NIST NCSTAR 1-1D (Draft)

Federal Building and Fire Safety Investigation of the World Trade Center Disaster

Fire Protection and Life Safety Provisions Applied to the Design and Construction of WTC 1, 2, and 7 and Post-Construction Provisions Applied after Occupancy (Draft)

Raymond A. Grill
Duane A. Johnson

For Public Comment

NIST National Institute of Standards and Technology • Technology Administration • U.S. Department of Commerce

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Rolf Jensen & Associates, Inc.

September 2005

U.S. Department of Commerce
Carlos M. Gutierrez, Secretary

Technology Administration
Phillip J. Bond, Under Secretary for Technology

National Institute of Standards and Technology
Hratch G. Semerjian, Acting Director

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In addition, a substantial portion of the evidence collected by NIST in the course of the Investigation has been provided to NIST under nondisclosure agreements.

Disclaimer No. 4

NIST takes no position as to whether the design or construction of a WTC building was compliant with any code since, due to the destruction of the WTC buildings, NIST could not verify the actual (or as-built) construction, the properties and condition of the materials used, or changes to the original construction made over the life of the buildings. In addition, NIST could not verify the interpretations of codes used by applicable authorities in determining compliance when implementing building codes. Where an Investigation report states whether a system was designed or installed as required by a code *provision*, NIST has documentary or anecdotal evidence indicating whether the requirement was met, or NIST has independently conducted tests or analyses indicating whether the requirement was met.

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ABSTRACT

This report was prepared to support the analysis of building and fire codes and standards of the National Institute of Standards and Technology World Trade Center (WTC) Investigation. To best analyze the performance of WTC 1, 2, and 7 in response to the September 11, 2001, attacks, the provisions of the design and construction of the buildings must first be understood. The purpose of this report is to summarize the fire protection (both passive and active) and life safety provisions that were used to design and construct WTC 1, 2, and 7 and to document the changes in building code regulations that occurred after their construction.

Determination of the applicable building provisions was a multi-step task. First, documentation (such as drawings, memoranda, and New York City building regulations) was analyzed to identify the initial construction provisions at the times of construction of the three buildings. Second, New York City building regulations, published since the time of construction, were analyzed to identify the new and amended building provisions. Third, the building provisions were analyzed to determine their applicability to the building characteristics of WTC 1, 2, and 7.

Keywords: Compartmentation, elevators, emergency power, fire alarm, fire protection, fire safety, fire sprinklers, high-rise buildings, inspections, interior finish, means of egress, pressurization, venting, voice communication, World Trade Center.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronyms

ASTM	ASTM International
BCNYC	Building Code of the City of New York (Local Law No. 76)
HVAC	heating, ventilating, and air conditioning
LL	Local Law to amend the New York City Administrative Code
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
PANYNJ	Port Authority of New York and New Jersey
RS	Reference Standard to the BCNYC
WTC	World Trade Center
WTC 1	World Trade Center 1 (North Tower)
WTC 2	World Trade Center 2 (South Tower)
WTC 7	World Trade Center 7

Abbreviations

ºF	degrees Fahrenheit
cfm	cubic feet per minute
cm^2	square centimeters
ft	foot
ft^2	square feet
gal	gallon
gpm	gallons per minute
h	hour
in.	inch
$in.^2$	square inches
lb	pound
min	minute
V	volt
W	watt

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METRIC CONVERSION TABLE

To convert from	to	Multiply by
AREA AND SECOND MOMENT OF AREA		
square foot (ft^2)	square meter (m^2)	9.290 304 E-02
square inch ($in.^2$)	square meter (m^2)	6.4516 E-04
square inch ($in.^2$)	square centimeter (cm^2)	6.4516 E+00
square yard (yd^2)	square meter (m^2)	8.361 274 E-01
ENERGY (includes WORK)		
kilowatt hour (kW · h)	joule (J)	3.6 E+06
quad (1015 BtuIT)	joule (J)	1.055 056 E+18
therm (U.S.)	joule (J)	1.054 804 E+08
ton of TNT (energy equivalent)	joule (J)	4.184 E+09
watt hour (W · h)	joule (J)	3.6 E+03
watt second (W · s)	joule (J)	1.0 E+00
FORCE		
dyne (dyn)	newton (N)	1.0 E-05
kilogram-force (kgf)	newton (N)	9.806 65 E+00
kilopond (kilogram-force) (kp)	newton (N)	9.806 65 E+00
kip (1 kip=1,000 lbf)	newton (N)	4.448 222 E+03
kip (1 kip=1,000 lbf)	kilonewton (kN)	4.448 222 E+00
pound-force (lbf)	newton (N)	4.448 222 E+00
FORCE DIVIDED BY LENGTH		
pound-force per foot (lbf/ft)	newton per meter (N/m)	1.459 390 E+01
pound-force per inch (lbf/in.)	newton per meter (N/m)	1.751 268 E+02
HEAT FLOW RATE		
calorieth per minute (calth/min)	watt (W)	6.973 333 E-02
calorieth per second (calth/s)	watt (W)	4.184 E+00
kilocalorieth per minute (kcalth/min)	watt (W)	6.973 333 E+01
kilocalorieth per second (kcalth/s)	watt (W)	4.184 E+03

To convert from	to	Multiply by
LENGTH		
foot (ft)	meter (m)	3.048 E-01
inch (in)	meter (m)	2.54 E-02
inch (in.)	centimeter (cm)	2.54 E+00
micron (m)	meter (m)	1.0 E-06
yard (yd)	meter (m)	9.144 E-01
MASS and MOMENT OF INERTIA		
kilogram-force second squared per meter ($kgf \cdot s^2/m$)	kilogram (kg)	9.806 65 E+00
pound foot squared ($lb \cdot ft^2$)	kilogram meter squared ($kg \cdot m^2$)	4.214 011 E-02
pound inch squared ($lb \cdot in.^2$)	kilogram meter squared ($kg \cdot m^2$)	2.926 397 E-04
ton, metric (t)	kilogram (kg)	1.0 E+03
ton, short (2,000 lb)	kilogram (kg)	9.071 847 E+02
MASS DIVIDED BY AREA		
pound per square foot (lb/ft^2)	kilogram per square meter (kg/m^2)	4.882 428 E+00
pound per square inch (*not* pound force) ($lb/in.^2$)	kilogram per square meter (kg/m^2)	7.030 696 E+02
MASS DIVIDED BY LENGTH		
pound per foot (lb/ft)	kilogram per meter (kg/m)	1.488 164 E+00
pound per inch (lb/in.)	kilogram per meter (kg/m)	1.785 797 E+01
pound per yard (lb/yd)	kilogram per meter (kg/m)	4.960 546 E-01
PRESSURE or STRESS (FORCE DIVIDED BY AREA)		
kilogram-force per square centimeter (kgf/cm^2)	pascal (Pa)	9.806 65 E+04
kilogram-force per square meter (kgf/m^2)	pascal (Pa)	9.806 65 E+00
kilogram-force per square millimeter (kgf/mm^2)	pascal (Pa)	9.806 65 E+06
kip per square inch (ksi) ($kip/in.^2$)	pascal (Pa)	6.894 757 E+06
kip per square inch (ksi) ($kip/in.^2$)	kilopascal (kPa)	6.894 757 E+03
pound-force per square foot (lbf/ft^2)	pascal (Pa)	4.788 026 E+01
pound-force per square inch (psi) ($lbf/in.^2$)	pascal (Pa)	6.894 757 E+03
pound-force per square inch (psi) ($lbf/in.^2$)	kilopascal (kPa)	6.894 757 E+00
psi (pound-force per square inch) ($lbf/in.^2$)	pascal (Pa)	6.894 757 E+03
psi (pound-force per square inch) ($lbf/in.^2$)	kilopascal (kPa)	6.894 757 E+00

To convert from	to	Multiply by
TEMPERATURE		
degree Celsius (°C)	kelvin (K)	T/K = t/°C + 273.15
degree centigrade	degree Celsius (°C)	t/°C ≈ t /deg. cent.
degree Fahrenheit (°F)	degree Celsius (°C)	t/°C = (t/°F - 32)/1.8
degree Fahrenheit (°F)	kelvin (K)	T/K = (t/°F + 459.67)/1.8
kelvin (K)	degree Celsius (°C)	t/°C = T/K 2 273.15
TEMPERATURE INTERVAL		
degree Celsius (°C)	kelvin (K)	1.0 E+00
degree centigrade	degree Celsius (°C)	1.0 E+00
degree Fahrenheit (°F)	degree Celsius (°C)	5.555 556 E-01
degree Fahrenheit (°F)	kelvin (K)	5.555 556 E-01
degree Rankine (°R)	kelvin (K)	5.555 556 E-01
VELOCITY (includes SPEED)		
foot per second (ft/s)	meter per second (m/s)	3.048 E-01
inch per second (in./s)	meter per second (m/s)	2.54 E-02
kilometer per hour (km/h)	meter per second (m/s)	2.777 778 E-01
mile per hour (mi/h)	kilometer per hour (km/h)	1.609 344 E+00
mile per minute (mi/min)	meter per second (m/s)	2.682 24 E+01
VOLUME (includes CAPACITY)		
cubic foot (ft^3)	cubic meter (m^3)	2.831 685 E-02
cubic inch ($in.^3$)	cubic meter (m^3)	1.638 706 E-05
cubic yard (yd^3)	cubic meter (m^3)	7.645 549 E-01
gallon (U.S.) (gal)	cubic meter (m^3)	3.785 412 E-03
gallon (U.S.) (gal)	liter (L)	3.785 412 E+00
liter (L)	cubic meter (m^3)	1.0 E-03
ounce (U.S. fluid) (fl oz)	cubic meter (m^3)	2.957 353 E-05
ounce (U.S. fluid) (fl oz)	milliliter (mL)	2.957 353 E+01

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GLOSSARY

active fire protection – A means to help prevent the loss of life and property from fire by extinguishing, suppressing, or controlling a fire through functional systems. Sprinkler systems, fire alarm systems, and smoke control systems are examples of active fire protection.

area of refuge – A floor area to which egress is made through a horizontal exit or supplemental vertical exit.

combustible – A material that is not determined to be noncombustible.

damper – A device installed in heating, ventilating, and air conditioning ductwork used to prevent the spread of fire and/or smoke. Dampers are provided to maintain a fire resistance rating of the assembly being penetrated.

detector – An initiation device that automatically detects a change in state, such as presence of smoke, high temperature, or abnormal rate of temperature rise.

fire alarm system – A system, automatic or manual, arranged to give a signal indicating a fire emergency and initiate the appropriate response.

fire resistance rating – The time in hours that materials or their assemblies will withstand fire exposure as determined by a fire test.

fireproofing – Materials or assemblies used to provide a fire resistance rating to a building component.

firestop – A solid or compact, tight closure to retard the spread of flames or hot gases within concealed spaces.

initiation device – A system component that originates a change-in-state signal in the fire alarm system. An initiation device begins the life safety processes, such as evacuation; heating, ventilating, and air conditioning shut down; elevator recall; etc.

manual fire alarm box – A manually operated initiation device that originates a change-in-state signal in the fire alarm system.

means of egress – A continuous and unobstructed path of vertical and horizontal travel from any point in a building to a public way. The means of egress consists of the exit access, the exit, and the exit discharge.

noncombustible – A material that, in the form in which it is used in construction, will not ignite and burn when subjected to fire. However, any material which liberates flammable gas when heated to any temperature up to 1,380 °F for 5 min shall not be considered noncombustible.

notification appliance – A fire alarm system component such as a bell, horn, speaker, or strobe that provides audible, tactile, or visible outputs, or any combination thereof.

passive fire protection – Fire protection features that are incorporated into the building construction or building materials that do not rely on active fire protection methods to limit fire ignition, fire growth, or material failure. Fire separations and divisions, sprayed-on fire proofing, and enclosing structural members with noncombustible materials are examples of passive fire protection.

smoke and heat venting – A process used to move products of combustion to the outdoor air.

