based on standard operating guidelines. The communications that did occur among the company officers were conducted face-to-face; the officers in charge of Engines 1 and 7 confirmed between themselves that Engine 1 would be assuming the rapid intervention team duty.

Engine 1 stopped in front of Engine 16 and the crew began performing rapid intervention team functions at the front of the house. The Captain and two firefighters from Engine 7 proceeded to the front door, while the apparatus operator laid a 5-inch supply line from a hydrant to Engine 16. Trucks 16 and 1 both positioned their apparatus short of the scene and their crew members walked up to the house to perform forcible entry and ventilation.

All of the visible windows and the front door were covered by plywood and heavy dark smoke was issuing from the eaves and around the boards. The officer and one firefighter from Truck 16 worked on removing the plywood from the front door, while other members removed plywood from windows at the front and on both sides of the house (sides B and D).

Squad 4, Battalion 3 and Battalion 2 all arrived from the north at 20:07 hours. The Captain in charge of Squad 4 called the Incident Commander on the tactical radio channel asking for instructions and was directed to bring forcible entry tools up to the fire building.

As the first arriving command officer, Battalion 3 was designated to assume command of the incident, while Battalion 2 was designated to assume the Safety Officer position. Battalion 3 assumed command of the incident almost immediately after arrival. The Battalion 3 vehicle was pulled into a driveway on the opposite side of the street, about 100 feet from the involved structure, to establish a fixed command post.

The two command officers conferred briefly at the command post, noting that there had been very little radio traffic on the tactical channel from the units that were already on the scene. From their vantage point they could see heavy black smoke issuing from eaves of the building. Their view was obstructed by parked fire apparatus and they could not see the activities that were occurring around the front door. Battalion 3 called to Engine 16 on the tactical radio channel, requesting confirmation that the rapid intervention team had been assigned; the acting officer of Engine 16 responded “repeat your traffic.”

At approximately the same time, the plywood covering the window to the left of the front door was pulled off and a large quantity of heavy dark smoke was released. Some flames also began to vent through this upper part of this opening. The Captain in charge of Engine 7 briefly contemplated making entry with the attack line through this opening, but determined that there was a steel casement window assembly blocking this access.

A few seconds later the plywood covering the front doorway was removed by the firefighter from Truck 16 and the interior door was pushed open. As soon as the door was opened, the charged attack line that had been positioned at the doorway was advanced inside by the crew of Engine 16; E-16 OIC and Firefighters Solomon and E-16 FF1. Firefighter Solomon had the nozzle and was backed-up by E16 FF1, while E-16 OIC followed. The Engine 7 crew, E-7 OIC and E-7 FF1 and E-7 FF2 were on or near the front porch preparing to enter through the same door.

E-16 FF1 and E-16 OIC reported that they immediately encountered high heat and zero visibility conditions and had to crouch or crawl as they entered the vestibule and turned right into the A/D corner room. E-16 OIC observed the seat of the fire toward the B/C corner of the house as he came past the end of the vestibule wall and tried to indicate to Firefighter Solomon to reposition the line in that direction to better attack the fire. Conditions deteriorated rapidly within a matter of seconds as the interior of the house ignited, forcing the three members who were inside to drop to the floor. E-16 OIC and E-16 FF1 stated they lost contact with Firefighter Solomon as they crawled back toward the front door and managed to escape.

An order to switch to defensive strategy was given by Battalion 3 almost simultaneously with the change in conditions inside the house. "Elm Command to all units on the scene let's go defensive for a minute. We've got too much fire involved. Everyone go defensive, stay out and get some lines in a window. We'll check on it and see if we can go back interior shortly."

A rapidly increasing volume of flames was visible from the command post when this order was transmitted. The Incident Commander could see that the house was becoming fully involved in flames, but he was not aware that the three firefighters from Engine 16 had already entered. The radio transmission calling for defensive strategy was recorded approximately twenty seconds after Battalion 3 had asked Engine 16 about the rapid intervention team assignment.

E-16 OIC and E-16 FF1 reported that they had only advanced a few feet into the house when they heard the order to switch to defensive strategy. The message was transmitted at virtually the same time as the interior conditions became untenable. They reported bumping into each other or colliding with other firefighters as they moved toward the doorway.

E-7 FF1, who had begun to make entry through the front door, also heard the order and reversed direction. E-7 FF1 was pulled outside by another firefighter who was on the front porch. E-7 FF2, who was still on the porch preparing to enter, was pulled away from the doorway as flames enveloped the vestibule and vented out through the front door opening. Within seconds the interior of the house became fully involved and flames were venting through every visible opening.

The members who had been inside were momentarily disoriented; they had to regroup and readjust their protective equipment before they could resume any firefighting activities. While this was occurring, three other members who had remained outside (T-1 OIC, E-7 OIC and E-1 FF1) observed the silhouette of a firefighter moving across the vestibule from left to right, enveloped in flames. The Incident Commander was advised that "someone" was still inside the house. Upon receiving this information the Incident Commander requested an Advanced Life Support unit – this request was transmitted less than 60 seconds after the order to switch to defensive strategy had been transmitted.

As the firefighters regrouped at the front door, E-7 FF1 retrieved the nozzle from inside the doorway and began to direct water into the room to the left (A/B corner). The nozzle was then handed over to T-16 OIC and the stream was directed into the A/D corner room, where the firefighter had disappeared into the flames. A second pre-connected line, which was being deployed by the rapid intervention team when the interior ignited, was quickly charged and the stream was directed into the windows in the A/B quadrant. The two hose lines knocked down the flames within approximately 60 seconds.

As soon as the fire was knocked down, search efforts were initiated for the firefighter who had been seen through the doorway. Squad 4 crew members, who were at the rear door, heard the report of a person inside and used a thermal image camera to scan the interior. They quickly located the victim who was on the floor near the D-side wall, approximately half way between the front and rear of the house. A rescue team from Squad 4 entered from the rear, while E-7 OIC and E-7 FF1 from Engine 7 entered through the front door and followed the walls in a right hand search pattern. Both teams reached Firefighter Solomon at the same time.

When he was found, Firefighter Solomon was unconscious and lying in a prone position, facing the rear of the house. He had removed his helmet, protective hood and self-contained breathing apparatus face piece and was severely burned around the face and head. His right boot was missing and the lower leg and foot were also severely burned. He was carried to the rear door and handed over to firefighters who were waiting outside. The total elapsed time from initial entry of the hose line team through the front door until Firefighter Solomon was removed through the back door was less than 5 minutes.

E-7 FAO began to provide advanced life support treatment as Firefighter Solomon was carried from the rear yard to the front of the house. The advanced life support ambulance from Grady Emergency Medical Services was arriving as they reached the street and Solomon was quickly loaded and transported to the main Grady facility, which includes a Level One Trauma Center and a Regional Burn Center.

Firefighter Solomon was initially treated in the Emergency Department and later moved to the Burn Center. His visible injuries included full thickness burns to the head, face and front of neck. He also had full thickness burns to the right foot, ankle and lower leg which correspond to the area a firefighter boot would cover. He had patches of burns to the upper arms and the hands. He also suffered severe burn injuries to the lungs and airway from the inhalation of superheated air. (See Appendix B for Dr. James Augustine's complete report)

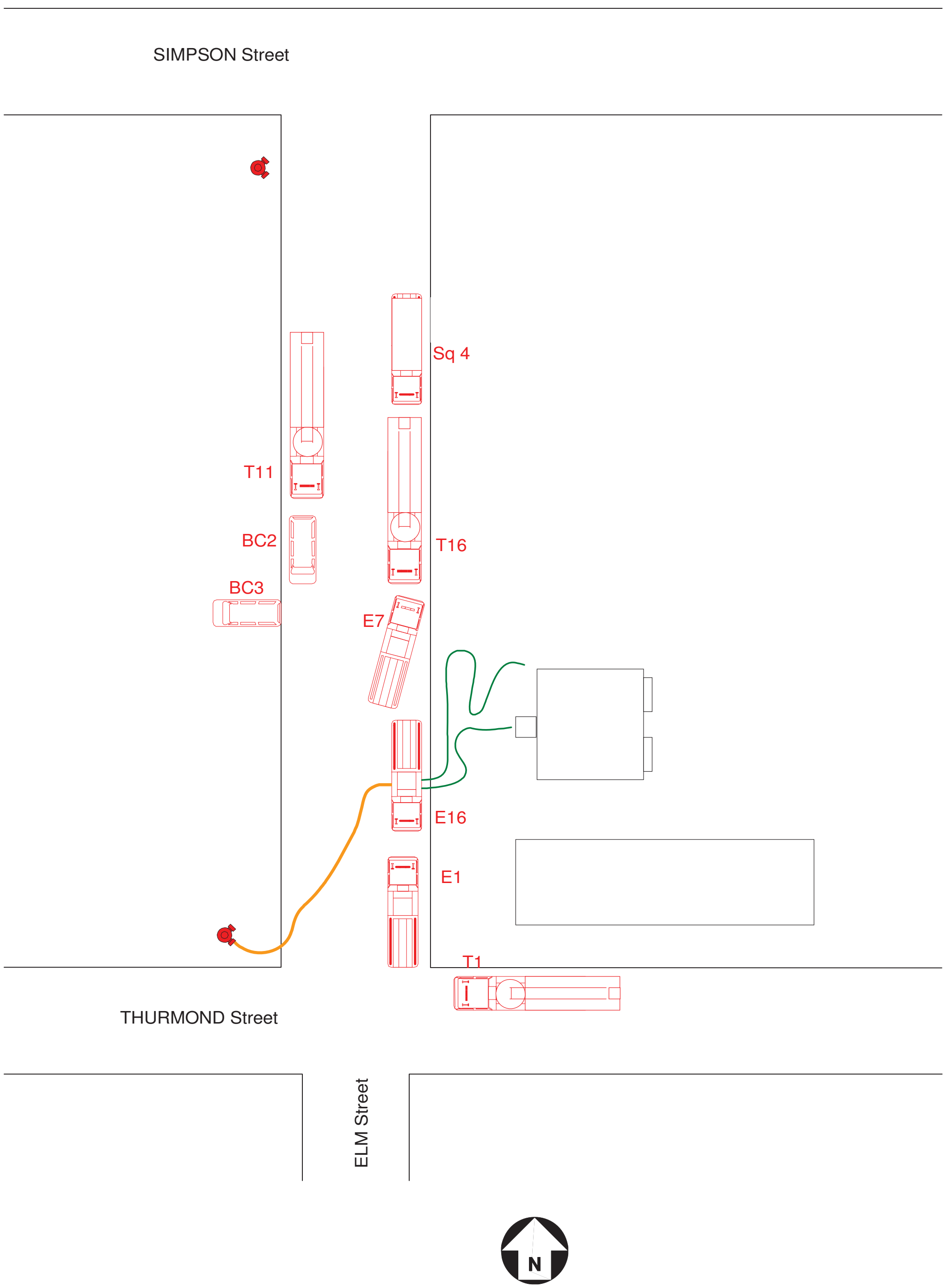


Figure 2 Apparatus' positions

Fire Model Analysis

Computer modeling of the fire scenario at 257 Elm Street was conducted by Schirmer Engineering Corporation using the Fire Dynamics Simulator software, developed by the National Institute of Standards and Technology. The computer model was used to develop an understanding of the most likely sequence of events as the fire progressed and the conditions that existed when the firefighters entered and while they were inside the dwelling.

The Fire Dynamics Simulator requires a series of inputs to represent the physical characteristics of the dwelling as it existed before the fire. The inputs include a 3-dimensional representation of the structure, including the locations and dimensions of all window and door openings, as well as the characteristics of construction materials, interior finishes and contents. This information was obtained from detailed examination and documentation of the fire scene.

Although the structure was relatively small, the interior was one relatively large undivided space, allowing heat and fire gases to flow freely throughout the dwelling. All of the ceilings and most of the wall coverings on the interior partitions had been removed, leaving the wood studs, rafters and the underside of the roof decking exposed. Also, there were very few contents inside the structure. The initial fuel package for the fire included the two mattresses and the few personal belongings that were on the floor in the B/C quadrant. The exposed wooden structural components provided most of the available fuel.

The model assumed that one of the mattresses was ignited by an open flame, approximately 10 minutes before firefighters arrived and began to conduct operations. The time of ignition is an approximation, based on witness reports and time references from the recordings of radio traffic. The sequence begins with all of the windows and doors closed, except for the rear door in the B/C quadrant which was partially open to simulate partial removal of the plywood covering. Additional doors and windows were programmed to open in the approximate sequence of ventilation actions, as described by the firefighters who were on the scene.

The FDS model predicted that the mattress would initially burn freely, producing flames and moderate quantities of smoke that would accumulate inside the structure. The fire would spread to the second mattress and the rate of combustion would increase until the fire was producing approximately 2 to 3 Megawatts of heat energy. At a certain point in the growth sequence, most of the available oxygen within the structure would have been consumed and the rate of combustion would have been regulated by the rate of oxygen replenishment from fresh air entering through the partially open doorway. From that point the fire would become ventilation-controlled; the supply of fresh air would regulate the rate of combustion and the growth of the fire.

During the ventilation-controlled phase, the fire would produce large quantities of smoke, which would completely fill the atmosphere inside the dwelling. The burning mattresses would release a highly combustible mixture of soot and gaseous products of combustion, including large quantities of carbon monoxide. This would produce an atmosphere that was hot and rich in fuel, but lacking sufficient oxygen to support combustion. A thermal column would have been created directly above the seat of the fire and convection currents would have distributed the heated fire gases throughout the structure.

As the fire continued to burn, the flames would have reached the underside of the roof decking and ignited the exposed wood directly above the seat of the fire. The wood would begin to glow, releasing additional heat energy and products of incomplete combustion. There would have been insufficient oxygen to allow this additional fuel to burn freely.

With all of the windows and doors covered by plywood, except for one partially-open doorway, most of the heat and fire products would have been trapped inside the structure. The roof decking was one-inch boards, covered by multiple layers of asphalt shingles - at least 5 layers in places. This roof construction helped to contain the heat and resisted burn-through, which could have provided vertical ventilation directly above the seat of the fire.

After 8 to 9 minutes, when firefighters would have been arriving, the model indicates that the interior atmosphere would have been filled with hot products of combustion and heavy smoke would have been escaping through any available openings. These predictions are consistent with the observations of firefighters as they arrived. The atmosphere inside the dwelling at this time would have been a fuel-rich mixture of soot, carbon monoxide and other highly flammable gases. The temperature of this mixture would have been stratified from the roof level down to the floor, with the upper level probably above its auto-ignition temperature and the floor level temperature in the range of 200^o to 300^{o}F. The lack of oxygen prevented this mixture from igniting spontaneously.

The computer model cannot account for every factor. For example, the roof structure was “stick built” (not prefab trusses) utilizing 2 X 6 rafters and 1 X 6 boards for decking. All of this wood, in addition to the wall studs, was exposed to the increasing temperatures produced by the fire. The wood was mostly soft pine, which has very high sap content. At elevated temperatures the sap would have been distilled from the wood, releasing flammable turpentine vapor into the atmosphere. This would cause the atmosphere to become even more fuel-rich than the model predicted.

The computer model was programmed to assume that firefighters began to remove the plywood coverings from the windows and doors at the 10 minute mark and one additional opening was uncovered every 15 seconds. When the first window coverings were removed, the interior pressure would have pushed smoke outward. As more windows were opened, the internal and external pressures would have equalized and fresh air would have begun to enter at the lower levels. Within approximately two minutes the model indicates that there would have been sufficient oxygen mixed into the atmosphere to allow the gaseous products near the roof level to begin to ignite. The rapid increase in heat production would cause the atmosphere to ignite from top to bottom within approximately 20 seconds.

The computer model predictions are consistent with the observations that were reported by firefighters on the scene. They reported that heavy smoke began to vent through the openings, as soon as the plywood was removed. Within 60 to 90 seconds they observed licks of flame at the upper levels of the window openings. As predicted by the model, they reported that the interior atmosphere ignited from top to bottom and within 30 to 60 seconds flames were issuing from every opening.

This sequence of events had begun at the time that the initial entry crew advanced the hose line through the front door and into the A/D quadrant of the house. Flames were observed at the upper level of the left front (A/B) window as they were preparing to enter. Within 60 seconds after they entered, the atmosphere became unbearably hot and forced them to the floor. The Incident Commander observed the flames and ordered the switch to defensive strategy at approximately the same time.

The computer model indicates that the temperature 3 feet above the floor (crouching or crawling level) would have been in the vicinity of 200^{o} to 250^{o} F when the firefighters entered the A/B quadrant of the house and the visibility would have been 6 feet or less. As the gases ignited, the temperature at this level would have exceeded 1500^{o}F within a few seconds. The model indicates that the intensity of the fire would have begun to decrease within approximately one minute, as the combustible products in the atmosphere were consumed.

The phenomenon that occurred inside the house is described as a flameover as opposed to a flashover. A flashover is defined as the rapid transition phase that occurs when all of the exposed and pre-heated combustible surfaces within a space ignite almost simultaneously. In this case the fire gases ignited, as well as the roof decking and rafters; however, the exposed combustible surfaces at the lower levels did not ignite. The burning fire gases created a mass of flames; however the exposed wood and other combustible materials at lower levels did not reach their ignition temperature before most of the fuel in the atmosphere had been consumed. The classic flashover sequence was not completed.

The model indicates that most of the combustible fuel in the atmosphere would have been consumed within approximately one minute and the intensity of the fire would have begun to diminish. This is also consistent with the observations of firefighters who reported that the fire was quickly controlled by the two hose streams. Only 150 to 200 gallons of water were discharged over 60 to 90 seconds to control the fire.

Actions of Firefighters Inside the Structure

The initial entry into the house was made by three members from Engine 16, as soon as the front door was opened by the firefighter from Truck 16. The 1-3/4 inch line had been charged and positioned near the front doorway. Firefighter Solomon had the nozzle and entered first, followed by E-16 FF1 and E-16 OIC. The entry team had one portable radio, which was carried by E-16 OIC.

The front doorway opened into a small vestibule that had provided access to the left and right side dwelling units. The back wall of the vestibule, facing the front door, was the only interior partition in the structure that had not been stripped of its wall coverings. The interior doors leading to the two dwelling units had been removed.

The front door swung inside and to the left and would become stuck in a position that blocked access to the left side of the house. E-16 OIC and E-16 FF1 reported that the smoke was so thick that they could not see the door or the vestibule wall as they entered. They ran into the wall straight ahead and felt the door to their left, leaving the opening to the right as the only available path to advance inside. (See Figure 3 showing partially open door.)

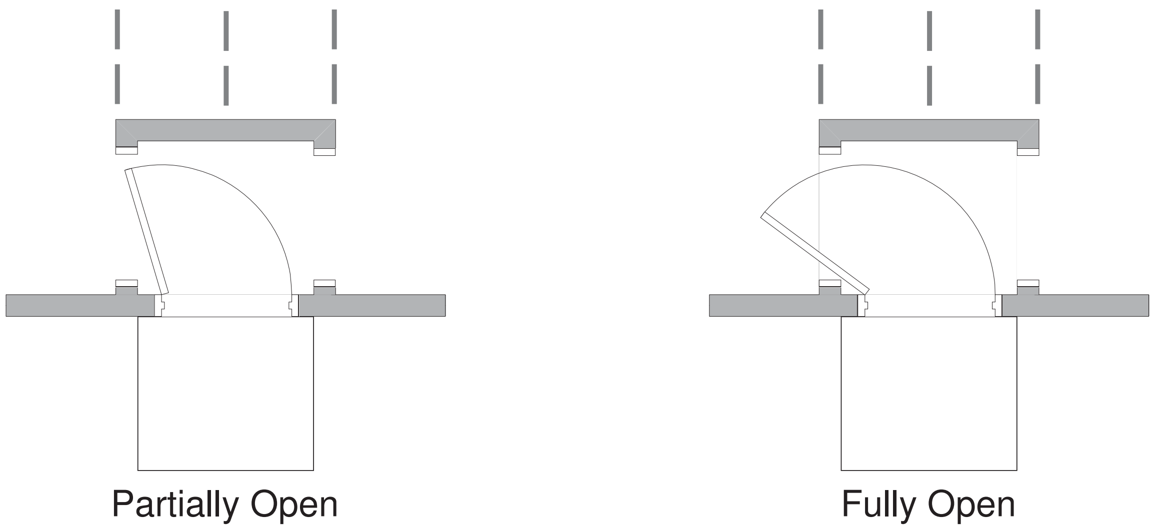


Figure 3

E-16 OIC and E-16 FF1 reported that they encountered unusually high heat conditions and had to crouch or crawl to stay low as they entered. They could not see each other and voice contact was muffled by their self-contained breathing apparatus masks. They followed the hose line to the right, into the A/D corner room, and believed that they were within close proximity to Solomon. They believed that one or two other firefighters followed them into the room, although they did not know who was behind them. No other firefighters reported that they had entered and turned to the right.

After moving a few feet inside, E-16 OIC became aware that the seat of the fire appeared to be in the diagonally opposite corner of the house, in the B/C quadrant. The lack of solid interior partitions and ceilings allowed him to sense the general location of the fire, although it was impossible to see anything clearly. The entry team members had begun to reverse direction to move toward the fire when the order to switch to defensive strategy was transmitted. E-16 OIC and E-16 FF1 estimated that they were not more than 6 to 8 feet inside the front door when they heard the instruction to evacuate. They were not sure if they heard the order over the radio or from other members shouting to them. They reported that the temperature was increasing rapidly at this time, forcing them to drop to the floor level. They stated that the line was charged, but they did not believe that the nozzle was opened while they were inside the house.

E-16 OIC and E-16 FF1 reported that they had to crawl along the floor and struggle to get through a crowd of firefighters in the vestibule and doorway in order to exit. They believed that they were only inside for about one minute and noted that flames were coming out over their heads as they crawled outside. At least one company officer was standing on the front porch pulling members back from the doorway as they exited. Several members stated that they found themselves on the ground outside, unsure how they got there.

Firefighter Solomon was observed running through the vestibule from left to right (from the A/B corner room to the A/D corner room) a few seconds after the last firefighters escaped from the house. The three members who saw him stated that they saw the silhouette of a firefighter wearing protective clothing enveloped in flames. They could not identify who it was or determine if he was wearing all of his protective clothing at that time.

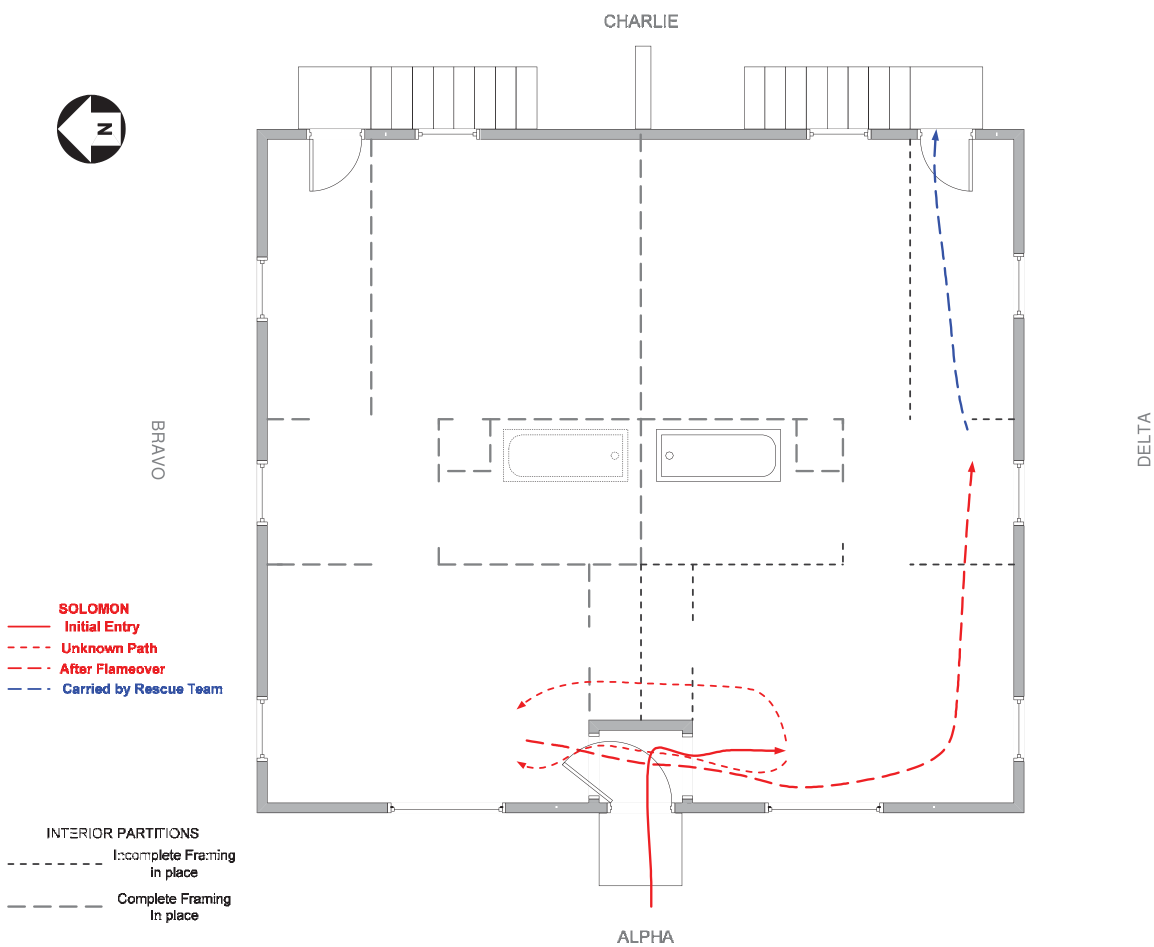


Figure 4

It is impossible to determine exactly when or how Firefighter Solomon moved from the right side to the left side of the house (from the A/D corner room to the A/B corner room). E-16 FF1 and E-16 OIC stated that they had followed the hose line and were certain that it went to the right, into the A/D corner room. While they were inside they did not see or communicate with Firefighter Solomon; however, they believed that he was just ahead of them. At some point Firefighter Solomon crossed over to the opposite side of the house.

It is possible that Firefighter Solomon became entangled in the crowded vestibule while attempting to exit and fell into the room on the opposite side. It is also possible that he was in the process of repositioning the line and had already crossed back through the vestibule into the A/B room when the situation became critical. A third possibility is that he could have crawled behind the vestibule wall and between the exposed studs of the partition to cross over to the dwelling unit on the opposite side.

Somewhere in the process of moving from the right side to the left side of the doorway, Firefighter Solomon lost contact with the nozzle and also lost his right boot. The nozzle was found on the floor near the doorway from the vestibule into the A/B corner room. The boot was found on the floor, more toward the center of the same room. These factors indicate that Solomon was in the room and became entangled in something that caused his boot to be pulled off.

On initial opening, the front door would stop in a position that blocked access into the A/B corner room, leaving only a few inches of clearance from the back wall. The door would swing fully open if it was pushed with moderate force, allowing access to the A/B corner room. Individuals who entered after the flameover noted that the door had been pushed fully open. The door could have been pushed open by Firefighter Solomon as he either crawled or stumbled into the A/B corner room. (see figure 3)

Firefighter Solomon's boot was found to the left of the front door in the A/B corner room. There was debris on the floor of this room that could have entangled a boot. The boot could have become entangled in the door as he was crawling through the vestibule or it could have been caught between studs as he crawled through the remains of an interior partition. The boot also could have become caught in another firefighter's equipment when they collided in the vestibule.

E-7 FF1 reported that he was just starting to enter the A/B corner room when he heard the shouted order to pull out. He stated that the front door was fully open at that time and that he saw the nozzle on the ground in the entrance to the A/B corner room. These observations suggest that Firefighter Solomon was already in the A/B corner room when E-7 FF1 attempted to enter. E-7 FF1 was pulled out by another firefighter and was on the ground outside when Solomon was observed running across the vestibule.

After becoming reoriented, E-7 FF1 was able to reach inside and pull the nozzle back to the front doorway. This was one of the two lines that were used to knock down the fire.

It was the only line that had been stretched, charged and advanced into the structure when the flameover occurred.

Protective Clothing and Equipment

All of Firefighter Solomon's protective clothing and equipment was recovered and sent to laboratories for examination. Preliminary examination indicated heat damage to all of the items consistent with exposure to a flashover or flameover environment. The gear report is included in Appendix F.

Firefighter Solomon did not have a portable radio when he entered the structure. When he was located, the personal alarm signaling system (PASS) device that was integrated into his self-contained breathing apparatus was sounding and the LED lights were flashing. Several members heard the PASS device and observed the flashing lights as they moved toward Solomon.

Firefighter Solomon's helmet and hood were found on the floor in the A/D corner room, along his assumed path of travel. The self-contained breathing apparatus face piece and regulator had been removed from his face. The regulator and face piece were still attached to the main assembly, which was still attached to Firefighter Solomon's body. His left boot was still in place. (The right boot was found in the room on the opposite side of the house.)

Initial examination of the self-contained breathing apparatus face piece indicates that the lens was intact, although most of the lens area had become opaque as a result of heat and flame exposure. The upper part of the lens appears to have been protected, most likely by Firefighter Solomon's protective hood. The condition of the lens suggests that Firefighter Solomon's vision through the face piece was compromised at some point while he was in the fire environment. This could explain why he removed his helmet, hood and face piece, which were all found along his assumed path of travel.

Recommendation

- Research should be conducted to determine whether existing performance standards for SCBA face piece lenses provide sufficient protection when firefighters are exposed to flashover conditions. Premature failure of the lens could have fatal consequences. If vision through the lens is suddenly compromised, the user could become disoriented and unable to locate a safe exit. The NIOSH report on the SCBA and face-piece was not available for review by this committee at the time this document was submitted.

Analysis of Operations

The operations that were conducted at the Elm Street incident were carefully reviewed by the Incident Review Committee to determine whether or not the applicable Atlanta Fire-

Rescue standard operating procedures and guidelines were followed and whether or not the personnel involved were adequately trained and equipped to conduct operations safely and effectively.

The Incident Review Committee also examined all of the relevant standard operating procedures and guidelines to determine if they provided appropriate direction for the situation that occurred. Several changes and clarifications to SOPs and SOGs are recommended. The applicable training programs were also examined to determine the need for changes or improvements.

Incident Command

Atlanta Fire Rescue Standard Operating Procedure 03.96 and Standard Operating Guideline 101.02 establish the departmental policies for establishing command of an incident and performing the functions of Incident Commander. In addition, Standard Operating Guideline 101.01 describes standard functions for engine and truck companies and Standard Operating Guideline 101.03 provides standard assignments for the initial arriving companies at a structure fire in a low-rise occupancy. The Standard Operating Procedures and Standard Operating Guidelines incorporate terminology, definitions and general concepts that are consistent with national models and are founded on accepted principles.

The responsibility to direct and coordinate operations at an emergency incident is assigned to the Incident Commander, beginning with the first arriving company officer. The initial Incident Commander is expected to make critical decisions that establish the foundation for all subsequent operations. Among the most critical responsibilities assigned to this individual are size-up and determination of the appropriate strategic mode (offensive, defensive or marginal).

Standard Operating Procedure 03.96, paragraph 8.7.6 states:

> All operations upon arrival are assumed to be in an offensive/rescue mode and phase of operation. When indications are present that justify a change in the mode/phase of operation, command is mandated to make the change. When command makes such a change, it is incumbent on command to announce this change to all personnel operating at the incident.

The guidelines for standard assignments (Standard Operating Guideline 101.03) provide a basic framework that is intended to allow the first three engine companies and the first three ladder companies arriving at a low-rise structure fire to initiate tactical operations without specific instructions from the Incident Commander. All of these standard assignments are based on an offensive interior fire attack strategy. The Standard Operating Guideline provides significant judgmental leeway for each company officer to take actions within the general guidelines, however there is a fundamental expectation that all arriving companies will automatically initiate offensive tactical activities, unless the initial Incident Commander provides different instructions.

