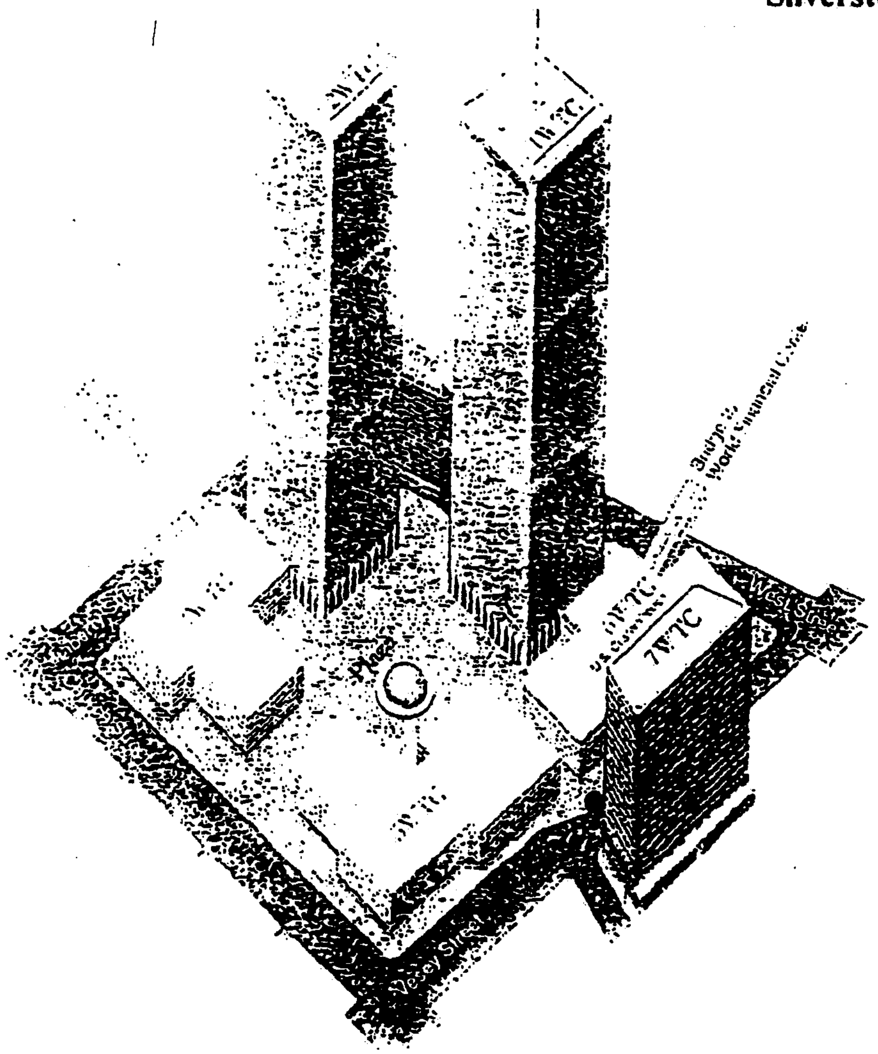
WORLD TRADE CENTER

Property Risk Report

Prepared for

Silverstein Properties, Inc



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OVERVIEW

The World Trade Center is one of the most prominent commercial real estate complexes in the world and a hallmark of the Manhattan skyline.

This document discusses many of the physical characteristics of the complex, various protection and risk control aspects and some of the potentially catastrophic incidents that might occur.

The discussion focuses on the following components of the complex:

- The two 110-story office towers (One and Two World Trade Center)
- The office portion of the two nine-story buildings (Four and Five World Trade Center
- The retail area of the World Trade Center, referred to in the report as the Mall which consists of retail space located on the Concourse level
- The Subgrade space, which consists of six basement, levels (B-1 through B-6) that project about 70 below the Concourse.

It is estimated that 50,000 people work in the World Trade Center and that 150,000 commuters' travel through the concourse to access Path and MTA subway trains, on a daily basis. Annually approximately 2 million tourists visit the Observation Deck.

Much of the discussion of the physical characteristics has been taken from documents developed by the Port Authority's real estate advisors. The loss estimates (PML's and MFL's) outlined in the report are predicated on conventional risk control conventions of the major HPR underwriters.

Building areas:

The total building area is 11,181,708 square feet and can be broken down as follows

	Stories/ levels	Year Built	Gross sq. ft.
One	110	1970	4,761,416
Two	110	1972	4,761,416
Four	6	1977	462,738
Five	6	1975	581,238
Subtotal - offices			10,566,808
Retail	3	1970	614,901
Total			11,181,709

The total Subgrade area is 2,656,435 square feet and can be broken down as follows:

Gross area		2,656,435
Open area		(266,963)
PATH use		(422,337)
Net area		1,967,135
Parking area		(633,575)
Usable area		1,333,560
Operations area'		(810,143)
Leasable area		523,417
Occupied as of 5/31/00	279,700	
Unoccupied as of 5/31/00	79,217	
Port Authority	164,500	

Operations area includes truck docks and platforms, mechanical equipment rooms, refrigeration plant, and vertical penetrations

Construction detail

Excavation: The Subgrade was constructed after a massive excavation project removed 1,200,000 cubic yards of fill from the site. The fill was placed into the Hudson River and also used to create 23 acres of the 90-acre Battery Park City complex on which the World Financial Center was constructed.

Foundation: The structural columns continue down to subgrade level B-6 where they are connected to grillages on concrete piers or rock. The caissons are large circular foundation supports set in bedrock to anchor the structures. The foundations are connected to a large concrete slab, which forms the lowest basement floor. The Subgrade consists of six basement levels of columns and slabs.

Structural framing: One and Two World Trade Center contain perimeter columns and beams which form a closely spaced rigid frame of steel that runs the full height of each building. There are rigid frames on each of the four sides of the lower that act together as a tube. This exterior tube can resist the effects of gravity and wind. Wind load was determined on the basis of a wind tunnel laboratory test.

Wind drift: Three feet.

Flooring. In One and Two World Trade Center, the concrete slabs are typically four inches thick with the exception of floors 7, 9, 41, 43, 75, 77, 107, 108, and 110, which are eight inches thick. Each floor is bridged by approximately three-foot deep structural steel floor trusses. The stairwells, bathrooms, equipment rooms and elevator shafts are center core, allowing windowed offices.

Floor loads Typical office floor

Dead load	Approximately 60 psf
Live load	100 psf reducible

Exterior walls. The exterior walls of One and Two World Trade Center consist of reflective floor to ceiling windows tightly fitted between anodized aluminum and steel columns. The exterior facade of Four and Five World Trade Center consists of black-anodized aluminum and glass.

Roof A flat roofing system, depending on building consists of built-up assemblies with tar and gravel cover or concrete slab.

Ceiling heights Ceiling heights in the office areas are typically 12 feet slab-to-slab and are typically eight feet, eight inches finished floor to finished ceiling. One, Two, Four, and Five World Trade Center have 12 foot slab-to-slab ceiling heights with the following exceptions, which include mechanical equipment rooms ("MERs"):

Tower and Plaza building ceiling heights

	Ceiling Height	
Floor	One World Trade	Two World Trade
MER 7/8	24' 0"	24' 0"
40	14' 0"	14' 0"
MER 41/42	28' 0"	28' 0"
43	14' 0"	12' 0"
44	14 '0'	14' 0"
67	16' 0"	12' 0"
74	14' 0"	14' 0"
MER 75/76	28' 0"	28' 0"
78	14' 0"	14' 0"
106	14' 4"	14' 4"
107	17' 6"	17' 6"
MER 108/109	25' 10"	25' 10"

Note: 1 WTC is six feet taller than 2 WTC

The Port Authority The Plaza, Concourse. and Subgrade levels have the following ceiling heights measured slab-to-slab:

Plaza, Concourse, and Subgrade level ceiling heights

Plaza	58' 0" for the 1 and 2 WTC lobbies above mezzanine 15' 0" for 4 and 5 WTC
Concourse	22' 0"
Subgrade B-1	16' 0"
Subgrade B-2 through B-4	10' 0"
Subgrade B5 and B-6	11' 0"

Column spacing

One and Two World Trade Center are virtually column free, while Four and Five World Trade Center have 30-foot-on-center column spacing and 30-foot-by-30-foot bays.

Windows.

The windows are nearly floor to ceiling strips between aluminum columns, measuring seven feet eight inches in height and one foot ten inches in width. The windows of One and Two World Trade Center are washed by wash robots which run on tracks along the perimeter from the roofs and in the facade of the towers. Four and Five World Trade Center window washing is performed by cleaners with the use of a mechanical scaffold.

Loading docks

Loading facilities are provided via Barclay Street and staffed by a security guard. The access ramps lead to the Subgrade, where loading docks are provided on level B-1. These loading docks consist of 40 bays, which can accommodate large trailer trucks up to a maximum height of 11 feet, 5 inches on the main truck dock, and 10 feet 6 inches on the lower truck dock. There are 17 bays on the main truck dock level and the balance are on the lower dock. There are also some van spaces. Seven of the truck bays are equipped with compactors, accommodating approximately 230 yards of refuse. None of the bays is equipped with hydraulic lifts.

Mechanical detail

Heating:

The heating system consists of a perimeter, two pipe induction system and hot water baseboard convectors, both of which have local zone temperature controls. The Complex purchases high-pressure steam from Con Edison. It is distributed to the Complex via steam meter rooms located in the Subgrade. High pressure steam enters the Subgrade on level B-6 and is reduced to low-pressure steam through-a series of regulating valves. Low-pressure steam risers carry the steam to the MERs in each building, where the steam is then distributed to each zone's heat exchangers and air handling units/far) coils. The heat exchangers convert the steam's energy to the recirculating water. The heated water is then pumped to the fin-tubed heating elements by individual constant volume hot water pumps to the various zones in the World Trade Center. Each system contains a redundant heat exchanger, as well as pumps for back-up duty. The hot water supplied temperature for each of the zones is automatically reset and maintained according to outdoor temperature conditions.

The automatic control valves which regulate the heat output are sequenced to operate with the overhead supply constant air volume systems. There are approximately eight heating zones (four interior, four perimeter) per floor in One and Two World Trade Center and five heating zones in Four and Five World Trade Center (three interior, two perimeter).

Thermal distribution:

Steam distribution system

High-pressure (125 psig minimum) steam is purchased from Con Edison steam is delivered to the World Trade Center via a distribution main which runs under Greenwich Street. From the main, steam is piped from the B-1 level into the steam meter room located on elevation 242 feet. From the steam meter room, it is piped via redundant risers to pressure-reducing valve ("PRV") stations located in the MERs in One and Two World Trade Center on floors 7, 41, 75 and 108. There is one dual path (high demand/low demand) PRV station located in each MER. The low pressure side of the PRV stations serves the heating coils in the air conditioning supply units and the secondary water systems in each respective MER. Steam condensate is collected via a system of drains and pipes under the floors of each MER and carried via the low-pressure return ("LPR") risers to the next lower MER. In the lower MER, the Condensate is utilized by the domestic hot water preheaters, collected again, and piped to the main condensate collection tank on elevation 242 feet. Flash tanks, provided in each MER, flash the high- and medium-pressure condensate into low-pressure steam, which is recovered and piped into the low pressure steam distribution system. Condensate is then drawn to the B-6 condensate tanks. At this point it can be pumped to the 289 MER in Four World Trade Center and used again in the domestic water preheat tank and interior reheat system.

Chilled water distribution system

The chilled water for cooling coils and secondary water coolers is supplied to the various MERs via two chilled water riser systems. For One and Two World Trade Center, one system supplies the low zone, which includes the 7th and 41 st floor MERs; the second system serves the high zone, which includes the 75th and 108th floor MERs. Branch piping for each MER is tapped off the chilled water supply and return risers. A pressure differential bypass assembly is provided in each MER. The function of this bypass is to compensate for variations in demand on the chilled water supply by the cooling coils and secondary water coolers, thus maintaining a consistent differential pressure between supply and return.

Condenser water distribution:

Hudson River water

Water pumped from the Hudson River supplies the complex with redundant condenser water via heat exchangers. The pump house for Hudson River water is located adjacent to the Battery Park City Boat Basin approximately one-half a mile from the World Trade Center. The pump house has two intake tunnels with two screen chambers. The north and south chambers contain four turbine pumps, each producing 13,000 to 19,000 gpm via 600-hp and 900-hp 2,300 volt motors, respectively. The water is then pumped via two main pipes, one 60-inch pipe and the newly installed 66-inch pipe, to the chiller plant on levels B-5 and B-6 and the computer cooling water system on levels B-3 and B4 of the Subgrade. The cooling system for the Complex is based upon a chilled water and condenser water circuit system. The chiller plant provides chilled water at a temperature of 38 to 54 degrees Fahrenheit. Condenser water is at a temperature range of 80 to 90 degrees Fahrenheit. Chilled water and condenser water are provided directly to certain tenants based upon their individual needs at additional cost

Secondary water systems

In One and Two World Trade Center, secondary water systems for the perimeter induction units are provided by 12 independent systems, typically zoned North and West or South and East. Each system Consists of a steam-to-hot water converter to generate heating water, a cooler (heat exchanger), two circulating pumps (one standby) and a differential pressure bypass. Depending on the season, heated or cooled water is produced via the converter or cooler and distributed by the circulating pump to the induction units.

Condenser water system

The condenser water systems provide the medium by which the various tenant supplemental air conditioning systems release their rejection heat. These systems are similar to tenant condenser water systems in a typical office building.

The cooling water for these systems is provided by use of river water through heat exchangers located in various machine rooms in the subgrade levels. Condenser water is pumped in a cascading fashion between systems of plate-and-frame and/or shell-and-tube heat exchangers located in mechanical spaces in One and Two World Trade Center. A typical system has two heat exchangers and two pumps (one standby). Cooling water is distributed as required by the pumps through risers to the various floors.

There are 10 of these systems throughout the complex. For example, System No. 2, which serves floors 43 to 108 in One World Trade Center, is provided with cooling water by Primary System No. 1. This system has an operating temperature range of 85 degrees to 95 degrees Fahrenheit, and consists of two shell-and-tube heat exchangers, two plate-and-frame heat exchangers and four circulating pumps. The circulating pumps and heat exchangers are sized to handle 1,400 gpm each. This system is configured to operate as two separate circulating loops. The two shell-and tube heat exchangers and two circulating pumps serve one loop, and the other two pumps and the two plate-and-frame heat exchangers serve the second loop. Only one pump and one heat exchanger in each loop is required to operate at a time.

Air conditioning system

Core areas, consisting of the elevator lobbies, toilets and associated circulation spaces, are air conditioned by means of centrally located constant volume air conditioning systems. There are no return fans directly associated with these units. These systems provide make-up air for the toilet exhaust systems via door louvers In addition, these systems provide ventilation makeup air to the various elevator machine rooms. Air is directly exhausted from the machine rooms and is not returned or recirculated within the room.

Interior office areas extending from the building core to a distance of 15 feet from the exterior walls are air conditioned by means of centrally located constant volume air conditioning systems. Each system supplies one quadrant (Southwest, Southeast, Northwest, Northeast) on multiple floors. Each system is interlocked with multiple return fans. Air is distributed to the floors via vertical risers. A constant volume air pressure regulator is provided at each office floor tap into the respective riser. The hung ceilings are utilized as return air plenums. Return fans are provided and interlocked with the respective supply systems. Only interior and perimeter fans are interlocked with return fans.

The perimeter offices or open office areas extending from the exterior wall for a distance of 15 feet are conditioned by means of two pipe induction units located below the sill of the windows. Induction units utilize a combination of tempered high-pressure air (primary air) and either heated or cooled water (secondary water) to provide cooling or heating. The primary air induces the flow of room air across the coil through which the secondary water is flowing. The induced air is either heated or cooled, depending upon the temperature of the secondary water flowing through the coil. The mixture of primary and induced air is then discharged to the room via the grilles on the top of each unit. The function of the primary air is to provide ventilation and dehumidification to offset the latent loads of the area served, and to provide the motivating force for the induction and circulation of the room air. The function of the secondary water is to offset the relevant heat gains or losses in order to regulate the room temperature. The induction units are controlled by pneumatic thermostats which measure return air and control pneumatically actuated secondary water control valves to maintain room temperature.

The primary air is furnished by centrally located, constant volume air conditioning systems. Each system supplies one exposure (North, South, East, West) of multiple floors. Each system is interlocked with multiple return fans. The distribution of air is via vertical risers in the core shafts and horizontal feeding ductwork in the hung ceilings directly below the induction units.

Miscellaneous systems

Centrally located air conditioning systems are provided for the public areas of the building, including the various lobbies and the observation deck and for the elevator machine rooms.

The central plant refrigeration plant on level B-5 contains numerous chillers ranging in size from 13.8 kV 7000 ton units (7 of them) to 2.3kV 2500 ton units (2 of them) and 10 CHW pumps ranging in size from 5,250 gpm to 10,500 gpm.

WTC - chiller plant addition:

The 1993 chiller plant addition at the B-6 level (elevation 242) was installed to provide 10,000 tons of additional cooling capacity. The addition consists of five 2,500-ton centrifugal machines with 4.16 kV electric driven compressors and five 400 hp, two 100 hp, variable speed 4.16 kV pumps and two 100 hp, variable speed.

The chiller plants have a total capacity of 59,000 tons plus two parallel 2,500-ton drive lines with 17 CHW pumps generating between 3,000 gpm and 10,500 gpm.

The central plants condition water to the average requirement in the complex which includes One, Two, Three, Four, Five, and Six World Trade Center, and the Concourse and Subgrade. Secondary units, either fan coils or induction units, make final zone adjustments which are served by chilled water and condenser water circuitry from the central plants. The system is based upon a complex series of hot and chilled water pipes, condenser water pipes, main air return ducts and main supply ducts. In addition to the large mechanical equipment and refrigeration rooms on levels B-5 and B-6 of the Subgrade, there are eight MERs, each two floors in height, serving zones one through six of One and Two World Trade Center along with two MERs located on the ninth floors of Four and Five World Trade Center. There are also two MERs on level B-6, which serve One and Two World Trade Center, and two MERs on subgrade elevations 289.5 and 285.5 serving Four and Five World Trade Center and the

Concourse. Each MER contains water pumps for the hot and chilled water and condenser water system, ventilation ducts, exhaust fans, electric distribution panels and elevator hoist motors.

Central air handling systems and ventilation

The central air handling systems for the Complex consist of air handling units located within the 16 MERs. Those not located in MERs include transfer fans, exhaust fans and garage ramp heaters in the Subgrade. The air handlers consist of heating ventilation and air conditioning (HVAC) system units, coils and fans.

One and Two World Trade Center contain central air handling systems in the five MERs (B-6, 7, 41, 75 and 108), and house five types of units: peripheral, interior, core, elevator machine room, and electrical substation units, along with return and exhaust fans. The peripheral and interior units distribute air on a quadrant basis; the core units serve the elevator core in two sections.

Four and Five World Trade Center contain central air handling systems MERs on the ninth floor and in the Subgrade. The ninth floor MERs house peripheral, interior, and core air handling units and return and exhaust fans that serve the third to ninth floors. The below grade MERs in Four and Five World Trade Center (289.5 and 285.5, respectively) serve the public spaces, Plaza and Concourse. In addition, they house auxiliary service outdoor units that serve the concourse mall tenants by providing conditioned outdoor air to the air handling units within the tenant spaces. There are also small MERs on the third floor of Four and Five World Trade Center.

The Subgrade is serviced by One and Two World Trade Center MERs from B-6, with main supply air. The subgrade contains a series of transfer fans, exhaust fans and unit heaters.

Electrical service

The Power Authority of the State of New York ("NYPA") is the sole supplier of electric power and energy to the World Trade Center. NYPA supplies the electricity under contract to the Port Authority for the Port Authority's own use and for redistribution to tenants. The Port Authority does not purchase electricity for the Marriott World Trade Center Hotel (Three World Trade Center) or Seven World Trade Center. Electricity for the World Trade Center is obtained from the main substation, maintained by Con Edison and located on Barclay St. and West Broadway under Seven World Trade Center. The substation supplies the World Trade Center through eight 1,200 ampere 13.8 kV feeders. The 13.8 kV feeders are distributed through the World Trade Center from the main power distribution center on the B-3 level to 25 Port Authority owned and operated substations and two refrigeration plants located throughout the World Trade Center. All of the transformers in the 25 substations are dry-type transformers. Electricity is sufficient on most floors of the World Trade Center to provide 10 watts per usable square foot with primary and secondary voltages of 480/277 volt, three phase, four wire and 208V/120 volt, three phase, four wire, respectively via a Bus Duct system in the towers. The 10 watts per square foot capacity is more than sufficient for lighting receptacles and supplemental HVAC installations.

Supplemental HVAC typically takes the form of localized electrically driven water cooled units which are required when demand exceeds 4 to 4.5 watts per square foot In addition, certain tenants require that their computer operations be maintained at low temperatures 24 hours a day requiring the installation of electrically driven water-cooled units. The World Trade Center is served by two backup systems: (1) stand-by generator systems on level B-6; and (2) tertiary power from Public Service Electric and Gas (PSE&G) of New Jersey which can, in the event of an emergency blackout by Con Edison and failure of the emergency generator plant on B-6 level, pick up selected life safety and egress loads. The tertiary power feeder from PSE&G is delivered via a tap to the PATH feeders run through the PATH tunnel under the Hudson River to the World Trade Center. In addition, certain tenants are tied into a tenant standby power system, which consists of four 2,200 kw Caterpillar 13.8 kV diesel generators. In the future, this will be expanded to six generators. The generator plant is located on the roof of Five World Trade Center. Power is distributed at 13.8 kV to various stand-by power substations located in selected MER rooms. Stand-by power is provided to certain tenants on a recoverable basis.

The stand-by generator system consists of six 1,000 kW Waukesha Diesel generators located on level B-6. The total plant capacity is at 277/480 volts three phase. All six generators feed into a common distribution bus, called the Left and Right Main Distribution Boards. From the Left and Right Main Distribution Boards power is fed directly to the Emergency Power Centers ("EPCs") of One, Two, Four, Five, and Six World Trade Center. EPCs are comprised of one or more air circuit breakers and two automatic transfer switches. EPCs also supply power to the elevator transfer switches for controlled emergency evacuation of elevator passengers. The stand-by generator will start automatically only when power to the emergency lighting panels fails.

Plumbing

The plumbing system for the World Trade Center is typical of other Manhattan office buildings with steel, copper and cast iron piping throughout the World Trade Center. Restrooms for men and women are located on each floor of the World Trade Center and in the Concourse and Subgrade.

Sanitary systems

The gravity sanitary system consists of soil and waste stacks and vent stacks which serve the plumbing fixtures, mechanical equipment, floor drains and kitchen equipment on the various floors in the building. The gravity system drains to the building drains to a large concrete pipe on the B-1 level, which connects the 30-inch sanitary line on B-1 to the, New York City sewer system.

The plumbing fixtures, mechanical equipment and floor drains located below grade drain to the various sewage ejector pits located on level B-6. The pump discharge from the ejector pumps is connected to the building drains, after the house trap, at the building wall.

Storm system

Roof drains and leaders convey the storm water by gravity to the various building drains, located on level B-1, which connect to the 36-inch storm watch drain that discharges into the Hudson River. The subsurface water and the machinery drips are drained into the various sump pits located in level B-6. The sump pumps discharge the clear water into two 36-inch storm water drains on level B-1.

Domestic cold water system

There are three pumping stations located in the MERs on level B-1 (elevation 294 feet), 41 and 75. Each pumping station consists of four pumps, a backflow preventer, an air cushion tank, a high pressure switch, a low pressure switch, main and standby pressure electric transducer, four individual controllers, a master controller, and a pressure-reducing valve system that controls the water pressure in the zone that it serves.

Domestic hot water system

The domestic steam-fired hot water system consists of hot water preheaters, hot water heaters, and hot water circulation pumps for each zone in the building. The equipment is located in the MERs on floors 7, 41, 75 and 108. The water from the hot water heaters is supplied at 105 degrees Fahrenheit to the various floors by means of the hot water distribution system. The hot water circulation pumps circulate water through the piping system to maintain the hot water temperature.

Elevators

The Complex's state-of-the-art internal transportation system includes a total 240 elevators and 63 escalators. Each tower building is serviced by 21 high-speed express elevator cars, and 72 local cars. In addition, One World Trade Center and Two World Trade Center are serviced by 10 and 8 large freight and service elevators, respectively. Several years ago a $127 million modernization program to install a state-of-the-art computerized elevator control system and refurbish elevator cab interiors was undertaken. The control system project is nearly 50 percent complete, and the elevator cab interiors are 100 percent modernized.

Elevators are also being upgraded to include new elevator car operating stations, car position indicators, corridor push button stations, lanterns and tactile markers for the disabled. This project is 99 percent complete. 108 passenger and three service elevators have been completed to date, including the addition of new elevator group dispatch, car signal controls, control systems with future capability to add new closed loop feedback motor control systems, new static power converters, trail cables, adjustments, signals, lobby panels, safety tests, emergency controls and related hardware. New static power converters have been installed on four shuttle cars in Two World Trade Center, two shuttle cars in One World Trade Center, and all local elevators.

Domestic water:

Domestic water for the World Trade Center is supplied by the City of New York from the water main on Greenwich Street to the Subgrade.

Fire and life safety:

The World Trade Center is sprinklered (wet system) with a combination fire standpipe sprinkler system. The fire system is fed by two, eight-inch fire loops located in the Concourse and in level B- 1 ceilings,- with Siamese connections located on the exterior walls of the complex for the use of the Fire Department. There are four fire pumps and four fire reserve tanks located in One World Trade Center and four each in Two World Trade Center.

The sprinkler system distributes water from holding tanks filled by the domestic water supply and distributed through three risers to One and Two World Trade Center. One and Two World Trade Center contain one riser per zone, accessible from each floor through the service closets. In each tower, the system includes one 5,000 gallon combination sprinkler/standpipe and one 10,000 gallon tank on the 110th floor, and one 5,000 gallon combination sprinkler/standpipe gallon tank on the 42nd floors. Additional 5,000 gallon tanks are on the 75d'floor MER for the standpipe system in each tower. Both One and Two World Trade Center contain two sprinkler pumps located on the B-1 level and 108th floor MER. The B-1 pumps pressurize the

Subgrade, Concourse, and Plaza building sprinkler systems. The 5,000 gallon tanks on 42 are shared with the fire standpipe system.

The sprinkler system for Four and Five World Trade Center and Subgrade are separate from those for One and Two World Trade Center. The Subgrade is served by downfeed risers from the B-1 loop while Four and Five World Trade Center are served by upfeed risers from the Concourse loop. The Concourse loop also serves the stores within the mall. One and Two World Trade Center contain two sprinkler pumps each, located in the B-1 level and 108th floor MER. The B-1 pump pressurizes the Subgrade, Concourse, and Four and Five World Trade Center sprinkler systems. The pump on 108th floor supplies fire protection water to the upper floors (99 to 110).

In addition, the complex features fire command stations in each lobby which is equivalent to a Class E fire alarm and recall system found in most Manhattan office buildings. Important elements of the fire safety system are summarized as follows:

- There are three stairwells per floor in One and Two World Trade Center and five stairwells per floor in Four and Five World Trade Center. The stairwells feature fire hoses on each floor and the stair-wells are compartmentalized and fire stopped. The stairwells are also painted with phosphorescent paint, which glows in the dark. At minimum, every fourth floor is a "re-entry floor" (i.e., unlocked and available for re-entry from the stairway). The remaining stairways may be secured for security purposes. Signage identifies re-entry and non-re-entry floors. There are no failsafe automatic opening devices on the stairway doors.
- An alarm system with auxiliary lighting, posted fire exits and pull boxes on each floor
- A detailed fire safety plan including periodic fire drills and evacuation supervisors on each floor
- Powered exit signs and lights, in addition to stair and elevator signs
- Automatic sprinklers on all floors of One, Two, Four, and Five World Trade Center (with the exception of the lobby and mezzanine levels) and the Concourse.
- A communication system details the location of the detection device on a CRT at the fire command station in the building lobby and on a printer and provides an audible alarm. In addition, a message is manually sent to the New York Fire Department detailing in what building the fire alarm has sounded. Floor warden stations are located on each floor to provide direct communication with the fire command stations, fire director and fire department

Antenna:

One World Trade Center contains a 360-foot welded steel tube antenna mast which rises 1,728 feet above ground and is used by 14 television and radio network broadcasting in the New York metropolitan area. The mast is protected from lightning by a metal earthing cable that connects steel building columns designated for earthing.

Telecommunications:

The World Trade Center offers telecommunications services from multiple vendors via diverse entrance facilities. The number of carriers, together with the degree of fiber and copper capacity, in the World Trade Center provides tenants with advanced telecommunications services, as well as a variety of disaster recovery options.
The World Trade Center has an on-site Bell Atlantic switching station, fiber optics service from every major vendor, and direct or common-carrier microwave capability.

