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“Oversight - Issues of Health and Safety Regarding the
Storage of Diesel Fuel at 60 Hudson Street, Manhattan”

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Chairman Gerson, Chairman Martinez, members of the Committees, I am pleased to appear today to testify on the National Institute of Standards and Technology's (NIST) preliminary findings with regard to the collapse of World Trade Center 7 and the diesel fuel that was stored in that building.

The objectives of NIST's federal building and fire safety investigation of the World Trade Center disaster with respect to WTC 7 are to: (1) determine why and how the 47-story building collapsed; (2) determine the procedures and practices that were used in the design, construction, operation, and maintenance of the building; and (3) identify, as specifically as possible, areas in current national building and fire model codes, standards, and practices that warrant revision.

NIST issued a progress report in June 2004 that contained information regarding our work on WTC 7 (page 17 of Volume 1 and Appendix L). NIST also issued reports documenting the fuel system present in WTC 7 (NCSTAR 1-1, Chapter 12 and NCSTAR 1-1J) in October 2005. These reports are available on the dedicated NIST World Trade Center website, <http://wtc.nist.gov>.

After the June 2004 progress report on was issued, NIST stopped working on WTC 7 and staff were assigned full-time through the fall of 2005 to complete the investigation of the WTC towers.

With the release and dissemination of the report on the WTC towers in October 2005, the investigation of the WTC 7 collapse resumed. Considerable progress has been made since that time and it is anticipated that a draft report will be released by early 2007.

In the June 2004 Progress Report, NIST presented a working hypothesis for the collapse of the 47-story WTC 7. If it remains viable upon further analysis, this hypothesis suggests that WTC 7 was a classic progressive collapse that included:

- An initial local failure at the lower floors (below floor 13) of the building due to fire and/or debris induced structural damage of a critical column (the initiating event), which supported a large span floor bay with an area of about 2000 ft²;
- Vertical progression of the initial local failure up to the east penthouse, as large floor bays were unable to redistribute the loads, bringing down the interior structure below the east penthouse; and,
- Horizontal progression of the failure across the lower floors (in the region of floors 5 and 7, that were much thicker than the rest of the floors), triggered by damage due to the vertical failure resulting in disproportionate collapse of the entire structure.

NIST has reviewed the fuel system for emergency power in WTC 7, which contained two independently supplied and operated fuel systems for emergency power. The two systems combined with all of the sub-systems, contained more than an estimated 43,000 gal of fuel, assuming all tanks were filled near capacity.

One of these systems (the base system) contained two 12,000 gallon (gal) storage tanks below the 1st floor loading dock. A duplex pump set on the 1st floor supplied fuel to a 275 gal capacity day tank in the 5th floor Generator Room and to a 50 gal capacity engine-mounted day tank on the 9th floor. A second duplex pump set supplied fuel from these storage tanks to a 275 gal day tank on the 8th floor. A 6,000 gal above ground storage tank on the 1st floor connected to a second pump set supplied a 275 gal day tank on the 7th floor. The sub-systems that comprised the base system were similarly designed but were independently operated by the fuel pump set controllers for each system.

The second fuel oil distribution system was supplied by two 6,000 gal storage tanks located under the loading dock. A duplex pump set on the 1st floor supplied fuel oil to nine generators on the 5th floor. Since there was already a day tank on the 5th floor associated with the base system and the New York City Building Code did not permit more than one day tank per floor, this system used a *continuously pressurized* fuel supply piping system without a day tank.

Fuel oil piping systems like these are fairly common and are used to operate diesel generators and oil fired furnaces in many applications. The systems generally use day tanks located at the generators kept filled from remote storage tanks through transfer pumps and piping. The pipe-in-pipe design used in WTC 7 is quite robust and reliable in preventing leaking fuel from escaping the system.

For the base system, mechanical equipment rooms were equipped with sprinkler systems. In addition, the fuel oil pump room on the first floor was protected with a sprinkler system. The 5th floor generator rooms did not contain an automatic fire suppression systems, but the generator rooms on the 8th and 9th floors were protected by sprinkler systems. The 7th floor generator room also did not contain a fire suppression system but did have smoke detectors. The 5th floor base system generator room appears to have been constructed of 8 inch thick concrete block. The other generator room enclosures were constructed using gypsum board. The first floor storage tank room was protected by an Inergen system and was enclosed in a 4-hour fire rated construction.

One possibility being considered in the NIST working hypothesis is that the impact sustained by WTC 7 from the collapse of WTC 1 may have resulted in fractures in the fuel piping system (both the fuel pipe and the containment pipe) especially at the point where the pipes entered the valve box, which was rigidly mounted to the underside of the floor slab. With the base system and all of the modifications thereto, such a fracture would result in a small leak of residual fuel in the pipes at the point of fracture. A fracture of the pipe at the valve box would release fuel under pressure that, if ignited, could produce a spray fire and/or pool fire very near the critical columns that initiated a local failure at the lower floors of the building.

Rupture of a day tank would release more fuel, but it would be contained by the overflow pan. Not until the generators ran long enough to drain the day tank to its low fuel level and bring on the transfer pumps would additional fuel and pressure in the transfer lines

cause a more significant fuel leak. Depending on the number of generators connected to the day tank, this would require several hours.

