DUPONT PLAZA HOTEL FIRE  
San Juan, Puerto Rico  
December 31, 1986

FIRE INVESTIGATIONS

NATIONAL FIRE PROTECTION ASSOCIATION

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INVESTIGATION REPORT ON THE DUPONT PLAZA HOTEL FIRE

December 31, 1986
San Juan, Puerto Rico

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QUINCY, MASSACHUSETTS
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ABSTRACT

A mid-afternoon fire at the Dupont Plaza Hotel in San Juan, Puerto Rico, on December 31, 1986, resulted in 97 fatalities, including 17 employees, and 146 reported injuries. Nearly all the fatalities were located in the casino or in the hotel's main lobby area.

The fire occurred in a nonsprinklered, 20-story hotel complex which had two basement levels. The hotel contained the first-floor grand ballroom, a second-floor (main entrance level) casino, retail shops, restaurants, a registration area, and a function room. In the complex's high-rise tower were 17 guest room floors and a roof-top restaurant.

The complex included unprotected noncombustible and some combustible construction in the ballroom area; and fire-resistant construction in the casino, lobby area, and high-rise tower.

There were no fire detection systems within the complex; nor was there a fire evacuation plan for the hotel, an employee policy for reporting fire emergencies, nor any training of employees to complement such a plan. The local-only manual fire evacuation alarm system installed in the high-rise tower was reportedly not working at the time of the fire. A standpipe and hose system in the high-rise tower also fed a partial automatic sprinkler system that protected areas remote from the fire and was not a factor in its outcome.

Local authorities, working with the Bureau of Alcohol, Tobacco and Firearms (ATF), determined that the fire was deliberately set using a single can of a "Sterno-type material" to ignite guest room furniture, still in shipping crates, stored in the unoccupied south ballroom. Once ignited, this abundant fuel load resulted in a rapidly developing fire that quickly ignited other combustibles within the south ballroom as well as the ballroom's combustible interior finish.

The fire was discovered in an advanced stage, beyond the control of some employees who attempted to suppress it. As word of the fire began to spread through the lower levels, flashover was reached in the south ballroom. Fire violently vented into an unenclosed stairway foyer area and began to spread products of combustion to the lobby/casino level. As the two-story-high foyer filled with heat and smoke, glass partitions in a masonry wall that adjoined the foyer and the casino soon failed. A smoke front, followed by a flame front, moved through the casino and lobby area and vented from the west wall to the exterior. For occupants still in the casino, there was little time between recognition of impending danger from the fire and its movement through that
area. Some of the casino’s occupants who acted early did escape, using one of the exits, during this time interval; some felt that they were in a smoke free area and closed exit doors to prevent infiltration; others broke exterior glass window walls and jumped to safety as the flame front was moving toward them.

Once the fire reached the lobby/casino level, products of combustion began to spread to the high-rise tower, trapping hundreds of unaware occupants. Rescue workers assisted many of the trapped occupants by directing them to the roof of the building, where they were removed by several helicopters making numerous return trips to complete their mission.

Even though significant amounts of smoke, heat, and toxic gases penetrated the high-rise tower, especially on its lower levels, there was only one fatality in the tower. It is felt that the exterior balconies provided occupants trapped for hours with a safe refuge area until the fire could be suppressed or they could be assisted by rescuers.

Just after the on site investigation was completed, Federal agents and local authorities arrested three individuals in connection with the fire. All three pleaded guilty to Federal charges levied against them and have received sentences ranging from 75 to 99 years. The criminal investigation of this fire is still ongoing.

The technology to prevent this tragedy is and has been available through fire protection engineering practice and the application of firesafety codes and standards that provide a means for continuous review and updating of the firesafety in hotels and similar occupancies. Had NFPA’s Life Safety Code®—which contains provisions requiring the upgrading of existing buildings—been used voluntarily by interested persons, or had it been adopted and enforced by public authorities, a tragedy of this magnitude would never have occurred.

NFPA’s analysis of the data points to four major factors contributing to the loss of life in the Dupont Plaza Hotel:

1. Lack of automatic sprinklers in the south ballroom (room of fire origin).
2. Rapid fire growth and spread.
3. Lack of automatic fire detection systems/inadequate exit for the casino.
4. Vertical opening between the ballroom and the casino levels.

Additional Findings:

5. Smoke movement to the high-rise tower by way of vertical penetrations.
6. Hotel tower occupants were not aware of a severe fire.
INTRODUCTION AND ACKNOWLEDGMENTS

AN INVESTIGATION OF THE Dupont Plaza Hotel fire was conducted by the National Fire Protection Association (NFPA) to document and analyze significant factors resulting in the rapid fire development and spread that led to the large loss of life. An investigation team of five specialists on the NFPA staff was assembled and dispatched to San Juan immediately after NFPA was notified of the fire; members of the team began to arrive to conduct the study within 24 hours after the fire had begun. Team members had extensive backgrounds in investigating major loss-of-life fires; three members had been involved in the Beverly Hills Supper Club fire study and in the investigation of the MGM Grand Hotel fire. Further, team members had diversified backgrounds in fire protection, building and fire code enforcement, and fire protection engineering. The NFPA team was led by Thomas J. Klem, Director of Fire Investigations, and included James K. Lathrop, Chief Life Safety Engineer; Richard L. Best, Fire Protection Specialist; Greg Kyte, Life Safety Specialist; and Robert E. Solomon, P.E., Fire Protection Engineer.

As in past major fires, NFPA worked in cooperation with the Bureau of Alcohol, Tobacco and Firearms (ATF) and local authorities. ATF dispatched its national response team at the request of the Superintendent, Police of Puerto Rico to help determine the cause and origin of the fire. Further, Governor Hernández Colón requested the assistance of the Federal Bureau of Investigation (FBI) in identifying victims. The Washington, D.C.-based FBI Disaster Squad, dispatched to the scene, has been used all over the world in identifying victims in like tragedies. In addition to the FBI’s disaster team, more than 80 agents and support staff from the San Juan FBI office supported the investigation.

ATF is a Federal law enforcement and compliance agency within the United States Treasury Department. It is responsible for enforcing the Federal firearms, arson, explosives, alcohol, and cigarette smuggling laws. The agency’s number one law enforcement priority is the investigation of arson/explosives-related incidents affecting interstate commerce. Each of the ATF response teams normally consists of 10 experienced criminal investigators specially trained in arson and bombing investigation, a forensic chemist, an explosives specialist, and a cause and origin specialist. On this fire, ATF’s teams from the northeast and southeast regions responded.

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

In addition to describing firesafety conditions at the Dupont Plaza Hotel, this report presents findings on factors contributing to the loss of life based on NFPA’s analysis of collected data and observations made during the investigation. NFPA codes and standards were used (except where otherwise noted) as criteria for this analysis, so that conditions at the Dupont Plaza on the date of the fire could be compared with current fire protection practice as represented by NFPA codes and standards in existence when the report was written. It is recognized that these codes and standards may not have been in effect during construction or operation of the Dupont Plaza. NFPA has not analyzed the Dupont Plaza as to compliance with codes or standards which were in existence in San Juan when the hotel was built or during its operation.

The objective of this report is to document and analyze a very significant fire incident in order to prevent recurrence of a multiple-death loss in the future. In view of the loss of life in the high-rise tower and casino areas, the scope of this report is limited to those portions of the Dupont Plaza Hotel complex pertinent to an examination of fire problems and factors associated with the loss of life.

During the period that this report was being developed, NFPA was advised that litigation had been initiated concerning the fire. It is not NFPA’s intention that this report pass judgment on, or fix liability for, the loss of life and property at the Dupont Plaza Hotel.
NFPA acknowledges the help and assistance in documenting this tragic incident provided by the Office of the Superintendent, Police of Puerto Rico; Puerto Rico's Fire Chief, The Honorable Aurelio Lopez Rivera; former Puerto Rican Fire Chief Raul Gandara; and the Federal Bureau of Investigation. The continued working relationship with agents and specialists from the U. S. Treasury's Bureau of Alcohol, Tobacco and Firearms during the on site documentation and throughout the documentation phase is also acknowledged. Of special note were the efforts of ATF Special Agents Andrew Vita, Robert Holland, and G. P. "Gus" Gary.

In addition, NFPA acknowledges the interface with Harold E. "Bud" Nelson, National Bureau of Standards, Center for Fire Research (NBS/CFR) in computer fire model applications to this incident, and with Russell P. Fleming of the National Fire Sprinkler Association regarding his assistance in the fire protection system response calculations.

The assistance of members of the NFPA investigative team is acknowledged for their guidance provided throughout the documentation of this fire, and particularly of Robert E. Solomon for his contribution to the Life Safety Code Analysis section. Further, to Laurie Ruszcyk, Evelyn Flanagan, and Josephine Standring, Project Secretaries, go thanks for their diligent efforts in the preparation of this report.
BACKGROUND

Hotel Firesafety

During the period 1980 through 1985, the U.S. averaged just over 100 hotel and motel fire deaths per year. In 1978 and 1979, the only years from the previous decade for which comparable estimates are available, the average annual death toll was 135. The estimated number of fire incidents in U.S. hotels and motels has declined steadily from a high of 14,000 in 1977—the first year for which comparable figures are available—to 7,500 in 1985; this is a decline of nearly 50 percent.

Deaths have not declined as much as fires have, however. Excluding the MGM Grand Hotel fire in 1980 and its 85 deaths, the hotel/motel fire death toll has fallen in the narrow range of 75 to 90 victims every year from 1980 through 1985 except for 1984, when it jumped to 120 for no obvious reason. There is, therefore, no evidence of continued life safety progress since the start of the current decade. Also, this means that even one fire of the severity of the MGM Grand Hotel fire or the Dupont Plaza Hotel fire by itself can double the annual death toll from hotel and motel fires.

In the last decade, the U.S. has experienced roughly two fires a year involving 10 or more deaths in hotels and motels. If residential (home) hotels and large rooming and boarding homes are excluded, the rate is roughly one fatal hotel fire per year. These fires have included many of the major hotel chains, demonstrating that firesafety concerns are not limited to marginal establishments having a poor transient population.

Overview

Constructed in the early 1960s and first occupied in the fall of 1963, the Dupont Plaza Hotel was located on Ashford Avenue in San Juan's Condado Beach section, a tourist area of the island. The ocean front building was positioned approximately 300 feet off Ashford Avenue; it was connected to the avenue by a circular driveway that gave access to the hotel's open-air main entrance area on the casino/lobby level. The Dupont Plaza Hotel complex contained numerous facilities to accommodate the needs of its guests drawn to the ocean front location. Included were the outdoor swimming pool, ocean beach, gambling casino, restaurants, meeting rooms, exhibit hall, guest rooms, retail shops, discotheque, and lounges.

Most of the facilities were located on the casino and ballroom levels and on the south side of the complex. The levels were connected by way of an open stairway foyer. Each of these floor areas contained an estimated 66,000 square feet, resulting in a large base level nearly 300 feet by 250 feet (see Figure 1 and 2). The grand ballroom, comprised of the north and south ballrooms, was positioned along the northeast portion of the complex. The casino/lobby level contained the hotel registration and main lobby areas, a discotheque, function room, retail shops, lounges, administrative offices, restaurants, and the casino. The main lobby and casino were contained within an area bounded by the high-rise tower.

The building also contained two basement levels, each approximately two-thirds the gross square footage of the casino and ballroom levels. Access to the basement was gained by way of one of the building's interior stairways, elevators, or from two exterior stairways located on the east and west sides of the building. The basements contained many of the support facilities for the building including laundry area, employee locker area, domestic water pump area, employee cafeteria, engineers' office, and storage areas.

During the busy Christmas/New Year holiday tourist season, when the fire occurred, the 423 guest rooms in the hotel were fully booked. But because of the time of
the fire (approximately 3:30 p.m.) many of the estimated 1,000 guests were at the hotel’s pool, in the beach area, or in the casino, rather than in their rooms when fire broke out.

Management of the Dupont Plaza was facing renewal of one of its contracts with the employees’ union, which represented approximately 250 of the hotel’s 450 employees. Since the contract was about to expire, negotiations between the union and hotel management were being held on a continuing basis. During a union meeting that took place in the north ballroom at approximately 2:00 p.m. on the day of the fire, the final proposal offered by the management was presented to the membership. The union rejected the offer and voted to strike beginning at 12:01 a.m. on January 1, 1987.

Witnesses’ statements indicate that in the days preceding the December 31st fire, four “minor” fires occurred at various locations throughout the building. All but one of the minor fires apparently resulted in the response of the fire department. All of the fires were extinguished by employees. Partially as a result of the fires and due to the ongoing heated labor contract negotiations, 28 extra security guards were hired by the hotel.

The fire department of Puerto Rico is responsible for the protection of 3.3 million people. The 3,421-square-mile island is approximately 100 miles in length and 35 miles wide. There are 88 fire stations on the island, staffed with 650 fire fighters who work eight-hour shifts. Many of the fire stations have one engine company, manned by one fire fighter. Seven aerial ladders were distributed across the island, but at the time of the fire only two were functioning. The San Juan area is serviced by equipment from five fire stations. Only 10 pieces of self-contained breathing apparatus were available in the San Juan area for use at the time of the fire.

Utilizing the powers of the Puerto Rico Fire Prevention Code, the fire service made periodic inspections of the Dupont Plaza; however, these inspections were mostly for preplanning purposes or were “housekeeping” in nature.

Construction Codes

Since the Dupont Plaza Hotel was built in the early 1960s, its construction was governed by the Building Regulation dated August 13, 1954. The building code, which uses some components of a national model building code, comes under the island’s Administration for Regulation and Permits. Unlike the model code requirements, however, this agency relies totally on self-certification of plans, specifications, and compliance with the building code by submitters. Further, construction sites are not usually inspected by the Administration, which relies on self-inspection and certification of the structure throughout construction by the builders, owners, or other responsible persons.

Although the building code was substantially amended in 1968, its administration remains largely unchanged.

The Building

General Description

Ashford Avenue is a 40-foot-wide, one-way road running east to west along the Condado Beach section of San Juan, leading past the Dupont Plaza and many other major tourist hotels. Located on the Dupont’s south side, it is the first street parallel to the ocean. From Ashford Avenue there were two entry points to the front of the hotel. A 15-foot-wide circular driveway gave access to the main entrance on the casino/lobby level. There was a slight incline from Ashford Avenue to the entranceway as the driveway approached the Dupont. The upper portion of the driveway and adjacent “green areas” were supported by concrete columns and deck that also provided roof cover for a portion of the open exterior lower-level parking area. The remainder of the parking area had no roof cover and ran along the entire south side of the building to a distance of nearly 1,000 feet.

Finally, there was access to the ballroom level by way of an entry point at the east edge of the building property line. This guarded entry point led directly to the lower-level parking area and to a narrow access road that ran along the two-story-high east side of the complex, between the building and a masonry retaining wall at the
property line. The access road led to the kitchen’s loading dock area, to a side entranceway, and to an exterior door opening to the grand ballroom. From the parking area, an exterior masonry stairway could be used to gain access to the main entrance level.

Two sides of the lower portions of the building had access for fire fighting purposes. However, access to the high-rise tower by fire department aerial apparatus could not be gained from any side of the building: the west side contained the hotel’s swimming pool; the north side was beach; and the south and east sides had lower-level building projections.