Bell Atlantic:	Bell Atlantic provides a full range of telecommunications services to World Trade Center tenants The utility maintains a switching office in Two World Trade Center on floors 10 and 11. It can also provide service from its 140 West Street and Pearl Street central offices to tenants requiring diverse routing and an alternate wire center or the highest reliability and business continuity. Bell Atlantic has installed a 204-fiber ring in One and Two World Trade Center that is routed to cover both sides of the buildings. Similar systems exist in the Four and Five World Trade Center. The fiber-ring systems assure that any single failure will immediately send an alarm to Bell Atlantic while assuring uninterruped service to the tenant. Breakout boxes installed every three floors provide tenants with convenient access to fiber connections.
Operations control center:	The operations control center, located in the Subgrade, is a sophisticated computer assisted monitoring system. Staffed seven days a week, 24 hours a day, it provides monitoring of all building systems including HVAC, fire alarm, elevators and security. The operations control center contains television screens which monitor the public areas of the complex through dozens of remote controlled cameras.
Access control	Access from the lobby areas of each building to the office floors is by access card or security desk check-in only. There are two types of access cards, proximity cards and scan cards. Proximity cards are used by tenants and long-term contractors while scan cards are used by less frequent visitors. In addition, the World Trade Center uses a system of over 100 turnstiles along with security cameras. This system is staffed at the security control area and linked by a fiber optic network. The parking garage is accessible by access card only; only tenant parking is permitted in the Subgrade. The loading docks, accessible from gated and guarded entrances off Barclay Street, use an identification system for all deliveries.
Port Authority Police:	The Port Authority police patrol the exterior areas of the World Trade Center as well as the Concourse, Subgrade and PATH station 24 hours a day and respond to calls from within the World Trade Center.
Interior detail office floors:	The office floors in One and Two World Trade Center are shaped with a square perimeter and have interior offices that are column free. The core is located in the center of each floor containing elevator shafts and stairwells, electric and telephone closets, service closets for steam, chilled water and sprinkler risers, and storage closets. The core includes a men's room and one or two women's rooms.
	The office floors in Four and Five World Trade Center are "L" shaped with perimeter and interior offices and 30-foot column spacing. The core is located in the center of each floor.
Plaza retail floors:	One, Two, and Six World Trade Center do not contain "plaza retail" space. Four and Five World Trade Center contain retail space on floors one through three (the Concourse, Plaza, and third floor). The second and third floors in these buildings also contain commercial and building service space.
Floors:	Floors through the office corridor and lobby areas contain either carpet, ceramic tile, granite, marble, terrazzo or terra cotta finish.

Ceilings:	The majority of the ceilings are suspended acoustical tile on the office floors and elevator corridors. Ceilings in the public areas consist of a variety of masonry types
Walls.	Walls in the office areas are covered with dry wall, vinyl wall coverings and paneling in some office areas. The lobbies, passenger elevator lobbies' trim, and Concourse contain marble and ter-ra cotta finish.
Lighting:	A combination of fluorescent and incandescent lighting fixtures are used throughout the office and retail areas as well as the elevator corridors. In addition, there are chandeliers in the lobbies and flood lights on the exterior areas.
Doors	The majority of the office entrance doors off the corridors are painted hollow or solid metal doors. There are also a wide variety of door types depending on use including large steel roll up doors for subgrade access.
Asbestos containing material:	The Complex, principally the lower floors or zones of One and Two World Trade Center and areas of the Concourse and Subgrade were constructed during the time period (1966 to 1970) when asbestos was used as a fire retardant. As a result, sprayed on asbestos is present within the sixth floor catwalks, mezzanine substructure, elevator shafts and machine rooms, interior core pipe chases, and electric and phone closets of One and Two World Trade Center. Additionally, asbestos-containing thermal system pipe insulation is present in the concourse ceiling plenum and in MERs, while vinyl asbestos floor tiles are present throughout the complex. The Port Authority has removed a large portion of the asbestos material typically located on the structural columns and on pipe insulation from tenant floors in One World Trade Center, and has removed much of the pipe wrap insulation found in the Subgrade. The practice of containment has not been implemented at the World Trade Center. In addition to full-scale abatement projects, the World Trade Center has instituted an ongoing operations and maintenance program whereby specific individuals on the staff are trained as certified ACM handlers and can respond with appropriate equipment and procedures to manage incidental ACM incidents. Tenants whose space may contain ACM have been formally notified.
Americans With Disabilities Act:	The Port Authority has completed a number of ADA projects. Common areas are equipped with access ramps, guard rails, automatic doors and elevators for the disabled. Signage and water fountains also have been modified for the disabled. There is also an ongoing program to replace all signs on multi-tenanted floors with ADA-compliant signs. The single tenant floors are, on a tenant-by-tenant basis, in the process of being equipped with bathroom facilities for the disabled and all new tenant installations include either both men's and women's accessible bathrooms with facilities for the disabled or a single unisex bathroom
Building Code:	The long-standing policy of the Port Authority has been to assure that the World Trade Center meets and, where appropriate, exceeds the requirements of the building and fire codes of the City of New York. The Port Authority has provided specific commitments to the City of New York that the World Trade Center would be

operated in conformance with the standards set forth in the New York City Building Code (the "Code"). In certain instances the Port Authority has established and may establish in the future standards that exceed those set forth in the Code, and the net lessee will be required to adhere to the Port Authority's standards in such cases.

Compliance with state and local laws

Pursuant to existing bi-State legislation, the Port Authority has exclusive jurisdiction with respect to certain administrative and governmental matters pertaining to the Trade Center. As such, in connection with the Transaction, the Port Authority will continue to maintain its jurisdiction and oversight with respect to these areas, including:

- Compliance with applicable building codes, as defined by the Port Authority and subject to agreements with the City of New York, for all future construction projects, both in tenant spaces and common areas
- Compliance with fire, environmental, and health codes
- Operating integrity of the elevator/escalator systems, electrical and mechanical systems, as well as the structural integrity of the Complex
- Administration of the high tension electrical distribution system
- Port Authority police services
- Office tenant eligibility consistent with legislation pertaining to the World Trade Center's world trade and commerce function

On site parking

There are 1,431 parking spaces located in the Subgrade that are available only on a monthly basis to employees and tenants of the World Trade Center. It is assumed that the Port Authority staff and police personnel will use 110 spaces as part of the PA lease free of charge, leaving 1,321 for the net lessee(s) to rent. Transient parking is, and under the net lease will continue to be, prohibited.

FIRE PROTECTION

FIRE ALARM SYSTEM

The Fire Alarm system in the WTC combines fire alarm signaling with an intercom, enabling fire safety personnel to speak to the person turning in the alarm. Alarms may be turned in at Break-Glass Stations in public and common areas throughout the Trade Center. Control and intercom equipment for the system is monitored in the Police Security Room located at level B-1.

An alarm signal is transmitted to one of many intercom panels in the Fire Alarm Console where it is processed. Each intercom panel represents a separate fire zone and there is a reel-to-reel tape recorder that transcribes conversations made over the fire intercom system.

PA employees test the fire alarm signal boxes monthly.

SMOKE DETECTION AND ALARM SYSTEM

There is smoke detection and alarm systems protecting the return air ducts, elevator lobby and the ventilation duct in the Mechanical Equipment Rooms (MER's).

The return air system has detectors in the hung ceiling of each tenanted floor, in close proximity to the intake of the return air ducts. The detectors are connected to a computer-multiplex system, which scans each smoke detector and reports alarm conditions to the Police Security Room on level B-1.

There is at least one smoke detector at the ceiling of each elevator lobby, directly above the elevator call button. These detectors transmit to the Police Security Room and cause the elevators to return to their main lobby.

The ventilation alarm system monitors the supply and return air ducts in the MER's. The system shuts down the affected ventilation fans and alerts police security personnel when smoke or products of combustion are detected in the supply or return air ducts. The MER exhaust fan ducts are monitored and controlled in a similar manner.

All detectors are inspected and tested annually by PA personnel.

TENANT SMOKE ALARM SYSTEMS

Many tenants have their own smoke alarm systems. These systems are inspected and tested at least annually in accordance with the equipment manufacturer's specifications.

SMOKE PURGE SYSTEM

After a fire has been extinguished in the Towers the smoke purge procedures draw in fresh outside air and exhaust the return air from the building. The Fire Safety Director initiates the operation by having the smoke purge switches (there is one for each quadrant) in the MERs turned on.

WATER SUPPIES FOR SPRINKLER AND STANDPIPE SYSTEMS

The primary water supplies for the WTC consist of connections to 12" city mains and total capacity in 14 steel gravity tanks of 70,000 gallons. These water supplies are delivered to sprinkler and standpipe systems by a total of 12 pumps. The tanks are automatically refilled from a 2" connection to the domestic water system.

Eight of the pumps are multi-stage, high net head pumps serving the standpipe system. These eight pumps are 3-stage, Peerless pumps rated at 750 gpm with net heads from 228 to 360 psi. These pumps are situated on the following levels: B-1, 7th, 41st, and 75th floors of each tower.

On floor 108 of both towers there are 500 gpm Peerless pumps with a net head of 60 psi. These pumps take suction from 5,000-gallon steel gravity tanks and provide water supplies to both the standpipe and sprinkler systems for the top floors (sprinklers - floors 99 to 107 and standpipe floors 99 to the roof)

At level B-1 there are two separate, 1500 gpm, Peerless pumps with net heads of 90 psi, taking suction from separate 12" connections to city mains and supplying the sprinkler systems protecting the Northeast Plaza Building (NEPB), Southeast Plaza Building (SEPB), Concourse level, and the 6 Subgrade areas.

SPRINKLER SYSTEMS

Sprinklers protect all tenanted floors in the towers. The exceptions are: all Mechanical Equipment Rooms (MERs), Chiller Plant, Power Distribution Plant and Auxiliary Condenser Water Room.

The design of the sprinkler systems of both towers is similar. The direction of water flow within the risers is downward. Each tower has three separate risers, with each serving different groups of floors. Riser A supplies the top most floors, 99 through 110; Riser B supplies floors 98 through 32; and Riser C supplies floors 31 through 1. Water supplies for systems A and B are from the 10,000- gallon, steel sprinkler tank on the 110th floor. The 5,000-gallon steel tank on floor 41 serves both sprinklers from riser C and standpipe systems. The C risers for both buildings are interconnected through a divisional control valve that allows isolating in the event of impairments. There are separate control valves for each floor in the towers as well as water flow switches, tamper alarms and 2" drains. The down risers are equipped with divisional or isolation valves on floors 1, 15,and 67 of Tower A and on floors 1, 15 and 77 of Tower B.

The 500-gpm 60-psi pumps on floor 108 of both buildings serve to boost water pressure to the sprinklers on floors 107 to 99 and the fire hose header on the 110th floor. As the downward distance from the holding tanks increases below the 99th floor additional pump pressure is not required. Pressure Control Valves (PCV's) are used to control water pressure on the lower floors.

The rest of the WTC complex, namely the Subgrades B-1 through 6, Concourse, NEPB, and SEPB are served by a second completely separate fire protection system. This system consists of two - 8" loop mains, with isolation valves, feed by two 1500-gpm 90 psi booster pumps. One loop main feeds sprinkler risers going down to the Concourse and Subgrades and up risers into the NEPB and SEPB are feed through the other loop main.

Sprinkler systems for the stores in the Concourse are fed off completely separate risers from the sprinklers in the common areas. The system was design in this manner to insure a fire originating in an impaired store would be confined to that store while sprinklers in the common area that were feed from a separate unimpaired riser.

The booster pumps deliver fire protection water at 150 psi to the loop mains.

Both the tower systems and the Concourse/Subgrade systems have multiple siamese connections for the NYC Fire Department.

The World Trade Center, "Design Guidelines, Guide Specifications, and Standard Details" requires all tenant areas to be protected by a sprinkler system designed in accordance with NFPA Standards. All systems are hydraulically designed. Office spaces are designed for light hazard occupancy with a minimum of 0.1 gpm per sq. ft. over the most remote 1,500 sq. ft. and protected area per sprinkler not exceeding 225 sq. ft. Protection for commercial spaces, and storage areas, are designed to the requirements of NFPA 13. Sprinkler systems for Restaurant Service Areas and Concourse Retail Stores are designed to 0.16 gpm per sq. ft. over 1,500-sq. ft. with a maximum 130-sq. ft. per head of protected area.

Electrical and telephone closets are not sprinkled, however no storage of combustibles is allowed. closets have 2 hour-rated walls with penetrations protected, and a smoke detector connected to the alarm system installed in the closet.

Smoke curtains, in the form of dropped soffits, with a water curtain provide protection for tenants with internal staircases. Water curtains consist of closed sprinklers spaced 6'-0" on center, 12 in. from the opening.

All openings between the main Concourse public corridors and tenanted spaces are protected with a water curtain. The Water curtain consists of closed heads spaced 6'-0" on center, 12 in. from the opening on the tenants side.

Sprinkler control valves are located in the janitor closets on each floor of the Tower buildings. The floor control valves consist of either a manual operated gate valve (OS&Y type) or a combination pressure reducing and shut-off valve, with tamper switch, water flow alarm, pressure gage, inspector's test connection and drain valve. Pressure reducing valves (PRV's) are set at a locked out outlet pressure (at no flow) of 125 psi.

FLOOD

The World Trade Center (WTC) is located near the southern tip of Manhattan Island and in close proximity to where the Hudson River becomes New York Harbor. The westerly side of the WTC is within the 100-year flood zone (zone A). A category 2 or 3 hurricane (wind velocities from 95 to 130 mph) has the potential to raise the river/harbor water above the level of West Side Highway (now known as Joe DiMaggio Highway) that runs along the west side of the property.

The following table displays the openings on the west side of the property and level that the 100-year flood would exceed the elevation of the openings.

OPENING	HEIGHT OF WATER ABOVE OPENING
1 WTC Sidewalk	0.00'
2 WTC sidewalk	0.00'
Vista Parking Lots	0.25'
H Ramp to Hotel	0.85'
6 WTC West Street Garage	1.05'
C Ramp - Down North Bound	1.25'
A Ramp - Up South Bound	1.50'
B Ramp - up North Bound	1.85'
D Ramp - Down South Bound	1.93'
6 WTC Vesey Street Doors	2.45'

The scenario that creates the 100 year flood assumes the storm striking the New Jersey coastline somewhere above Atlantic City, tracking north-northwest, with its eastern edge, where the winds are the highest, pushing the storm surge through the outer reaches of New York Harbor (between the New Jersey and Long Island Coasts) and up into New York Harbor. This scenario further assumes the storm striking at high tide and when there is a full moon.

The National Weather Service forecasts and tracks hurricanes. They also provide advisories as to where the storm is located, wind intensity and speed as well as the direction of travel. A "hurricane watch" is issued for coastal areas when there is a threat of hurricane conditions within 24 to 36 hours. A "hurricane warning" is issued when hurricane conditions are expected in a specified coastal area in 24 hours or less. These warnings provide ample time for the implementation of emergency procedures. With this advanced notice from the National Weather Service, a worst case assessment of a tidal surge can be made at least 12 to 16 hours in advance. Then in conjunction with the Mayor's Office of Emergency Management (which is located in 7 WTC) there is ample time to make the decision to close the WTC and protect exposed openings.

Any seepage of storm water through the exposed and sandbagged openings can be expected to migrate through the subgrade levels until reaching level B-6. At this point any seepage would continue to flow down on to the Path Train tracks that run at a still lower elevation. The Path systems sump pumping system would then evacuate the water.

The following pages are taken from the Emergency Procedures Manual and illustrates the number of sandbags required at each location and the assignments for personnel from each department.

100 YEAR FLOOD PENETRATION POINTS

RAMP H TO HOTEL OPENING 16'
FLOODWATER HEIGHT .85'
SANDBAG TO HEIGHT 1.25'
SANDBAGS REQUIRED 92

RAMP A (SOUTHBOUND)
OPENING 16.5' FLOODWATER
HEIGHT 1.5' SANDBAG TO
HEIGHT 2.0 SANDBAGS
REQUIRED 148

HOTEL PARKING LOTS-WEST ST.
OPENING 30'
FLOODWATER HEIGHT .25' SANDBAG
HEIGHT .50' SANDBAGS REQUIRED 86

SOUTH PROJECTION OPENING
14' FLOODWATER HEIGHT 1.5'
SANDBAG TO HEIGHT 2.0'
SANDBAGS REQUIRED 124

RAMP C(NORTHBOUND)
OPENING 15.5' FLOODWATER
HEIGHT 1.25' SANDBAG TO
HEIGHT 1.75' SANDBAGS
REQUIRED 120

RAMP B (NORTHBOUND)
OPENING 16' FLOODWATER
HEIGHT 1.85' SANDBAG TO
HEIGHT 2.40' SANDBAGS
REQUIRED 184

6 WTC - VESEY ST. GLASS DOORS
OPENING 24'
FLOODWATER HEIGHT 1.75
SANDBAG TO HEIGHT -2.25'
SANDBAGS REQUIRED 240

RAMP D (SOUTHBOUND)
OPENING 16' FLOODWATER
HEIGHT 1.93' SANDBAG TO
HEIGHT 2.50' SANDBAGS
REQUIRED 184

NORTH PROJECTION VENT
OPENING 11' FLOODWATER
HEIGHT 3.25' SANDBAG TO
HEIGHT 1.75' SANDBAGS
REQUIRED 80

NORTH PROJECTION DOOR
OPENING 5'
FLOODWATER HEIGHT 1.25'
SANDBAG TO HEIGHT 1.75'
SANDBAGS REQUIRED 38

6 WTC -WEST ST. GARAG E
OPENING 60' FLOODWATER
HEIGHT 1.05' SANDBAG TO
HEIGHT 1.55' SANDBAGS
REQUIRED 516

6 WTC VESEY ST. - DOOR A
OPENING 3.5' FLOODWATER
HEIGHT 2.45' SANDBAG TO
HEIGHT 3.0 SANDBAGS
REQUIRED 38

6 WTC - VESEY ST. GARAGE
OPENING 31' FLOODWATER
HEIGHT 2.45' SANDBAG TO
HEIGHT 3.0' SANDBAGS
REQUIRED 412

12-5.1 LIFE SAFETY AND SECURITY

- Depending on the circumstances and activities, respond to the scene of the incident or the appropriate Fire Command Station to assume fire safety responsibilities.
- If necessary, coordinate activities with the New York City Fire Department and other emergency response personnel.
- Initiate evacuations, if necessary.
- Direct use of public address announcements, if necessary.
- Deploy security officers to secure area(s) and deny access to unauthorized individuals.
- Dispatch "key runs" as appropriate.
- Authorize use of temporary or special identification cards valid for duration of emergency.
- Authorize and issues temporary parking permits to emergency response personnel as necessary.
- Direct security contractor to have personnel "stand by" as needed.
- Call in additional Life Safety and Security staff as needed.

12-5.2 POLICE

- Make all appropriate notifications listed in Exhibit 12A.

Note: If requested, dispatch officers to close roadways and redirect traffic to facilitate the installation of sandbags.

12-5.3 OPERATIONS and MAINTENANCE MANAGEMENT

- Make all appropriate notifications listed in Exhibit 12A.
- Secure parking garages and install sandbags as indicated in Exhibit 12D.
- Request the assistance of Construction if necessary.
- Inventory barricades, cones, emergency signs and emergency lights to close off the peripheral roads and the Plaza.
- Direct Porters to clear all drains in Plaza, both Towers and truck dock ramps.

Mechanical Section

- Supervisor reports to River Water Pump Station with two craftpersons and initiates these procedures:

◊ Verify that all floor deck hatches in the "un-diked" areas to sluiceways and pump station chambers are secured and sealed.
◊ Verify that all watertight bulkhead doors are secured, namely to the switchgear room and to the traveling screen room.

In the Event of a Power Failure

- Start one or both of the emergency pumps and maintain operations even if the water rises above the operating floor level..
- Recheck the river water level in the sluiceway and throttle the associated sluice gate accordingly to prevent flooding.

Electrical Section

- Secure affected electrical systems.
- Operate Emergency Generator Plant as needed.
- Provide portable emergency power where needed.

General Maintenance Section

- Assist in installing sandbags as requested.

Supervising Engineer

- Based upon most current weather forecast, perform facility survey and identify equipment to be secured. Report findings to Life Safety & Security Division and Director's office.

12-5.4 VERTICAL TRANSPORTATION

- Direct elevator maintenance contractor to secure affected elevators, monitor conditions and make any necessary repairs if necessary.

12-5.5 CONSTRUCTION DIVISION

- Assist in installing sandbags as requested.

12-5.6 PROPERTY MANAGEMENT

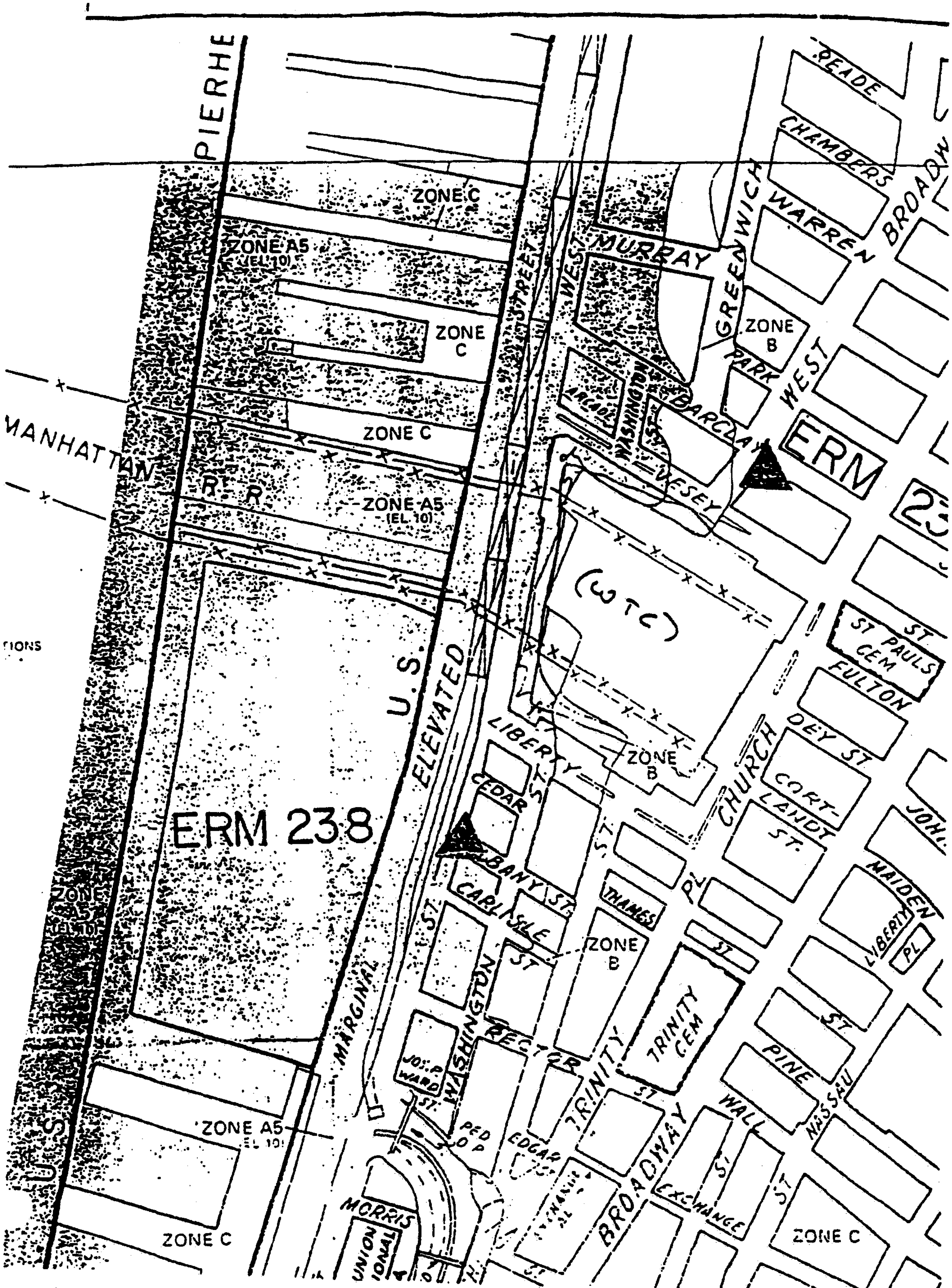
- The General Property Manager responsible for the property involved in the incident will assume full responsibility as the WTC Liaison Officer and will be stationed in the lobby at the Fire Command Station/Elevator Console area.
- The General Property Managers from the other buildings along with the Senior Property Manager and staff of the affected property will assist the Liaison Officer in the lobby.
- The Senior Property Managers and their staff from the unaffected properties will report to the Situation Room and Property Management Office at the Operations Control Center and activate all telephones, computers and the Emergency Tenant Notification System.

- The Senior Property Managers will assume all responsibility for disseminating all pre-cleared information to staff and tenants. One staff member will act as the official scribe, maintaining a constant record of events as they occur.
- The Liaison Officer will be responsible for notifying the Chief Operating Officer and Media Relations, if applicable, and will work closely with Senior World Trade and Port Authority Staff as well as all World Trade Center Units – Life Safety & Security, Police, Vertical Transportation, Engineers Office, Central Systems, General Maintenance, Locksmith Shop, Construction, Project Management and Operations Management.
- If necessary, a representative from Media Relations will also be in the lobby to field questions from the media/press.

- ◊ Verify that climax plugs are secured in place in the floor drains located in the fresh air intake plenum in areas 1 and 2.
- ◊ Notify Operations Control Center and Refrigeration Plant of high water conditions.
- ◊ Transmit north and south sluiceways high level alarm and diked area alarm to verify their performance.
- ◊ Place electrical disconnect switches in the off position for the two tubular chlorine pumps.
- ◊ If sodium hypochlorite solution tanks are empty, or near empty, partially fill with fresh water to prevent buoyancy.
- ◊ Provide an emergency water hookup from the hose bib at the water meter to the main flushing piping to the river water pump line.
- ◊ Place electrical disconnect switches in off position for the domestic water bearing lubricants and flush pumps.
- ◊ Prior to the tidal serge, place plastic sheets and sandbags over fresh air intake plenum and the exhaust fan discharge grills on top deck of Pump Station.
- ◊ Keep Pump Station chambers empty.
- ◊ If tide water rises to one foot above capacity level, contact Mechanical Contract Management, Port Authority Chief Maintenance Supervisor or Port Authority Maintenance Unit Supervisor.

- Activities During Actual Tidal Surge (To be performed under the direct supervision of the Mechanical Contract Supervisor)

- ◊ Select a pump suction chamber that will be dewatered.
- ◊ Notify Refrigeration Plant Engineer that all river water pump will be secured for a 10 to 15 minute period.
- ◊ Secure all operating river water pumps.
- ◊ Close sluicegate #3 or #5 depending on which pump suction chamber will be dewatered.
- ◊ Close sluicegate #4.
- ◊ Start necessary river water pumps in active pump suction chamber to support restoration of Refrigeration Plant.
- ◊ Notify Refrigeration Plant to start necessary refrigeration machines to the limit that one active pump suction chamber can handle.
- ◊ Start one river water pump in the pump suction chamber that will be dewatered.
- ◊ Intermittently operate one river water pump to lower the water level to a depth of 12 feet below the slab.
- ◊ The water level in the operating sluiceway should be below the operating floor deck but higher than the minimum level required to maintain adequate suction pressure.


PIERHE
ZONE C
ZONE A5
(EL 10)
ZONE C
MANHATTAN R R
ZONE C
ZONE A5
(EL 10)
ERM 238
U.S. ELEVATED
MARGINAL
WEST STREET
MURRAY
GREENWICH
WARREN
CHAMBERS
READE
BROADW
ZONE B
PARK
WEST
BARCLAY
WASHINGTON
VESEY
ERM
(WTC)
ST PAULS CEM
FULTON
LIBERTY ST.
ZONE B
CEDAR
CHURCH
DEY ST.
CORTLANDT ST.
ALBANY ST.
CARLISLE ST
THAMES
ZONE B
RECTOR
TRINITY
TRINITY CEM
MAIDEN
LIBERTY PL
PINE
WALL ST
NASSAU
BROADWAY
EXCHANGE
MORRIS
EDGAR
ZONE A5
ZONE C
ZONE C

PROBABLE MAXIMUM LOSS

Probable Maximum Loss From Fire

This discussion is based on circumstances and protection criteria outlined in the "Risk Classification and Loss Estimate for High-Rise Buildings", PM.5.6.1, dated September 1995 (see appendix) and the FM's Property Loss Prevention Data Sheet 1-3, titled "High-Rise Buildings" and "MFL of High-Rise Buildings".

The underlying premise of this PML is that a fire originates on an upper floor (assume 90th floor) with the sprinkler protection out of service and that the fire floor is connected to the floor above via unprotected, open stairs.

Under these conditions fire damage would be expected on floors 90 and 91. Floors 93 through 97 would receive varying degrees of smoke damage and floors 85 through 89 would receive damage from the water used to extinguish the fire.