At the Elm Street incident, the initial Incident Commander did not provide any specific direction or instructions for the four companies that arrived on the scene within seconds after Engine 16. The only recorded radio traffic was "Engine 16 on the scene at Elm and Thurmond. We have a working fire in a one story brick. Engine 16 is assuming command and accountability and pulling two attack lines." This radio traffic met the criteria for the required initial radio report, or the *Six Points of a Brief Initial Report* per the training received by Company Officers and documented with wallet cards. If the initial Incident Commander provides no direction, all of the other arriving companies can be expected to initiate offensive tactical operations on their own initiative.

The initial Incident Commander was in command of the incident for less than 2 minutes and 30 seconds before Battalion 3 arrived and assumed command. During this period, the initial Incident Commander was personally involved in advancing the first attack line and preparing to make entry to the house. The next four companies arrived and initiated operations without direction. The recorded radio traffic indicates that the only direction provided by the initial Incident Commander during this period was for Squad 4 to bring forcible entry tools to the house.

At the time Battalion 3 assumed command of the incident, five companies were already operating and the crew of Engine 16 was in the process of making entry to conduct an offensive attack. Within 45 seconds after assuming command, Battalion 3 called for a switch to defensive tactics based on fire conditions that could be observed from the command post. At this time the Incident Commander did not know that an attack team had already entered the structure or how any of the other companies on the scene had deployed. There was no "passing" of command to Battalion 3. There were assumptions of command.

There was no back-up hose line in position when the attack line was advanced into the structure and the assigned rapid intervention team was not prepared to make immediate entry if needed. At least one member of a second engine company stated he entered the house without a hose line and without the knowledge of his company officer. The personnel accountability system had not been activated to keep track of personnel operating in the hazardous (IDLH) area. The command technician from Battalion 2 was walking to the apparatus to pick up the accountability tags when the event occurred.

As the interior of the house erupted in flames, the accountability system could not be used to determine who managed to escape and who could still be inside. The requirement in Standard Operating Guideline 101.07 to conduct an immediate Personnel Accountability Report when switching from offensive to defensive strategy was not implemented.

Although three members outside reported seeing a firefighter still inside and enveloped in flames, the May Day Procedures (Standard Operating Guideline 101.09) were not initiated. The Incident Commander received a verbal report that "someone was still inside" but he did not know for several minutes that a firefighter was missing. When a

Personnel Accountability Report was requested two minutes later, the Incident Commander received an erroneous report that all of the crew members from Engine 16 were accounted for.

The Incident Commander was located at a Command Post that was approximately 100 feet from the front of the house and across the street. The Incident Commander could not see the activities that were occurring around the front door, because the view was blocked by parked apparatus. He was not aware that the crew of Engine 16 had already entered when he called for defensive strategy. He received very limited information from radio reports and face-to-face verbal reports while Firefighter Solomon was missing. He was not aware of the situation that was occurring and could not coordinate the rescue efforts.

The interviews that were conducted with members who were on the scene indicate that the operations at the front of the house, involving five companies, were uncoordinated through the critical period of the incident. The Incident Commander did not have effective control of the operation until after the fire was under control and Firefighter Solomon had been removed from the house.

Initial Incident Commander

The initial Incident Commander at this incident was the Acting Officer in charge of Engine Company 16. This individual was a firefighter who normally worked on a different shift at Fire Station 16. He was working on a shift trade and was not personally familiar with the other crew members who were on duty.

The initial Incident Commander is required to select the appropriate strategy for the incident and to select an appropriate command mode for himself or herself, depending on the situation, as well as providing direction for the other companies arriving on the scene. The initial Incident Commander had several additional responsibilities that are listed in Atlanta Fire Rescue Standard Operating Guidelines, which include making a 360 degree size-up of the incident scene.

At this incident, the initial Incident Commander selected a “quick attack” mode, directly involving himself in the tactical operations of his company. He did not conduct the required 360 degree size-up or provide any direction for the other companies. His attention was directed toward advancing the attack line to the front door and preparing to make entry as soon as the door was opened. This was described by several participants as “business as usual” for the companies that were involved in the operation.

The “quick attack” mode is considered appropriate in situations where the first company arrives alone and the personal involvement of the company officer will have a significant positive impact on the initial operation. This mode is only appropriate when the involvement of the initial Incident Commander in interior operations is essential. This mode is not appropriate for a situation where 5 companies and 20 firefighters are arriving almost simultaneously. Instead of being directly involved in stretching the attack line and making entry to the house, the initial Incident Commander should have directed his efforts toward conducting a size-up, determining the appropriate strategy and tactics, providing direction to the other companies and then briefing the Battalion Chief on actions taken prior to his arrival.

It must be noted that the initial Incident Commander was a firefighter, while two Lieutenants and one Captain were in charge of companies arriving almost simultaneously. In the culture of Atlanta Fire-Rescue (and many other fire departments), it is rare to see a firefighter giving definitive orders to a Lieutenant or a Captain, even if the firefighter is designated as the initial Incident Commander.

If the 360 degree size-up had been conducted, the open door at the rear (B/C) corner of the house would have been discovered. The seat of the fire was immediately inside this door. The fire could have been safely attacked and controlled by advancing the attack line to this location and hitting the seat of the fire from the outside.

Strategy and Tactics

The initial operations at the scene of the fire on Elm Street were conducted in an offensive strategy and in a fast-attack mode. The basic plan, which was almost unanimously expressed by all of the company officers and members on the first arriving companies, was to conduct an interior attack through the front door with a 1-3/4 inch pre-connected hand line. This was described as "business as usual" by almost everyone who was involved in this phase of the operation. No other options were suggested or considered.

The alarm was dispatched as a fire in an abandoned house in an area where fires in abandoned houses were frequently encountered. Upon arrival, the companies observed a small structure with no significant exposures and all visible openings boarded-up with plywood. There was a column of smoke visible from several blocks away and, on arrival, heavy black smoke could be seen coming from the eaves and leaking through every visible gap in the structure.

The Standard Operating Guidelines identify life safety of firefighters as a primary consideration and refer to the Atlanta Fire Rescue risk management plan to govern the acceptable level of risk to firefighters. This policy includes the statement, "We risk nothing on what is not savable or worth nothing."

Although the initial Incident Commander did not specifically identify the strategy to be employed, all of his actions and all of the actions taken by the initial arriving companies were consistent with an offensive strategy. The situation was easily recognizable as a serious working fire in an abandoned property, with no exposures. There was no indication of occupants inside the structure in need of rescue and an assessment of the visible smoke and heat conditions would lead to the conclusion that no one could be alive inside to be rescued. Several members reported that the smoke appeared to be heavier, darker and hotter than they usually encountered. All of these indications should have called for a defensive strategy to be adopted from the outset.

The Rules of Engagement for Structural Firefighting and the Acceptance of Risk, published by the International Association of Fire Chiefs Health and Safety Committee provide very explicit guidance for this type of situation.

- The exposure of firefighters to an elevated level of risk is acceptable only in situations where there is a realistic potential to save known endangered lives
- No property is worth the life of a firefighter
- No risk to the safety of firefighters is acceptable in situations where there is no possibility to save lives or property
- Firefighters shall not be committed to interior offensive fire fighting operations in abandoned or derelict buildings that are known or reasonably believed to be unoccupied

In spite of these clear indications of an unacceptable risk situation, the arriving companies initiated an offensive strategy and directed their efforts toward making an interior attack. Only two of the individuals who were interviewed from the first five arriving companies expressed any concern with this approach; although both of these individuals were company officers, they did not express their concerns to the Incident Commander at the time. There was almost universal agreement that the fire was inside the structure and the only consideration was to "go in and get it."

The strategy was quickly switched to defensive when Battalion 3 arrived and assumed command, based on observations of unusually heavy smoke and flames from the command post. The visible fire conditions were immediately recognized as an unacceptable risk situation. The new Incident Commander was not aware of the actions of the companies on the scene prior to his arrival and could not see the front door where the critical activities were occurring. He did not know that the crew of Engine 16 had already entered or where they were located inside the structure.

At the time the first firefighters entered the structure, the fire was at a critical stage and the flameover was imminent. The disastrous outcome could have been prevented by coordinating ventilation with exterior fire attack, allowing the flammable gases to vent to the exterior and cooling the inside atmosphere with hose streams without placing firefighters inside.

Vertical ventilation would have been the most efficient tactic to release the trapped fire gases without allowing a large quantity of fresh air to enter the structure; however vertical ventilation of the roof of an abandoned structure would be an unacceptable risk. In many similar situations the fire would have burned through the roof and self-vented before the fire department arrived. In this case the multiple layers of shingles on the roof contained the heat instead of allowing it to burn through the roof and release the hot gases. It would have been feasible to make ventilation openings in the gable ends of the attic to release the gases at the highest possible level.

The flameover probably could have been prevented by opening the nozzle and directing the stream into the upper part of the atmosphere for several seconds to cool the gases below their ignition temperature.

Firefighter Accountability System

The Firefighter Accountability System that is used by Atlanta Fire-Rescue is documented in Standard Operating Guideline 101.07. This Standard Operating Guideline establishes a set of policies and procedures that are intended to keep track of all firefighters operating within a hazardous area at an incident scene. The Standard Operating Guideline also includes requirements for obtaining Personnel Accountability Reports (PAR) from each company or team at regular intervals and when particular events occur during an emergency operation.

The Atlanta Fire-Rescue accountability system is based on company passports. A Velcro® fastener type name tag is attached to the passport for each member who is on duty. Each company officer is expected to deposit the company's passport with a designated individual upon arrival at the incident scene and before initiating operations in a hazardous area.

Standard Operating Guideline 101.07 states that no member will be allowed to enter the hot zone, IDLH environment, and/or hazardous area without first depositing their PASPORT (sic) cards outside those areas. The apparatus operator of the first due engine company is usually designated to gather the passports from the first arriving companies. When an Accountability Officer is designated by the Incident Commander, the passports are turned over to this individual.

The initial radio report from Engine 16 included "assuming command and accountability," indicating that the passports would be collected at Engine 16. The interviews indicate that none of the arriving companies deposited their passports at Engine 16 prior to beginning operations. All of the passports were still on each company's apparatus. The passports had not been gathered when the flame-over occurred. The objective of ensuring that every member operating in the hazardous area was accounted-for through the passport system was not accomplished.

When Battalion 3 assumed command, the radio announcement also included "assuming accountability," indicating that the accountability function was being transferred to the Command Post. The command technician assigned to Battalion 2 was assigned to gather the passports and bring them back to the Command Post. This was also described as "business as usual" by the members who were interviewed.

Further investigation determined the master accountability list that is maintained by the Shift Commander's office did not coincide with the crews on four of the five first arriving companies. Two firefighters had switched places between Engine 16 and Truck 16. (Firefighter Solomon was one of those individuals. According to information received in the interviews with both officers, the OIC on Truck 16 and the Acting OIC on Engine

16, Firefighter Solomon was assigned to Truck 16 by the station officer for that shift, but arrived on Engine 16 and operated as a crew member of Engine 16 for this incident). A firefighter who was assigned to Engine 1 was actually riding on Truck 1, resulting in a 5 person crew on the truck and a 3-person crew on the engine. In both cases the company officers were not aware of the deviations from pre-assigned riding positions. It was not determined if the name tags for the individuals who were actually riding on each vehicle had been properly placed on the company passports.

Personnel Accountability Reports

A Personnel Accountability Report requires each company officer (or each team leader if a company is split into separate teams) to report that all assigned crew members are present, safe and accounted for. Standard Operating Guideline 101.07 calls for a Personnel Accountability Report to be obtained from each company when specific events occur during an operation, including:

- Any report of a missing, trapped or injured firefighter
- Any change from offensive to defensive mode
- Any sudden hazardous event – back draft, flashover, collapse, etc.

All three of these situations occurred in rapid succession at the Elm Street fire; however a request for a Personnel Accountability Report was not initiated until more than two minutes after the strategy was changed and the flameover occurred. The call for a Personnel Accountability Report was initiated by the Lieutenant in charge of Truck 1, who had seen an individual move from Side B to D across the vestibule. At the time he called for a PAR, he was not certain it was a firefighter, just knew he had seen an individual. This was observed from the front yard through the left front window on side A.

Although it is not specifically stated in the Standard Operating Guidelines, it was understood that an officer reporting a Personnel Accountability Report must have direct voice and/or visual contact with all of the assigned members of the crew before a positive Personnel Accountability Report can be reported. The officer must ensure that the specific individuals assigned to the crew are accounted-for.

The only Personnel Accountability Report that was actually recorded came from the Acting Officer in charge of Engine 16, who reported that he had his whole crew. This erroneous report resulted from confusion regarding the identities of the members who were safely outside at that time. In the darkness and confusion, the acting company officer believed that he had the two crew members who had entered with him safely outside. He knew that there was concern about a missing firefighter, but he did not realize that the missing individual was Firefighter Solomon.

E-16 OIC stated that he thought that he had both of his firefighters (Solomon and E-16 FF1) with him. E-16 FF1 stated that he immediately recognized that Solomon was not with him and began looking for him among the crowd of firefighters outside the front door. The situation near the front door at that moment was dark and confusing. Members of the initial entry team had barely managed to escape and other firefighters had been pulled away from the doorway as the flame-over occurred. Numerous firefighters were now crowded into a small area trying to make entry to conduct a search for a missing member. Several firefighters were wearing helmets without company number shields and there were no names or identifiers on their protective clothing. Faces could not be distinguished through self-contained breathing apparatus face pieces.

It is the opinion of the Review Committee that the application of the existing Firefighter Accountability System was not a contributing factor in Firefighter Solomon's death, however the weaknesses in this system could have been critical under different circumstances. If Firefighter Solomon had not been seen inside the structure, search and rescue efforts might have been delayed until it was realized that he was missing.

The interviews that were conducted with members involved in this incident indicated that company officers were often unaware of the specific locations and functions of their crew members. Firefighters operated in IDLH conditions without supervision, without partners, without portable radios and without lifelines or hose lines, both before and after the flameover occurred. This appeared to be a routine mode of operations for most of the companies. The interviews suggested that the members understand the principles and procedures, however there is a very casual approach to their application during the early stages of an incident and during incidents that appear to be "routine".

Personnel Accountability Reporting Recommendations:

- The procedures for initiating firefighter accountability should be reviewed and revised to ensure that a positive system is in place from the outset of operations.

- The procedures for personnel accountability reports should be reviewed to ensure that they are fully understood and properly implemented at all incidents.

- Company officers must maintain continuous accountability for all of their crew members and ensure that they can provide an accurate PAR when required.

- Company members must maintain contact with their company officers in order to make the accountability system effective.

- A training program for all Atlanta Fire-Rescue members should be conducted to review and reinforce the procedures and rules for operating in IDLH conditions

- All firefighters should wear clearly visible and accurate company identifiers on their helmets or somewhere on their protective clothing. The numbers should be change to reflect the member's actual assignment at any point in time.

- Each member's name should be displayed on the back of the turnout coat in a location where it will be visible while wearing self-contained breathing apparatus.

Rapid Intervention Team:

Atlanta Fire-Rescue Standard Operating Procedure 02.26 specifies the procedures that are to be followed to comply with the 2-in/2-out requirements of the OSHA Respiratory Protection Standard (29 CFR 1910.134). These requirements are also incorporated into NFPA Standard 1500. The specific requirements of Standard Operating Procedure 02.26 include:

8.1 All operations involving entry into an IDLH atmosphere will be performed using the "buddy system" of two (2) or more personnel in direct visual or voice contact operating as teams. Radio contact is not an acceptable substitute for visual or voice contact among the members of a team. All teams should be equipped with a radio for contact with Command.

8.2. No entry into an IDLH atmosphere will be initiated until a Rapid Intervention Team is stationed outside the IDLH atmosphere. This requirement may require that interior operations be delayed until such time as a rapid intervention team can be assembled. Units on the scene should use this time to perform all necessary preliminary functions.

Standard Operating Guideline 101.06 establishes the guidelines for a Rapid Intervention Team at incidents where firefighters will be operating in an IDLH atmosphere. In addition, Standard Operating Guideline 101.03 states that the second arriving engine company and the second arriving truck company on a structural fire in a low-rise building will be automatically assigned to the Rapid Intervention Group.

Members who were interviewed indicated the written Standard Operating Procedure is out of date and the operational guideline has been changed to assign the third arriving truck to this function in place of the second truck. The revised policy called for Truck 11 to perform this assignment instead of Truck 1.

The Standard Operating Procedure (02.26) specifically requires an initial rapid intervention team with at least two dedicated members to be in position, ready to enter and assist or rescue the entry team, before the initial entry is made to an IDLH environment. Standard Operating Guideline 101.06 requires the rapid intervention team to deploy a back-up hose line and position a thermal imaging camera and rescue equipment, although it does not specifically require that all of these resources be assembled before an IDLH entry can be initiated.

The Standard Operating Guideline states that "other members of the team" may engage in other activities as long as they do not interfere with their readiness to take action if members inside the IDLH area require assistance. Outside truck company functions, such as opening egress points and raising ladders, are identified as appropriate duties for rapid intervention team members in Standard Operating Guideline 101.06.

In accordance with this Standard Operating Guideline 101.03, Engine 1 assumed the initial rapid intervention team function and the acting officer in charge of Engine 1 assumed the responsibilities of initial Safety Officer. The acting officer verbally confirmed with the Captain of Engine 7 that Engine 1 was second arriving and would be assuming this function.

All three crew members from Engine 1 participated in removing the plywood from the windows at the front and on one side of the house (Sides A and B). They were in the process of deploying a back-up hose line when the flame-over occurred inside the house. The back-up hose line was quickly charged and operated through windows in the A/B quadrant to assist in controlling the fire.

It is unclear if the rapid intervention team members knew that the initial entry had occurred and firefighters were inside when the flameover occurred. They were unaware that a firefighter had been seen inside enveloped in flames. The rapid intervention team was not activated to take action and its members did not know that a firefighter rescue operation was occurring inside the structure. Several other members went into "rescue mode" while the assigned RIT members were deploying and operating the second hose line.

Truck 11 arrived after the flameover occurred, just a few seconds after the Incident Commander learned that there was a report of a person inside the house. The Incident Commander assigned Truck 11 to ventilate and remove bars from the windows to support a search effort. By the time the crew members from Truck 11 reached the front of the house, Firefighter Solomon had been located and was being removed through the back door.

Rapid Intervention Team Recommendation:

- While the Rapid Intervention Team did not play a role in the events and/or injuries of Firefighter Solomon, the presence of so many personnel on scene in a short amount of time contributed to his rapid removal. We recommend retaining the number of response personnel on calls of this nature.

Search and Rescue Operations:

When the members outside the front door realized that a person was still inside the house, they immediately initiated aggressive search and rescue efforts. As soon as the flames had been knocked down, several firefighters entered, almost simultaneously, through the front and rear doors, to begin the search. Several members reported that they knew they were searching for a person, but they did not know they were searching for a missing firefighter, nor that the individual had been seen moving in a particular direction.

At least 10 members from Engine 7, Engine 16, Ladder 1 and Truck 16 entered through the front door, however, none of these companies entered intact and none of the company officers could account for all of their crew members. The searchers entered without hose lines and operated under high risk conditions inside the house. The members who had seen Firefighter Solomon through the front door went toward the A/B corner following his direction of travel.

The entry from the rear was performed by members of Squad 4. Noting that the flame-over was occurring and the Incident Commander was calling for defensive strategy to be implemented as they approached the house, the crew of Squad 4 went to the rear (side C) and removed the coverings from windows and doors. Hearing the radio traffic that someone was inside, they went to the rear (C/D corner) door and scanned the interior with their thermal imaging camera. The camera operator was able to locate Firefighter Solomon inside and a rescue team was deployed as soon as the fire was darkened down.

The entry team from Squad 4 reached Firefighter Solomon at the same time as two members from Engine 7 who had entered through the front door. Both teams helped to carry the unconscious firefighter to the rear door. The remaining members of Squad 4 were outside and assisted in removing him from the house and transporting him to the ambulance.

The rapid entry and search resulted in Firefighter Solomon being very quickly located and removed from the house. The radio log indicates that Firefighter Solomon was located within 3 minutes after the flameover occurred and was removed from the house within less than one minute after being found. Advanced life support treatment was initiated as soon as he was removed and he was transported to Grady Memorial Hospital without delay.

Search and Rescue Recommendations:

- Provide on-going training for the removal of a downed firefighter to all members.
- The Incident Commander should ensure that initial rapid intervention team is deployed as quickly as possible with a back-up hose line, thermal imaging camera and rescue equipment. Unless there is an urgent and realistic rescue situation, the initial entry team should wait until the rapid intervention team is in place before advancing into an IDI area.
- At no time should firefighters enter a structure to search or engage in firefighting on their own, without instructions from Command.

Safety Officer:

In addition to establishing the initial rapid intervention team, the officer in charge of the second arriving engine company is designated as the initial Safety Officer at the incident scene. The second arriving Battalion Chief is designated to assume the Safety Officer position upon arrival.

At this incident the Acting Officer in charge of Engine 1 was automatically designated as the Safety Officer upon arrival. He was engaged with the rest of his crew in removing plywood from the windows and deploying the back-up hose line. He did not perform any other Safety Officer functions during the brief period before Battalion 2 arrived.

Battalion 2 had just arrived on the scene and was in the process of donning his protective clothing when the flame-over occurred. He conferred briefly with the Incident Commander (Battalion 3) who was in the process of sizing up the situation and making the decision to switch to defensive strategy. Battalion 2 then proceeded to the rear of the house and began performing the Safety Officer duties as the team from Squad 4 was entering to rescue Firefighter Solomon.

Safety Officer Recommendations:

> Provide training to all personnel who ride in charge of the apparatus on the roles of a Safety Officer including the 360 degree walk-around described in the Atlanta Fire-Rescue Operations Manual**.**

Staffing Issues:

Atlanta Fire-Rescue had been adding personnel to fill vacant positions and increase staffing on companies during the year preceding the Elm Street fire. As a result of the rapid hiring, there were many relatively new members within the department. The two firefighters who were working on Engine 16 were both new to Atlanta Fire Rescue and had worked only a few shifts at Station 16, although they had several years of experience with other fire departments.

Full four-member crews were assigned to all of the engine and ladder companies that responded to the Elm Street fire. Due to the Thanksgiving holiday, several members were assigned in “moved-up” positions, filling-in for members who had taken vacation leave. Several were also working “off-shift” as a result of shift trades or on overtime.

It is a common practice within Atlanta Fire-Rescue for individuals to “move-up” to fill higher level supervisory positions when the assigned officers are on leave or positions are vacant. Each fire station in Atlanta has a Captain assigned on each shift. In single company stations the Captain normally functions as the engine company officer. In double company (engine and truck) stations, the Captain normally functions as the truck company officer and a Lieutenant is assigned on each shift as the engine officer. Lieutenants routinely move over to the truck to fill-in for absent Captains in the double company stations. A qualified firefighter or fire apparatus operator is usually “moved-up” as an Acting Officer on engine companies.

At the Elm Street fire, the only company officers on the first alarm assignment who were working in their normally assigned positions were the Captains in charge of Engine 7 and Squad 4. Both Battalion Chief positions were filled by

Captains, who were usually in charge of truck companies. The three truck companies were all supervised by Lieutenants, who were moved over from the engine companies in their stations. The officer positions on Engines 16 and 1 were filled by a firefighter and a fire apparatus operator, who were both qualified to work as Acting Officers.

Moving-up to Acting Officer is commonly referred-to as "riding the seat" within Atlanta Fire-Rescue. As an Acting Officer, the member is the direct supervisor of a company and must also be prepared to function as the initial Incident Commander at an emergency incident. The department does not have a structured training program to prepare members for these responsibilities and there are no specific criteria or performance standards. The basic requirements for an acting officer are identical to the qualifications for a fire apparatus operator and the final determination is left to the discretion of the Captain who normally supervises the individual.

The Acting Officer who was in charge of Engine 16 was a firefighter who met the requirements and had performed in this capacity a number of times over the previous year. This individual was normally assigned to a different shift at Fire Station 16 and was working on a shift trade.

This meant he was riding with firefighters he was not familiar with. This included the driver and both firefighters. The Committee also found that Firefighter Solomon was actually assigned to Truck 16 but arrived on this call on Engine 16. A swap between Solomon and another firefighter occurred without the knowledge or consent of either company officer. The situation this presents for the officers in general was that they were not knowledgeable enough of the crews to know as to whether to exercise control over their crews' members, who may be overly aggressive or inexperienced.

The timing of this call on a holiday evening with low traffic led to a large number of engine & truck companies arriving on the scene simultaneously. While challenging for fire ground commanders, this large number of personnel undoubtedly led to the rapid location, extrication, & transportation of Solomon. This sequence of events went very well.

Staffing Recommendations:

- A program to train individuals who may serve as an acting officers should be developed and implemented. This increased training should include but not be limited to leadership, decision-making, strategy & tactics, and incident command.

Review of Training:

Firefighter Solomon had been employed by Atlanta Fire-Rescue since September 13, 2006 and was working his 6th shift at Fire Station 16 on November 23, 2006. Prior to being assigned to Station 16 he completed a 4-week "fast-track" training program that was provided for experienced and certified firefighters who transferred to Atlanta Fire Rescue from other fire departments.

The "fast-track" program was developed for new employees who came to Atlanta Fire-Rescue with previous experience and valid state and/or national training certifications. The newly hired pre-certified firefighters attend the 4-week training and orientation program before being assigned to regular duty in Atlanta fire stations. Several other fire departments in metropolitan Atlanta have similar programs.

Firefighter Solomon was employed with the Macon-Bibb County Fire Department for five years and 5 months before becoming employed by Atlanta Fire-Rescue. He went through 14 weeks of entry-level training, including two weeks of EMS-First Responder training, at Macon-Bibb County. He was National Professional Qualification (NPQ) certified as a Firefighter I and Airport Firefighter. He was also a Georgia state certified firefighter and state certified airport firefighter.

Firefighter Solomon's initial training at Macon-Bibb County included the following:

- 480 hours of cognitive study inclusive of 100 hours psychomotor firefighter skills
- A daily physical fitness regiment
- Live fire training at the Georgia Public Safety Training Center and smoke house training at the Charles A. Smallwood training complex, Macon Georgia
- Hazardous Materials awareness training
- Vehicle Extrication
- Introduction to High Angle & Confined Space Training

Firefighter Solomon was trained as a designated First Responder, inclusive of the use of Automated External Defibrillator (AED); certified Community Emergency Response Team Member (CERT); certified reserve engine operator. He was in full compliance with the State of Georgia Firefighters Standards and Training annual firefighter skills maintenance.

During his tenure, from April 2001, until July 2001. with Macon-Bibb County Fire Department, he was assigned at Station 1 which houses an engine, rescue and water rescue. His next assignment from July 2001 to January 2003 was at Airport Rescue Company 102. From January 2003 until September 2004 he was assigned to Station 106. His final assignment from September 2004 until his resignation in July 2006 was with Macon-Bibb was Station 11, which houses Engine 11 and Aerial Truck 30.

Firefighter Solomon attended class 06-03, which was the third "fast-track" class conducted by Atlanta Fire-Rescue during 2006. The scheduled program for this class was adjusted due to the following circumstances: On two days, the regularly assigned instructor was not available and a substitute was assigned (Oct 16 and Oct 23). The one-day search and rescue class day was cut short by 2 to 3 hours, due to a fire in the city which took the air truck away from the fire academy. A RIT and firefighter survival class was planned and taught October 27, 2006 when only one of the two assigned instructors was present. (see Fast- track schedule app E) The one instructor present expressed the class should be two days.

Physical Evidence and Tests Requested:

The scope of this report does not include a comprehensive list of chain of custody for the physical evidence collected by Atlanta Fire-Rescue Investigations. This committee did have the opportunity to inspect the turn out gear and self-contained breathing apparatus for a short time on November 25..th The Committee did request several tests to be conducted on Firefighter Solomon's personal protective equipment, as well as the structure located at 257 Elm Street. The following is a list the agencies and the information they were requested to provide:

1. TenCate, Inc. was requested to evaluate the heat exposure to Firefighter Solomon's personal protective clothing. The protective clothing, including pants, coat, helmet, gloves, boots and hood were all sent to the testing laboratory at Southern Mills, which supplies fibers and fabrics to all the major turnout gear manufacturers.

   The employees are very familiar with the characteristic of the fabrics and what they are, and are not, able to withstand Initially tests were run on the gear using a patch from the coat. Later tests were run using the same layers of gear liner and vapor barrier to try to match the conditions that were indicated in the fire model and assist in confirming the movements of Firefighter Solomon with in the structure.

   Tests were later run on hoods that matched the hood he was wearing to approximate the temperatures and timing that he was possibly in the environment. Since his helmet was not found near where he was laying but his hood and mask were. It can be surmised that he was without his helmet for a time inside the building and during the flameover, possibly undergoing direct flame contact. See Appendix D for full report.
   .
2. Schirmer Engineering was utilized to conduct fire modeling to determine heat and flame conditions that may have occurred inside the structure. Results can be found in Appendix C.

3. NIOSH was requested to conduct evaluations of the self-contained breathing apparatus and face-piece. At the time of this report, those results were not available.

Documents Reviewed:

Incident # 06053780
257 Elm Street N.W Atlanta, Georgia

1. Photographs of fire building taken by Atlanta Fire-Rescue fire investigators on 11-23-06 &11-24-06
2. Photographs of fire taken by FAO SQ4-FAO, Squad 4-C, on the night of the fire
3. Photographs of Firefighter Solomon's PPE taken by Atlanta Fire-Rescue fire investigators
4. Daily accountability staffing sheet for 11-23-06 provided by Division 1
5. Elm Street Fire radio traffic (recording of actual radio traffic supplied by ATLANTA FIRE RESCUE communications)
6. Elm Street Fire telephone call (recording of actual telephone traffic supplied by ATLANTA FIRE RESCUE communications)
7. Apparatus assignments for responding equipment (compiled by C/T Donnie Waynick & Captain Hale OIC B-2)
8. Statement from T-16 OIC(handwritten 11-23-06)
9. Statement from T16 FAO F (handwritten 11-23-06)
10. Statement from T-16 FF-1 (handwritten 11-23-06)
11. Statement from T-16 FAO T (handwritten 11-23-06)
12. Statement from E-16 OIC(handwritten 11-23-06)
13. Statement from E-16 FAO (handwritten 11-23-06)
14. Statement from E-16 FF-1(handwritten 11-23-06)
15. Narrative from Chief of Arson containing statements of the homeless couple that took residence within the house.
16. Response Synopsis; AFD Line of Duty Injury Report submitted by Captain James Nelms (this is a draft document)
17. AFD.SOP.02.26 Rapid Intervention Team – 2In/2 Out
18. AFD.SOP.02.51 Protective Clothing Procedures
19. AFD.SOP.02.56 Incident Safety Officer
20. AFD.SOP.02.86 SCBA Use in the Atlanta Fire Rescue
21. AFD.SOP.02.107 Engine Company Operations
22. AFD.SOP.02.108 Truck Company Operations
23. Atlanta Fire-Rescue Manual of Standard Operating Guidelines Preamble
24. Operations Guideline #101.01 Engine and Truck Company Operations
25. Operations Guideline # 101.02 Incident Command
26. Operations Guideline # 101.03 Structural Fire / Low-Rises
27. Operations Guideline # 101.06 Rapid Intervention Team
28. Operations Guideline # 101.07 Firefighter Accountability System
29. Operations Guideline # 101.08 Emergency Evacuation Procedures
30. Operations Guideline # 101.09 May Day Procedures

31. 17-2 & Memo COA Fire Incident Report from B-3
32. 17-1 from Company 1
33. Statement from T-1 OIC
34. Statement from T-1 FAO
35. Statement from FAO E-1 OIC
36. Statement from T-1 FF-2
37. Statement from T-1 FF-1
38. Statement from E-1 FAO
39. Statement from E-1 FF-1
40. 17-1 from Engine 7
41. Statement from E-7 OIC
42. Statement from E-7 FAO
43. Statement from E-7 FF-2
44. Statement from E-7 FF-1
45. 17-1 From Squad 4
46. Statement from SQ-4 FAO
47. Statement from SQ-4 FF-5
48. Statement from SQ-4 FF-4
49. Statement from SQ-4 FF-2
50. Statement from SQ-4 FF-1
51. Statement from SQ-4 FF-3
52. 17-1 from Truck 11
53. Statement from T-11 OIC
54. AFD.SOP.03.39
55. Unedited transcript of interview with E 7 FF-1
56. Unedited transcript of interview with E 7 FF-2
57. Block Plan with apparatus and hose lines
58. Floor plan (prepared by J. Gordon Routley)
59. Initial entry paths (before flare-up) prepared by J. Gordon Routley
60. 2006 "Fast Track" Recruit Class 06-03 Schedule submitted by Chief of Training for Atlanta Fire-Rescue
61. Copy of memorandum in reference to Deviations from the Fast Track Schedule 06-03
62. Initial report from Southern Mills regarding Solomon's turn out gear
63. Death certificate
64. Autopsy report from FCMEO
65. Division 1 Staffing Protocols
66. Statement Amendment from E 16 FAO
67. Floor plan with approximate routes of travel indicated from: E 7 FF-1
68. Floor plan with approximate routes of travel indicated from: E 16 FAO
69. Floor plan with approximate routes of travel indicated from: E 16 OIC
70. Floor plan with approximate routes of travel indicated from: T 16 FF-1
71. Floor plan with approximate location of down firefighter, helmet & hood from: SQ 4 FF-5
72. Floor plan showing approximate location of boot from: T 16 FAO T
73. Floor plan with approximate routes of travel indicated from: E 16 FF-1

74. Floor plan with approximate routes of travel indicated from: E 7 OIC
75. Floor plan with approximate routes of travel indicated from: E 1 FAO
76. Floor plan with approximate routes of travel indicated from: T 1 OIC
77. Floor plan with approximate routes of travel indicated from: T 1 FF-1
78. Floor plan with approximate routes of travel indicated from: E 1 FF-1
79. Floor plan showing vent locations from: E 1 OIC

Literature Review:

Many documents were reviewed for relevancy. The panel looked for incidents that had similar situations or results. Several were found to have similar situations, responses, or patterns. The relevant portions are summated herein along with the citations. The use of these documents in training and prevention is encouraged. We hope this list will help in any fire trainer or fire officers research when looking at training on firefighter safety.