Located on the poolside exterior portion of the building were five poured concrete columns. The approximately 30-foot-high columns flared at the top to a flat concrete surface that provided some roof cover for occupants below at the exterior poolside bar. In addition, located between the building’s west exterior wall and columns were wood joist and roof materials that joined the columns and the building. This arrangement provided roof cover for the poolside bar and spiral stairway areas. For additional protection for the bar and dance floor adjacent to it, a light-weight, metal-frame awning of canvas-type material was positioned below the wood roof. The poolside bar and dance floor ran from the approximate location of the spiral stairway’s discharge point to the northernmost corner of the building a distance of approximately 90 feet. The bar area contained metal bar room stools with padding, the wooden bar, and various other items of limited combustibility.

In addition to the main entranceway, access to the building could be gained by an outside spiral stairway located on the west side of the building (the pool side), connecting the swimming pool area with the casino/lobby level. Contained in the northeast corner at this level was the “U”-shaped casino of approximately 4,760 square feet. The interior walls of the casino were common to three of the center core’s walls for the high-rise tower (see Building Construction section).

On the exterior north side of the building were a “green area,” a retaining wall separating the beach from the complex, and a sidewalk connecting the pool side of the building with a patio area adjacent to the grand ballroom. From the patio, access to the ballroom level and foyer could be gained through two exterior doors placed in a 20-foot-high glass wall partition. In addition to the large grand ballroom located in the northeast portion of the complex, this level also contained the kitchen and its support facilities, some of the hotel staff offices, and the receiving dock.

The high-rise tower was positioned above the area enclosed by the casino and main lobby. It contained 17 guest room floors, a roof-top restaurant, and a two-level penthouse area housing mechanical and elevator equipment rooms. Stairways B and C contained in the two-hour-rated stairway enclosure, connected the guest room floors with the lower levels of the complex.

Building Construction

The building was of mixed construction which included unprotected noncombustible, some combustible construction in the ballroom foyer area, and fire-resistive construction in the casino/lobby area and the high-rise tower. Classification, according to NFPA 220, Standard on Types of Building Construction, included Type I, II, and III construction. Exterior walls were masonry, as were interior load-bearing partitions; other interior partitions were mostly gypsum material applied to wood studs and finished with a skim coat of plaster. Many of the interior partitions (both masonry and frame) were covered with combustible interior finish materials, ranging from light-weight wood paneling to a light-weight carpeting-like material.

The casino/lobby level contained both fire-resistive and unprotected noncombustible construction. The main lobby and casino were in an area enclosed by the structural members of the approximately 110-square-foot fire-resistive high-rise tower. An approximately 20-foot space was between the concrete floor and the floor above (i.e. the first guest room floor). The metal lathe and plaster suspended ceiling system created a 5-foot void space containing heating, ventilating, and air conditioning (HVAC) return and supply ducts, electrical cables supplying lighting fixtures, etc. The remainder of the one-story casino/lobby level that contained administrative offices, lounges, restaurants, discotheque, and a function room was of unprotected noncombustible construction. The finished ceiling for these areas consisted of a suspended metal grid system with lay-in mineral tiles.

The stairway foyer area contained a wood frame roof which extended over the foyer landing area on the casino
level. The wood joists were exposed except for the foyer landing area where a suspended metal grid system with lay-in mineral tiles was provided.

The ballroom level and basement areas were generally of unprotected noncombustible construction. A suspended grid ceiling system with lay-in mineral tiles provided the finished ceiling for the ballroom level; however, most portions of the basement contained no finished ceiling.

The high-rise tower was of fire-resistive construction having poured concrete floors and support columns. The tower was designed with a center core housing service equipment, passenger and service elevators, utility and pipe chases, the building's two interior stairways, and HVAC ducts. The center core was intended to provide a two-hour fire resistance rating. While some of the openings to the core were properly protected, numerous horizontal and vertical voids were identified.

On guest room floors, painted masonry walls separated the rectangular exit access corridor from the guest rooms. The core walls in the corridors were vinyl-covered. The finished ceiling for guest room floors consisted of a skim coat of plaster applied over the concrete floor/ceiling assembly. On the 20th floor, however, a suspended metal grid system with lay-in mineral tiles made up the finished ceiling.

Casino/Lobby and Ballroom Levels

Entering the hotel complex from Ashford Avenue, by way of the long circular driveway, provided access to the main open-air entrance arcade. Several steps led from the driveway to the entranceway. From the approximately 100-foot-long arcade, access was available to several retail shops, administrative offices, and two of the hotel's restaurants. Further along the path to the main lobby, patrons passed a statue and several other decorative items including large potted plants positioned in the center of the 25-foot-wide corridor. The entrance arcade was designed to meet the main lobby/registration area where an entering guest would pass the bell captain's station.

Although not intended as a main entrance for guests, an additional corridor (arcade) was provided along the west exterior wall of the building adjacent to the administrative offices. This corridor, which also led from the main lobby to the front entrance steps and the circular driveway, was 10 feet wide but narrowed at one point to 6 1/2 feet. A small lounge was located at the southernmost portion of the corridor. The one-story lounge was the westernmost projection of the building's south side (see Figure 3).

From the main lobby, guests had access to the building's four passenger elevators, a lounge, the casino, a discotheque, restaurants, and rest rooms. They also had access to the lower-level ballroom by way of the open foyer stairway located at the approximate midpoint of the building complex at this level.

In addition to serving as the discharge level for the high-rise tower, this level was the exit path for the building's two restaurants, two lounges/bars, and half of the occupant loads from this level's function room and the discotheque. The two restaurants did not have an approved secondary means of egress (see Life Safety Code Analysis section for details).

Interior structural columns in the main lobby and casino areas were covered with ceramic-type tile. Metal furring strips were attached to the columns, gypsum material applied, and then finished with a skim coat of plaster. In addition, in the main lobby area, columns were surrounded by wooden benches with foam plastic cushioning.

The masonry center core—the construction design for the high-rise tower—at this point contained two levels. The lower level included rest rooms, passenger and service elevator openings, discharge corridors for the two interior stairways, and storage areas and support rooms for the casino. Located on the second-story level were two HVAC system rooms (see Mechanical Systems section for details). The systems were positioned on the east and west sides of the center core. Several large voids were found in the east and west masonry core walls that were common to the casino. The voids were near the finished ceiling level and provided direct access to each of the HVAC rooms. Sandwiched between these rooms, but physically separated from them, was a casino dealers' lounge and locker room area. The lounge area had a spiral stairway leading to an emergency escape hatch and the guest room floor above. A 3-foot diameter circular metal hatch covered the emergency escape opening; when in position, the cover was part of the third floor service elevator's floor area. During the fire, this unpro-
tected opening was used as an escape route by employees trapped in the casino, but at the same time it allowed products of combustion to rise from the casino to guest room floors by way of the service elevators (see Figure 4).

Entrance to the casino was from the main lobby area. The casino contained slot machines and blackjack, roulette, and dice tables. Wood framing materials supported the slot machines, generally positioned along interior and exterior walls of the casino. The gambling area contributed various other combustibles to the room including wooden chairs and gambling tables with foam plastic padding. The entire casino was carpeted over a foam-type padding material layered on the concrete floor.

Inside the casino, attached to center core's walls, were wooden furring strips holding 3/8-inch wood paneling materials. Glued to the south wall of the casino along the core was a mirrored glass covering. At the end of the casino's west corridor, along an inner wall of the casino and an outer wall of the offices, were two couches arranged at right angles to each other to form an "L" shape.

Structural columns for the high-rise tower also were located around the perimeter of the casino. Glass partitions in wood frames placed between the columns permitted panoramic views. Witnesses' statements and the remains of metal traverse rods indicated that, although the casino had drapery materials along its perimeter walls, the draperies normally were kept in the open position to expose views of the ocean.

Two of the three glass partitions along the east wall of the casino adjoined the foyer area, while the third partition at the northernmost point adjoined the exterior of the building.

Also found within the casino were some wood frame materials thought to have been part of the finished ceiling; they may have been part of a decorative cornice where the ceiling met the exterior walls.

Within the void space above the casino's ceiling were various utility pipes such as waste water, domestic water, and chilled water lines. The vertical openings in which these lines were run created an open shaft from the casino to all levels of the high-rise tower. These lines also penetrated the center core, thus communicating with other penetrations to the tower.

Also on the casino/lobby level near the casino's west exit door were three small offices, used as the cash count room and for other support functions for the casino. Constructed using gypsum material applied to wood studs, the offices were partially contained in the casino and the main lobby area. As a result, entrance to the offices could be gained from either side of the casino's west exit door. A suspended metal grid system having lay-in mineral tiles was used for the ceiling arrangement for the offices. Ceiling height in the offices was determined to be 9 feet.

A metal lathe and plaster partition was provided above the west door of the casino. Rising to the underside of the finished ceiling, the partition extended from the west exterior wall, over the offices, and to an interior support column in the main lobby. It is believed that this partition was intended for decorative purposes. Several voids in the partition, including a space of approximately 1 foot between its bottom portion and the top structural members of the offices, were identified. Smoke that would have accumulated in the main lobby area along the finished ceiling easily could have penetrated the partition and passed freely into the casino once it banked to the level of the voids.

The casino had two egress doors that discharged into the main lobby. Its main entrance/exit was positioned in a glass wall partition separating the casino from the main lobby area. This exit was at the end of the casino's east corridor and consisted of two 36-inch-wide glass doors set in a metal frame. The doors were designed to open in either direction. The casino's west exit was a 36-inch-wide wooden door set in a wood frame that opened into the casino. When closed, the door required two simultaneous actions to unlatch it and an additional action to open it (see Life Safety Code Analysis for further details).

Exit access from the casino to outside exits was through the main lobby to the main entrance previously described and through an opening to the spiral stairway on the west side of the building. A 6-foot open-air doorway was located at the top of the stairway adjacent to the casino's west exit. The 6-foot 1 1/2-inch stairway discharged to the swimming pool.

Foyer

A two-story-high foyer contained the open stairway that provided a connecting link between the ballroom
level and the lobby/casino level. The stairway was approximately 10 feet wide, with a clear exit width of 9 feet 10 inches. The wooden roof covering for the foyer was supported by masonry projections from the grand ballroom and the high-rise tower. The joist channels opened directly to the exterior of the building.

Along the foyer’s east side, approximately 12 feet above the finished clay tile floor, was a balcony that did not extend over the entranceway to the north ballroom but which did project over the remainder of the east side of the foyer. The 10-foot-wide balcony connected the balcony area of the grand ballroom and the foyer landing area on the lobby/casino level.

A glass partition separated the foyer balcony from the balcony area of the grand ballroom and an upper-level function room. Glass doors were placed in the partition where it met the grand ballroom balcony and the foyer landing. The ceiling-high glass partition continued along the outer edge of the foyer landing to the foyer stairway. At that point was an approximately 10-foot-wide opening for the stairway, then the partition continued until it reached the common west wall of the foyer and the casino. This portion of the glass partition apparently had been constructed to reduce the effects of tropical breezes entering the foyer through the louvered openings in its north wall.

Below the balcony was a glass partition that separated the north and south ballroom from the foyer. Only 12 feet of the partition was common to the north ballroom. Since the balcony did not extend the full length of the east wall, the glass partition wall was approximately 20 feet high at this point. The center portion of the partition consisted of two decorative wood doors, 9 feet high and 3 feet wide, leading to the north ballroom. A solid wood panel was installed in the partition over the doorway. Adjacent to the entrance doors to the north ballroom were two identical entrance doors to the south ballroom. The glass partition continued along the remainder of the common wall between the south ballroom and the foyer until it reached a masonry wall separating the foyer (south wall) from the kitchen area.

The lower foyer area contained, along its south wall, a service door leading to the kitchen area, a service bar, and an entrance to rest rooms. This wall was finished with a vinyl wall covering material that was partially consumed during the fire.

The north wall of the foyer was a two-story-high glass partition that adjoined the building’s exterior patio area. The partition contained two single doors one that opened into the foyer, and one that opened outward. The doors, each approximately 36 inches wide, were not provided with illuminated exit signs above them. Wooden louvers were positioned above each door and along their outer edges to allow ocean breezes to enter the foyer area.

The two-story masonry west wall of the foyer was finished with a skim coat of plaster with a piece of sculpture attached to the wall at approximately mid-height. The wall was common to the casino at its upper level and to a restaurant at its lower level. On the casino level two 12 by 10-foot glass partitions were contained in the foyer’s west wall. One partition was positioned adjacent to the stairway landing area, while the remaining interior partition was adjacent to the north wall of the foyer.

The foyer landing area at the top of the stairway was approximately 20 by 25 feet at the casino/lobby level. This area connected to the main lobby to its west, to the discotheque to its east, and to a lounge to its south. The far wall of the foyer landing had a common wall to the lounge. Constructed with wood framing and gypsum material, the wall had an ornate wood carving attached at mid-height. The foyer’s wood roof was not exposed at the landing area; a suspended metal-grid ceiling system with laid-in mineral tiles comprised the finished ceiling for this area. The ceiling height was approximately 10 feet.

Grand Ballroom

The grand ballroom adjoined the foyer at the eastern portion of the hotel complex. The grand ballroom consisted of the north and south ballroom and an “L”-shaped balcony along its south and east sides. Depending on the intended use, the grand ballroom was capable of being divided into a north and south ballroom by means of a combustible removable partition that could be positioned below the steel support beam for the balcony (see Figure 5). Metal bar joists were used to support the metal deck and poured concrete floor for the balcony. The area could be used as an exhibit hall or for multiple assembly purposes. The north ballroom had a
ceiling height of approximately 23 feet while the south ballroom ceiling height was approximately 10 feet. The north ballroom section was equipped with a proscenium, stage lighting, and a sound system. The total size of the ballroom areas, including the balcony area, was determined to be just over 9,000 square feet.

On the day of the fire, the grand ballroom was divided into the north and south ballroom using a removable partition.

**North Ballroom**

ENTRY TO THE NORTH BALLROOM was gained from the foyer area by way of the two wood doors that swung so they opened into the foyer. The doors did not contain panic hardware but were equipped with large decorative metal handles for opening.

The 66-foot-square north ballroom was equivalent to two stories in height. The finished ceiling consisted of a suspended metal grid system to which plaster was applied. Attached to the finished ceiling were accessories for stage illumination, the sound system, etc. The 15-foot-wide balcony area that partially extended over the ballroom was used by projectionists and contained stored chairs and tables, a piano, and lighting equipment. A 44-inch-wide open stairway adjacent to the separating partition connected the lower north ballroom to the balcony area.

On the west side of the north ballroom were three exits that led directly to the outside patio area. Each exit contained two 36-inch-wide doors with a center mullion; these doors were equipped with panic hardware. Glass partitions over the doors ran to the underside of the roof. Glass partitions were also adjacent to each of the double doors.

The east wall of the ballroom contained a folding partition that could be opened to provide access for equipment and furniture being brought in from outside the building. The folding partition was hinged so it opened into the north ballroom with its clear open width determined to be 11 feet 9 inches. The partition was determined to be in the open position throughout the fire. The hinged door had an exit sign positioned above it. Although one of the leaves of the folding partition had panic hardware, a pushing force from the interior would not open the door when the partition was in its closed position. This opening led to a service area off the ballroom and to the outdoors through a 10-foot-wide opening having a sliding metal door. At the time of the fire, it was determined that the door was in the open position, incapable of being shut.