PREFACE

Genesis of This Investigation

Immediately following the attack on the World Trade Center (WTC) on September 11, 2001, the Federal Emergency Management Agency (FEMA) and the American Society of Civil Engineers began planning a building performance study of the disaster. The week of October 7, as soon as the rescue and search efforts ceased, the Building Performance Study Team went to the site and began their assessment. This was to be a brief effort, as the study team consisted of experts who largely volunteered their time away from their other professional commitments. The Building Performance Study Team issued their report in May 2002, fulfilling their goal "to determine probable failure mechanisms and to identify areas of future investigation that could lead to practical measures for improving the damage resistance of buildings against such unforeseen events."

On August 21, 2002, with funding from the U.S. Congress through FEMA, the National Institute of Standards and Technology (NIST) announced its building and fire safety investigation of the WTC disaster. On October 1, 2002, the National Construction Safety Team Act (Public Law 107-231), was signed into law. (A copy of the Public Law is included in Appendix A.) The NIST WTC Investigation was conducted under the authority of the National Construction Safety Team Act.

The goals of the investigation of the WTC disaster were:

- To investigate the building construction, the materials used, and the technical conditions that contributed to the outcome of the WTC disaster.
- To serve as the basis for:
  - Improvements in the way buildings are designed, constructed, maintained, and used;
  - Improved tools and guidance for industry and safety officials;
  - Recommended revisions to current codes, standards, and practices; and
  - Improved public safety.

The specific objectives were:

1. Determine why and how WTC 1 and WTC 2 collapsed following the initial impacts of the aircraft and why and how WTC 7 collapsed;
2. Determine why the injuries and fatalities were so high or low depending on location, including all technical aspects of fire protection, occupant behavior, evacuation, and emergency response;
3. Determine what procedures and practices were used in the design, construction, operation, and maintenance of WTC 1, 2, and 7; and
4. Identify, as specifically as possible, areas in current building and fire codes, standards, and practices that warrant revision.

NIST is a nonregulatory agency of the U.S. Department of Commerce's Technology Administration. The purposes of NIST investigations under the National Construction Safety Team Act are to improve the safety and structural integrity of buildings in the United States, and the focus is on fact finding. NIST investigative teams are required to assess building performance and emergency response and evacuation procedures in the wake of any building failure that has resulted in substantial loss of life or that posed significant potential of substantial loss of life. NIST does not have the statutory authority to make findings of fault or negligence by individuals or organizations. Further, no part of any report resulting from a NIST investigation into a building failure or from an investigation under the National Construction Safety Team Act may be used in any suit or action for damages arising out of any matter mentioned in such report (15 USC 281a, as amended by Public Law 107-231).

Organization of the Investigation

The National Construction Safety Team for this Investigation, appointed by the NIST Director, was led by Dr. S. Shyam Sunder. Dr. William L. Grosshandler served as Associate Lead Investigator, Mr. Stephen A. Cauffman served as Program Manager for Administration, and Mr. Harold E. Nelson served on the team as a private sector expert. The Investigation included eight interdependent projects whose leaders comprised the remainder of the team. A detailed description of each of these eight projects is available at http://wtc.nist.gov. The purpose of each project is summarized in Table P–1, and the key interdependencies among the projects are illustrated in Figure P–1.

Table P–1. Federal building and fire safety investigation of the WTC disaster.

Technical Area and Project Leader	Project Purpose
Analysis of Building and Fire Codes and Practices; Project Leaders: Dr. H. S. Lew and Mr. Richard W. Bukowski	Document and analyze the code provisions, procedures, and practices used in the design, construction, operation, and maintenance of the structural, passive fire protection, and emergency access and evacuation systems of WTC 1, 2, and 7.
Baseline Structural Performance and Aircraft Impact Damage Analysis; Project Leader: Dr. Fahim H. Sadek	Analyze the baseline performance of WTC 1 and WTC 2 under design, service, and abnormal loads, and aircraft impact damage on the structural, fire protection, and egress systems.
Mechanical and Metallurgical Analysis of Structural Steel; Project Leader: Dr. Frank W. Gayle	Determine and analyze the mechanical and metallurgical properties and quality of steel, weldments, and connections from steel recovered from WTC 1, 2, and 7.
Investigation of Active Fire Protection Systems; Project Leader: Dr. David D. Evans	Investigate the performance of the active fire protection systems in WTC 1, 2, and 7 and their role in fire control, emergency response, and fate of occupants and responders.
Reconstruction of Thermal and Tenability Environment; Project Leader: Dr. Richard G. Gann	Reconstruct the time-evolving temperature, thermal environment, and smoke movement in WTC 1, 2, and 7 for use in evaluating the structural performance of the buildings and behavior and fate of occupants and responders.
Structural Fire Response and Collapse Analysis; Project Leaders: Dr. John L. Gross and Dr. Therese P. McAllister	Analyze the response of the WTC towers to fires with and without aircraft damage, the response of WTC 7 in fires, the performance of composite steel-trussed floor systems, and determine the most probable structural collapse sequence for WTC 1, 2, and 7.
Occupant Behavior, Egress, and Emergency Communications; Project Leader: Mr. Jason D. Averill	Analyze the behavior and fate of occupants and responders, both those who survived and those who did not, and the performance of the evacuation system.
Emergency Response Technologies and Guidelines; Project Leader: Mr. J. Randall Lawson	Document the activities of the emergency responders from the time of the attacks on WTC 1 and WTC 2 until the collapse of WTC 7, including practices followed and technologies used.

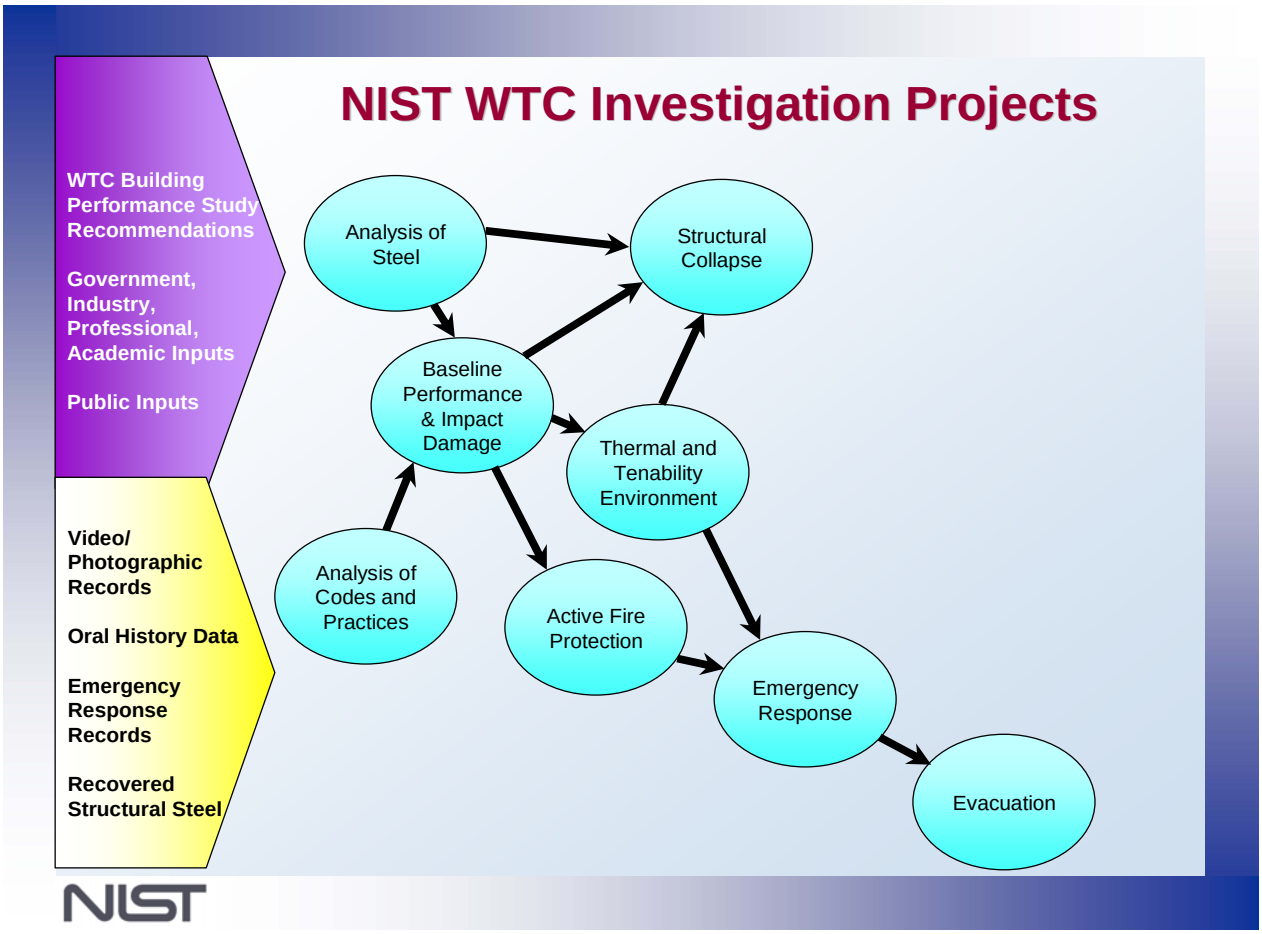

Figure P–1. The eight projects in the federal building and fire safety investigation of the WTC disaster.

National Construction Safety Team Advisory Committee

The NIST Director also established an advisory committee as mandated under the National Construction Safety Team Act. The initial members of the committee were appointed following a public solicitation. These were:

- Paul Fitzgerald, Executive Vice President (retired) FM Global, National Construction Safety Team Advisory Committee Chair
- John Barsom, President, Barsom Consulting, Ltd.
- John Bryan, Professor Emeritus, University of Maryland
- David Collins, President, The Preview Group, Inc.
- Glenn Corbett, Professor, John Jay College of Criminal Justice
- Philip DiNenno, President, Hughes Associates, Inc.