NIOSH Report # F2003-12
Flashover kills one firefighter and injures two.
Factors included a mistaken PAR. Engine Company Officer sees three firefighters on porch and assumes all the interior crew had escaped.

Victim moved past the exit into the fire as his crew left the building gear smoldering.

Conditions were heavy smoke and high or intense heat.

Victim was seen by several firefighters outside the structure.

Ventilation was not coordinated with attack (or was incomplete).

Team continuity was not maintained.

Occupancy unoccupied not known by crews.

NIOSH Report # F2002-34
Lieutenant and Firefighter die in flashover in live fire training in Florida.

1600 square foot building.

Victim #2 on his 2nd shift.

Heavy smoke conditions.

Venting produced the flashover. i.e. venting should be closely coordinated with fire attack.

State Fire Marshal Texas Investigation 03-193-01 January 19, 2003
Firefighter Gary Staley, Porter Volunteer Fire Department.

Another firefighter removed gloves, hood, and mask as he was exiting. Why? Disoriented? He survived with serious burns.

Deceased firefighter had no gloves and regulator was disconnected.

Crew integrity, all members did not escape together.

Hose team had only 1 radio.

No mayday was transmitted.

USFA TR-084 March 1995
Entrapment in Garage kills one Firefighter

Face piece disconnected (no air?).

No 360 degree scene survey was performed.

Primary means of egress must be protected.

Risks of residential fires not recognized even by experienced firefighters and officers.

USFA Report 078 Of the Major Fire investigation Project
Three Firefighters die in Pittsburg House Fire , Feb 14,1995

Relevant lessons include:
Residential House Fire, routine for this dept.

Only 5 of the 17 responders on the 1st alarm were in the assigned positions. The others were riding up, fill in, overtime, trades or other reason.

Example Captain was riding battalion chief, battalion chief was riding district chief and a firefighter was a company officer on a truck with a Capt filling in for a firefighter.

Could not escape a room with windows and door.

SFMO Texas investigation 05-218-02 Feb 19,2005
And NIOSH Report #2005-09
Captain Grady Burke, Houston Fire Dept

Abandoned, known crack house

Crew was first in building and in the fast offensive attack mode partial collapse.

Literature search conclusion.

All of the above situations had factors similar to the incident on Elm St. in November 2006. They should be used in training and studied to prevent additional loss of life.

Recommendations:

Research should be conducted to determine whether existing performance standards for SCBA face piece lenses provide sufficient protection when firefighters are exposed to flashover conditions. Premature failure of the lens could have fatal consequences. If vision through the lens is suddenly compromised, the user could become disoriented and unable to locate a safe exit. The NIOSH report on the SCBA and face-piece were not available for review by this committee at the time of this document submission.

The procedures for initiating firefighter accountability should be reviewed and revised to ensure that a positive system is in place from the outset of operations.

The procedures for personnel accountability reports should be reviewed to ensure that they are fully understood and properly implemented at all incidents.

Company officers must maintain continuous accountability for all of their crew members and ensure that they can provide an accurate PAR when required.

Company members must maintain contact with their company officers in order to make the accountability system effective.

A training program for all Atlanta Fire Rescue members should be conducted to review and reinforce the procedures and rules for operating in IDLH conditions

All firefighters should wear clearly visible and accurate company identifiers on their helmets or somewhere on their protective clothing. The numbers should be changed to reflect the member's actual assignment at any point in time.

Each member's name should be displayed on the back of the turnout coat in a location where it will be visible while wearing self contained breathing apparatus.

While the Rapid Intervention Team did not play a role in the events and/or injuries of Firefighter Solomon, the number of personnel on the scene in a short amount of time contributed to his rapid removal and we recommend retaining the numbers and configuration of the response that allows for this function on the fireground to be staffed early in an event.

Provide on-going training for the removal of a downed firefighters to all members.

The Incident Commander should ensure that the initial rapid intervention team is deployed as quickly as possible with a back-up hose line, thermal imaging camera and rescue equipment. Unless there is an urgent and realistic rescue situation, the initial entry team should wait until the rapid intervention team is in place before advancing into an IDLH area.

At no time should firefighters enter a structure to search or engage in firefighting on their own without instructions from Command.

Provide training to all personnel who ride in charge of the apparatus on the roles of a safety officer including the 360 degree walk-around as described in the Atlanta Fire-Rescue Operations Manual**.**

A program to train individuals who may serve as an acting officers should be developed and implemented. This increased training should include, but not be limited to, leadership, decision-making, strategy & tactics, and incident command as a minimum.

SOP's should be regularly reviewed by all personnel, practiced in training, and adhered to in operations.

Each Fire Department member on the emergency scene and engaged in suppression operations should have a radio.

The practice of switching positions or apparatus should only be allowed when approved by the company officer.

Ventilation should be coordinated with fire attack.

Thermal imaging cameras should be used on initial attack.

Train on procedures to make sure people operate under those procedures.

Train company officers to become incident commanders

Knowledge of PASS device activation and significance should be trained upon and learned.

Chin straps and buckles should be secured on helmets. It is the committee's opinion that the helmet came off early in the scenario and may not have been properly secured.

Committee Chair Commentary:

As we worked through this report, additional information came to light that we felt important to relate to the reader and while not included in report recommendations, they can be used in training and development of additional operational procedures.

For an unknown reason, Solomon's boot came off. This may have been one of the most serious problems Firefighter Solomon may have experienced in all the confusion he faced.

While the hose-line was charged, there was no evidence that the nozzle was opened and water flowed into the building prior to flameover. Had the nozzle been opened, this would likely have had a very different outcome. A closed nozzle points out the need for training on how to cool a room before entering.

A critical factor contributing to the severity of Solomon's injuries and death was the removal of his face-piece and standing up in elevated temperatures.

A vacant, unoccupied, building with un-survivable conditions does not meet the call for aggressive interior operations. (ref: IAFC Rules of Engagement)

The risk benefit decision-making model is different from the traditional Fire Service thinking of "we must go in" on all working fires. This view requires a cultural shift for all fire service personnel and recognition that at the scene, it is everyone's responsibility to speak up. Experienced officers watched things go from black smoke to flameover conditions within a minute, but did not react and take a different course of action. One finding of this event includes the uniqueness of the actual building. It was essentially one large room. No crew expected or anticipated this configuration.

As we learned during the Literature Search, there were factors in this event that are similar to those found in the National Fallen Firefighters Foundation Courage To Be Safe program, specifically the Oscar Armstrong story. We recommended the use of that program for all firefighters, so they recognize and appreciate the difficulty in overcoming the cultural issues they are faced with regarding past suppression applications.

There were also some very positive actions that occurred on this fire ground that we felt worthy of mention. They include Battalion Three asking about RIT early deployment and the quick decision to go defensive. The rapid removal of Firefighter Solomon from the building was due to the large number of firefighters who were present on the scene that evening. We also found that the fire service experience of the firefighters on the scene that day was high, even with the higher than usual number of personnel riding out of position.

PHOTOS

FF Solomon's Helmet: After reviewing the damage to the coat, pants, and hood of FF Solomon, attention was also given to his helmet found inside the structure approximately 10-12 feet away from the location from where he was extricated. We were unable to determine the sequence of events that led to his helmet removal and exactly when it was removed. It appears the helmet was removed early in the flameover event. While moderate heat damage appears to the outer shell, evidence indicates that severe damage to the underside of the helmet where the face shield melted in towards the inner shell possibly occurred on the floor and was not indicative of being on his head. On one side of the helmet, the buckle was melted; therefore it is difficult to determine if the strap was in place. If the helmet had been properly secured by the strap under the chin, then it would seem likely that if it had been knocked off, then it would stand to reason that it would have been caught by the regulator. Because it was found on the floor away from FF Solomon with significant damage to the underside, it is the panel's opinion that it was not secured properly. (See other photos in Appendix G).

Squad Photos: These are a remarkable set of photos taken by the driver of Squad 4 which depicts the heavy fire conditions just after the flame over event occurred.

Note the quantity of firefighters at the front door. At least 7 individuals in PPE are visible. It is not clear if the OIC & firefighters are in this group or in the process of exiting.


11/15/2006

APPENDIX A

Timeline

Time Line
257 Elm Street NW Atlanta Georgia

20:00:10	Call received at 9-1-1
20:02:16	Companies toned out (just over 1 minute to dispatch alarm)
20:05	*E-16* on scene working fire *T-16* on scene *E-1* on scene
20:06	*E-7* on scene
20:07	Air 7, cars 722 & 723 dispatched *E-1* level 1 *T-1* level 1 *S-4* on scene *E-16* requests S-4 with forcible entry tools
20:08:22	B-3 on scene assuming command & accountability
20:08:37	*B-3* calls E-16 *E-16* tells B-3 go ahead *B-3* Asks if anyone has been assigned as RIT *E-16* in very excited voice asks B-3 to repeat traffic *B-3* orders defensive mode and advises all companies
20:09:47	Request ALS transport unit 1 person trapped *T-11* on scene request assignment T-11 assigned ventilation 1 person trapped
20:10:27	*S-4* on 'C' side door open using TIC to look for victim
20:11:03	*T-1* tells command we need PAR immediately
20:11:35	*B-3* to E-16, T-16, E-1, T1 request PAR *E-16* has PAR *B-2* advises S-4 making entry Firefighter Down Firefighter down 'C' side
20:12:45	Firefighter on 'C' side *T-16* asks is ambulance on scene? *E-7* Hand line in house *B-2* Needs stokes basket on 'C' side
20:13:16	*T-1* requests to go in and do a thorough search
20:13:39	T-1 is interior doing search

	Command all units going back to offensive *S-4* Firefighter on C side we need Grady immediately we have firefighter burned & stokes basket needed *Radio* advise if firefighter is down *B-3* trying to ascertain at this time we do know we have 1 firefighter with burns *Radio* switch to admin channel *T-11* building ventilated T-11 do primary *Command* E-7 what is your status
20:16	*Command* Grady 7256 on scene
	Command to safety what is condition of building & how many crews inside? *Safety* crew operating from A side, 1 crew on back side hitting hot spots now
20:17:48	*Car 203* has firefighter been located at this time? *Command* affirmative in route to Grady by Grady 7256
20:18:35	*T-1* primary all clear
	B-2 to command did you initiate a Par? *Command* received Co 16 I need a Par
20:19:39	*PS-1* to command do you need assistance? *Command* negative we already have firefighter in route to Grady *Command* company 1 I need a PAR, Company 1 has a PAR *Command* to E-7 I need a Par & what is you location?

APPENDIX B

Medical Report

Medical Report
Submitted by: Dr. Jim Augustine

Clinical summary of injuries to Firefighter Steven Solomon resulting from fire on November 23, 2006.

I met Firefighter Solomon during his care in the Emergency Care Center at Grady Hospital about 2100 hours on November 23. He was receiving care from the emergency physician on duty, Dr. Brian McNally, who is a personal friend. We agreed after reviewing his injuries directly and together on these points:

He had been unconscious since his rescue. His jaws had been clenched, and they had to sedate him to capture his airway in the Emergency Care Center. He had full thickness burns involving his entire head and face, and the front of this neck. He had full thickness burns involving his right foot, ankle, and lower leg, corresponding exactly to the area covered by a firefighters boot. He had patches of full thickness burns on both upper extremities. The largest area was on his left upper arm, in the lateral area of the biceps. The larger coverage of the patches was on the left arm, as opposed to the right. Neither arm had a circumferential burn. The hands also had patches of burn, full and partial thickness.

His total burn area was calculated at 30%. This was confirmed on his arrival in the Grady Burn unit, with the burn nurses there. It was confirmed again when Dr. Walter Ingram, the Medical Director of the Grady Burn Unit arrived and examined the patient.

Steven was given large doses of a sedative agent, an agent to paralyze his muscles to allow him to be ventilated, and narcotics for pain control. These were continually administered in a drip form. The initial chest x-ray in the Emergency Care Center showed no obvious chest injury. Dr. McNally stated the vocal cords did not appear burned on intubation. He related that his blood carbon monoxide level was 27%, a value indicting poisoning and significant inhalation. The oximetry levels for oxygen saturation were in the 70s to 90s, despite being administered 100% oxygen. This was the early indication of significant inhalation injury.

I talked with Dr. Ingram after his initial evaluations of Steven, at about 2200 hours. No other injuries were found on his examination. It was necessary to perform a bronchoscopy to evaluate his lungs, and he did so at about 2300 hours. He found extensive burn injury to all areas of both lungs, in all airways. He attempted to irrigate both lungs, but found only burned tissue, indicating the inhalation of superheated air.

During the subsequent day, Steven had very low oxygen levels, and required frequent irrigation and breathing treatments in an attempt to resolve some of the lung injury. His low oxygen levels resulted in him having a cardiac arrest three times in the first 24 hours. His status at that point was stabilized on very large doses of intravenous fluids and various medications, including some that cause blood flow to the extremities and the kidneys and intestines to be reduced. Ultimately, this compromised those organs, and resulted in his unburned leg suffering from low blood supply, and his kidneys requiring support from dialysis.

The combination of burn and inhalation injuries resulted in the ultimate death of Firefighter Solomon.

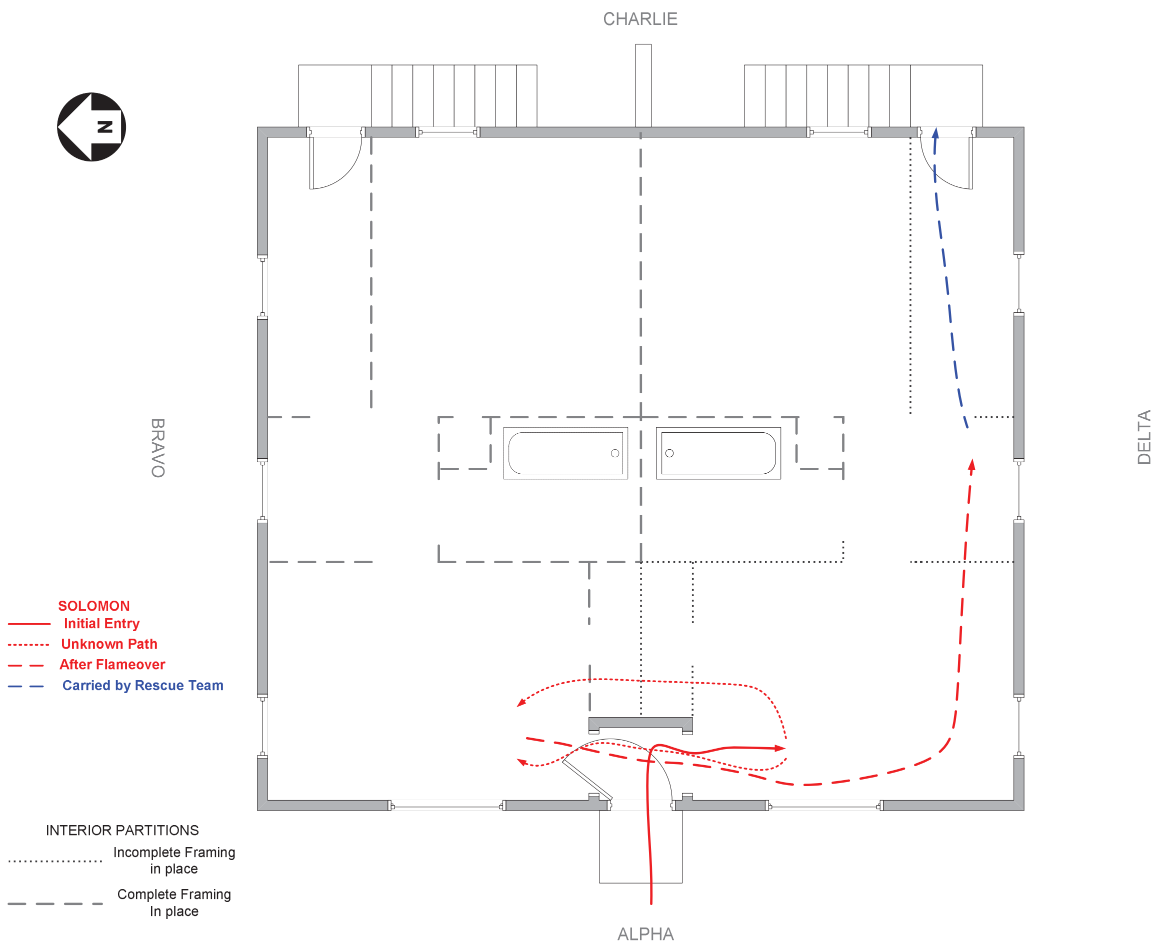
I would anticipate the autopsy results will confirm those findings.

James J. Augustine, MD
Medical Director, Atlanta Fire Rescue
Emergency Physician, and Clinical Assistant Professor, Emory University Department of Emergency Medicine

APPENDIX C

Map of Entry Routes

Map of Entry Routes



APPENDIX D

Report by Southern Mills

Gear Report by Southern Mills

Estimated Heat Exposure on Turnout Gear Worn by Firefighter Steven Solomon; Testing conducted by TenCate, Southern Mills, Inc.

To estimate the heat exposure to the upper portion of Firefighter Steven Solomon's coat, we washed new composite samples one time to approximate the bulk of the worn garment and rant standard 2 cal/cm2 TPP exposures for 12, 14, 16, 18, and 20 seconds to compare to the garment.

In my opinion, the 16 an 18 second exposures, representing 32 and 36 cal/cm2, are the closest matches to the heavily exposed areas of the coat. This is based on the degree of discoloration and the force required to tear the outer shell by hand.

The 16 and 18 second exposures appear to have more damage to the moisture barrier substrate than the coat, which is probably due to the fact that the samples are secured in the TTP test so that they do not move and the coat sections have some thermal shrinkage in the moisture barrier membrane that created some space/air pockets. The 14 second TPP exposure is a closer match to the coat's moisture barrier substrate, but does not match the outer shell.

Based on the above exposures, my best estimate is that the upper portion of the coat saw a heat exposure in the mid 30 cal/cm2 range.

Since both temperature and the time of exposure have a significant impact, it is difficult to give a temperature estimate that the coat may have been exposed to. However, based on the fact that the exposure was relatively short and the thermal characteristics of Kevlar and PBI, I would estimate that the fabric temperature exposure was probably above 700° F and less that 1400° F. The exposure was high enough to cause some loss of strength, but not char the outer shell. This indicates to me that the fabric did not exceed the approximately 1400° F degradation temperature of PBI.

Lee Lipscomb
Quality Assurance Director

Definition:Thermal Protective Performance (TPP) Test
The Thermal Protective Performance (TPP) Test measures the amount of thermal energy that is transferred through a specimen or composite that is sufficient to cause a second degree burn. The test compares materials by exposing them to a consistent heat source and measuring the calories and time exposure required to reach the 2nd degree burn threshold. Burn injury in human tissue occurs when the tissue is heated and kept at an elevated temperature for a period of time, and the degree of burn injury depends on both the level and duration of the temperature. In the test, a sample or composite is mounted in a static horizontal position, placed a specific distance from a combined convective/radiant heat source, and exposed until sufficient energy passes through the sample to cause the equivalent of a second degree burn in human tissue. The test

exposure is composed of convective energy supplied by two gas burners and radiant energy from nine quartz radiant tubes. The total heat flux is set and calibrated to 2.0 cal/cm2/s. A TPP test result of 36 means that 36 calories of heat energy per cm2 were required to reach the 2nd degree burn threshold. Since the exposure was 2 cal/cm2 heat energy, 18 seconds (36 divided by 2) exposure was required to reach the 2nd degree burn threshold.

APPENDIX E

Atlanta Fire-Rescue “Fast-Track” Schedule

2006

“Fast-Track” Recruit Class 06-03
Schedule

Week 1

- **Thursday Oct 5 B** — Orientation, Human Resources **(DOWNTOWN)**
- **Friday Oct 6 C** — Orientation, Human Resources **(DOWNTOWN)**
- **Monday Oct 9 C** — CPR-PCR **(EMS) Capt. Revere/Capt. Beckman**
- **Tuesday Oct 10 A** — Patient Care **(EMS) Capt. Revere**
- **Wednesday Oct 11 B** — **(SOG/SOP) Chief Slaughter /Capt. Heard**

Week 2

- **Thursday Oct 12 C** — Truck Operations **(Eng.20C Capt. Edwards)**
- (SEARCH AND RESCUE)
- **Friday Oct 13 A** — Truck Operations **(Truck 1A Capt. Rawls)**
- (LADDERS AND VENTILATION)
- **Monday Oct 16 A** — Truck Operations **(Truck 17A Capt. Perdue-?)**
- (FORCE ENTRY TOOLS AND EQUIPMENT)
- **Tuesday Oct 17 B** — Car Seat Class
- **Wednesday Oct 18 C** — Car Seat Class

Week 3

- **Thursday Oct 19 A** — Car Seat Class
- **Friday Oct 20 B** — Car Seat Class
- **Monday Oct 23 B** — Engine Operations **(Eng. 12B Lt. Richardson)**
- **(Engine?)**
- (3” AND 5” SUPPLY, FOR/REV LAYS)
- **Tuesday Oct 24 C** — Engine Operations **(Eng. 31C Lt. Gray)**
- **(Eng. 2C Lt. Smith)**
- (ATTACK LINES, STINGER, DECK GUN,
- LADDER PIPE)

- **Wednesday Oct 25 A** Engine Operations **(Eng. 16A Lt. Dobson)**
- (STANDPIPE AND SPRINKLER SYTEMS)

Week 4

- **Thursday Oct 26 B** Burn(**Eng 12B Lt. Richardson, Eng 20B Capt. Dewitt)**
- **Friday Oct 27 C** FF Sur/ RIT (**Trk16C Cpt. Simmons, Eng 20C Edward**
- **Monday Oct 30 C** Extrication (**Truck 1C Capt Beckman)**
- **Tuesday Oct 31 A** **Marta 0900hrs**
- **Wednesday Nov 1 B** Scott NX-G2 BA Class

APPENDIX F

Photos from Squad 4

<u>This photo shows the A / B corner. Note the number of firefighters at the front of the structure. This photo was taken as the flameover began.</u>

<u>This photo shows the B side of the structure. Note the left window covering on the ground that is still smoking. The amount of firefighters at the front door has not significantly changed.</u>

Fire issuing from the B / A corner of the structure.

Fire issuing from the door and window of the room of origin on the C / B side of the structure.

<u>Same as previous photo.</u>

<u>Same as previous photo.</u>

APPENDIX G

Photos of FF Solomon's Gear

Underside of Firefighter Solomon's Helmet. Damage can be seen on the eye shield, the underside of the brim, and the suspension.

Top side and crown of Firefighter Solomon's helmet. Lack of damage to the crown and reflective trapezoids indicate the thermal damage to the helmet may have occurred with the helmet laying upside down on the floor.

Rear brim of Firefighter Solomon's helmet. Note the relative lack of damage to rear brim.

Firefighter Solomon's SCBA facepiece. Note crazing of the lens at the lower part of the face piece but relatively undamaged at the top. This could be due to coverage by Firefighter Solomon's hood. Also note the absence of damage to the harness This may also indicate that he was wearing his facepiece when the flameover occurred.

Thermal damage to outside of Firefighter Solomon's SCBA regulator.

Firefighter Solomon's hood showing one layer of fabric burned away.

Thermal damage to Firefighter Solomon's hood/

Firefighter Solomon's hood melted to a piece of a rug.

Firefighter Solomon's turnout coat and inner liner showing thermal damage.

Firefighter Solomon's turnout pants and inner liner showing thermal damage.

APPENDIX H

Photos of 257 Elm Street

This is a photo of the A-Side of 257 Elm Street (post-incident).

This is a photo of the B-Side of 257 Elm Street (post-incident).

This is a photo of the C-Side of 257 Elm Street (post-incident).

This is a photo of the A/D Side of 257 Elm Street (post-incident).

APPENDIX I

Report by Schirmer Engineering

APPENDIX I

Report by Schirmer Engineering

INTRODUCTION

Schirmer Engineering Corporation has been asked by the Atlanta, Georgia Fire-Rescue Department to provide fire modeling services to gain an understanding of the conditions experienced by fire fighter Steven Solomon the night of November 23, 2006. A site survey was performed at the fire scene to capture the severity of the damage and to gain any information useful to the inputs of the fire model. This intent of this report is to summarize the analysis of the predicted temperatures of the compartment experienced by Steven Solomon at the point of flameover.

Over the last 20 years fire modeling has evolved significantly. Some of the earliest fire modeling involved complicated hand calculations based on empirical test data and the conservation laws of physics. These hand calculations were the foundation for the development of some of the earlier zone models such as DETACT-QS, CFAST and ASET. Today, field models are widely used among fire protection engineers to model complicated fire scenarios. A field model takes a computational domain and divides the domain into many small grid cells and solves the conservation laws at each of the grid cells. While field models are not appropriate for every fire modeling application, they are considered the most state-of-the-art in fire modeling. As a result, a field model was found suitable for the modeling of the Elm Street fire.

The Fire Dynamics Simulator (FDS) is a computational fluid dynamics (CFD) model developed by the National Institute of Standards and Technology (NIST) used to simulate the behavior and dynamics of a fire. FDS is a comprehensive tool that allows the user to input various boundary conditions and measure a variety of different gas quantities such as temperature, velocity, and concentration at user defined locations. The outputs of FDS can be visualized through its companion software Smokeview.

MODELING APPROACH

A site survey was conducted on December 8, 2006 to document and record the various elements needed to model the fire. The geometry of the building was measured and sketched as the basis for the input for obstructions into FDS. Building materials where also documented as inputs into thermal properties into FDS. The location of the fire source was observed to be the along the back wall. FDS requires numerous inputs for simulating a fire such as grid spacing, obstruction and vent dimensions, thermal properties of materials, and ambient conditions. The various FDS inputs are discussed below.

Grid

FDS uses a rectilinear coordinate system where the domain is comprised of individual grid cells. The number of grid cells depends on the resolution desired by the user. A fine grid should, theoretically, yield more accurate results than a coarse grid. However, a fine grid results in a high number of grid cells and this can be computationally expensive (i.e. longer computation times). As a result, multiple meshes where used in the simulation to achieve high resolution where needed. Six meshes (grid systems) were used in total. One mesh was prescribed so that the boundaries of the mesh coincided with the exterior walls and the top of the roof. The five remaining meshes where prescribed around the five planes of the building exposed to the atmosphere. Grid spacing inside the building was approximately 4 inches in all coordinate directions. Grid spacing outside of the building was approximately 10 inches in all coordinate directions.

Obstructions

An obstruction in FDS is essentially a three-dimensional block that can have different thermal properties used to model different materials. The building consisted of four exterior walls, an exposed ceiling, interior walls, a sloped roof, door, windows, and wood paneling covering the door and windows. There was not much in the way of interior furnishings inside the building other than the mattress which was the fuel source. All obstruction were prescribed their corresponding thermal characteristics. The roof, ceiling construction, and east wall were made "invisible" so that visualization of the fire was not obstructed. The graphical user interface PyroSim was used to help create obstructions and write the FDS input file. Figure 1 shows a PyroSim screen shot of the building.

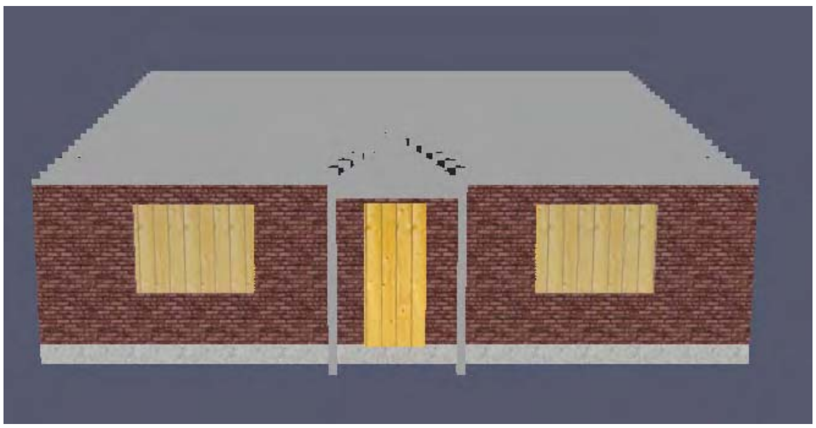


Figure 1: Screen shot of exterior of building.

Sloped and curved surfaces must be approximated using rectilinear obstruction in FDS. The sloped roof was modeled using a "stair-stepping" technique. However, using a "stair-stepping" technique to model a sloped surface introduces changes in the flow of gases around the rectangular corners and edges. To lessen this effect "SAWTOOTH=.FALSE" was added to the each line of every "step" of the roof obstructions.

Each window and door was covered by a piece of plywood. Once the fire fighters arrived to the scene different wood panels were removed at different times. FDS allows obstructions within the computational domain to be created or removed at user prescribed times. This was useful when trying to model fire fighters removing the panels. The sequential order of panels that were removed was documented and implemented into the computer model. However, the times given for removing the panels were given based on the time of fire fighters arriving on the scene. This posed a problem due to the fact that removing the panels in the computer model is based on a reference time (typically time t = 0 sec), and the time between ignition and fire fighter arrival is not known. This is discussed further in the Model Uncertainty section below.