The north end of the ballroom was a stage area elevated about 30 inches. The stage had a ceiling level approximately 3 feet higher than the rest of the ballroom.

The walls of the north ballroom consisted of concrete, plaster, and gypsum board materials. Most of the walls had a light weight fabric covering. On the day of the fire, approximately 200 chairs were arranged in the north ballroom in preparation for the union meeting.

**South Ballroom**

THE OVERALL DIMENSIONS of the south ballroom were determined to be 66 feet by 40 feet. This ballroom was formed when the grand ballroom was separated into the north and south ballroom by means of a combustible removable partition which, when in place, formed the south ballroom's north wall. The partition consisted of a series of panels each approximately 4 feet wide by 10 feet high. It was reported that one person could handle hanging the partition. The partition was constructed of two outside sheets of high pressure laminate material between which were foam plastic material and support bracing. The laminated outer surface of the partition was determined to be approximately .06 inches thick. The suspension system for the panels is not known; however, there was evidence of studs in the balcony support beam at logical points of attachment.

Two 36-inch-wide main entry doors were in the west wall of the ballroom. Glass set in wood frames comprised the remainder of the partition between the structural columns. Metal venetian blinds covered the 10 by 12-foot glass panels at the west end of the south ballroom.

The ceiling system consisted of mineral lay in tiles in a suspended metal grid. In the ceiling void space were HVAC ducts plus support beams and bar joists for the balcony and the function room located directly above. Along the finished ceiling were eight combination light fixture/air supply registers equally spaced throughout the south ballroom. Two return air grilles for the HVAC system were set in the room's east wall. The return air grilles were 1 by 3 feet, positioned approximately 8 feet
above the finished floor. The separate HVAC system for the south ballroom was not operating at the time of the fire.

The masonry north wall contained two door openings leading to the service area for the kitchen. The 34-inch-wide doors were arranged in typical service fashion, one opening into the ballroom and one opening in the direction of the service area. An illuminated exit sign was placed over one of the doors.

The south and east walls of the ballroom were of reinforced concrete construction finished with a light-weight fabric cover. The wall covering material appeared to have been a polyester (or similar) fiber weighing slightly more than one pound per square yard. Test results indicate that the light-weight material had an ignition temperature of between 1160°F and 1270°F (see NBS/CFR Test Results in Appendix A).

Recently delivered guest room furniture still in cardboard boxes lined 30 feet of the east wall of the ballroom on the day of the fire. These materials, stacked 6 feet high, occupied an area approximately 18 feet wide. The closely stacked crates contained dressers of wood and particle board, sofa beds with foam mattresses, and other furniture. Shipping documents indicate that 91 crates of furniture had been delivered to the south ballroom. The crates were adjacent to the portable partition; in fact, it was reported that one or more of the panels could not be placed in position due to the projection of the stored materials. Along the south wall of the ballroom were approximately 50 stacked metal chairs having padded backs and seats of vinyl-covered foam. The floor of the ballroom was an oak hardwood material over a soft wood sub-flooring glued to the poured concrete floor.

High-Rise Tower

The guest room tower occupied the area above the main lobby and casino. The complex contained a total of 17 guest room floors numbered 3 through 20; there was no designated 13th floor. A restaurant with kitchen facilities was located on the 21st floor. The remaining upper levels of the building contained an abandoned HVAC system for floors 11 through 20 (see Mechanical System section) and elevator equipment rooms, maintenance facilities, and other support service areas. The equipment rooms were a two-story projection from the restaurant level, approximately 50 feet square. Access to these floor levels and the roof was gained by way of stairway B, which at its top landing had a wall-mounted ladder that provided access to a hatch and the topmost roof of the building. The roof area contained a large billboard, antennas, water drainage items, and vents for the elevator equipment room and for the upper-level HVAC system. The roof of the restaurant was below this roof level and protected approximately 50 feet beyond its outer edge. The outer edge of the restaurant roof contained wooden lattice work. Including the lattice work, the roof dimensions were approximately equal to the outside dimensions of the high-rise tower. On the restaurant's roof, in the area between its edge and the masonry enclosure for the two-story mechanical area, was the operating space for rescue helicopters. During the fire, evacuating occupants assembled along the outside wall of the mechanical equipment room to wait while helicopters hovered near the lattice work.

The building's two interior stairways (except as noted) and passenger and service elevators served all occupied levels of the building. The four passenger elevators opened directly onto the exit access corridor. The two service elevators opened onto a service room, which included a maid's storage area, ice machine, janitor's closet, and access to trash and laundry chutes. Louvered doors led from the service area to the exit access corridor.

The number of guest rooms varied on guest room floors. Each guest room floor could contain as many as 25 guest rooms located along the perimeter of the tower (see Figure 6). Access to the guest rooms was through a rectangular exit access corridor leading from the core. Carpentry material covered the floor of the corridor on each guest room level. Access to individual guest rooms was gained through solid wood doors having thin laminated exterior finish. The doors were 3/4-inch thick and had no self-closing mechanisms. Furnishings in guest rooms were typical. Each room contained an exterior door which led to a balcony. Guest rooms did not contain individual smoke detectors.

The scissor stairway arrangement provided not only the means of exit from the high-rise tower, but also the exit routes for the roof-top restaurant. The 42 1/2-inch-wide stairways, separated within the enclosure by ma-
sonry material, discharged into the unsprinklered, un-
protected main lobby area and to exterior points of
discharge from the building. On guest room floors, ac-
cess to the stairways was gained from the east and west
sides of the exit access corridor through 36-inch, self-
closing fire doors. Because of its scissor design, entry
points for an individual stairway would alternate from
east to west through the tower. Although the interior
stairways did not contain emergency lighting, entrance
points from guest room floors did have illuminated exit
signs. Neither of the stairways was clearly marked with
illuminated directional signs on its interior to indicate
the exiting point at the casino/lobby level.

A printed, nonilluminated directional sign was pro-
vided in stairway C on the casino/lobby landing level,
before the stairway continued to the basement levels.

The exit discharge point was more obvious for stair-
way B, since it did not continue to the basement; how-

FIGURE 6: TYPICAL GUEST ROOM FLOOR PLAN
ever, this stairway connected at a right angle to a corridor leading toward the service elevator area in one direction and the door opening to the lobby in the opposite direction. It appears that a fire door once may have been in position at the connection of the stairway and the corridor. A labeled metal frame remained; however, the opening had no door. Apparently to provide enclosure or separation for the stairway, a wooden door was provided where the corridor met the main lobby.

Doors to the stairways at the lobby/casino level opened into the lobby. The wood panel door to stairway B (and to the corridor leading to the service elevators) was determined to have been in the open position throughout the fire. The door to stairway C appeared to be a standard class B fire door which was in the closed position throughout the fire. Significant amounts of heat and smoke penetrated stairway B and consumed the door; however, even though equally exposed to the massive fire in the main lobby, few effects could be seen in stairway C.

Only stairway C continued to the basement levels. In this fire incident, this was fortunate since stairway C led escaping occupants, in poorly illuminated conditions, past the nonobvious discharge point at the casino/lobby level to the unaffected basement and to the exterior of the building.

**Mechanical Systems**

**Numerous mechanical systems** provided conditioned air to the various portions of the complex. This section will discuss a partially abandoned HVAC system that once had supplied the casino, main lobby, and exit access corridors on guest room floors. In addition, this section will discuss the HVAC system arrangement for individual guest rooms.

The HVAC units that comprised the system supplying the casino, main lobby, etc. were positioned at two locations (i.e. lobby and penthouse levels) within the core for the high-rise tower. Two units were positioned on the east and west sides of the core for the tower at the casino/lobby level. These units at one time had provided conditioned air for the lobby, casino, and exit access corridors on guest room floors 3 through 10; however, to save energy the system was abandoned, but portions of the remaining duct work were used by another HVAC system to supply conditioned air to the casino. From the handling units, an approximately 6-foot-wide vertical duct was run to guest room floors 3 through 10. This duct apparently was run in a masonry enclosed shaft; however, no fire dampers were provided at locations where the duct penetrated floor/ceiling assemblies or at locations where sub-ducts penetrated the core on individual guest room floors. On individual guest room floors, the supply grilles were located above stairway door openings. A similar design arrangement was provided for the two penthouse units that at one time supplied conditioned air to exit access corridors on guest room floors 11 through 20.

The lower level HVAC system was arranged so it no longer provided conditioned air to the main lobby, casino, or guest room floors. Even though the system was nonfunctional, the ducts provided open conduits connecting the casino/lobby level with upper-level guest room floors 3 through 10. Further, as smoke reached the exit access corridors for guest room floors 11 through 20, the ducts would have provided a similar circulating medium (see further discussion in Smoke Spread section).

An individual HVAC unit provided conditioned air to each guest room. The units were located in the plenum area above the bathrooms. Make-up air for guest rooms was taken from the corridors, conditioned, and distributed into the rooms. The 6-inch by 12-inch access grilles were at approximately the 8-foot level of the exit access corridor wall. Also located in the plenum area was an unenclosed vertical shaft that contained pipes for chilled water feeding the HVAC systems, for the domestic water supply, and for drainage. Individual bathroom vents also were common to this plenum area and the associated vertical utility shaft penetration (see Figure 7).

**Fire Protection Systems**

The hotel portion of the high-rise tower contained a local fire alarm system, with each guest room floor containing manual pull stations and alarm sounding devices located near the entranceway to each stairway. The fire alarm system for the tower was reported not to be working at the time of the fire. None of the more than 400 persons interviewed following the fire reported hearing the fire alarm sounding during the fire.

The building was equipped with a wet standpipe
system having a fire department siamese connection; the vertical risers were located in each of the stairways. At each floor landing was a 2 1/2-inch standpipe connection and 100 feet of 1 1/2-inch hose with a fog nozzle for occupant use.

Partial automatic sprinkler protection was provided for the laundry and storage areas and for laundry and trash chutes. Because of the very limited coverage and their location remote from the fire area, sprinkler operation and performance was not a factor in this incident.

Sprinklers were located at the top of the laundry and trash chutes that ran the full height of the building. Building plans indicate that these sprinklers were fed from the domestic water system likely installed during original construction. Although the sprinklers did not operate during the fire, one apparently operated later as a result of laundry smoldering in the chute. The laundry chute emptied into a room protected by a dry chemical extinguishing system adjacent to the basement laundry area.

Based on review of automatic sprinkler plans, 67 additional sprinklers appeared to have been installed in 1978 as a retrofit project. These sprinklers were fed by a main from the building’s standpipe system. The majority of these sprinklers protected the laundry area and certain storage areas within the basement. A vertical riser extended from this partial system from the basement to the 20th floor, protecting the laundry storage area on each guest room floor and the maid’s closet adjacent to it.

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Weather Conditions

Weather conditions at the time of the fire were reported by the U. S. Department of Commerce’s National Oceanic and Atmospheric Administration through its National Weather Service located at the Luis Muoz Marin Airport in Puerto Rico.

The conditions were: visibility 20 miles, temperature 82°F, winds from the north northeast at 10 knots. There was little change in any of these variables throughout the first 1 1/2 hours of the fire.

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THE FIRE INCIDENT

Fire Discovery

It was approximately 3 P.M. when the union meeting being held in the north ballroom broke up and the attendees began to leave or disperse throughout the building. Several clusters of employees who had been attending the meeting continued to discuss the issues. One group was assembled in the kitchen area only a short distance from the south ballroom, to which it was connected by a service corridor. During their discussions, members of this group began to hear cries of a fire in the ballroom.

One individual from the group left the kitchen through a service door leading to the foyer, and tried to force open the set of doors to the south ballroom that had been secured with chains. Unable to open the doors, he went to the next set of doors leading to the north ballroom and opened them. He entered the north ballroom and observed flames extending approximately 3 feet above the stored furniture and 5 feet through the opening in the partition that separated the north and south ballroom. At that time the fire had completely engulfed the top half of the first two panels of the partition. From a position near the partition, he observed that the south ballroom was very hot and filling with smoke. Apparently in an attempt to clear the smoke also accumulating in the north ballroom, the employee opened each of the three exit doors leading to the outside patio area. The employee also attempted to use a fire extinguisher that he had brought from the kitchen. However, he described the heat and smoke as too intense, so he left the building.

The cries of fire heard by the employees in the kitchen most likely were from several other employees—including the building engineer—who had been made aware of the fire and had taken a position in the service corridor near the service doors to the south ballroom. The employees described seeing the fire through the top of one of the open doors behind the stored furniture and attempting to advance an occupant fire hose from a nearby stairway. Rapidly changing conditions within the ballroom were described as thick, black smoke and heat coming from the ballroom. Sensing that they could not extinguish the developing fire, the employees left the building by way of a nearby exterior doorway.

At about the same time others were discovering or being made aware of the fire, a recently hired security guard also learned of it. The guard was positioned in the patio area outside the north ballroom when an employee approached him from within the ballroom and reported the fire. The security guard moved to a position in the north ballroom where he saw the fire as extending through the opening in the partition. He later said he could see "red flames on top of large boxes in the room."

The guard took no fire control or alarm action. He left the area and proceeded to the eighth floor of the high-rise tower where he attempted to locate his supervisor. Unable to find his supervisor there, the security guard took a stairway down. He went into the lobby area where he was joined at the top of the stairway foyer landing area by two other employees. From this position, the security guard said smoke was coming from the north ballroom through its open doors and into the foyer. He described the smoke as moving up the stairway and onto the casino/lobby level. He then proceeded into the casino through the main entranceway and advised occupants that "there is a fire and all should get out." The security guard stated that several of the occupants of the casino moved toward exits but most stayed inside the casino. The guard then entered the casino's west door to notify other occupants about the fire and advise them to evacuate immediately. The guard observed that more people paid attention and proceeded to exit through the west door of the casino as a result of this warning. Before leaving the casino, the security guard stated, "the smoke was now getting pretty thick in the casino area...."

At about the same time, the sales office manager
positioned in the registration area observed “a light cloud of smoke” coming from the area of the foyer stairway. The manager went toward the foyer, descended the stairway, and looked through the open doors to the north ballroom where he saw smoke and flames coming from the south ballroom. The manager went back up the stairs and attempted to telephone the fire department from the bell captain’s station, but the telephone was not operating.

The manager then turned and started back toward the stairway, noticing that the smoke conditions had developed significantly. During this short time, he said, the smoke had changed from the light haze he described earlier to being very thick and black. The manager also described the smoke as appearing to be “rolling.” As it reached the top of the stairway, the smoke went through the opening in the partition and into the landing area and the main lobby, he added. At the top of the stairway, he turned toward the spiral stairway and saw the main lobby filling with thick black rolling smoke.

The manager then went to the office area behind the registration desk to instruct employees to leave as quickly as possible, and then returned to the lobby. He described the smoke then as extending halfway down from the ceiling. He saw guests in the lobby and those coming from the west door of the casino trying to get to the exterior spiral stairway. The manager moved along with the guests toward the spiral stairway where, he said, the smoke was “moving very quickly behind us.” Other guests told of seeing portions of the smoke igniting “like fireworks” at this time. Once at the top of the spiral stairway, the manager found “a really terrible commotion—people pushing and trying to crawl over each other....” Soon after the manager got to the bottom of the stairway, he stated, “all the windows of the casino started blowing out....” It was also at about this time that the manager heard a rather loud “boom or explosion” within the building.