The pressurized system, which supplied the nine generators on the 5th floor, was different. If the supply or return pipes were fractured along with the containment pipe and the generators started, the fuel pipes would be continually pressurized, and any leak would continue until the storage tanks were empty as long as any one generator was running.

NIST reviewed the report of an environmental contractor hired in the months after the collapse of WTC 7 to recover remaining fuel and mitigate any environmental damage from the second system's two 6,000 gal tanks. The tanks were damaged and appeared to be empty and the report stated that neither the underground storage tanks nor their associated piping contained any residual petroleum product. No residual free product or sludge was observed in either underground storage tank. Evidence suggests that this fuel did not leak into the underground soil and contaminate it, and, therefore, could have been consumed in the building.

In summary, NIST has presented a working hypothesis for the collapse of WTC 7 and fully documented the fuel systems present in the building on September 11, 2001. NIST's investigation of the collapse of WTC 7 is continuing with a focus on identifying the factors that contributed to the collapse of the building. NIST has not reached a final determination on the role of the diesel fuel in sustaining the fires that burned in WTC 7 and is continuing to study its role in contributing to the collapse of the building.

Thank you. I will be pleased to answer any questions.

(Appendix 1 – NCSTAR 1-1, Chapter 12, “WTC 7 Fuel System”)

(Appendix 2 – NCSTAR 1-1J Chapter 2, “Fuel Oil Provisions of the BCNYC”)

APPENDICES

Chapter 12

WTC 7 FUEL SYSTEM

World Trade Center (WTC) 7 was constructed and owned by Silverstein Properties (Silverstein) on land owned by the Port Authority of New York and New Jersey (Port Authority). It was built and operated by Silverstein as a Port Authority tenant alteration. Many of the tenants conducted critical business operations in the building and required uninterruptible power to prevent the loss of information or operational continuity in the event of a power failure. Backup power was provided by diesel generators located in the mechanical spaces of the building. These generators were designed to start automatically in the event of an interruption of the utility supply. The total generator capacity and quantity of fuel stored in the building was sized to tenant needs.

12.1 CODE REQUIREMENTS

Design and installation of the WTC 7 emergency power and associated fuel systems was consistent with the 1968 New York City (NYC) Building Code. The base system was installed in 1987 with modifications occurring in 1990, 1994, and 1999. Over the period 1987 to 1999, the NYC Building Code provisions discussed below were not changed, so all systems were installed to the same requirements. Some of the key code provisions for the construction and location of fuel storage tanks, piping, and controls are discussed here, and additional details are contained in NIST NCSTAR 1-1A.

12.1.1 Tanks (27-828 and 27-829)⁵⁰

All tanks must be fabricated of steel and coated to prevent corrosion. Minimum thicknesses are specified by tank diameter for storage tanks and for so-called “day tanks” (60 gal or 275 gal). Large storage tanks (up to 20,000 gal) may be buried inside or outside the building or on the lowest floor of the building with protection related to the tank capacity. For example, tanks from 550 gal to 1,100 gal must be enclosed in 2 h fire rated, noncombustible construction and tanks larger than 1,100 gal in 3 h construction.

Tanks on floors above the lowest floor are limited to 275 gal and one such tank per story. These “day tanks” must be surrounded by a concrete curb or steel pan with the capacity to hold twice the volume of the tank in the event of a leak. The curb or pan must be provided with a float switch to sound an alarm and shut off the transfer pump in case of tank failure. Appropriate controls (generally a float switch in the day tank) must be provided to transfer fuel from the storage tanks to the day tank through a transfer pump and piping, with only one such transfer pump and piping network per day tank.

12.1.2 Piping (27-830)³⁷

Piping from transfer pumps to day tanks is required to be enclosed in a shaft of 4 in. thick concrete or masonry with a 4 in. clearance to the fuel pipe. Horizontal offsets may be enclosed in a steel sleeve two

⁵⁰ Sections of the NYC Building Code in which these requirements are found. These provisions are found in the subchapter on “Heating and Combustion Equipment.”

(pipe) sizes larger and enclosed in 2 h fire rated construction. The spaces between the fuel pipe and sleeve or shaft must lead to an open sight drain or an open sump so leaks can be detected.

12.1.3 Power Systems Designs

National Institute of Standards and Technology (NIST) located and reviewed specifications and drawings for each of the emergency power systems. Some of the fuel risers were installed in existing shafts containing other utilities. The NYC Building Code requires that pipe shafts containing piping from the transfer pump to storage tanks above the lower floors not be penetrated by or contain other piping or ducts (27-830(f)(5)). Correspondence relating to the system for the Mayor's Office of Emergency Management shows that this system was reviewed and inspected by the New York City Fire Department (FDNY), a list of needed corrections was produced, and each item was initialed as the corrections were verified.

12.2 BASE BUILDING SYSTEM

The initial base emergency power system was installed in 1987, and consisted of two 900 kW generators and a 275 gal day tank located on floor 5. Main fuel storage was in two 12,000 gal tanks buried under the loading dock on the south side of the building. The tanks were double wall fiberglass⁵¹ with leak detectors between the walls.

