Investigation Report

Hospital Fire
Winston-Salem, North Carolina
August 12; 1984
Successful Evacuation

Prepared by

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In Cooperation With

Federal Emergency Management Agency/
United States Fire Administration

and

National Bureau of Standards/
Center for Fire Research
This investigation was conducted by the National Fire Protection Association (NFPA) under an agreement with the Federal Emergency Management Agency/United States Fire Administration (FEMA/USFA) and the National Bureau of Standards/Center for Fire Research (NBS/CFR). The investigation was jointly funded by these agencies and the NFPA.

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ABSTRACT

On August 12, 1984, a fire originating in a high voltage electrical feeder busway forced the evacuation and relocation of approximately 200 patients at the Forsyth Memorial Hospital located in Winston-Salem, North Carolina. While the fire was confined to the busway and to exposed storage areas in the vicinity of a basement loading dock, smoke spread to several upper floors of the hospital. Portions directly exposed to smoke conditions included operating suites, post-operative and critical care areas, and pediatric units of the hospital. The exposure of these areas to smoke and the potential for exposure of oxygen and gas lines, along with loss of normal and emergency power and communications, precipitated the relocation and evacuation of patients and staff. The smoke spread was also limited by construction features and the successful operation of smoke barrier and fire doors.

A short in the main electrical feeder busway also resulted in the loss of primary and emergency power to critical care units. The loss of emergency power was due to fire damage to emergency generator control wiring which was located near the busway.

The successful relocation and evacuation of patients were due to the prompt actions of the hospital staff trained in fire emergency procedures and the support of the fire department and emergency medical services. Effective fire and rescue operations were managed from fire and EMS command posts according to fire ground tactical and EMS disaster plans.
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I. **INTRODUCTION**

The National Fire Protection Association (NFPA), with the assistance of the Southern Building Code Congress International (SBCCI), investigated the Forsyth Memorial Hospital fire in order to document and analyze significant factors in the incident.

This study was conducted under a fire investigation agreement between the Federal Emergency Management Agency/United States Fire Administration (FEMA/USFA), the National Bureau of Standards/Center for Fire Research (NBS/CFR), and the NFPA. The agreement, funded by FEMA/USFA, NBS/CFR and the NFPA, provides for the investigation of technically significant fires by the NFPA's Fire Investigations and Applied Research Division to document and analyze incident details and report lessons learned for loss prevention purposes.

The NFPA was assisted in data collection and analysis by the Southern Building Code Congress International (SBCCI) under an agreement between NFPA and the three model building code organizations to investigate significant structural fires throughout the United States. In addition to the SBCCI, the other cooperating building code groups are the International Conference of Building Code Officials (ICBO), and Building Code Administrators International, Inc. (BOCA). The three model code groups are supporting NFPA by lending technical staff support for on-site field work and building code analysis.

The NFPA became aware of the fire on the day of occurrence, August 12, 1984, and James R. Bell, Fire Analysis Specialist, traveled to Winston-Salem, North Carolina, to document the facts related to the fire. The NFPA investigator was joined and assisted by Richard A. Vognild of the Southern Building Code Congress International. A four-day on-site study and subsequent analysis were the basis for this report and NFPA's analysis of the event.
Entry to the fire scene and data collection activities were made possible through the cooperation of the Winston-Salem Fire Department and the Forsyth Memorial Hospital. This report presents the findings of the NFPA data collection and analysis effort.

This report is another of NFPA's studies of fires having particular educational or technical interest. The information presented is based on the best data available during the on-site data collection phase and further data acquired through subsequent follow-up. It is not NFPA's intention that this report pass judgment on, or fix liability for, property loss at the Forsyth Memorial Hospital fire.

The cooperation and assistance of the following hospital and fire department personnel is acknowledged and appreciated: Mr. Rupert Bowen, Vice President-Administration; Ms. Carol Boger, Vice President for Nursing Service; Ms. Linda Hege, RN and Ms. Jo Apple, RN, Associate Directors of Nursing; Mr. C. D. Bridges, Director for Safety and Security; Mr. Harry Hauser, Chief Engineer; and Dr. Lew W Stringer, Chief of Disaster Committee, of the Forsyth Memorial Hospital; and District Chief Stephen F. Baldwin, Battalion Chief W. S. Wadkins, Assistant Fire Marshal E. W Hooven, and Captain C. N. Everhart of the Winston-Salem Fire Department.
II. BACKGROUND

The Building

Forsyth Memorial Hospital opened in 1964 as a voluntary, non-tax supported, not-for-profit hospital. Since early 1984, the hospital has been operated by Carolina Med corp, Inc., a private, not-for-profit company.

The original structure was built in 1964. Since that time, the hospital has undergone several expansions and renovations (1972, 1976 and 1983) to provide the present capacity of 897 beds (see Photo 1). Two of the additions, a 3-story addition constructed in 1976 and a 10-story, 100-bed patient tower constructed in 1983, were involved in this incident (see Figure 1 and Photo 1).

The Forsyth Memorial Hospital is presently the third largest hospital in the Carolinas. The facility has over 2,100 employees, and on the day of the fire there were 600 patients in the hospital.

The 1976 building addition, in which the fire occurred, consisted of a mix of low-rise and high-rise construction. The low-rise portion of the addition was generally 3 stories throughout with major dimensions of 120-feet by 380-feet on the east side of the complex and 50-feet by 210-feet on the south side of the L-shaped building. The high-rise tower was 10 stories in height.

The building was of Type I, or Fire Resistive, construction. Structural framing consisted of steel columns encased in concrete and a 6-inch concrete on steel deck floor assembly. The 12-inch and 14-inch I-beams of the flooring system and the underside of the steel deck were covered with a sprayed-on mineral fiber fireproofing. The construction surrounding the loading dock area provided four-hour separation from the remainder of the hospital.