- Robert Hanson, Professor Emeritus, University of Michigan
- Charles Thornton, Co-Chairman and Managing Principal, The Thornton-Tomasetti Group, Inc.
- Kathleen Tierney, Director, Natural Hazards Research and Applications Information Center, University of Colorado at Boulder
- Forman Williams, Director, Center for Energy Research, University of California at San Diego

This National Construction Safety Team Advisory Committee provided technical counsel during the Investigation and commentary on drafts of the Investigation reports prior to their public release.

Public Outreach

During the course of this Investigation, NIST held public briefings and meetings (listed in Table P–2) to solicit input from the public, present preliminary findings, and obtain comments on the direction and progress of the Investigation from the public and the Advisory Committee.

NIST maintained a publicly accessible Web site during this Investigation at http://wtc.nist.gov. The site contained extensive information on the background and progress of the Investigation.

NIST's WTC Public-Private Response Plan

The collapse of the WTC buildings has led to broad reexamination of how tall buildings are designed, constructed, maintained, and used, especially with regard to major events such as fires, natural disasters, and terrorist attacks. Reflecting the enhanced interest in effecting necessary change, NIST, with support from Congress and the Administration, has put in place a program, the goal of which is to develop and implement the standards, technology, and practices needed for cost-effective improvements to the safety and security of buildings and building occupants, including evacuation, emergency response procedures, and threat mitigation.

The strategy to meet this goal is a three-part NIST-led public-private response program that includes:

- A federal building and fire safety investigation to study the most probable factors that contributed to post-aircraft impact collapse of the WTC towers and the 47-story WTC 7 building, and the associated evacuation and emergency response experience.
- A research and development (R&D) program to (a) facilitate the implementation of recommendations resulting from the WTC Investigation, and (b) provide the technical basis for cost-effective improvements to national building and fire codes, standards, and practices that enhance the safety of buildings, their occupants, and emergency responders.

Table P–2. Public meetings and briefings of the WTC Investigation.

Date	Location	Principal Agenda
June 24, 2002	New York City, NY	Public meeting: Public comments on the *Draft Plan* for the pending WTC Investigation.
December 9, 2002	Washington, DC	Media briefing on release of the *Public Update* and NIST request for photographs and videos.
April 8, 2003	New York City, NY	Joint public forum with Columbia University on first-person interviews.
April 29-30, 2003	Gaithersburg, MD	National Construction Safety Team (NCST) Advisory Committee meeting on plan for and progress on WTC Investigation with a public comment session.
May 7, 2003	New York City, NY	Media briefing on release of the *May 2003 Progress Report*
August 26-27, 2003	Gaithersburg, MD	NCST Advisory Committee meeting on status of WTC investigation with a public comment session.
September 17, 2003	New York City, NY	Media briefing and public briefing on initiation of first-person data collection projects.
December 2-3, 2003	Gaithersburg, MD	NCST Advisory Committee meeting on status and initial results and the release of the *Public Update* with a public comment session.
February 12, 2004	New York City, NY	Public meeting: Briefing on progress and preliminary findings with public comments on issues to be considered in formulating final recommendations.
June 18, 2004	New York City, NY	Media briefing and public briefing on release of the *June 2004 Progress Report.*
June 22-23, 2004	Gaithersburg, MD	NCST Advisory Committee meeting on the status of and preliminary findings from the WTC Investigation with a public comment session.
August 24, 2004	Northbrook, IL	Public viewing of standard fire resistance test of WTC floor system at Underwriters Laboratories, Inc.
October 19-20, 2004	Gaithersburg, MD	NCST Advisory Committee meeting on status and near complete set of preliminary findings with a public comment session.
November 22, 2004	Gaithersburg, MD	NCST Advisory Committee discussion on draft annual report to Congress, a public comment session, and a closed session to discuss pre-draft recommendations for WTC Investigation.
April 5, 2005	New York City, NY	Media briefing and public briefing on release of the probable collapse sequence for the WTC towers and draft reports for the projects on codes and practices, evacuation, and emergency response.

- A dissemination and technical assistance program (DTAP) to (a) engage leaders of the construction and building community in ensuring timely adoption and widespread use of proposed changes to practices, standards, and codes resulting from the WTC Investigation and the R&D program, and (b) provide practical guidance and tools to better prepare facility owners, contractors, architects, engineers, emergency responders, and regulatory authorities to respond to future disasters.

The desired outcomes are to make buildings, occupants, and first responders safer in future disaster events.

National Construction Safety Team Reports on the WTC Investigation

A draft of the final report on the collapses of the WTC towers is being issued as NIST NCSTAR 1. A companion report on the collapse of WTC 7 is being issued as NIST NCSTAR 1A. The present report is one of a set that provides more detailed documentation of the Investigation findings and the means by which these technical results were achieved. As such, it is part of the archival record of this Investigation. The titles of the full set of Investigation publications are:

NIST (National Institute of Standards and Technology). 2005. *Federal Building and Fire Safety Investigation of the World Trade Center Disaster: Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers.* NIST NCSTAR 1. Gaithersburg, MD, September.

NIST (National Institute of Standards and Technology). 2005. *Federal Building and Fire Safety Investigation of the World Trade Center Disaster: Final Report of the National Construction Safety Team on the Collapse of World Trade Center 7.* NIST NCSTAR 1A. Gaithersburg, MD, December.

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Fanella, D. A., A. T. Derecho, and S. K. Ghosh. 2005. *Federal Building and Fire Safety Investigation of the World Trade Center Disaster: Design and Construction of Structural Systems.* NIST NCSTAR 1-1A. National Institute of Standards and Technology. Gaithersburg, MD, September.

Ghosh, S. K., and X. Liang. 2005. *Federal Building and Fire Safety Investigation of the World Trade Center Disaster: Comparison of Building Code Structural Requirements.* NIST NCSTAR 1-1B. National Institute of Standards and Technology. Gaithersburg, MD, September.

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SECTION I

FIRE PROTECTION SUMMARY FOR THE WORLD TRADE CENTER TOWERS

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EXECUTIVE SUMMARY

As part of the analysis of building and fire codes and standards of the National Institute of Standards and Technology (NIST) World Trade Center (WTC) Investigation, this report supports the effort to determine the minimum construction requirements used in the design of WTC 1 and WTC 2. The purpose of this report is to summarize the fire protection (both passive and active) and life safety provisions used to design and construct WTC 1 and WTC 2.

Although the Port Authority of New York and New Jersey (PANYNJ) was not subject to the Building Code of the City of New York (BCNYC), WTC 1 and WTC 2 were to be designed in accordance with the BCNYC and all applicable Reference Standards (RS). The initial building concept, including an early conceptual design by Skidmore, Owings & Merrill, was based on the 1938 BCNYC. In 1965, PANYNJ instructed the designers to follow the latest (second and third) drafts of the revised (what would become the 1968) Code to take advantage of relaxations that could save on construction costs.

The BCNYC, building characteristics, and early design choices were used to determine the minimum construction requirements for the design of WTC 1 and WTC 2. Because the BCNYC contains requirements for various types of buildings, it was important to identify certain building requirements early in the design. By identifying specific building characteristics, the designer can determine which requirements must be complied with and which requirements are not applicable.

The information included in Table E–1 was used to classify the buildings and determine the minimum requirements within the BCNYC. Based on the height, area, primary occupancy classification, and no sprinkler protection, the minimum construction type (permitted by the 1968 BCNYC) was I-B (3 h protected) for both buildings. Fire resistance ratings for the structural components, fire divisions, and fire separations were based on this classification. Many of the means of egress, fire suppression, and fire alarm requirements were also based on the information in Table E–1. An abbreviated list of the fire protection provisions is as follows. A complete list of the requirements is identified in the main body of this report.

- A standpipe system was required.
- An automatic sprinkler system was only required in spaces below grade.
- A telephone and signaling system was required for fire department use in operating the standpipe system.
- Detectors were only required to sense smoke entering return grills of the heating, ventilating, and air conditioning system and to shut down fans.
- Manual fire alarm boxes were not required.
- Audible/visual devices were not required.

- Although a fire alarm and voice communication system was not required, a system was installed.
- Exit signs and emergency lighting were required in specified spaces.
- An emergency power system was not required.
- Smoke and heat venting was required in certain shafts, including elevators.
- Stair pressurization was not required.
- A smoke purge system was not required.

Table E–1. Building characteristics used to determine BCNYC requirements.

Building	Height	Number of Floors Above Grade	Footprint	Primary Occupancy Classification
WTC 1	1,368 ft	110	42,900 ft^2	Group E (Business)
WTC 2	1,362 ft	110	42,900 ft^2	Group E (Business)

Source: Merrit 2000a, 2000b; PANYNJ.

Chapter 1
INTRODUCTION

1.1 PURPOSE

The purpose of this report is to summarize the major fire protection (both passive and active) and life safety provisions used to design and construct the World Trade Center (WTC) towers.

1.2 INTRODUCTION

The regulation of building construction is a direct result of the recognition that life safety is served by the best available knowledge and practice. Codes and standards are created to establish minimum requirements. Model codes have been published throughout the United States since 1905 (Boring 1981). Through the use of technology advancements and serious incidents, such as fires, codes are developed and later revised to continually implement increased knowledge. Establishing reference standards is just as important to establishing codes. Referenced standards act as a technical basis of the code and provide further methods of testing, installation and maintenance. Municipalities can adopt model building codes and national standards or develop their own. Alternatively, many municipalities throughout the United States have adopted model building codes and national standards, and then amended portions as deemed necessary. New York City, however, developed their own building code and provide a technical basis with a mixture of nationally recognized standards (National Fire Protection Association, ASTM International, American National Standards Institute, etc.) and New York City developed reference standards (denoted by RS ##).

In accordance with the instructions issued by the Port Authority of New York and New Jersey (PANYNJ or Port Authority) at the start of the project, construction drawings for the WTC were to conform with the requirements of the Building Code of the City of New York (BCNYC), although as a so-called state compact under the U.S. Constitution, the Port Authority was exempt from state or local laws, including the BCNYC. Any variations from the Code were to be called to the attention of the Port Authority for final decision and authorization (Solomon 1975). Variances from the 1968 edition of the BCNYC, along with the applicable provisions of the Code, will be identified (to the best extent possible) in this report.[1] This report summarizes the major provisions of the BCNYC. Readers interested in the more detailed analysis should seek information directly from the BCNYC.

The design of the WTC towers took many years to develop. The initial design was to be in conformance with the 1938 BCNYC. However, in 1965, a decision was made to use the provisions of the newly proposed BCNYC (Kyle 1965). This decision included the rationale that (1) the new Code had been reviewed by technical groups and modified to meet the major objections; (2) the Code would probably be adopted before the WTC towers were constructed and (3) the Building Commissioner favored the approach of using advanced techniques in the design of the towers. Additionally, the PANYNJ repeatedly pointed out that it was not subject to the provisions of the BCNYC (e.g., Tozzoli 1966). Drafts

[1] The applicable provisions of the BCNYC, given throughout the report, are denoted by C26-###.

of the newly proposed code were used until December 1968 when the new BCNYC was adopted. The December 6, 1968, BCNYC was referred to as the applicable building code for the construction of WTC 1 and WTC 2 and is the base document for identifying the design and construction provisions in this report.