FDS takes a computational domain and sub-divides the domain into many small rectangular grid cells. As a result of the rectilinear subdivision, all obstructions (i.e. walls, wood studs, etc.) in and FDS simulation “snap” to the nearest grid cell. For example, if a 2-inch wall is placed in the center of a 3-inch grid cell, the wall boundaries will “snap” to the 3-inch grid cell. When calculations begin, FDS will view the wall as a 3-inch wall and not the prescribed 2-inch wall. Similarly, if the 2-inch wall is placed in the center of a 12-inch grid, the wall will appear as a thin sheet in the FDS simulation as it “snapped” to a nearest grid which, in this case, was the same grid cell face.

The fact that obstructions shift to the nearest grid cell posed an interesting problem when trying to accurately model the surface area of the ceiling structure. The building’s roof was supported by 2×6 inch wood frames. However, grid spacing was approximately four inches in all coordinated directions. Therefore a 2×6 obstruction would shift to the nearest grid cell and cause a different surface area than in reality. To account for this discrepancy the total surface area of the wood construction was taken and equally divided into the appropriate number of grid cells. In other words, the number of wood obstructions in the FDS simulation is less than the number of wood studs used in the actual building, but the exposed surface area of the two are the same.

Vents and Openings (Holes)

Vents in FDS are rectangular planes that allow the transfer of smoke and/or heat from one boundary to another. Vents in FDS are not physical vents such as typical HVAC units in buildings, but rather a slice that is used to prescribe a heat source such as a fire or radiant panel. Vents can also be used at the boundaries of the computational domain to allow natural gas flow to occur between the domain and the atmosphere. In this model vents were used to simulate open air boundaries and the fire source.

Holes in FDS take a solid obstruction and create a three dimensional void in it. Whereas an FDS vent allows transfer of smoke and heat through boundaries in the domain, holes in FDS allow transfer of smoke and heat through a solid obstruction. Holes in FDS can be created and removed at user prescribed times within the simulation. Holes in this model were used to simulate open windows, doors, and roof vents.

Measuring Devices

The main objective of modeling the Elm Street fire is to predict the environmental conditions experienced by Fire Fighter Solomon. This objective is achieved through placing thermocouples within the computational domain at user defined locations. Thermocouples used in FDS simulations are different than real life thermocouples in that FDS thermocouples measure various gas quantities, not just temperature. Since FDS thermocouples are not actual physical devices, multiple thermocouples were placed at the same location. This was useful when trying to measure multiple gas quantities at the same location within the domain. The various gas quantities measured where radiant intensity, temperature, visibility, carbon monoxide concentration, oxygen concentration and soot concentration.

Radiant Intensity: Radiant intensity is the amount of radiant energy being emitted from a surface.

Temperature: Extremely high temperatures can cause various adverse effects. Besides the obvious burning that can be caused be high temperatures, temperature can also cause the person experiencing the high temperatures to lose consciousness or go into panic.

Visibility: Visibility was measured within the domain to gain some sort of insight on the smoke movement and therefore gain some understanding as to the visibility experienced by Solomon while trying to escape the building.

Carbon Monoxide: This odorless, colorless gas is one of the byproducts made from an incomplete combustion process. Lethal levels of CO are on the order of 500 ppm.

Oxygen: Oxygen is supplied to the fire fighter through is mask. However, oxygen concentration was measured to predict what levels of tenability were present if the mask were removed.

Soot: Soot is mainly made up of carbon and is can be a result of an incomplete combustion (i.e. under-ventilated conditions). Soot is also a residue that can cause obstruction to vision.

Location of Measuring Devices

Measuring devices where placed within the computational domain on the path believed to be traveled by Fire Fighter Solomon as he entered and tried to exit the building. As discussed in other sections of this report it is believed that he started on the southwest corner of the building ran passed the front door to the southeast corner of the building and proceeded toward the northeast corner where he collapsed. Thermocouples where placed along his assumed exit path at heights of 1.0, 3.0 and 6.0 feet above the floor. The height of the thermocouple placement were decided with collaboration from the fire department to capture gas quantities at heights where the fire fighter collapsed (1.0 feet), crawled (3.0 feet), and walked (6.0 feet). Table 1 shows the coordinates of the thermocouple placement, and Figure 2 shows a plan view of the thermocouple placements along the x-y plane. Table 1 only lists eight thermocouples; however it should be noted that each of the eight listed thermocouples measures the six different gas quantities listed above.

Table X: Coordinates of thermocouple placement

Thermocouple	Location # (see Fig. 2)	x-coordinate (ft)	y-coordinate (ft)	z-coordinate (ft)
1	1	4	2	6
2	2	17.5	2	6
3	3	32	8	1
4	3	32	8	3
5	3	32	8	6
6	4	32	23	1
7	4	32	23	3
8	4	32	23	6

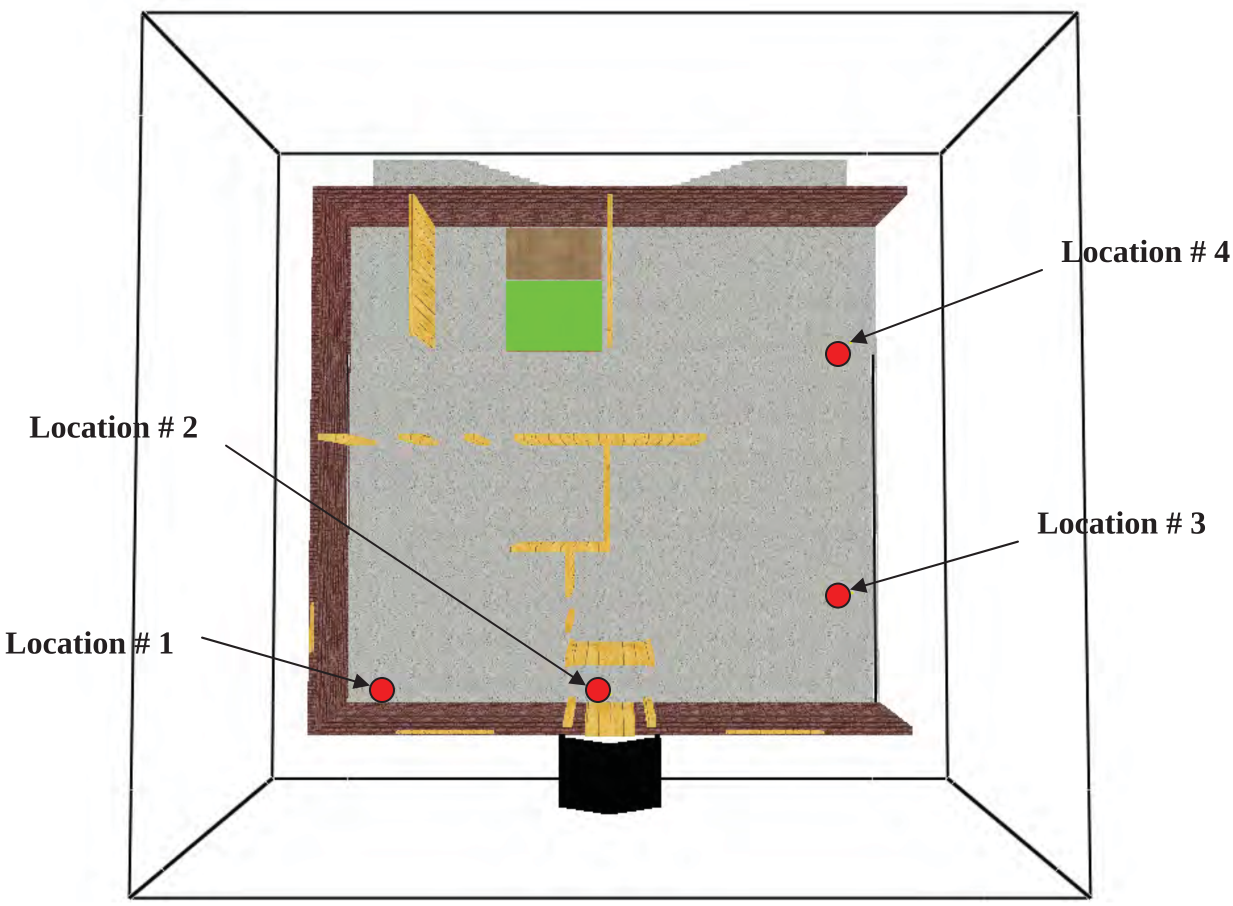


Figure 2: Placement of thermocouples along x-y plane.

Model Uncertainty

Calculations performed by FDS are dependent on various parameters such as vent openings, obstructions, and grid spacing. A site survey was performed to capture the necessary parameters needed for an FDS simulation. However, certain variables needed to run and FDS simulations were needed, but not available. Therefore, certain assumptions and estimates had to be made in order to run and FDS calculation. When assumptions and estimates are made then model uncertainty comes into play and the results of a calculation have to take into account the uncertainty. Uncertainty can come from various sources. For example, if measurements for the dimension of the compartment were not taken accurately, then minor uncertainty will exist in the FDS simulation. The accuracy of FDS predictions depends on how accurate the user replicates the dimensions, obstructions, and other parameters of a fire scene into an FDS simulation. In other words, FDS "sees" what the user tells it to "see". The following are the main sources of model uncertainty:

- Time of ignition
- Time of fire fighter arrival relative to ignition
- Time of vent openings relative to ignition
- Thermal properties for some materials
- Replicating "incomplete" walls

While precise information for the above mentioned parameters were not available, estimates were made from timeline of fire fighter operations, interviews, and recordings of the dispatch operator.

The inside of the exterior walls were, for the most part, exposed brick. However, there were some locations were a thin layer of a plaster-type material was mounted on top of the brick. This thin layer of material was absent throughout most of the surface area of the wall. Therefore this material was not included in the simulation as the thickness of this material was very small compared to the grid size and much of the material was not present in the compartment. Also, many interior partition walls were knocked down and many walls were missing or damaged. Therefore, an estimate of the available partitions was used in the FDS simulation.

RESULTS

FDS predictions are given as a series of spreadsheets as well as a visualization output through Smokeview. To evaluate the various predicted gas quantities in the compartment the spreadsheets were tabulated into a graph with time as the independent variable. The main findings of the FDS simulation will be discussed here. The appendix contains the individual graphs of the time dependent gas quantities for each of the measuring devices in the simulation.

The fire originally started under fuel-controlled conditions. Once the mattress ignited, the fire plume grew steadily until it reached a height to where the underside of the roof began to burn. The flames slowly extended along the slope of the roof towards the front of the building while pyrolysing the available wood.

Ventilation to the inside of the building was very limited as the windows and doors were initially boarded up with plywood. Therefore, the fire initially consumed the available oxygen to a point were the fire transitioned to ventilation limited conditions. During this period the fire and upper layer gas temperature continued to grow. Fire fighters arrived on the scene and began their operations at approximately 8-9 minutes from ignition. Approximately 10 minutes after ignition, the first piece of plywood covering the window was removed. The chronological order of vent openings is outlined in Table 2:

Table 2: Sequence of vent openings[1].

Sequence	Window/Door	Time (after ign.) [sec]
1	A/1	600
2	A/3	615
3	B/1	630
4	B/2	645
5	A/2	675
6	D/3	720

The front door (A-2) was removed at approximately 675 seconds after ignition and this is when firefighter Solomon entered the front door with a fire hose and backed-up by Firefighter Evans and Acting Officer Joseph. The thermocouple placed in location # 2 (see Figure 2) recorded the environmental conditions experienced by firefighter Solomon. FDS predicted a temperature of 170 °C (338 °F) at the time Solomon entered the building. As Evans and Joseph entered the building and proceeded towards the A/D corner they observed the location of the fire and directed Solomon to reposition the line in the direction of the fire. Shortly afterwards the compartment conditions deteriorated forcing all three firefighters to drop to the floor. Communication with Solomon was lost as they proceeded to exit the building through the front door.

A term used to describe a particular fire phenomena is “flashover”. Within the fire protection community there is conflict as to the exact meaning of the term “flashover”. However, flashover can be defined as the transition from a localized fire to combustion of all exposed combustible surfaces of the room[2]. This phenomena occurs when the radiant heat from the upper gas layer reaches an intensity such that it ignites all combustible items within the compartment. As mentioned earlier, the building had very little in the way of furnishings or combustible items. Therefore, flashover is not considered an appropriate term to describe the segment on a fire curve where a sharp increase in temperature occurs. Rather “flameover” would be a more fitting term to describe a sharp increase in temperature. “Flameover” will be defined as a flash fire which occurs over the surface of a wall or ceiling which is caused by the sudden ignition of combustible vapors that are produced by heating the surface of that wall or ceiling[3]. While there were no furnishings in the building, the roof was constructed with wood material and was the source of the flameover.

The predicted time of flameover was approximately 740 seconds after ignition (12.4 minutes). Figure 3 shows the evolution of the flame spread viewed from the top of the building

[1] It should be noted that vent C-1 was half-open from the beginning.

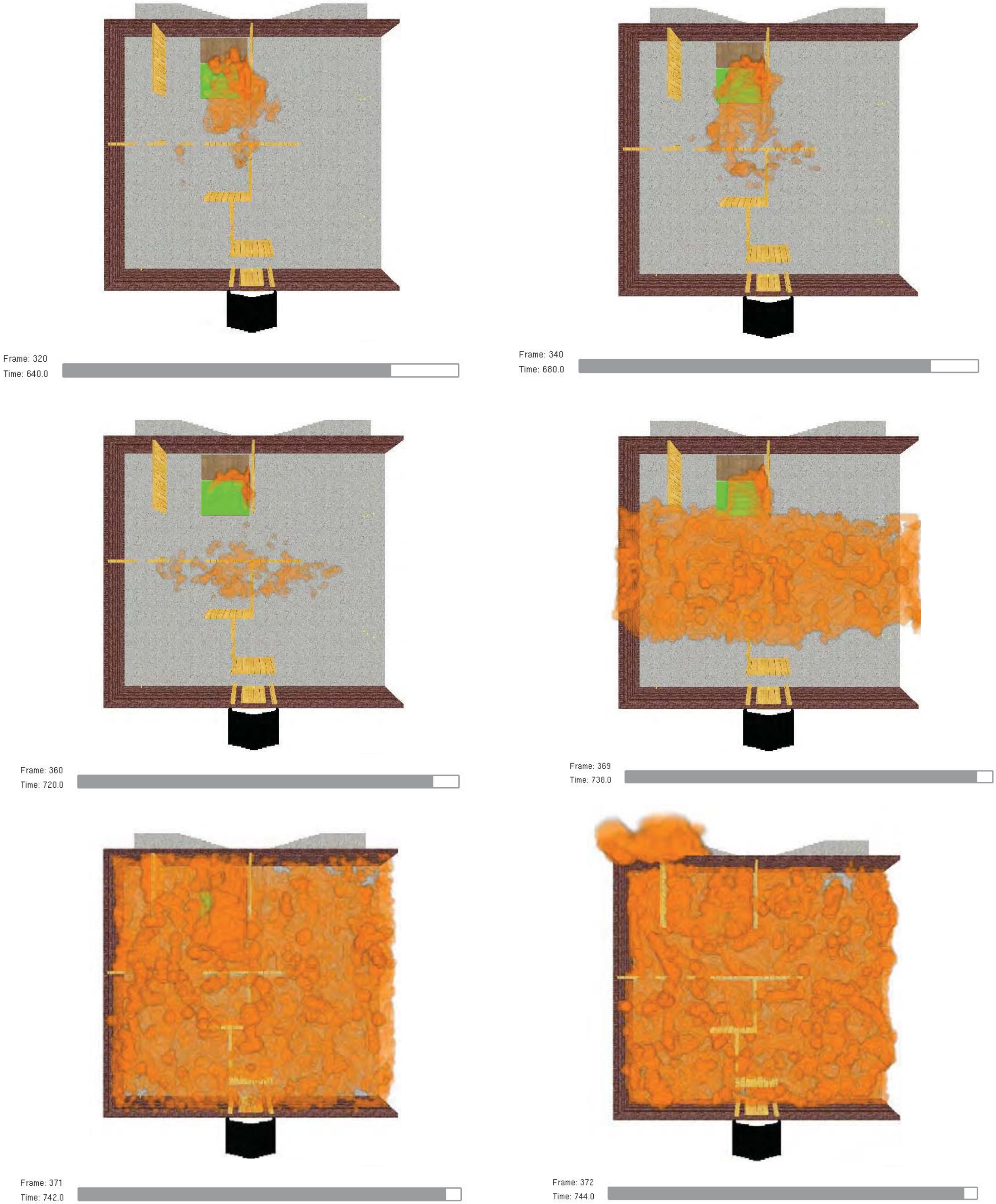


Figure 3: Flame spread from ignition to flameover.

(the ceiling construction was made "invisible" for visualization purposes). The fire spread progressed towards the front of the building along the slope of the roof. As the available oxygen in the room was being consumed, the fire transitioned into ventilation-limited conditions until fire fighters opened windows and doors. The opening of the windows and vents introduced more oxygen into the compartment and therefore allowed the fire to grow to the point of flameover. The predicted flameover occurred in such a way that the flames appeared to "roll" from the peak of the roof slope downwards.

If Solomon entered the building at 675 seconds after ignition and flameover occurred 740 seconds after ignition then there is approximately 65 seconds (1.1 min) from the time where he entered to the time of flameover. Therefore it is possible that fire fighter Solomon experienced flameover while positioned at the A/B corner of the building. FDS predictions for flameover temperatures along the assumed path of travel of Solomon ranged from 700 to 900 °C (1290 to 1650 °F). Solomon's turnout gear has since been tested by Southern Mills, Inc. to estimate exposure temperature of his gear. Southern Mill's estimated exposure temperatures of 370 to 760 °C (700 to 1400 °F).

The term usually applied to the location of the fire source is "room of origin"; however, in this case there was no individual "room" as the building was essentially an open, undivided space. Since a "room of origin" did not exist the fire was not confined to a room and smoke and flame spread throughout the building was expected. In other words, the temperatures produced from the gases would affect everyone in the building. It is unknown how fire fighter Solomon ended up in the A/B corner of the compartment. However, since the building was essentially a large room, he would of experienced flameover conditions anywhere in the building.

Part of fire fighting maneuvering tactics include crawling on the floor as opposed to walking upright. The intent of this tactic is to be able to maneuver within a space without having smoke obstruct vision. However, FDS simulations show that once flameover occurred within the compartment, high temperature occurred at all elevations of the building. In other words, once the entire compartment was engulfed in flames, the temperature experienced by Solomon was not dependent on the relative elevation of his body and head. Figure 4 shows the temperature distribution at the time of flameover at selected vertical planes.

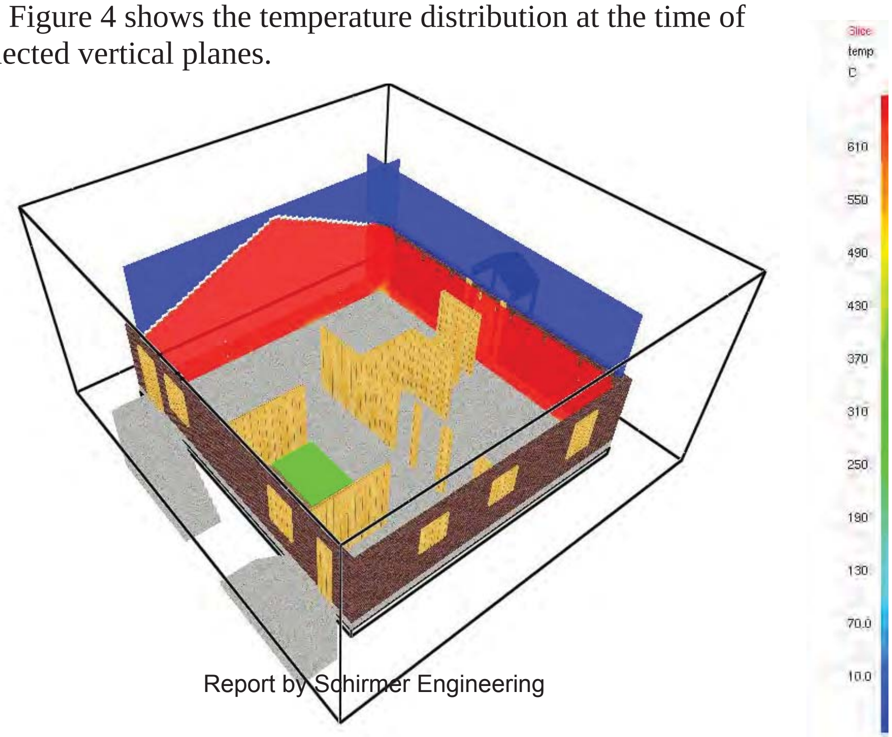


Figure 4: Temperature distribution at time of flameover. (Note: Temperature scale should be used as an approximation and not exact predicted temperature. For exact temperature predictions see appendix.)

As seen in Figure 4 above, once flameover was reached high temperatures were predicted at all elevations as well as the remote locations from the fire source. Two things can be concluded from this image. First, anyone within the compartment during flameover would experience the high temperatures, regardless of their location within the compartment. Second, Solomon would have experienced the same adverse conditions whether he was crawling or standing.

CONCLUSION

The Fire Dynamics Simulator was used to predict gas quantities inside 257 Elm St where Fire Fighter Solomon experienced life threatening conditions. Due to the lack of precise timeline, some input variables had to be estimated or assumed. Solomon entered the building shortly before an order was made to exit. During this time Solomon experienced flameover conditions and lost radio contact. The range of maximum temperature experienced by Solomon was between 700 and 900 °C. While Solomon's path of travel inside the building is unknown, he would have experienced flameover conditions anywhere in the building. Also, Solomon would have experience extreme temperatures whether he was crawling or standing. Schirmer Engineering Corporation hopes that modeling the fire conditions of the compartment helps to better understand the fire and possibly avoid incidents such as the tragic loss of Fire Fighter Solomon.

APPENDIX: The graphs shown in the appendix follow the naming convention for thermocouple placement shown in Figure X.

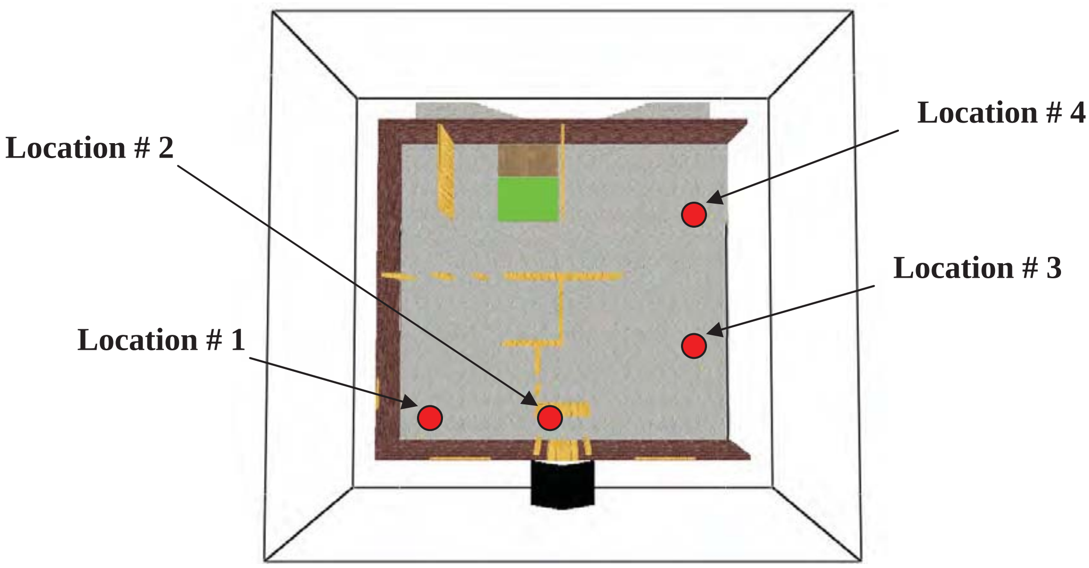


Figure X (reproduced here for convenience).

List of Graphs.

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RADIANT INTENSITY

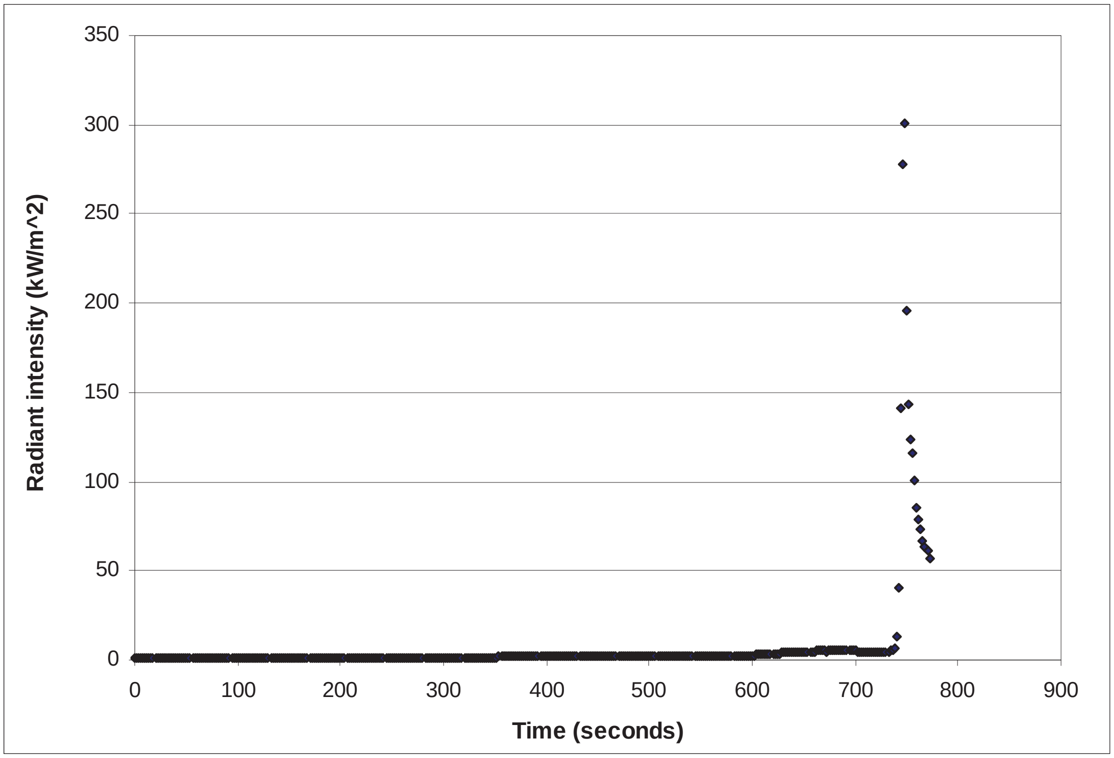

Figure A1: Radiant Intensity at Location 1, six feet above the floor.

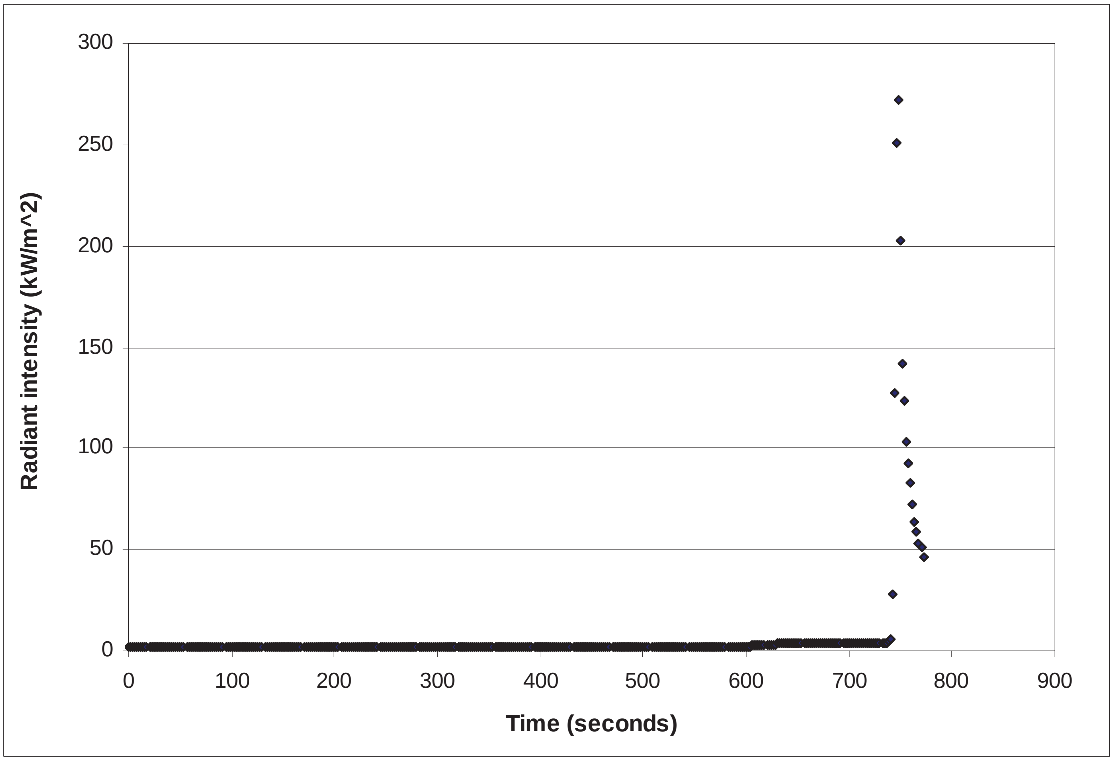

Figure A2: Radiant Intensity at Location 2, six feet above the floor.

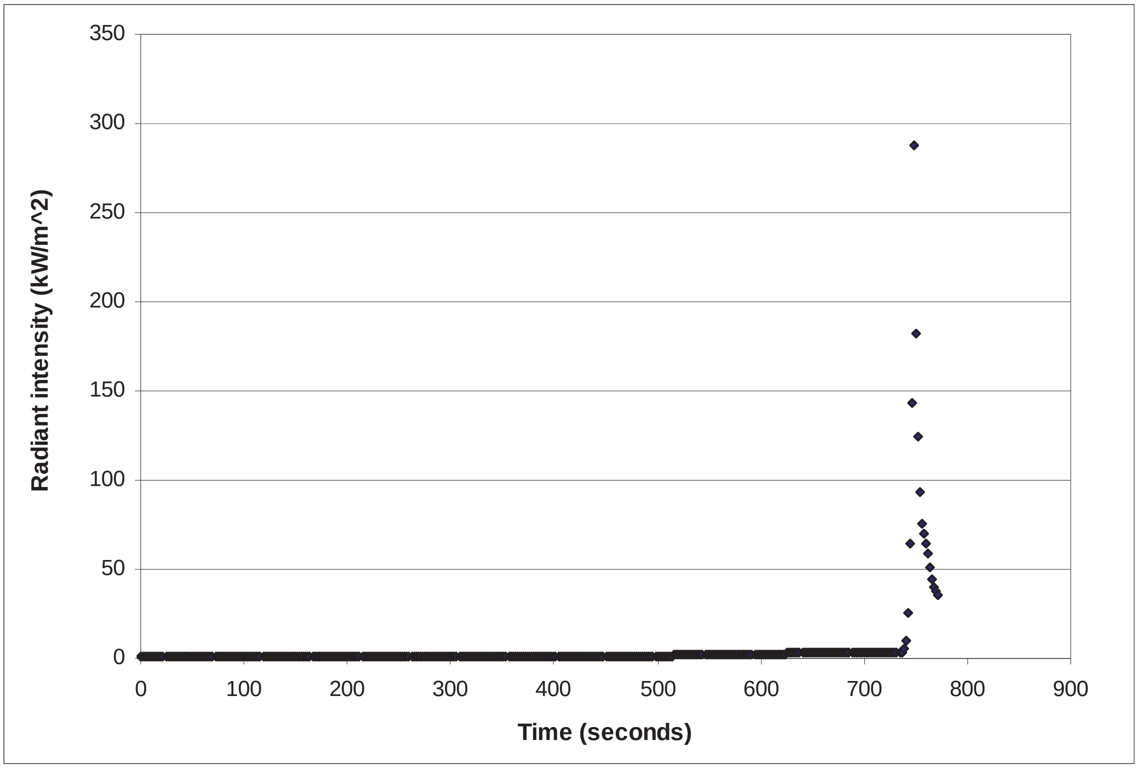

Figure A3: Radiant Intensity at Location 3, one foot above the floor.