The portion along the eastern side of the complex contained many of the service functions of the hospital. The basement level included: the truck
loading dock, purchasing department, general stores storerooms, laundry, kitchen, cafeteria and x-ray file storage. Adjacent to the general stores storerooms was an electric panel and generator room.

The northeast quadrant of the first floor contained the radiological department, laboratory, intensive care unit (ICU) and post surgical unit (PSU). The operating room and recovery room were located in the adjoining portion of the original (1964) building. A mezzanine level over the basement level x-ray file storage room also contained x-ray file storage.

The second floor contained the labor and delivery suite and postpartum unit, which adjoined the newborn nursery, special care nursery and general obstetrics and gynecology units that were located in the original building.

The third floor contained the pediatric unit in the 1976 portion of the floor and general medical-surgical beds adjoining floor areas in the original building.

The fourth, fifth, sixth, seventh and eighth floors contained general medical beds. The ninth floor contained 28 general beds and 18 beds in two cardiac care units.

To provide fire separations, limit smoke spread and provide areas of refuge, fire doors and smoke stop doors were located in each corridor, many at bearing walls between 1964, 1976 or 1983 construction. These doors, held open with magnetic devices, closed automatically on activation of the fire detection and alarm systems.

Adjoining the main hospital complex on the north was a three-story Paramedical Building. The building was used primarily as a day care center and for offices for major hospital support services. The Paramedical Building was joined to the main hospital building by means of a 100-foot enclosed walkway between the buildings.
Area of the Fire

The truck loading dock, located on the east side of the 1976 addition at the basement level, originally contained four truck loading bays. As part of recent renovation, one of the four bays had been enclosed and the floor raised to the interior floor level. The renovated storage room provided storage of general, non-food hospital stores. The present three-bay loading dock had overall dimensions of 75 feet by 85 feet. A 12-foot wide loading platform ran the 75-foot width of the loading dock.

The loading dock had a two-hour fire rated suspended ceiling installed 20 feet above grade; the ceiling assembly consisted of plaster on metal lath steel cross-ties and hangers. (See Photo 2.)

Various utility and service lines ran within the 4-foot high concealed space below the first floor deck. These included an electrical feeder busway, electrical conduit for electrical conductors and instrument controls, cold and hot water pipes, steam piping for suspended unit heaters, sprinkler piping, metal heating, ventilation and air conditioning ducts wrapped with aluminum covered fiberglass insulation, various waste water plumbing drains for the laboratory and x-ray areas above, and natural gas, vacuum, air and oxygen lines. Wiring for x-ray equipment was installed in 3-inch rigid plastic conduit. The concealed space was not used for plenum (HVAC) air movement purposes. The 12-inch and 14-inch steel beams and steel deck of the first floor were sprayed with mineral fiber fireproofing material.

On the west wall of the loading dock, adjacent to the loading dock platform, was (from south to north) a roll-up steel door to the purchasing office, two bottled gas storage rooms and a roll-up steel door to the laundry. On the south wall was an open doorway with plastic draft curtains leading to a basement corridor, storerooms and kitchen area.
The north wall of the loading dock was constructed of 8-inch concrete block and slab-to-slab steel columns that were encased in concrete. The present south wall of the loading dock had been added following conversion of the fourth loading dock to a general storage storeroom. The 8-inch concrete block and steel encased columns extended from grade to the suspended plaster on metal lath ceiling installed approximately 20 feet above. This wall did not extend to the floor slab above. The concealed space above the loading dock was therefore undivided and open to the space above the general stores storeroom.

The original south wall of the loading dock consisted of 8-inch concrete block with concrete encased steel columns and extended from grade to the first floor slab. This wall now served as a common wall between the general stores storerooms.

Contents in the general storage rooms, located adjacent to the south side of the loading dock, included bulk medical supplies and general goods in boxes and cartons on low rack storage racks to approximately 15 feet in height.

In the radiological department office, adjacent to the south side of the loading dock, x-rays in paper filing covers were stored on motorized steel storage shelves. The shelves, which were 8 feet high by 2 feet wide and 10 feet long, were movable and controlled by electric motors allowing compact storage of large numbers of x-ray files without aisleways separating adjacent shelving units.

Mechanical Systems

The 1964 and 1976 sections of the building were on separate air handling systems. The 1964 building had six air handling units and one exhaust system. The 1976 building had five air handling units and a single exhaust unit.
HVAC systems were provided with automatic fan shutdown capability by smoke detectors located in return air plenums. The systems also shut down upon activation of any fire alarm signaling device.

HVAC systems, serving either building, were also provided with fire/smoke dampers, designed to shut down upon activation of fire alarm and detection systems installed in that building without affecting the other.

Utilities

Electrical power for the hospital complex entered the building from a utility company pole, located on the northeast side of the building, and was provided with a manually operated, air-break disconnect switch. The electrical service was 480/277 volts, three-phase four wire with 4,000 ampere capacity. A service cable from the pole served a substation located at the northeast corner of the building. Service entrance panels were located adjacent to the substation which consisted of three 1500 kVA transformers (see Photo 3).

Electrical power was supplied to the 1964 and 1976 sections of the hospital building through separate service panels. Electrical current was carried by electrical feeder busways to distribution panels in the separate electrical and generator rooms for each portion of the hospital.