It was the policy of PANYNJ to follow the requirements of the BCNYC. Thus, since not all of the documentation used in the design and construction of the towers was identified, the assumption has been made that the construction followed the requirements of the BCNYC. Where documentation was identified, illustrating either conformance with or deviation from a BCNYC provision, a reference has been provided. This report does not evaluate whether or not the design provisions, indicated on drawings and in correspondence, were actually incorporated in the construction of the towers, but merely identifies the provisions established in the design. Since the buildings no longer exist, it is generally impossible to verify the inclusion of specific design features beyond their being discussed in other documents.

Chapter 2
GENERAL

2.1 APPLICABLE CODES AND STANDARDS

1. Building Code of the City of New York, 1968.[2]

2. USASI 17.1 (1965) including Supplement A17.1a (1967) – USA Standard Safety Code for Elevators, Dumbwaiters, Escalators, and Moving Walks (as modified by Reference Standards [RS] 18-1).

3. National Fire Protection Association (NFPA) 13 – Standard for the Installation of Sprinkler Systems, 1966 (as modified by RS 17-2).

4. NFPA 22 – Standard for Water Tanks for Private Fire Protection, 1962 (as modified by RS 17).

5. NFPA 72 – Proprietary and Auxiliary Protective Signaling Systems, 1967 (as modified by RS 17-5).

6. NFPA 80 – Installation of Fire Doors and Windows, 1967 (as modified by RS 5-8).

7. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilating Systems, 1967 (as modified by RS 13-1).

8. NFPA 204 – Guide for Smoke and Heat Venting, 1961 (RS 5-11).

9. ASTM International (ASTM) E 84 – Standard Method of Test for Surface Burning Characteristics of Building Materials, 1961 (as modified by RS 5-5).

10. ASTM E 119 – Standard Methods of Fire Tests of Building Construction and Materials, 1961 (as modified by RS 5-2).

11. RS 5-15 – Minimum Covering of Prestressing Steel for Various Fire Resistance Ratings.

12. RS 17-1 – Standpipe Construction.

13. RS 17-3 – Standards for the Installation of Fire, Sprinkler, Standpipe, Smoke Detection…and other Alarm and Extinguishing Systems.

[2] Including the BCNYC Reference Standards that modify national standards as deemed necessary.

2.2 BUILDING SUMMARIES

Table 2–1. Building characteristics used for design development.

Building[a]	Height	Number of Floors Above Grade[b]	Footprint	Construction Type (1968 BCNYC)	Primary Occupancy Classification
WTC 1[c]	1,368 ft	110	42,900 ft^2	I-B	Group E (Business)
WTC 2[d]	1,362 ft	110	42,900 ft^2	I-B	Group E (Business)

a. These buildings are located inside the Borough of Manhattan Fire District without additional restrictions imposed based on its use and occupancy (C26-402.1, C26-403.1).
b. Documentation indicates that the Concourse Level was treated as an underground street (Solomon 1975). Thus, the Plaza level is the first floor.
c. WTC 1 characteristics are from Merritt 2000a.
d. WTC 2 characteristics are from Merritt 2000b.

Source: Merrit 2000a, 2000b; PANYNJ.

Chapter 3
CONSTRUCTION

3.1 CONSTRUCTION CLASSIFICATION

The minimum construction type permitted for both World Trade Center (WTC) towers was Class I-B (3 h protected).[3]

3.2 BUILDING LIMITATIONS

In accordance with Table 4–2 of the Building Code of the City of New York (BCNYC) the height and area are not limited for an unsprinklered Class I-B construction building housing a Group E occupancy:

- Height – No Limit
- Area – No Limit

3.3 SECONDARY/ACCESSORY OCCUPANCIES

Occupancy	Fire Index
B-1, Storage (Moderate Hazard)	3
B-2, Storage (Low Hazard, Garage)	2
C, Mercantile	2
F-4, Assembly (Restaurant)	1

3.4 FIRE RESISTANCE RATINGS

The minimum required fire resistance ratings listed as follows are in accordance with Table 3–4 of the BCNYC, unless noted otherwise. According to Solomon 1969 and Bracco 1969, the fire resistance ratings of the buildings were designed in accordance with the BCNYC.

[3] Because there was considered to be "no economic advantage" to design WTC 1 and WTC 2 to a higher construction classification (i.e., Class I-A), the buildings were constructed to the minimum construction class required by the BCNYC (Feld 1987). Thus, all BCNYC requirements identified herein, which are dependent upon construction class, are given for Class I-B.

	Fire Resistance Rating (Hours)
1. Exterior Bearing Walls	3
2. Exterior Non-bearing Walls having an Exterior Separation of:[4]	
Three ft or less with 0 percent openings	2
Greater than 3 ft to less than 15 ft with 3½ percent protected openings	2
15 ft to less than 30 ft with 3½ percent openings[5]	1½
30 ft or greater with unlimited openings	NC[6]
3. Interior Walls:	
Interior bearing walls and bearing partitions	3
Exit access corridors (C26-604.2(h))	1[7]
4. Enclosure of vertical exits,[8] exit passageways, hoistways, and shafts	2
5. Columns, girders, trusses (other than roof trusses) and framing:	
Supporting one floor	2
Supporting more than one floor or a floor and roof	3

[4] When two or more buildings are constructed on the same lot and the combined floor area of the buildings does not exceed the limits established by BCNYC Tables 4–1 and 4–2 for any one of the buildings, no fire-resistance rating shall be required for non-bearing portions of the exterior walls of those buildings facing each other, and there shall be no limitation on the permitted amount of exterior openings.

[5] According to Solomon 1975, fire protected openings on exterior walls with a separation of less than 30 ft were omitted.

[6] Noncombustible.

[7] According to Solomon 1975, corridor partitions were designed to meet 2 h construction to minimize the limitations of dead end corridors.

[8] See sections C26-504.6 and C26-604.8(i) for exceptions to shaft and stair enclosures requirements.

	Fire Resistance Rating (Hours)
6. Structural members supporting a wall	Same as required fire resistance of wall supported, but not less than rating required for member by the class of construction
7. Floor construction including beams	2
8. Roof construction – including beams, trusses, framing, arches, domes, shells, cable supported roofs, and roof decks (based on height of lowest member above floor):	
15 ft or less	1½
Greater than 15 ft to 20 ft	1
20 ft or more	NC
9. Area of refuge separation (C26-604.5, C26-604.6)	2
10. Escalators not used as exits (C26-604.11)[9]	¾
11. Enclosures:	
Transformer vaults (greater than 35,000 V) (National Fire Protection Association [NFPA] 70)	3
Emergency generator and fire pump rooms	2
Storage rooms (B-1 occupancy) greater than 75 ft^2 (Table 5–1 note c)	1
Telephone closets	1[10]

[9] Escalators that connect two stories may be unenclosed.

[10] According to Solomon 1975, the original drawings indicated a 2 h rated shaft enclosure with louvers in a 1 ½ h rated door for the telephone closets. Additionally, a variance was granted permitting the omission of dampers. The requirements were changed in 1969 to permit 1 h rated construction with 1 ½ h rated doors. The shaft requirements were eliminated and all floor openings left for future installation of cables had to be firestopped.

The minimum covering of prestressing steel shall comply with the requirements of Reference Standard (RS) 5-15 (C26-502.2(d).

The design and installation provisions for fireproofing are not specifically contained in the BCNYC. The specific requirements for these provisions are derived from calculations, tests, and manufacturer's requirements. Although, C26-501 and C26-502 require that the fire resistance rating of construction assemblies and the protection of structural members shall comply with the requirements of the reference standards of RS-5. Furthermore, the materials or combinations of materials shall be in accordance with the specifications of materials used in the ASTM International (ASTM) E 119 test.

3.5 OPENING PROTECTION

	Fire Resistance Rating (Hours)
1. Openings in a 3 h rated Fire Division or Fire Separation wall (C26-504.4 and Table 5–3).	3 (Class A)
2. Openings in 2 h or 1½ h rated Fire Division or Fire Separation wall or vertical communication enclosure (C26-504.4, C26-604.4(a), C26-1800.6 and Table 5–3).	1½ (Class B)
3. Openings in 1 h rated Fire Division or Fire Separation walls, corridors or partitions (C26-504.4, C26-604.4(b) and Table 5–3).	¾ (Class B)
4. Openings in 1 h rated vertical communication enclosure.	1 (Class B)
5. Required protected openings in exterior walls (Class E or Class F) (C26-503.1(b)).	¾

Noncombustible mail slots not exceeding 40 in.^{2} may be provided in corridor doors (C26-604.4(b)).

Noncombustible louvers may be installed in corridor doors opening into toilets, service sink closets and electrical closets (C26-604.4(b)).[11]

Openings in Fire Divisions and Fire Separations shall not exceed the size limits in Section C26-504.4(a).

In shafts that contain only one opening below the roof, no opening protective is required (C26-504.6(c)).

Exterior street floor exit doors with a fire separation distance of more than 15 ft need not have a fire resistance rating (C26-604.4(a)(1)).

[11] BCNYC does not limit the size of the louver, however, the Board of Standards and Appeals permits louvers of 2 ft^2 in ¾ h rated doors (Solomon 1975).

Openings in elevator and dumbwaiter shafts shall comply with RS 18 (C26-504.6(c)).

3.6 SEPARATION OF OCCUPANCIES

	Fire Resistance Rating (Hours)
1. Fire Divisions	
Between Group B-1 and B-2, C, E, or F-4.	3
2. Fire Separations	
Between Groups E and B-2, C, or F-4.	NR[12,13]
Between tenant spaces (C26-504.3(a)).[14]	1[15]

Spaces classified in occupancy groups having a higher fire index than the occupancy group classification of the building shall be separated by "Fire Divisions" constructed in accordance with Section C26-504.1(a) and treated as separate buildings (C26-301.4(a)).

Spaces classified in occupancy groups having the same or lower fire index than the occupancy group classification of the building shall be separated by "Fire Separations" constructed in accordance with Section C26-504.1(b) (C26-301.4(b)).

When a building or space is used for multiple purposes at different times, the building/space shall be given a separate occupancy group classification for each of the activities. The design and construction shall be in accordance with the most restrictive provisions that apply to any of the classifications (C26-301.6).

A minor variation of occupancy or use of a space is acceptable without multiple classifications if the variation is normally associated with the occupancy classification and no specific danger or hazard is created (C26-301.6).

Fire divisions shall be constructed of noncombustible materials or assembly of noncombustible materials to provide the fire-resistance ratings (C26-504.2). The following requirements apply:

1. Vertical fire divisions shall be continuous between foundation, roof, or horizontal fire divisions, and through any concealed space in floor or roof construction.

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[12] No Requirement.