An employee within the casino—a cashier—heard an “explosion” at approximately 3:20 p.m. in the area of the ballroom. He looked up and saw fire venting from the ballroom/foyer to the outside. The cashier made this observation through one of the window openings that adjoined the casino and foyer areas. He and co-workers tried to secure the money at the cashier’s booth, then attempted to exit through the main casino doors, but could not due to the smoke and fire in the hotel lobby area. The cashier then heard another explosion that he described as being within the casino (northeast corner), stating that “black smoke and flames began to pour out of the corner. People in the casino then began screaming and breaking windows.”

The cashier and four other casino employees escaped from the area by using a spiral stairway from the dealers’ lounge area to the third floor service elevator area. These employees then took the service elevator, along with many others already inside, to the basement where they exited the building.

Most witnesses interviewed by local and Federal law enforcement officials corroborate these discovery scenarios. Witnesses, at various locations throughout the casino and ballroom levels, began to detect the fire within the building between 3:20 and 3:30 p.m. Their discovery largely depended on their location within the building. Those positioned close to the area of origin observed “flames” within the south ballroom; those in adjacent areas generally described smoke in the ballroom area. People who saw the fire described it as extending above the stored furniture. They also told of a series of explosions with heat and smoke traveling through the casino/lobby level very quickly, and then flames extending from the opening to the spiral stairway and out of the casino’s exterior window openings. The majority of the people interviewed described the movement of the fire as “very fast,” “very quick,” or as extending from the casino “within minutes” of discovery.

The hundreds of people located in the high-rise tower were not aware of the developing fire. Some of the guests interviewed were telephoned from the lobby by relatives, but there was little time for any extensive effort to telephone others. In addition, since the fire alarm for the high-rise tower was not working, most of the guests became aware of the fire by seeing or smelling products of combustion coming into their rooms, by word of mouth, or by hearing noises associated with fire depart-

1 Investigators believe that these sounds were associated with the rapid growth and spread of the fire and the breakage of glass partitions as the fire spread through the building. In addition, investigators found several ruptured pressure vessels ruptured that also could have resulted in similar sounds.
ment response. Once aware of the fire, the high-rise occupants especially on the lower floor levels discovered that severe amounts of smoke prevented them from escaping through the interior of the building. As a result, many moved to the exterior balcony area of their guest rooms and awaited rescue.

**Casino Occupant Notification/Awareness/Reaction**

**Best Estimates Indicate** that approximately 150 people were in the casino at the time of the fire. Due to the New Year’s holiday, the casino was scheduled to close at 6:00 p.m. December 31, so a higher-than-normal number of players were in the casino on the afternoon of the fire. Partially because of the casino’s semi-isolated position within the complex, its occupants became aware of the fire by several means and not all were made aware at the same time. As a result, people in the casino began to move at different times based on different cues. Hearing of the fire from others, seeing smoke on the exterior of the building, and then observing smoke inside the casino were the observations most often described to investigators. Apparently, the first verbal warning of the fire and even the smoke being observed on the exterior of the building did not produce a unified evacuation movement. A few people did, however, begin to exit based on these cues. Investigators recorded several eyewitness accounts regarding the deteriorating events in the casino.

A security officer, located at the main entrance to the casino, noticed smoke in the area of the ballroom and notified his supervisor. The security officer described how several people then attempted to enter the casino from the main lobby which was beginning to fill with smoke.

Other witnesses described similar actions occurring at the west door of the casino. Apparently because of the smoke conditions in the main lobby, these occupants sought refuge in the casino because at the time it was free of smoke.

The security officer stated that smoke soon began to penetrate the casino and that he also noticed smoke coming from the air conditioning ducts. The officer observed that smoke conditions increased very quickly and then “a window located on the casino’s east wall adjacent to the casino’s main entrance exploded.” As the security officer moved from the east corridor, he notified occupants in remote locations of the casino (e.g., the employees’ room) of the fire and told them to get out. The security officer then moved to the west corridor where he was met by “numerous people” heading in the opposite direction. The officer described smoke and heat conditions as worsening very rapidly. As a result, he picked up a chair and broke one of the casino’s exterior windows along its north side and then jumped to safety. Apparently, another casino employee was able to jump from the same window opening moments after the security guard. No one else is believed to have jumped from this side of the building.

Another witness stated that at approximately 3:30 p.m. he was positioned at the blackjack table at the west end of the casino when he heard a loud “explosion.” He looked in the direction of the ballroom, through the glass partition within the east wall, and observed “white smoke” on the exterior of the building. The gambler continued to play blackjack and moments later began to observe light black smoke coming from the casino’s “air conditioning vents.” Shortly thereafter, a woman entered the west door of the casino and began yelling “Fire! Fire!” The gambler stopped playing, collected his money, and began to walk toward the west exit door of the casino. From this position he could see fire in the lobby area. The gambler then tried to break one of the glass partitions along the casino’s west wall. After some difficulty, he broke the window. Just as he was about to jump, he turned to see a flame front moving toward him from the east, and a friend “ignite from the waist up.” Also shortly before he jumped, he “could see the ceiling tiles turning black, and moving toward me.”

Another patron said he entered the casino during the midafternoon through the west door which was in the open position. After watching gambling activities for a while, he took a position at a blackjack table. This was along the west corridor of the casino, from which he could view the west exit door and the glass partitions in the east wall. He had been gambling for a period of time when he overheard a conversation “about there being
smoke.” The patron turned and observed black smoke through the glass partition. He told investigators that the smoke was “on the outside first” and that “at first no one said anything, but after a little while someone said to get your chips and get out.” This patron, along with a group of about 20 others, started to move toward the west exit door. As he got to the door, he saw that it was closed and that “someone was standing there saying they were not letting anyone out the door.” The patron turned back and saw heavy black smoke “coming out of the air conditioning vent that was above the table where I had been playing.” He also described the smoke as “billowing into the casino” from the east end. When this occurred, the patron picked up a metal chair and threw it through an exterior window on the west side of the casino. He said that he broke the window at first in order to vent the smoke, but after he broke it “the smoke was getting much more intense and it was now below my head level.”

The patron then pulled his shirt over his head and got down on the floor. The patron then began to feel heat and stated that he could no longer see. Next people “started climbing over me and there was a lot of panic.” The patron then saw daylight, moved toward it, and apparently jumped from the building although he later said that he did not remember doing so. This patron broke an ankle and cut his hands during the jumping process. This type of injury, along with associated burns to his hands and head, were typical injuries of survivors from the casino.

In addition to these individual descriptions, investigators were able to assemble some general descriptions of movements in the casino based on other survivors’ accounts. Once the majority of people began to evacuate the casino, the occupants apparently divided into two groups. One of the occupants, moving toward the west exit, saw “smoke and flame” coming from the area of the exit door. This person then began to move toward the other exit but was met by the second group returning from the main exit which apparently was blocked by smoke.

The groups merged at the west side of the casino in their attempt to exit the building. Apparently the west exit door became closed at about this time. Investigators were unable to determine if the door was closed to prevent smoke infiltration or if it were closed as a security measure. A secondary “explosion” was then heard in the northwest corner of the casino above the occupants’ heads. This is the point where occupant descriptions of the conditions align. One patron observed the ceiling turning black, and others told of seeing a ceiling-level flame front moving toward them. At this time, occupants who were not preparing to jump or in the process of jumping were overrun by the flame front and were killed.

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**High-Rise Tower**

**Occupant Awareness/Reaction**

Awareness of a severe fire on the lower levels of the complex came slowly and by various means to the hundreds of guests in the high-rise tower at the time of the fire. Included in the methods of awareness were observation of products of combustion; hearing screams, cries, etc. from other guests; and noticing fire suppression, rescue, police, and other response vehicles.

Once the guests were made aware of the fire, their location within the high-rise tower was the most significant factor affecting their safety. Generally, guests located on lower levels (guest room floors 3 through 10) were more severely exposed to the products of combustion and faced more danger than did guests on upper levels. In addition, those lower-level guests whose rooms were located on the west side of the building not only were confronted with smoke penetrating their rooms from a number of internal sources (see Smoke Movement section), but also faced a smoke front entering from the exterior of the building. Once the fire penetrated the exterior of the casino/lobby level and vented from the roof cover over the poolside bar, the intense thermal column drove the combustion products back into the high-rise tower. Balconies that extended from the face of the building may have served to disrupt the thermal column, and favorable winds may have partially affected rooms located on the perimeter. However, severe heat exposure was detectable on several of the lower guest room floors, and smoke staining to the

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2 *This gentleman was 6 feet 4 inches tall.*
The Fire Incident

The exterior of the building was noted on the majority of the west side floors. It is probable that guests on this side could not or did not migrate to their exterior balconies at least not until the main body of the fire was extinguished.

Exterior migration of the smoke may have been to other sides of the high-rise tower as well. This was especially noticeable at times (depending on venting, fire extension, and suppression activities) on the east side of the building. However, the location and proximity of the venting fire and favorable wind conditions helped to keep exterior balcony conditions tenable at most times on most floor sides and levels.

Those lower-level guests forced from their rooms by severe smoke conditions did not find improved conditions within the exit access corridor. Placing towels over their faces, many of these occupants attempted to move to the interior stairways or to a location more favorable than their rooms. Some found their way to stairway C where conditions were quite favorable for evacuation (up or down). Guests who located stairway B had to look for an alternate safe refuge area, since stairway B was charged with heat and smoke.

Once on balconies, it appears that the glass partitions separating adjoining guest room balconies were broken by guests. This enabled people to form clusters to devise strategies for survival. Apparently these strategies were influenced by a group's location, knowledge of fire survival techniques, and rescuers including the helicopters hovering at the roof level. Many trapped occupants devised unique means for moving away from smoke-filled areas to safety. Some scaled the exterior of the building, others used fire department roof ladders, and others climbed down the decorative wooden lattice work on exterior balconies.

During the hours when guests were trapped, many moved together to the roof area (both assisted and unassisted by rescuers). Using the interior stairways (mainly stairway C), occupants gained access to the roof-top restaurant. Guests began to congregate in the restaurant area where they started breaking exterior glass partitions as smoke migrated to this level as well. From this point, they gained access to the outer 20-foot exterior projection of the building that contained mostly flowering plants. From this position, guests then broke the wooden lattice work that projected from the building's next higher floor level, approximately 10 feet above their heads, and climbed to the roof.

Guests established a human chain to facilitate the smooth flow of people to the topmost roof, where they would wait for helicopter removal. Once on the roof, the assembled guests were organized and led to the helicopters in a very orderly manner. Leaders who emerged from the group were joined by rescue personnel to achieve the smooth, dramatic roof-top evacuation.

Despite some severe smoke conditions, some guests within stairway B moved onto the restaurant level or further ascended through the top mezzanine levels which had access to the roof. These guests managed to climb up the metal ladder, break the lock on the latch, and gain access to the highest roof level. Once on the roof, apparently they climbed down the exterior wall (using the building's exterior sign) to the roof level where other guests were being assembled. The groups merged at this location and awaited removal by helicopter.

The roof-top evacuation began when an alert private helicopter pilot became aware of the severe fire. He undertook the dramatic removals at great personal risk, considering clearances and exterior conditions. He was soon joined by helicopters from the Puerto Rican Police, U. S. Coast Guard, U. S. Navy and the National Guard. Numerous return trips, removing approximately 200 occupants, continued for the next five hours. These efforts were coordinated by the Coast Guard to ensure safety.

Fire Service Response

The fire department received telephone notification of the incident from an employee of the hotel and responded to the first alarm at 3:40 p.m. This was about 10 minutes after the time most witnesses placed the discovery of the fire. The first alarm assignment responded from a fire station several miles away; the closest company's response time was estimated to be within five minutes. Upon their arrival on the south side of the building, as fire fighters described it, smoke and flames were coming from the main entrance arcade and thick black smoke could be seen coming from the bedroom area. Immediately, fire fighters faced the problem of
numerous guests on exterior balconies signaling for help. Furthermore, fire fighters were confronted with severely injured people being brought on lounge chairs to the circular driveway area from the pool side of the building. Carried by guests, employees, and other civilians, these victims had sustained injuries jumping from the casino and/or were burned during their escape.

A CALL FOR ALL AVAILABLE AMBULANCES was made, and rescue vehicles soon began to arrive at the Dupont complex. As the call for assistance rang out from the fire scene, fire service, police, ambulance, civil defense, and other emergency response equipment became stopped in the congestion that soon built up in the area. The narrow one-way road and circular driveway, coupled with numbers of curious onlookers, mobile TV units, and other media representatives, resulted in severe access problems for responding emergency vehicles including ambulances transporting the injured to hospitals.

Emergency medical personnel from a nearby hospital were dispatched to the scene when the civil defense emergency plan was activated. These personnel assisted medical technicians in establishing a triage area for the injured.

During the initial minutes of the emergency, fire fighters reported that some trapped guests were threatening to jump from the building. Fire fighters and other rescue personnel using broadcast devices persuaded these occupants to stay at their locations and await rescue and/or move to the roof for emergency removal by helicopter.

Meanwhile, fire fighters advanced one of the first hand lines into the building through the main entrance arcade. Fire fighters estimated that the 1 1/2-inch line was advanced after approximately 12 minutes of preparatory work, including donning of self-contained breathing apparatus by some of the crew. This hand line was advanced approximately 50 feet inside the arcade until smoke and heat forced the fire fighters to abandon their position. The situation was difficult even though the majority of the fire was not venting from this side of the hotel.

Other fire fighters were joined at this point by police officers (both on and off-duty), civil defense personnel, and civilians. As ground and aerial ladders were raised to the lower-level roof areas of the complex, one of the first responding officers went to the west side of the building where he observed an "enormous flame front" venting from the casino level. He described the flames as leaping out the front of the roof that covered the poolside bar and extending up several floor levels. The officer described thick black smoke that obscured this entire side of the high-rise tower. Observing additional severely injured guests, the officer called for a 2 1/2-inch line to be brought to the pool side. After it was advanced, he recruited a former fire fighter whom he recognized and assembled a civilian crew to apply water to the fire through the exterior window openings. The officer then assessed conditions on the north side of the building where he observed fire venting from the casino and from the exterior partition to the foyer area. Once again a call was made to advance hose lines to the north side of the building.

Access to the north and west sides of the complex was poor. Fire fighters carried large-diameter hose lines from the front of the building to these positions where water was applied from the exterior. While the extinguishment attempts and care of the injured were taking place, fire fighters were joined by numerous other rescue personnel who gained access to the high-rise building in several ways and began to assist trapped guests.

Many of those lower level guests who took refuge on their exterior balconies eventually were assisted by rescuers who had gained access to the tower from the exterior or from the basement levels using stairway C. Using ground ladders and ropes, rescuers lowered some guests to lower roofs where they were taken to the ground by other rescue personnel over ground and aerial ladders.

AS RESCUE WORKERS BECAME FAMILIAR with the internal smoke conditions, they were able to conduct internal rescue efforts more effectively. They directed guests to stairway C because it was fairly clear of smoke. However, due to darkened interior conditions, doors to stairway C were propped open, allowing some smoke as well as light to migrate into the stairway. Rescue personnel also worked from stairway B even though it was charged with products of combustion. Conditions on upper floors were more favorable, but still quite severe. On these upper levels, rescuers strung rescue ropes along the interior leading to higher levels and the roof area in
The Fire Incident

order to assist guests moving in the relative darkness.