The 1976 hospital addition was provided electricity by means of a 4,000 ampere, 3 phase-4 wire aluminum totally enclosed, indoor feeder busway which extended from the main disconnect switch located near the power substation through concealed spaces to a main distribution panel located in the generator room at the east side of the building (see Figure 1). The disconnecting means was a 4,000 ampere switch provided with ground fault protection set at 700 amperes. On the horizontal runs, the busway was supported by hangers and wall flanges at wall penetrations of the concrete block walls.
On the north side of the loading dock, the busway penetrated the 8-inch masonry wall and extended through an x-ray storage area. The electrical feeder busway penetrated the wall 21 feet above grade, entering an x-ray department secretary's office located on the mezzanine level. The busway extended 2 feet 8 inches into the room, turned 90 degrees, and ran 4 feet before passing through a wall into a separate room. A mineral tile in steel grid suspended ceiling was installed in the office. On the south side of the loading dock, the busway ran through the concealed spaces above the ceilings of purchasing department storage rooms.

The 1964 and 1976 buildings were provided with separate emergency power systems. Emergency power for the 1976 building was supplied by two 900-kW diesel engine driven generators located in the generator/electrical room located on the east side of the building adjacent to the loading dock.

Control wiring for both of the emergency generators for the 1976 addition ran from the electrical/generator room to a control panel in the engineering office. The control wiring was installed in rigid steel conduit which was run through the loading dock area in the concealed space above the suspended ceiling. The electrical conduits were run parallel and in close proximity to the feeder busway.

In addition to emergency lighting provided on the life safety branch, the operating rooms, labor and delivery, nurseries, coronary care, and recovery room had been provided with a battery-powered back-up emergency lighting unit. However, ICU, PSU, corridors, stairways, and other areas were not provided with battery operated emergency lighting.

Fire Protection Systems

Partial automatic sprinkler protection was installed throughout both the 1964 and 1976 portions of the hospital. Sprinklered areas included all of the basement and first floor, laboratories, closets and storage rooms.
The truck loading dock and the general storage rooms were protected by a dry-pipe automatic sprinkler system supplied by a 4-inch riser. This area had 81 pendent, 165°F sprinklers extending below the suspended ceilings. Two bottled oxygen and medical gas storage rooms located off the loading platform were also protected by the automatic sprinkler system. (In the sprinklered areas, sprinklers were not installed in concealed spaces above suspended ceilings.) The remaining systems were wet-pipe systems, and in total there were four sprinkler risers with water flow devices connected to the fire alarm system.

Class I and Class III (wet) standpipe systems were provided throughout the hospital and supplied by four risers. Standpipe connections were located in stairways and hose cabinets were distributed in corridors throughout the hospital.

A 750-gpm fire pump and a 1,000-gpm pump supplied the automatic sprinkler systems and standpipe systems throughout the complex. Water from the public water system was provided through 16-inch and 30-inch mains. A private-loop main system surrounded the hospital with 16-inch and 24-inch mains in the yard-loop. System plans indicated normal static pressure of approximately 82 psi in the public mains.

Smoke detectors were installed in all of the corridors of the hospital. In addition, heat detectors were located in laboratory areas. Activation of manual pull-stations, smoke detectors, heat detectors or automatic sprinkler systems would initiate simultaneous functions: zoned signals on the alarm panels located at the hospital switchboard and in the engineering office at the hospital boiler room, shut-down of HVAC fans and release of fire doors and smoke stop doors. Building fire-evacuation alarms are designed to sound following a 30-second pre-signal delay. Release of fire doors and smoke stop
doors, HVAC-fan shut-down and initiation of the evacuation alarm signal were designed to function by zones, which coincided with major configurations of the original building and the subsequent additions.

**Fire Emergency Plan and Communications**

The hospital had a detailed Fire Emergency Plan covering fire brigade organization, alarm and emergency procedures, evacuation, and communications. The fire department conducted pre-fire planning activities and hospital staff training for fire emergencies. Communications capabilities within the hospital included several different modes. A centralized, in-house telephone system operated through a computerized switchboard which allowed direct extension dialing from the outside. In addition, several of the switchboard system telephones dispersed throughout the hospital were equipped with direct outside lines.

A public address system was provided for general announcements, including hospital-wide fire emergency announcements. Fire brigade members and hospital staff normally received the initial notification and location of a fire alarm as well as other priority incidents, over the public address system.

Hospital administrative, supervisory and engineering staff could also be paged on a beeper system tied into the telephone system. The paging system was designed to normally function through and in conjunction with the central switchboard.

The security department also carried two-channel portable radios. Base radio stations were located at the switchboard operator, emergency room and security office. Emergency communication phones were also located in the stairway on eight floors of the newest (1982) high-rise residential tower addition.
Operating Status

At the time of the fire, there were 600 patients in the hospital and there were approximately 220 staff members on duty, of which 145 were nursing staff. Staff in the intensive care and post surgical care units normally work 12-hour shifts with shift changes occurring at 7:00 a.m and 7:00 p.m. At the time the fire occurred, these units had two levels of staff present preparing for the change of shift. Also, since the fire occurred on a Sunday evening during peak visiting hours, a large number of visitors were in the hospital.

Fire and Emergency Medical Services

The City of Winston-Salem, located in the northern central portion of North Carolina, has a population of 139,500 and an area of 70 square miles. The Winston-Salem Fire Department has 191 personnel and 14 stations. In addition to Fire Department personnel, the city utilizes public safety officers, who are cross-trained in both police and fire functions.

Public safety officers respond to alarms to augment engine company manning. For example, an engine company with three personnel would be joined by a public safety officer at the fire scene.

An engine company was located approximately 1 1/2 miles from the hospital. The first alarm assignment included three engine companies, two truck companies, a battalion chief with a complement of 17 officers and fire fighters (counting public safety officers).