[13] Separations are not required between accessory business and mercantile activities limited in area to 100 ft^2, and closets 75 ft^2 or less in area (Table 5–1 notes b and c).

[14] The rated partition was coordinated to terminate at a 1 h rated ceiling in lieu of extending the partition to the underside of the slab above (Solomon 1975).

[15] Solomon 1969 confirms the use of 1 h fire resistance rated demising walls between tenant spaces.

2. Horizontal fire divisions shall be continuous between exterior walls and/or vertical fire divisions.

3. Fire divisions shall be made smoketight at their junction with exterior walls.

4. Fire divisions may be offset if the construction between the offset divisions, including their supports, has the same fire-resistance rating as the fire division, with all hollow spaces within the construction firestopped with noncombustible material.

5. Where combustible members such as joists, beams, or girders bear on, or frame into, vertical fire divisions, such members shall not extend through the wall and shall have at least 4 in. of solid noncombustible material below, at the sides, and at the ends of each such member.

6. Chases or recesses shall not be cut into fire divisions so as to reduce their thickness below that required for the fire-resistance rating.

7. Vertical fire divisions that are hollow shall be firestopped with at least 4 in. of noncombustible material so as to prevent passage of flame, smoke, or hot gases through the hollow spaces to the story above or below, or to hollow spaces within connecting floor or roof construction.

3.7 FIRESTOPPING

All firestopping or fill materials shall consist of approved noncombustible materials that can be shaped, fitted, and permanently secured in place (C26-504.7(a)).

Concealed spaces within partitions, walls, floors, roofs, stairs, furring, pipe spaces, column enclosures, etc., that would permit passage of flame, smoke, fumes or hot gases from floor-to-floor shall be firestopped or filled with noncombustible material in the following locations (C26-504.7):

1. Hollow partitions and furred spaces.

2. Concealed spaces within stair construction.

3. Ceiling spaces.

4. Exterior cornices.

5. Duct and pipe spaces (C26-504.5 and RS 13-1 Sec. 313 and 314).

6. Hollow vertical Fire Division (C26-504.2(i)).

The concealed space above a fire resistance rated ceiling shall be firestopped into areas not exceeding 3,000 ft^2, except where (C26-502.5):

1. Structural members within the concealed space are individually protected, or

2. The concealed space is sprinklered.

3.8 THROUGH PENETRATION PROTECTION

Noncombustible pipes and conduits may pass through fire resistance rated construction provided the following (C26-504.5(b)):

1. Space between the pipe or conduit and its sleeve or opening does not exceed 2 in. and is packed with noncombustible material.

2. Close-fitting metal escutcheons are provided on both sides of the construction.

3. Aggregate net area of openings does not exceed 25 $in.^2$ in any 100 ft^2 of wall or floor area. Openings in excess of this limit are not permitted unless tested as part of a rated assembly and so protected.

Ceilings required to have a fire resistance rating may be pierced to accommodate noncombustible electric outlet boxes, recessed lighting fixtures, pipes and ducts as follows (C26-502.5(b)):

1. The aggregate area of outlet boxes and lighting fixtures does not exceed 16 $in.^2$ in each 90 ft^2 of ceiling area.

2. Outlet boxes and lighting fixtures are constructed of steel at least 0.022 in. thick and sealed tightly at the ceiling.

3. Additional or larger services are permitted only when tested as part of the assembly and protected as provided in the test.

The concealed space above fire resistance rated ceilings may be used as a return air plenum if listed (tested) for that purpose provided (RS 13-1 Sec. 316(a)):

1. All openings are tested as part of the assembly and protected in accordance with the test,

2. The integrity of firestopping is not destroyed,

3. No combustible materials are incorporated in the floor and ceiling construction, and

4. Electrical wiring is plenum rated (NFPA 70 Sec. 300-22).

3.9 FIRE AND SMOKE DAMPERS

Fire dampers shall be provided in accordance with RS 13-1 in each of the following locations (C26-504.5):

1. Duct penetrations of walls with a 2 h fire resistance rating or greater (RS 13-1 Sec. 902(a)).

2. Each opening in required vertical shaft enclosures (RS 13-1 Sec. 902(b)).

3. Each outlet or inlet opening in vertical shaft enclosure of duct systems serving two or more floors (RS 13-1 Sec. 902(c)). As an alternate, dampers may be provided at each point where the vertical duct pierces a floor it serves (RS 13-1 Sec. 902(c)).

4. Branch duct penetrations of vertical duct shaft enclosures (RS 13-1 Sec. 902(c)).

5. Fresh air intakes (RS 13-1 Sec. 902(e)).

6. Aluminum Class I duct penetrations of fire resistance rated floors (RS 13-1 Sec. 902(d)).

Fire dampers are not required at the following locations (RS 13-1 Sec. 903):

1. Non-aluminum or Class I vertical shaft branch duct penetrations with a cross-sectional area of less than 20 $in.^2$ which supply only air conditioning units discharging air at not over 4 ft above the floor (RS 13-1 Sec. 903(a)).

2. Non-aluminum or Class 1 duct penetrations of a floor (at one place only) with a cross-sectional area of less than 20 $in.^2$ which supply air conditioning units in one story only that discharge air at not over 4 ft above the floor (RS 13-1 Sec. 903(b)).

3. Duct penetrations in systems serving only one floor and used only for exhaust to the outside and not penetrating a fire wall or fire partition or passing entirely through the vertical shaft enclosure (RS 13-1 Sec. 903(d)).

4. Branch ducts connected to a return riser where subducts are extended at least 22 in. upward (RS 13-1 Sec. 903(e)).

5. Fire dampers shall be automatic closing 1½ h fire rated with a fusible link or other heat actuated device rated approximately 50 °F above the maximum system operating temperature (RS 13-1 Sec. 905(a)(g)).

Duct openings permitted in fire resistance rated ceilings are required to be protected with fire dampers (C26-502.5(b)).

Smoke dampers are required to be installed in the main supply duct and the main return duct in systems over 15,000 cfm capacity (RS 13-1 Sec. 1003).

Smoke dampers are required to be arranged to close automatically when the system is not in operation, by the operation of duct smoke detectors, and by the manual emergency fan stop (RS 13-1 Sec. 1003).

Chapter 4
INTERIOR FINISH

4.1 INTERIOR FINISH FLAME SPREAD RATINGS

The minimum interior finish flame spread ratings as defined in ASTM International (ASTM) E 84 and shown below are based on Table 5–4 of the Building Code of the City of New York (BCNYC) and other sections as noted.

	Classification
1. Exits and shafts (C26-504.10(c), C26-604.8(i)(3))	Class A (0-25)
2. Corridors (C26-504.10(c), C26-604.2(k)):[16,17]	
Group B-1	Class A (0-25)
Groups B-2, C, E, F-4	Class A or B (0-75)
3. Rooms greater than 1,500 ft^2 (C26-504.10(c)):	
Groups B-1, B-2, F-4	Class A or B (0-75)
Group E	Class A, B, or C (0-225)
4. Rooms less than 1,500 ft^2 (C26-504.10(c)):	
Groups B-1, B-2, E, F-4	Class A, B, or C (0-225)
5. Interior finish in kitchens, cooking spaces, pantries, repair and maintenance shops, boiler rooms, and incinerator combustion rooms (Table 5–4 note f).	Class A or B (0-75)

[16] When used in corridors, Class B finish material shall not extend more than 50 ft between separations of Class A finish material that are at least 2 ft wide (BCNYC Table 5–4 note b).

[17] Spaces through which it is necessary for occupants of an adjacent room to pass in order to reach the only exit are considered as corridors.

4.2 SMOKE DEVELOPED RATINGS

Interior finish materials shall be limited to smoke developed ratings as defined in ASTM E 84 in the locations specified:

1. Twenty-five or less in exits and corridors (C26-504.10(d)).

2. One hundred or less in rooms where the net floor area per occupant is 10 ft^2 or less (C26-504.10(d)).

No material shall be used in any interior location that upon exposure to fire will produce products that are more toxic in point of concentration than those given off by wood or paper (C26-504.10(e)).

4.3 INTERIOR TRIM

Up to 20 percent of the aggregate wall and ceiling area of any room or corridor may be finished with Class A, B, or C (0-225) materials and be exempt from the smoke developed rating requirements (C26-504.10(c)(4), C26-504.10(d)). This allowance shall include the area of doors, folding partitions, windows, glazing, skylights, luminous ceilings, trim, bases, chair rails, panels, moldings, etc.

4.4 FLOOR FINISH

Finish flooring in all exits shall be of noncombustible material (C26-504.13, C26-604.8(h)).

In all other areas, combustible finish flooring may be used when installed in accordance with Section C26-504.13(b).

Chapter 5
MEANS OF EGRESS

According to Feld (1987), the egress requirements were in accordance with the provisions of the Building Code of the City of New York (BCNYC).

5.1 GENERAL

Clear width measurement is the net, unobstructed width of a means of egress without projections in such width (C26-604.2(a), C26-604.3(b)):

1. In corridors, projections up to 18 in. wide to the extent of 2 in. per unit of egress width are permitted if the total area of such projections does not exceed 5 percent of the area of the wall on which they occur (C26-604.2(a)).

2. Handrails shall project not more than 3½ in. and stringers 2 in. (each side) into the required stair width (C26-604.8(b), C26-604.8(f)).

Headroom (C26-604.2(b), C26-604.3(c)):

1. Corridor and exit passageway minimum height of 7 ft 6 in. for 75 percent of the floor area with no point less than 7 ft.

2. Projections from the ceiling shall be at least 7 ft above the floor and located so as not to obstruct full view of exit signs (C26-604.2(b), C26-604.3(c)).

Changes in level requiring less than two risers in a corridor or exit passageway shall be by a ramp (C26-604.2(e), C26-604.8(d)(2)).

Obstructions to means of egress:

1. The required width of a means of egress shall not be obstructed or reduced in any manner (C26-604.2).

2. Corridors shall be kept free of combustible contents (C26-604.2).

3. All exterior means of egress elements, including exterior corridors and stairs, shall be maintained free of ice and snow accumulation (C26-604.2, C26-604.9).

Corridors may be used as supply or return air ducts or plenums if equipped with an approved smoke detector or thermostatic device to shut down fans (C26-604.2(j), RS 13-1 Sec. 316(d)).

Stairways connecting two or more stories shall not be used as plenums (RS 13-1 Sec. 316(e)).

5.2 EXITS

Every floor area shall be provided with at least two approved independent exits (C26-603.2).

Public garages shall be provided with at least two exits from each tier of parking (C26-709.8).

A minimum of two exits or exit access doors shall be provided from every room or space in which the occupant load exceeds the following limits (C26-603.1):

Occupancy	Occupant Load
B (Storage)	50
C (Mercantile)	75
E (Business)	75
F (Assembly)	75

All required exits shall be located such that they are clearly visible, accessible, and have unobstructed access at all times (C26-602.1).

In multi-tenant configurations, each tenant shall have access to the required numbers of exits without passing through other tenant spaces (C26-602.2).