Fuel was transferred by one of the two pumps through a 2 in. supply line in an existing shaft containing other utilities, near the west bank of passenger elevators. The transfer pump was controlled by a float switch in the day tank with a low (pump on) and a high (pump off) position. An alarm would be sounded if the fuel level in the day tank fell below the low level or went above the high level. The day tank was located within a 550 gal pan fitted with an alarm and another pump cutoff. The vent for the day tank terminated outside the south wall.

The 2 in. fuel lines were encased in a second pipe covered with 2 in. of calcium silicate to provide the required 2 h fire rating. Pipe supports were located approximately 10 ft apart, and inspection plugs were provided approximately 50 ft apart. Mechanical equipment rooms were sprinklered (ordinary hazard group I), and the fuel pump room was sprinklered (ordinary hazard group III). The generator area on floor 5 was not sprinklered.

12.2.1 Modifications to System

From 1990 to 1999, four major modifications (additions) were made to the base emergency power system. These modifications are summarized in Table 12-1. Of significance are the 1990 modification (Salomon Brothers) that required a pressurized fuel supply system, because a day tank already existed on floor 5, and the 1999 modification (Mayors' Office of Emergency Management) that required a separate 6,000 gal tank on the first floor. Figure 12-1 is a schematic of the locations of the various components of the base system and the four major modifications.

⁵¹ While the NYC Building Code requires steel tanks, effective in November 1985 the U.S. Environmental Protection Agency required (40CFR280) that all new underground fuel storage tanks be double wall fiberglass and that any steel tanks older than 20 years be replaced by double wall fiberglass.

For the Salomon Brothers system, the transfer pumps were powered from the output of the generators. In the event of a failure of utility power, all nine generators were started automatically to ensure that if any of the nine did not start there would be enough power. Once the generators were up to speed, the control system would shut down those that were not needed, but these could be restarted later if power demand increased. There was enough fuel and residual pressure in the lines to start the generators and to run them for a few minutes, but once running, the fuel pumps were powered to supply fuel. As long as any one generator was running, the pumps ran at full capacity.

Table 12–1. Summary of modifications to base emergency power system in WTC 7.

Year	Day Tank/Generator	Storage Tank	Piping	Comments
1990	No day tank permitted since base design included one on floor 5/nine generators on floor 5, 1,750 kW combined capacity	Two 6,000 gal next to base tanks.	Two 2½ in. pipes in separate rated shaft	50 psi pressurized fuel system
1994	50 gal/125 kW on floor 9; generator room sprinklered	Used existing base tanks	1¼ in. in new 2 h rated dedicated shaft	New transfer pump connected to existing storage tanks
1994	275 gal/350 kW on floor 8; generator room sprinklered	Used existing base tanks	2 in. in same dedicated shaft as above	New transfer pump connected to existing storage tanks
1999	275 gal/three 500 kW on floor 7; smoke detectors in generator room	6,000 gal on floor 1, in 4 h rated enclosure; gaseous (clean) fire suppression system; space below tank sprinklered	10 gauge conduit in 2 h rated enclosure	Storage tank kept filled from base storage tanks.