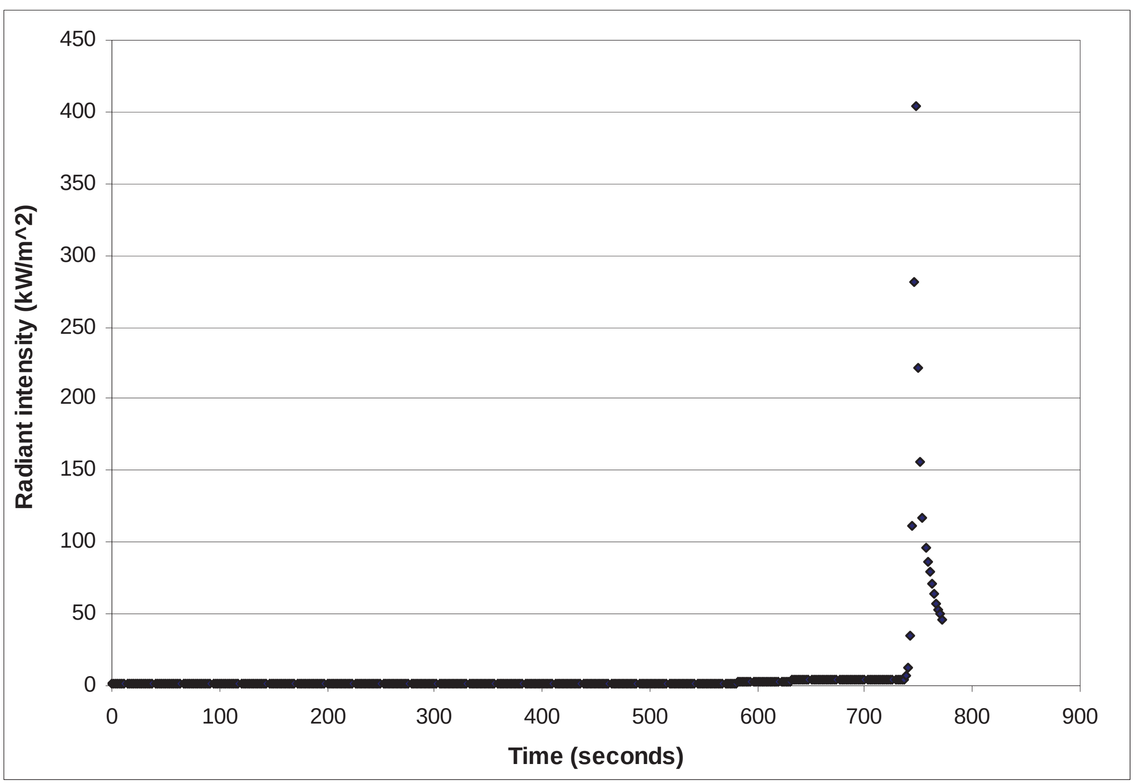

Figure A4: Radiant Intensity at Location 3, three feet above the floor.

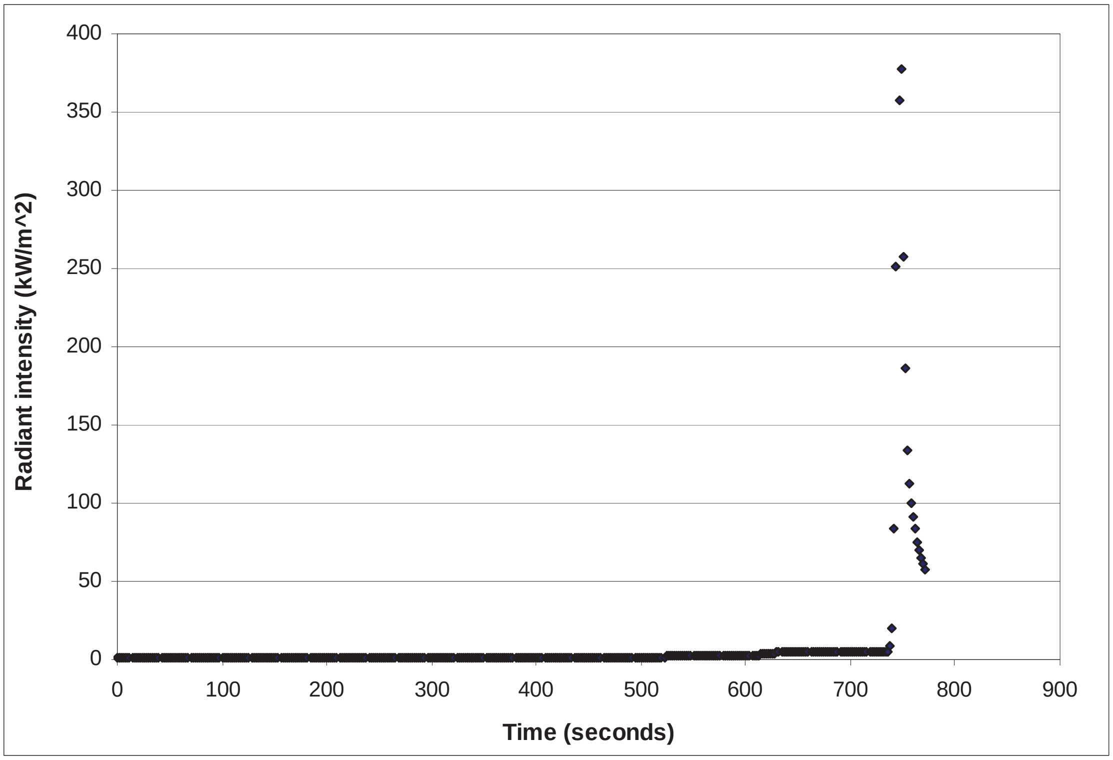

Figure A5: Radiant Intensity at Location 3, six feet above the floor.

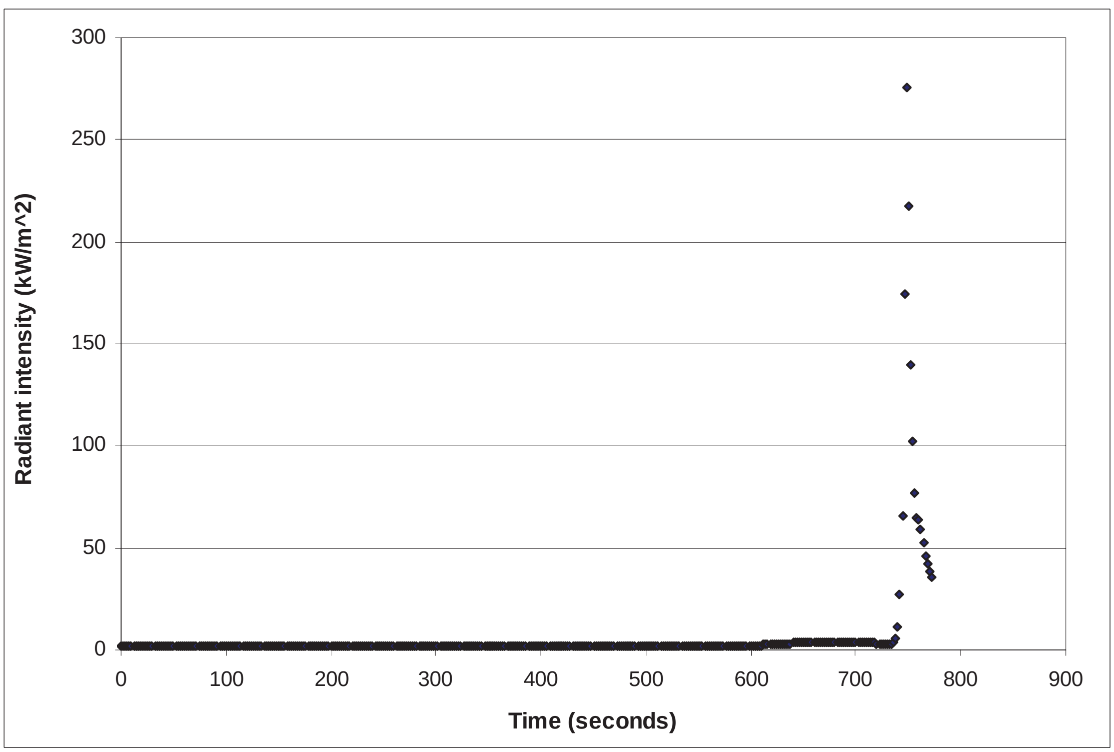

Figure A6: Radiant Intensity at Location 4, one foot above the floor.

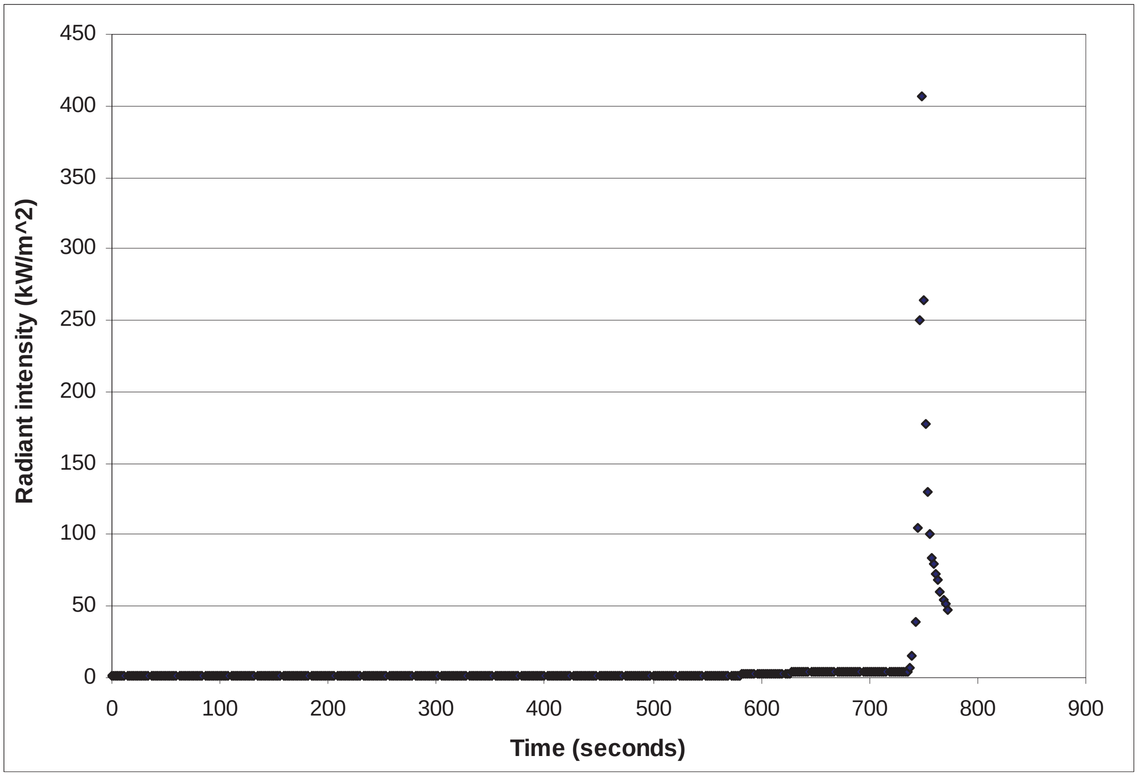

Figure A7: Radiant Intensity at Location 4, three feet above the floor.

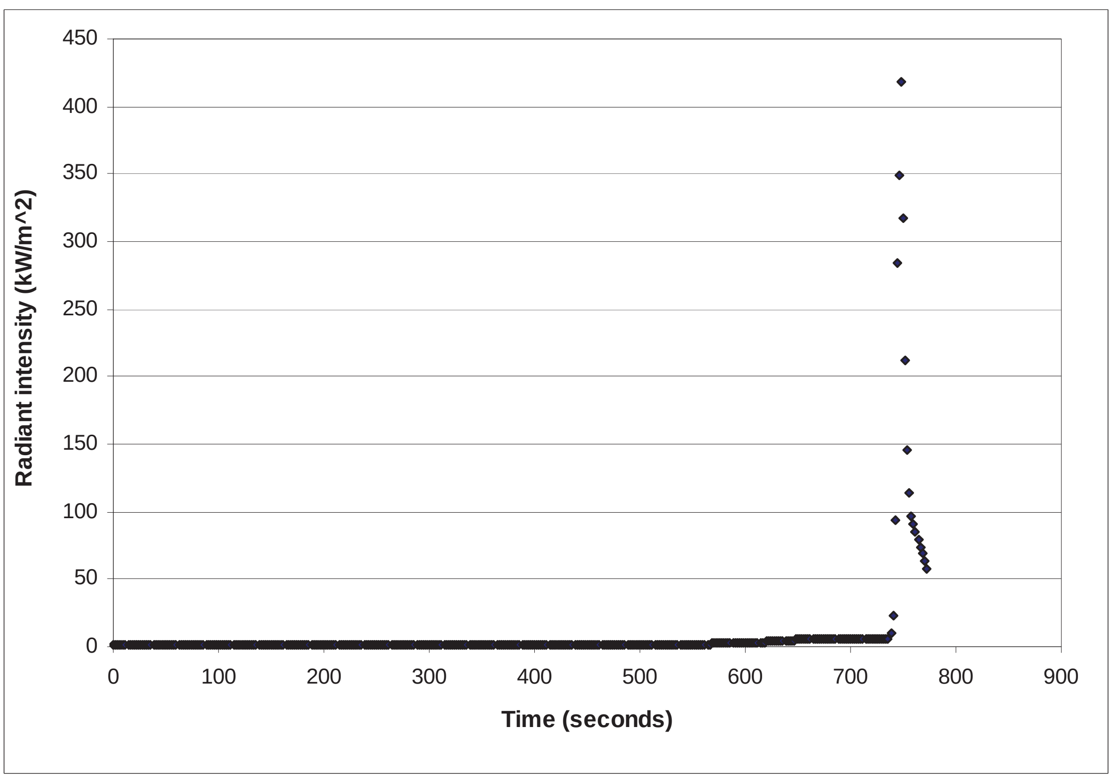

Figure A8: Radiant Intensity at Location 4, six feet above the floor.

TEMPERATURE

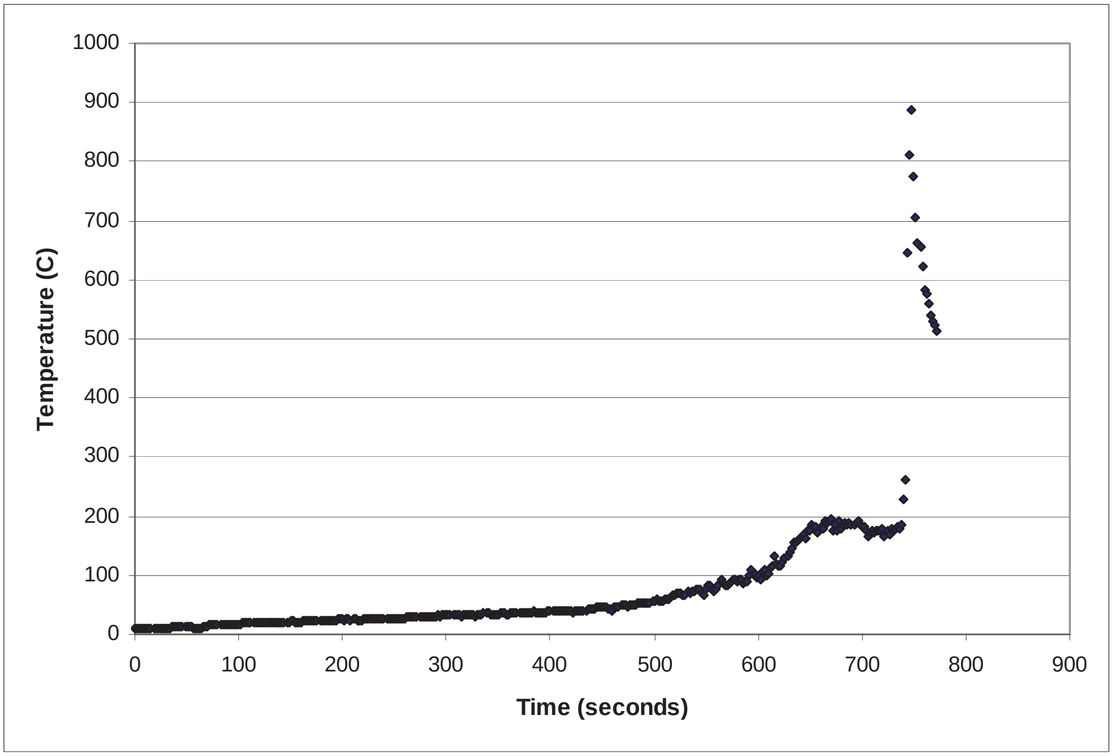

Figure A9: Temperature at Location 1, six feet above the floor.

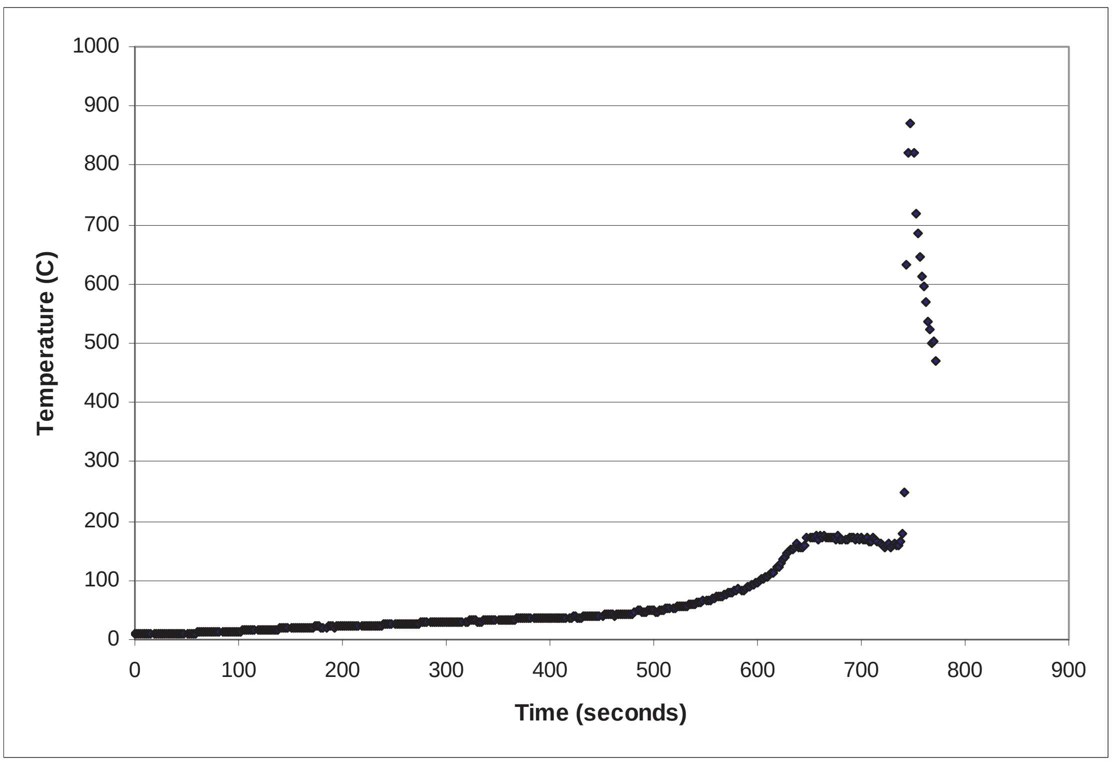

Figure A10: Temperature at Location 2, six feet above the floor.

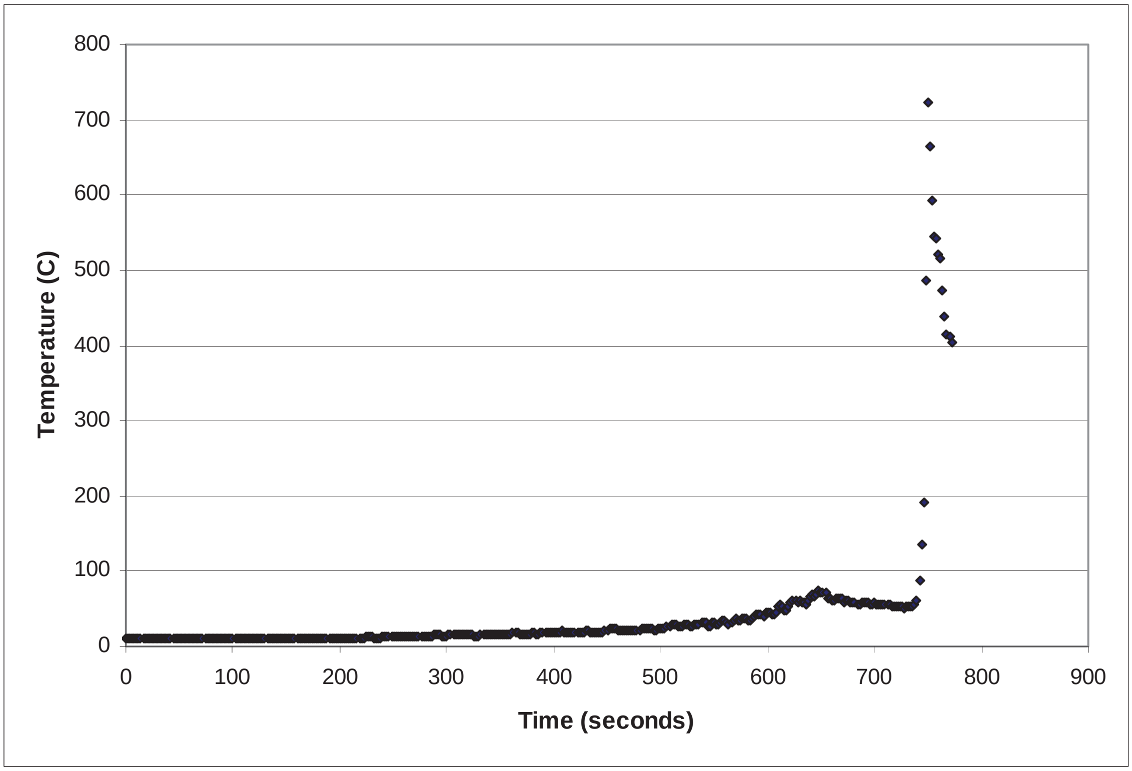

Figure A11: Temperature at Location 3, one foot above the floor.

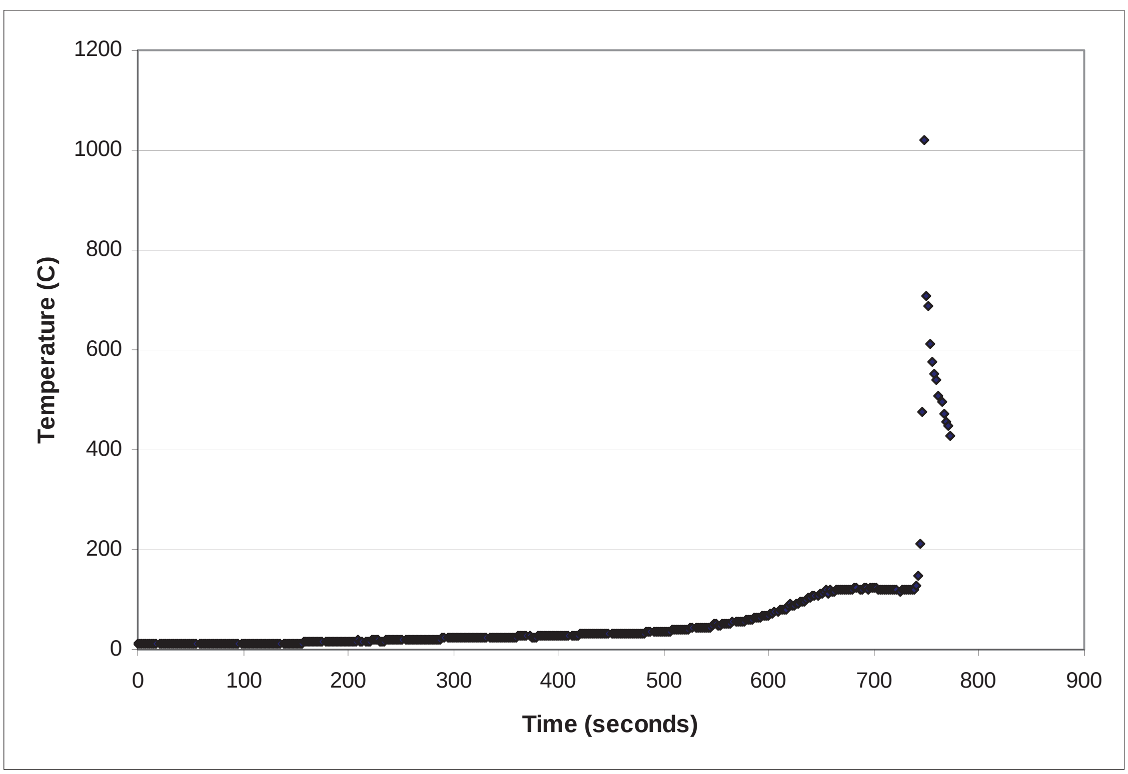

Figure A12: Temperature at Location 3, three foot above the floor.

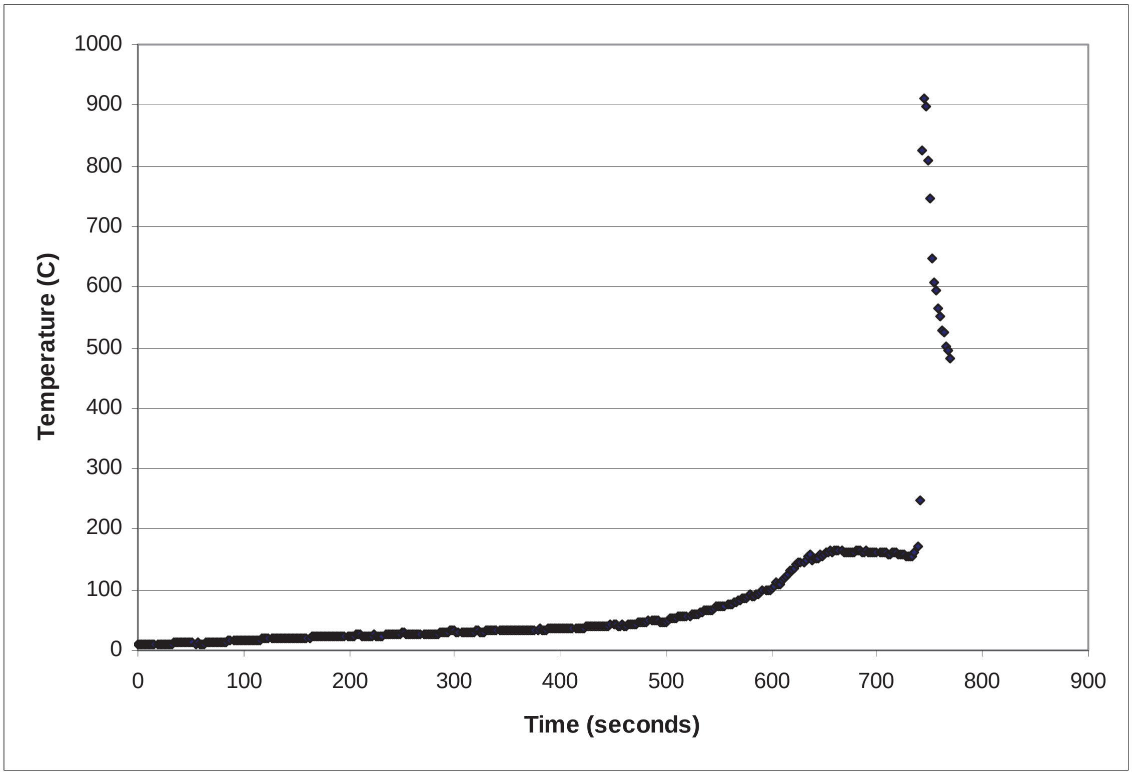

Figure A13: Temperature at Location 3, six foot above the floor.

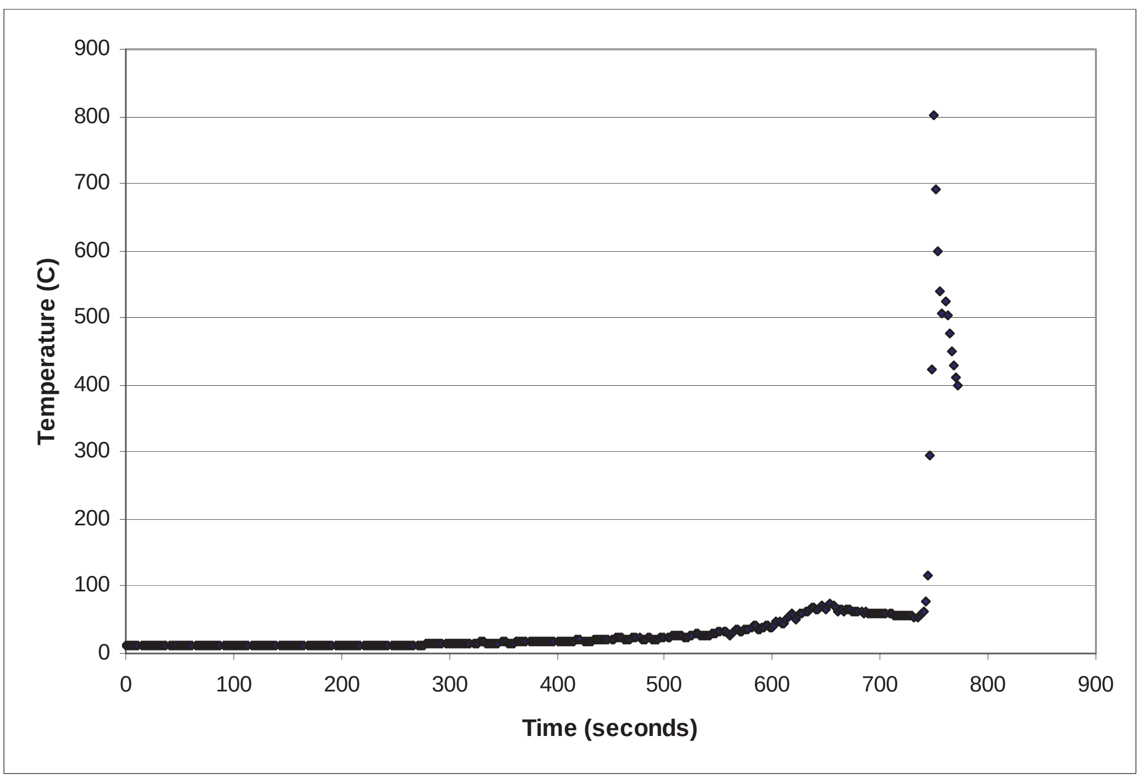

Figure A14: Temperature at Location 4, one foot above the floor.