Whenever more than one exit or exit access is required from any room, space, or floor of a building, they shall be located as remote from each other as practicable (C26-602.3).

Door openings to scissor stairs shall be at least 15 ft apart (C26-602.3).

All vertical exits shall extend in a continuous enclosure to discharge directly to an exterior space or at a yard, court, exit passageway, or street floor lobby of the required width and size to provide all occupants with a safe access to an open exterior space. Where vertical exits serving floors above grade continue in the same enclosure to serve floors below grade, the portion of such vertical exits above grade shall be separated from the portion below grade by construction having at least a 1 h fire resistance rating, with ¾ h self-closing doors opening in the direction of exit travel from the floors below grade (C26-602.4).

A maximum of 50 percent of the required number of vertical exits is permitted to discharge through a single exit passageway (C26-604.3).

One hundred percent of the number of vertical exits may discharge through a street floor lobby if egress is provided in two different directions from discharge points to open exterior spaces remote from each other (C26-604.3(h)(1)).

The clear width of an exit passageway serving two or more vertical exits shall be equal to 75 percent of the width of all vertical exits it serves (C26-604.3(b)).

The width of street floor lobbies serving as exit passageways shall be increased to accommodate the occupant load of all communicating spaces on the lobby floor that exit through them (C26-604.3(h)(2)).

No openings other than exit doors are permitted in exit passageways (C26-604.3(f)).

Openings between street floor lobbies serving as exit passageways and elevators or communicating spaces and show windows protected in accordance with Section C26-604.3(h)(3) are permitted.

Street floor lobbies serving as exit passageways may be occupied by newsstands, candy and tobacco stands, information booths, or similar occupancies if constructed of noncombustible materials, occupying not more than 5 percent of the net lobby floor area, and if not reducing the required clear width at any point (C26-604.3(h)(4)).

Horizontal and Supplemental Vertical Exits (C26-604.5 to C26-604.7):

1. The occupant load capacity for vertical exits may be reduced by 50 percent when one area of refuge is provided and by 66 percent when two or more areas of refuge are provided (C26-603.3).

2. At least 3 ft^2 per person of clear public space, or space occupied by the same tenant or owner, shall be provided within the area of refuge for the occupant load received in addition to its own occupant load (C26-604.5(b)).

3. Each area of refuge shall be provided with at least one vertical exit and when located above the 11th floor, the vertical exit shall be supplemented by at least one elevator (C26-604.5(c)).

4. Access to an area of refuge, on the same floor, through a horizontal exit, may consist of doors, balconies, bridges and tunnels (C26-604.6):

    a. Doors must swing in the direction of exit travel and be self-closing having a fire resistance rating of 1½ h. Where areas of refuge are provided on both sides of a horizontal exit, two door openings shall be provided, each swinging in opposite directions (C26-604.6(b)).

    b. Balconies, bridges and tunnels serving as horizontal exits shall comply with Section C26-604.6(c).

5. Access to an area of refuge on a floor nearer to the street, through a supplemental vertical exit, may consist of enclosed interior stairs, ramps, or escalators (C26-604.7):

    a. Supplemental vertical exits shall comply with the requirements for interior stairs, and serve no other purpose than to connect a floor area with an area of refuge with no openings in the enclosure other than exit doors (C26-604.7).

    b. Every supplemental vertical exit shall have a sign at the entrance stating EXIT TO AREA OF REFUGE ON _____ FLOOR (C26-604.7).

5.3 EXIT WIDTH AND CAPACITY

Occupant load shall be calculated based on the net floor areas in square feet divided by the occupant load factor (square foot per person) or the actual number of occupants from whom each occupied space is designed, whichever is greater (C26-601.2):

1. Non-simultaneous Occupancy – The occupant load of toilets, locker rooms, meeting rooms, storage rooms, employee cafeterias, and similar rooms or spaces that are not occupied at the same time as other rooms or spaces on the same floor may be omitted from the occupant load calculation of the floor on which they are located (C26-601.2(c)).

2. The occupant load of any space shall include the occupant load of all spaces that discharge through it in order to gain access to an exit (C26-601.2).

Occupancy	**Occupant Load Factor**
Business (offices)	100
Conference rooms (tables)	12
Conference rooms (chairs)	10
Dining spaces	12
Mercantile:	
1st floor/basement	25
All other floors	50
Assembly (fixed seats)	No. of seats
Waiting space (standing)	4
Garages/parking	250
Storage rooms	200
Mechanical rooms	200

Where vertical exits serve more than one floor, only the occupant load of each floor considered individually is used in computing the required capacity of exits at that floor, except where one floor is used by another as a means of egress (C26-601.1).

Exit capacity (width) shall not decrease in the direction of exit travel (C26-604.8).

The width of each means of egress component shall be that computed using the appropriate egress unit factor but not less than the minimum width prescribed for the component (C26-601.1, C26-601.3):

1. Where computations give fractional results, the next larger integral number of egress units or integral number plus ½ shall be used (C26-601.3).

2. A fraction less than ½ may be neglected when constituting less than 10 percent of the total required number of egress units.

When a floor area has access to areas of refuge that comply with the requirements of Section C26-604.5, the number of persons for whom vertical exits are to be provided may be reduced to 50 percent of the occupant load of the floor area when one area of refuge is provided, and may be reduce to 33 1/3 percent of the floor area when two areas of refuge are provided (C26-603.3).

Egress capacity factors – capacity per egress unit (C26-601.1, C26-601.3):

1. One unit of egress width is equal to 22 in.

2. Doors to outdoors at grade:

    a. Occupancy Group B (Storage) – 75 persons per unit.

    b. Occupancy Groups C (Mercantile), E (Business), and F (Assembly) – 100 persons per unit.

3. Other exit and corridor doors:

    a. Occupancy Group B (Storage) – 60 persons per unit.

    b. Occupancy Group C (Mercantile), E (Business), and F (Assembly) – 80 persons per unit.

4. Stairs and escalators:

    a. Occupancy Group B (Storage) – 45 persons per unit.

    b. Occupancy Groups C (Mercantile), E (Business), and F (Assembly) – 60 persons per unit.

5. Ramps, corridors, exit passageways, horizontal exits:

    a. Occupancy Group B (Storage) – 75 persons per unit.

    b. Occupancy Groups C (Mercantile), E (Business), and F (Assembly) – 100 persons per unit.

    c. When ramp slope exceeds 1 in 10, the capacity shall be reduced by 25 percent (Table 6–1 note b).

Where a door is divided by mullions into two or more door openings, each opening shall be measured separately in computing the number of egress units (Table 6–1 note m).

5.4 DOORS

Minimum nominal width shall be 32 in. except for corridor and exit door openings, which shall be 36 in. (C26-604.4(e)):

1. Door jambs or stops and the door thickness when open shall not reduce the required width by more than 3 in. for each 22 in. of width (C26-604.4(e)).

2. In all cases where a door opening is divided by mullions into two or more door openings, the minimum nominal width of each such opening shall be 32 in. (C26-604.4(c)).

Maximum width of leaf (C26-604.4(e)) is 48 in.

Minimum height (C26-604.4(f)) is 6 ft 8 in.

Door jambs, stops, sills, and closers shall not reduce the clear opening to less than 6 ft 6 in. (C26-604.4(f)).

The floor on both sides of all exit and corridor doors shall be substantially level and have the same elevation for a distance at least equal to the width of the leaf (C26-604.4(h)).

Where doors lead out of a building, the floor level inside may be 7½ in. higher than the level outside (C26-604.4(h)).

Exit doors, corridor doors serving high hazard occupancy Group A spaces, and corridor doors from rooms required to have more than one door shall swing in the direction of egress (C26-604.4(g)).

Vertically sliding doors, rolling shutters, and folding doors shall not be used as exit doors or as corridor doors (C26-604.4(d)).

Revolving doors designed and constructed in accordance with Section C26-604.4(m) are permitted to be used as exits except that revolving doors shall not be used as interior exit access doors, at the foot of stairs, or at the head of basement stairs (C26-604.4(d)).

Turnstiles designed and constructed in accordance with Section C26-604.4(n) may also be permitted.

Power operated or power assisted manually operated doors may be used as exit or corridor doors provided they remain closed in case of power failure and are manually operable. To be credited as a required exit, power operated doors must swing in the direction of exit travel (C26-604.4(l)).

Exit doors and corridor doors shall normally be kept in the closed position (C26-604.4(i)).

Latch bolts shall be provided on all exit doors and corridor doors to hold them in a closed position against the pressure of expanding gases (C26-604.4(j)(1)(c)).

Obstruction of means of egress during door opening:

1. Doors providing access to stairways or ramps shall not block stairs/ramps or stair landings or reduce the width of landings/stairs/ramps to less than 75 percent of the required width or to less than the width of the door opening on them (C26-604.8(g), C26-604.10(c)(4)).

2. No door shall swing over the sloping portion of a ramp (C26-604.8(c)(4)).

Exit and corridor doors and doors providing access to areas of refuge shall be readily openable at all times from the side from which egress is made without the use of a key (C26-604.4(j)(1)(a), C26-604.5(d)):

1. Locks may be used in places where extra safeguards are required (banks, museums, etc.), subject to approval of the commissioner, provided the locks are equipped with electrical release devices for remote control in case of emergency (C26-604.4(j)(1)(a)(2)).

2. Doors opening into interior enclosed stairs shall not be locked from either side except that doors may be locked to prevent access to the stair from the outside at the street floor (C26-604.4(j)(1)(b).

5.5 EXIT ACCESS

Minimum clear width of corridors shall be:

1. Occupancy Groups B (Storage), C (Mercantile) - 36 in.

2. Occupancy Groups E (Business), F (Assembly) - 44 in.

The maximum travel distance shall not exceed the following limits. Travel distance shall be measured along the natural and unobstructed path of travel. Where the path of travel is over an access stair, it shall be measured along an inclined straight line through the center of the outer edge of each tread (C26-601.4(a)(c), Table 6–1).

Occupancy	**Distance (Feet)**[18]
B-1 (Storage)	100
B-2 (Storage)	125
B-2 (Parking garage)	100
C (Mercantile)	150
E (Business)	200
F (Assembly < 75 persons)	150

[18] Distances given are for unsprinklered conditions (BCNYC Table 6–1).

The maximum dead-end distance shall not exceed the following limits (C26-604.2(d), Table 6–1):

Occupancy	Distance (Feet)[19]
B-1 (Storage)	50
B-2 (Storage)	NR
C (Mercantile)	50
E (Business)	50
F (Assembly)	30

5.6 STAIRWAYS

Minimum clear width shall be at least 44 in. (C26-604.8(b)):

1. The width of stairs shall be the clear width between walls, grilles, guard, or newel posts. Stair stringer projections which do not exceed 2 in. on each side and handrail projections of 3½ in. are permitted.

2. Vertical exits in public garages may be 36 in. wide.

3. The minimum width of landings and platforms shall be at least the required width of the stairway. On a straight run stair, landing and platform widths need not be more than 44 in.

Minimum headroom shall be at least 7 ft (C26-604.8(c)).