Emergency medical services for Winston-Salem are provided by the Forsyth County Emergency Medical Service which operates 13 units and has 54 full-time, 3 part-time and 19 volunteer reserve personnel. This emergency medical resource is dispatched by the Forsyth County Communications Center (with radio and direct telephone links to the city communications center).
**Weather Conditions**

The weather conditions recorded for August 12, at 7:00 p.m. (Greenboro-High Point-Winston-Salem Airport) were:

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<tr>
<td>Temperature</td>
<td>78°F</td>
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<tr>
<td>Wind Direction</td>
<td>NNW at 5 Knots</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>79%</td>
</tr>
<tr>
<td>General Conditions</td>
<td>High/Thin Cloud Cover</td>
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III. THE FIRE INCIDENT

Ignition Sequence and Discovery

Shortly before 7:00 p.m. on Sunday, August 12, a fire alarm signal was received on the annunciator panel located at the operator's switchboard from a smoke detector on the first floor of the Paramedical Building. The hospital operator called the Winston-Salem Public Safety Communications Center to report the alarm as required in the hospital's emergency plan. The Communications Center received the call from the hospital at 6:57 p.m. and made the initial dispatch of the first alarm assignment.

The hospital operator then announced a "Signal 505" for the Paramedical Building over the hospital's public address system. Following the three announcements of the fire alarm and the location over the address system, the operator notified security personnel of the fire over the radio system. As also required in the plan, the operator called the on-call administrative officer advising him of the receipt of an alarm.

Shortly after these calls had been completed, the electrical supply for the telephone, public address system and paging functions was interrupted (apparently a breaker tripped due to a power surge). At approximately 6:59 p.m., normal electrical power was lost in the 1976 addition, and emergency electrical generators were automatically activated.

As members of the hospital fire brigade were responding to the Paramedical Building, laboratory and x-ray staff on the first floor of the Main Building, located over the loading dock, began to smell and see smoke in areas of the x-ray and microbiology laboratory areas. They activated manual pull stations.

The operator began receiving multiple fire alarm signals at the annunciator panel. Fire alarm signals came in not only from the first floor manual pull stations, but also from smoke detectors located in the basement areas. A staff member from the laboratory came to the switchboard in order to call a laboratory supervisor. The laboratory staff member reported to the
operator that there was smoke in the laboratory area. The operator advised security personnel by radio of the additional fire alarms/signals in the area of the laboratory and x-ray on the first floor, in the basement and from the loading dock area.

The security personnel found nothing in the quick search of the Paramedical Building. They were quickly joined by other fire brigade members and the associate directors of nursing on duty at the time. With other fire brigade members they headed to the first floor x-ray and laboratory areas in response to the information from the hospital operator. In x-ray, the radiologist on duty led the fire brigade members to the x-ray file storage room where smoke was filling the room. Smoke was found entering the x-ray and laboratory rooms through electrical ducts in the concrete slab floors. Smoke also issued from electrical control cabinets located over or in close proximity to the electrical ducts penetrating the floor slab.

As engineering staff members attempted to shut off power in the area, remaining fire brigade members led by the evening nursing supervisors attempted to locate the fire. Using wet towels over their faces, they tested each door for heat. When found to be cool, entry was made into each room to determine conditions in the room. As the x-ray file storage rooms filled with smoke, the fire brigade backed out of the room, closed the door and sealed the door at the bottom with wet towels.

In the microbiology laboratory, they also found smoke issuing from a chemical cabinet and the counter-top hot to the touch. After applying a CO₂ extinguisher to the cabinet they were driven from the room by thickening smoke. They closed the door to the room and also placed towels at the bottom of the door. Arriving fire fighters appeared in the hallway and took over efforts to locate the fire, and one nursing supervisor remained in the area to
assist fire fighters in attempting to identify the types of chemicals in the laboratory.

Fire Department Response

At 6:57 p.m., the Winston-Salem Fire Department was notified of the alarm and dispatched by the Winston-Salem Public Safety Communications System. A Fire Department acting battalion-chief was in the vicinity of the hospital. As he responded he saw a large cloud of smoke above the north side of the main hospital structure. He requested a second alarm and notified communications that he was establishing a command post at the rear of the hospital. At 6:59 p.m., he pulled into the north driveway leading to the Paramedical Building and found that the cloud of smoke had largely dissipated. First responding apparatus arrived at 7:00 p.m., immediately behind the battalion chief.

A hospital security officer, responding to the announced location of the fire alarm, passed by the electrical/generator room on the east side of the building and saw smoke issuing from the fresh air grating in the exterior wall of the generator room. The security officer met the battalion chief and directed him to the generator room. A rapid check of the generator room found no fire or smoke. Crews from the first two arriving companies went into the hospital to search for the source of the smoke and assess conditions in the building. On the first floor, they found the fire brigade members checking x-ray and laboratory rooms which were filling with smoke. The fire department personnel then took over the search for the fire.

At approximately 7:20 p.m., a small hole was seen in the ceiling of the loading dock at the intersection with south wall. White light and flashes from the burning and arcing of the electrical feeder busway could be seen through the hole.
Shortly after the burning busway was located, the rated ceiling assembly began to give way. Starting at the south wall of the loading dock, the ceiling sagged and fell in a sequential pattern toward the north wall. The amount of smoke on the exterior of the building increased and the loading dock filled with thick smoke.

Due to the heavy smoke on the loading dock, the command officer, watching from outside of the loading dock, was unable to ascertain whether the collapse was limited to the ceiling assembly or whether it involved structural members. He ordered fire crews working on the floor above to pull out of the area. Steaming water was observed pouring from above the ceiling. Later investigation indicated that sprinkler branch lines (for sprinklers below the ceiling) in the vicinity of the busway had failed due to the arcing busway.