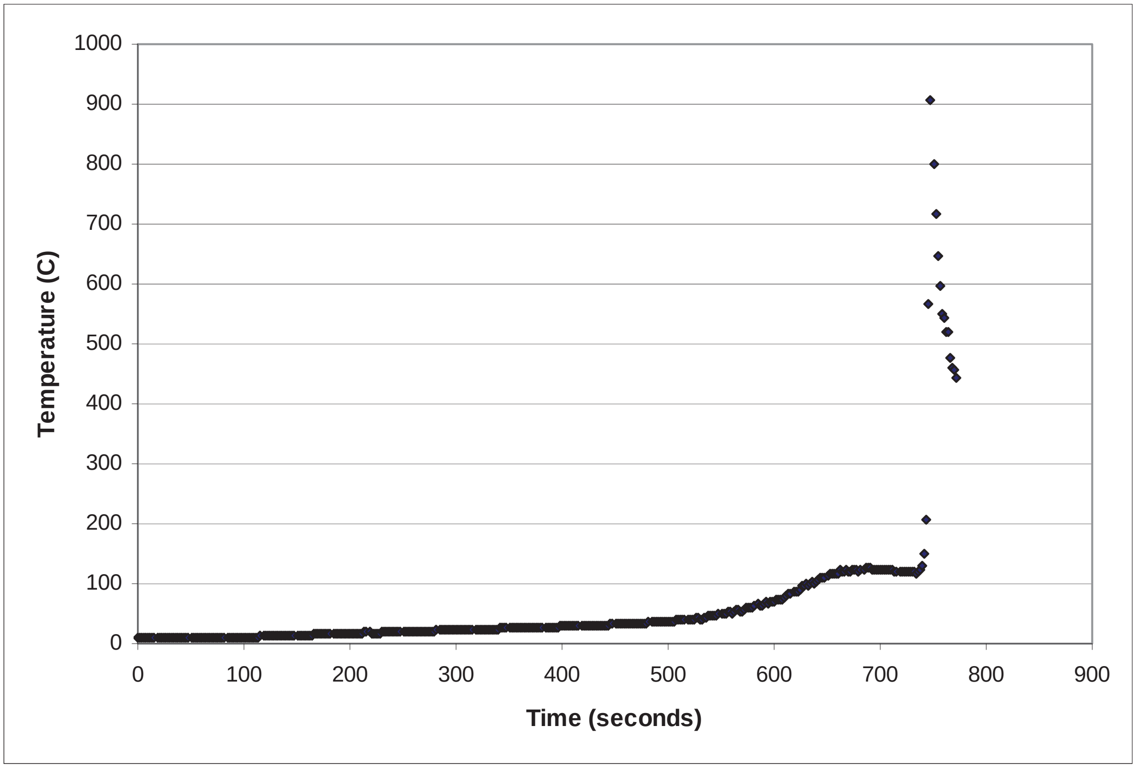

Figure A15: Temperature at Location 4, three feet above the floor.

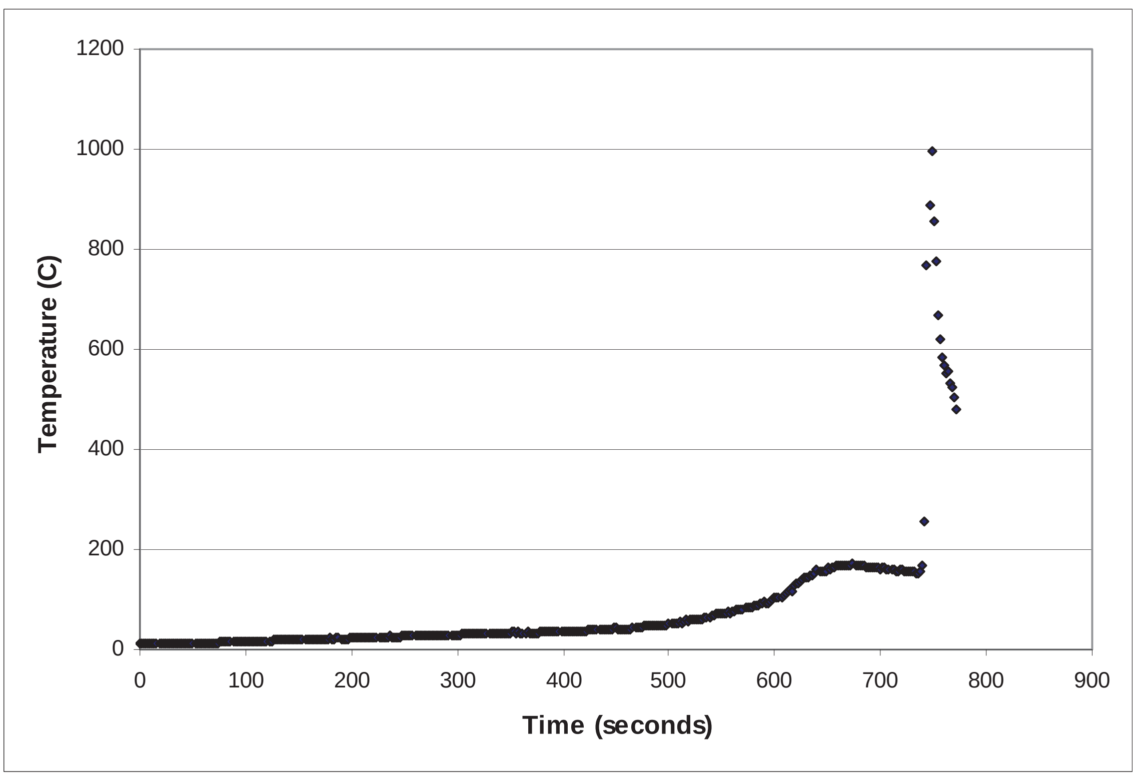

Figure A16: Temperature at Location 4, six feet above the floor.

VISIBILITY

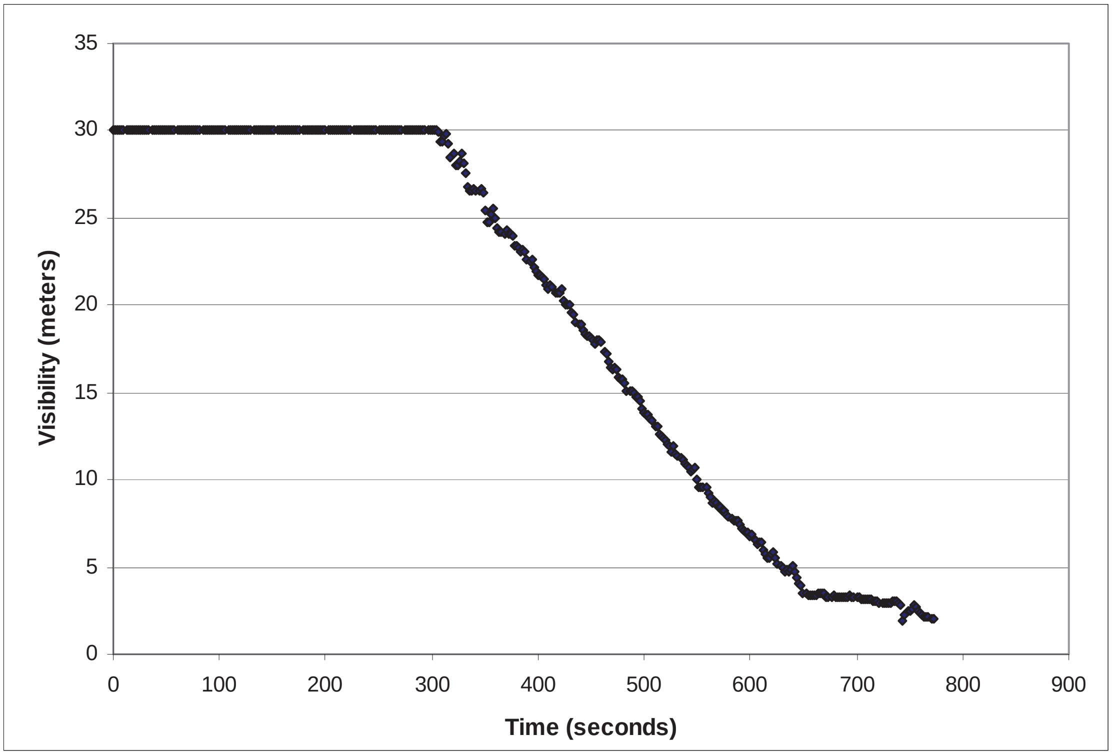

Figure A17: Visibility at Location 1, six feet above the floor.

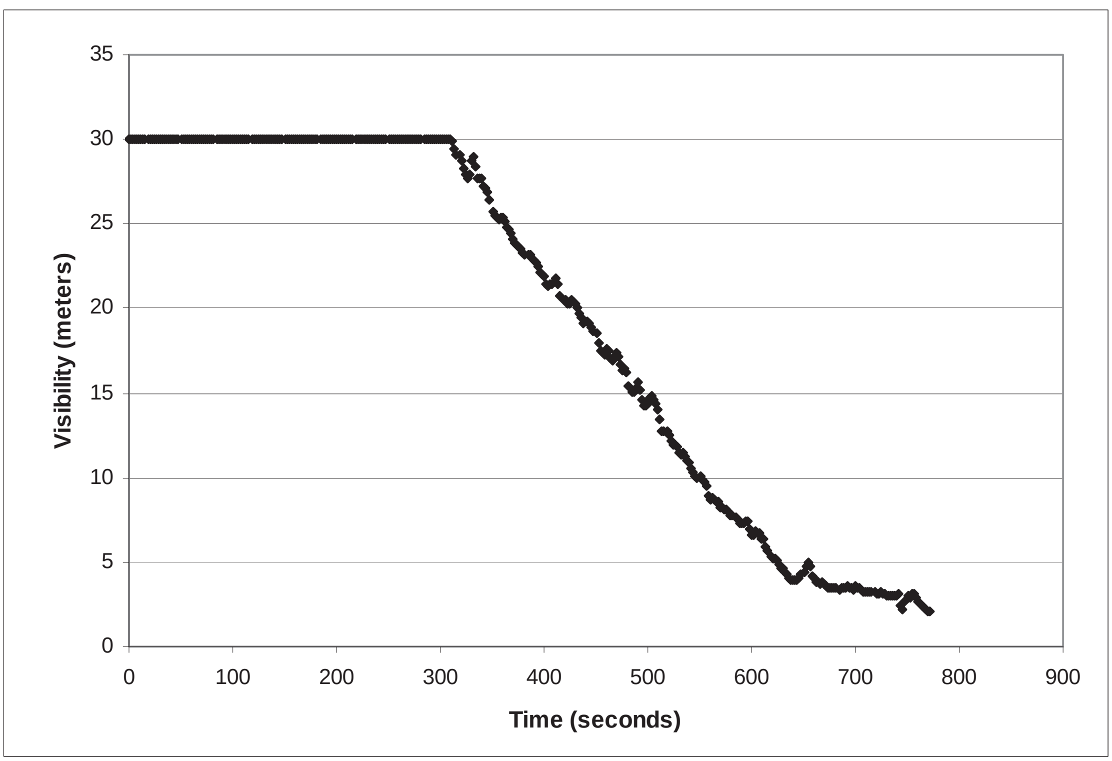

Figure A18: Visibility at Location 2, six feet above the floor.

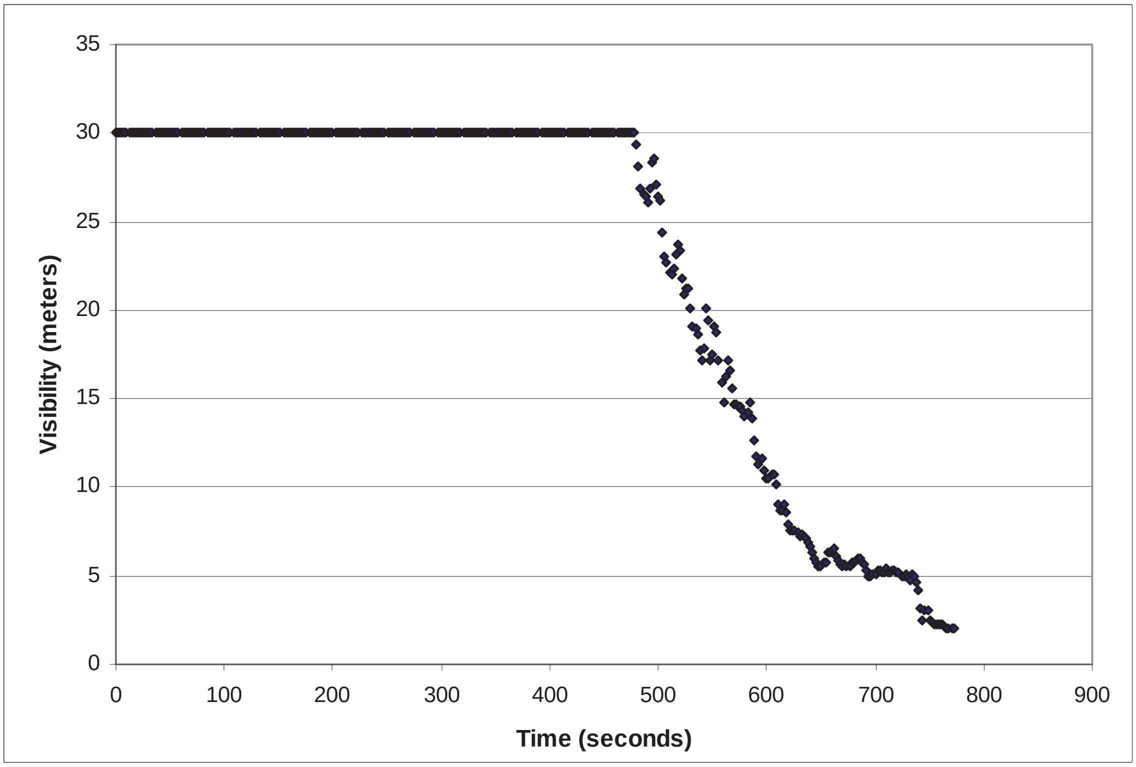

Figure A19: Visibility at Location 3, one foot above the floor.

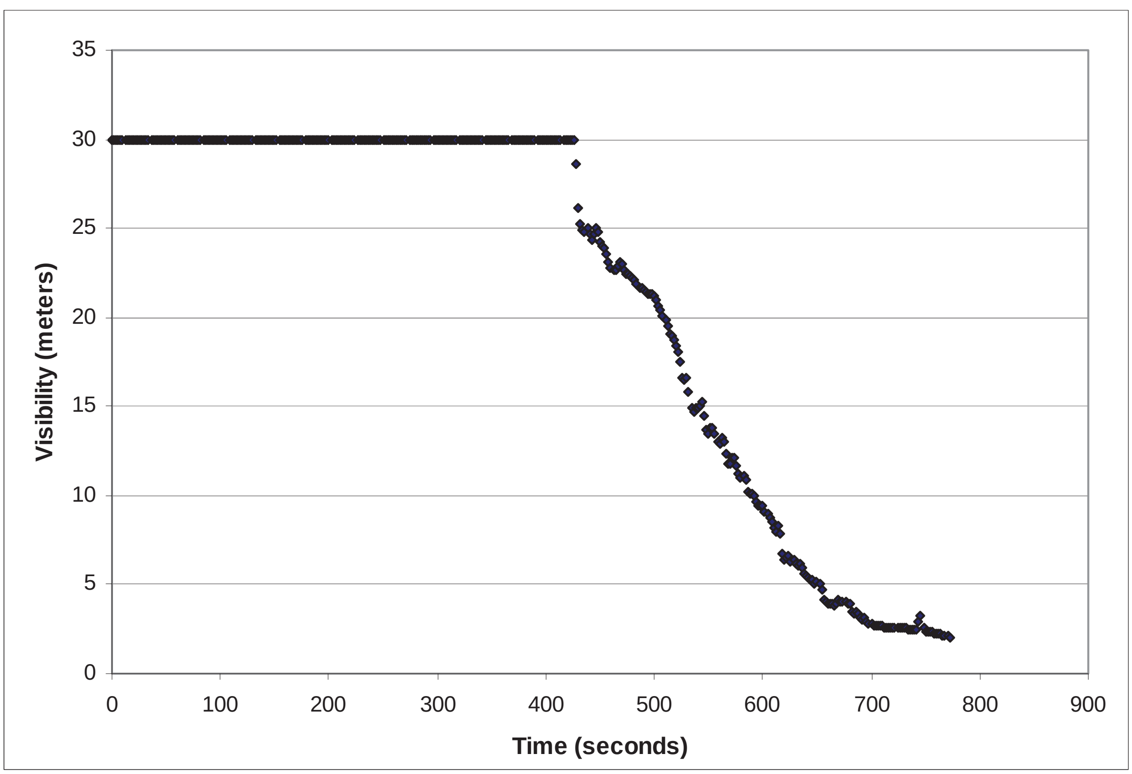

Figure A20: Visibility at Location 3, three feet above the floor.

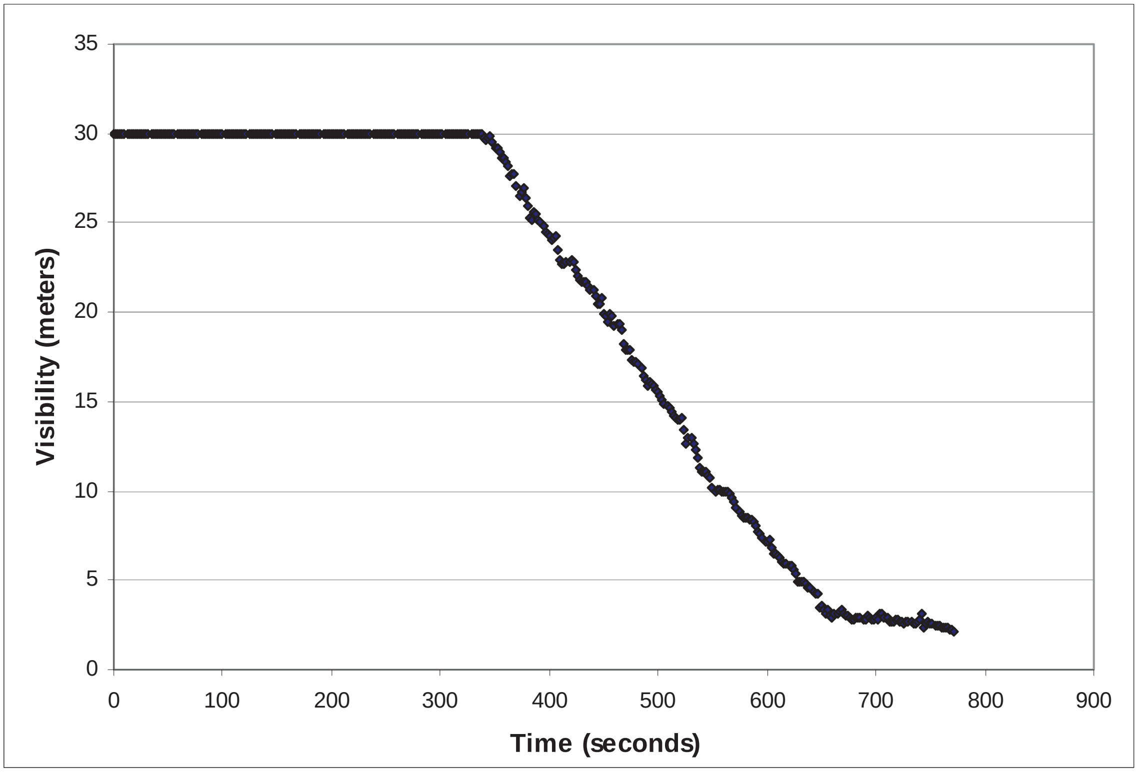

Figure A21: Visibility at Location 3, six feet above the floor.

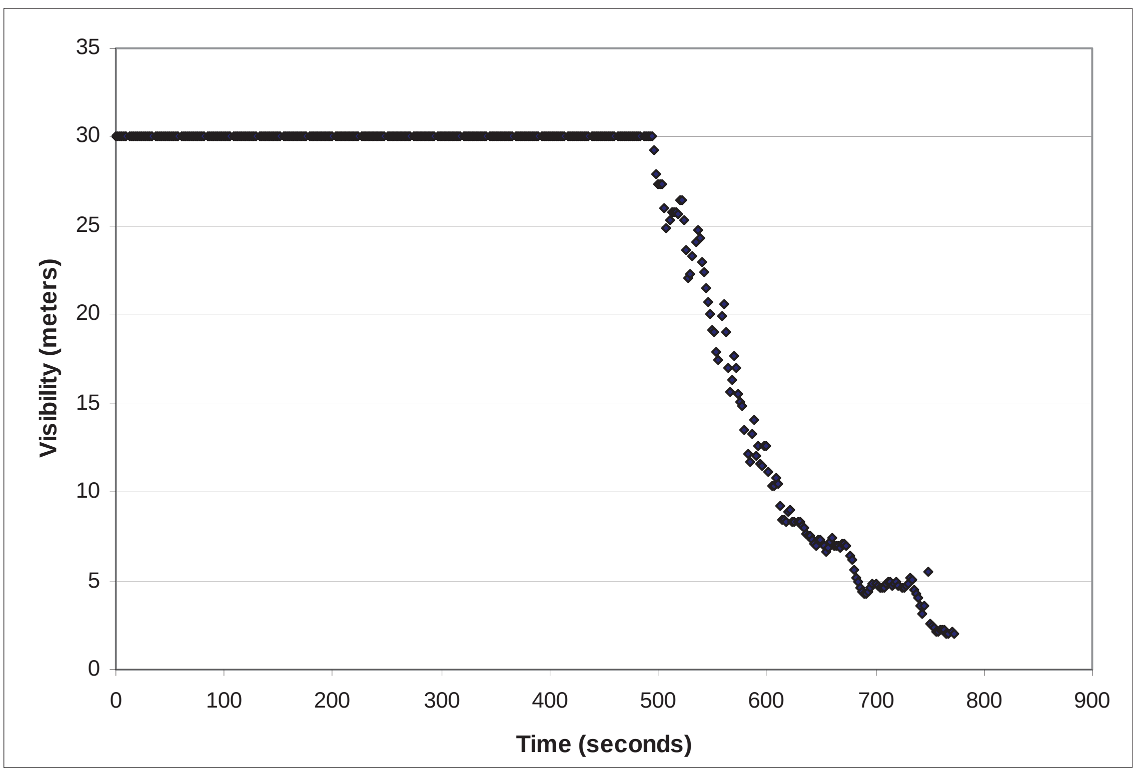

Figure A22: Visibility at Location 2, one foot above the floor.

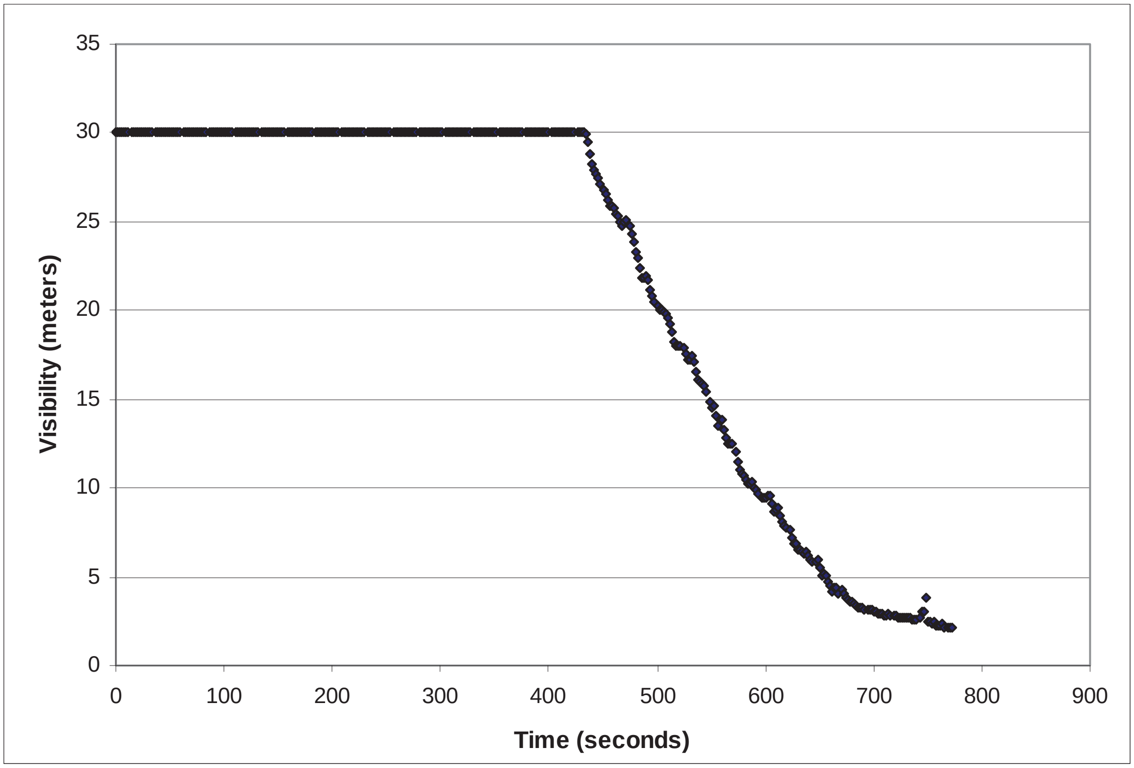

Figure A23: Visibility at Location 4, three feet above the floor.

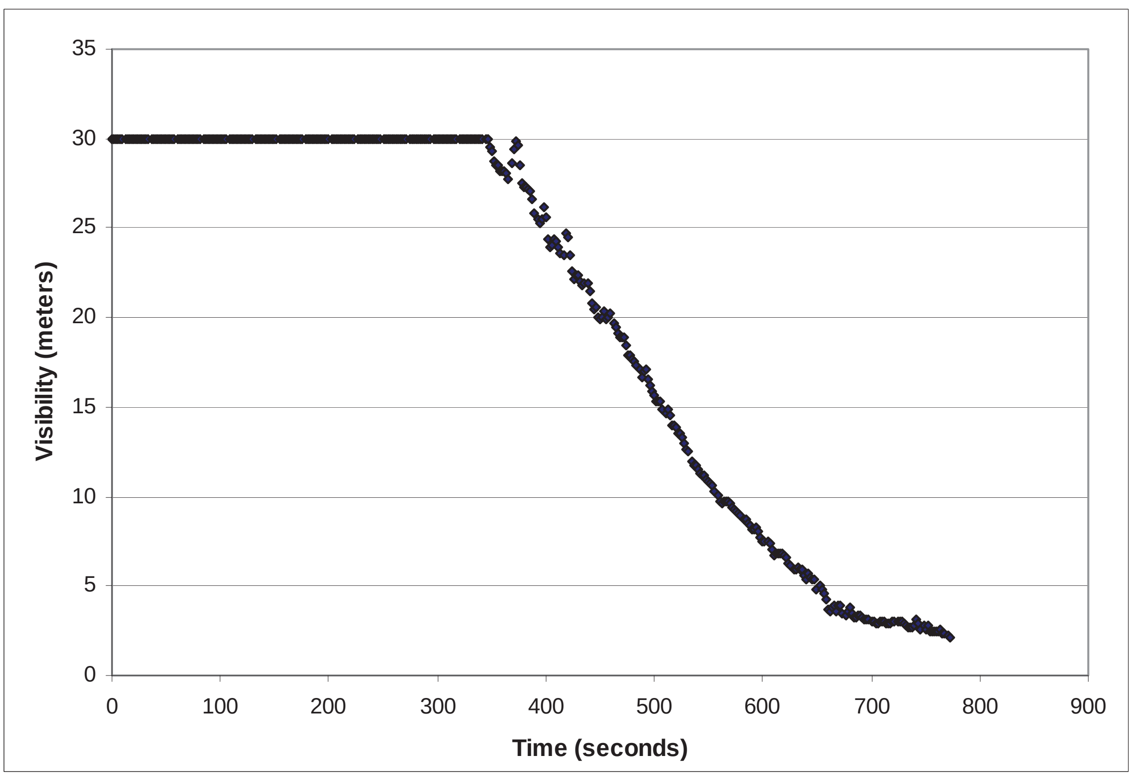

Figure A24: Visibility at Location 4, six feet above the floor.

CARBON MONOXIDE VOLUME FRACTION

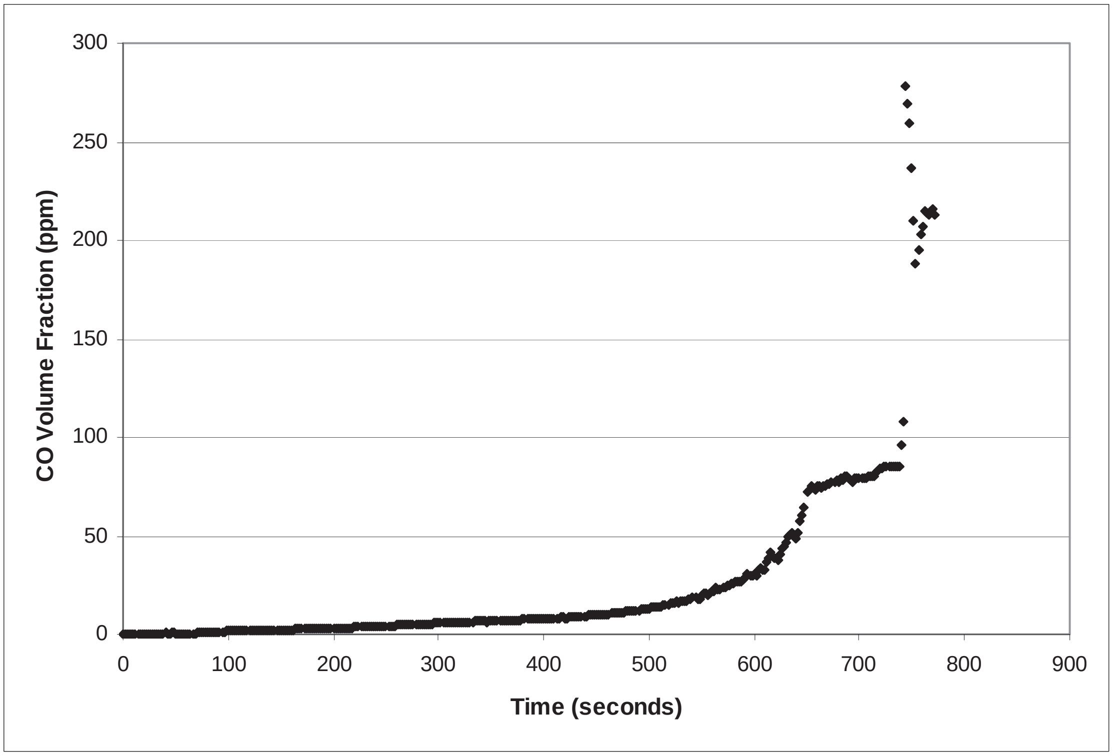

Figure A25: CO Volume Fraction at Location 1, six feet above the floor.

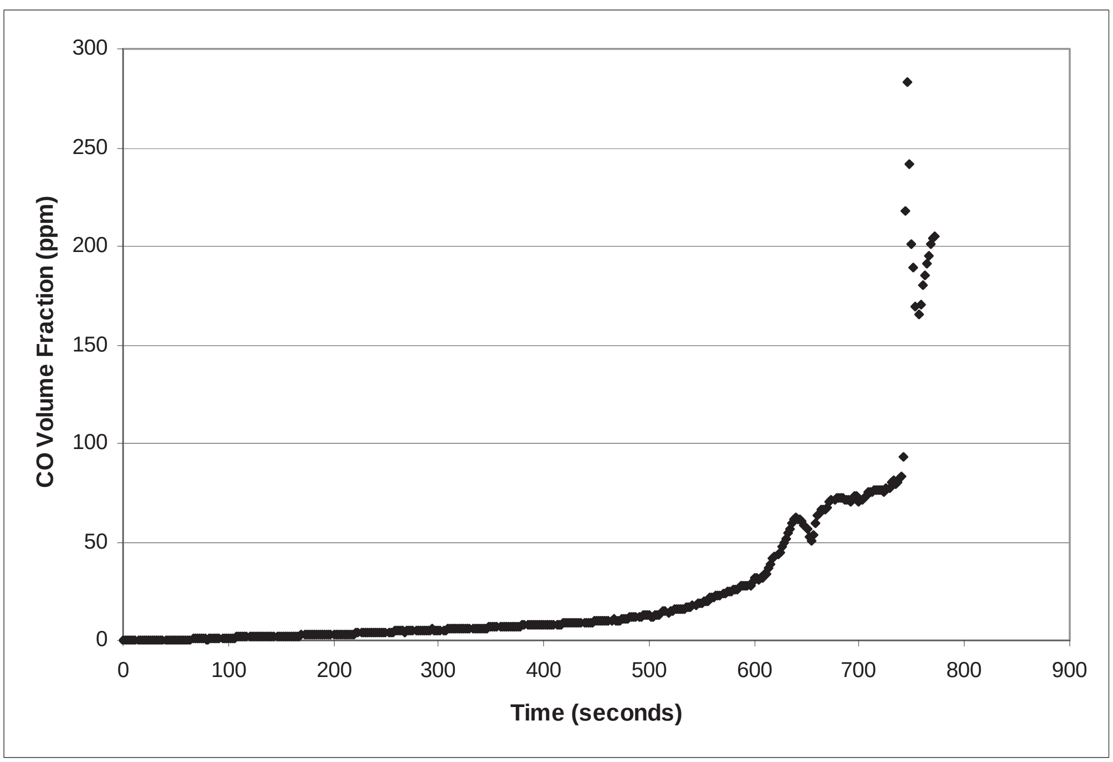

Figure A26: CO Volume Fraction at Location 2, six feet above the floor.