Maximum height between landings shall be 12 ft (C26-604.8(d)).

Treads and risers (C26-604.8(e), Table 6–4):

1. Maximum riser height:

   a. Occupancy Group F (Assembly) – 7½ in.

   b. All others – 7¾ in.

2. Minimum tread depth – 9½ in. plus nosing

3. The sum of two risers plus one tread exclusive of the nosing shall not be less than 24 nor more than 25½ in.

4. Stair riser and tread dimensions shall be constant in any flight of stairs from story to story.

Curving or skewed stairs that conform to Section C26-604.8(e)(4) are permitted to be used as exits.

[19] Distances given are for unsprinklered conditions. When a corridor is completely enclosed in 2 h fire resistance rated construction with 1/2 h fire rated doors, the permissible length of dead end may be increased by 100 percent (C26-604.2(d)).

Where exit stairways serving floors above grade continue in the same enclosure to serve floors below grade, the above and below grade portions shall be separated by 1 h fire resistance rated construction.

Stair identification signs shall be posted on the occupancy side of the stair door indicating the letter designation of the stair.

In buildings or in building sections more than three stories or 40 ft high with roofs having a slope of less than 20 degrees, access to the roof shall be provided by at least one interior stair. Access to set back roof areas may be through a door or window opening to the roof.

No openings of any kind are permitted into stair enclosures other than windows, fire department access panels, and exit door.

Exterior stairs designed and constructed in accordance with Section C26-604.9 may be used as exits in lieu of interior stairs.

No exterior stair shall exceed 75 ft or six stories in height.

Escalators designed and constructed in accordance with Section C26-604.11 may be used as exits in lieu of interior stair.

5.7 RAMPS

The minimum clear width of exit ramps is 44 in. (C26-604.10, C26-604.8(b)).

Level platforms or landings at least as wide as the ramp shall be provided at the top and bottom of all ramps and at intermediate levels as necessary:

1. Level platforms shall be provided on each side of door openings into or from ramps.

2. Platforms shall be at least 3 ft wide; 5 ft when a door swings onto the platform.

Minimum headroom is 6 ft 8 in.

Changes in direction of travel shall be made only at landings (or platforms) (C26-604.10(c)).

Ramps with a slope not greater than 1 in 12 at any place may be curved.

Ramps shall not have a slope steeper than 1 in 8 and sloping portions shall be at least 3 ft but not more than 30 ft long between platforms or landings.

Level and ramped moving walkways designed and constructed in accordance with Section C26-604.12 may be used as exits (C26-604.12).

5.8 HANDRAILS AND GUARDRAILS

Continuous handrails are required on both sides of all stairs, and all ramps with a slope exceeding 1 in 12:

1. Stairs less than 44 in. wide may have a handrail on one side only.
2. Intermediate handrails shall be provided to divide stairs more than 88 in. wide into widths that maintain nominal multiples of 22 in. and widths not greater than 88 in. nor less than 44 in.
3. Handrail height shall be 30 to 34 in. measured vertically above the nosing of treads.
4. Handrail ends shall be returned to walls and posts when terminated.
5. Handrails shall provide a finger clearance of 1½ in. and shall project not more than 3½ in. into the required stair width.

Stair landings and platforms shall be enclosed on sides by walls, grilles, or guards at least 3 ft height.

5.9 EXIT SIGNS

In all buildings, the location of every exit on every floor shall be clearly indicated by approved EXIT signs (C26-606.1).

EXIT signs shall be placed at an angle with the exit opening if such placement is required for the signs to serve their purpose.

In areas where the location of the exit may not be readily visible or understood (including long corridors and open floor areas), directional signs shall be provided to serve as guides from all portions of the corridor or floor.

The size, color and illumination of EXIT signs shall conform to Section C26-606.3. Directional signs shall conform to Section C26-606.4.

All EXIT signs shall be illuminated at all times when the building is occupied.

Where a total of more than four signs (exit and/or directional) are required, all EXIT signs shall be connected to circuits that are separate from the general lighting and power circuits. These circuits shall be taken off ahead of the main switch or connected to an emergency lighting power source when such source is provided.

Any door, passageway, stair, or other means of communication that is not an exit shall be so identified with a NOT AN EXIT sign and a sign indicating its use or purpose or a directional exit sign shall be provided.

5.10 MEANS OF EGRESS LIGHTING

Corridors and exits shall be equipped with artificial lighting facilities to provide at least 5 ft candle intensity floor lighting continuously during the time that conditions of occupancy of the building require that the exits be available (C26-605.1).

Lighting shall be provided to illuminate changes in direction in and intersections of corridors, balconies, exit passageways, stairs, ramps, escalators, bridges, tunnels, landings, and platforms.

Illumination shall be arranged so that failure of any one light does not leave any area in darkness.

Where a total of more than four lights are required, exit lighting shall be connected to circuits that are separate from the general lighting and power circuits. The circuits shall be taken off ahead of the main switch or connected to an emergency lighting power source when such source is provided.

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Chapter 6
FIRE SUPPRESSION

6.1 AUTOMATIC SPRINKLER PROTECTION

Automatic sprinkler protection shall be designed and installed in accordance with Section C26-1703.1 and Reference Standard (RS) 17-2 in the following areas:

1. Spaces in group B-1 > 500 ft^2.

2. Spaces in group B-1 < 500 ft^2 when required by the commissioner.

3. Spaces in group B-2 > 5,000 ft^2 or 75 ft in height.

4. Spaces in high-rise buildings classified as mercantile occupancy group C > 7,500 ft^2 in floor area or with an unenclosed stair or escalator between any two or more floors.

5. Regardless of occupancy, any story above grade and the first story below grade without required ventilation.

    a. All other stories below grade.

    b. Sprinklers may be omitted in toilets, shower rooms, stair, and mechanical and electrical rooms.

A wet-pipe sprinkler system shall be provided throughout all areas requiring automatic sprinkler protection. In areas subject to freezing, the sprinkler system shall be protected (insulation, heat trace, antifreeze solution) from freezing or a dry-pipe system shall be provided (C26-1703.13).

A sprinkler alarm system shall be provided when more than 36 heads are installed in any fire area or section (C26-1703.4).

6.2 STANDPIPES

Wet standpipes designed and installed in accordance with Section C26-1702.1 and RS 17-1 shall be provided (C26-1702.1(a)(1)):

The number and location of standpipes shall be such that every point of every floor can be reached by a 20 ft stream from a nozzle attached to not more than 125 ft of hose connected to a riser outlet valve (C26-1702.4):

1. Standpipe risers and 2½ in. hose valves shall be located within stairway enclosures (C26-1702.5(a)).

2. When stairway enclosures are not available within the 125 plus 20 ft distance (145 ft total), risers and valves shall be located as near to the enclosure as practicable (C26-1702.5(a)).

The highest riser shall be extended above the roof with a 3-way manifold with 2½ in. hose valves (C26-1702.11(a)(2)).

A 2½ in. hose outlet shall be provided at each standpipe riser on each floor served, and on the entrance floor above the riser control valve, located between five and six ft above the landing or floor (C26-1702.11(a)(1)).

Hose stations shall be located at the standpipe risers, either inside or adjacent to the entrance of stairway enclosures (C26-1702.11(b)):

1. Hose stations shall be located to satisfy the 125 plus 20 ft (145 total) requirement (C26-1702.11(b)(1)).

2. Hose shall be (C26-1702.11(c)):

   a. 1½ in. unlined (flax-line) linen hose in Groups C, E, and F.

   b. 2½ in. (unlined) in Group B.

3. Auxiliary hose stations equipped with 1½ in. (unlined) hose are permitted in Groups C, E, and F (C26-1702.11(c)(4), C26-1702.11(d)).

Standpipe systems that include more than one riser shall have all risers cross-connected at, or below, the street entrance floor level (C26-1702.10(a)).

Standpipe systems having more than one zone shall be arranged such that the risers supplied from each zone are cross-connected below, or in, the story of the lowest hose outlets from the water source in each zone (C26-1702.10(b)).

Standpipe risers shall be at least 4 in. in diameter where the riser height is 150 ft or less from the highest hose outlet to the level of the entrance floor, 6 in. in diameter where greater than 150 ft (C26-1702.7, Table 17–1).

6.3 WATER SUPPLY

Standpipe systems shall have a primary water supply available at all times to every hose outlet or made available automatically when the hose valve at any outlet is opened (C26-1702.14).

Combinations of two or more of the following sources shall serve as the primary water supply (C26-1702.14(b)):

1. Direct connection to city water system.

2. Direct connection to a private yard main.

3. Pressure tank(s).

4. Automatic fire pump (C26-1702.14(b)(5)).

    a. In buildings higher than 300 ft, the automatic fire pump shall be used only for the lower 300 ft.

    b. Zones above 300 ft shall be supplied by either a gravity or pressure tank.

5. An additional standpipe system water supply shall be provided for standpipes in buildings over 300 ft high (C26-1702.15(a)). The primary water supply to the standpipe system shall be supplemented by one or more manually operated fire pumps (C26-1702.15(a)).

At least one of the following automatic source of water supply shall be provided for sprinklers (C26-1703.8(a)):

1. Gravity tank(s).

2. Pressure tank(s).

3. Automatic fire pump.

4. Direct connection to public water system.

Domestic water supply may be used to supply cooling tower sprinklers and sprinklers installed in buildings classified in Occupancy Group E (Business) in accordance with Section C26-1703.9(e) (C26-1703.9 (c) and (d)).

Auxiliary sources of water supply for sprinkler systems may include a manually actuated fire pump or siamese connection (C26-1703.8(b)).

Combined Water Supplies:

1. Fire pumps may simultaneously serve as the required auxiliary water supply for standpipe and sprinkler systems in accordance with Section C26-1702.15(d).

2. Tanks used to provide the required primary water supply to a standpipe system may also be used as a supply for an automatic sprinkler system (C26-1703.8(c)).

One standpipe system and one sprinkler system siamese connection shall be provided for each 300 ft of exterior building wall or fraction thereof facing each street or public space (C26-1702.9(a), C26-1703.6(a)(1)). In addition:

1. Modifications based on street frontage are permitted by Sections C26-1702.9(b)-(f).

2. Each siamese connection shall be connected to a riser or to a cross connection connecting other siamese connections or risers (C26-1702.10(f)).

3. In below grade sprinkler systems for garage occupancies, a sprinkler siamese connection shall be provided within 50 ft of every exit or entrance used by motor vehicles (C26-1703.6(a)(2)).

4. Siamese connections for partial sprinkler systems shall be in accordance with Section C26-1703.6(a)(3).

Chapter 7
FIRE DETECTION AND ALARM

7.1 FIRE ALARM SYSTEM

A fire alarm system was not required by the Building Code of the City of New York (BCNYC) at the time of design and construction of World Trade Center (WTC) 1 and WTC 2, but smoke detectors were required to be provided to prevent the recirculation of smoke through certain heating, ventilating, and air conditioning (HVAC) systems (C26-1300.7(a)). A sprinkler alarm system shall be provided when more than 36 heads are installed in any fire area or Section (C26 1703.4). (Note that the underground spaces and parking garage were originally sprinklered.)