Assuming that criteria, a building value for a tower of $1.19b ($250/sf) and a floor value of $10.8m, then the damage to the fire floors, at 100%, would amount to $21.6m. If smoke damage averaged $2m for the 5 floors above the fire or a total of $10m and water damage of $2m to the 6 floors below the fire floor, then a PML in the range of $40m could result. In reality the combustible loading of the typical occupancy in the Towers is not sufficient to create the spalling and ensuing structural damage associated with this scenario and a PML in the $10-20M range is reasonable.

The mitigating circumstances are an outstanding, well-trained PA emergency organization and the close proximity of the NYC Fire Department that monitors the PA's emergency communication channels and would be responding before being called.

Probable Maximum Loss From Flood

In the event of a stage 2 or 3 hurricane coming ashore along the New Jersey Coast and coinciding with a full moon and high tide, it is possible for the waters of New York Harbor to rise to a level where the water level might be slightly higher than some of the grade level openings along the west side of the WTC complex. See Flood Appendix for a discussion of this type of event and emergency procedures to deal with it.

The failure at one of the sandbagged openings could allow floodwaters to enter the Subgrade levels. There could be some build up of water in levels B-1 to B-5 with the greatest buildup at level B-6 with ensuing damage to the electric motors and controls for the New Chiller Plant.

Assume:

- Catastrophic failure of the sandbagging protection at the lowest opening - 6WTC Vesey Street Door.
- Tidal flow of 2 knots per hour = 12,200 feet / hour.
- Opening allowing water to enter Subgrade 2.45' high and 30' wide = 73.5sf
- Failure lasts for 3 hours
- Floor area of B-6 level = 1/6th of 2,656,435sf or 442,739sf

Then: Depth of water at B-6 level = 73.5sf X 12,200ft/hr X 3hrs / 442,739sf = 6 feet.

The mitigating circumstance to this scenario is that the B-6 level has a large opening into the Path train tracks. This opening is large enough to allow major pieces of equipment to be brought to this area by Path train, then off loaded into the B-6 level. Therefore storm floodwaters seeking the lowest level would leave the B-6 level filling the Path tunnel (if the tunnel's sumps failed).

Assuming the Path Tunnel to be 1.5 miles long and having a 30-foot diameter or an area of 1400sf

1.5mi X 5280f/mi X 1400 = a volume of about 11 million cu. ft.

It would take about 12 hours to fill the Path tunnel at this rate of flow, of 2 knots per hour, through the failed sandbag dike at the Vesey Street Door.

Conservative estimates of the potential damage to machinery, electric motors and electronic controllers on levels B-1 to B-5 run to $2-3m per level or a total of $15m on the high side with the potential of another $10m on level B-6, for a total PML of $25m.

MAXIMUM FORSEEABLE LOSS

1993 Terrorist Bombing

The 1993 terrorist bombing of the WTC resulted in a maximum foreseeable property loss. This event shut Tower 1 down for 6 weeks and Tower 2 for 4 weeks. The explosion, that occurred in the garage area of B-2, caused portions of the Plaza and two Subgrade floors (about 4 bays by 4 bays) to collapse on to the B-6 level damaging mechanical and electrical equipment of the Chiller Plant. As large a blast as it was, there was negligible structural damage done to structural members. Damage was limited to the replacement of these concrete floors, repairing spalled concrete where reinforcing steel had been exposed and rebuilding non-bearing walls.

The magnitude of this type of MFL loss can be estimated at 5 weeks rent or 1/10th of the $364m annual rent or $35m. Plus property damage to the building from the 1993 incident is estimated to be $175m and equipment damage of $120m or a total of $330m.

The mitigating circumstance to a reoccurrence is the control that is in place to prevent this from happening again. The rigorous security controls now in place have significantly reduced the likelihood of this type of incident. No one can gain entrance to the towers without authorization from a tenant, presenting a photo ID and being photographed. There is a lower than average probability of a reoccurrence as access to the premises is now severely restricted. Expert opinion suggests that there are many more easily accessed sites for any group attempting this sort of protest. The guards physically check trucks delivering to the facility. Delivery documentation or manifests are reviewed, as are the contents of the vehicles. The guards use mirrors to examine the under carriage of each vehicle before it enters the Subgrade. Substantial mechanical barriers allow only one truck to enter at a time. These barriers are of sufficient strength to lift a car or truck 3 or so feet off its tires and immobilize it by suspending it on the barrier. Drivers are identified by photo ID. Similar physical barriers have been erected at the entrances to the parking garages. The parking patron vehicles and drivers are identified and matched electronically. If they cannot be matched entrance is denied. Only employees of tenants have access to the parking garage and a through background check is made before issuing a parking permit.

Aircraft Striking a Tower

This scenario is with in the realm of the possibie, but highly unlikely.

In 1946 a military aircraft struck the Empire State Building. Since that time the manner in which aircraft are "controlled" has dramatically changed. In the event such an unlikely occurrence, what might result? The structural designers of the towers have publicly stated that in their opinion that either of the Towers could with stand such an impact from a large modern passenger aircraft.

The ensuing fire would damage the "skin", in this scenario, as the spilled fuel would fall to the Plaza level where it would have to be extinguished by the NYC Fire Department. The replacement of the "skin" is estimated at 35% of the building replacement value or $420m. Loss of rents for 1 year or $150m for a total estimate of < $600m

500 Year Flood

Conditions surrounding this event are, at best, difficult to document. In the appendix of the report a discussion of flood and the procedures to protect against it are reviewed. A significant factor in this scenario would be the tidal action. Normal tidal variation, in this area of New York Harbor, is about 6 feet. The 100-year flood assumes increasing this by about 6 feet and the 500-year flood would add another 2 feet. This 500-year storm and ensuing flood would most probably be a Category 4 hurricane with prior warning from the National Weather Service and allowing time to obtain additional sandbags to raise dikes another 5 feet. If the same catastrophic failure outlined in the flood PML occur, then 3.5 times as much water could enter the opening with the expectation that the flood waters would be 21 feet deep inundating the B-6 level and rising 5 feet above the B-5 floor. Under these conditions an MFL loss of $200-300m seems likely.

FIRE

The following estimates of damage from a MFL fire have been estimated using the criteria outlined in FM Global's "MFL of High-Rise Buildings".

Assume:

- Special Category when 1.5h<H<1.75h
- Sprinkler system on fire floor is out of service
- Perimeter flue space with adequate safing
- NYFD expected to be able to handle an "exterior" fire
- Poke-through / penetrations properly sealed
- No interconnected floors with unprotected openings
- Building value of $1.2b and floor value of $10.8m

If 5 floors involved in the fire and 25 floors with water damage

Then

5 X $10.8 X 70% = $37.8m
25 X $10.8 X 15% = $40.5m
$78.3m

A more conservative scenario would have the fire originating just above one MER and progressing externally to the next MER where due to the double height (24') the fire would stop. The only combustibles in an MER are the filters in the air handling equipment and they are sprinklered. The MER's are double floors at levels 7/8, 41/42, 75/76, and 108/109.

If fire originates on the 43rd floor and progresses externally from floor to floor until it is stopped at the 75th floor and the first 41 floors have some water damage :