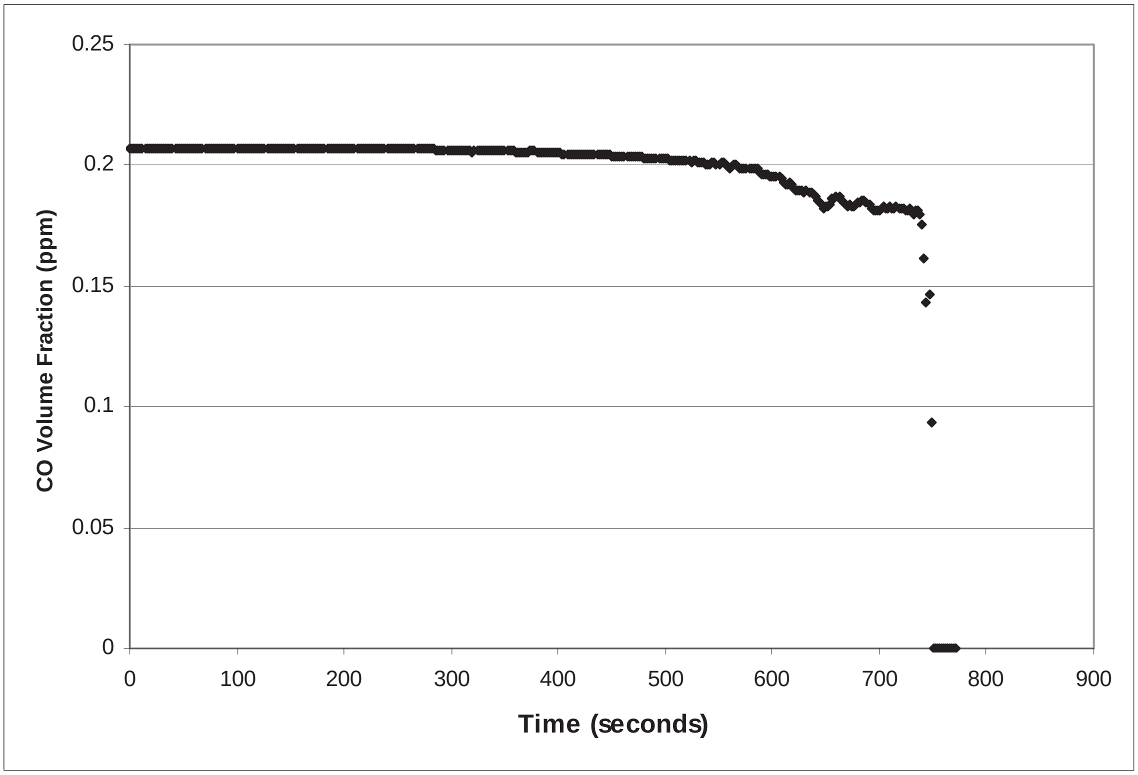

Figure A27: CO Volume Fraction at Location 3, one foot above the floor.

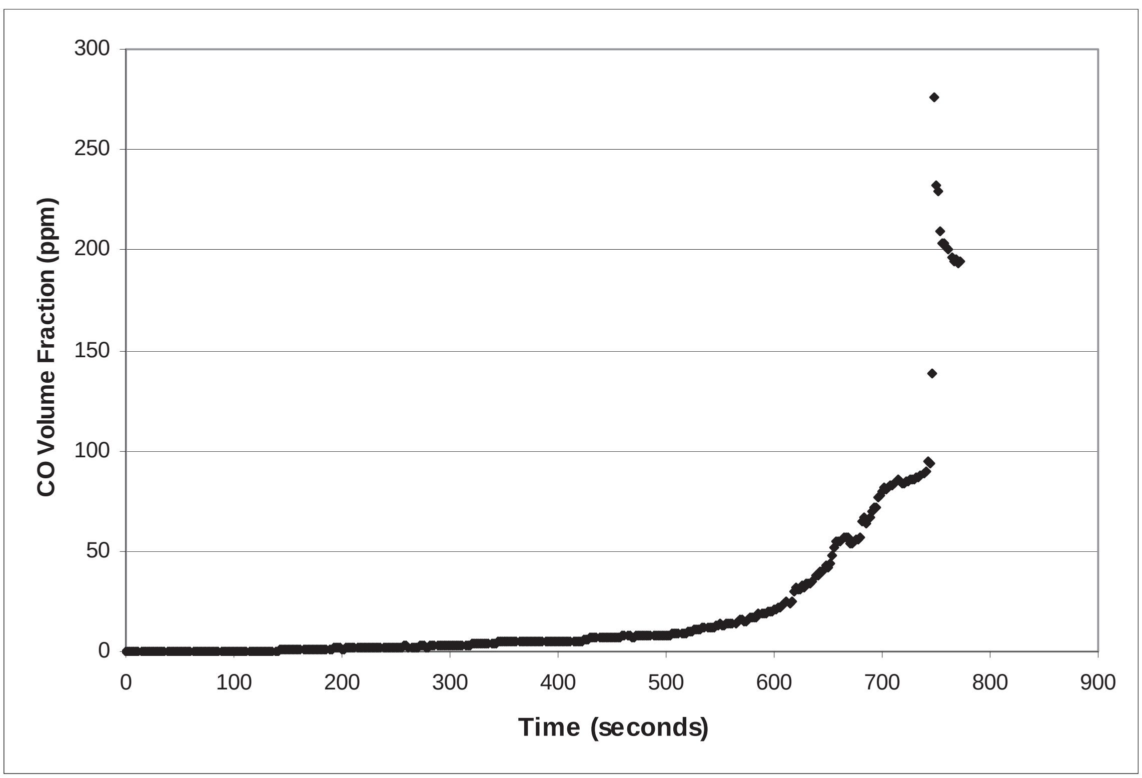

Figure A28: CO Volume Fraction at Location 3, three feet above the floor.

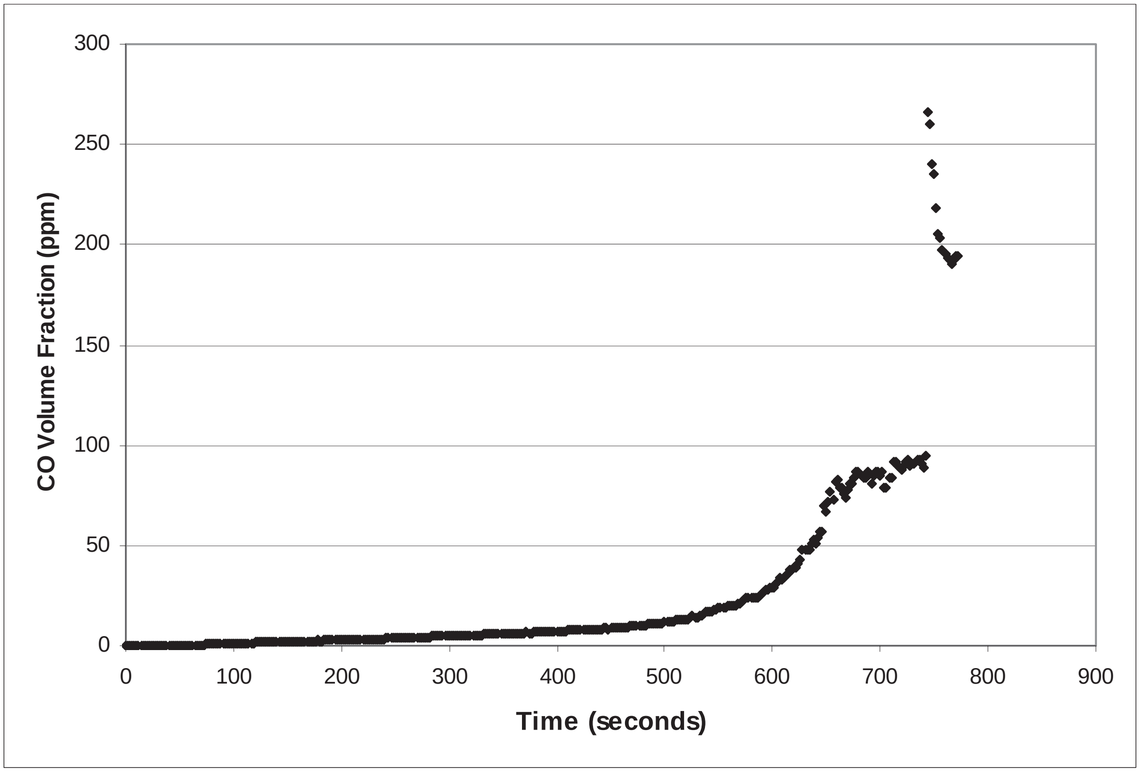

Figure A29: CO Volume Fraction at Location 3, six feet above the floor.

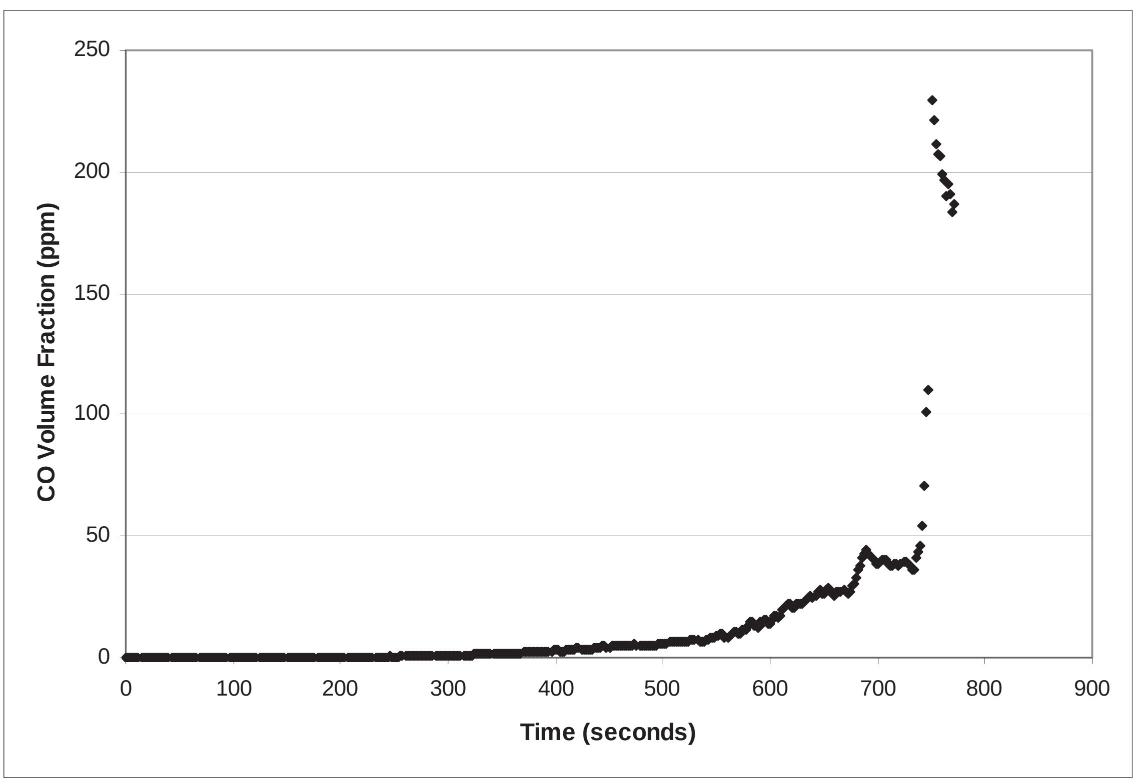

Figure A30: CO Volume Fraction at Location 4, one foot above the floor.

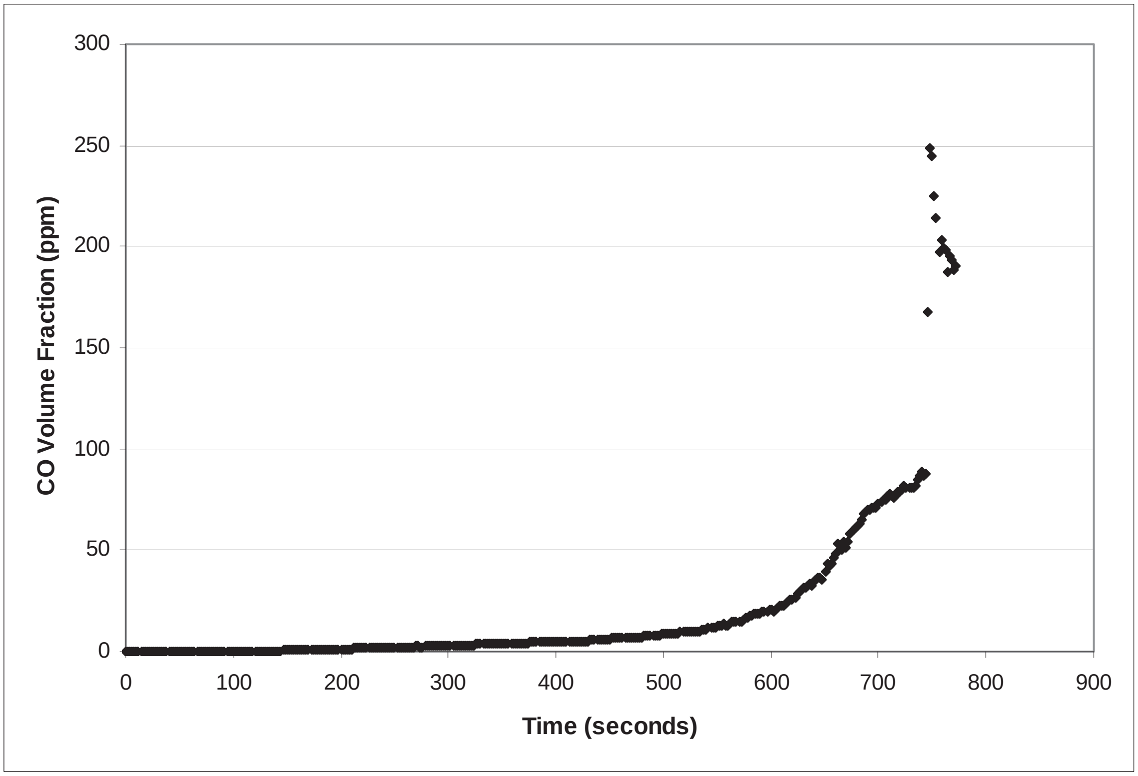

Figure A31: CO Volume Fraction at Location 4, three feet above the floor.

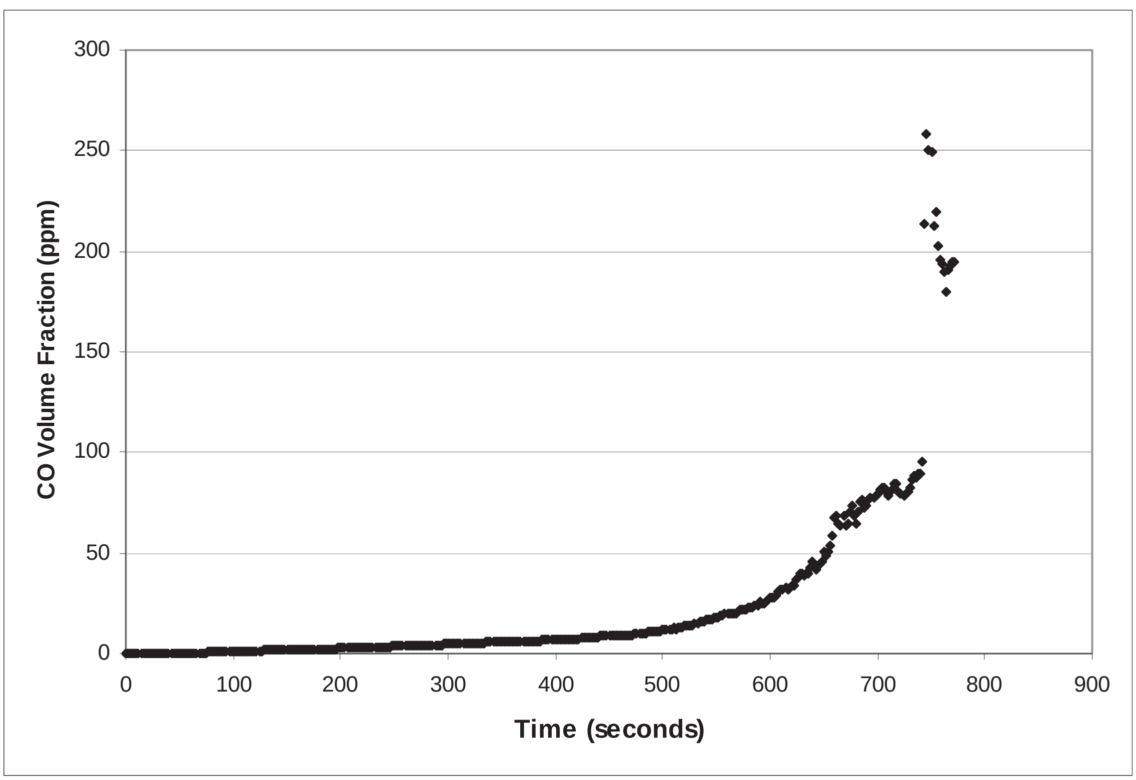

Figure A32: CO Volume Fraction at Location 4, six feet above the floor.

OXYGEN VOLUME FRACTION

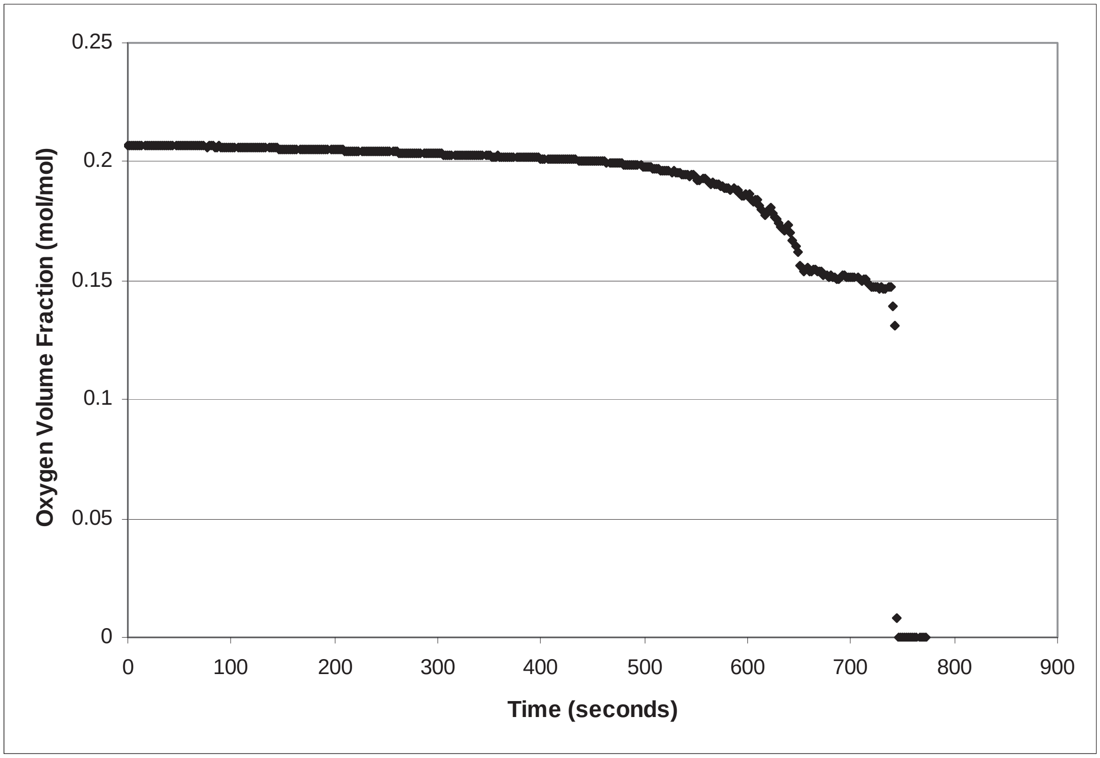

Figure A33: O_2 Volume Fraction at Location 1, six feet above the floor.

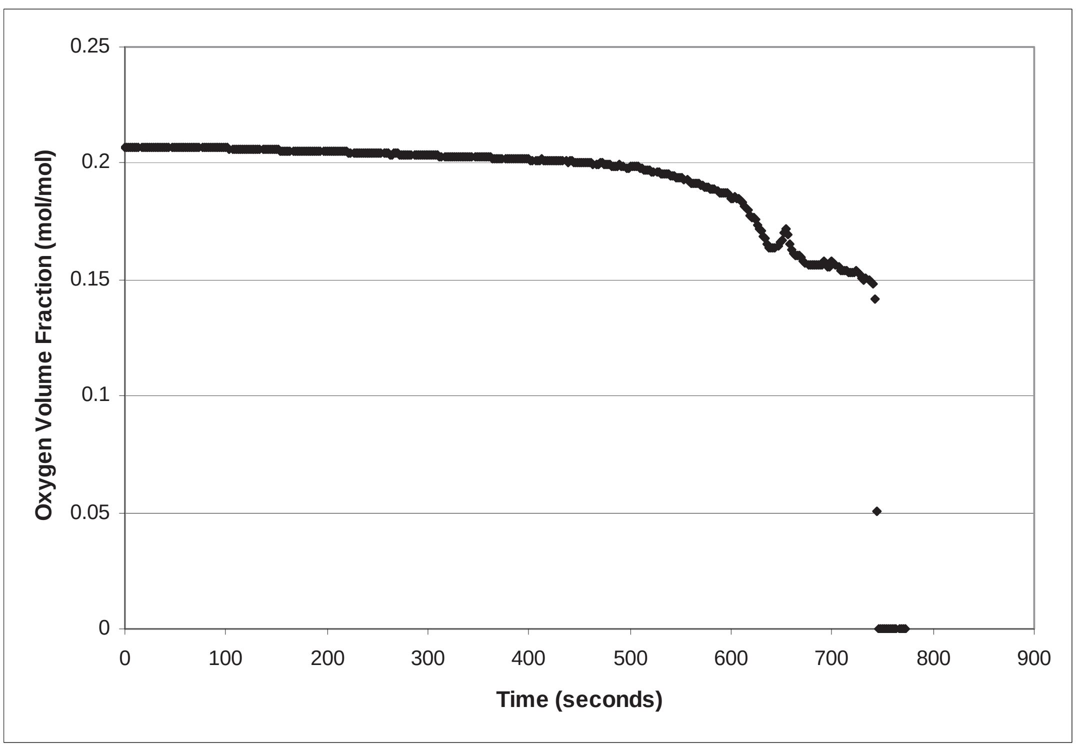

Figure A34: O_2 Volume Fraction at Location 2, six feet above the floor.

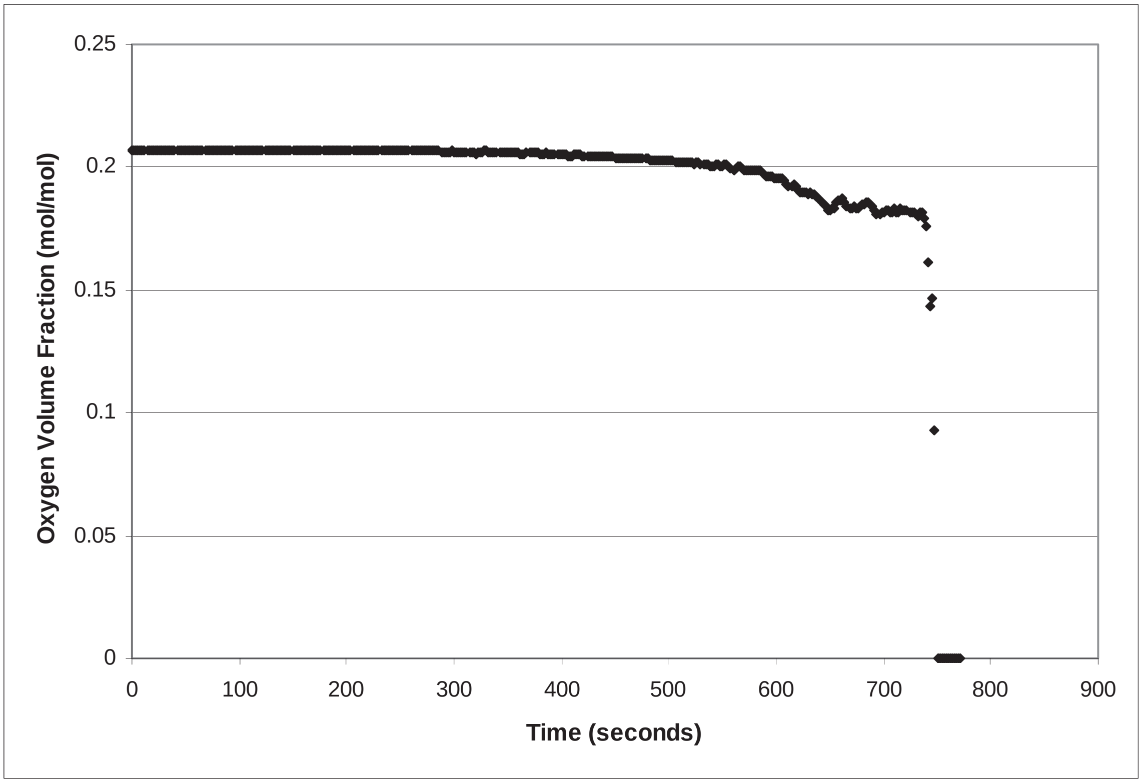

Figure A35: O_2 Volume Fraction at Location 3, one foot above the floor.

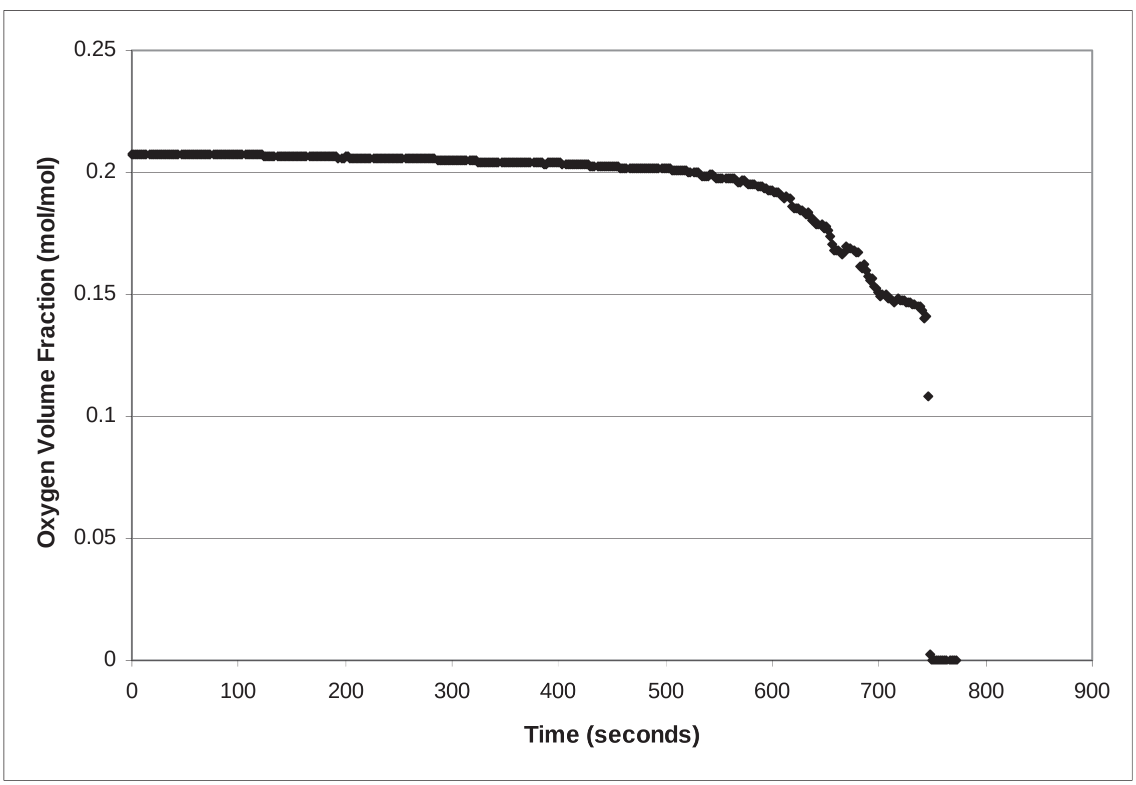

Figure A36: O_2 Volume Fraction at Location 3, three feet above the floor.

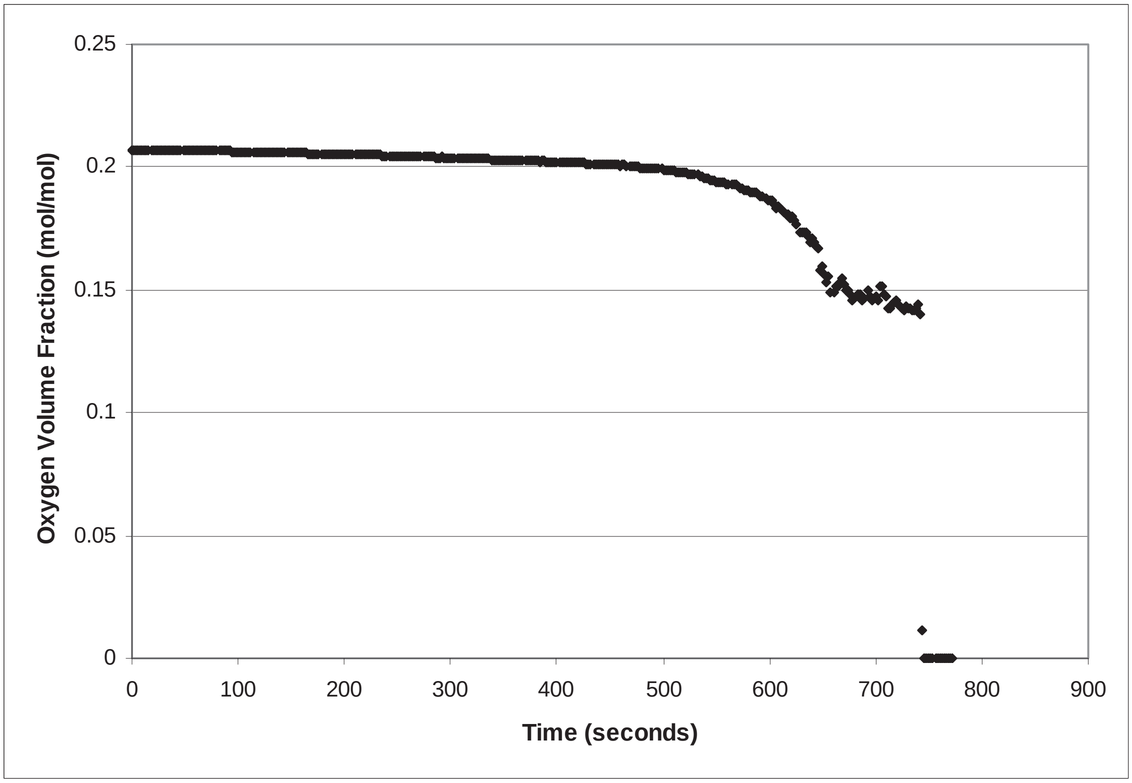

Figure A37: O_2 Volume Fraction at Location 3, six feet above the floor.