After the second alarm was sounded at 7:00 p.m for two engine companies, two additional alarms and two special calls brought more apparatus and personnel to the scene. An air supply unit was dispatched at 7:10 a.m, the third alarm for two engine companies was dispatched at 7:33 and an additional special call brought two more engine companies. A total of nine engine companies, two truck companies and 47 officers and fire fighters were on the scene.

As discussed above, the first arriving battalion chief established the command post near the loading dock and served as the incident commander. Under the Fire Department Incident Management Plan, the fire scene was divided into command sectors. A company officer was assigned a sector on the first floor above the fire, and a second battalion chief was responsible for the first floor ICU sector and patient relocation. In addition, an officer established a staging area at the perimeter of the hospital property. The staging officer maintained two companies at the area throughout, the incident for immediate deployment by the incident commander.
Staff Actions

Just after receipt of the fire alarm signals and completion of the initial notifications, the hospital operator called the on-call administrative officer who was at home. She advised him of the receipt of the smoke detector alarm (Smoke detector activations were frequent and routine occurrences requiring little if any action on the part of the administrative officer.) After several minutes, the on-call administrative officer attempted to call the hospital for an update. There was no answer at the main switchboard. After calling several other numbers and failing to get through, the officer called the telephone company to report the abnormal condition. He also called the senior vice president and operating officer and then decided to drive to the hospital to check into the situation.

As he drove to the hospital, he was still unaware of the extent of the fire or the level of emergency actions taking place. Arriving at 7:45 p.m., he saw the extensive amount of fire equipment, billowing smoke and flashes from the arcing busway at the rear of the hospital.

The engineering officer on duty attempted to place several outside calls and found that the telephones were not working. Suspecting that calls had not been made to key hospital personnel, he went to the Medical Park Hospital located across the street and placed calls through their switchboard. Initial calls were made to several administrative officers advising them of the situation. He then returned to the hospital to continue to direct the actions of the engineering staff.

Engineering staff members recognized that electrical equipment was involved and proceeded toward the outside service entrance panel to disconnect electrical service to the busway. They found the panel hot to the touch and "humming" loudly and they attempted to throw the breaker but found the breaker "frozen." After several unsuccessful attempts to trip the breaker, they
returned to the command post to advise the fire ground commander of the inability to shut off power to the feeder. The command officer requested notification of the local power company to disconnect the power supply and an emergency crew arrived at approximately 7:50 p.m.

With the loss of the primary power supply, both generators started up and automatically transferred to provide emergency power. Later the generator for the critical care facilities in the 1976 addition stopped running. (The investigation determined that the loss of emergency power to these facilities occurred when the control wiring in the vicinity of the burning busway was impaired.) It was felt that the emergency power was also feeding the arcing busway, and the operating generator was shut down. This left the 1976 addition of the hospital without primary or emergency power.

The chief engineer received a call at home informing him of an apparent fire in the laboratory. He arrived at the hospital at approximately 7:50 p.m. After being briefed by the engineering staff, the chief engineer went to the outside service entrance panel breaker to determine why power to the busway could not be disconnected. He found the power company crew attempting to disconnect the breaker on the service entrance panel, and it was determined that power would have to be shut off by the power company ahead of the substation.

He directed the engineering staff to start up the emergency generators for the 1964 building so that public utility service to the hospital could be shut off.* He then directed the power company to disconnect the electrical service to the entire hospital. At approximately 8:07 p.m. the power to the hospital was shut off by a service disconnect switch located on the last utility.

*Two 750-kw emergency generators for the 1964 addition were located in a room next to the boiler room.
pole ahead of the substation, and the busway ceased arcing and burning. Later one of the 900-kw generators was restarted, and by approximately 8:15 p.m emergency power was restored to most areas of the 1976 addition, including the ICU and PSU facilities.

Patient Relocation

After surveying the Intensive Care (ICU) and Post Surgical Care (PSU) Units on the first floor, the nursing supervisor went to the incident command post. The nursing supervisor advised the incident commander of the proximity of the ICU and PSU units on the first floor and the build-up of smoke conditions in those areas. The hospital engineering staff had made the incident commander aware of oxygen supply lines for the laboratory areas which were in the concealed space above the loading dock. Fearing the possible involvement of the oxygen supply, the decision was made to immediately evacuate the first floor critical care units.

In the ICU, there were 11 patients of whom seven were on ventilators, and they were moved horizontally to the recovery room. In the PSU, non-ambulatory patients were moved to the recovery room and operating suites and to the first floor outpatient area. The outpatient area had previously been the emergency room, and operational oxygen, vacuum and essential care emergency power systems were still in place.

Eight ambulatory patients were walked, by a PSU staff nurse, to the ground level by means of a nearby stairway. Once outside the building, the eight patients were taken to the Whitacker Building. Relocation of the patients in the ICU and PSU units was accomplished quickly due to the availability of two shifts of personnel, extra hospital staff sent to assist and fire department personnel.
Since there was no in-house telephone or public announcement capability, the nursing supervisor decided to use the remaining fire brigade members as runners. She assigned each runner three floors of the tower. The runners were instructed to tell each charge nurse on the tower floors to relocate their patients horizontally into the adjoining floors and units in the older section of the building. The radiologist, having evacuated x-ray and laboratory staff from those areas, advised the nursing supervisor of their availability. X-ray and laboratory staff were immediately sent onto the various floors to assist floor staff with patient relocation.

On the second floor of the 1976 building, pediatricians in the nursery and intensive care units decided to evacuate babies and mothers due to the smoke entering those areas, and nurses were notified to evacuate their patients. The babies from both the newborn nursery and special care nursery were evacuated to the first floor by way of the stairway to the outside of the building. Security personnel opened the outpatient and heart station areas to provide a safer environment for the babies. After discharge by physicians, the mothers were brought by stairway to the heart station area, given their babies and then placed on a bus for transport to the Red Cross Chapter building.