Then

42 X $10.8 X 70% = $234
41 X $10.8 X 10% = $ 82
$316

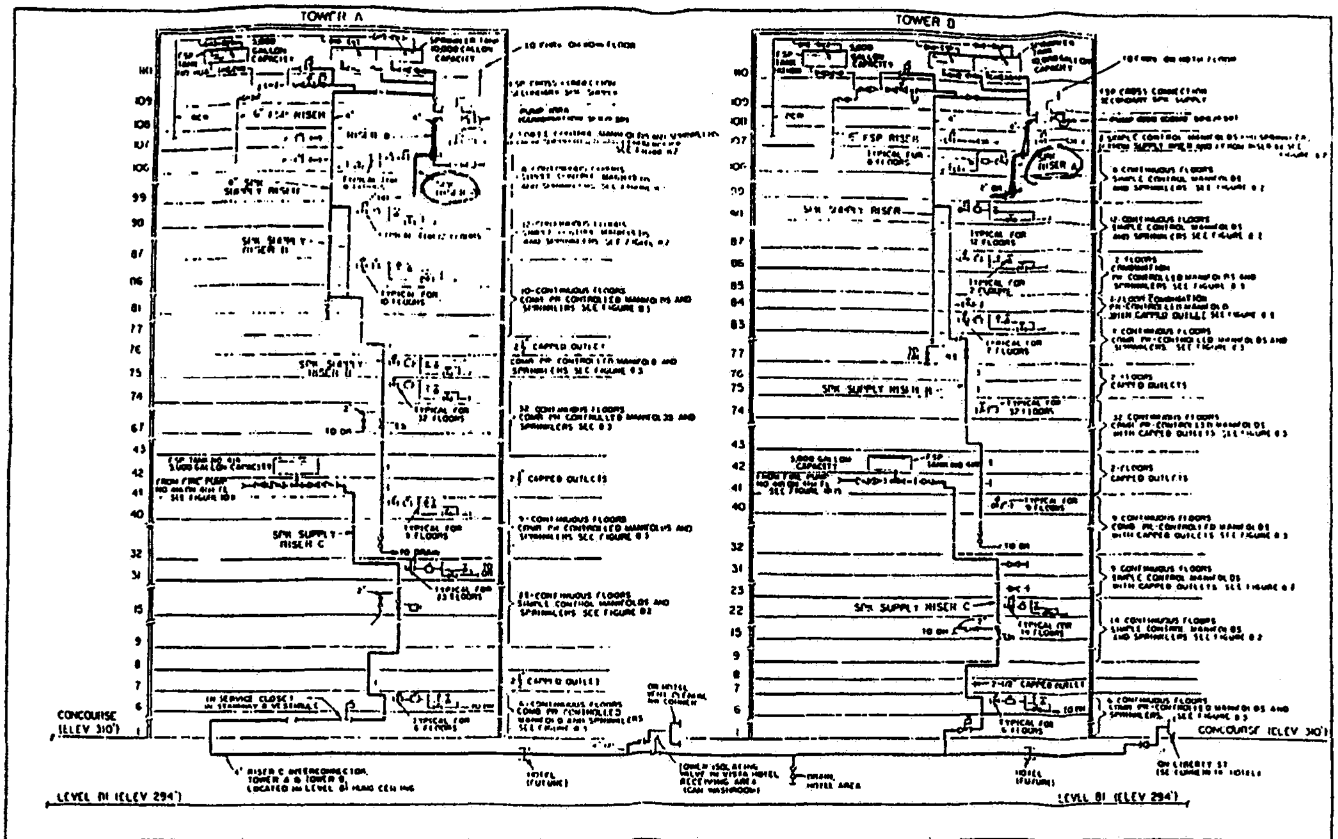


Figure 8.1 Riser Diagram—Sprinklers Towers A And B

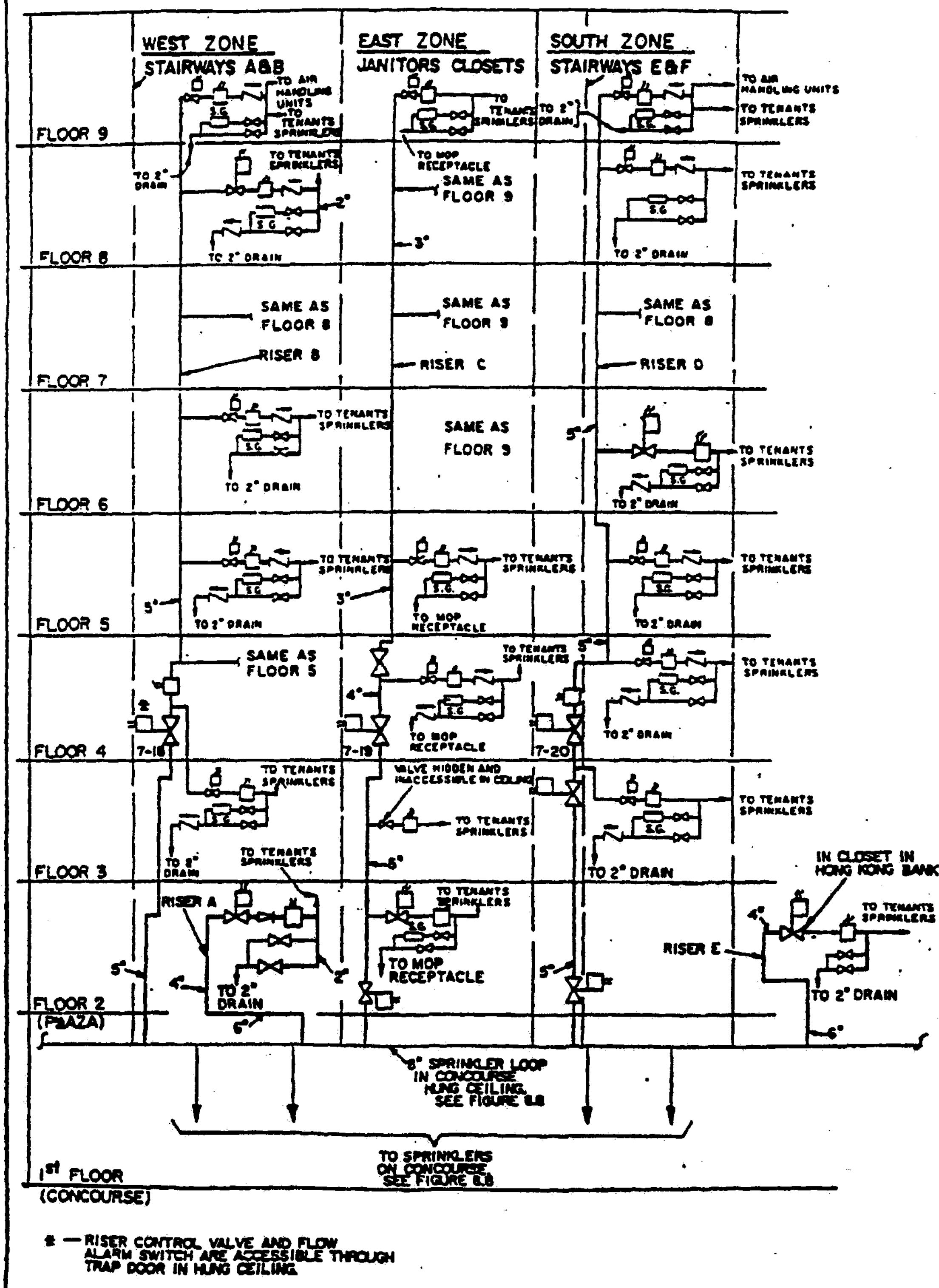


Figure 8.9 **Riser Diagram**
Sprinklers—Northeast Plaza Building

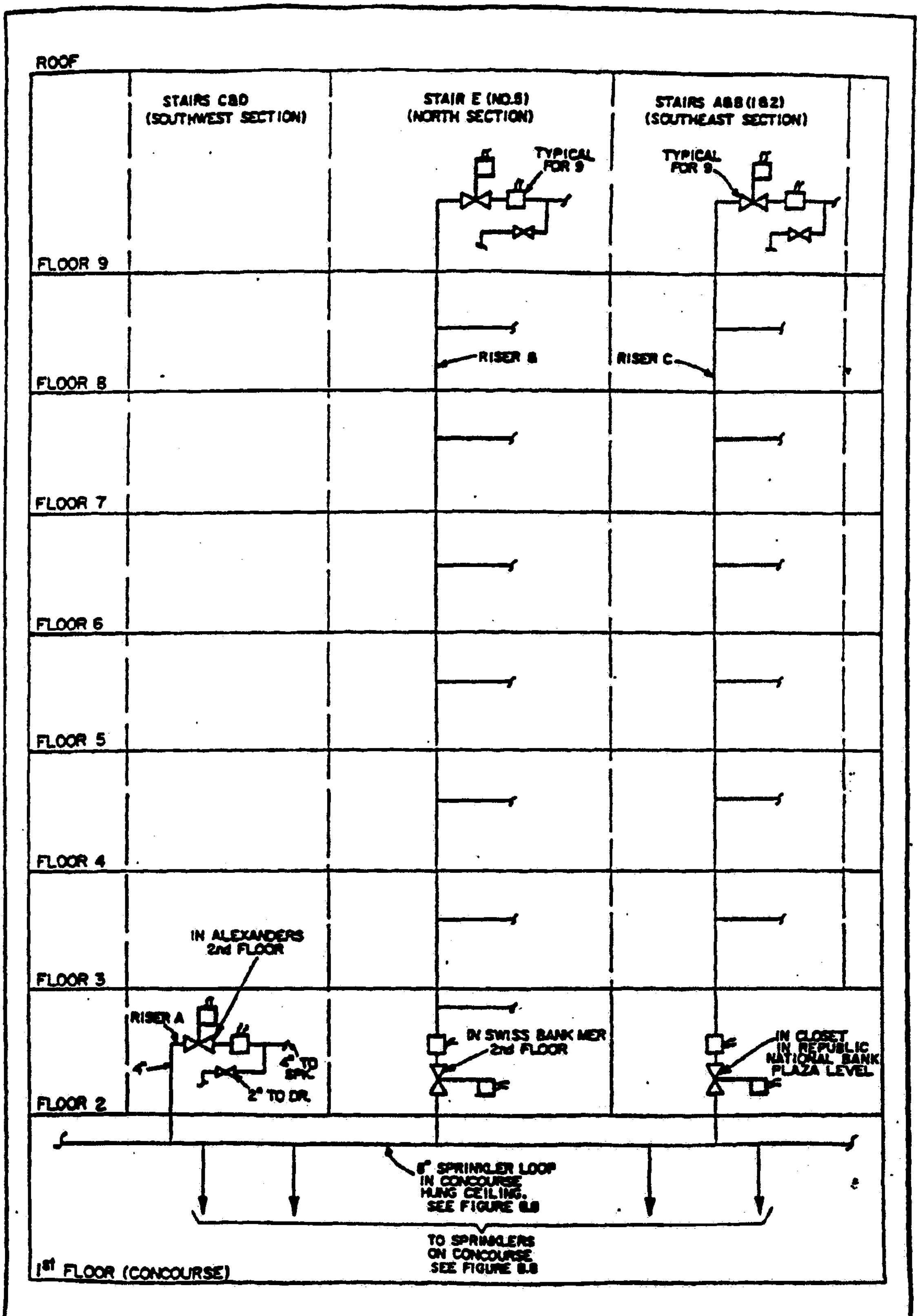


Figure 8.10 Riser Diagram Sprinklers—Southeast Plaza Building

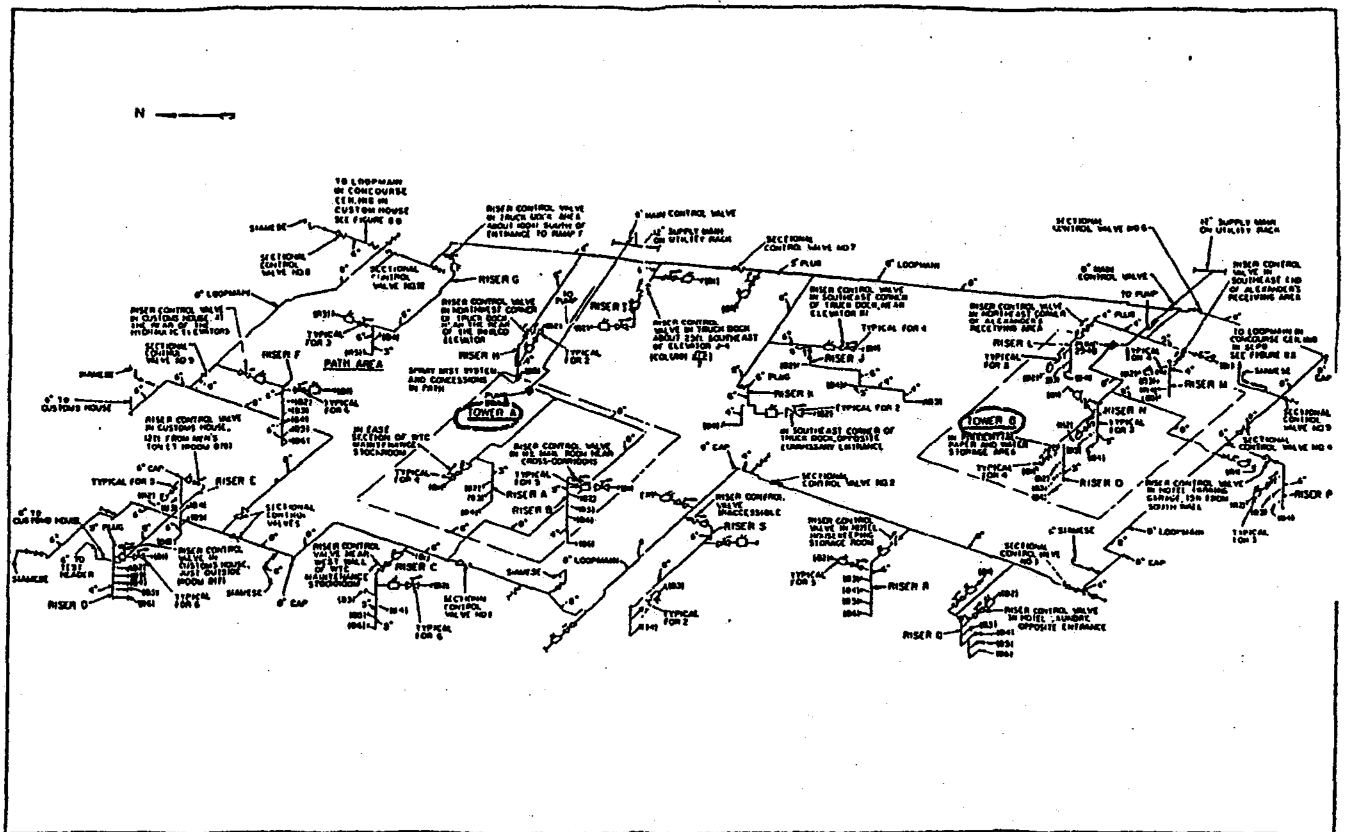


Figure 8.7 Schematic
Sprinkler Loopmain — B1 Level

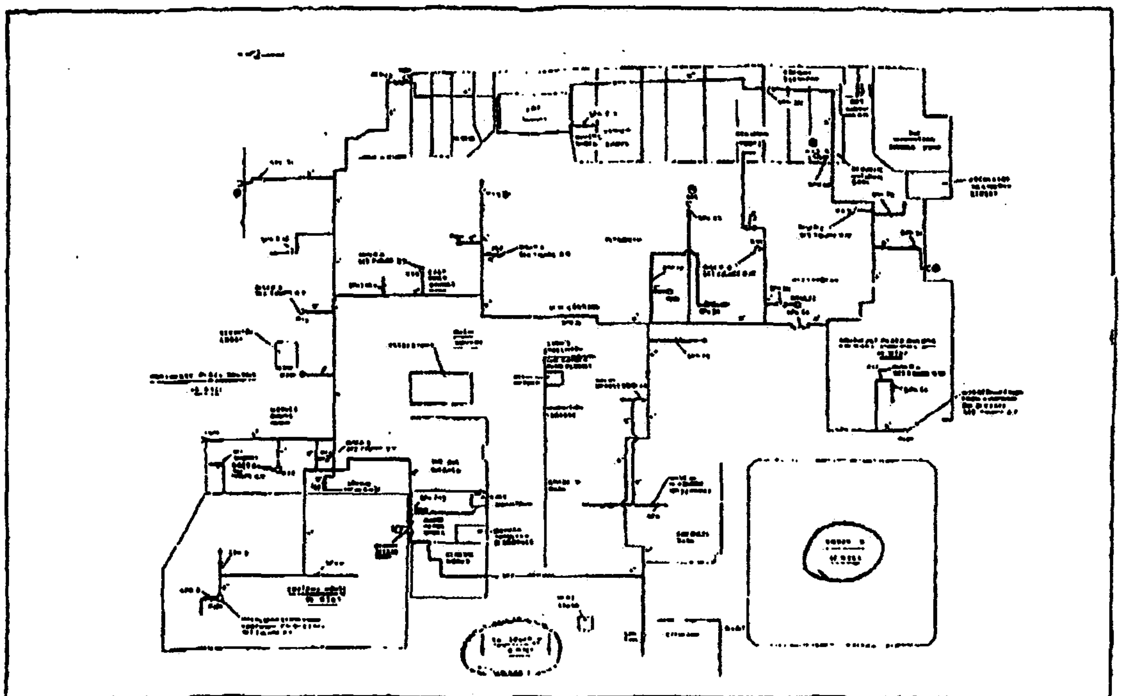


Figure 6.8 Schematic
Sprinkler Loopmain – Concourse Level

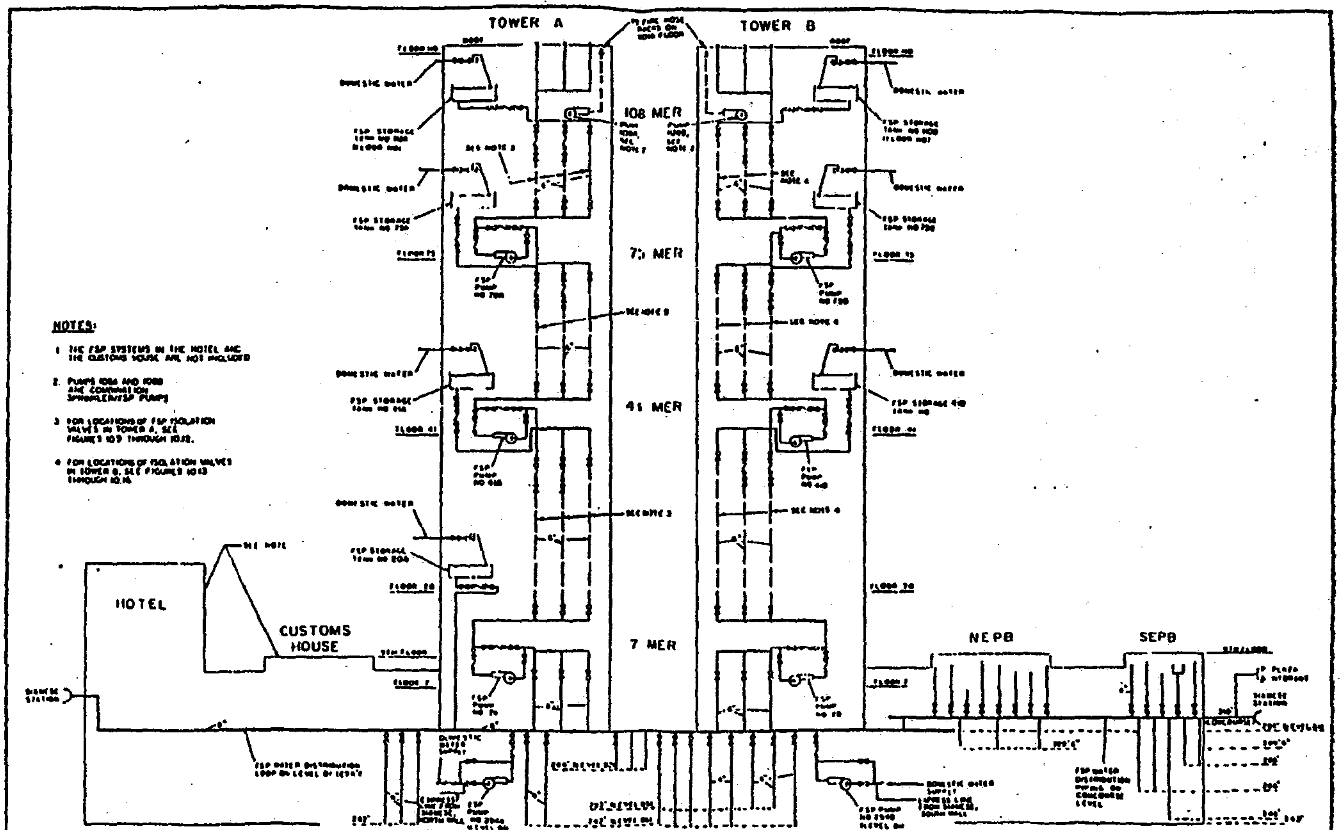


Figure 10.1 Schematic
Tank And Pump System – Fire Standpipe – World Trade Center

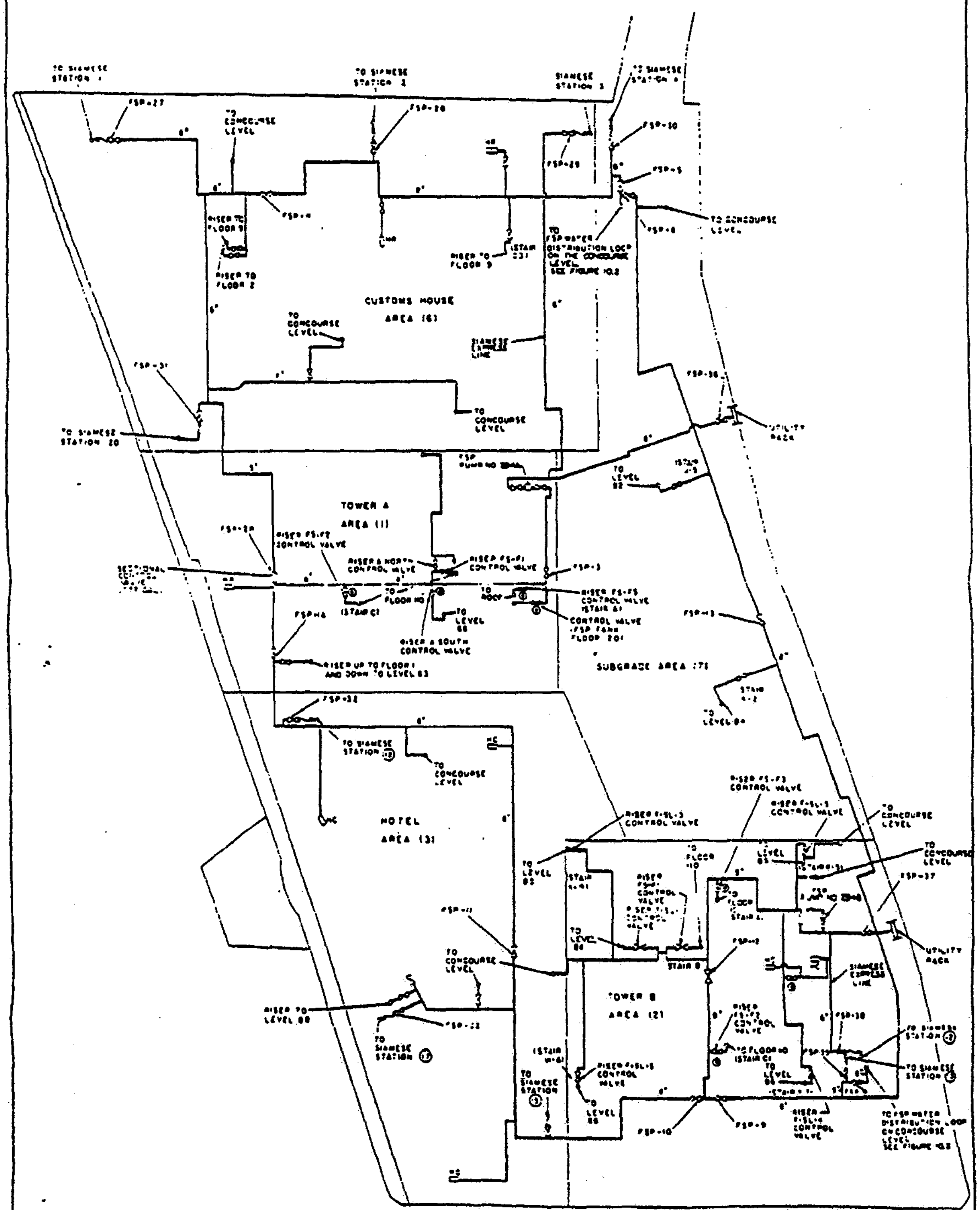


Figure 10.3 Distribution Loop
Fire Standpipe—Level B1

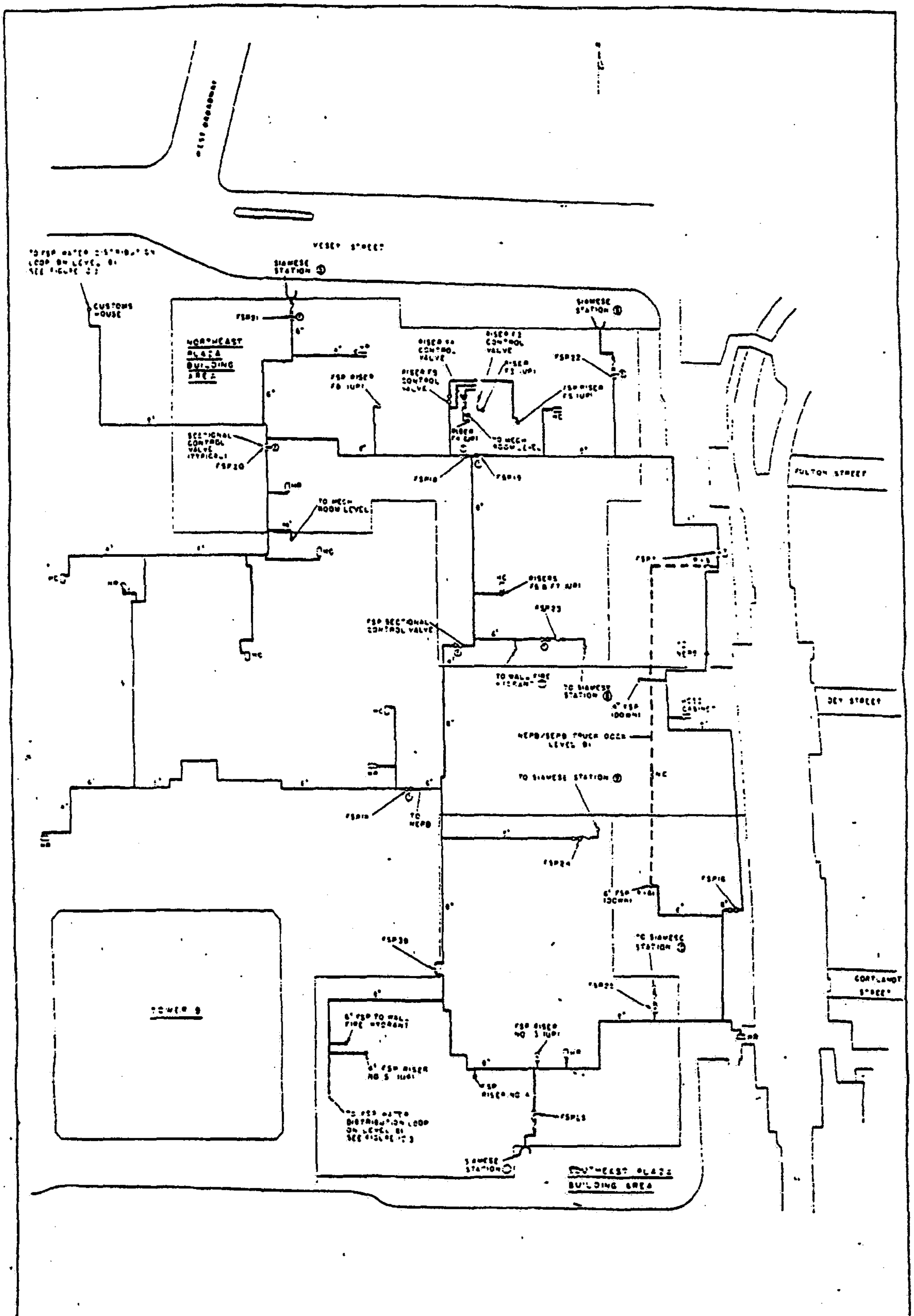
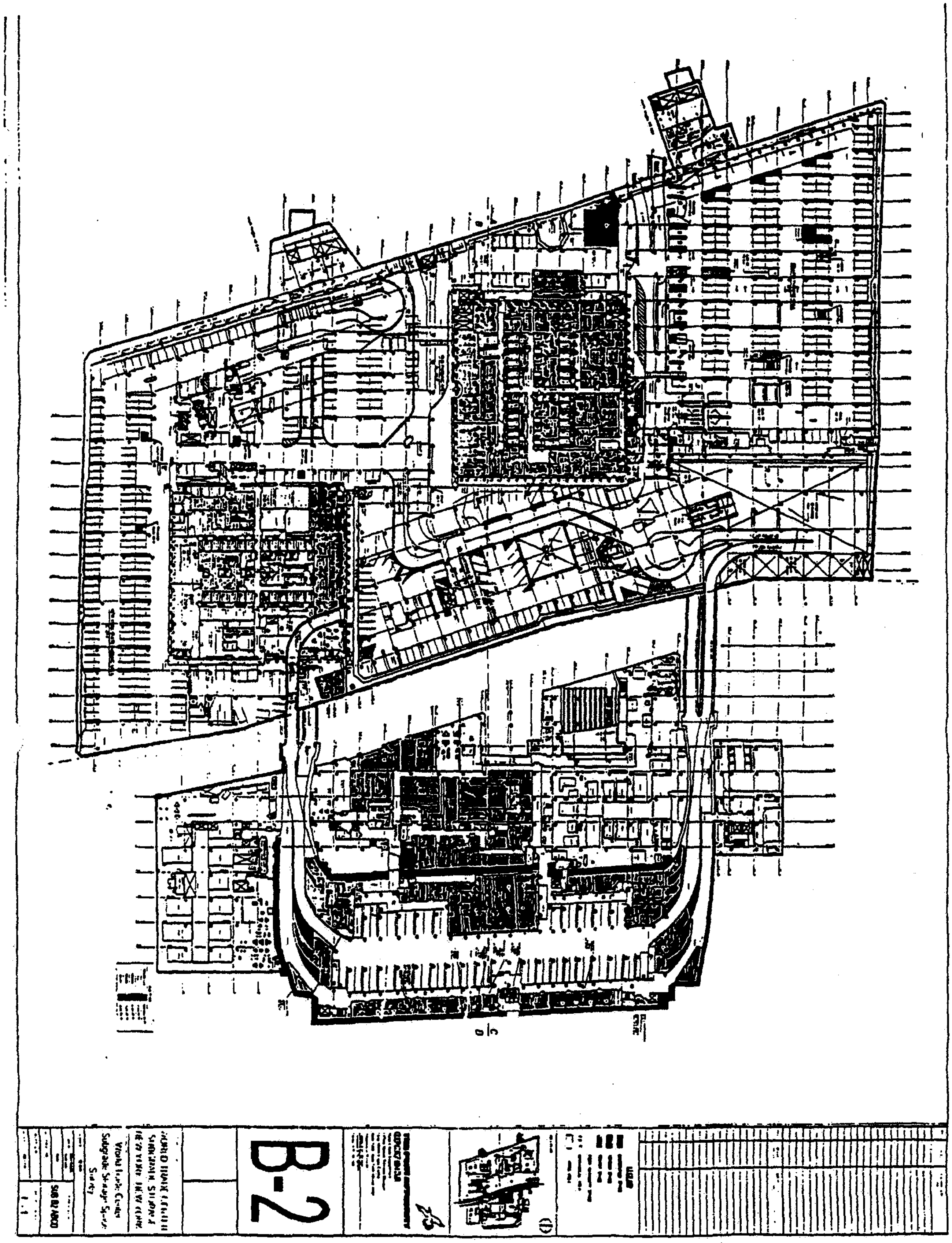
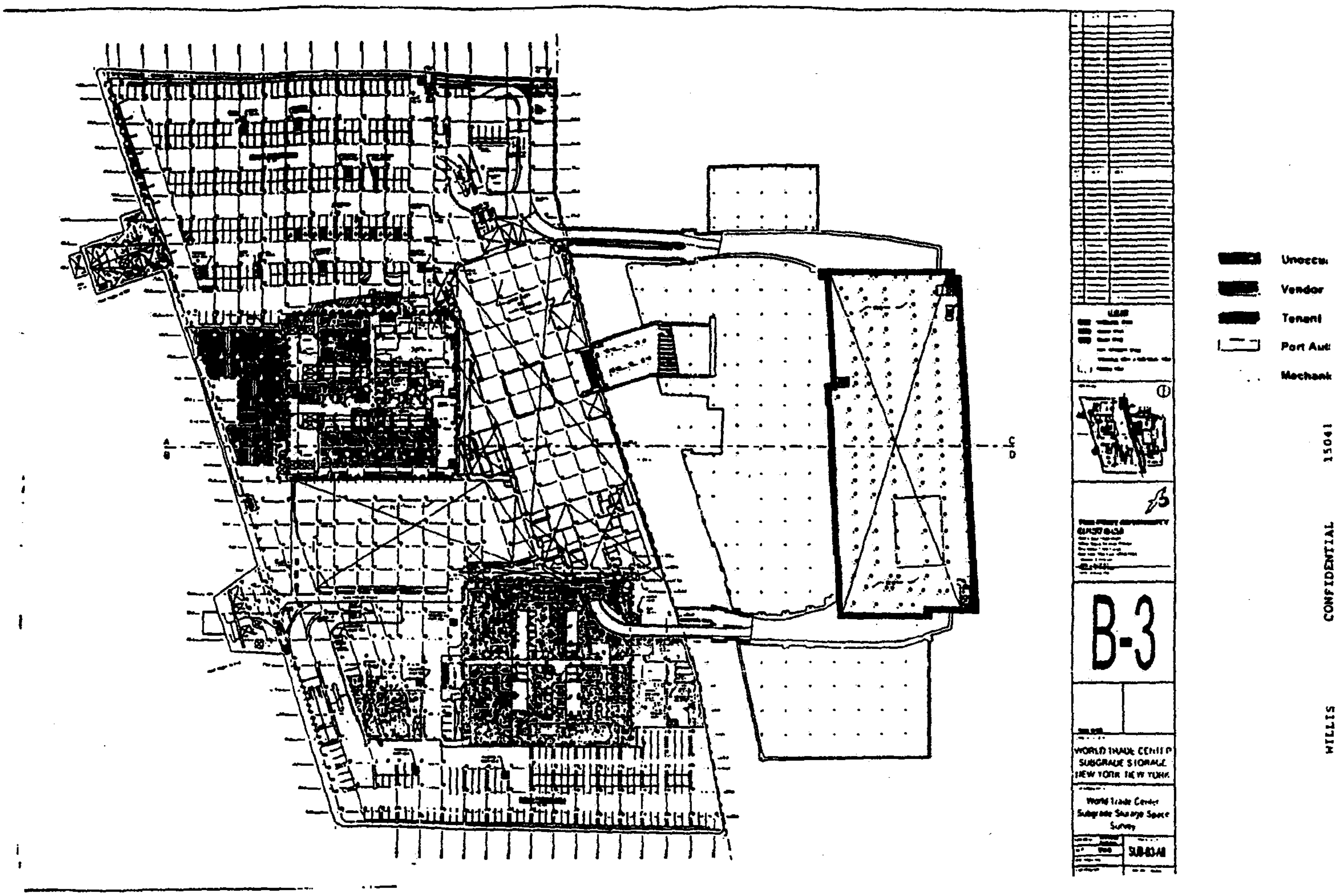


Figure 10.2 Distribution Loop
Fire Standpipe – Concourse Level

WILLIS CONFIDENTIAL 15039



Unoccupied
Vendor
Tenant
Port Authority
Mechanical



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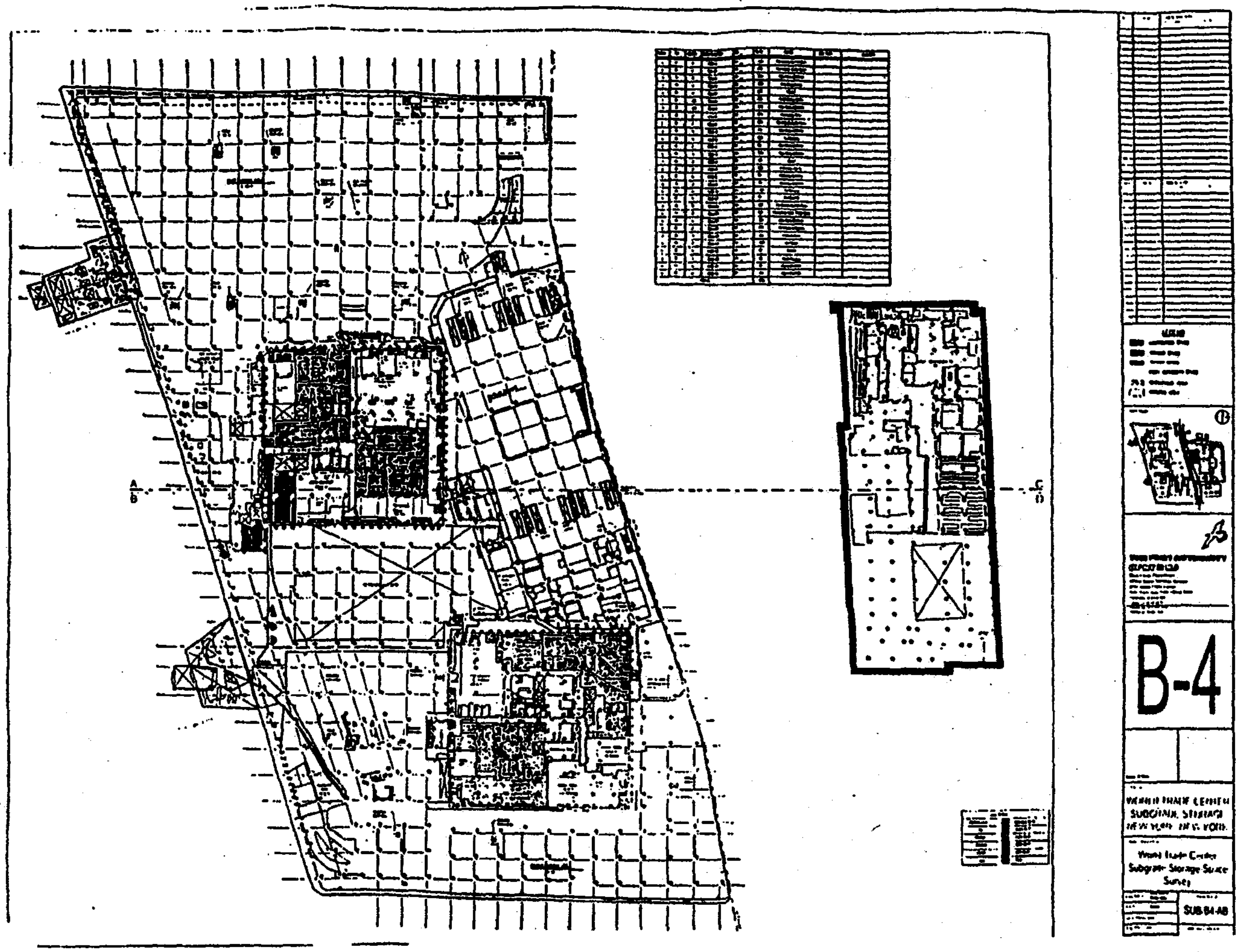

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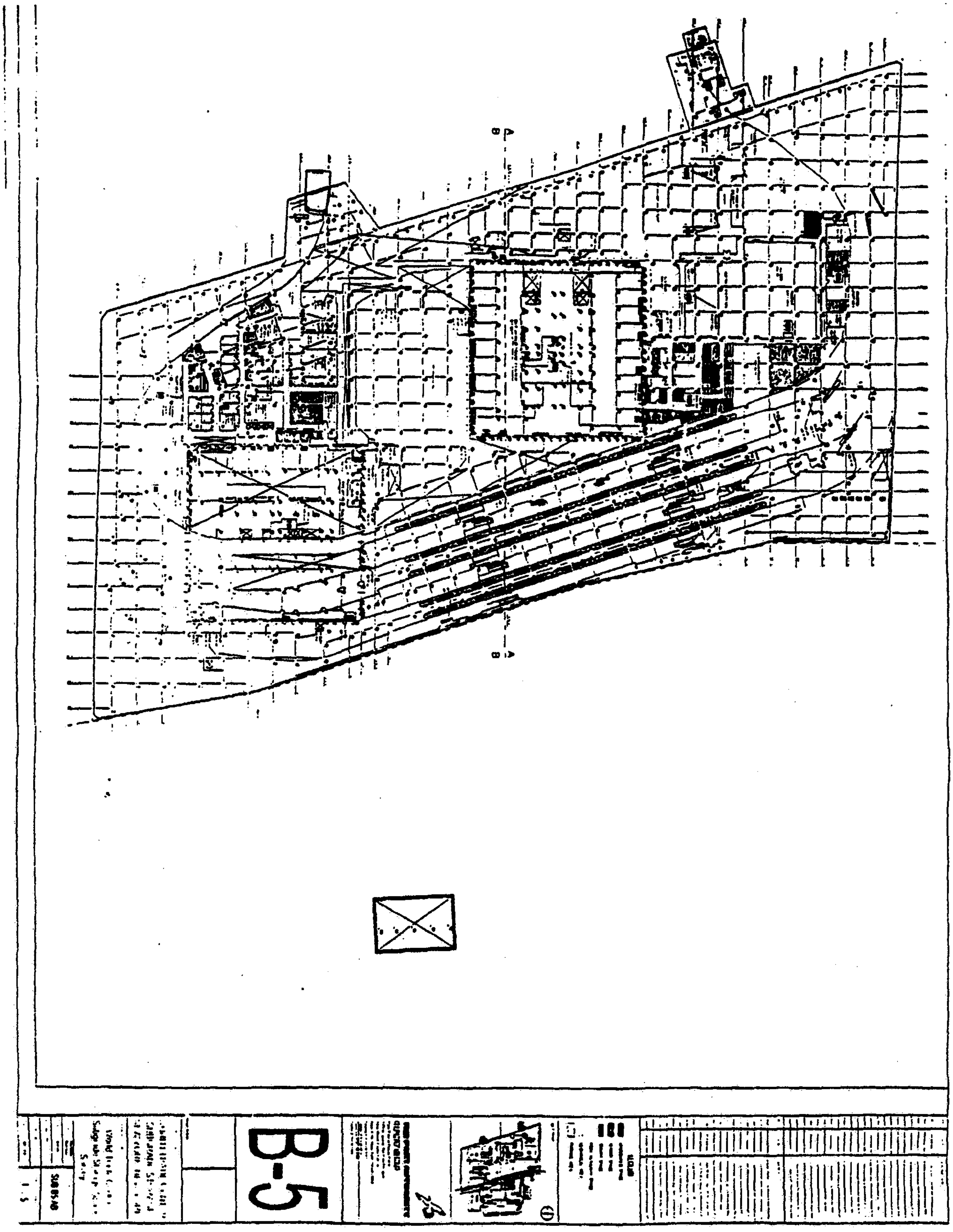
Mechanical



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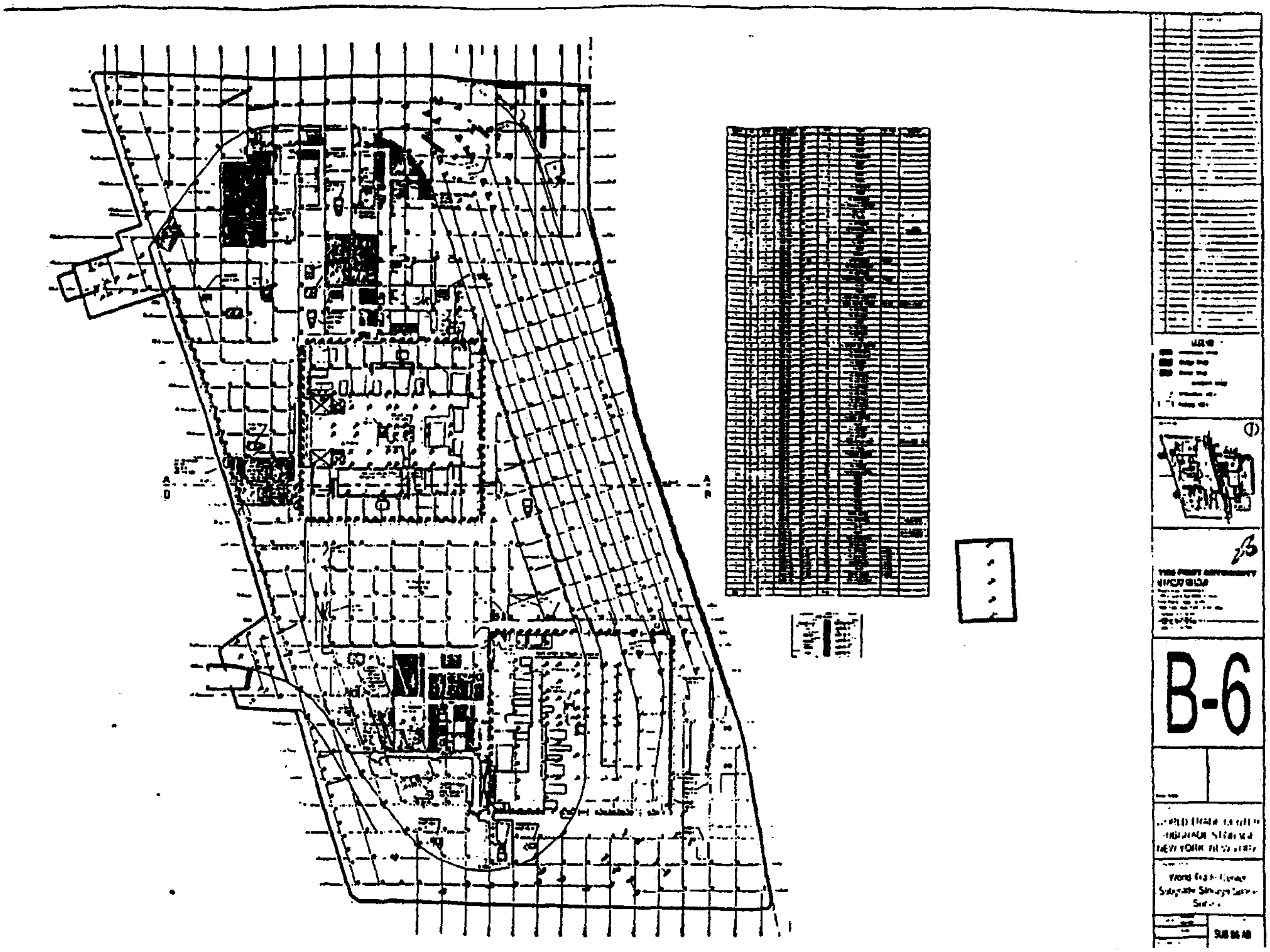


Unoccupied

Vendor

Tenant

Port Authority Mechanical

15044

CONFIDENTIAL

WILLIS

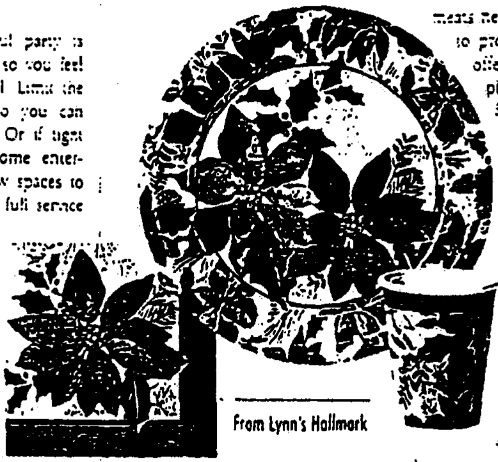
partyperfect

PARTY PLANNING TIPS

Welcome to the season of joy, laughter and most of all celebrations. Whether you're prepping for a casual office get-together or a gala holiday feast, you'll want to create a memorable and delicious holiday affair.

The secret of a successful party is orchestrating the occasion so you feel comfortable and in control. Limit the size of your gathering so you can manage your party easily. Or if tight living space rules out home entertaining, consider some new spaces to host a private party. From full service restaurants and local bars to loft spaces and "occasion rooms," hosts are throwing parties where they can enjoy the planning and entertaining but (usually) none of the cleanup. Add to that all the food, bar and decor necessities and there's plenty of room for personalization. The experts at Xando Cosi Inc. tailor the menu to the client's taste and suggest that the client add their own personalized touches to make sure they feel like it's their party, not the caterers'.

Be sure, however, to plan festivities that fit your budget and schedule. If you don't have the time or the money to prep for a full blown sit-down dinner or lavish buffet, opt for a single course affair like an appetizer buffet, or dessert party. Ecce Panis is ready for just such a party with fresh baked breads, pies and other delectable goodies including their intoxicating Pecan Chocolate Bourbon Pie. Ben & Jerry's suggests hosting a holiday ice cream party. Choose from more than 35 flavors as well as frozen yogurts and non-dairy sorbets.



From Lynn's Hallmark

When planning the food, be sure to balance the menu. Combine foods with contrasting colors, textures and temperatures. Offer hot appetizers alongside room temperature dips, rich cheeses beside low fat veggies, spicy meats next to delicate salads. And try to provide at least one vegetarian offering. Au Bon Pain party platters include assorted cheeses, fruits and vegetables as well as sandwiches of rare roast beef, country-cured ham and smoked turkey. Authentic Italian fare can be customized to suit your needs by the staff at Pastabreak. Or, call Fine & Schapiro for a full range of catering options ranging from appetizers to desserts. Devon & Blakely also offers a vast array of special catering services for the holiday season.

Welcome guests to a party filled with warmth and good cheer — twinkling lights, shiny tableware, the sparkle of silver and gold. Visit Lynn's Hallmark for delightful holiday accents, themed paper goods and decorations, and charming keepsake ornaments. Lechters carries a full range of festive dinnerware and glasses as well as party platters and other essentials for hosting the perfect event. And for the final touch, fill your party with festive music from Sam Goody.

WHO TO CALL FOR CATERING

Devon & Blakely
Max Guerrero
212-432-0222

Ecce Panis
Doty Kenul
212-432-2820

Fine & Schapiro Restaurant
Joanne C[illegible]
212-775-7500

New York Marriott
World Trade Center Hotel
Event/Booking Center
212-266-6145

Pastabreak
Idi Drawaro
212-488-2300

Windows on the World
Sales & Catering Office
212-524-7011

Xando Cosi
Stefan Hartman
212-653-1625

TO HOLIDAY SHOP

Cole Haan, a leading designer and marketer of high-quality hand-crafted footwear and accessories, opens at the Mall this month. Discover mens and womens dress and casual footwear, men's belts and hosiery, as well as womens handbags and personal leather goods. By blending craftsmanship, design, innovation and character, Cole Haan has given its products what can be truly described as a "modern artisan" aesthetic.