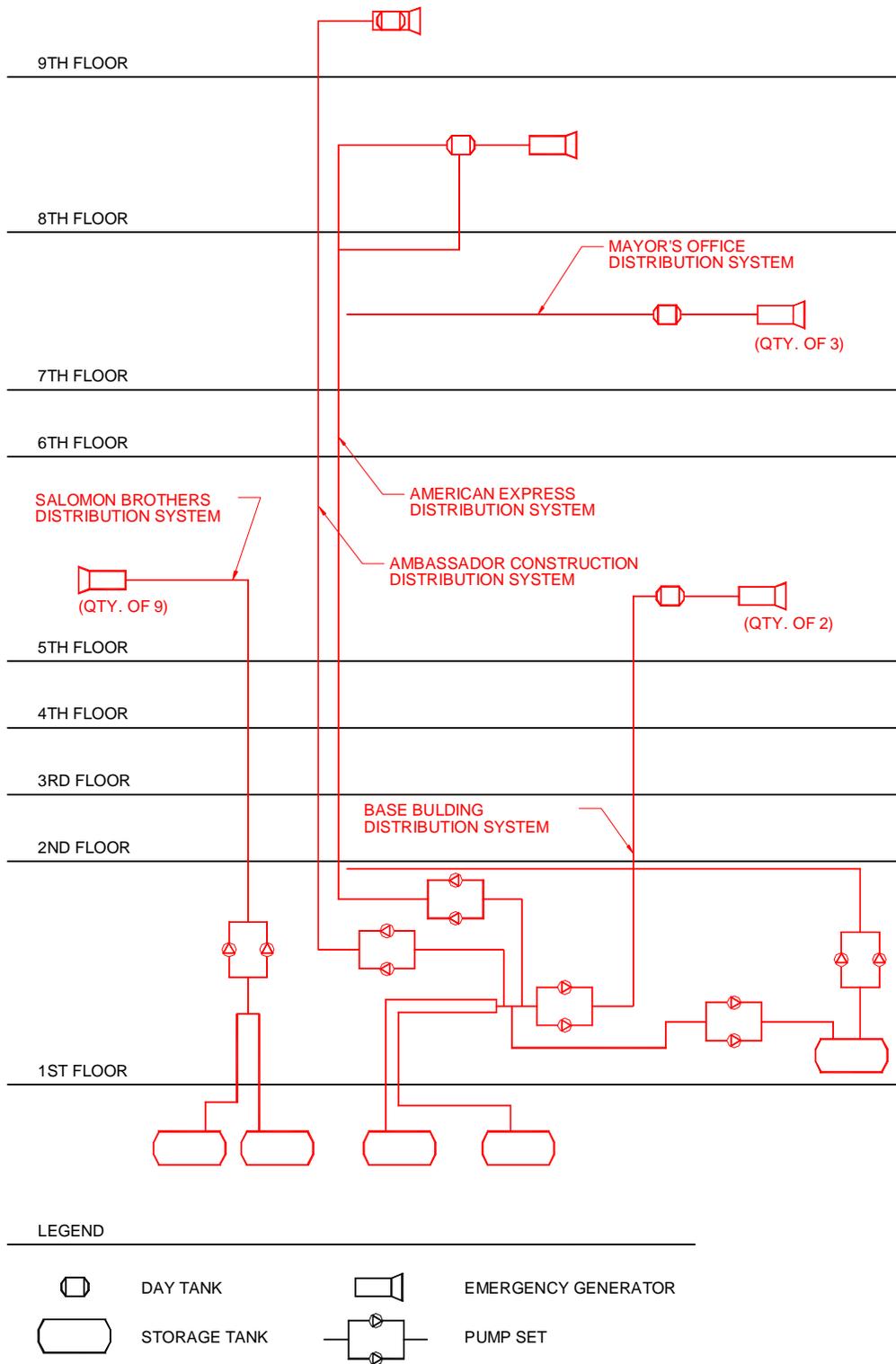


Figure 12–1. Section plan showing the final locations of the fuel oil distribution components.

12.2.2 Ambassador Modification

The Ambassador modification to the base system was performed in 1994. A new transfer pump set (145 gph at 100 psi) was installed and connected to the existing main storage tanks. A new 1¼ in. supply riser was located in a new 2 h shaft dedicated for the fuel distribution system, constructed of 4 in. masonry and located at the south end of the center bank of passenger elevators. The line ran to a single 125 kW generator with a 50 gal day tank mounted in a 100 gal basin on the 9th floor. Controls and alarms were the same as the base system. The transfer pipes were the same double wall design and, outside the masonry shaft, were covered with a 2 h vermiculite. The area of the generator on the 9th floor was sprinklered. No design criteria were located, but the pipe sizes for the entire 9th floor are consistent with a light hazard pipe schedule design.

12.2.3 American Express Modification

At about the same time in 1994, American Express installed a system to supply their operations. Another new pump set rated 170 gph (at 100 psi) was installed on the first floor and was tapped into the existing base system pipes and tanks. Another 2 in. supply pipe ran in the same masonry shaft used for the Ambassador system to a 275 gal day tank and a single 350 kW generator on the 8th floor. Controls and alarms were the same as the base system. The 8th floor generator room was protected with sprinklers designed to light hazard criteria.

12.2.4 Mayor's Office of Emergency Management (OEM) Modification

In 1999, the Mayor's Office of Emergency Management was constructed on the 7th floor. This system differed from the others because the specifications were to provide an independent source of power for full operations for at least one week, requiring the installation of a new, 6,000 gal storage tank and three 500 kW generators fed from a single 275 gal day tank on the 7th floor. The main storage tank was located on the 1st floor of the building in an existing storage room adjacent to the elevators. The room was modified by installing a raised structure on which the tank was installed, enclosed in 4 h masonry (8 in. concrete masonry unit) construction.

A new fill pump set rated 2,000 gph at a design pressure of 125 psi was located in the 1st floor pump room along with a transfer pump set rated 700 gpm at a design pressure of 125 psi. The 6,000 gal OEM tank was kept filled from the two 12,000 gal base system tanks by means of the fill pump. The 1st floor tank room was protected with an Intergen suppression system with the space below the tank still sprinklered (high hazard). The 7th floor generator room was not sprinklered but was protected by smoke detectors connected to the building alarm system.

12.2.5 Salomon Brothers Emergency Power System

In 1990 Salomon Brothers installed a system to provide emergency power to their trading floor that was independent from the other systems in the building. The Salomon Brothers system involved two 6,000 gal tanks identical to and buried adjacent to the base system tanks under the loading dock on the south side of the building. Salomon Brothers had a contract with a fuel delivery service who always

maintained the tanks full.⁵² Therefore, both tanks likely contained 6,000 gal of fuel on September 11, 2001.

The system utilized nine generators on the 5th floor with a combined capacity of 1,750 kW. Seven cooling fan sets (four fans per set) were installed to provide cooling and combustion air to the generators. Three fan sets were installed on the north end of the east wall and four fan sets on the north end of the west wall. There were exhaust louvers on the south end of the west wall. These fans were arranged to come on when the generators were running.