As the fire began to come under control, fire fighters located several fatalities on the west side exterior of the building in the area of the poolside bar, and one fatality at one of the casino's glass partitions, the latter victim was located at an opening used by others to escape; however, this victim was overrun by the fire before she could jump to safety.

As the fire was knocked down from the exterior and fire fighters began to extend hose lines to the interior casino area, additional fatalities were discovered. Fire fighters then began to realize the magnitude of the incident.

The main body of the fire on the casino/lobby level was knocked down by fire fighters, or the fuel was consumed, within the first several hours of the emergency. Final extinguishment of the pocketed fires in the discotheque and other remote areas continued into the early evening. The rescue operation continued as well until officials were sure that all trapped occupants had been removed. Rescue workers apparently entered every guest room, using forcible entry tools in most cases, to search for trapped or unconscious guests.

The enormity of the fire upon the fire department's arrival and the vast extent of the rescue effort completely outstripped the department's ability to alter the outcome of the fire or the amount of property damage. This is not an unusual circumstance in large, undivided, nonsprinklered, poorly protected buildings—especially when fire fighters are summoned for help after room flashover has occurred, as in this case.

Casualties

The fire at the Dupont Plaza Hotel resulted in 97 fatalities, including 17 employees, and more than 140 injuries. Eighty-four of the 97 fatalities were located in the casino; the majority were located in its west corridor (see Figure 8). Five fatalities occurred in the lobby area, three were found in a passenger elevator stopped between the basement and first floor level, one fatality was in a guest room on the west side of the fourth floor, and two victims were found on the exterior of the building at the poolside bar. One of the hospitalized victims died within one week of the fire; another died a month later.

Even though a majority of fatalities were located beyond the room of origin, their cause of death apparently was not associated with elevated levels of toxic gases but was from trauma associated with thermal burns. Further, in spite of significant amounts of smoke that spread throughout the complex, only a few fatalities can be directly linked to the effects of smoke. Finally, the fire killed over 50 percent of all occupants in the casino at the time of the fire.

Because so many victims were found in the area of the casino's west exit door, initial concern of investigators was directed toward reports that the casino's west door was "locked." Based on examination of evidence and witnesses' accounts, the door was found in the closed position. However, from descriptions of the extent of fire in the lobby area during evacuation from the casino, it is believed that the door may have been closed by an occupant in order to protect the remaining occupants from products of combustion moving into the casino; or it may have been closed during the fire as a casino security measure. But like the five occupants trapped in the lobby, the 84 victims in the casino were caught by the violent extension of the fire through the casino/lobby level.

It is not known if the three victims found in one of the passenger elevators were attempting to evacuate an upper level or if they unfortunately were using the elevator when the fire moved through the lobby. Based on the position in which she was found, the one fatality discovered in room 404 of the high-rise tower may have been asleep as the massive amount of smoke moved to her guest room on the building's west side. The two victims located at the poolside bar were unable to move away from the fire venting and extending over their heads from the west side casino level and were killed.

3 During the NFPA study, death certificates were examined; however, detailed autopsy reports were not readily available.
The Fire Incident

Damage

Initial property damage estimates are between 6 and 8 million dollars. It has not been determined if the complex will be rebuilt. All combustible contents of the south ballroom were consumed except for some of the stored furniture that was partially protected by other stored items in the large pile. Even these remaining combustibles were heavily damaged by fire, and the pile was reduced to approximately one half of its original height. The ceiling tiles for the south ballroom were totally consumed near the fuel package and for a distance of approximately 40 feet beyond, leaving the exposed metal ceiling grid system. Severe structural damage occurred to the unprotected bar joists and steel support beams adjacent to the area of fire origin. Some limited structural damage also affected a support beam for the balcony area. There was beam deflection in this area where fire vented through the opening in the partition and impinged onto the balcony. The oak floor of the south ballroom was totally consumed for approximately 10 feet from the outer edge of the fuel package. There was partial consumption of the floor beyond this area as well, but less extensively. There was little evidence or remains of the combustible removable partition, even beyond the point of origin. This probably means that the partition was consumed in its functional position. If this were not true, and considering the uniformity and amount of damage sustained by the ceiling tiles and flooring close to the fuel package wall, investigators would have expected to locate more remains of the partition.

The north ballroom, with the exception of the balcony area and space immediately adjacent to the area of fire origin, sustained little heat damage. In fact, none of the light-weight carpet-type material applied to walls was consumed even at the ceiling level. Further, although the glass partitions over the east side exit doors were intact, they showed signs of some heat and severe smoke staining. The approximately 200 metal frame chairs arranged for the union meeting were not damaged by the fire but showed evidence of soot deposits.

On the balcony level, and especially in that portion of the "L"-shaped balcony that was above the south ballroom, the stored combustible materials (chairs etc.) were totally consumed. Further, there was evidence that this area reached flashover conditions and spread products of combustion into the foyer, north ballroom, the adjacent balcony area, the upper function room, and the rear portion of the discotheque. These latter two areas showed signs of near-total consumption of all combustibles; they were the areas that burned for hours after the initial alarm. In addition, the service areas for the discotheque sustained structural collapse, as did parts of the main discotheque and, especially, those areas elevated from the main floor level. The combustibles on the main floor area were not totally consumed but did sustain some fire damage.

The foyer area immediately adjacent to the north and south ballrooms contained few combustibles except for the wooden structural materials and wood decking for the roof cover. These wooden members showed signs of severe burning; however, there was no structural collapse. Several portions of the roof immediately above the vertical plane defined by the edge of the balcony area were burned through, however.

The top landing of the foyer area at the casino/lobby level also was severely damaged by fire, as were those portions of the entryways to the discotheque. The suspended ceiling system in this area was damaged and failed. The ornate wooden decorative panel at the rear of the landing area also sustained extensive damage.

Combustibles in the lobby area were almost totally consumed, along with combustibles within the casino. Because of minor extensions of the fire into adjacent corridors around the lobby, these areas were subjected to some fire damage; however, most of the damage to the retail shops and the two restaurants beyond the immediate area of the lobby was due to smoke.

The fire also was able to damage portions of the building's exterior, especially beyond its west side where the poolside bar and dance floor were located. Once the fire vented out the openings, the west side of the building at the casino level radiated to the combustibles below. The fire eventually consumed the outside wood members that spanned the concrete pillars supporting the roof members.

Although severe heat was able to penetrate the first 10 floors of the high-rise tower especially as transported to the upper floors via stairway B there was no fire
extension into the tower. All levels of the tower did show some evidence of smoke damage. The lower 12 floors were most severely damaged, with the upper floors showing moderate smoke damage. Floors 14 through 17 appeared to suffer the least smoke damage.

### TIME LINE

<table>
<thead>
<tr>
<th>Time (p.m.)*</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:22 - 3:25</td>
<td>Employee discovers a free-burning fire involving stored furniture in south ballroom. No significant heat felt. Employee looks for fire hose. Another employee joins extinguishment attempt. During a meeting in the kitchen, “Fire in the ballroom!” is heard. Fire is observed approximately 5 feet from the floor, involving stored furniture. Employee opens exit doors to north ballroom.</td>
</tr>
<tr>
<td>3:25 - 3:28</td>
<td>Employees advancing hose line return, noting significant amounts of heat and smoke. They abandon extinguishment attempt. Light smoke is detected in ballroom foyer area, moving onto the casino/lobby level.</td>
</tr>
<tr>
<td>3:28 - 3:30</td>
<td>Initial cues of a fire within the building are seen or are heard by casino occupants.</td>
</tr>
<tr>
<td>3:32</td>
<td>Fire conditions within the south ballroom result in flashover, breaking glass partition that connects to a foyer and the casino level.</td>
</tr>
<tr>
<td>3:33</td>
<td>“White” smoke is first observed outside casino, followed shortly by black smoke within casino. Fire builds in the foyer area and continues to spread to the lobby.</td>
</tr>
<tr>
<td>3:35</td>
<td>Exiting through west door of casino ends; west door is closed. Some casino occupants break window wall panels and jump to safety.</td>
</tr>
<tr>
<td>3:36</td>
<td>Flame front moves through casino and vents through window openings; exiting from casino ends.</td>
</tr>
<tr>
<td>3:40</td>
<td>Fire Department receives notification of fire at the Dupont Plaza Hotel.</td>
</tr>
<tr>
<td>3:40 - 3:45</td>
<td>Most victims’ watches found stopped ceased to operate during this interval.</td>
</tr>
<tr>
<td>3:45</td>
<td>Fire Department arrives at hotel, observes “full involvement” of casino level.</td>
</tr>
<tr>
<td>4:00</td>
<td>Helicopter removal begins.</td>
</tr>
<tr>
<td>7:30</td>
<td>Fire extinguished.</td>
</tr>
<tr>
<td>8:00 - 8:30</td>
<td>Fire search, evacuation, and rescue actions completed.</td>
</tr>
</tbody>
</table>

*All times are estimates based on best eyewitness statements.*
III ANALYSIS

Fire Cause and Origin

Local police authorities, assisted by agents from the Bureau of Alcohol, Tobacco and Firearms, determined that the fire at the Dupont Plaza Hotel was deliberately set and originally involved the stored guest room furniture in the south ballroom. The authorities reported that the ignition scenario involved a single can of "Sterno-type" material placed on the stacked cardboard packing crates containing the replacement furniture. This open-flame initial fuel source was positioned at midpoint on the stored material by a person reaching through the opening created by a missing panel in the partition separating the north and south ballrooms. It was reported that the panel had not been placed in position because the furniture partially extended into the north ballroom. The fire scenario was initiated by an off-duty employee soon after the end of the union meeting in the north ballroom. This employee was provided with the initial source of fuel by a second employee, and his actions were shielded by still another employee.

Soon after completion of the on-site investigation, all three individuals were charged with arson and murder. They pleaded guilty in a Federal district court to charges of arson, conspiracy, and assault of a Federal officer, and received sentences between 75 and 99 years.

Each also faces 97 counts of murder in Puerto Rican local court.

Fire Growth and Development

Investigators estimate that the employee placed the burning can of "Sterno-type" material on the stack (at midpoint) of furniture at approximately 3:15 p.m. The material was placed in the stack adjacent to the ends of several crates.

The initial burning fuel resulted in ignition of the combustible packaging materials used to protect the stored furniture during shipment. Among the combustible packing materials identified were wood, cardboard, and foam plastics. At the time of initial discovery (approximately 3:22 p.m.), packaging materials adjacent to and above the initial fuel source were likely the only materials involved. Flames were seen extending above the height of the fuel package and smoke was accumulating at the ceiling level.

The arrangement and position of the initial developing fire in relation to the combustible wall surfaces and the finished ceiling resulted in the rapid growth and extension of fire to adjacent areas of the stored furniture, to the combustible wall finish, and to the combustible removable partition. Although the 18 by 30 by 6-foot-high fuel package was tightly stacked during the burning process, small channels that contributed to the burning rate would have formed between the stacked items as the stack began to burn. As the fire grew and spread in this manner, the furniture items began to be more substantially involved. These items included dressers and night stands, constructed mostly of wood and particle board, and upholstered sofa beds containing urethane foam mattresses.

The growth process to this point occurred within the estimated three to four minutes that it took employees to advance a handline from an adjacent stairway to service doors to the south ballroom. They described the fire as growing during this time from flames reaching above the stored furniture (initial discovery description) to smoke and flames completely filling the south ballroom. The fuel package in the south ballroom most likely resembled test fuel arrays that reach a heat release rate of 1000 Btu in 100 seconds after established burning. These

4 A U.S. Secret Service Officer was one of the 97 fire victims.
eyewitness accounts seem to corroborate this “fast” fire development.

There were a sufficient number of openings for combustion air to continue this early growth process. Included were the open 36-inch door along the south wall; the 4-foot opening in the removable partition; and leakage points including but not limited to areas around and between sections of the removable partition.

Soon after discovery, the fire not only was building as described within the room of origin, but flames also were seen extending through the opening in the partition into the north ballroom. As a result, products of combustion began to accumulate along the high ceiling of the north ballroom and extend to the balcony area by way of the adjacent open stairway within the north ballroom. This mechanism would eventually lead to ignition of the stored combustibles on the balcony.

At this point in the discovery sequence, in order to clear the accumulating smoke an employee opened the three sets of exit doors to the north ballroom. These openings plus the 10-foot opening in the east wall of the north ballroom created additional inlets for combustion air. Further, the exterior wind velocities and direction at the time of the fire would have provided an additional volume of combustion air to continue the rapid growth of the fire in the south ballroom and its spread to adjacent areas.

Even with these additional openings, at this point in the progression of the fire the openings to the south ballroom, previously noted, were limiting the amount of combustion air to the developing fire. Initial fire growth modeling work conducted by NBS/CFR indicates that several panel openings were necessary for the south ballroom to reach flashover. Eyewitness accounts indicate that the tops of several panels were burning early in the discovery period.

The behavior of the panels under burning conditions is not known, nor is it known how long the panels would have stayed in place. What is known is that only a few fragments of the panels remained unburned. This would tend to indicate that the panels burned in place, and that as they were consumed, more and more ventilation openings were provided.

This growth and extension process continued for an estimated 10 minutes after initial discovery until flashover conditions were reached in the south ballroom. The first “explosion” heard by witnesses was most likely associated with flashover and failure of the glass partition that adjoined the south ballroom and foyer.

Flashover of the south ballroom sent an abundant amount of super-heated products of combustion into the foyer where they began to accumulate at the ceiling level, ignite the combustible roof, extend into the main lobby, and move toward the spiral stairway. Thick, black smoke was seen building in the foyer and moving through the lobby, igniting as it moved toward the spiral stairway. Its ignition would indicate that the smoke contained super-heated, fuel-rich gases that ignited as they mixed with air.

The super-heated products of combustion accumulated in the foyer for only several minutes before the glass partitions at the lobby/casino level failed, sending a smoke front, soon followed by a flame front, through the lobby and casino. Untenable conditions were reached in these areas in approximately one minute after the partition failure. The flame front then violently vented from the west side of the building on the casino level.

The super-heated, fuel-rich smoke that penetrated the casino and lobby needed only air to combust. This is important, since it indicates that it is likely that none of the fuels in the casino or lobby were needed to contribute to the burning process in order for untenable conditions to be reached.

Preliminary computer fire growth modeling work of the NBS/CFR indicates that the fire took about 13 minutes from established burning until flames extended from the windows of the casino. Analysis of the witness accounts corroborate this estimate.


6 The fire modeling work used various programs, some modified to meet existing conditions or eyewitness statements. For further discussion, see NBSIR 87-3560, “An Engineering Analysis of the Early Stages of Fire Development The Fire at the Dupont Plaza Hotel and Casino December 31, 1986,” written by Harold E. Nelson, Center for Fire Research, National Bureau of Standards.