Victoria's Secret, the world's most famous lingerie shop, is now open on the Liberty Street side of the Mall. Make holiday wishes come true with a gift that dazzles in red or shimmers in satin.

Xando Cosi opens soon at Four World Trade Center (on Church St.) offering the best from New York's favorite casual restaurant — Cosi sandwiches and catering, Xando coffee, and a full bar for happy hour. After 5:00 p.m., a new dinner menu including Cosi pizzas, salads and sharable appetizers are served up with Xando's famous s'mores and coffee cocktails. Big couches, cafe tables and Mondrian-inspired decor make this a great spot to grab a quick bite or settle in with friends to wine, dine and unwind.

World of Christmas has also returned for the holiday season. Located next to Sunglass Hut, the seasonal shop offers a dazzling selection of holiday goods — ornaments, artificial trees, wreaths and garlands, toys and corporate gifts. Decorating staff can also help bring holiday cheer to your office.

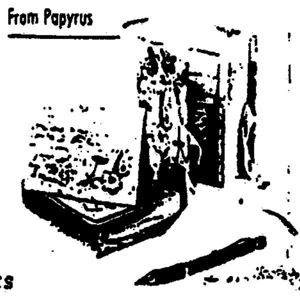
K•B Toys Express is back for the holidays, on the Liberty Street side of the Mall. The store is stocked with a large selection of value-priced merchandise including dolls, games, action figures, preschool games, Barbie, crafts, plush toys and lots more.

Executive Gifts continued from page 1

from Papyrus. Add a Sensa pen for smooth, clear and crisp writing and it's a special reward for those who value the handwritten word as well as the typed one.

For a new idea, consider giving a "mentoring" book, like *Accidental Genius* by Marc Levy, from Borders. Not only is it a great source for helping someone develop business writing, but it also shows you care about the person, as well as their career.

From Papyrus



world trade center

The U.S. Post Office, DHL Airways, [illegible] ess, and United Parcel Service are open weekdays from 9:00 a.m. to 5:00 p.m.

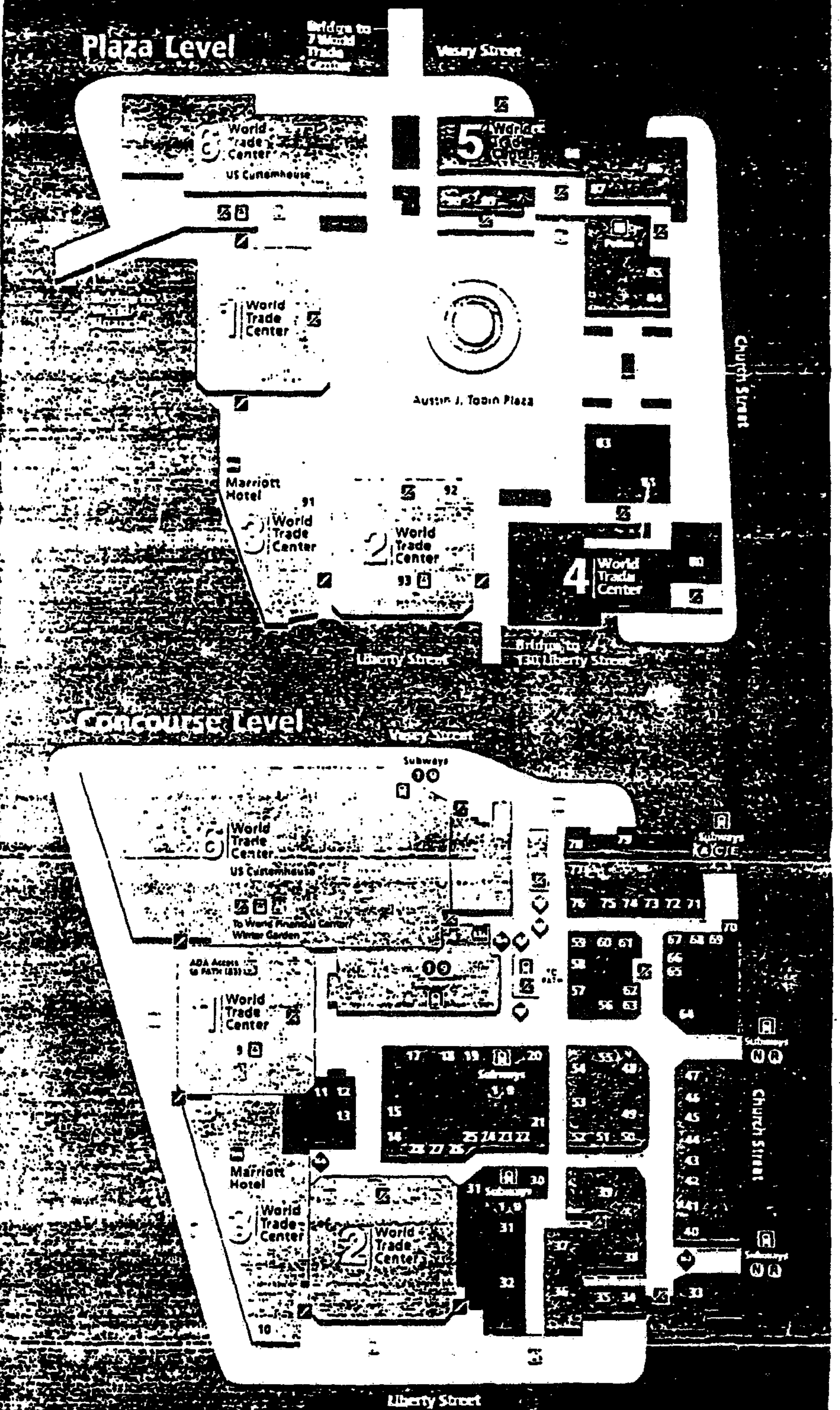
[illegible]ing home for the holidays? The convenient the Airline Tickets Center also on the Plaza of Five World Trade Center houses ticket counters for major airlines including American Airlines, [Conti]nental, Delta, United, and US Airways. You [can] even find a bargain fare at Lowestfare.com, [which] is also open at the Center. Stop by the Center [week]days from as early as 8:00 a.m. to as late as [...] p.m. to obtain tickets. And, if you're staying [in the] city and entertaining out-of-town guests, [remem]ber two little magic words — extra keys! [Have] them made at Daniel Pelz Locksmith on [Liber]ty Street side of the Mall.

The Mall at the World Trade Center

MONDAY - FRIDAY
7:00 a.m. - 8:00 p.m.
SATURDAY
10:00 a.m. - 7:00 p.m.
SUNDAY
11:00 a.m. - 6:00 p.m.

Individual store hours may vary.

Store Listing



Key

- ADA Access
- ★ Coming Soon
- Elevator
- ▲ Entrance
- Escalator/Stairs
- Kiosk
- Marriott Hotel
- PATH Trains
- PA Police
- Restrooms
- ★★ Seasonal Stores
- Stairs
- Subways

Mall Holiday Hours

MONDAY - FRIDAY
7:00 a.m. - 8:00 p.m.
SATURDAY
10:00 a.m. - 7:00 p.m.
SUNDAY
11:00 a.m. - 6:00 p.m.
Individual store hours may vary.

Port Authority Police
5 World Trade Center
Plaza Level
(212) 435-3540

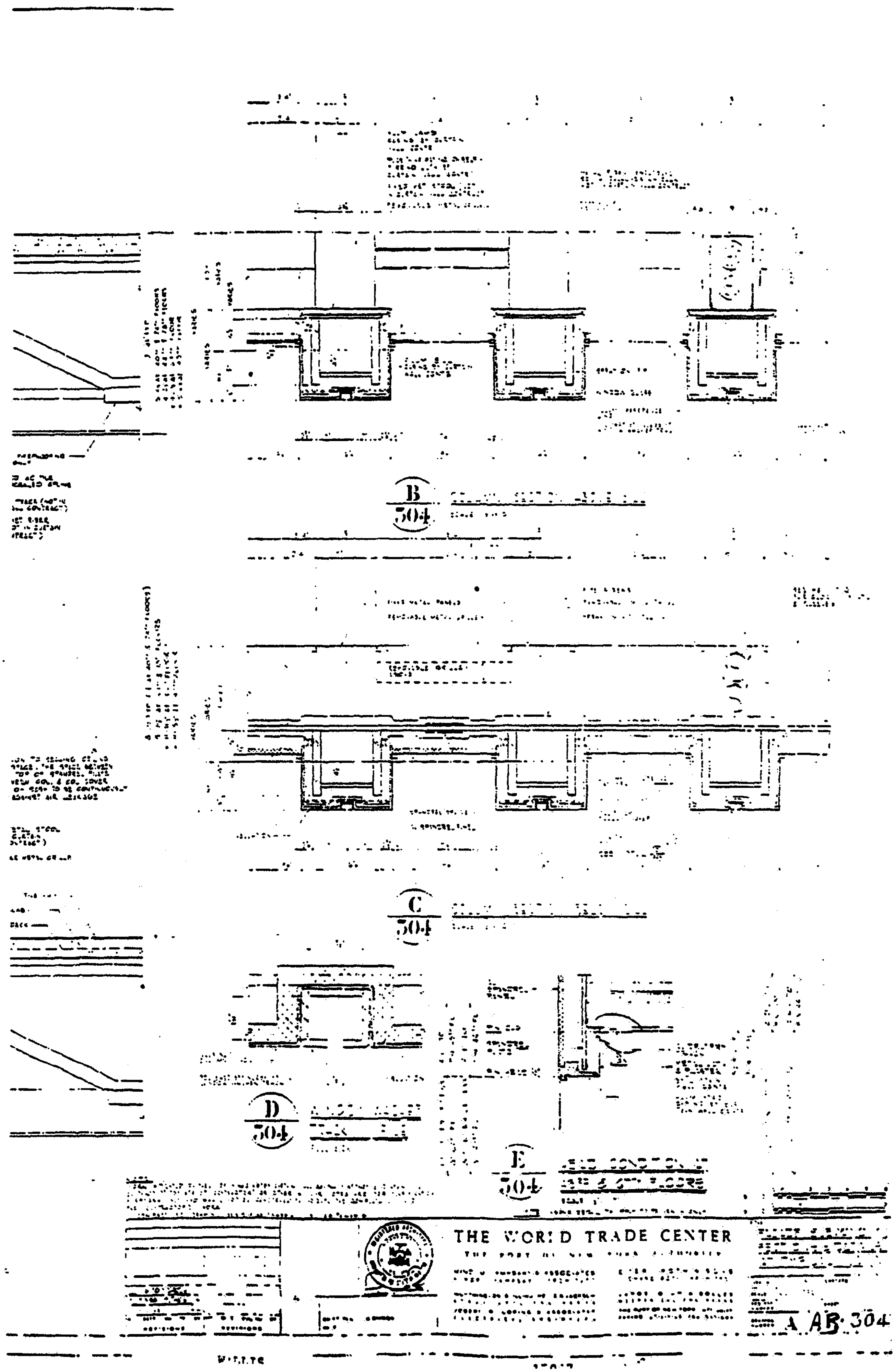
Lost & Found
(212) 435-3540

WORLD TRADE CENTER
General Information
(212) 435-6500

Attractions
(212) 435-4170

WORLD TRADE CENTER
THE PORT AUTHORITY OF NY & NJ

WILLIS



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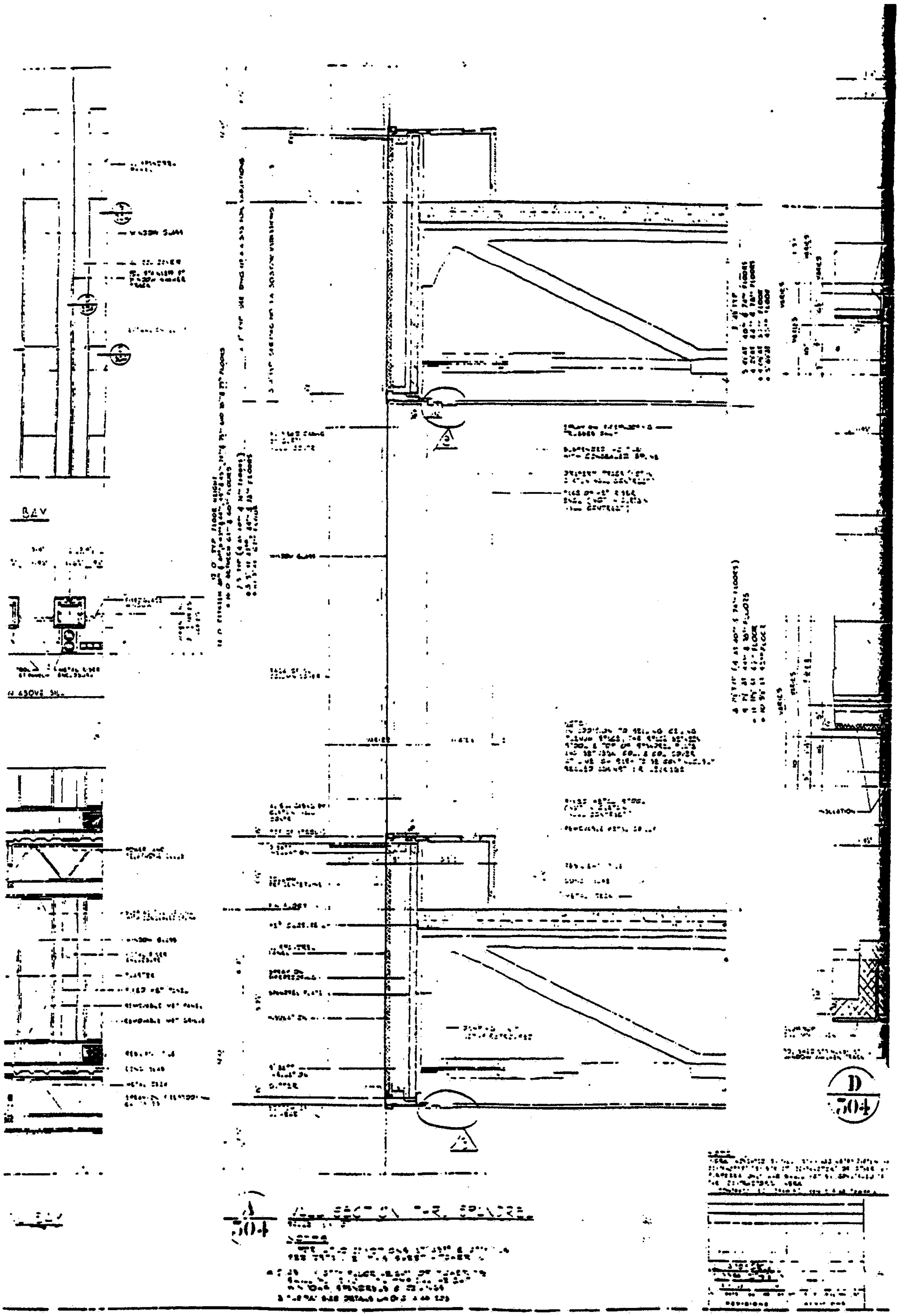
THE WORLD TRADE CENTER
A AB 304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Jaufr

THE PORT AUTHORITY OF NY & NJ MEMORANDUM

TO: Joseph Amatuccio, Carla Bonacci, Jerrold Dinkels, Frank DiMartini, Eric Hauser, Louis Menno, Edwin Monteverde, Francis Riccardelli, Nancy Seliga

FROM: John Castaldo

DATE: September 19, 2000

SUBJECT: ASBESTOS POSITIVE LOCATIONS AT THE WORLD TRADE CENTER: UPDATE.

REFERENCE: J. Castaldo to Addressees; Memorandums Dated 5/4/98 and 12/21/99; Same Subject.

COPY: L. Ardizzone, S. Benjamin, I. Chachkes, J. Connors, W. Devlin, M. Finegold, M. Hurley, M. Jakubek, M. Kirshner, T. Lynch, U. Mehta, G. Meyer, R. Muessig, C. Nanninga, A. Reiss, E. Strauss, G. Tabek, P. Taylor, F. Varriano, L. Zucchi, Operations Control Desk, S-4's

Attached please find an update to my initial May, 1998 memorandum wherein the known asbestos locations at the World Trade Center were disclosed. The information provided in this disclosure is a compulation of avaliable bulk sampling and analytical results from both the World Trade and Engineering Departments' data bases.

In compliance with the disclosure requirements of the U.S. Occupational Safety and Health Administration's asbestos standard, I am requesting that this information be distributed to all World Trade Department, Engineering Department, PA Office Space, and Leasing Division property managers, project managers, construction managers, construction inspectors, operations supervisors, security supervisors, facility maintanence supervisors, and leasing agents associated with the allocation of space, and the design and implementation of World Trade Center projects. Additionally, please forward this information to those contractors under your administration. If there are questions as to the presence of asbestos-containing materials at a particular location, or if the scope of demolition and/or renovation work may impact asbestos-containing materials, please contact Art Burton, Assistant Environmental Coordinator, at 435-8364.

RECEIVED
SEP 19 2000

Those on the copyline are requested to contact this office for the appropriate response action if asbestos-containing materials may be impacted by work under your jurisdiction. The Port Authority complies with Industrial Code Rule #56 relative to worker certifications, contractor licensing, and work procedures if asbestos is going to be disturbed or impacted. Please contact me at 435-8518 should you have any questions.

John Castaldo
General Manager,
Base Building Services

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located In One World Trade Center - Exclusive Of Elevator Shafts

Full Floor Locations	Random Locations On Floor	Subgrades	Convector Uni
- Lobby Mezzanine	- 43rd / 44th Floor PA Exhaust Duct	- B1 Level:	- 77th Floor
- 1st - 6th Floors: Core		- Core, N/E Quadrant	- 79th Floor
- 6th Floor Catwalk	- 82nd Floor	- B6 Level	- 88th Floor
- 7th / 8th Floor MER	- 104th Floor		- 101st Floor
- 41st / 42nd Floor MER	- Core Electric Closets On The 1st – 40th floors		- 103rd Floor
- 75th / 76th Floor MER			- 105th floor
- 108th / 109th Floor MER	- Perimeter Electric Closets On The 30th Floor		

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located In Two World Trade Center - Exclusive Of Elevator Shafts

Full Floor Locations	Random Locations On Floor	Quadrant Location	Convector Units
- 6th Floor Catwalk	- Lobby Mezzanine	- S/W, 43rd Floor Kitchen Exhaust Duct	- 22nd Floor
- 10th – 13th Floors (Bell Atlantic)	- 7th / 8th Floor MER		- 24th Floor
	- 9th Floor		- 59th Floor
- 41st / 42nd Floor MER	- 19th Floor		- 72nd Floor
	- 20th Floor		- 79th Floor
	- 26th Floor		- 81st Floor
	- 33rd Floor		- 84th Floor
	- 71st Floor		- 86th Floor
	- 75th / 76th Floor MER		- 87th Floor

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located In Four And Five World Trade Center

There is no asbestos-containing sprayed-on fireproofing in Four and Five World Trade Center.
A cementitious patch has been identified on a beam in the south wing of the southwest portion on the 5th floor in 5 WTC
Thermal system insulation is present in the form of pipe saddles.

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located On The Concourse

There is no asbestos-containing sprayed-on fireproofing in the plenum of the Concourse.
Thermal system insulation material is present.

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located On The B1 Level And The Truckdock

Asbestos-containing sprayed-on fireproofing and thermal system insulation material is present.

Miscellaneous Asbestos-Containing Materials At The World Trade Center

Base building flooring throughout the facility is vinyl asbestos floor tile (VAT).

World Trade Center Elevator Shafts With Asbestos-Containing Surfacing Insulation Material

One World Trade Center

Pits and Shafts

1 / 2	39 / 40 / 41
3 / 4	42 / 43 / 44
5 / 48	45 / 46 / 47
8 / 9	51 / 52 / 53
16 /17	54 / 55 / 56
49	57 / 58 / 59
18 / 19	60 / 61 / 62
20 / 21	63 / 64 / 65
22 / 23	66 / 67 / 68
50	69 / 70 / 71
24 / 25 / 26	72 / 73 / 74
27 / 28 / 29	
30 / 31 / 32	
33 / 34 / 35	
36 / 37 / 38	

Two World Trade Center

Pits and Shafts

5 / 48	36 / 37 / 38
10 / 11	39 / 40 / 41
14 / 15	42 / 43 / 44
24 / 25 / 26	45 / 46 / 47
27 / 28 / 29	54 / 55 / 56
30 / 31 / 32	57 / 58 / 59
33 / 34 / 35	63 / 64 / 65

There is no asbestos-containing surfacing insulation material in the J and K elevator cars in 1 and 2 WTC.

There is no asbestos-containing surfacing insulation material with the elevator shafts in 4 and 5 WTC.

RISK CLASSIFICATION AND LOSS ESTIMATES FOR HIGH-RISE BUILDINGS

This document is to be used, in conjunction with PM.5.0, to determine the class and PML for all high-rise building except hospital buildings. A high-rise building as defined in IM.17.6.1 is "one in which fires must be fought internally because of height, i.e., the upper stories are beyond the effective reach of fire department aerial equipment commonly considered to be over 75 ft (23 m)."

CLASS DETERMINATION

A fully sprinklered high rise building is to be classed a HPR2.

Buildings where public protection is available and where significant sprinkler protection is needed, those over 250 ft (76 m) with a single pumping supply or are non-sprinklered must be classed a Standard 1. Any risk that does not fall into the above categories is a Standard 2 risk.

PML DETERMINATION

To determine the PML of a high rise building, many construction, protection, and occupancy features must be known. If the building has numerous openings in the floor/ceiling assembly, such as space between curtain walls and floor systems, unprotected shafts, or open stairs and escalators, a fire could rapidly spread to the upper floor. An unprotected opening would be:

- Any vertical shaft enclosed with less than a 2 hour fire rated wall construction or any opening into the shaft with less than 1½ hour fire rated doors. This would include passenger and freight elevators.
- Cable openings without a listed, fire rated through-penetration system.
- Vertical run of a duct without fire dampers, or listed, fire rated through-penetration system.
- Atriums and open space light shafts.

The PML will also depend upon whether the building is sprinklered. The location of the shutoff valves for each floor and the area covered by one system should be considered. The adequacy of hose connections and standpipes should help reduce the PML.

Sprinklered Building

When determining the PML, use the floor with the highest value, then assume the sprinkler system on that floor is impaired and a fire would destroy the entire floor (100% of the floor). If there are floors with vertical openings between them, use the single fire area as 100% of floors, these floors should be considered a single fire area. When there are no vertical openings, start the single fire area calculations eight floors down from the top.

In addition to the fire damage, water and smoke damage must be considered. For smoke damage, use 100% contents and 100% building for the floor above the fire floor and 5% for each of the 2^{nd} thru 6^{th} floors above the fire floor. Water damage can be calculated using 25% of the building and 75% of the contents for the floor below the fire floor and 5% for each of the 2^{nd} thru 6^{th} floors below the fire floor.

Example 1: A building is 25 stories, with a PD building value of $15,000,000 or $600,000 per floor and contents valued at $10,000,000 or $400,000 per floor. There is an open stairwell between the 10^{th} and 11^{th} floors, protected vertical shafts, proper AS density, sprinkler shutoff valves on every floor, and adequate water supplies. (See Figure 1.)

Fire damage in the single fire area would be 2 × $600,000 + 2 × $400,000 = $2,000,000.

Smoke damage would be 100% building and contents for the 12^{th} floor, 5% of the 13^{th} thru 18^{th} floors or 100% of $600,000 + 100% of $400,000 + 5 × 5% of $1,000,000 = $1,250,000.

Water damage would be 25% building and 75% contents for the 9^{th} floor, 5% of the 8^{th} thru 4^{th} floors, or 25% of $600,000 + 75% of $400,000 + 5 × 5% of $1,000,000 = $700,000.

Total PD PML would be $2,000,000 + 1,250,000 + 700,000 = $3,950,000 / $25,000,000 = 0.158 or 16%: round up to 20%.

Example 2: A building is 25 stories, with a PD building value of $15,000,000 or $600,000 per floor and contents valued at $10,000,000 or $400,000 per floor. The sprinkler shutoff valve covers 4 floors. There are no vertical openings. There is proper AS density and adequate water supplies. Start the calculations at the 14^{th} floor. (See Figure 2)

Fire damage in the single fire area would be 4 × $600,000 + 4 × $400,000 = $4,000,000.

Smoke damage would be 100% building and 100% contents for the 18^{th} floor, 5% contents for the 19^{th} thru 23^{rd} floors or 100% of $600,000 + 100% of $400,000 + 5 × 5% of $1,000,000 = $1,250,000.

Water damage would be 25% building and 75% contents for the 13^{th} floor and 5% contents for the 12^{th} thru 8^{th} floors, or 25% of $600,000 + 75% of $400,000 + 5 × 5% of $1,000,000 = $700,000.

Total PD PML would be $4,000,000 + 1,250,000 + 700,000 = $5,950,000 / $25,000,000 = 0.238 or 24%: round up to 25%.

Unsprinklered Buildings

Normally, a 100% PML should be used unless physical characteristics suggest otherwise. Such things as fire resistive construction throughout with light combustible interior loading, or an office complex with multiple towers and several common connecting levels would warrant a lesser PML. When a PML less than 100% is used, the detailed review of the circumstances must be approved by the AVP-ALP.

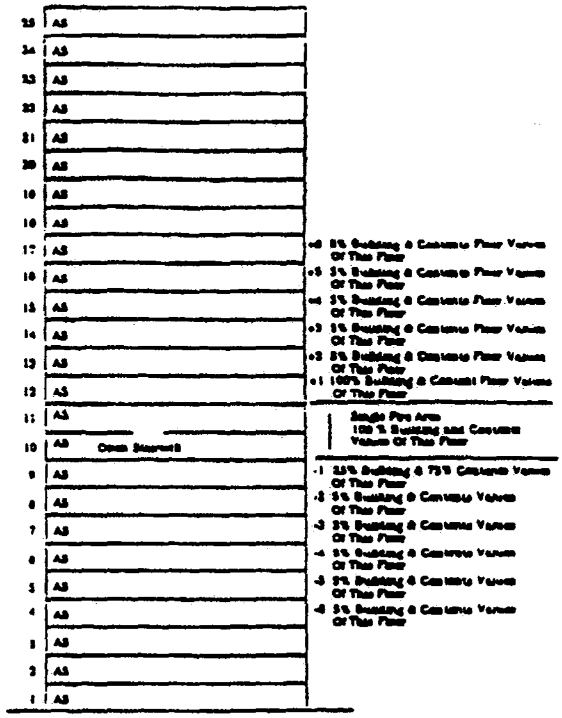


Figure 1. Stairwell Opening Between The 10th And 11th Floors.

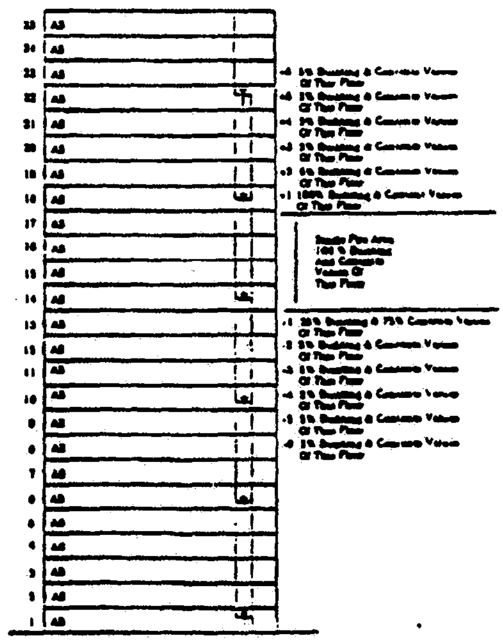


Figure 2. Sprinkler Shutoff Valves Controlling 4 Floors.

MFL DETERMINATION

To determine the MFL of a high rise building, construction features must be known. If the building is constructed with all glass exterior walls, then the MFL would be 100% of the entire building. If the building has glass windows and noncombustible curtain wall for the exterior, and interior partitioning the likelihood of a 100% MFL is low. For example: the Empire State Building has small glass windows and concrete curtain walls. It could be difficult to have a 100% loss of the building.

January 1999
Revised September 1999
Supersedes March 1990

HIGH-RISE BUILDINGS

List of Figures

FACTORY MUTUAL

1.0 SCOPE

This data sheet examines the unique fire hazards associated with high-rise buildings whose upper floors are above the public fire department's ability to fight a fire from the exterior of the building. Emphasis is placed on conditions that require special attention including exterior and interior fire spread, steel protection, fire exposure, smoke control, sprinkler protection, and manual fire fighting.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Construction

1 For new high-rise buildings, the fire resistance of major structural components should be at least equal to:

2 hours for floor slabs and beams
3 hours for columns
2 hours for shafts and chases
2 hours for stairwell and elevator enclosures.