Since there was already a 275 gal day tank on the 5th floor associated with the base system, the New York City (NYC) Building Code did not permit another tank on that floor. The Salomon Brothers system was designed with a pressurized fuel system without a storage tank near the generators. Two 70 gpm at 50 psi total head pumps were located in a separate enclosure in the existing fire pump room (not in the fuel pump room with the other transfer pumps). A double supply and return pipe (each 2½ in. covered in 2 in. of calcium silicate) were run in a separate shaft to the 5th floor where the pipes ran outside the mechanical room to the generators in three groups. At the end of the pipe run, where the fuel supply pipe ended and the fuel return pipe began, there was a valve box containing a backpressure regulator, gauges, and a by-pass line. This liquid tight valve box was mounted to the underside of the floor slab for the 6th floor near generator #1.

The transfer pumps were powered from the output of the generators. In the event of a failure of utility power, all nine generators were started automatically. This is to ensure that if any did not start there would be enough power. Once up to speed, the control system would shut down generators that were not needed, but they could be restarted later if demand increased. There was enough fuel and residual pressure in the lines to start the generators and to run them for a few minutes, but once running, the fuel pumps were powered to supply fuel. As long as any one generator was running, the pumps ran at full capacity.

The system also included cooling fan units (each consisting of four fans) with three units (rated 30,000 cfm per fan, 12 fans) installed in the northeast corner of the 5th floor near generators 1 through 4, six units (rated 38,000 cfm per fan, 24 fans) in the northwest corner near generators 8 and 9, and exhaust louvers in the southwest corner near generators 5 through 7. The fans were powered from the generators and ran whenever the generators were running. They brought outside air into the building and across the generators.

12.3 POSSIBLE FAILURE MODES

Fuel oil piping systems like these are fairly common and are used to operate diesel generators and oil fired furnaces in many applications. The systems generally use day tanks at the appliance kept filled from storage remote tanks through transfer pumps and piping. The pipe-in-pipe design used in WTC 7 is quite robust and reliable in preventing leaking fuel from escaping the system.

At the time WTC 7 was designed and built there were no seismic design requirements for buildings in New York City much less for piping systems. More recent research into the failure of fire sprinkler

⁵² Interview with Mike Catalano, maintenance person for Salomon Brothers, who was responsible for these systems.

systems in earthquakes has resulted in seismic design requirements for critical piping systems in seismic zones. The research on sprinkler systems has shown the need for lateral bracing to prevent the failure of the piping systems due to differential movement between the pipes and the building in an earthquake.

A working hypothesis is that the impact sustained by WTC 7 from the collapse of WTC 1 resulted in fractures in the fuel piping system (both the fuel pipe and the containment pipe) especially at the point where the pipes entered the valve box, which was rigidly mounted to the underside of the floor slab. With the base system and all of the modifications thereto, such a fracture would result in a small leak of residual fuel in the pipes at the point of the fracture. A fracture of the pipe at the valve box would release fuel under pressure that, if ignited, could produce a spray fire and/or a pool fire very near column 79.

Rupture of a day tank would release more fuel, but it would be contained by the overflow pan. Not until the generators ran for long enough to drain the day tank to its low fuel level and bring on the transfer pumps would additional fuel and pressure in the transfer lines cause a more significant fuel leak. Depending on the number of generators connected to the day tank, this would require several hours.

The Salomon Brothers pressurized system is different. If the supply or return pipes were fractured along with the containment pipe and the generators started, the fuel pipes would be continuously pressurized, and any leak would continue until the storage tanks were empty as long as any one generator was running.

NIST reviewed the report of an environmental contractor (Langan 2002) hired in the months after the collapse of WTC 7 to recover remaining fuel and to mitigate any environmental damage from the Salomon Brothers tanks. The Salomon Brothers tanks were damaged and appeared to be empty, “ ... Neither the UST’s (underground storage tanks) nor their associated piping contained any residual petroleum product. No residual free product or sludge was observed in either UST.”

The tanks were installed on a concrete slab over existing silty sand. A layer of bedding gravel on the slab provided a foundation for the tank. Examination of the gravel below the tanks and the sand below the slab showed some fuel contamination but none was observed in the organic marine silt/clay layer below. Also, the sand and soil below the slab was continuous below the adjacent base system tanks, which contained a total of 24,000 gal of fuel. Thus, it is likely that a fuel leak in any of the tanks would result in fuel contamination in this soil.

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Chapter 2

FUEL OIL PROVISIONS OF THE BCNYC

The facilities of the Port Authority of New York and New Jersey (PANYNJ) are not subject to the requirements of the local building codes, although PANYNJ policy was to follow the New York City codes where applicable. The distribution system was to be designed to the provisions of the Building Code of the City of New York (BCNYC). As previously stated, the fuel oil distribution systems were installed in 1987 and 1990 with modifications occurring in 1994 and 1999. Generally, building construction is performed to the most current code provisions at the time of installation. The code provisions are often updated as technology and experience advance. However, between 1987 and 1999, the fuel oil system provisions of the BCNYC remained unchanged. Thus, a single set of code provisions can be summarized for the initial design and the subsequent modifications. The BCNYC code provisions used for the installations and modifications to the fuel oil distribution systems in World Trade Center (WTC) 7 are listed in the remaining sections of this chapter.