7 Ibid.
Analysis

Smoke Movement

The smoke spread mechanisms at the Dupont Plaza complex were similar to those in other large-loss-of-life hotel fires, which warrant close examination of smoke movement potential by fire and building officials with similarly arranged and constructed buildings. In spite of significant amounts of smoke that spread throughout the building and the high-rise tower, only a few fatalities can be linked directly to the effects of smoke. Nonetheless, the potential for a much greater number of fatalities existed; only a few fortunate circumstances, such as time of day and the balcony arrangement, prevented further deaths.

Study of smoke movement through the Dupont complex is divided into two categories. The first category evaluates the products of combustion initially released from the ballroom level, which directly affected occupants on the casino level (see Fire Growth section for additional details). The second category evaluates smoke which moved throughout the high-rise hotel and roof-top restaurant.

Smoke Movement to the Ballroom and Casino Levels

Before flashover, smoke was accumulating in the south ballroom and spread to adjacent areas through openings. The most significant spread was toward the north ballroom and balcony through the opening in the partition. Smoke would have accumulated along the ceiling of the north ballroom and would have moved through the open main entrance doors and into the foyer. Although the smoke would have cooled during this process, it still contained enough buoyancy to move from the foyer toward the main lobby. The movement toward the main lobby was also influenced by prevailing wind currents within the building. This initial smoke, light in color, was seen by occupants on the ballroom level and in the main lobby area. It resulted in people investigating its source, notifying others, and evacuating. None of the witnesses interviewed felt that the smoke was, at this point, life threatening.

The failure of glass partitions to the south ballroom sent significant amounts of black, fuel-rich, superheated smoke to the foyer. These gaseous fuels accumulated in the foyer ceiling area, some spreading to the lobby through the opening at the top of the stairway. Once the smoke was in the lobby, common HVAC ducts would likely have distributed it to the interior of the casino where occupants first saw smoke coming from distribution grilles. This would have been the first signs of products of combustion penetrating the interior of the casino.

Within a few minutes, witnesses who had been in the lobby described it, rolling black smoke quickly began moving toward them and the spiral stairway. This wave of smoke was much hotter, and flashes of fire were seen in the smoke front above evacuating occupants’ heads. With these conditions occurring in the lobby, some people actually sought refuge in the casino which at this point was more tenable than the lobby. It is likely that at this point the west door to the casino was closed.

The buildup of combustion products in the foyer area existed for only several minutes before the upper portions of the glass partitions along the entire perimeter of the foyer failed. The failure resulted in a massive smoke front moving through the foyer and into the casino. It was estimated that the smoke front moved through these areas in less than a minute.

Smoke Movement to the Tower

Smoke temperature and buoyancy, the stack effect, and the role played by vertical openings to the high-rise tower influenced smoke movement there. Further, the opening of doors to exterior balconies and the predominant movement of wind from east to west complicated smoke movement and likely resulted in smoke reentering the tower.

The stack effect is characterized by a strong draft from the ground floor to the roof of a tall building. The magnitude of this effect is a function of the building height, the air-tightness of exterior walls, air leakage between floors, and the temperature difference between the inside and the outside of the building.

The stack effect accounts for most of the natural air movement in buildings under normal conditions. During a fire, the stack effect often is responsible for the wide distribution of smoke and toxic gases in a high-rise building.
As previously described, the open-air architecture commonly found in tropical climates allowed for a relatively unobstructed path for air movement. The difference in temperatures between the interior and exterior of the complex was estimated to be 7°F, with the higher temperature occurring outside the building. Climatic conditions noted on the day of the fire showed an outside temperature of 82°F. The inside building temperature, achieved by means of artificial cooling, was estimated to be 75°F.

Under normal circumstances, this particular set of conditions would result in a reverse stack effect, with the predominant air movement being from top to bottom. Although all openings would be influenced by the stack effect, the path of air travel was most affected by the passenger and service elevator shafts and the open door to stairway B. As the fire developed into more advanced stages, the higher temperatures of the smoke layer influenced the stack effect. The buoyancy force of the heated air eventually would overcome normal air movements to the tower.

Several mechanisms enabled smoke and heat to penetrate the high-rise tower, although not all of these mechanisms were significant for all the guest room floors and the roof-top restaurant. The mechanisms were passenger and service elevator shafts, utility shaft penetrations, stairways (especially stairway B), the building’s HVAC systems for providing conditioned air to guest room corridors, individual guest room HVAC systems, and the exterior of the building. In addition, an area’s proximity to the casino was a factor. There were distinct differences in the amount of smoke that penetrated guest room floors 3 through 10 and that which penetrated guest room floors 11 through 20.

Because the door to stairway B was open throughout the fire, significant amounts of smoke and heat were able to penetrate the guest room floor landings on floors 3 through 10. Heat damage was detected in the stairway up to and including the 10th floor where the plastic nozzle for the standpipe hose had melted. It is believed that this stairway was completely untenable from at least the 10th floor down; quite possibly the entire stairway was untenable throughout the initial portion of the fire incident. Since this stairway was part of the scissor arrangement for the high-rise tower, smoke and heat were able to penetrate the guest room floors alternately on the east and west corridors. This occurred due to stairway doors being opened and from leakage around the doors.

Although the performance of stairway C was much better than that of stairway B, smoke did infiltrate stairway C on several guest room floors. It is felt that guests and/or rescuers opening the stairway doors—especially on those floors that were smoke-filled—allowed some smoke to enter this stairway. Stairway C lacked emergency illumination to help guide occupants down the steps and out of the building. As a result, doors may have been propped open by guests and rescuers to help illuminate and to clear smoke from within the stairway. Even with these conditions and perhaps guided by the handrails, it is felt that evacuating occupants found stairway C tenable throughout the fire incident. In fact, it was used by some occupants to exit the building through the basement, and by others to gain access to the roof-top restaurant and then the roof area where helicopter removal was taking place.

Both stairways for the high-rise tower were designed to discharge into the unsprinklered, unprotected lobby and then to the exterior of the building. Due to the raging fire at the casino level, neither stairway could be utilized for exiting as designed. Lacking adequate protection at the casino level, stairway B was charged with smoke, especially on the lower 12 floors. Because the super-heated smoke began to cool after it reached the 10th floor and above, the stairway was used by some people moving to the roof area. These people were able to travel through smoke by breathing through towels, by being guided by rescue ropes, and by being assisted by rescuers.

Smoke from the casino-level fire penetrated the voids in the center core of the building and was able to gain access to the lower-level HVAC equipment located in the core area. These systems were determined to have had enough voids so that the smoke and heat easily could have penetrated the vertical run of the supply duct to the first 8 floors of the high-rise tower. Smoke moved vertically through the ducts and was distributed onto guest room floors through supply grilles located over stairway doors. As a result, smoke entered the exit access corridor for guest room floors 3 through 10 by this means.

Due to the voids and their proximity to the casino,
the HVAC system that served guest room floors 3 through 10 was much more of a factor than the roof-mounted HVAC units; however, smoke was likely circulated through the open conduits of the upper-level HVAC systems as well.

Smoke and heat also penetrated passenger and service elevator shafts at the casino level. These shafts were responsible for distribution of heat and smoke to the upper levels of the building. Smoke also was able to penetrate the service elevator shaft from an emergency hatch used for escape from the building by several casino employees. This shaft opening was into the third floor, allowing heat and smoke to penetrate the third floor service elevator lobby area. Once in the third floor service area, products of combustion were able to enter the service elevator shaft and penetrate the third floor area by way of the louvered door that provided access to the corridor.

As smoke within the service elevator shaft reached the top, it began to fill the shaft and to migrate onto guest room floors through the voids around the elevator doors. The migration was most severe on the uppermost levels—the 20th floor and roof-top restaurant. Service elevators did not open directly into the exit access corridor for the guest rooms, but instead opened at each level into a utility area, containing trash and laundry chute, maid’s storage area, and storage room. However, smoke was able to gain access to the corridor by penetrating the louvered door separating the corridor from the service elevator area. On the 20th floor only, a rug covered the inside of the louvered door, preventing much of the smoke from migrating from the service elevator area onto the guest floor. Heavy soot staining on the 20th floor service area was indicative of the amount of smoke migrating to the high-rise tower by means of the service elevator shaft.

The passenger elevator shaft also was directly exposed to products of combustion at the casino/lobby level. Although the amount of smoke distributed by this path to the upper portions of the high-rise tower was not as easily distinguishable as smoke that traveled up the service elevator shaft, both mechanisms would have been influenced equally by the stack effect for upper-level smoke distribution.

Once smoke penetrated an upper guest room floor and began to accumulate in the exit access corridor, it could be circulated into guest rooms by their individual HVAC systems. The smoke would enter the make-up grille, under a slightly negative pressure, from the exit access corridor. Then it would enter a plenum area containing the HVAC unit and be distributed into the room, entering by way of its distribution grille. Also contained in this same plenum area were the vertical penetration shafts for domestic water supply lines for guest rooms and for chilled water lines for the HVAC system. Venting for individual guest bathrooms also had access to this plenum area and resulted in smoke penetrating bathroom areas as well. None of the openings to the plenum were provided with fire dampers, nor was there any means by which the HVAC system could be shut down during a fire emergency. As a result, smoke could be circulated from the corridor to rooms and back to the corridor under certain conditions.

Smoke penetrating from the exterior of the building seemed to play a more dominant role on the lower floors than it did higher up. The ballroom and casino level fire vented violently from the west exterior wall of the casino and through the foyer’s exterior partition. The fire plume created by this venting severely stained the exterior of the building, and heat was able to crack windows of many lower-level guest rooms on the building’s west side.

Smoke entering from the exterior was most severe on guest room floors 3 through 10, although there was evidence of some staining and entry on several floors above as well. The fire vented less violently from the north-side windows of the casino. This side of the high-rise tower did not show the severity of exterior soot staining and smoke entry that the west side displayed. Only the first several floors of guest rooms could be identified as having soot staining. The moderate wind conditions, blowing from the northeast at the time of the fire, may have been responsible in part for this phenomenon.

The fire also vented from the stairway foyer area through the glass partition wall to the exterior. Significant amounts of smoke were seen blowing in the direction of the east side of the high-rise tower. As doors to guest room balconies were opened, they would serve as entry points for smoke. Although smoke did enter the side of the tower, the wind carried much of the smoke away from the east side.
There was little evidence of significant smoke staining or smoke entering the southern face of the building.

The most severe guest room floors for smoke penetration on the upper levels were the 19th and 20th. On these floors, there was evidence of smoke filling the vertical shafts and then penetrating guest rooms and the exit access corridor where the circulating medium once again was influential. Guest room floors 15 through 18 showed some evidence of smoke penetration. However, in comparison with other floors, 15 through 18 were only lightly subjected to smoke. Floors 11, 12, and 14 (no floor was numbered 13) were more heavily damaged by smoke for several reasons. The severe smoke on the lower floor levels may have migrated to these floors due to the stairway doors being propped open; once smoke entered the corridor it could have moved further up the building by way of HVAC ducts and have been circulated into guest rooms. Further, some cooling of the super-heated smoke may have moved it from the vertical shafts onto the corridor.

Individual guest room doors appeared to have been rather good barriers to prevent smoke spread from exit access corridors to guest rooms. Doors in the closed position nevertheless allowed some smoke passage around the frame. Several doors were under-cut by more than half an inch, which could have allowed entry of smoke. In addition to these variables, the amount of smoke passage into guest rooms around voids in this barrier—the doors—depended on the level and location of the room, external openings, exterior wind conditions, and the amount of smoke in the exit access corridor.

As the smoke became less buoyant, its spread mechanisms to the upper floor levels transported less smoke. On upper floor levels, those mechanisms having access to the casino level and offering the least resistance to smoke flow dominated smoke distribution. These mechanisms were service and passenger elevators and vertical utility shaft penetrations.

The amount of smoke encountered by trapped guests was influenced by their location. Especially significant was their proximity to the casino and to the many avenues for smoke spread to the high-rise tower. Although it is believed that exterior balconies played a role in lowering the number of high-rise fatalities, many balconies on the lower-floor levels were untenable during the first few hours of the fire.

Life Safety Code Analysis

The code analysis for this report is based entirely on the requirements found in NFPA 101,® Life Safety Code.® No attempt was made to provide any comparison of the conditions found at the Dupont to compliance with the local code in existence during its construction or the current Puerto Rican Building Code.

The 1985 edition of NFPA 101 was used for this analysis. This was the current edition of the Code on the date of the fire, although it had not been adopted by the authority having jurisdiction over the Dupont Plaza Hotel.

NFPA 101 stipulates requirements which afford a reasonable degree of protection to building occupants from fire. The Code establishes performance requirements that will protect the public but not hinder the normal use of a structure. In these criteria, the Code addresses those items which usually affect the survivability of occupants when a fire does occur. These items include types of building construction, number and arrangement of exits, interior finish, alarm and detection systems, automatic suppression systems, and day-to-day operating features of the structure. The Code includes occupancy chapters which address each of these items.

In some cases, the Code intentionally refrains from specifying allowable types of construction. This is due in part to the fact that model building codes usually include such requirements. Another reason is that building construction type has not been a major factor in life loss fire experience for certain occupancies.

The analysis for this fire centers on those occupancies which were predominant in the Dupont Plaza Hotel, namely Existing Places of Assembly (Chapter 9) and Existing Hotels and Dormitories (Chapter 17). The analysis focuses first on those areas within the ballroom level and casino level where most of the fatalities occurred.

Ballroom Level

As in past multiple-death fires, a certain sequence of
events had to occur in order for this tragic event to occur. In this case, it was the combination of the previously discussed storage of furniture in the south ballroom and an intentionally set fire. The ignition of the furniture resulted in a rapidly developing fire. The furniture was stored in a room that lacked adequate fire protection features that may have permitted the storage. The Life Safety Code Section 9-3.2.3.2 would not have allowed storage in an unprotected area.  

9-3.2.3.2 Rooms or space for the storage, processing, or use of the materials specified in this section shall be protected in accordance with the following:
(a) Rooms or spaces used for the storage of combustible supplies in quantities deemed hazardous by the authority having jurisdiction, hazardous materials in quantities deemed hazardous by recognized standards, or fuel shall be separated from the remainder of the building by construction having not less than 1-hour fire resistance rating with all openings protected by self-closing or smoke-actuated fire doors, or such rooms or spaces may be protected by an automatic extinguishing system as set forth in Section 6-4.  

Both the north and south ballrooms would be classified as Existing Places of Assembly by the Code. At the time of the fire, both ballrooms were unoccupied. Although the arrangement of the ballroom exits was questionable.  

The aggregate size of the two ballrooms put them into the Class A assembly category, which is a capacity of 1,000 or more occupants. Requirements for interior finish discussed in Section 9-3.3 of the Code would have stipulated a Class A or Class B interior finish for all wall coverings. The combustible removable partition which segregated the north and south ballrooms also would have had to meet these requirements.  

9-3.3.3 Interior finish in general assembly areas of Class A or Class B assembly occupancies shall be Class A or Class B. In Class C assembly occupancies it shall be Class A, B, or C.

The Code would have permitted the interior finish in the ballrooms to remain if there had been an automatic sprinkler system. The Code permits one less restrictive type of interior finish when a sprinkler system is present.  

Casino Level

The vertical opening which connected the ballroom and casino levels was unprotected. While an unenclosed vertical penetration between these two floors would have been permissible under the Code, other fire protection measures are necessary to compensate for the opening. These measures help to ensure that the occupants on both of the floors will have adequate warning of any fire and ample time to make their way out of the building. Section 9-3.1 of the Code gives permission for the unenclosed vertical opening in Exception No. 1.  