Where spalled or missing fire-resistive coatings are encountered in new or existing construction, the maximum area of spalling that can be tolerated before repair is needed is only a few square inches.

Where High-Strength Concrete (HSC) is proposed for new construction, one of the design considerations outlined below should be employed to limit spalling and weakening of the concrete during fire exposure:

a Provide a fire resistant covering over the outer surface of the column, or

b Provide an additional thickness of HSC, or

c Modify the HSC mix, as verified by fire test

It is the responsibility of the designer to verify that the proposed protection thickness or formula variation provides adequate fire resistance as recommended above.

2 The exterior vertical spread of fire in unsprinklered buildings can be minimized when the distance between any floor and the bottom of the window on the next story above that floor (H) is at least 2.8 times the window height (h) if windows are closed, and at least 3.8 times the window height if windows can be opened. (See Fig. 1A.) Exterior vertical fire spread can be prevented if

$H \geq 2.8\ h$, if windows are closed (permanently)
$H \geq 3.8\ h$, if windows can be opened

When there is more than one window per floor (in the vertical direction), the distance (H') between the top of the floor of expected fire origin and the *top* of the *lower* window on the floor above should be at least equal to 3.8 times the sum of the window heights on an individual floor to help prevent vertical exterior fire-spread. (See Fig. 1B.)

$H' \geq 3.8\ h_{tot}$

where: h_{tot} = height of lower window plus height(s) of upper window(s)

Such protection is considered equivalent to $H \geq 2.8\ h$, when there is only one window. This assumes all windows are closed.

When windows can be opened, the following criteria should be met:

$H' \geq 4.8\ h_{tot}$

If separation is less than recommended above or if the exterior walls contain combustibles, the potential for exterior vertical firespread via windows exists.

$h_{tot} = h_1 + h_2$
$H' \geq 3.8\ h_{tot}$ (For Closed Windows)
$H' \geq 4.8\ h_{tot}$ (For Open Windows)

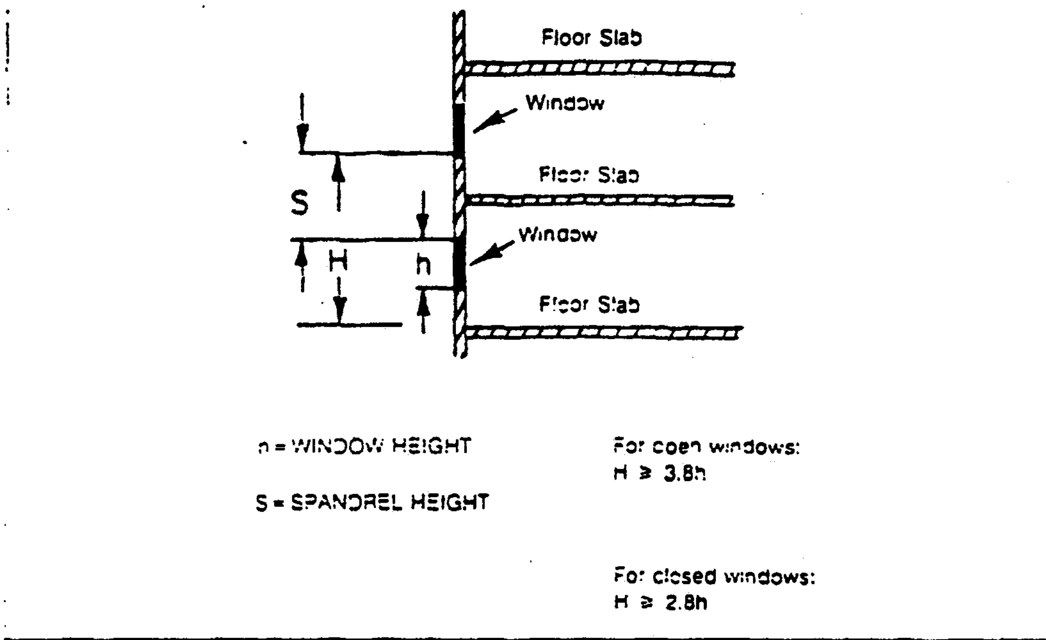


Fig. 1A. Typical exterior window arrangement

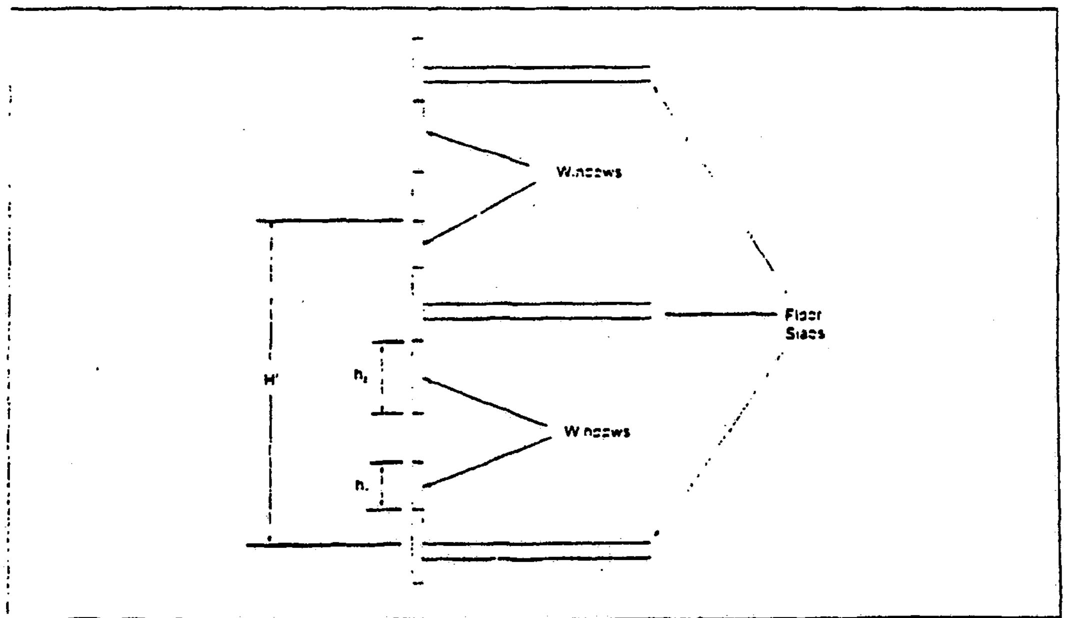


Fig. 1B. Window heights

3 Openings between floors found in shafts, chases and stairwells or openings in partitions between floor areas, should be protected with Factory Mutual Research Corporation (FMRC) approved and labeled normally closed or automatic closing fire doors having a fire rating of at least 1½ hours (unless otherwise noted) and installed in accordance with Data Sheet 1-23.

4 Openings in floor slabs used for utilities (poke-throughs) should be protected with FMRC-approved floor penetration fire stops with a 2-hour fire resistance rating.

5 Panels used for exterior walls should be noncombustible. Examples include concrete, masonry, or glass fiber insulated steel sandwich panels. The panels and frames should be tightly secured at each floor (to prevent outward buckling under fire exposure), with the space between the panels and the floor slabs filled with a noncombustible firesafing (fire-stopping) material such as mineral wool or ceramic fiber, which has passed a fire resistance test by a recognized testing lab for a minimum of two hours. Because floor dimensions are usually limited in a high-rise building, internal expansion joints between floor sections are rarely provided. However, if such a situation is encountered, similar protection as described above should be recommended.

Glass fiber is not acceptable as firesafing. The firesafing should be securely held in place. Z clips may also be used to support the underside of, or to pierce, the firesafing and hold it in place. (See Figures 2A to 2C for appropriate designs.)

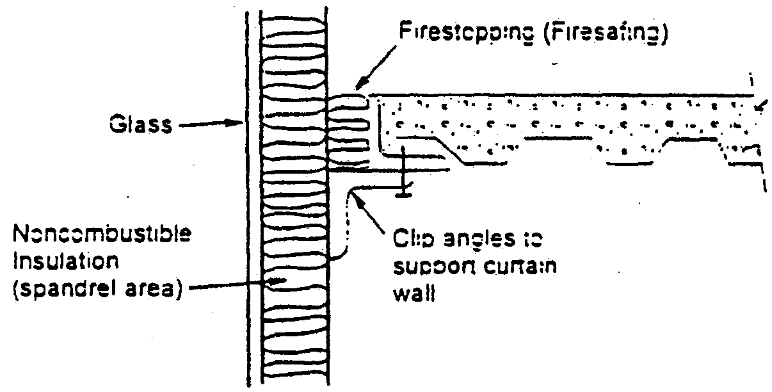


Fig. 2A Exterior wall glass in metal frame. Firestopping friction fit in space and supported by clip angle.

Glass exterior cladding may also be utilized as long as interior cladding, such as steel panels or gypsum board, limit the window height to within the range noted in Recommendation No. 2 above.

When glass exterior cladding is utilized, spandrel heights must be defined by interior cladding such as steel panels or gypsum board.

The location of the horizontal joint between vertical sections of glass panels is also critical. If a vertical section of glass panel spans from floor to floor with horizontal joint in line with the floor, the shattering of glass on the fire floor and the floor above should be assumed, and the analysis of exterior fire spread potential should be the same as that for openable windows (H ≥ 3.6 n)

If the horizontal joint between vertical sections of glass panels occurs at the top of the spandrel immediately above the assumed fire floor (see Fig. 2D), and the window sill is steel, it should be assumed that the glass on the fire floor will shatter but that the next glass panel above will remain intact and seal off the window opening on the floor above the fire if the window ratio is H ≥ 2.8 h

Sandwich panel curtain walls utilizing aluminum skins, combustible insulation (such as foam plastic) or no insulation should be completely interrupted at each floor with a barrier of equal fire resistance to that of the floor.

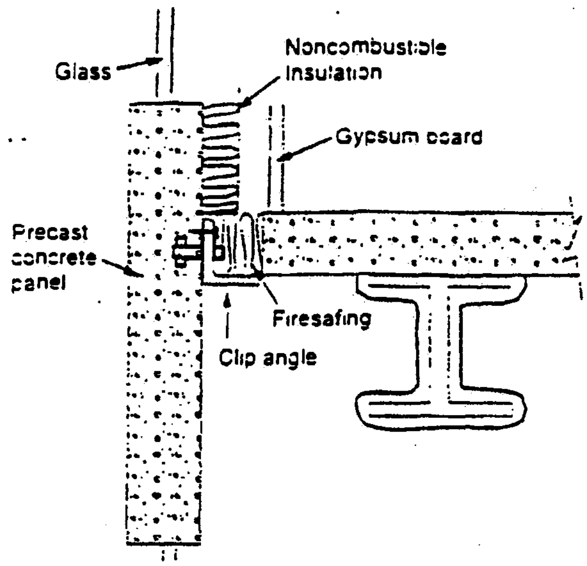


Fig. 2B. Firesafing friction fit into space and held in place by clip angle secured to exterior precast concrete panel.

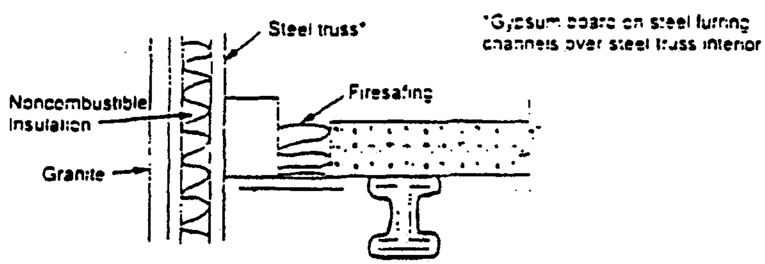


Fig. 2C. Firesafing support welded in place

6 Atriums and other open areas that extend between multiple floors should be separated from adjacent occupied areas by a smoke-tight fire partition having a fire-resistance rating of at least two hours. Openings should be protected with FMRC Approved and labelled (normally closed or automatically operated by smoke detection) fire doors with a minimum 1-1/2 hour fire rating. If windows are provided in the fire partition, they should have a minimum 1-1/2 hour fire rating.

7. Protection against wind and earthquake should be accomplished in accordance with Data Sheet 1-7 and Data Sheet 1-2, respectively. Roof assemblies on high-rise buildings should be designed in accordance with those of the following references which apply: Data Sheets 1-28, 1-29 and 1-49, and the FMRC *Approval Guide*.

8 Guidelines relating to vertical firespread in Data Sheet 1-3 do not apply to leaning high-rise buildings. (See Fig. 3.)

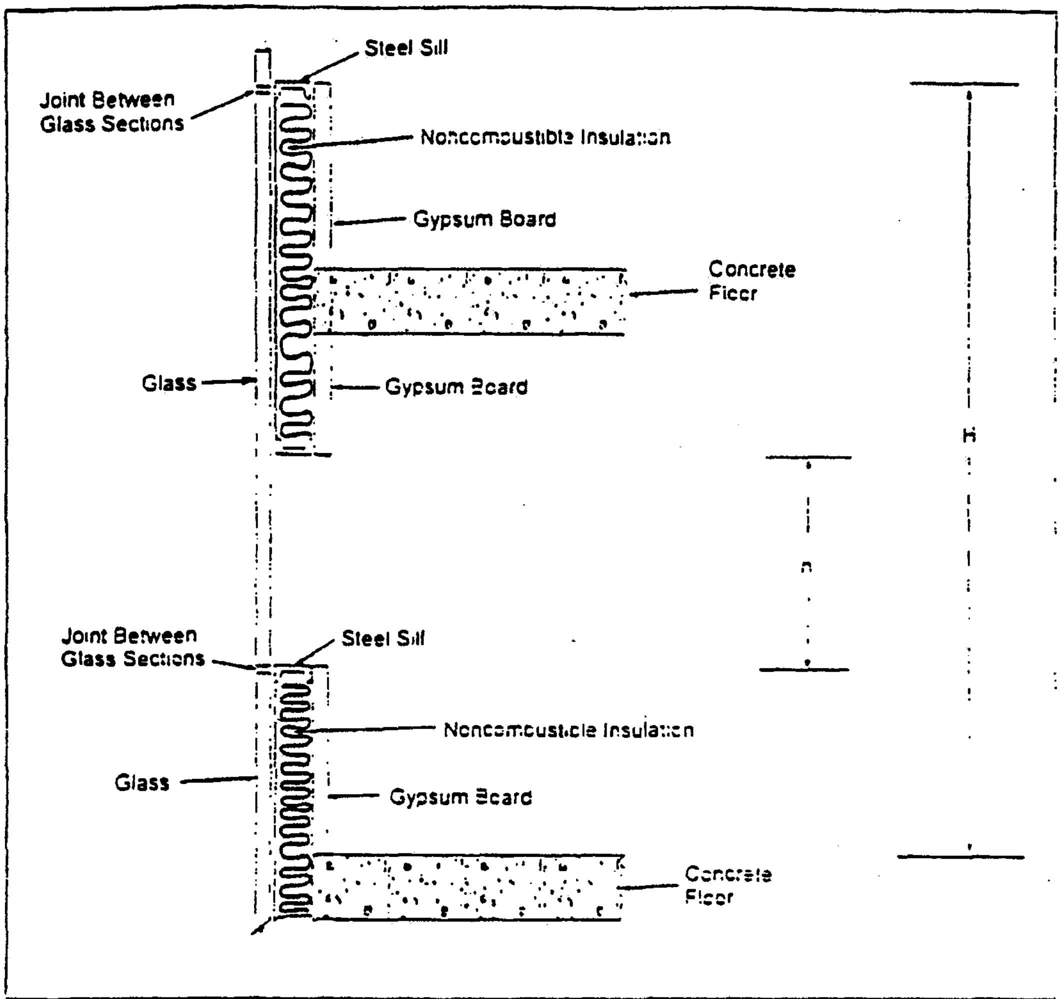


Fig. 2D. Continuous glass exterior

2.2 Fire Protection

1. Sprinkler protection is desirable for all high-rise buildings and is recommended as follows

   a. For new construction, automatic sprinkler protection should be provided throughout all high-rise buildings.

   b. For existing buildings, sprinkler protection should be provided for areas with a significant combustible loading.

   c. All atriums should be provided with sprinkler protection at the roof level as well as at each floor, under corridors or balconies facing the atrium. If the ceiling or roof is more than 30 ft (9 m) high, the combustible loading should be maintained at a limited level

   d. When installing new sprinkler risers in existing buildings, valved hose outlets should be provided at all floors where sprinklers are not provided. Valving should not be provided on the riser itself, upstream of the fire department pumper connection

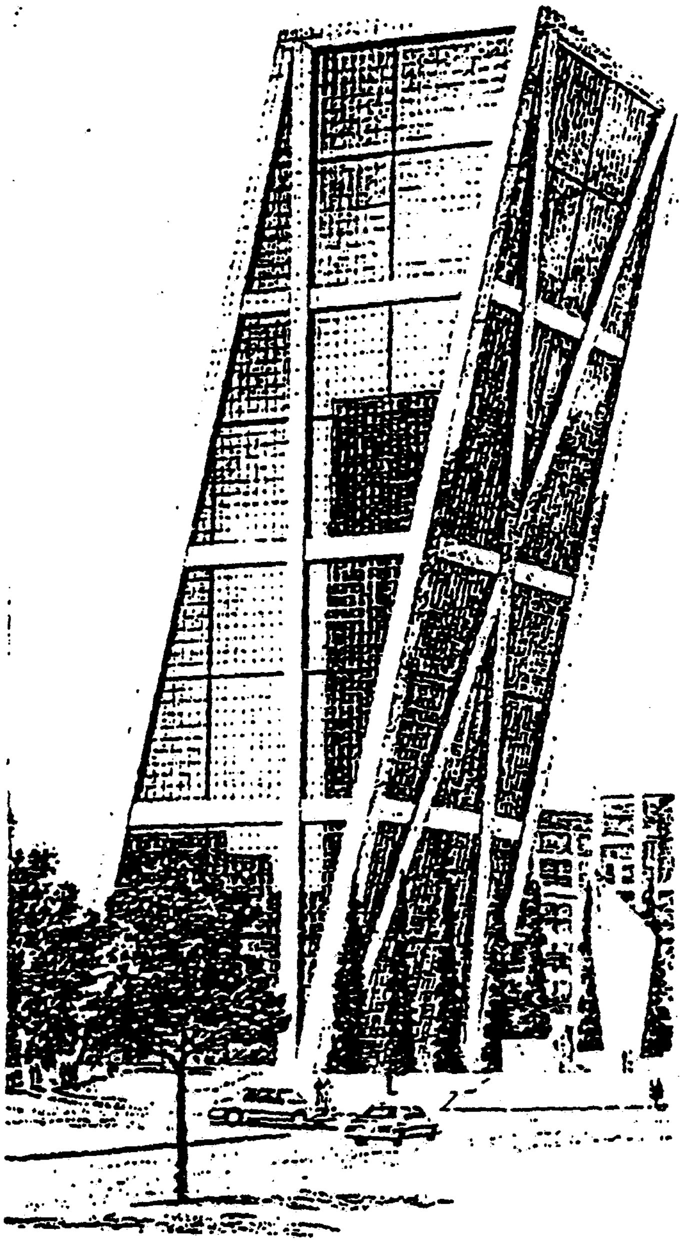


Fig 3 Leaning high-rise buildings

2 Sprinklers should be installed in accordance with Data Sheets 2-8N and 3-26 Pipe sizes may be based on pipe schedules or hydraulically designed systems, as appropriate for the occupancy Wet pipe sprinkler systems may be hydraulically designed as follows:

In office or residential areas, sprinklers should provide a minimum of 0.10 gpm/sq ft (4 mm/min) over the most hydraulically remote 1500 sq ft (280 sq m). See Data Sheet 3-26, Section 2.3.2, for modifications to densities and areas.

Libraries with large stack rooms should be protected as outlined in Data Sheet 2-8N.

In mercantile areas, sprinklers should provide a minimum of 0.15 gal/min/sq ft (6 mm/min) over the most hydraulically remote 2500 sq ft (232 sq m).

In all of the above cases the hose stream allowance is 250 gal/min (945 cu dm/min), the duration is 60 minutes, and the sprinkler temperature rating is 165°F (74°C).

Special arrangements, such as storage, exhibition halls, etc., should be protected according to applicable data sheets.

3. Provide an adequate water supply for fire protection according to Data Sheet 3-26, Data Sheet 3-7N/13-4N, and Data Sheet 2-8N. Pressure should not exceed 175 psi (1206 kPa) (12.1 bar) on sprinkler piping, sprinkler heads and backflow preventers.

4. Whenever possible, design water supply and fire protection systems to avoid the need for pressure reducing valves. When unavoidable, pressure reducing valves should be installed in accordance with Data Sheet 3-11.

5. Provide standpipes for Class III service with both 2½-in. (64 mm) and 1½-in. (38 mm) hose connections in accordance with Data Sheet 4-4N. The water supply should be able to provide a total demand of 500 gal/min (1890 cu dm/min) plus 250 gal/min (945 cu dm/min) for each additional standpipe at an adequate pressure at the topmost outlet. The fire department should be contacted to determine needed water pressure, taking into consideration the operating pressure for the particular nozzles used and friction loss through the hose. The sprinkler and hose demand outlined in Recommendation No. 2 need not be added to the immediately above demands, but should be available as recommended.

6. Install grouped electrical cables according to the National Electrical Code and Data Sheet 5-31/14-5 *Cables and Bus Bars*.

7. Provide a supervised fire alarm system connected to a constantly attended location. The alarm system should at least monitor waterflow alarms for each sprinklered floor, all smoke detectors, and heat detectors in unsprinklered areas, and should provide electrical supervision for fire pumps, tanks and reservoirs in accordance with Data Sheet 9-1 and other applicable data sheets. Due to the large number of sprinkler valves and the impact of a shut valve, constantly monitored valve tamper alarms are also preferred.

8. Provide portable fire extinguishers in accordance with Data Sheet 4-5.

2.3 Smoke Control

Because of the many variables of building construction, contents, etc., only the very broadest of generalities can be addressed concerning the features of a smoke-control system. For additional information, refer to Section 4.2, Smoke Control.

1. Ducts for air conditioning and exhaust systems should be protected in accordance with Data Sheets 1-45 and 7-78.

2. Smoke control for atriums should be provided as follows:

   a. An independent, mechanical smoke exhaust system should be provided at the top of the atrium for removal of smoke which rises to this level from the base of the atrium or from floors opening to it. The exhaust system should be designed to provide at least six air changes per hour in the atrium. When the volume exceeds 600,000 cu ft (16, 800 cu m), the exhaust system should be designed to provide at least four air changes per hour.

   b. The activation of the exhaust system should be accomplished with smoke detectors installed at the atrium ceiling level, in accordance with Data Sheet 5-48 and the FMRC *Approval Guide*.

   c. Where practical, the air-handling systems in areas facing the atrium should be designed to pressurize these areas upon smoke detection to lessen the smoke damage.

2.4 Fire Department Operation

1 In existing unsprinklered buildings. stairwells or other enclosures where manual fire fighting equipment (standpipes, fire extinguishers, etc.) is located should be protected as follows

a The enclosures should have at least a 2-hour fire rating.

b Openings in the enclosures should be protected with minimum 1½-hour fire rated normally closed or automatically operated fire doors

c Where practical, openings to accommodate at least two 2½-in (64 mm) hose lines should be provided in the enclosure, at each floor level, to allow passage of hose lines from the protected enclosure. These openings should be maintained normally closed with caps or dampers of equal fire resistance to that of the enclosure. They should be used only by the fire department or authorized building personnel.

2 To keep the stairwell enclosures free of smoke during a fire, the enclosures should be pressurized as recommended under "Smoke Control" and Recommendation 3 below

3 An independent air supply system should be provided to pressurize the stairwells as follows

a The air preferably should be supplied through a single duct running vertically inside the stairwell

b Air injection should be provided at every other floor to ensure air movement, which will maintain pressurization.

c The air-distribution system should be continuously self-balancing, eliminating the need for extensive adjustments following installation.

d The stairwell pressurization system should be arranged in zones comprising a maximum of 14 stories per zone. The system should be designed to maintain pressurization with three doors open per zone.

e Fans, power supply, and distribution system should be protected by enclosing them in construction of at least 2-hour fire resistance

f If two different zones are located on the same floor they should be separated from each other by fire walls of equal fire resistance to that of the stairwell enclosure

4. Combustibles should not be stored in the stairwell enclosures

5 Provide a diesel or gasoline emergency generator, capable of furnishing power for emergency lighting, communication, emergency elevators, fire pump, and smoke control operation as a minimum The fuel supply should be adequate for the full demand for a minimum of two hours

6 The fire pumps, the emergency generator or other power supplies and associated fuel supplies, should be protected by enclosing them in construction of 2-hour fire resistance.

7 Elevator protection depends on the size and type of the building The following recommendations are adaptable to the particular need.

a High-rise buildings should be designed so that elevator shafts are away from the areas of potential fire danger: i.e., on the perimeter or in an isolated core. If this is not the case, elevators and shafts should be otherwise protected against heat and smoke as recommended under "Smoke Control."

b. Elevators should be positioned so that activation of a fire alarm in the emergency communication center will send them directly to the first floor or lobby.

c. At least two elevators servicing each floor should have the ability to be dedicated for fire fighters' use and to be operated with special keys. These elevators should be in protected shafts For new construction these shafts should have a 2-hour fire resistance

8 An emergency communication center should be established for the following functions, according to the size of the building and its fire hazards:

a. The control point for emergency communication.

b. The control point for emergency operation of all the building electromechanical systems such as fans, elevators, smoke control, fire protection, etc.

c. The center for directing fire fighting and rescue operations

2.5 Human Element

1. An Emergency Organization should be established and trained for emergency action. It should be under the direction of building management and trained to handle emergency situations. Key personnel should include a person in charge, someone to call the public fire department, fire pump operator, and sprinkler valve operators, as a minimum. The cooperation of the building owner and tenants should be sought so that ample trained personnel will be available at all times to handle emergencies. The person in charge should coordinate with the public fire department in planning for any emergency. These plans should then be reviewed annually. A person knowledgeable of the building construction and occupancy should be stationed at the building command center to assist and direct the public fire department.

2. The fire alarm and smoke control systems, including alarms and shutdown devices, should be thoroughly inspected and checked for proper operation by adequately trained personnel at least every six months. In particular, the following equipment should be examined:

a. The system activating devices, such as fusible links or heat or smoke detectors, should be checked to see that they are not covered with or contain residues, or are otherwise impaired.

b. Fire and smoke dampers should be inspected at least annually to detect damage, obstructions and corrosion.

c. Heat and smoke detector systems should be inspected and tested. Manufacturers' or installers' recommendations should be followed in maintaining, inspecting and testing the equipment.

d. The overall system should be arranged so that it can be adequately tested every six months by simulating emergency mode conditions.

3. All equipment requiring servicing and testing should be readily accessible, and a practical means should be provided for adequate cleaning.

4. Sufficient instrumentation should be provided for testing and maintaining the fire protection equipment.

5. Fire pumps, sprinkler systems and standpipe systems should be maintained, inspected, and tested in accordance with the applicable FMRC data sheets. All equipment and controls should be clearly identified.

6. Testing and maintenance manuals for other fire protection equipment should be provided in accordance with the manufacturers' and installers' instructions. These should include operating, servicing, testing and troubleshooting instruction.

Table of Contents

MFL OF HIGH-RISE BUILDINGS

REFERENCE: FM GLOBAL OPERATING STANDARD (O.S.) 1-3;
E. D. DIRECTIVE 5-96 DATED 3/15/96;

I. THE REQUIREMENT

To communicate complete and accurate high-rise building MFL information to the account team in a consistent and efficient manner.

II. MEASUREMENT

A. The account team will be satisfied with accuracy and completeness of high-rise MFL evaluations.

B. Improved accuracy of high-rise MFL evaluations will result in optimized reinsurance costs.

III. INTRODUCTION

A. This P&P provides guidance on analyzing the MFL of high-rise buildings, which are buildings whose upper floors are above the reach of fire department aerial hoses (usually more than 75 ft. [(23 m)] grade). It helps evaluate various unique factors of construction, and it makes specific use of fire department response. This will allow the reader to determine the MFL area, advise when to make this determination the first time, and give guidance on the inspection and report.

B. The P&P text and MFL Decision Tree are an integral unit and need to be used together to properly determine the number of fire floors. Once the number of fire floors is determined, the text gives guidance on smoke and water damage. See O.S. 1-3, "High-Rise Buildings," for definitions and technical descriptions of various construction features.

C. This P&P was written considering normal construction practices for High-Rise Buildings. It is expected that there will be some unusual features or conditions (such as leaning buildings) where considerable judgement will be required to augment this guide.

D. If unusual construction features are encountered, discuss them with the FM Global operations center high rise or MFL specialist, standards engineer, or engineering field manager.

E. These guidelines should not be used wholly or in part for other than high-rise buildings or for occupancies beyond the scope of this P&P.

F. As with nonhigh-rise MFL evaluations, protection reliability should be determined using O.S. 3-29.

IV. WHEN TO EVALUATE MFL

Analyze the MFL during all candidate, first and regular visits where it has not previously been done. For existing locations not evaluated per this P&P, re-evaluate only if TIV exceeds $50 million. For any high-rise MFL analysis done during special visits, follow the instructions on the "Authorization for Engineering Services" Form 135 or equivalent.