2.1 GENERAL REQUIREMENTS

The hydrocarbon fuel oil used shall be as classified in Reference Standards (RS) 14-3 and RS 14-12 and shall have a flashpoint not lower than 100 °F (27-827).^{1, 2}

2.2 FUEL OIL STORAGE EQUIPMENT

All fuel oil storage tanks shall be built of steel plates or sheets, made by the open hearth or basic oxygen process (27-828(a)(1)).

Tanks shall be welded, riveted and caulked, or riveted and welded. Flanges or other pipe connections may be welded. Filler of any kind between plates shall be prohibited (27-828(a)(2)).

Tanks to be buried shall be cleaned and then coated on the outside with two coats of red lead, or equivalent. Tanks shall be further protected by a coating of hot tar, asphalt, or equivalent rust resistive material, applied at the work site. Tanks installed inside buildings above ground shall be coated with one coat of red lead, or equivalent (27-828(a)(3)).

All buried storage tanks shall be constructed of at least ¼ in. thick metal and shall be designed to withstand any external loads to which the tank may be subjected (27-828(a)(4)).

Shop fabricated storage tanks shall be installed without structural alteration (27-828(a)(5)).

All openings shall be through the top of the storage tank (27-828(a)(6)).

¹ The fuel oil used in WTC 7 was no. 2 fuel oil.

² The BCNYC references given, denoted by 27-XXX, is the new numbering system.

Tanks for no. 2 commercial grade oils need not have manholes. However, if manholes are used for such oils, the manhole covers shall be bolted and made gastight (27-828(a)(7)).

Tanks shall be located at least 7 ft, measured in the most direct manner, from any source of exposed flame unless protected as provided in 27-829(a)(2) or 27-829(a)(3) and at least 2 ft from any surface where the temperature exceeds 165 °F (27-828(a)(9)).

Cylindrical tanks, except vertical tanks above ground outside of buildings, of more than 275 gal capacity shall be constructed as follows (27-828(b)):

1. Tanks 36 in. in diameter and less – at least ¼ in. shell and ¼ in. heads.
2. Tanks 37 to 72 in. in diameter – at least ¼ in. shell and 5/16 in. heads.
3. Tanks 73 to 120 in. in diameter – at least 5/16 in. shell and 3/8 in. heads.
4. Tanks over 120 in. in diameter shall be of at least 3/8 in. steel and shall be stiffened by angle rings or equivalent members so as to retain their cylindrical form.

All oil storage tanks of 275 gal capacity or less that are not buried shall have a minimum thickness of shell and head plates of no. 10 manufacturer's standard gauge steel plate. Storage tanks of 60 gal capacity or less shall be similarly constructed but need not be thicker than no. 14 manufacturer's standard gauge (27-828(d)).

2.3 LOCATION OF TANKS

Inside of buildings, above ground, on the lowest floor as follows (27-829(a)):

1. Storage tanks having a capacity of 550 gal or less may be installed above ground on the lowest floor of a building, provided that such tanks are mounted on adequate noncombustible supports, with the tank anchored thereto. No more than 550 gal of total storage capacity may be connected to one burner or may be installed without the protection provided in paragraph 27-829(a)(2) or 27-829(a)(3).
2. Storage tanks having a capacity of more than 550 gal but less than 1,100 gal may be installed above ground on the lowest floor of a building, provided that all portions of such tanks above the floor are completely enclosed with noncombustible construction having at least a 2 h fire resistance rating. Weep holes 1 in. in diameter shall be provided at least every 3 ft along the bottom of the enclosure unless at least 15 in. of clearance, together with access door, is provided between the tank and the enclosure.
3. Storage tanks having a capacity of 1,100 gal or more may be installed above ground on the lowest floor of a building, provided that all portions of such tanks above the floor are completely enclosed with noncombustible construction having at least a 3 h resistance rating. At least 15 in. clearance shall be provided over the tanks and on all sides between the tanks and the enclosure. A noncombustible access door, constructed so as to preserve the integrity of the fire resistive enclosure, shall be installed in the enclosure above the point where the

capacity of the enclosure below the door sill would be equal to the capacity of the largest tank installed. When the longest inside dimension of the enclosure exceeds 35 ft, access doors shall be installed at intervals not exceeding 12 ft. Columns, pipes, or similar obstructions may project into the required 15 in. of space within the enclosure, provided that access door or doors are so arranged that all portions of the enclosure are accessible for servicing.