9-3.1 Protection of Vertical Openings. All interior stairways and other vertical openings shall be enclosed and protected as provided in Section 6-2.  

Exception No. 1: Unprotected openings connecting not more than three floors may be permitted provided that they comply with 6-2.2.3.4.  

The Code recognizes five additional requirements that must be met in order to compensate for the opening.  

6-2.2.3.4 Where permitted by Chapters 8 through 30, unenclosed openings comprising a portion of the total area of the building are permitted for the purpose of communicating between three floor levels, providing the following conditions are met:
(a) The communicating area has a low hazard occupancy, or ordinary hazard occupancy protected throughout by an approved automatic sprinkler system.  
(b) The lowest or next to the lowest level of the portion so designated is a street floor.  
(c) The entire portion so designated is open and unobstructed in a manner such that it may be assumed that a fire in any part of the space will be

9 Classically, fire prevention codes would have prohibited such storage in the south ballroom as well.
readily obvious to the occupants.
(d) Exit capacity is sufficient to provide simultaneously for all the occupants of all levels to egress the portion so designated by considering it to be a single floor area for the determination of required exit capacity.

(e) Each floor level, considered separately, has at least one-half of its individual required exit capacity provided by an exit or exits leading directly out of that level without occupants having to traverse another communicating floor level or be exposed to the smoke or fire spreading from another communicating floor level.

At the time of the fire, only items (b) and (d) were evident. The Code would have required the following upgrades in order to recognize the arrangement:

1. An automatic sprinkler system, installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, required in all areas of the ballroom and casino levels. As defined in NFPA 13, system design would have been for light hazard, or for ordinary hazard if the ballroom were used for displays or exhibits.

2. While not specifically spelled out in the Code, it has been the opinion of many users of the Code that, when a “clear and unobstructed” physical design cannot be achieved, an automatic detection system on the communicating levels can be used. The detection system usually would consist of smoke detectors installed in accordance with NFPA 72E, Standard on Automatic Fire Detectors. The intent of this design is to enable occupants to become aware of a fire in a timely manner by the use of an early warning (detection) system.

3. Additional exits would have been required from certain areas on the casino level. Exits from the casino, discotheque, both restaurants, and the function room were arranged so they all required travel through an area that would have exposed the occupants to a fire on either floor. Under Code provisions for unenclosed openings, only 50 percent of the required exits can discharge through the communicating area; the other 50 percent in this case would have had to be arranged to discharge directly to the outside.

Further, in the casino, 81 of the 97 fatalities were found near the west door. An examination of this door pointed to three significant deficiencies which may have contributed to the high number of fatalities in the casino.

Section 9-2.3.2 of the Code requires that the main exit of the occupancy be sized to accommodate 50 percent of the maximum population of the occupancy. The east door of the casino was considered the main exit and no specific problems were found here. Section 9-2.3.3 requires other exits, when combined, to accommodate two-thirds of the maximum population. The exception to this rule is when only two exits are required; then each exit must be sized to accommodate 50 percent of the occupants.

9-2.3.2 Main Exit. Every assembly occupancy shall be provided with a main exit. The main exit shall be of sufficient width to accommodate one-half of the total occupant load but shall not be less than the total required width of all aisles, exit passageways, and stairways leading thereto and shall be at the level of exit discharge or shall connect to a stairway or ramp leading to a street.

9-2.3.3 Other Exits. Each level of an assembly occupancy shall have access to the main exit and shall be provided with exits of sufficient width to accommodate two-thirds of the total occupant load served by that level. Such exits shall discharge in accordance with 9-2.7. Such exits shall be located as far apart as practicable and as far from the main exit as practicable. Such exits shall be accessible from a cross aisle or a side aisle (see 9-2.3.2).

Exception: Where only two exits are required, each exit shall be of sufficient width to accommodate not less than half the total occupant load.

The maximum number of patrons in the casino was calculated to be 480. Based on this figure and assuming a horizontal flow of 100 persons per unit of exit width, it was determined that the east door was adequate but that the west door was considerably narrower than the required minimum width of 56 inches. Since the maximum width of the doors was 48 inches, and the minimum width 32 inches, two 32-inch doors would need to have been provided in the west end of the casino in order to meet requirements of NFPA 101.
Exit problems due to the narrow width of the west door were compounded by the fact that the door swung into the casino. Section 5-2.1.4.1 requires a door in the means of egress to swing in the direction of exit travel when the door serves an occupant load of 50 or more persons.

5-2.1.4 Swing and Force to Open.

5-2.1.4.1 Any door in a means of egress shall be of the side-hinged, swinging type. The door shall be so designed and installed that it shall be capable of swinging from any position to the full use of the opening in which it is installed. Doors shall swing in the direction of exit travel:

(a) When used in an exit enclosure, or
(b) When serving a high hazard area, or
(c) When serving an occupant load of 50 or more.

Further, the west exit door required two simultaneous actions to unlatch it and an additional action to open it. The Code requires that doors in the means of egress be arranged so they can be readily opened by the occupants. In addition, if doors are latched, they must be equipped with hardware that can be operated by occupants in an obvious manner.

5-2.1.5 Locks, Latches, Alarm Devices.

5-2.1.5.1 A door shall be so arranged as to be readily opened from the side from which egress is to be made at all times when the building served thereby is occupied. Locks, if provided, shall not require the use of a key, tool, special knowledge or effort for operation from the inside of the building.

The general features are further supplemented by a provision in Section 9-2.11.1 which requires panic hardware on any door which is latched and which serves an occupant load of 100 or more persons.

9-2.11.1 Panic Hardware or Fire Exit Hardware. Any door in a required means of egress from an area having an occupant load of 100 or more persons may be provided with a latch or lock only if it is panic hardware or fire exit hardware.

It is felt that the items covered thus far in the analysis contributed directly to the consequences of this particular fire. Numerous other deficiencies existed in the complex at the time of the fire.

The next portion of this analysis concerns those areas of the lower levels and high-rise tower which did not directly contribute to the results of this fire. However, had the fire occurred at another time of the day (evening or early morning hours), the number of fire deaths could have been much worse.

In buildings without automatic sprinkler protection, the travel distance to an exit is limited by the Code to 150 feet. The travel distance from the Chow Dynasty Restaurant on the casino level was approximately 180 feet to the nearest exit. Section 9-2.6 allows this distance to be increased to 200 feet when automatic sprinklers are installed.

9-2.6 Travel Distance to Exits. Exits shall be so arranged that the total length of travel from any point to reach an exit will not exceed 150 ft (45 m) in any assembly occupancy.

Exception: The travel distance may be increased to 200 ft (60 m) in assembly occupancies protected throughout by an approved automatic sprinkler system.

The lower levels and the hotel portion lacked an operable fire alarm system. The Code requires an alarm system when the occupant load exceeds 2,000. Again, an aggregate of the potential number of occupants on the ballroom and casino levels showed that the occupancy level would have been in excess of 2,000, thereby requiring an alarm system.

9-3.4.1 General. Assembly occupancies required to be sprinklered by 9-3.5.1, theaters with more than one audience viewing room, and all assembly occupancies of over 2,000 occupant load shall be provided with an approved fire alarm system in accordance with this section.

Activation of the alarm system is to be by an “approved” means as specified in section 9-3.4.2. This typi-
cally means by any required detection systems, automatic sprinkler systems, or manual pull stations. Upon initiation of the alarm activating device, the occupant notification is to be accomplished by a voice alarm as specified in section 9-3.4.3.2.

This type of system is required in lieu of the more conventional audible warning devices. It is felt that the voice alarm, which gives specific instructions to occupants, facilitates orderly evacuation of a structure.

9-3.4.2 Initiation. Initiation of the required fire alarm system shall be by approved means, capable of transmitting an alarm to a receiving station, located within the building, which is constantly attended when the assembly occupancy is occupied.

9-3.4.3.2 Occupant notification shall be by means of either voice or prerecorded message announcement initiated by the person in the constantly attended receiving station.

(a) Such exits discharge to a free and unobstructed way to the exterior of the building, which way is readily visible and identifiable from the point of discharge from the exit.

(b) The entire area on the level of discharge is separated from areas below by construction having a minimum of 2-hour fire resistance rating.

(c) The level of discharge is protected throughout by an approved automatic sprinkler system and any other portion of the level of discharge with access to the discharge area is protected throughout by an approved automatic sprinkler system or separated from it in accordance with the requirements for the enclosure of exits (see 5-1.3.1).

Exception to (c): The requirements of 5-7.2(c) may be waived if the discharge area is a vestibule or foyer meeting all of the following:

1. The depth from the exterior of the building is not greater than 10 ft (3 m) and the length is not greater than 20 ft (6.1 m).

2. The foyer is separated from the remainder of the level of discharge by construction providing protection at least the equivalent of wired glass in steel frames.

3. The foyer serves only for means of egress including exits directly to the outside.

Of the three conditions required, item (a) was the only one satisfied. By application of a Formal Interpretation rendered in 1982, it was determined that a vertical opening between floors, which is protected in accordance with Section 6-2.2.3.4 of the Code, would meet the requirements of item (b). The requirement for automatic sprinklers is again evident in item (c).

It must be noted that this requirement permits only one of the two required stairways to discharge in the lobby. The other stairway must still comply with the requirements for exit discharge from the building. Due to the design of the complex, it is evident that a limited number of options are available to correct the exit arrangements. The most readily available solution would
be to convert the lobby discharge part of stairway C to a
protected passageway. Permission for this concept is
given by Section 5-2.6.1 and Section 5-1.3.1 of the Code.

5-2.6 Exit Passageways

5-2.6.1 General. Any hallway, corridor, passage, tunnel, underfloor passageway, or overhead pas-
sageway shall be permitted as an exit passageway and as an exit or exit component when conforming
to all other requirements of Section 5-1 as modified
by the provisions of this section.

5-1.3 Separation of Means of Egress (see also
Section 6-2)

5-1.3.1 When an exit is required to be protected by
separation from other parts of the building by some
requirement of this Code, the separating construc-
tion shall meet the requirements of Section 6-2 and
the following requirements:

(a) The separation shall have at least a 1-hour fire
resistance rating when the exit connects three
stories or less. This applies whether the stories
connected are above or below the story at which
exit discharge begins.

(b) The separation shall have at least a 2-hour fire
resistance rating when the exit connects four or
more stories, whether above or below the level of
exit discharge. It shall be constructed of an assem-
bly of noncombustible or limited-combustible mate-
rals and shall be supported by construction having
at least a 2-hour fire resistance rating.

(c) Any opening therein shall be protected by an
approved self-closing fire door (also see 5-2.1.8).

(d) Openings in exit enclosures shall be limited to
those necessary for access to the enclosure from
normally occupied spaces and for egress from the
enclosure.

The exit passageway would have to be constructed
to provide the same fire resistance rating (2-hour) as the
stairway. The passage is basically a continuation of the
stairway and would have to be enclosed with 2-hour
construction, have limited access, and have 1 1/2-hour
fire rated doors to protect the openings. Assuming that
it would be prudent to maintain the maximum usable
space in the casino, the passageway for stairway C
would have continued to the exterior of the west side of
the complex near the existing circular stairs—and termi-
nated at ground level adjacent to the pool.

Each level of the high-rise hotel tower had several
problems associated with it. The first problem area cen-
tered on the use of corridors as a supply air plenum.
While this practice has been prohibited since 1950 by
NFPA 90A, Standard for the Installation of Air Conditioning
and Ventilating Systems, the Life Safety Code recognizes
an arrangement which permits some existing conditions
to remain if additional protection were provided. Sec-
tion 17-3.6.6 discourages this practice, but the exceptions
would allow the existing arrangement with certain de-
tection or protection provisions to offset the deficiencies.

17-3.6.6 Transfer grilles, whether protected by fus-
ible link operated dampers or not, shall not be used
in these walls or doors.

Exception No. 1: Where a corridor smoke detection
system is provided which when sensing smoke will
sound the building alarm and shut down return or
exhaust fans which draw air into the corridor from
the guest rooms. The grilles shall be located in the
lower one-third of the wall or door height.

Exception No. 2: Where automatic sprinkler protec-
tion is provided in the corridor in accordance with
19-3.5.1 and where the transfer grille is located in the
lower one-third of the wall or door height.

The corridor detection system noted in Exception
No. 1 was not present, nor was there the automatic sprinkler system noted in Exception No. 2. The addition
of the detection system requires notification of the build-
ing occupants and automatic shutdown of the HVAC
system. The automatic sprinklers are required in the
corridor and just inside the door of every guest room.

For both conditions, the transfer grille would have to
be relocated to the lower third of the corridor wall.
In addition to detector requirements to offset the deficiencies previously described, the Code requires single station smoke detectors in each room for self-preservation of the occupants. These detectors must be powered from the building electrical service and give a "local" alarm. A corridor detection system connected to the building fire alarm system may be used in place of the individual room detectors.

17-3.4.4 Detection. Each sleeping room shall be provided with an approved single station smoke detector, in accordance with 7-6.2.7. powered from the building electrical service.

Exception: Buildings having a corridor detection system, in accordance with Section 7-6. connected to the building fire alarm system.

The restaurant located on the top floor of the complex is classified as a Class B place of assembly, in that it could accommodate approximately 350 patrons. The exit stairways for the 20th floor restaurant were the same stairways used to exit from floors 3-19 of the hotel. Deficiencies in the arrangement of stairways previously discussed under the hotel occupancy also apply here. Similarly, requirements for a fire alarm system also apply to the 20th floor.

The lack of an automatic elevator recall system may have played a roll in three fatalities. Sections 7-4.3 and 7-4.4 of the Code require an elevator recall system which will send the equipment to a designated floor in the event of a fire emergency.

7-4.3 Existing elevators, escalators, dumbwaiters and moving walks shall conform to the requirements of ANSI/ASME A17.1, Safety Code for Elevators and Escalators, Part X "Acceptance and Periodic Test and Inspections and Maintenance" and Part XII "Alterations, Repairs and Replacements."

7-4.4 All elevators having a travel of 25 ft (7.6 m) or more above or below the level that best serves the needs of emergency personnel for fire fighting or rescue purposes shall conform to the requirements of ANSI/ASME A17.1, Safety Code for Elevators and Escalators, Rule 211.3 “Operation of Elevators Under Fire or Other Emergency Conditions.”

Operating Features

The operating features of certain occupancies can play a significant role in the survivability of the occupants. Chapter 31, “Operating Features,” of the Code covers important firesafety functions such as emergency organization, staff training and drills, maintenance of the means of egress, and fire protection equipment maintenance. The philosophy here is that facility management and employees are responsible for firesafety conditions, and that in an emergency they can help achieve an orderly egress from the building. There were no indications that employees of the DuPont Plaza complex had been trained to handle a fire emergency.

Specific requirements are contained in Section 31-2, Assembly Occupancies, and Section 31-6, Residential Occupancies.

31-2.1 Drills. The employees or attendants of places of public assembly shall be schooled and drilled in the duties they are to perform in case of fire, panic, or other emergency in order to be of greatest service in effecting orderly exit of assemblies.

31-2.1.1 Employees or attendants of assembly occupancies shall be instructed in the proper use of portable fire extinguishers and other manual fire suppression equipment if provided.