There are instances where a full high-rise MFL analysis should not be done, such as locations where the insurance companies have limited interests or where the building is only a few stories above the reach of fire department aerial hoses. In such cases use judgement. Either do not change the MFL or do an abbreviated evaluation, and comment in "Items of Interest" on the report.

V. GENERAL MFL SCENARIO

This brief scenario covers the main features of an MFL high-rise fire, and gives added perspective to what follows.

- A fire starts on a floor above the reach of mobile fire department apparatus. In buildings with multi-floor openings (stairs, escalators, open atriums) on lower levels or in communities with volunteer fire departments, a fire may start on a lower floor and spread upward to involve the high-rise.
- The floor of origin is fully involved by the time the fire department can actually access the floor and fight the fire (delay is expected due to tenant evacuation, discovery time, traffic, set-up time, etc.).
- Special features of building construction may limit the fire to extensive involvement on only one floor, with some fire damage above it due to unprotected poke-throughs. Beyond this, many variations are possible based on construction and fire department response.
- If *only interior* avenues of additional vertical fire spread are likely (e.g., via poke-throughs, but not atriums, open stairs, etc.), a paid PFD with good response can generally contain the expected small fires above the floor of origin. This would result in fire limited to two floors with heavy damage to the floor of origin, and lesser fire damage above that (plus smoke and water damage). Variations in construction discussed in the text and shown in the decision tree may increase this two-fire floor scenario to three, four, five or more fire floors.
- If *exterior* vertical spread is possible, the fire can spread by both interior and exterior avenues. It is dramatically more challenging due to increased size, speed and intensity. Fighting it requires a few hundred personnel, extensive breathing apparatus equipment and refilling ability, special planning and training, etc. The fire may spread to the roof although favorable features of construction and PFD response may limit it to only five (5) floors.
- If the fire can't be contained within five burning floors, it will probably not be controlled at all. It will spread to all upper floors unless stopped by a fire break such as a tall, blank, noncombustible mechanical equipment floor with blank exterior walls.

VI. BEFORE USING THE MFL DECISION TREE

The decision tree is a job aid for predicting the number of fire floors in the MFL area.

Several assumptions and conditions guide its logic, and apply to those stories located above the elevation of fire department reach up the building exterior:

A. 1. The decision tree is intended for typical high-rise buildings containing commercial, business and residential occupancies. It applies to ancillary occupancies common to these buildings like file rooms, retail shops, display areas, show rooms, stock rooms, print shops and shipping/receiving areas. It does not apply to garment or other warehousing, department stores, malls, garment or other manufacturing. It is based on high-rise loss experience of mostly offices and hotels and some hospitals, dormitories and shops.

The decision tree is not intended to apply to other occupancies or to non high-rise buildings.

2. In occupancies with scant combustible loading, serious fire exposure and spread to upper floors is not expected, so this procedure will not apply. (See O.S. 1-3 for definition of scant combustible loading.)

B. To qualify as protected steel construction in Table 1, the fire resistance of major structural components must be at least equal to:

1. 2 hrs. for floor slabs and beams
2. 3 hrs. for columns
3. 2 hrs. for shafts
4. 2 hrs. for stairwell enclosures

If the fire resistance of shaft or stairwell enclosures, floor slabs or secondary beams is deficient, consider the fire will involve all floors above the fire floor, with structural damage limited to the related member. If the fire resistance of columns or primary beams is deficient, consider that the fire will involve all floors above the fire floor and that major structural damage will occur. Where column fire resistance is less than 3 hours but at least 2½ hours, conditions may be tolerable based on Figure 4. No tolerance is allowed for other building members.

C. Except for limited isolated areas, ceilings should be noncombustible.

If not: The fire will spread up to all floors rapidly from window to window.

D. Interconnected stories occur when two or more stories are connected by an open stairway (or equivalent ready pathway of vertical interior fire spread).

1. When H > 2.8h and exterior walls of masonry, granite or concrete construction are connected directly to floor slabs, any number of interconnected floors are permitted. (See O.S. 1-3 for definitions of H, h.) (See result of "N+1" fire floors in the decision tree.)

2. For all other types of exterior wall construction and H:h ratios, no more than two stories may have a common interconnection(s) (e.g., one broken floor slab). A building may have any number of such pairs as long as the single broken floor slabs are separated by three or more unbroken floor slabs. If these limits are exceeded, consider the fire will spread from these floors up to the roof or possibly to a fire break. See Figure 1 for examples, and see Section VIII.H. for fire break details.

E. Building fire pumps are considered to be out of service.

F. There may be poke-throughs (openings for pipes, wires, etc.) between floors, but there should be no continuous openings outside the core areas connecting multiple floors.

G. Where there are continuous multi-floor openings outside the core, there will be fire involvement of the entire building above the fire floor. (Small isolated shafts, such as gravity mail drops, need not be considered unless they contain conveyors or other mechanisms for suspending combustibles throughout their length.)

H. The tower is not exposed by abutting structures such as malls, casinos, etc. (whether connected or not):

1. having an occupancy capable of causing roof collapse thereby exposing the tower (any occupancy requiring sprinklers can collapse an unprotected steel roof); and

2. so large that hose streams cannot reach the tower itself to prevent vertical spread.

Note: If, in this case, the PFD is considered to be unable to prevent exterior spread, the decision tree may still be used, but all questions related to PFD must be answered "No." In addition, a high-rise that is exposed by such an abutting structure would have many lower floors involved in fire simultaneously; unless construction features prohibit interior and exterior spread, all floors would probably become involved.

In the instances where a high-rise building is abutted by or above a low-rise commercial or mall building and a fire in the lower building exposes the high-rise, several evaluations may be required to determine the largest MFL area, which might include the tower, the low-rise, or both buildings. In these instances the evaluation for the low building should be done per conventional MFL guidelines.

VII. USING THE DECISION TREE

The following explanation of terms may be helpful:

A. "Masonry, Granite or Concrete Walls Connected to Floor Slabs."

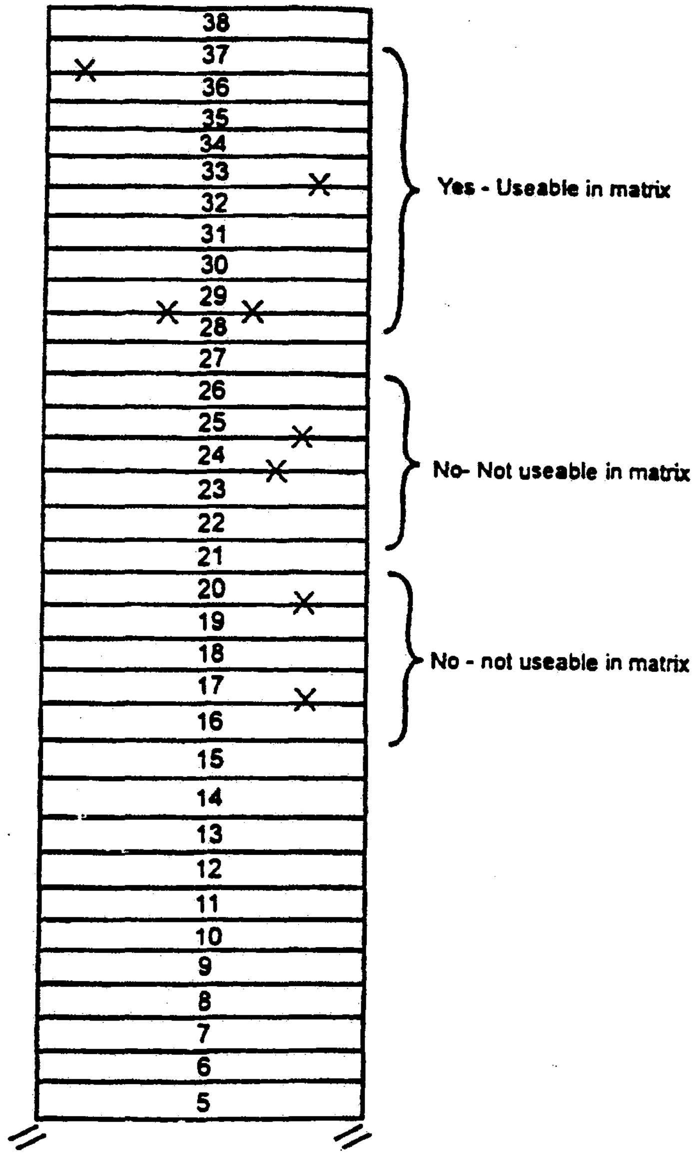
The floor supports the masonry, granite or concrete wall, or is constructed so no floor-wall gap exists or can be readily created by the fire. This prevents upward fire spread inside the building at the floor-wall connection. Answer "NO" if there are no such masonry walls, or these walls exist but are not connected to the floor slab.

B. "Perimeter Flue Space."

The space that occurs between the edge of the floor slab and the inside surface of the curtain wall panel in modern construction. This can be several inches to more than 1 ft. wide and will allow the passage of fire, heat, smoke and water between floors. This space is usually filled with a noncombustible or fire resistive material called "Fire Safing."

FIGURE 1

Examples of interconnected floors per assumption/condition Section VI.D.2 only.



Note: Fire would already be spreading around floor slab edges and via poke-throughs for conditions of Section VI.D.2. The "No" arrangements would facilitate significant additional interior vertical fire spread to a degree where we expect an uncontrolled fire situation.

C. "Adequate Safing."

This asks whether the perimeter flue space has fire safing. A "YES" can include friction-fit safing with minor voids. This would still impede upward spread of fire and allow the fire department to gain control. This is the criteria for a YES-NO decision. Note the safing material must be fire-resistant; ordinary fiberglass thermal insulation does not qualify as safing. New fire safing should have a two-hour fire rating as specified in O.S. 1-3. For additional information, refer to Engineering Bulletin F9-91.

D. "PFD Can Control Interior Fire Spread."

To answer YES, we need all three of the following conditions:

1. A *fully* paid fire department.

2. A pumping capacity of 500 gpm (1.9 cu.m./min) per each fire floor predicted by the decision tree at effective pressures (100 to 125 psi [703 x 102 to 880 x 102 kg sq. m]) at the hose station outlet to support hose streams on the fire floors.

3. Standpipes are in service. This means they are arranged so that no single valve can stop the flow of water from the pumper siamese to all standpipes. In the rare case that such a single valve exists, is accessible, and is expected to be checked, consider standpipes to be in service. Note: we can expect it to be checked if the site has an adequate valve inspection program and checking the valve is part of emergency procedures.

Also consider the presence of pressure regulating valves (PRVs). Where PRVs are present, they must be properly set, well maintained, and fire department and emergency organization personnel should be familiar with their operation. If not, the fire department should not be credited to controlling interior fire spread. (See Data Sheet 3-11 for information and guidance on PRVs.)

The paid fire department aspect reflects the traditional ability of a department to have the training, personnel, and equipment to successfully attack an indoor fire. This is the same general criteria as we have been using to mark PAID on the F&EC Survey.

The ability of fire fighters to prevent both interior and exterior vertical fire spread is limited to that portion of the building within the pumping capacity of the fire department (usually about 30 stories). Above the level of adequate water flow, do not credit any fire department to be able to control interior or exterior fire spread. The pumping source is most likely fire department pumpers but it may also include fixed, off-site pumps that feed standpipes in the subject building. (See O.S. 3-7N for information about the capabilities of mobile fire department pumpers.)

E. "PFD Can Control Exterior Fire Spread."

This special category of response requires a very large commitment of equipment and specially trained personnel. We need the items in Section D (above) plus an evaluation of the responding fire department. The evaluations were based on:

1. A minimum of 250 fire fighters available per shift.

Note: Additional factors to be considered:

a. Quality of personnel including training.

b. Proximity of personal residences (relates to ease of off-duty recall).

2. Mutual Aid arrangements in place with formal agreements and actual joint training conducted (not necessarily high-rise specific training); or, manpower level of 500 per shift.

3. Use of the Incident Command System or equivalent, for fire ground control.

4. A documented departmental high-rise procedure that covers such items as high-rise preplans, training and general fire attack methods.

In addition to the above, the following favorable factors may have been considered. The fire department:

5. Will preferably conduct actual field high-rise training drills for fire fighters.

6. Will maintain detailed building specific preplans for all high-rise buildings. This program should include a method of updating the preplan.

7. Will preferably have an increased initial response to a high-rise fire or an increased initial response to a confirmed fire alarm.

These seven items are for information only. Actual evaluations use more detailed criteria and normally include a visit to the department headquarters.

A list of public fire departments (see Appendix A) that have been evaluated, including those that qualify as being capable of controlling exterior fire spread, is reevaluated and updated annually. Note that if building conditions do not permit the fire department to be capable of controlling interior fire spread, an otherwise qualified department will not be able to control exterior fire spread. Also, if water sources for standpipes/hoses cannot effectively reach the upper floors (see Section VII.D.3), then the fire department cannot be expected to control fire spread on those upper floors.

F. "$1.5h < H < 1.75h$"

This is a special category where exterior fire spread is possible, but it may still be controlled by favorable factors. In general, these favorable factors assure that fire fighters need to be concerned only with exterior spread (window-to-window); all predictable avenues of interior spread would be stopped by the construction arrangement.

This arrangement rules out any interconnected floors, requires excellent fire department response, and includes two features even better than in other categories:

1. Safing is mechanically secured in place — it remains there even if the exterior wall buckles a few inches. (See Figure Nos. 2a, 2b, and 2c in O.S. 1-3 and Engineering Bulletin F9-91 for examples of acceptable mechanical securement.)

2. Poke-throughs/penetrations are properly sealed with fire resistant materials or fire rated devices. For example, duct dampers rated at two or more hours are provided on ducts as they pass through a floor; or, a two-hour rated fire stop system seals floor penetrations for a group of vertical water and steam pipes.

SPECIAL NOTE: A continuous high level of integrity of these favorable features is critical in this category to limiting the MFL to only five fire floors. These factors should be verified annually. See comments that follow under "THE INSPECTION."

VIII. OTHER BUILDING FACTORS

A. Atriums

Atriums that terminate below the threshold of high-rise height don't adversely affect the outcome of the decision tree since they are reachable at all levels by ladder trucks. Atriums that extend up to or beyond the high-rise height threshold can be considered as not contributing to vertical spread if they are arranged in a manner equivalent to stair towers, i.e.:

1. two-hour rated walls
2. all openings with automatic closing fire doors

Some modern hotels have this arrangement.

If the atrium does not have these cutoff features (e.g.: glass-walled shops open to the atrium), consider it as interconnected floors.

B. Perimeter Air Duct Penetrations

Usually this will involve vertical HVAC ducts feeding floor level registers on several floors.

1. Consider as a poke-through if a duct is in a fire rated, slab-to-slab enclosure. It may have undampered outlets at floor level.
2. Consider as N-inter-connected floors:
   a. If ducts are not in fire rated enclosures slab-to-slab for N floors.
   b. If duct(s) feed ceiling level registers on N floors.

C. Steel Protection

There should be complete coverage at adequate thickness (see specs./drawings for thickness requirements). Small holidays (missing coating of only a few square inches), such as for beam clamps, are tolerable. Variations in thickness are tolerable as long as overall thickness is there.

Architectural drawings (sometimes) and specifications (always) have information on fire proofing, and these two sources are usually easiest to find. There is no simple guideline for estimating fire rating of an installed material. There are three basic types: insulating (rock wool, ceramic fiber, vermiculite, perlite, etc.); energy absorbing (gypsum, portland cement, magnesium oxychloride, etc.); or intumescent mastic coatings [paints with spray-on thickness of up to ¼ in. ([0.6 cm]). Hourly rating varies with types of coating, manufacturer, coating density, thickness, and the characteristics of the structural steel member.

If drawings/specs. are not available, it's reasonably safe to use the code requirements in effect at the time of construction. The FM Global operations center should have some guidance on local codes. Codes do change over time, but once identified, they apply to all buildings constructed under the code at that time, thereby saving a lot of individual research effort on buildings in a given area.

As a last resort, try the following sources:

1. City building inspector or building code enforcement division - they may have records for the particular site or can provide code requirements.
2. Fire department division dealing with construction safety code enforcement.
3. Building architect.
4. Building general contractor.
5. Fire proofing installer.

D. Large Holidays (bare spots in fire-resistive coating):

1. Are a serious deficiency to a steel member.

2. During construction, holidays are usually corrected via code inspections.

3. Such code inspections cease once a building is occupied.

4. If there are large holidays on a secondary beam, consider that the beam will sag and floor will crack. This will increase local damage, but will not increase the number of fire floors predicted in the decision tree.

5. If there are large holidays on a column or primary beam, the structure above deforms. All floors above are gutted. (A recommendation to correct this deficiency is almost always warranted.) Note: See O.S. 1-3 for further discussion of bare spots in fire-resistive coatings.

E. Helicopters

Helicopters have negligible effect on our MFL considerations. They are used mostly for evacuation and rescue, and some departments avoid their use. Helicopters need no investigation or reporting unless some unusual or essential use regarding response to an MFL fire is anticipated.

F. Openable Windows

Openable windows are rare in modern office high-rises in the United States. However, some older buildings, hotels, health care facilities, and some non-United States high-rise buildings do have them. Open windows facilitate exterior firespread and we need the larger ratio of $H>3.8h$ per O.S. 1-3 in order to prevent exterior vertical spread since at $H=3.8h$, the theoretical flame tip height is already at the bottom of the window on the next upper story. A ratio less than 3.8h would allow flame to enter an open window; this would involve direct flame entry to the floor above and facilitate vertical fire spread.

With open windows and $H < 3.8h$, vertical exterior fire spread would be very rapid due to the ready availability of combustibles to the flames entering each upper floor window.

Using the decision tree and considering openable windows, a "NO" to "Exterior Walls H > 3.8h" would lead directly to "All Floors Above PFD Reach Involved." A "YES" would follow the normal path through the matrix.

Noncombustible balconies of adequate size can deflect flames and stop upward exterior fire spread. When noncombustible balconies are provided below all openable windows, are at least 4 ft. (1.2m) deep, and are continuous or extend at least 4 ft. (1.2m) beyond the window edges, exterior vertical fire spread should not occur.

G. Smoke Control System

Building smoke control systems, even if elaborate, have little effect on an MFL scenario. These systems are easily overwhelmed by propped-open stairwell doors for fire hoses, broken windows and the large extent of smoke production (often orders of magnitude larger than the systems are designed for). These systems should not be considered for MFL analysis.

H. Mechanical Floors as Fire Breaks

A mechanical floor may serve to stop the vertical spread of fire. The floor stops interior spread via negligible combustible loading and good cutoffs. It stops exterior spread if its walls are high enough so exterior flames don't reach beyond the top of the window on the floor above the mechanical floor. The formula that follows will account for this, and Figure 2, Part "B" shows the minimum allowable mechanical floor height.

Experience shows that even if up to five floors are to be involved in fire, the lower of those floors are consumed by the time the upper floors are involved. So only up to three floors are expected to be fully involved at once. This applies to buildings with no combustible ceilings, with closed windows, and within other assumptions and conditions listed under Section VI., "BEFORE USING THE MFL DECISION TREE". If not, many more than three floors may be involved simultaneously and this will not apply.

The chief application as a fire break occurs where H > 2.8h. Here, unfavorable conditions that facilitate interior spread may lead to several floors burning simultaneously. Where H > 2.8h, flames exiting exterior windows reinforce each other negligibly and a mechanical floor with minimal combustibles can halt interior fire spread. The decision tree shows in this case that a mechanical floor is always a viable consideration, and it need not have a slab-to-slab height greater than that of other floors to be effective. Note that the arrangement of wall-type and interconnected floors is still limited by Section VI.D.

Also, note that if H > 2.8h and the building has masonry, concrete or granite walls connected to floor slabs, we don't need a blank mechanical floor to stop fire ascent. The scenario here is that the building construction resists fire ascent once the fire runs out of interconnected floors. The only remaining avenue of vertical spread is poke-throughs, and most any fire department response could arrest flames spreading only via poke-throughs.

In the 1.75 < H < 2.8h range, fire can spread both internally and externally. But there may still be conditions where a mechanical floor will have both the minimal combustibles to stop interior fire ascent plus have tall enough walls to prohibit exterior flames from passing to the floors above it.

There are three conditions in this H:h range which could lead to fire spreading to the roof. These are:

1. inadequate safing
2. PFD's that cannot control exterior fire spread
3. interconnected floors within the limits of Section VI.D.

If only ONE of these unfavorable conditions is present, we may expect only three floors will be burning simultaneously. A mechanical floor may then still serve as a fire break. A mechanical floor cannot be used as a fire break if interconnected floors are excessive (use limits of section VI.D. as a guide) or if H < 1.75h.

Assuming only three floors are burning, a mechanical floor would need a height Br (expressed in number of floor heights) to stop exterior spread as follows:

Equation (1): $Br = 4.78h - SL - 2S$

where:

Br = required height of mechanical floor as firebreak in feet (or meters)

h = window height in ft. (or meters)

SL = height of lower spandrel (above floor surface) in ft. (or meters)

S = total height of spandrel in ft. (or meters)

NOTE: Floor height equals S + h for fire floors.

EXAMPLE:

A 30-story protected steel frame high-rise building has no interconnected floors. 12 ft. (3.7m) high stories with 5.8 ft. (1.8m) high windows, and spandrels centered on the floor slabs. It has a 20 ft. (6m) high, 17th story mechanical floor with no windows and with negligible combustibles. Fire department apparatus can reach the ninth floor. Safing consists of friction-fit fiberglass insulation. The building meets various other assumptions/conditions (e.g.: adequate fireproofing of steel, standpipes are in service, etc.) and the PFD can control exterior fire spread. What is the MFL fire area?

SOLUTION:

H = 2.6H, (e.g., from H = 12 + (12-5.8)/2 = 15.1; and h = 5.8). We enter the decision tree in the "1.75h < H < 2.8h" category. Since safing is not adequate (because it is fiberglass), the MFL area would be "All Floors Above PFD Reach Involved," i.e., floor 10 and above.

However, the 17th floor may be a fire stop since there is only one unfavorable condition -- the safing. It won't transmit an interior fire upward due to scant combustibles, so we only need check whether the height is adequate to interrupt exterior spread of fire.

We can use Equation (1) where:

h = 5.8

SL = (12 - 5.8)/2 = 3.1

S = 12 - 5.8 = 6.2

S+h = 12

Then Br = (4.78 x 5.8) - 3.1 - 12.4 = 12.2 ft.

So the mechanical floor needs a slab-to-slab height of at least 12.2 ft. (3.7m) to be a fire break. Since the mechanical floor is 20 ft. (6m) high, it can interrupt exterior spread. (See Figure No. 2, Part A for a scaled version of the floor heights and predicted flame height.)

We would be left with a seven-floor area below the mechanical floor and a 13-floor area above it. The 13-floor area would be our MFL fire area.

NOTE: This choice involves burning 13 floors and having damage to the other 17 floors by water. The seven floor choice would burn only seven floors and do less damage to the other 23 floors by water/smoke.

Also note Figure No. 2, Part B. The mechanical floor height is the minimum 12.2 ft. (3.7m) just calculated. This visually shows the threshold for vertical exterior fire spread. If the flame tip extends only to the top of the window (or lower), vertical spread is not expected. This aspect is built into the H > 2.8h ratio for avoiding vertical spread. For example, with only one floor burning and a ratio of H = 2.8h, the flame tip is at the top of the window on the next upper floor.

EXAMPLE:

Same as before except the 16th story directly below the mechanical floor is 14 ft. (4.2m) high to accomodate deeper steel beams supporting the mechanical floor and that portion of the spandrel is 2 ft. (0.6m) deeper. This increased distance can be credited towards the required height of the mechanical floor.

Br = 12.2 ft. - 2 ft. = 10.2 ft. (3.1m)

So, the mechanical floor would only need to be 10.2 ft. (3.1 m) to act as an effective fire break.

I. **Building Dimension Reductions as Fire Breaks**

A high-rise may have one or more abrupt reductions in floor area. Consider the reduction deep enough to stop exterior spread if its depth is at least equal to the height needed for a mechanical floor break and if it covers the entire building perimeter. In the previous example, we needed a mechanical floor height (Br) > 12.2 ft. (3.7m), so a reduction > 12.2 ft. (3.7m) would be sufficient to stop vertical exterior fire spread.

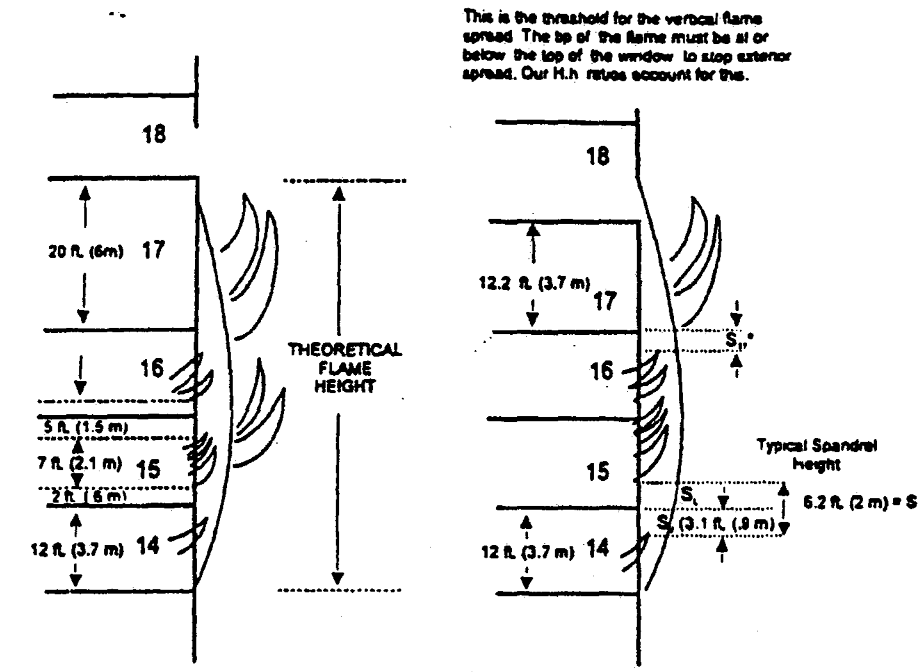
J. **Asbestos and PCB's:**

See Section XIII.G., THE REPORT.

IX. **PERCENT FIRE DAMAGE**

Use the decision tree (Figure 3) to determine the number of MFL fire floors involved. Then use the following percentages to estimate damage on various floors.

FIGURE 2

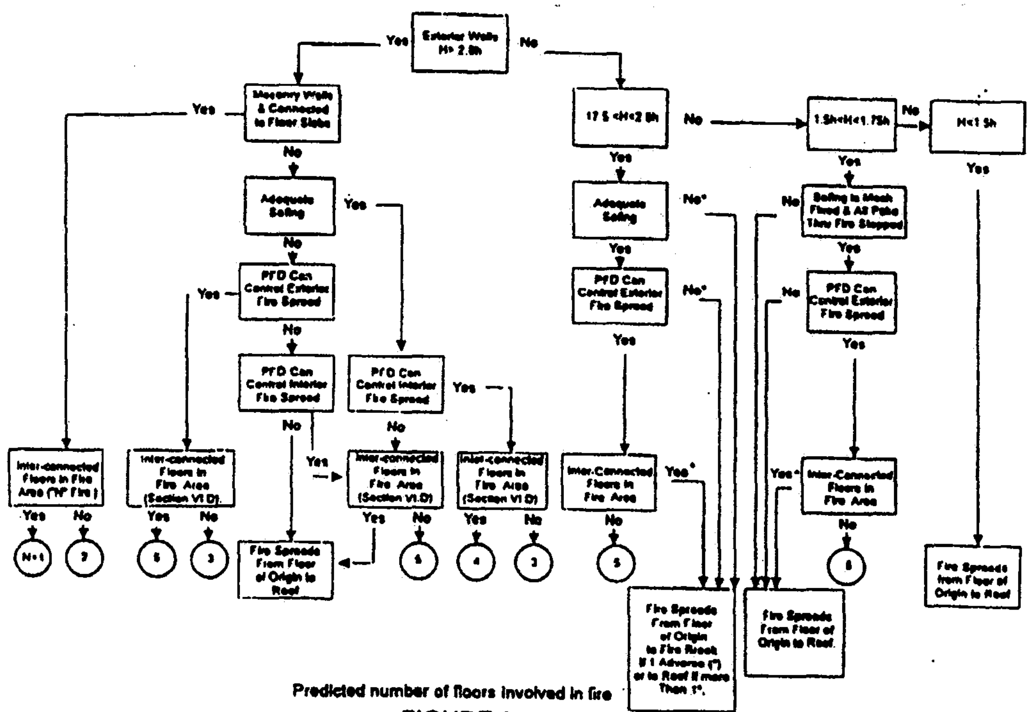


A- Conditions for Example

B- Same as A but 17th floor is only 12.2 ft. (3.7 m) high, the minimum floor height needed to stop exterior fire spread.