4. The capacity of individual storage tanks in no case shall exceed 20,000 gal.

Inside of building above the lowest floor as follows (27-829(b)):

1. Fuel oil storage tanks having a capacity of 275 gal or less may be installed inside of buildings above the lowest story when provided with a 4 in. thick concrete or masonry curb, or with a metal pan of gauge equal to the gauge of the tank, completely surrounding the tank and of sufficient height to contain two times the capacity of the tank. The number of such oil storage tanks shall be limited to one per story.
2. Storage tanks having a capacity of 275 gal or less, installed above the lowest floor inside a building shall be filled by means of a transfer pump supplied from a primary storage tank located and installed as otherwise required. A separate transfer pump and piping circuit shall be provided for each storage tank installed above the lowest floor. No intermediate pumping stations shall be provided between the storage tank and the transfer pump. Appropriate devices shall be provided for the automatic and manual starting and stopping of the transfer pumps so as to prevent the overflow of oil from these storage tanks.
3. A float switch shall be provided with the curb or pan around the storage tank and shall be arranged so as to sound an alarm and stop the transfer pump in case of failure of the tank or the control in the tank. The operation of the float switch shall be tested at least once each week. An alarm bell shall be located in the same room with the tank and a visual and audible alarm shall be located in a maintenance office.

Inside of buildings, below ground as follows (27-829(c)):

1. Storage tanks having a capacity greater than 275 gal may be buried inside a building provided that the top of the tank is at least 2 ft below floor level. In lieu of 2 ft of earth over the tank, the tank may be covered by concrete flooring having the same thickness as the basement floor, but not less than 4 in. concrete and reinforced with 2 in. by 2 in. mesh of at least no. 20 U.S. standard gauge steel wire. Tanks shall be placed in firm soil and shall be surrounded by clean sand or well-tamped earth, free from ashes and other corrosive substances, and free from stones that will not pass through a 1 in. mesh. When necessary to prevent floating, tanks shall be securely anchored.
2. No tank shall be buried within 3 ft of any foundation wall or footing.

Outside of building, below ground as follows (27-829(d)):

1. Storage tanks located outside of buildings and below ground shall be buried with the top of the tank at least 2 ft below ground. Tanks shall be placed in firm soil and shall be surrounded

by clean sand or well-tamped earth, free from ashes or other corrosive substance, and free from stones that will not pass through a 1 in. mesh. When necessary to prevent floating, tanks shall be securely anchored.

2. No tank shall be buried within 3 ft of any foundation wall or footing.

2.4 PIPING

Exposed piping shall be protected against mechanical damage and shall be adequately supported with rigid metal fasteners or hangers. All pipes connected to buried tanks, except test well piping, shall be provided with double swing joints at the tank (27-830(a)(1)).

Only new wrought iron, steel, or brass pipe, or type K or heavier copper tubing, or aluminum alloy tubing, properly identified, may be used. Metal tubing when used for conveying oil shall be adequately protected. Such tubing may be installed at the burner without protection. Drawn tubing when used in domestic installations shall be of at least 3/8 in. inside diameter up to the shut-off valve at the burner. Soldered connections shall be prohibited (27-830(a)(2)).

Overflow pipes, where installed, shall not be smaller in size than the supply pipe (27-830(a)(3)).

Where a shut-off valve is installed in the discharge line from an oil pump, a relief valve shall be installed in the discharge line between the pump and the 1st shut-off valve (27-830(b)(1)).

A relief or pressure regulating valve shall be provided in the oil piping system on the heater side of the shut-off valves (27-830(b)(2)).

Relief valves shall be set to discharge at not more than one and one-half times the maximum working pressure of the system. The discharge from relief valves shall be returned to the storage tank or to the supply line. There shall be no shut-off valve in the line of relief (27-830(b)(3)).

Fuel oil heaters shall not be installed within the steam or water space of a boiler. Fuel oil heaters and the connecting piping shall be arranged to prevent oil leakage from being transmitted to the boiler. This may be accomplished by any of the following methods (27-830(c)):

1. By discarding the condensate from the heaters.
2. By using approved double tube or other approved heaters.
3. By means of a secondary hot water or steam heating system where the water or steam from the boiler has no direct contact with the oil heater.
4. By a sight tank arrangement for collecting and inspecting the condensate which is provided with a pump controlled by a hand switch for returning the condensate to the normal return system.
5. By such other method as may be permitted by the commissioner.

A vent pipe of iron or steel, without trap, draining to the tank, shall be provided for each storage tank. The lower end of the vent pipe shall not extend more than 1 in. through the top of the storage tank. Cross-connection between a vent pipe and fill pipe is prohibited (27-830(d)(1)).

Where a battery of storage tanks designed to hold the same grade of oil is installed, vent pipes may be run into a main header (27-830(d)(2)).

Vents shall be at least one and ¼ in. in diameter for storage tanks not exceeding 1,100 gal capacity and at least 2 in. in diameter for storage tanks of 1,100 gal or more except that vents for storage tanks of 60 gal capacity or less shall be at least ½ in. in diameter. Vents for tanks inside of buildings above the lowest floor shall be run into the primary storage tank vent (27-830(d)(3)).

Vent pipes shall be provided with an approved weatherproof hood having a free area of at least the pipe size area. Vent pipes shall terminate outside the building in a non-hazardous location, at least 2 ft from any building opening and not less than 2 ft nor more than 12 ft above the fill pipe terminal, unless otherwise permitted by the commissioner. If the vent pipe terminal is not visible from the fill pipe terminal location, a 1 in. tell-tale line shall be connected to the tank and shall parallel the fill pipe and terminate at the fill pipe terminal with an unthreaded end. Such tell-tale lines shall be provided with a check valve set to prevent flow of surface water to the storage tank (27-830(d)(4)).