Obstetrical patients in labor and delivery were transferred to the emergency room. (During the duration of the fire emergency, five babies were born in the emergency room to mothers relocated from the labor and delivery units.) Due to the absence of both normal and emergency lighting, a doctor delivering a baby by cesarean section in the labor and delivery operating room successfully completed the procedure by flashlight. Babies in the intensive care nursery were taken to the outpatient area. The babies were then transferred to Baptist Hospital by ambulance with their nurses for continued care.
On the general floors, patients were moved horizontally into other areas on the same floor but in older portions of the hospital building. Vacant rooms were filled, then private rooms were converted to semi-private rooms with beds and equipment that could be moved from the 1976 section of the building.

The physician in charge of disaster planning and operations for the hospital arrived at 7:40 p.m. He functioned as the medical director and as a roving medical command post within the hospital maintaining communications with a portable telephone. He coordinated with the fire department command post through a hospital administrative officer who was located and remained at the fire department command post. Communications were maintained by means of the portable radios carried by the hospital's security personnel.

The medical director was given a briefing by the nursing supervisor. After a rapid review with the nursing supervisors of the evacuation and relocations that had been accomplished, they made a survey of each floor in order to ascertain specific equipment and other resources needed by each unit. At the same time they informed the hospital staff regarding the status of the fire. The medical director then directed the relocation of equipment, supplies, personnel and medications as needed. In addition, two physicians were assigned to each relocated unit.

An emergency medical services command post was set up at the front of the hospital to coordinate outside emergency management resources, including transportation, with the medical director within the hospital. The Office of Emergency Management Mobile Disaster Unit (a 20-bed self-contained portable medical unit) and the rescue units which responded to the hospital were utilized to supply portable equipment for use within the hospital. Equipment supplied included portable suction units, portable oxygen units, large oxygen
cylinders, electrical generators, lights and electrical cables, and water coolers. Coordination between the medical director and the emergency medical services command post was maintained by means of portable radios carried by an emergency medical services officer who remained with the medical director.

Additional resources were obtained by the medical director, utilizing the portable telephone and dialing directly into the Forsyth County Communications Center. In this incident the total EMS response included four EMS units, a rescue unit, two heavy duty (volunteer) rescue squads, the disaster unit and approximately 50 personnel.

Visitor Control

Based on the emergency plan, visitors to the hospital were asked to leave the hospital building. Some visitors, unaware of the magnitude of the incident in progress, did not understand the request to leave. As the awareness of the fire emergency became more apparent, visitors also became concerned that they were prevented from re-entering the hospital. The administrative on-call officer and security officer were able to reassure upset family and visitors who had remained throughout the fire in front of the hospital.

Staff Response

Telephone calls were made to key staff members and, in turn, they called their employees. Others heard of the fire on the news, and a large number of off-duty employees responded to the hospital to assist. However, due to the lack of hospital staff identification, they had difficulty passing through police lines around the hospital. Once they arrived at the hospital, they also had trouble entering the building through card operated doors because of the power outage.
**Operational Recovery**

At 12:00 midnight, the hospital administrator held a meeting of key administrative and hospital staff personnel to establish a plan to maintain services and to plan recovery. By 2:00 a.m., the plan had been developed, and hospital architects and contractors were notified. By 4:00 a.m., workers for the electrical contractor were arriving to begin stringing temporary electrical supply cables to restore power to the 1976 portion of the building.

**Smoke Spread and Fire Damage**

In the basement of the 1976 addition building, heavy smoke conditions were limited to areas of the basement immediately adjoining the loading dock and first floor areas located directly above. Light smoke penetrated the 1964 portion of the main building (see Figures 1 and 2).

During the early stages of the fire, smoke was largely contained in the concealed space above the loading dock. As the volume of smoke and accompanying heat increased, smoke began to penetrate the envelope around the concealed space, through unsealed floor penetrations for conduits, pipes, ducts, and around conduits and pipes damaged by heat.

As the arcing and burning of the busway continued, heat was intense and localized. Combustible materials melted and/or burned as the burning progressed along the busway, depending on the location relative to the busway. Heat from the arcing busway affected steel pipe, rigid metal and plastic conduit, tubing, ducts and other utility conductors located in the concealed space. Ignition of additional combustible materials added to the amount of smoke produced;

Hospital laboratory, x-ray personnel and nursing supervisors noticed that the primary route of smoke onto the first floor was through the electrical ducts, receptacles and control panels located in rooms above the fire.
Post-fire inspection of the ducts by the hospital engineering staff indicated that the high temperatures from the busway melted plastic x-ray control cable conduits and also damaged metal electrical service conduits. Heavy smoke was able to penetrate the first floor, around and through electrical ducts within the floor.

In the basement, smoke was able to enter the laundry, the general stores storeroom and the adjoining purchasing office, since roll-up type metal fire doors between those areas and the loading dock were open throughout the duration of the fire.

On the first floor of the 1976 building, portions of the intensive care unit were located directly over the loading dock and remodeled general stores storeroom. Smoke described as both light in color and light in density was able to seep into the intensive care area. Although staff was able to breathe satisfactorily in the area of the fire, evacuation was considered necessary for those patients whose conditions were defined as critical.

Smoke was able to progressively penetrate into the patient care floors in the high-rise tower through interior stairways and also from the exterior as windows were opened for ventilation.