* The bottom section of mechanical spandrel, S_{17}, in this case, may appear deeper then typical spandrels to cover deeper beams usually needed for mechanical floors. If S_{17} is deeper, we can consider the 17th floor fire break to be higher by that difference. eg. If S_{17} were 5 ft. (1.5 m) the effective height of floor No. 17 in Figure 2B would be 12.2ft. +(5 - 3.1)ft. (1.5-.9)m = 14.1 ft. (4.3 m).

HIGH RISE MFL DECISION TREE



Predicted number of floors involved in fire

FIGURE 3

TABLE 1 - PERCENT FIRE DAMAGE

	FIRE FLOOR(S)[1,2]	
	BLDG. %	CONTS. %
REINFORCED CONCRETE	60	100
PROTECTED STEEL	70	100
NON-COMB.	Consider Bldg. & Conts. a Total Loss	

[1] All percentages include demolition costs.
[2] Use 25 to 50% of these values to account for anticipated smaller fire areas in buildings with small subdivided rooms such as hotels, apartments or hospitals if the following conditions are met:

- rooms have slab-to-slab partitions or partitions that fit tightly to plastered or concrete ceilings
- each room has a self-closing or normally closed fire door.

X. WATER DAMAGE

Once the number of fire floors is determined from the MFL decision tree, Table No. 2 may be used to estimate the vertical extent and average percent of water damage.

Example No. 1: Consider an office building where four fire floors are predicted, and for various reasons involve floors 22 to 25. Then from the "F" and "W" rows of Table No. 2, 14 floors will be water damaged -- in this case Nos. 8 to 21. Finally, for N=14, the average water damage for all those 14 floors will be 10.7% for building and 26.8% for contents.

Table 2 is a suggested job aid and reflects some general trends from loss experience. There is generally a gradient of water damage starting at 20% to the building value and 50% to contents value just below the fire floor, and diminishing to zero just after the 4, 8, 14, 21 or 25 floors shown in Table No. 2. The table assumes the gradient is uniform. It shows a running average of percentages for gradients that run the full number of expected water damaged floors (as in Example No. 1) and for gradients that are truncated (as in Example No. 2 below).

For example, sometimes the fire floors will be low enough in the building that below them there will not be available the full number of expected water damaged floors (shown in the "W =" row). This means the lowest floor will intercept water that would have gone down farther to the other floors. Also, water will stay there longer since there are no poke-throughs, openings., etc. for water to readily drain away. (Floor drains are usually available and may eventually evacuate the water, but they have far less capacity than normal openings in and around upper floors.)

As a guideline in this type of situation, figure 40% damage to the building and 75% damage to contents on the lowest floor unless you have reason to believe it will be different.

TABLE 2 — WATER DAMAGE PERCENTAGES

F = W =	2 4		3 8		4 14		5 21		≥ 6 25	
	BLDG-	CONTS	BLDG	CONTS	BLDG	CONTS	BLDG	CONTS	BLDG	CONTS
1	20.0	50.0	20.0	50.0	20.0	50.0	20.0	50.0	20.0	50.0
2	17.5	43.8	18.8	47.0	19.3	48.3	19.5	48.8	19.6	49.0
3	15.0	37.5	17.5	43.8	18.6	46.5	19.0	47.5	19.2	48.0
4	12.5	31.3	16.3	40.8	17.9	44.8	18.6	48.5	18.8	47.0
5			15.0	37.5	17.1	42.8	18.1	45.3	18.4	46.0
6			13.8	34.5	16.4	41.0	17.6	44.0	18.0	45.0
7			12.5	31.3	15.7	39.3	17.1	42.8	17.6	44.0
8			11.3	28.3	15.0	37.5	16.7	41.8	17.2	43.0
9					14.3	35.8	16.2	40.5	16.8	42.0
10					13.6	34.0	15.7	39.3	16.4	41.0
11					12.9	32.3	15.2	38.0	16.0	40.0
12					12.1	30.3	14.8	37.0	15.6	39.0
N=13					11.4	28.5	14.3	35.8	15.2	38.0
14					10.7	26.8	13.8	34.5	14.8	37.0
15							13.3	33.3	14.4	36.0
16							12.9	32.3	14.5	35.0
17							12.4	31.0	13.6	34.0
18							11.9	29.8	13.2	33.0
19							11.4	28.5	12.8	32.0
20							11.0	27.5	12.4	31.0
21							10.5	26.3	12.0	30.0
22									11.6	29.0
23									11.2	28.0
24									10.8	27.0
25									10.4	26.0

F = Predicted number of MFL fire doors
W = Expected number of water-damage floors
(Additional floors may be damaged where water falls to the bottom of stairwells, elevator shafts, etc. Those require separate consideration.)
N = Actual number of floors available for water damage.

Example No. 2: Same as No. 1, except the four fire floors begin at floor No. 9. Assume the building has one basement. Then the basement through floor 8 will contain the water that would have passed through 14 floors. The basement would sustain 40% water damage to building and 75% to contents. From Table No. 2, we still have F=4 and N=8 for the remaining eight floors; so we find that those eight floors sustain an average 15% water damage to building and 37.5% to contents.

The table also assumes the occupancy is uniform from floor to floor. If a floor has an unusual or concentrated value, the gradient concept in the table may still be useful. The percent damage normally attributed to that floor may be used as a guide in assessing severity of occupancy damage. The percentage for any given floor will decrease from 20% in the gradient and is found from:

Equation (2)*: $PERCENT_n = 20\left(1 - \frac{n-1}{W}\right)$

where $PERCENT_n$ = percent water damage on the n'th floor below the lowest fire floor

n = the n'th floor below the lowest fire floor

W = Table No. 2 value for expected number of water damaged floors

*NOTE: Note that Equation (2) gives the percent water damage for a single, specific floor. Percentages in Table No. 2 are average values for a group of "N" floors anywhere in the range of one to "W" floors.

Example No. 3: Same as No. 1, and the following data is gathered:

- Protected steel frame building has 10,000 sq. ft. (929 sq. m.)/flr.
- FM Global insures building and contents
- Floor 15 has executive offices where contents = $250/sq. ft. (0.09 sq.m.) and building = $300/sq. ft. (0.9 sq. m.) Otherwise the building value is $115/sq. ft. (0.09 sq. m.)
- Other floors have contents ranging from $70 to $110/sq. ft. (0.09 sq. m.), but the average is $98/ sq. ft. (0.09 sq. m.)

What is the estimated damage by water?

Solution:

We'll have the same 14 floors damaged as in Example No. 1, but floor 15 values seem high enough to consider their own impact on the total.

The easiest way here is to figure water damage for all 14 floors at the $98 and $115 values, then add to that the additional difference for floor 15 values.

Floor 15 is 6 floors below the fire, so n=6 and W still is 14.

Using Equation (2):

$$PERCENT_6 = 20\left(1 - \frac{6-1}{14}\right) = 12.9\%$$

The water damage for the building is:

$WATER_{BLDG}$ = $115/sq. ft. (0.09 sq. m.) x 10,000 sq. ft. (929 sq. m.)/flr. x 14 flr.

x 0.107 + $(300-115)/sq. ft. (0.09 sq. m.) x 10,000 sq. ft. (929 sq. m.) x .129

$WATER_{BLDG.}$ = $1,722,700 + 238,650

$WATER_{BLDG.}$ = $1,961,350

$$PERCENT_6 = 50\left(1 - \frac{6-1}{14}\right) = 32.1\% \text{ (Contents).}$$

Water damage for contents is:

$WATER_{CONTENTS}$ = $98/sq. ft. (0.09 sq. m.) x 10,000 sq. ft. (929 sq. m.)/flr. x 14 flrs. x 0.268 + $ (250-98)/sq. ft. (0.09 sq. m.) x 10,000 sq. ft. (929 sq. m.) x 0.321

$WATER_{CONTENTS}$ = $3,676,960 + $487,920

$WATER_{CONTENTS}$ = $4,164,880

TOTAL WATER DAMAGE = $1,961,350 + $4,164,880

= $6,126,000 (rounded)

XI. SMOKE DAMAGE

Smoke damage depends on so many factors that a detailed guideline would be extremely complicated and unwieldy. Presently, smoke damage is estimated on an individual building basis.

However, Table No. 3 does present a general guideline that reflects both the strong tendency of smoke to rise very freely but to diminish somewhat on its impact per floor after rising many floors. Even on floors where the percentage is shown as zero, a smoke odor will likely be present, i.e., you can smell it but can't detect a visual difference after wiping surfaces with a clean cloth. These floors can usually be deodorized with aerosol cleaners at a cost low enough to be negligible for MFL purposes. Table No. 3 is NOT meant to be a rigid rule; it is a guideline intended to be modified as needed for local conditions.

Example No. 1:

Consider a 60-story high-rise with H/h=2.9, inadequate safing, an "exterior" PFD, and an open stairwell in the floor slab of No. 16 and No. 22. Two of three stair shafts terminate at the top floor; the other stair shaft and three elevator shafts terminate at the top floor with small tightly closed penthouses atop the shafts. Describe the smoke damage percentages.

Solution:

The MFL decision tree gives us answers of Yes-No-No-Yes-Yes - five fire floors, and these must involve at least one of the open stairs. Consider the five floors at Nos. 15, 16, 17, 18 and 19. Table No. 3 indicates 20% building and 50% contents damage to the next two floors -- Nos. 20 and 21. But the open stair in No. 22 is such a ready means of smoke spread that No. 22 would be similarly damaged to No. 21.

In addition, the tops of stair shafts and elevator shafts would trap buoyant smoke. It could seep through door seams and other possible openings into at least the top floor and cause considerable damage there. So figure the same 20% building and 50% contents damage due to the heavy smoke concentration. Include more upper floors if, in your judgement, local conditions warrant it.

The penthouses are of low value in this case, so neglect them. (Include them if values warrant it.)

Result:

We estimate the following percentages of damage to buildings and contents by smoke from the above analysis, and using Table 3:

	BUILDING	*CONTENTS*
Nos 20 to 22	20	50
Nos. 23 to 37	10	25
Nos. 38 to 52	10	25
Nos. 53 to 59	8	20
Nos. 60	20	50

TABLE 3 - HIGH-RISE MFL PERCENT SMOKE DAMAGE

Floors Above The Fire	*PERCENTAGES APPLY TO INDIVIDUAL SMOKE DAMAGED FLOOR(S)* *Number of Fire Floors*					
	2		3, 4, or 5		≥6	
	BLDG	CONTENTS	BLDG	CONTENTS	BLDG	CONTENTS
First 2	20	50	20	50	20	50
Next 15*	8	20	10	25	10	25
Next 15*	4	10	10	25	10	25
Next 15*	2	5	8	20	10	25
Next 15*	0	0	6	15	10	25
Next 15*	0	0	4	10	10	25

* Modify as follows:
- 15 or through next HVAC zone
- 15 or to mechanical floor, whichever is smaller
- whatever else is warranted by conditions

Note: The top floor(s) may accumulate smoke and sustain damage percentages similar to the "First 2" floors

XII. THE INSPECTION

This refers to first-time evaluation of MFL using this P&P.

A. Advance Notice

Call before visiting to assure drawings/arrangements/extra help will be available.

B. Thoroughness

Spot check coatings where steel is protected, plus check factors enough to establish a YES or NO in various parts of the decision tree. We recognize only a few floors may be accessible, and this is usually sufficient to assess the overall quality of a factor.

Open stairways are important and are worth investigating since they may have been the result of post-construction renovation. These will usually occur only where a single tenant occupies consecutive stories. If these cannot be visited, question both the building manager and the tenant.

Usual available areas to check:

1. Basements
2. Floors being renovated
3. Idle floors
4. Minimal interruption areas like storage rooms or switchgear rooms
5. Penthouses
6. Mechanical Floors

If you feel more checking is needed but enough areas are not accessible,

7. Consider a return visit when more areas may be accessible.
8. Qualify your conclusions by mentioning the extent to which you were able to check things.

Note: This problem can usually be avoided by describing your needs to the insured during Advance Notice.

C. Special Category of "$1.5h \le H < 1.75\ h$"

A building in this category with an MFL limited to five floors depends heavily on above-mentioned favorable factors. The fire will likely be all floors above the original fire floor if these factors are compromised. Therefore, these factors should be verified annually to the extent of detail needed to be confident of their continual integrity. This would include checking each floor likely to have interconnections or unprotected poke-throughs. We should concentrate our effort in areas or floors where:

1. a tenant expands its space or makes a significant occupancy change (e.g.: adds pipes, cables, dumbwaiters, chutes).
2. tenants have moved in or out.
3. a tenant occupies two or more adjacent floors.
4. renovations that may affect fastening of safing.

XIII. THE REPORT

Suggested handling covering first-time use of this procedure at a location:

A. Recommendations - make the usual recommendations where MFL is a factor, e.g.: to reduce to system maximum where feasible, alarm service, etc.

B. Items of Interest - mention study was made using the high-rise MFL analysis for the first time.

C. LPR Supplement

1. Use sections for Construction, Protection, etc. as needed to cover factors affecting the MFL: e.g., safing, interconnected floors, H:h ratio or fire resistance of various building components.

Where curtain walls are exterior glass panel tyle, describe if the panel joints occur at every floor slab, at every other floor slab, and where they are in relation to the floor slab. Also describe the arrangement of the components being considered for spandrels (wallboard, rigid insulation, firesafing, metal panels).

2. Under the F&EC Survey section of the LPRS, indicate your path through the decision tree, e.g.: "Yes-No-Yes-No-No-5 floors." Briefly discuss smoke and water damage, such as including floors damaged and percentages. Cover anything unusual such as severe structural damage or major deviations from the fire, smoke or water damage guidelines (Tables 1, 2, 3).

D. Time Charges - an extra day for this type evaluation is not unusual, and an explanation is generally not needed.

E. Send the report to the FM Global operations center for review, regardless of your review status, unless notified otherwise by the office.

F. Since these reports (even specials) will likely go to the insured, avoid direct reference to "maximum foreseeable loss" in the body of the report, and reference anywhere in the report to your evaluation as a "study." For example, a general term like "fire spread potential" is okay in the PURPOSE of a special report, and "evaluation of MFL" is fine in ITEMS OF INTEREST.

G. Cover in the appropriate section of the Report Supplement whether either asbestos or PCBs are present. If present, briefly discuss their extent and location. There will be exceptions, but asbestos is usually a Construction section item and PCBs are usually an Occupancy section item.

State the source of this conclusion: e.g., "Mr. Chopin reported that the building does/does not have asbestos or PCBs." Do not make the conclusion based only on your investigation; e.g., don't say "There is/is no asbestos on site."

If either is present, determine the MFL as if they were absent. Then add a statement on the F&EC Survey in the MFL comments section explaining that the presence of this material(s) may increase the MFL and that a special study, beyond the scope of this evaluation, would be needed to determine that increase.

Duration is the time a fire will burn given fuel loading and various geometric features of a particular building floor.

$$\text{Duration} = \frac{0.1364\, L\, (KA_{fl})^{1/2}}{fh^{3/2}\, (K+1)} \text{ hours}$$

where:

L = combustible load in LB/FT2

K = ratio of overall floor length/width

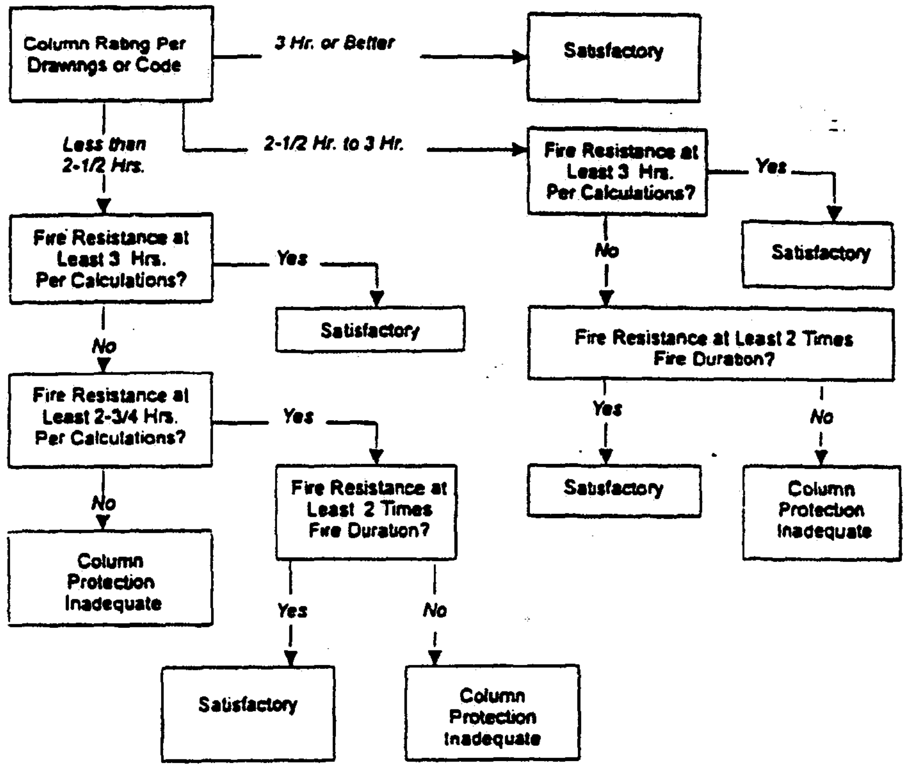
A_{fl} = floor area, ft2

f = ratio of total window widths/perimeter

h = window height, ft

In metric units of kg., m, s: $D = \dfrac{5.56L\, (KA_{fl})^{1/2}}{fh^{3/2}\, (K+1)}$

FIGURE 4
Flow Chart to Determine if Existing Column Fire Resistance is Satisfactory



Note: Column Fire Resistance can be calculated per 11/8/90 memo by R. Davis which is in the "MFL Determined for High-Rise Buildings" Report (EC88-50).

APPENDIX A

FILE WITH P&P FA514.33 — HIGH-RISE PFD RESPONSE LIST — January 1999

(List Shows all PFDs Evaluated. Those Qualifying as Exterior are Underlined)

ANNECY OPERATIONS
No Evaluations Reported

CANADIAN OPERATIONS
- Brampton, ON
- Burlington, ON
- Calgary, AB (100 ft)
- East York, ON
- Edmonton, AB (100 ft)
- Etobicoke, ON
- Halifax, NS (100 ft)
- Hamilton, ON
- London, ON (110 ft)
- Markham, ON
- Mississauga, ON
- Montreal, QU (100 ft)
- North York, ON (105 ft)
- Oakville, ON
- Oshawa, ON
- Ottawa, ON (100 ft)
- Sarnia, ON
- Scarborough, ON (100 ft)
- Toronto, ON (100 ft)
- Vancouver, BC (125 ft)
- Vaughan, ON
- Windsor, ON
- Winnipeg, MA

FRANKFURT OPERATIONS
- Budapest, Hungary (150ft/45m)
- Frankfurt, Germany (75ft/23m)
- Warsaw, Poland (165ft/50m)
- Zurick, Switzerland (65ft/20m)

GREAT LAKES OPERATIONS
- Cincinnati, OH (100 ft)
- Cleveland, OH (100 ft)
- Columbus, OH (100 ft)
- Detroit, MI (100 ft)
- Fort Wayne, IN
- Frankfort, KY
- Grand Rapids, MI
- Indianapolis, IN (135 ft)
- Kalamazoo, MI
- Lansing, MI
- Louisville, KY (100 ft)
- South Bend, IN
- Toledo, OH

LONDON OPERATIONS
- Oslo, Norway
- Stockholm, Sweden

MELBOURNE OPERATIONS
No Evaluations Reported

MID-ATLANTIC OPERATIONS
- Anne Arundel Co., MD (100 ft)
- Baltimore Co., MD (100 ft)
- Baltimore, MD (100 ft)
- Charlotte, NC (110 ft)
- Charlston, WV (100 ft)
- Fairfax Co., VA (135 ft)
- McKeesport, PA (75 ft)
- Montgomery Co., MD (110 ft)
- Parkersburg, WV (100 ft)
- Philadelphia, PA (100 ft)
- Pittsburgh, PA (100 ft)
- Prince George Co., MD (110 ft)
- Washington, D.C.

MIDWEST OPERATIONS
- Chicago, IL (135 ft)
- Kansas City, MO
- Milwaukee, WI (110 ft)
- Minneapolis, MN (110 ft)
- St. Louis, MO (110 ft)
- St. Paul, MN (100 ft)

NORTHEAST OPERATIONS
- Boston, MA** (110 ft)
- Bridgeport, CT
- Buffalo, NY (100 ft)
- Jersey City, NJ*
- Newark, NJ
- New Haven, CT
- New York, NY** (100 ft)
- Rochester, NY (100 ft)
- Stamford, CT
- Worcester, MA (100 ft)

SINGAPORE OPERATIONS
No Evaluations Reported

SOUTH AMERICAN OPERATIONS
No Evaluations Reported

SOUTHEAST OPERATIONS
- Atlanta, GA (70 ft)
- Cobb Co., GA (100 ft)
- Jackson, MS (110 ft)
- Jacksonville, FL (100 ft)
- Metro-Dade Co., FL (100 ft)
- Memphis, TN (100 ft)
- Miami, FL (150 ft)
- Nashville, TN (100 ft)
- New Orleans, LA (100 ft)
- Savannah, GA (100 ft)
- Shreveport, LA* (110 ft)

SOUTHWEST OPERATIONS
- Albuquerque, NM*
- Dallas, TX (100 ft)
- Denver, CO (110 ft)
- Fort Worth, TX
- Houston, TX (110 ft)
- Oklahoma City, OK (100 ft)
- Phoenix, AZ (100 ft)
- San Antonio, TX (100 ft)
- Scottsdale, AZ*
- Tucson, AZ*
- Tulsa, OK

WESTERN OPERATIONS
- Albany, CA
- Anaheim, CA*
- Bakersfield, CA*
- Beverly Hills, CA*
- Burbank, CA*
- Clark Co., NV (110 ft)
- Costa Mesa, CA*
- Culver City, CA*
- El Segundo, CA*
- Fullerton, CA*
- Glendale, CA*
- Honolulu, HI*
- Inglewood, CA*
- Kern Co., CA*
- Las Vegas, NV*
- Long Beach, CA*
- Los Angeles, CA** (100 ft)
- Los Angeles Co., CA (100 ft)
- Newport Beach, CA*
- Oceanside, CA*
- Ontario, CA*
- Orange, CA
- Orange Co., CA (100 ft)
- Oxnard, CA
- Pasadena, CA
- Pomona, CA*
- Portland, OR (100 ft)
- Riverside, CA*
- San Bernadino, CA*
- San Diego, CA (100 ft)
- San Francisco, CA (100 ft)
- San Jose, CA (100 ft)
- Santa Ana, CA*
- Santa Monica, CA*
- Seattle, WA (100 ft)
- Torrance, CA*
- Ventura, CA*

*Small city & PFD - No report made or needed
**Original 1988 study
( )-max aerial reach

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E.D. Directive 5-96
[File with P&P F(A)-514.33]

FACTORY MUTUAL | Factory Mutual System

INTEROFFICE CORRESPONDANCE

TO	Distribution	AT	
FROM	P.C. Blanchard	AT	F&EC Engineering
SUBJECT	Use of MFL High-Rise Methodology for Libraries	DATE	March 15, 1996

ACTION REQUESTED

The MFL high-rise methodology should be applied only to buildings and occupancies outlined in P&P F(A)-514.33, section VI.A.1, page 4. Libraries are excluded from this P&P's application and those locations where F(A)-514.33 has been used should be reevaluated.

DISCUSSION

The MFL high-rise methodology is an underwriting tool used for specific occupancies in specific buildings as outlined in P&P F(A)-514.33. It is intended for use in evaluation of buildings meeting the definition of high-rise buildings and within the intended occupancies. These occupancies are commercial, business and residential occupancies with small storage locations as part of the occupancy. It is based on high-rise loss experience of mostly offices, hotels, hospitals, dormitories and ancillary occupancies. Specific examples of occupancies not applicable are cited in the P&P, such as garmet or other warehousing, department stores, malls, and manufacturing.

Another occupancy that is not applicable to this methodology is libraries. There have been several cases where the high-rise methodology has been improperly applied to libraries (at both buildings termed high-rise and low-rise). Due to the concentration of combustibles and open landscape arrangement typical to a library, these do not meet the intended application of P&P F(A)-514.33. This has resulted in additional reinsurance costs not originally expected when insurance was bound.

Distribution: F(A) Series P&P Holders (023)

ALTERNATIVE INSURANCE WORKS, LLC

OVERVIEW

Alternative Insurance Works, LLC was founded in November, 1994. AJW's primary mission is to offer commercial entities alternative risk management and alternative risk finance services, which can most efficient protect asset and operational risks. AJW has several principals, experienced in all areas of risk management, risk finance, and employee and specialty benefits. In addition to our principals, we maintain a network of affiliates and partners throughout the United States and the world, bringing our clients services wherever they may be needed.

AJW prides itself on finding or developing creative, uncommon solutions to both typical and extraordinary risk and management needs of its clients. As such, AJW often works adjunctively with brokers and agents, to bring the best possible solutions to their mutual clients. AJW's compensation is typically fee based, carefully defining our roles and responsibilities to the client.

On the following pages are the biographies of the two AJW principals involved in this project, Mr. John Hickey, project leader, and Mr. Tim Breen, project review and assist. Also included is a representative listing of AJW's many client relationships and experiences.

?6 Hillcrest Park Road, Old Greenwich, Connecticut 068?0 Telephone 203-63?-8003 Fax. 203-63?-8010
??? Fifth Avenue, Suite 1700, New York, New York 10175 Telephone. 212-292-422? Fax. 212-5?5-6355

JOHN P. HICKEY, CSP, PE

Summary: John Hickey has over 30 years experience in the field of insurance and risk management. His specific focus has been in loss control and claims management, guiding large, multi-national organizations to most effective ways to reduce the costs of risk by controlling risks. John's work with diverse entities from petrochemical, to oil and gas exploration, to manufacturers have given him a broad set of perspectives when applying loss control and claims management techniques. Also, John has worked with many captive insurance and self-insurance structures, where pro-active cost containment is critical to the financial success of such alternative programs. John's thorough, analytical approach to service issues, coupled with a keen insight into client need, make him among the most respected risk management executives in the consulting and brokerage industries. Below is a synopsis of his career.

5-1-96 to present: Managing Director of Alternative Insurance Works (AIW).

1989-1996: Newman Agency (Bank of New York captive). Vice President & Manager - Risk Management Division.

1987-1989: Oland International. Manager - Risk Management Department.

1978-1987: Bayly, Martin, & Fay. Manager - Technical Services Division.

1968-1978: Johnson & Higgins. Assistant Vice President & Senior Consultant.

1957-1968: FIA (now Industrial Risk Insurers) and Allendale. Varied positions from Training Director, to Field Supervisor, to Supervisor of Engineering.

Education: B.S., Civil Engineering, Northeastern University, 1957
M.S., Occupational Safety & Health, New York University

Certifications & Affiliations: Licensed in Connecticut and Pennsylvania as a Professional Engineer.
Certified Safety Professional
Past President of American Society of Safety Engineers - New York
Past Director & Secretary of Safety Executives of New York
Member of National Safety Management Society
Member of Society of Fire Protection Engineers

BACKGROUND AND RESUME OF H. TIMOTHY BREEN

Summary: Tim Breen has over 19 years experience in the insurance industry. This has been principally in risk management consulting to large, multinational corporations, as well as guiding organizations in the utilization of alternative risk financing techniques. Alternative distribution of insurance and related services have also been a main part of his activities. A few specific accomplishments include the formation of several captive insurers for varied commercial enterprises; the development of several finite risk programs for enhancing credits within asset backed securitizations; work with The Bank of New York on using insurance products to generate new fee income; the creation and management of Marsh & McLennan's Risk Evaluation Group which offers risk management consulting to merger and acquisition activity. Tim has published several articles on the topic of risk evaluation for corporate acquisitions, as well as on alternative insurance distribution and funding. Below is a synopsis of his career.

11-15-94 to present: President and Founder of Alternative Insurance Works (AIW).

1991-1994: UNI-TER Corporation. President. Managed and developed alternative programs for the subsidiary of a reinsurance broker.

1989-1991: Newman Agency (Bank of New York captive). Executive Vice President. Oversaw all business development activity.

1986-1989: Marsh & McLennan, Inc. Vice President. Created and chaired the Risk Evaluation Group (as described above).

1983-1986: Alexander & Alexander International. Vice President and Director of Foreign Multinational Business.

1978-1983: Fred. S. James & Co. Vice President. Commercial account executive and Manager of Product Development.

1976-1978: Chubb & Son, Inc. Underwriter for commercial property risks.

Education: B.A., Political Science, Hobart College, 1976
Various Courses, College of Insurance, 1976-1980

htbre.wp

PARTIAL LIST OF CLIENT INVOLVEMENT

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Avnet, Inc.

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U.N.T.S.* ***
Young & Rubicam, Inc. *

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* Denotes "alternative risk financing structures" used
** Painting and Decorating Contractors of America
*** United Network of Temporary Services, LLC

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