Fill pipes shall terminate outside the buildings, with the fill pipe terminal located at or above grade, at least 2 ft from any building opening and 5 ft from any subway grating at or below the level of the fill pipe terminal. No fill pipe shall be less than 2 in. in diameter. Where there are facilities for the delivery tank truck to drive onto the premises, the fill terminal may be located elsewhere than at the curb (27-830(e)(1)).

Each storage tank shall be provided with a separate fill pipe, except that where a battery of tanks is installed containing the same grade of oil, a common fill and header pipe may be installed (27-830(e)(2)).

Where the top of the storage tank is above the fill pipe terminal, the fill pipe shall be connected to the top of the tank and provided with a shut-off valve and swing check valve both of which shall be located at the fill pipe terminal. However, the shut-off and check valves may be installed in an accessible location inside the building at or below the level of the fill pipe terminal (27-830(e)(3)).

All fill pipe terminals shall be of an approved type, and shall be provided with lugs for embedding in concrete. In lieu of lugs, a set screw or threads to fasten the terminal to the fill pipe may be used (27-830(e)(4)).

Piping from transfer pump to storage tanks above the lowest floor as follows (27-830(f)):

1. The piping from a transfer pump to storage tanks at levels above the lowest floor in buildings, the return piping, and vent piping shall comply with the applicable provisions of subdivisions 27-830(a) and 27-830(d) and shall be enclosed in a shaft constructed of 4 in. concrete or masonry having a 4 in. clearance from all pipe or pipe covering. Provision shall be made for expansion in piping without the use of expansion joints.

2. Where it is necessary to make horizontal offsets in the supply piping and pipe shafts such piping shall be enclosed in a sleeve of other piping of at least no. 10 manufacturer's standard gauge steel, two sizes larger and arranged to drain into the shaft. Horizontal piping offsets shall be further enclosed in construction having a 2 h fire resistance rating.
3. A drain pipe shall be installed at the base of shafts enclosing the supply and overflow piping. The pipe shall lead to an open sight drain or to an open sump.
4. Oil lines for tanks above the level of the lowest floor shall be seamless steel pipe of a weight not less than ASA schedule 40 with welded connections.
5. Pipe shafts shall not be penetrated by or contain other piping or ducts.

The heating of oil in storage tanks shall be by means of coils using low pressure hot water or steam, or by means of electric heaters approved for use in oil storage tanks (27-830(g)).

Where more than one storage tank is connected to a common supply line, a shut-off valve shall be provided in the supply line at each tank. Where more than one burner is connected to a supply line a shut-off valve shall be provided at each burner. Where a single tank and a single burner are installed, a shut-off valve shall be required in the supply line at the tank and another at the burner. Valves shall be brass or equivalent in corrosion and fire resistance, shall provide tight shut-off, and shall be rated at 125 psi or greater as required by the pressure in the system (27-830(h)(1)).

Where a storage tank is located so that the top of the tank is above the oil inlet to the burner or to the fuel pump, and the storage tank capacity is greater than 275 gal, the supply line to the burner shall be provided with an approved anti-syphon device. The device shall be located at the highest point in the supply line. Where an approved foot valve is used in the tank and the tank is constructed with a manhole, an anti-syphon device shall not be required (27-830(h)(2)).

The pressure in oil lines to burners located above the lowest floor of a building shall not be more than is required to circulate oil to and from the burners, and all parts of the oil system shall be capable of withstanding the maximum working pressure in that part of the system (27-830(h)(3)).

A remote control shall be provided to stop the flow of oil to any burner. Such control shall be located outside the entrance to the room in which the burner is located and as close to such entrance as practicable, except that when an outside location is impracticable, such control may be located immediately inside the room in which the burner is located, provided such location is accessible at all times. On storage tanks of 60 gal or less capacity used with manually operated burners, such remote control may be installed in the supply lines between tank and burner (27-830(h)(4)).

Pressure in a storage tank for the purpose of discharging oil shall be prohibited (27-830(h)(5)).

In systems where either steam or air is used for atomizing the oil, the oil and the atomizing supply shall be interlocked so that where the supply of either is interrupted, the supply of the other will be immediately cut off (27-830(h)(6)).

All tanks located inside buildings shall be provided with an oil level indicating device. Test wells shall be prohibited in tanks located inside of buildings. Unused tank openings shall be permanently sealed to prevent the removal of plugs or cover (27-830(i)(1)).

Oil level indicating devices shall be designed and constructed of substantial materials so that there can be no leakage of oil or oil vapor (27-830(i)(2)).

Test wells in storage tanks located outside of buildings shall be capped oil tight and kept closed when not in use (27-830(i)(3)).

2.5 CONTROLS

With each automatic burner a set of safety controls of the electric, pneumatic, hydraulic, or mechanical type shall be installed and maintained in good working order. The controls shall provide the following functions (27-831):

1. Ignition
2. Stack or combustion control
3. High temperature or pressure control

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