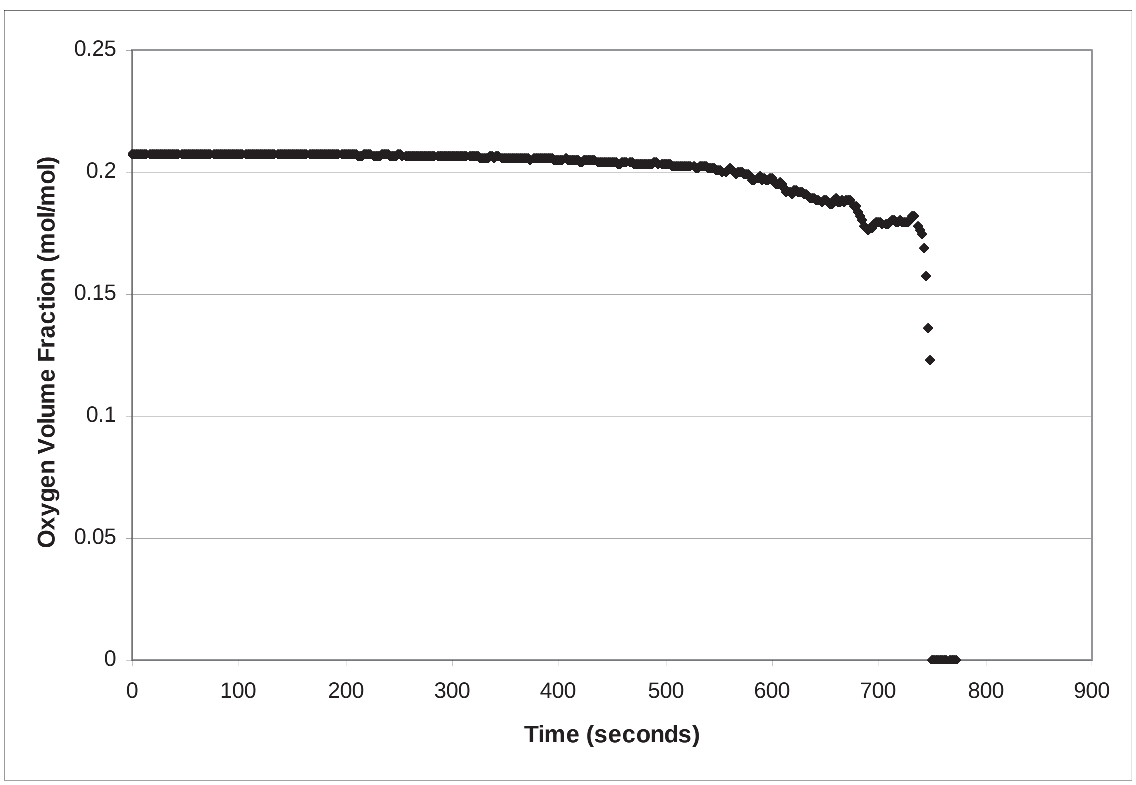

Figure A38: O_2 Volume Fraction at Location 4, one foot above the floor.

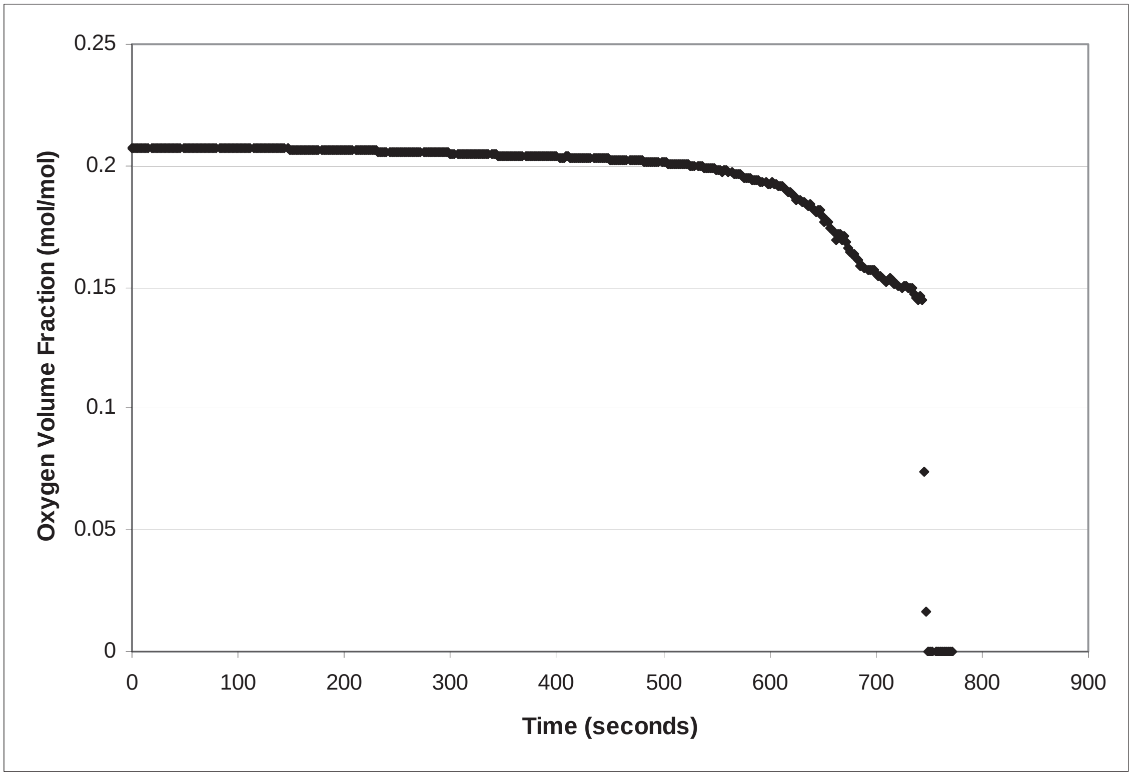

Figure A39: O_2 Volume Fraction at Location 4, three feet above the floor.

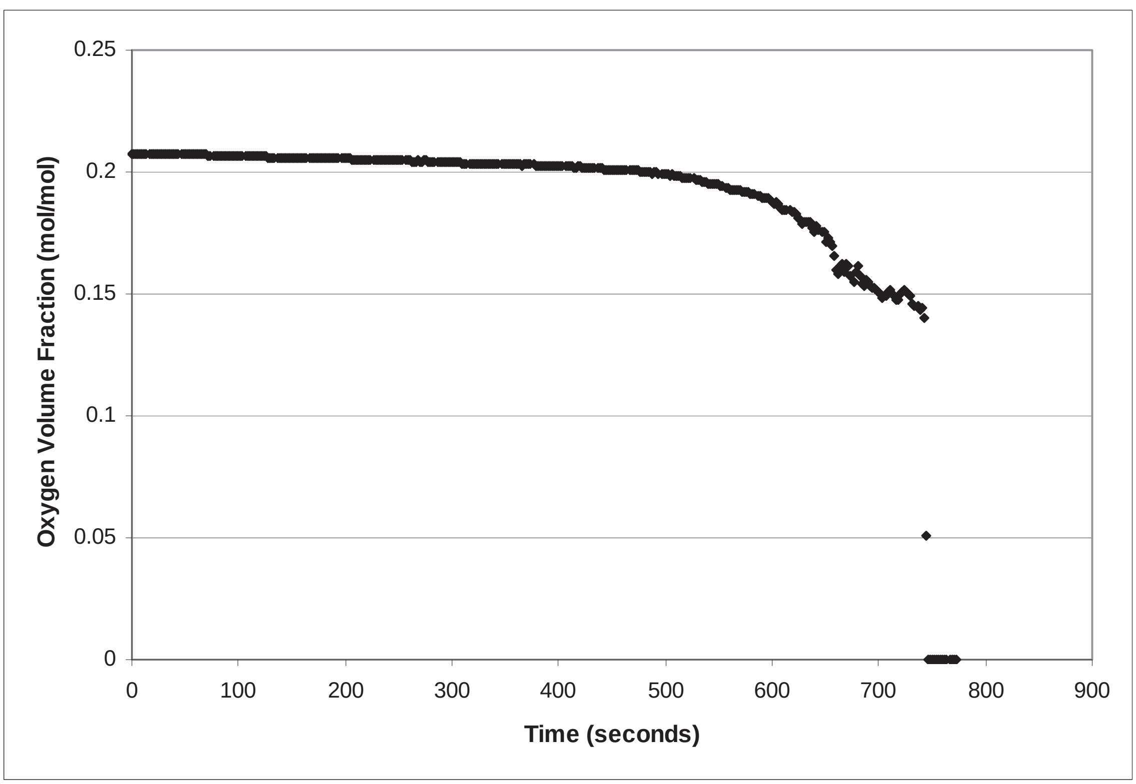

Figure A40: O_2 Volume Fraction at Location 4, six feet above the floor.

SOOT DENSITY

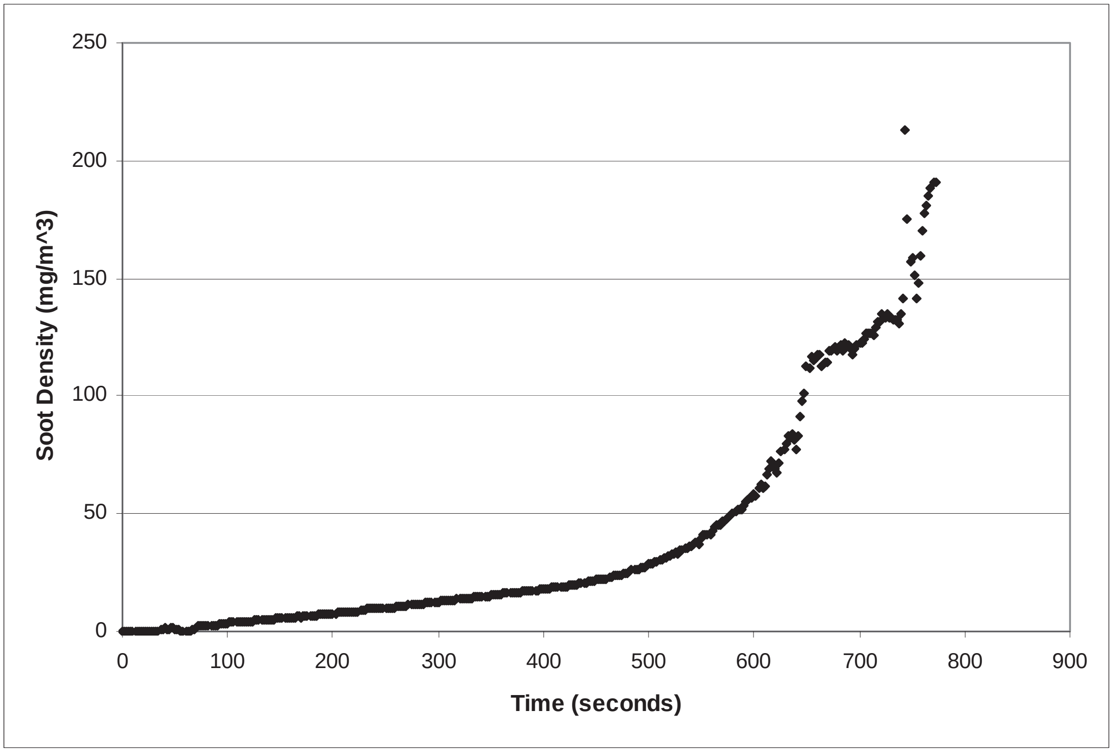

Figure A41: Soot Density at Location 1, six feet above the floor.

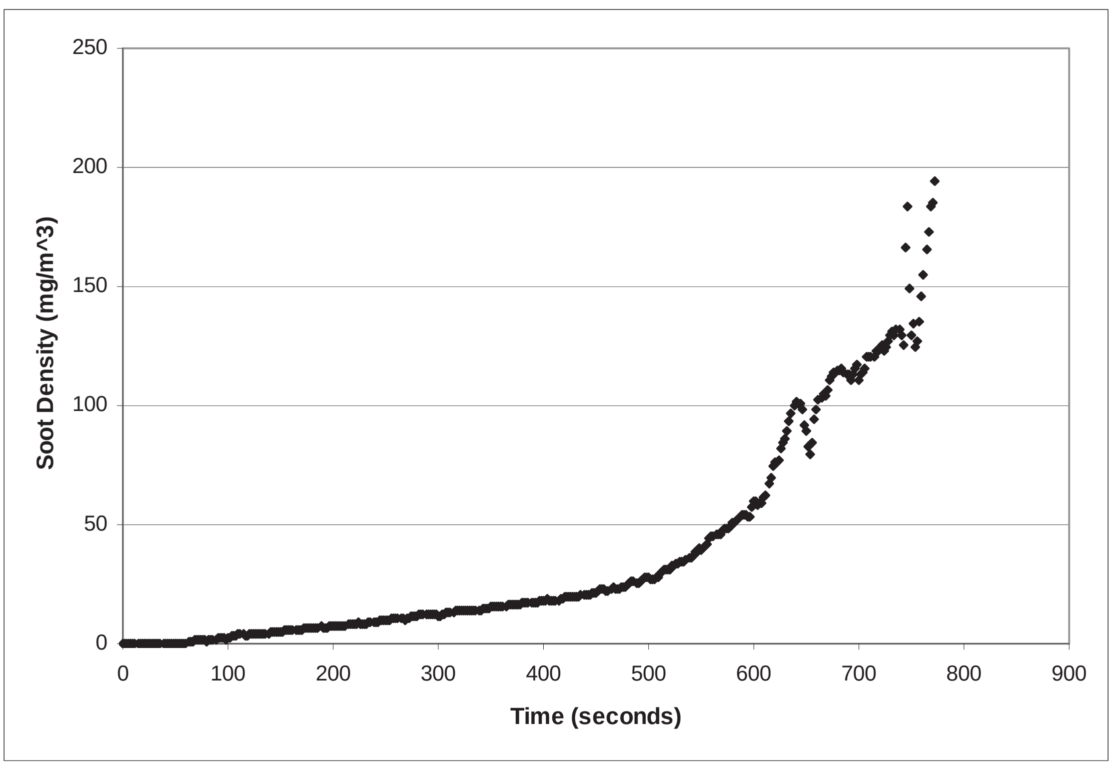

Figure A42: Soot Density at Location 2, six feet above the floor.

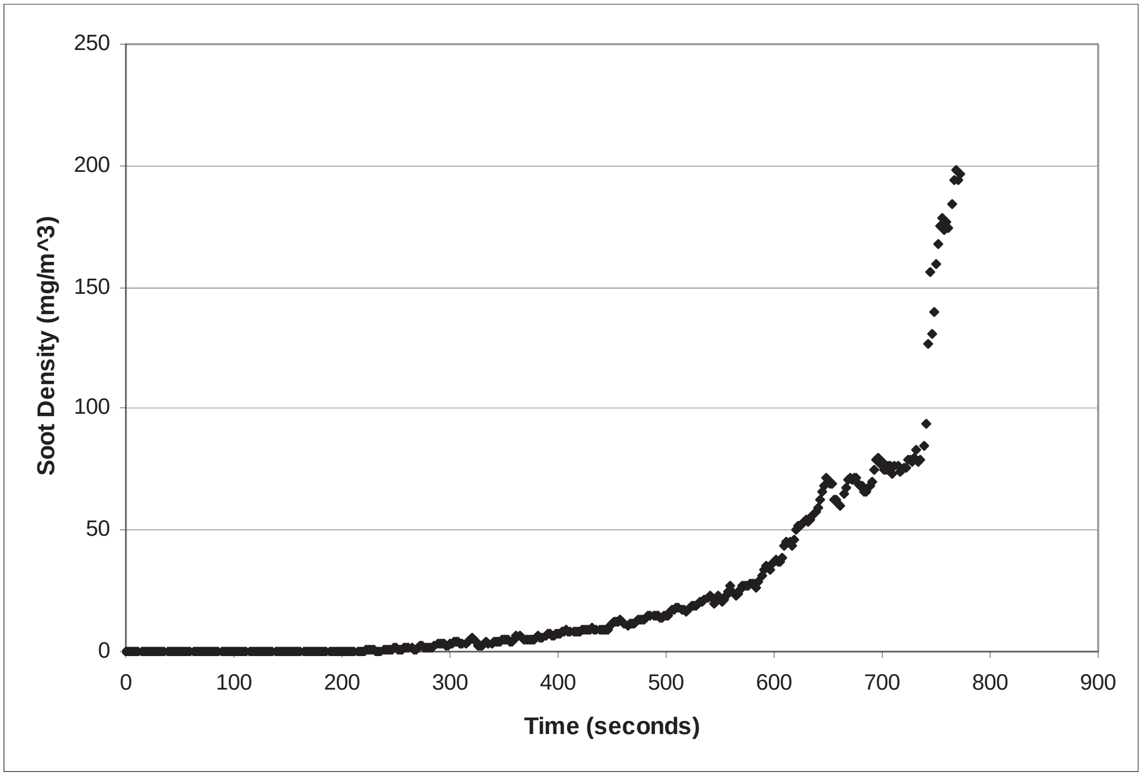

Figure A43: Soot Density at Location 3, one foot above the floor.

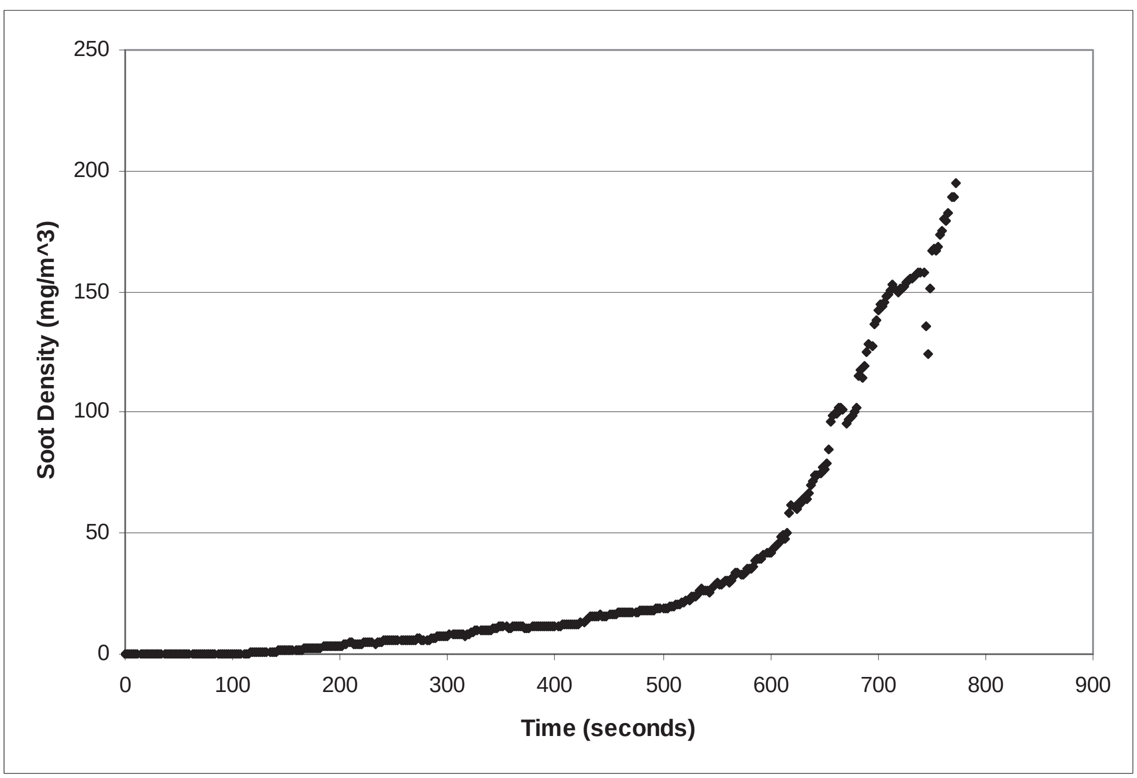

Figure A44: Soot Density at Location 3, three feet above the floor.

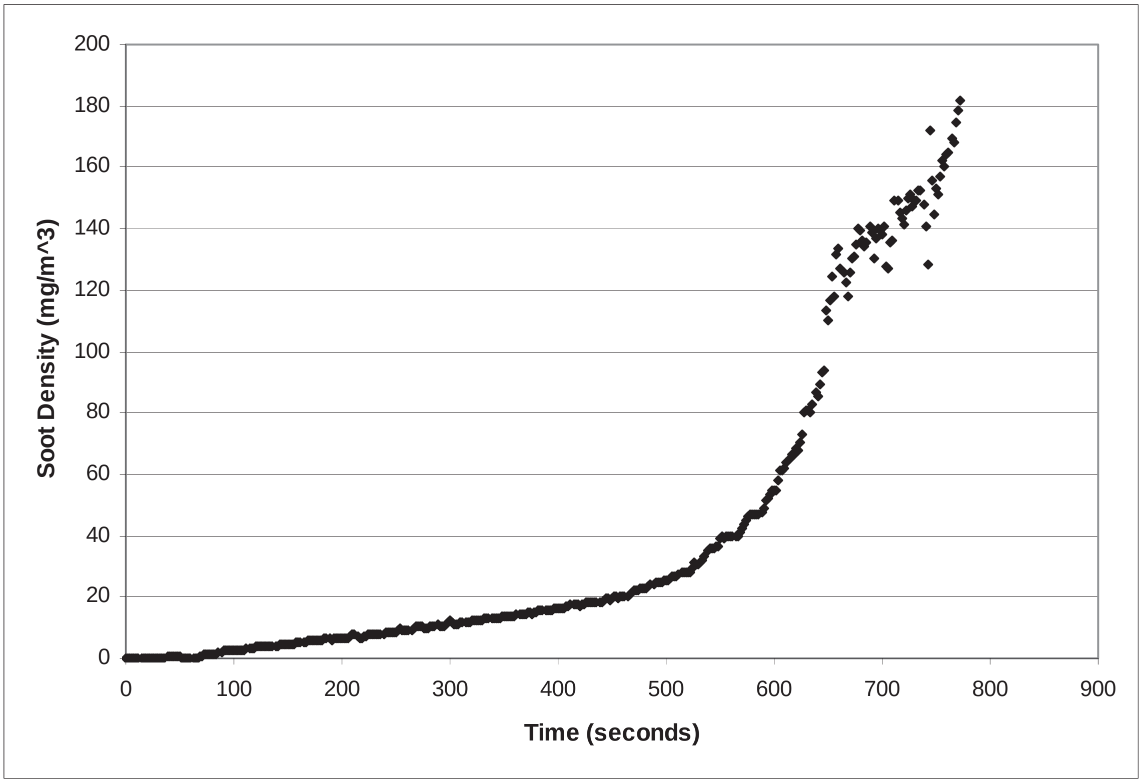

Figure A45: Soot Density at Location 3, six feet above the floor.

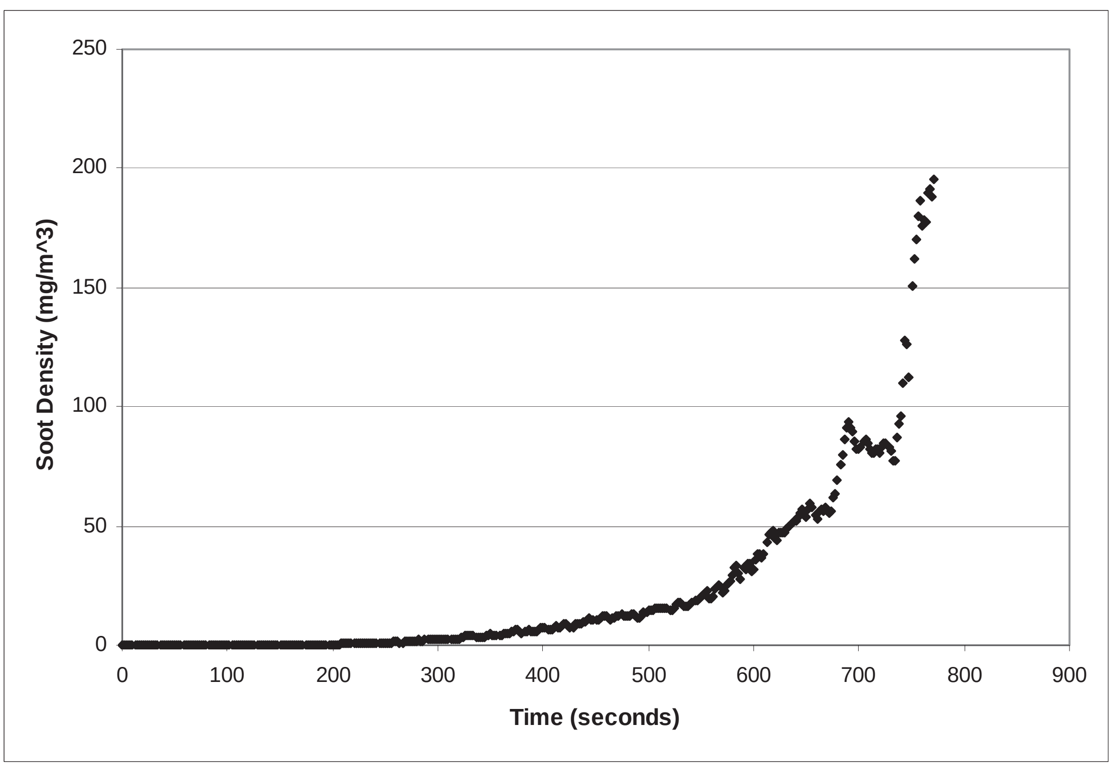

Figure A46: Soot Density at Location 4, one foot above the floor.

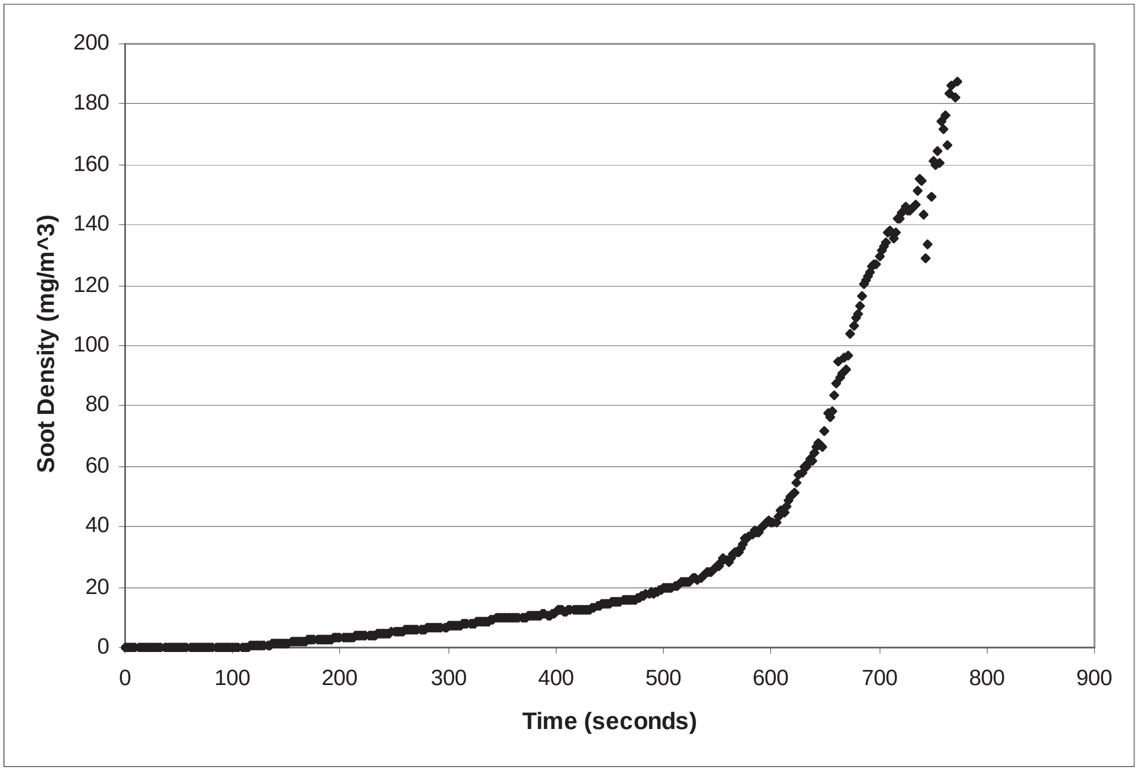

Figure A47: Soot Density at Location 4, three feet above the floor.

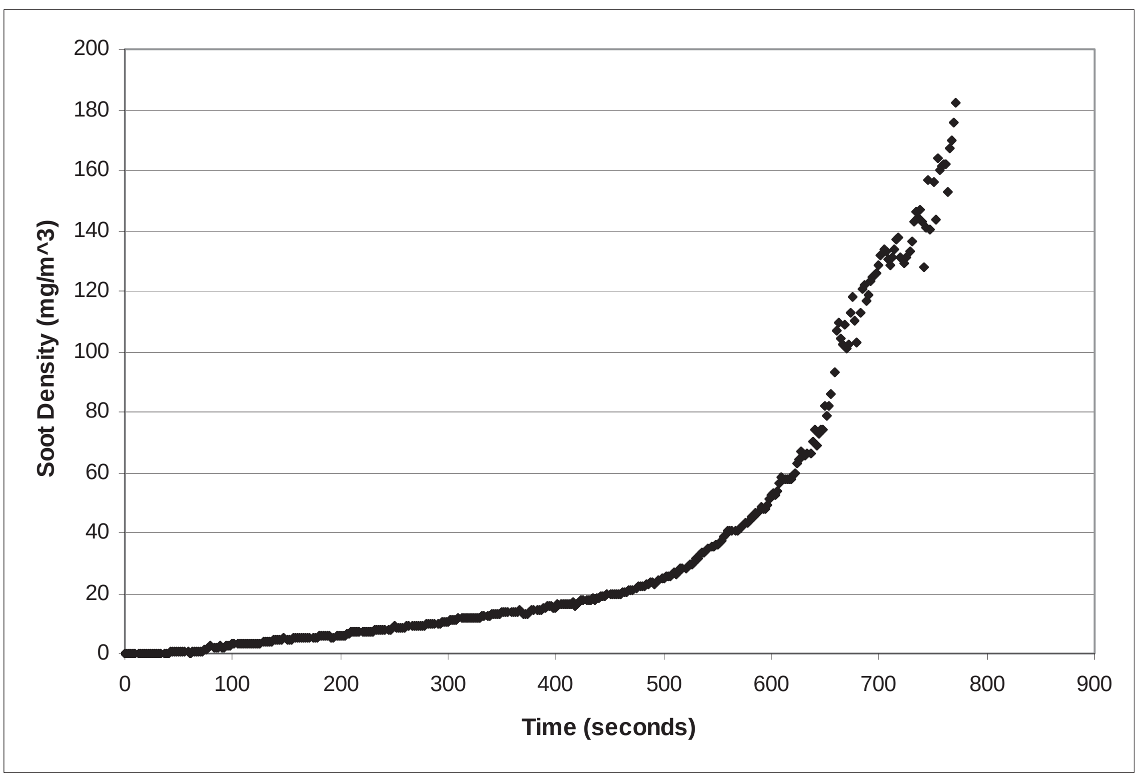

Figure A48: Soot Density at Location 4, six feet above the floor.