The initial estimate of damage to the hospital was $1.7 million dollars. Fire damaged areas included: the concealed space over the loading dock, the x-ray file storage room on the mezzanine level to the north of the loading dock, and the small general stores storeroom adjoining the south wall of the loading dock. These areas were directly exposed to the burning busway. On the first floor several x-ray machines and their control units were damaged, requiring complete replacement. Projected loss for the x-ray equipment was $450,000. In addition to the 125 feet of electrical feeder busway, that disintergrated during the 70 minutes of burning, most of the remaining busway sections were reportedly damaged by extensive heating to the extent that they were not re-usable.
**IV. ANALYSIS**

**Discussion**

The fire originated in a main electrical feeder busway supplying electricity to the 1976 addition to the main hospital building. The fire in the 4,000 ampere, 3 phase-4 wire indoor aluminum feeder busway caused the disintegration of nearly 125 feet of the 515-foot long busway. The busway extended from the main disconnect switch located near the power substation on the exterior of the north side of the building, through concealed spaces, to a main distribution panel located at the generator room on the east side of the building. The distribution panel in the room provided electrical power to approximately one-third of the main hospital building. This was the second fire involving a main electrical feeder busway to occur at the hospital.*

Prior to the most recent fire, the hospital engineering department indicated that no water leaks were known to be in that area. In addition, an infra-red scan of the entire busway, conducted by the engineering department in April, 1984, found no indication of abnormal heating within the busway. A post-fire spot inspection of connector bolts conducted along the length of the busway found that they were installed according to the specifications of the manufacturer. In the investigation of this incident, the cause of the shorting was not determined.

In this fire, the electrical fault appeared to have occurred in the busway located within the concealed space over the general stores storeroom that had

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*The previous fire, which occurred on April 26, 1978, had originated in the same electrical feeder busway. In that incident, 12 feet of the busway shorted out, burning toward the service entrance panel and the main breaker. Investigation of the previous fire concluded that water apparently leaked into the busway causing subsequent shorting or grounding of the busway.
been created by renovation of one bay of the original four-bay loading area. The location of the initial arcing in the busway was approximately 465 feet from the main service entrance circuit breaker at the service equipment and 50 feet from the main distribution panels for the 1976 portion of the building.

The first indication of an abnormal condition of the electrical system in the hospital was the fire alarm signal received when a smoke detector activated at 6:57 p.m.

The fire was initially limited to arcing and burning of the electrical feeder busway. The circuit breaker located at the service entrance panel failed to trip either due to overload condition or ground fault, and the busway continued to carry electrical current. The burning continued along the busway for 125 feet in the direction of the service entrance panel until the electrical service was de-energized at approximately 8:07 p.m.

During the early stages of the fire, the heat and smoke released by the arcing and burning of the busway was contained in concealed spaces. The heat not only caused ignition of combustible materials in the concealed space, but also caused disintegration of metal and steel located in close proximity to the busway. This included the steel supports for the ceiling assembly over the loading dock, electrical conduits, ducts and other utility piping.

In the general stores storeroom, the ceiling assembly remained in place except for the area closest to the busway which did sag. However, the heat from the burning busway above the ceiling caused the sprinklers to activate. Sprinkler activation prevented involvement of combustible materials in the room. The busway continued burning, through the flange in the concrete block wall into the concealed space above the loading dock.

A sprinkler system branch line was installed in the vicinity of the run of the busway. The arcing of the busway burned through the steel pipe of the
The ruptured sprinkler line allowed water to pour onto the ceiling assembly, adding weight to the heat-weakened assembly which eventually caused the ceiling assembly to fall.

On the north side of the loading dock, the busway penetrated the wall, entering the mezzanine room used for the storage of x-ray files on metal racks. The hot slag from the burning busway was able to ignite the x-ray film and files on the racks. Automatic sprinklers in the room were activated by the heat, but due to the deflection of the spray by the racks, the water could not reach the fire beneath the shelves. The fire was controlled but not extinguished. Fire fighters, unable to move the racks to gain access to the fire because of the electrical system damage, later breached the concrete block wall behind a rack to complete extinguishment.

**Electrical Systems in Hospitals**

Hospitals and other health care facilities, because of their nature, require a reliable source of electrical power. The electricity is needed for vital medical functions unique to health care facilities, and for life safety of the occupants.

Failure of the normal electrical supply is to be anticipated, and an emergency electrical power source provided. The emergency system must be installed in such a manner that, should the normal electrical supply system be interrupted by natural forces or faults within the electrical system, the emergency system will remain operational.

To ensure the reliability of the alternate power system, high priority should be given to maintaining continuity of the source and electrical feeders. This can be achieved by selecting electrical distribution arrangements where the normal and emergency systems are far enough away from
each other to minimize simultaneous damage to both systems from the occurrence of abnormal events.*

In this incident, due to the arrangement of the emergency generator control wiring in the vicinity of the busway, emergency power to critical care facilities was interrupted in addition to the loss of primary power.

Smoke Spread

Although smoke was initially contained within the concealed space above the loading dock, it soon spread into areas of the first floor directly over the loading dock. Hospital staff in the laboratory and x-ray areas located above the loading dock saw smoke filtering into various offices and work rooms through electrical connections, floor electrical trench ducts, and equipment cabinets connected to electrical circuits run in the trench ducts.

The exposure of electrical wiring in conduits located in the vicinity of the burning busway most likely produced some of the dense smoke that poured into this area. Plastic conduits, containing x-ray machine control wiring, also either melted or burned through in several locations creating openings for vertical smoke movement into the first floor areas. The burning conduits also produced smoke.

In addition, smoke was able to penetrate the rated floor assembly through unprotected utility openings. This allowed smoke spread to the first floor in the vicinity of the intensive care unit, located above the general stores storeroom. Witnesses reported that smoke developed slowly in this area. Even in the latter stages of the incident, smoke concentration remained low in these critical care areas. The smoke entering the x-ray and laboratory areas to the north was dense and black.