31-6.1 Hotel Emergency Organization.

31-6.1.1 All employees of hotel shall be instructed and drilled in the duties they are to perform in the event of a fire, panic, or other emergency.

31-6.1.2 Drills of the emergency organization shall be held at monthly intervals, covering such points as the operation and maintenance of the available first aid fire appliances, the test of guest alerting devices, and a study of instructions or emergency duties.
Theoretical Automatic Sprinkler and Detector Analysis

The preceding Code analysis indicates that had the 1985 edition of the Life Safety Code been enforced in Puerto Rico, in addition to meeting other requirements for an existing building, the most economic and practical method of solving the life safety problems at Dupont Plaza most likely would have been to protect the building with a complete automatic sprinkler system.

NFPA conducted an analysis of the theoretical response of an automatic sprinkler over design ranges for an NFPA 13-complying system. The analysis included, among other variables, systems designed for both light and ordinary hazard, and included maximum spacing while providing complete protection.

Sensitivity of the sprinklers also was varied, from those with high Response Time Index (RTI) values to those having more typical RTI values. Fast response sprinklers also were part of the analysis. Temperature range of sprinklers was also varied. A heat release rate which tracked the reported time of room flashover was used for the fuel package.

The design layout considered the construction arrangement of the south ballroom including obstructions caused by light fixtures; water supply for the design area was considered sufficient. The analysis was done using a computer program, DETACT-QS, to test the variables.

Results of the analysis indicate that, in any arrangement tested, the response of an automatic sprinkler would have taken place in less than five minutes and well before flashover occurred in the south ballroom. Most likely the sprinklers would have operated 2 to 4 minutes into the fire. If fast response sprinklers had been installed, activation would have been likely in 1 1/2 to 2 minutes. Actual fire experience of sprinklers in such situations is excellent, leaving little doubt that, had automatic sprinklers been installed, room flashover would have been prevented thus eliminating the possibility of a multiple-death fire.

Smoke detector response also was of interest. The analysis indicates that a system designed according to NFPA 72E would have activated within 1/2 to 1 minute. If the evacuation signal were arranged to sound upon activation of the system, the occupants of the casino would have received earlier notification than was experienced. This could have increased their chances of survival.

Aftermath of the Fire

Soon after the fire, Puerto Rico's Department of Occupational Safety and Health cited the Dupont Plaza Hotel for a total of 28 alleged violations of the Commonwealth's safety and health standards and proposed $527,400 in penalties. Among the nine alleged willful violations were employees who did not know the preferred means of reporting emergencies, employees who did not hear the fire alarm, no review of emergency action, and no fire prevention plan.

In the wake of the Dupont Plaza fire, a committee of nationally recognized fire protection experts studied the entire field of fire protection in Puerto Rico and presented an extensive report to Puerto Rico Governor Rafael Hernández Colón. This report contained 70 to 80 recommendations for improvements. One of these recommendations was that all existing hotels retrofit with complete automatic sprinkler systems. Governor Hernández Colón has asked each of the hotels to comply voluntarily with this recommendation. He has made it clear that if retrofitting is not done voluntarily, it will be mandated through legislation. At this point, legislation looks unnecessary. Most of the hotels have agreed to begin plans to voluntarily retrofit with complete automatic sprinkler systems.
Findings

NFPA's analysis of the data points to the major factors contributing to the large loss of life in the Dupont Plaza Hotel:

1. Lack of Automatic Sprinklers in the South Ballroom (Room of Fire Origin).
   Once ignited, the amount, arrangement, and combustibility of the stored materials in the south ballroom resulted in a rapidly developing fire. The fire was discovered in advanced stages and initial attempts to control it were not successful.
   Automatic sprinklers, properly installed and maintained, would have controlled the developing fire well before flashover occurred, thus averting the tragic multiple-deaths. Studies of similar fires show that multiple-deaths can and do occur throughout a building after flashover conditions are reached in the room of origin. This happens when heat, smoke, and toxic gases spread to remote areas of the building by means of vertical and horizontal penetrations. Because flashover can be prevented by sprinklers, the record of life safety protection in sprinklered buildings is excellent.
   The NFPA has no record of a multiple-death fire in a completely sprinklered building of this occupancy type where the system was properly operating, except in an explosion or flash fire.

2. Rapid Fire Growth and Spread.
   Agents from ATF and local Puerto Rican authorities determined that the fire was deliberately set among the stored materials in the south ballroom. The combination of open flame ignition, the amount of stored combustible materials in the south ballroom, the materials' geometric arrangement, and that of the room of origin, the abundant amount of air, and the heat release characteristics of the stored materials resulted in an extremely rapid buildup of the fire. The removable combustible partition, separating the north and south ballroom, and the interior finish attached to the walls of the south ballroom also contributed to the rapid fire growth.

   The casino was located in a semi-isolated area of the hotel. There were no automatic fire detection systems in the casino or elsewhere in the Dupont Plaza Hotel complex to alert occupants when the fire was in its incipient stage. Occupants of the casino were not aware of the fire until it was in an advanced stage of development.
   After flashover in the south ballroom, only a short interval elapsed before untenable conditions were reached in the casino and lobby.
   The casino was designed so patrons would exit (1) through the hotel lobby which discharged to the exterior of the building by means of the main (south) entrance and (2) by way of the exterior spiral stairway on the west side. The west
exit for the casino had a door which, when closed, required two simultaneous actions to open; in addition, the door opened inward.

Each exit from the casino should have been capable of accommodating one-half of the total occupant load; the west door could not accommodate the total occupant load for the casino. The lack of early awareness of the fire by the occupants of the casino, combined with inadequate exits, resulted in insufficient time for total evacuation.

4. Vertical Opening Between Ballroom and Casino Levels.

The vertical opening between the ballroom and casino levels, created by the ballroom foyer, allowed smoke and fire to move to the casino level and then into the casino itself. As a result, smoke and fire spread to the hotel lobby, effectively blocking the exit paths from the casino and from the high-rise tower. Within minutes, the glass partitions between the foyer and the casino failed and the products of combustion swept through the casino, trapping those occupants who had not escaped.

Additional Findings

5. Smoke Movement to the High-Rise Tower by Way of Vertical Penetrations.

Products of combustion were able to infiltrate the high-rise tower through several means:
- Movement from the exterior of the building into guest rooms;
- HVAC systems for exit access corridors and guest rooms;
- Passenger and service elevator shafts;
- Utility penetrations, including pipe chases and exhaust ducts in the guest room bathrooms; and
- One of the stairways (stairway B).

6. Hotel Tower Occupants Were Not Aware of a Severe Fire.

The building did not contain automatic fire detection and alarm systems that could have provided early warning to occupants of the high-rise tower. Occupants were trapped in the hotel tower when smoke and fire moved through the lobby and penetrated exit stairways.
Conclusions

Findings of this investigation powerfully demonstrate an all-too-familiar life safety lesson:

There always is potential for high life loss in any setting where people gather—especially when conditions exist for rapid fire growth and room flashover.

These conditions can occur whenever there is a concentration of combustible contents and/or when there is highly combustible interior finish. In this fire situation there were:
- No sprinklers to prevent flashover;
- No detection systems to warn the occupants;
- Many occupants of the casino who were unable to escape because of exit deficiencies; and
- Unprotected vertical and horizontal openings that allowed heat, smoke, and toxic gases to spread rapidly throughout the building.

Once again history repeats itself, and this investigation reveals many of the same conditions shared by almost all devastating fires.

The fact is that the technology is and has been available to prevent such a tragedy. Firesafety codes and standards are available for use by architects, engineers, owners, operators, and others responsible for the life safety of the public.

These codes and standards provide a means for continuous review and updating of the quality of firesafety in hotels and similar occupancies.

Had the Life Safety Code, which contains provisions requiring the upgrading of existing buildings, been used voluntarily by interested persons, or had it been adopted and enforced by public authorities, a tragedy of this magnitude would never have occurred.
Results of Tests of the Fabric Wall Covering as Reported by NBS/CFR*

Several tests were conducted to obtain information on the burning properties of the fabric wall covering used in both the North and South Ballrooms. The NBS experiential ignition and flame spread apparatus described by Quintiere and Harkleroad [24] and the Cone Calorimeter [3] were used.

In these tests the carpet was cemented to the soot surface of a 2-inch (50mm) thick, well cured concrete substrate. The adhesive used to cement the fabric to the concrete is believed to be similar to that used in the ballrooms. The adhesive used was 72 Pressure Sensitive Adhesive manufactured by 3M Corporation. A thin coat of adhesive was spray applied to cover the entire surface of the concrete face. No adhesive was applied to the fabric. As soon as the adhesive surface became tacky, the fabric was hand pressed in place.

The fabric was conditioned for several days prior to attachment at 70°F (21°C) and 50% relative humidity. After cementing the fabric to the concrete the assembled test sample was returned to the conditioning room for about 30 hours before testing. The test facility is housed in an air conditioned laboratory.

The following properties were indicated by these tests:

a. Heat of Gasification: approximately 8 kJ/g
b. Ignition Temperature: 1160°F (670°C) to 1270°F (688°C)
c. Thermal Inertia/phi: 72 to 94
d. Critical Ignition Energy: between 4.6 and 5.4 kW/m²

Included in this appendix are:

a. Figure F-1. Wall lining (vertical) rate of heat release and heat of combustion at 50 kg/m² irradiance, Cone Calorimeter
b. Figure F-2. Wall lining (vertical) rate of heat release and heat of combustion at 60 kg/m² irradiance, Cone Calorimeter
c. Figure F-3. Ignition results for wall lining
d. Figure F-4. Correlation of ignition results for wall lining
e. Figure F-5. Correlation of spread velocity for wall lining

Figure F-1. Wall Lining (vertical) Rate of Heat Release and Heat of Combustion at 50 kW/m² Irradiance, Cone Calorimeter

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Figure F-2. Wall Lining (vertical) Rate of Heat Release and Heat of Combustion at 60 kW/m² Irradiance, Cone Calorimeter
Figure F-3. Ignition Results for Wall Lining

Figure F-4. Correlation of Ignition Results for Wall Lining
Figure F-5. Correlation of Spread Velocity for wall Lining
Bibliography


Photographs numbered 1 through 8, found on pages 46 through 50, are not available in the electronic imaged file.

Photo 1. From Ashford Avenue, smoke can be seen rising from the ballroom area. Entering exterior openings to the high-rise tower was one way smoke spread to guest rooms. Note congestion along the beach-front avenue. (Photo courtesy of El Nuevo Día, San Juan)
Photo 2. Helicopters remove trapped tower occupants who had moved through the building to the roof. Note smoke venting from openings to mechanical and elevator rooms. (Photo courtesy of El Nuevo Día)

Photo 3. North side of complex shows north ballroom and high-rise tower with the casino on its second level. Note fire in ballroom foyer area. (Photo courtesy of Carlos Taboas)
Photo 4. (above) Products of combustion accumulate in the ballroom foyer area and extend into the casino when glass partitions fail. (Photo courtesy of Carlos Taboas)

Photo 5. A flame front moves rapidly through the casino and vents on the building's west side. (Photo courtesy of Carlos Taboas)
Photo 6. The fire violently vents from openings on the casino/lobby level and extends above the exterior poolside bar. (Photo courtesy of Carlos Taboas)

Photo 7. Rescuers remove a badly burned victim. (Photo courtesy of El Nuevo Día)
Photo 8. Using a lounge chair from the pool area, rescuers move a severely burned victim toward the ambulances. (Photo courtesy of *El Nuevo Día*)

Photo 9. The south ballroom contained stored guest room furniture still in packing crates that provided an abundant fuel supply. Burning of these materials, along with other stored items and combustible interior finish material, resulted in rapid growth and spread of the fire. (NFPA Photo)
Photo 10. Three sets of exit doors for the north ballroom were opened during the early stage of the fire. These and other openings permitted entry of an abundant amount of air for combustion. (NFPA Photo)

Photo 11. The fire vented into the ballroom foyer through the common glass partitions to the south ballroom (lower center openings). Products of combustion filled the foyer and extended to the balcony area above it. (NFPA Photo)
Photo 12. In the ballroom foyer area, louvered wood vents above and beside door openings provided a source of combustion air. The combustible roof members contributed to the fuel load. (NFPA Photo)

Photo 13. At the top of the stairway was one of two glass partitions that were common to the casino. As products of combustion filled the foyer, the partitions failed, resulting in a flame front moving through the casino. The stairway also was a means of fire spread to the lobby area. (NFPA Photo)
Photo 14. Occupants of the main lobby first saw smoke moving up the open stairway from the ballroom level and into the lobby through openings between structural columns (center). (NFPA Photo)

Photo 15. Fire fighters were able to advance initial attack lines only a short distance into the main entranceway before being driven from the area by the intense fire conditions. (NFPA Photo)
Photo 16. A view of the west exit doorway from the lobby; this door was closed early in the fire. However, the fire was coming into the casino by other means, trapping the remaining occupants. (NFPA Photo)

Photo 17. A view of the casino's interior from the northwest corridor. Some casino occupants first became aware of the fire by seeing smoke on the exterior of the building. These observations were made through one of the casino's glass partitions (center opening showing white exterior stucco of the north ballroom and smoke stains). (NFPA Photo)
Photo 18. Most of the victims were found clustered in the west corridor of the casino near one of its exits. Some guests broke exterior glass partitions and were able to jump to safety before the flame front moved through the casino. (NFPA Photo)

Photo 19. Wooden supports for slot machines within the casino plus other combustibles, including combustible interior finish materials, were identified as having contributed to the fuel load. (NFPA Photo)
Photo 20. The spiral exterior stairway on the building's west side was used for escape by occupants of the casino and main lobby. The fast-moving fire violently vented from openings along the west side. (NFPA Photo)

Photo 21. Once the fire vented from the casino's exterior openings, it ignited exterior wooden roof materials that provided cover for the poolside bar. Two victims were found in the bar area. (NFPA Photo)
Photo 22. Voids in the center core of the casino allowed products of combustion to enter an HVAC system which distributed them throughout the casino, main lobby, and guest room floors 3 through 10. (NFPA Photo)

Photo 23. Three of the 97 fatalities were found in passenger elevators. Passenger and service elevator shafts plus other vertical openings were a main source of smoke spread to the high-rise tower. (NFPA Photo)
Photo 24. The wooden door to stairway B (rear opening) was determined to have been open during all of the fire incident. Significant amounts of heat and smoke were able to move throughout the high-rise tower by this means. (NFPA Photo)

Photo 25. Supply HVAC grilles were located above stairway entrance points. The grilles were part of the HVAC system that provided conditioned air to exit access corridors on guest room floors. (NFPA Photo)
Photo 26. (above) Individual guest room HVAC systems took make-up air from the exit access corridor into a plenum area above the bathrooms. Smoke entering the plenum in a variety of ways thus was distributed into guest rooms. (NFPA Photo)

Photo 27. Utility pipes in the casino area penetrated the center core of the high-rise tower; their vertical chases connected with plenum areas above the guest room bathrooms. This was one of the methods by which smoke was able to enter guest rooms. (NFPA Photo)
Photo 28. Despite significant amounts of smoke and heat that penetrated the high-rise tower, only one fatality occurred on the tower’s guest room floors. (NFPA Photo)