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When the ceiling assembly over the truck loading bays began to fail, smoke and steam were released from the concealed space. The venting of the space most likely helped slow the spread of smoke into first floor areas. However, the collapse of the loading dock ceiling did not occur until 30 to 45 minutes into the fire.

Smoke was also able to spread throughout major portions of the basement level due to migration of smoke into the laundry, corridor, and purchasing areas. The roll-up fire doors between the loading dock platform and the laundry and purchasing storeroom were in the open position throughout the fire. Smoke was able to extend through the laundry work spaces and purchasing storeroom, which included portions located in both the 1964 and 1976 sections of the main building.

The operation of smoke barrier doors and fire doors by activation of the fire alarm system and actions of the hospital staff successfully controlled further smoke spread in the basement and on the first floor (see Figures 1 and 2).

People Movement

With the initial announcement placing the fire alarm in the adjoining Paramedical Building, and the subsequent loss of central communications capability within the hospital, many of the hospital staff did not know until well into the incident that a fire was in progress. Many were especially confused to find that the fire was located in the main hospital building. However, nursing units responded to the initial alarm by closing doors and taking other actions outlined in the fire emergency plan. As the true nature and scope of the emergency became apparent, nursing units made further preparations necessary to initiate relocation of their patients.

With the loss of emergency power, nursing units with critical care patients were forced to take over some critical care functions, including
ventilation and visual monitoring, by hand. Units without battery powered emergency lighting units were forced to carry on using flashlights.

As the nursing supervisors were able to withdraw from their efforts to locate the fire, runners were sent to the units to have each prepare for relocation. Supervisors then proceeded to each unit to inform staff of the situation. As faint smoke became apparent in the critical care units on the first floor, the decision was made to begin relocation.

Using two shifts of critical care unit nursing staff, extra staff from other parts of the hospital, and fire department personnel, the movement of critical care patients in the PSU and ICU were evacuated to non-exposed sections of the hospital. Relocation of patients on the first floor PSU and critical care units was accomplished horizontally to locations in the older (1964) section of the building. The areas to which the relocations were to be made were not set out in the fire emergency plan. Nursing supervisors, nursing unit charge nurses, and staff physicians made decisions based on needs of their patients and the support capabilities in specific areas of the hospital not affected by smoke.

Mothers, babies and staff from the second floor obstetrics and gynecology units were moved horizontally to stairways in the 1964 portion of the building and to the areas of the emergency room and outpatient clinic. Due to the lack of lighting in the hallway of the outpatient clinic, babies from the special care nursery were transported to the nursery at Baptist Hospital.

The Hospital Emergency Plan prohibited the use of elevators for relocation or evacuation of patients. All patients from the second floor were relocated via stairways.

Compartmentation and subdivision of the building area limited smoke movement in the building. Compartmentation of spaces on each floor was enhanced by walls between the additions. Subdivision of floors by smoke barriers provided smoke-free areas that could be used as areas of refuge for
patients. Patients in the high-rise general nursing tower were able to move from units in the 1976 section of the building to similar units in the 1964 portion of the main building.

**Summary**

In this hospital fire, the areas most directly exposed to the rapidly deteriorating conditions and loss of emergency power were those which included the most vital critical care, laboratory, and support functions. Major exposure of these areas required the relocation and evacuation of patients and staff on several different floors. Following the termination of the actual fire emergency, the loss of these areas due to direct fire or smoke damage required rapidly instituted recovery activities to prevent major crippling of the continued functions of the hospital.

This fire emphasizes the importance of electrical power and communications reliability in both the day-to-day and emergency operations of health care facilities. Even with planned redundancy of electrical systems, unanticipated loss of both primary and backup sources of electrical supply can impose serious limitations on hospital emergency plans and functions. The hospital environment is increasingly dependent upon electrical power to maintain environmental operations, provide basic care, enhance life safety and, in many cases, preserve the lives of hospitalized patients. In critical care areas, in particular, the need for a reliable, uninterrupted supply of electrical power has been the source of increased concern and attention.

As in prior fires, the critical systems adversely affected during the emergency were internal telephone and public address communications.* Loss of communications capabilities can affect well-developed emergency plans dependent on such communications. Most health care disaster emergency plans

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* Footnote text (if any) would typically be included here.
for external and internal emergencies provide for alerting, coordination, and direction of emergency activities through an extensive array of communication systems.

This incident re-emphasizes the importance of training of staff members at all levels in emergency plans and procedures. It also demonstrates that trained and experienced staff and supervisory personnel can function in a developing emergency, given a clear understanding of the concepts of the emergency plan regarding evacuation or relocation and knowledge of hospital configuration and systems. Hospital staff members, supervisors, and unit nursing staff were able to recognize the changing conditions, evaluate hazards, form alternative plans and, in many cases, implement those actions independently. Many of the actions taken throughout this incident were determined based on prior training and individual judgment; and implemented based upon individual initiative.

An objective of emergency training is to prepare individuals to evaluate emergency conditions, make judgments and carry out appropriate actions. In this incident, training paid off and the hospital staff took correct actions to limit smoke spread and successfully relocate patients to ensure their safety.

APPENDICES
KEY

- FIRE DAMAGE OR HEAVY SMOKE SPREAD
- MODERATE TO LIGHT SMOKE SPREAD
- BUILDING BOUNDARIES

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NOT TO SCALE

FIGURE 2
PHOTO 1: An overview of the hospital complex from the southwest. (NFPA)
PHOTO 3: The electrical power substation with the service entrance, equipment, and busways in the background.
PHOTO 4: A section of the damaged aluminum busway. (NFPA)