A local water flow alarm unit shall be provided (outdoor water motor or electric alarm gongs) where there is no watchman with watch service (Reference Standard [RS] 17-2 Sec. 3721).

Central station water flow alarm service is desirable but does not waive the local alarm requirement (RS 17-2 Sec. 3721).

7.2 SMOKE AND HEAT DETECTOR LOCATIONS

HVAC Systems (C26-1300.7(a), RS 13-1):[20]

1. In systems over 5,000 cfm capacity, thermostatic devices shall be provided for automatic fan shut-down as follows (RS 13-1 Sec. 1002):

    a. 125 °F (max) devices located in the return air stream prior to exhaust or dilution by outside air (RS 13-1 Sec. 1002(a)).

    b. 50 °F (max) above maximum operating temperature devices located in the main supply duct down stream of the filters (RS 13-1 Sec. 1002(b)).

    c. Where thermostatic devices are installed in systems utilizing recirculated air on floors protected by sprinkler or fire alarm systems, fans shall automatically shut down on alarm (RS 13-1 Sec. 1005).

2. In systems over 15,000 cfm capacity smoke detectors shall be provided for automatic fan shutdown as follows (RS 13-1 Sec. 1003).

    a. Smoke detectors shall be located in the main supply duct downstream of the filters (RS 13-1 Sec. 1003(b)).

[20] A Port Authority fire safety report contained in Appendix A of NIST NCSTAR 1-1H indicates that smoke detectors were installed on each floor at return air ducts. The NIST NCSTAR 1-1H report is one of the companion documents from this Investigation. A list of these documents appears in the Preface.

b. Smoke detectors shall be arranged to provide audible and visual annunciation at a local supervisory control board in the building in accordance with RS 13-1 Sec. 1003(c).

3. In systems utilizing recirculated air, smoke detectors shall be provided for automatic fan shut-down when any of the following conditions exists (RS 13-1 Sec. 1003(a)):

   a. System supplies an exit passageway, or a space leading from elevators to a street or to the exterior.

   b. System supplies spaces on more than one story or spaces in different fire areas in the same story.

   c. Where the area of a building or space served is over 20,000 ft^2 in mercantile or indoor assembly occupancies.

   d. Where there is a duct opening in a required 2 h fire resistance rated interior Fire Division.

   e. Where a duct passes through a firewall.

   f. Where a corridor is used as a plenum.

4. Systems incorporating automatic exhaust in lieu of automatic fan shutdown are acceptable provided they are equipped with smoke detectors (RS 13-1 Sec. 1004).

5. Each installation shall be equipped with a manual emergency stop for quick shut down of the fan(s) in case of fire (RS 13-1 Sec. 1001).

7.3 MANUAL FIRE ALARM BOXES

No requirement per BCNYC.

7.4 AUDIBLE/VISUAL ALARM NOTIFICATION APPLIANCES

No requirement per BCNYC.

7.5 COMMUNICATION SYSTEM

In every building more than 300 ft high, a telephone and signaling system shall be provided for fire department use in operating the standpipe system (C26-1702.21, C26-1704.7(a)).

The standpipe telephone system shall be as follows:

1. System shall permit communication by permanent telephones in the following locations (C26-1704.7(b)):

   a. Pump rooms.

   b. Entrance floor.

c. Gravity tank rooms.

d. Each floor near main standpipe riser.

2. The system shall be a selective ringing, common talking system supplied by a 24 V direct current power source (C26-1704.7(b)).

3. Permanent wall telephones shall be provided with 6 in. gongs except in the pump room where a loud speaking receiver shall be provided (C26-1704.7(c)).

4. Where portable phones are used, jacks protected by break-glass boxes shall be provided (C26-1704.7(c)).

   a. At least three portable phones shall be provided for each standpipe installation, kept in a dedicated, locked cabinet located in the main hall of the entrance floor (C26-1704.7(d)).

   b. A pilot light shall be provided over the cabinet to indicate if the system is in use or a receiver is off the hook (C26-1704.7(e)).

5. Manual, individually coded sending stations shall be located in the main corridor of the building arranged to transmit a signal to alarm sounding devices (C26-1704.7(f)(1)). The system shall be installed in accordance with RS 17-3 (C26-1704.7(f), C26-1704.8).

6. An 8 in. gong shall be provided in the pump rooms and in elevator shafts at intervals not exceeding 10 floors (C26-1704.7(f)(1)).

7. Adjacent to each telephone station and near the main standpipe riser, a closed circuit strap key connected in series with the box circuit of the signal sending station shall be provided (C26-1704.7(f)(2)).

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Chapter 8
ELEVATORS AND HOISTWAYS

8.1 GENERAL

Elevators or escalators shall be provided in accordance with Section C26-1800.1 and Reference Standard (RS) 18-1 in all new buildings exceeding four stories in height (C26-604.1(a), C26-1800.6(d)).

1. When areas of refuge are provided above the 11th floor of a building, they shall be served by at least one elevator (C26-604.5(c)).

2. Escalators may be used as exits in lieu of interior stairs (C26-604.11, C26-1800.6(g).

In every building exceeding 100 ft in height, at least one elevator shall be kept available for immediate use by the fire department during all hours (C26-1702.22, C26-1800.8).[21]

In buildings exceeding 150 ft in height, there shall be an operator available at all times (C26-1800.8).

Automatic passenger elevators shall be equipped with emergency controls for fire department use (RS 18-1 Rule 210.13).

1. A two-position keyed switch shall be provided at a main floor of each elevator or group of elevators for recall to the main floor in accordance with RS 18-1 Rule 210.13(a).

2. A keyed switch shall be provided in or adjacent to an operating panel of each elevator to initiate emergency service in accordance with RS 18-1 Rule 210.13(b).

Fire drills shall be conducted in accordance with the fire safety plan at least once every 3 months for existing buildings during the first 2 years. Thereafter, fire drills shall be conducted at least once every 6 months. The occupants of the building, other than building service employees, shall not be required to leave the floor or use the exits during the drill.

[21] According to Bracco 1969, all passenger elevators were capable of being recalled to their respective lobbies using manual controls. The control over-rides all individual floor hall calls, preventing manual or heat activation from calling a car to a "fire floor" and makes the car available for manual operation by the Fire Department. This arrangement is similar to requirements for emergency operation added by LL 5/1973, to which the elevators were retrofit later.

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Chapter 9
SPECIAL FEATURES

9.1 EMERGENCY POWER SYSTEMS

No requirement per Building Code of the City of New York (BCNYC).

9.2 PUBLIC GARAGES

A public garage used exclusively for parking of vehicles having fuel storage tanks of 26 gal capacity or less is classified in storage Occupancy Group B-2 (C26-709.2(b)).

All floors shall be concrete or equivalent noncombustible material and columns shall be protected from vehicle impact or designed to resist lateral forces in accordance with Section C26-902.4 (C26-709.3).

Public garages shall be ventilated in accordance with Section C26-709.7.

Ramps serving as required exits shall be enclosed in 2 h fire resistance rated construction with vehicle openings at each parking tier protected by a 3 gpm per linear foot deluge type sprinkler water curtain (C26-709.9).

9.3 SMOKE AND HEAT VENTING[22]

Elevator and dumbwaiter shafts shall be in accordance with RS 18-1.

Other closed shafts shall be as follows:[23]

1. All closed shafts having an area exceeding 4 ft^2 shall be provided with a smoke vent having an area of at least 3½ percent of the maximum shaft area at any floor but not less than ½ ft^2 (C26-504.6(d)).

2. Smoke vents may be windows, louvers, skylights, vent ducts or similar devices (C26-504.6(d)).

3. Vent ducts shall be enclosed by construction having the same fire resistance rating as required for the shaft and extend vertically, diagonally, or horizontally in accordance with Sec. C26-504.6(d)(1)(2).

[22] A Port Authority fire safety report contained in Appendix A of NIST NCSTAR 1-1H indicates that a smoke purge configuration (not yet required by BCNYC) for the heating, ventilating, and air conditioning system was installed. Requirements for smoke purge systems were adopted in LL 16-1984.

[23] The original design omitted vents from closed shafts (Solomon 1975).

4. Of the total required vent area for shafts at least 1/3 shall be clear to the outdoors either in the form of fixed louvers, ridge vents, or hooded or goose-necked openings (C26-504.6(e)).

5. As an alternate, skylights or trap doors may be arranged to open automatically by fusible link or other mechanical device when subjected to 160 °F fixed temperature or 15-20 °F per min temperature rise (C26-504.6(e)).

6. The remaining portion of the required vent area may be a window or skylight glazed with plain glass not more than 1/8 in. thick or slow burning plastic (C26-504.6(e)).

Machine Rooms.

1. Any compartment containing machinery that communicates with a shaft enclosure shall comply with all requirements for shafts (C26-504.6(f)).

2. The required louver or glazing shall not be located in any door leading into such compartment (C26-504.6(f).

Chapter 10
REFERENCES

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Section II
Fire Protection Summary for World Trade Center 7

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EXECUTIVE SUMMARY

As part of the analysis of building and fire codes and standards of the National Institute of Standards and Technology (NIST) World Trade Center (WTC) Investigation, this report supports the effort to determine the minimum construction requirements used in the design of WTC 7. The purpose of this report is to summarize the fire protection (both passive and active) and life safety provisions used to design and construct WTC 7.

Although the Port Authority of New York and New Jersey (PANYNJ or Port Authority) was not subject to the Building Code of the City of New York (BCNYC), WTC 7 was intended to be designed in accordance with the BCNYC and all applicable reference standards. Based on citations in the construction documents, the 1968 BCNYC, including amendments to January 1, 1985, appears to have been used for the design and construction provisions of WTC 7.

The BCNYC, building characteristics, and early design choices were used to determine the minimum construction requirements for the design of WTC 7. Because the BCNYC contains requirements for various types of buildings, it is crucial to identify applicable building requirements early in the design. By identifying specific building characteristics, a designer is able to determine which requirements must be complied with and which requirements are not applicable.

The building summaries in Table E–1 were used to classify the building and determine the minimum requirements of the BCNYC. Based on the height, area, primary occupancy classification, and installation of a fire sprinkler and standpipe system, the minimum construction type (permitted by the BCNYC) was type I-C (2 h protected). However, some documentation, including some building drawings and specifications for bidders on the contract for fireproofing the structural steel, indicate a type 1-B (3 h) classification. No documents were found containing measured thicknesses of fireproofing which might settle this difference. Fire resistance ratings for the structural components, fire divisions, and fire separations were based on this classification. In this report, type 1-C is assumed, but the possibility exists that the actual classification might have been 1-B. Many of the means of egress, fire suppression, and fire alarm requirements were also based on the building summaries of Table E–1. An abbreviated list of the fire protection requirements is as follows. A complete list of the requirements is identified in the main body text of this report.

- Standpipes were required.
- A complete automatic sprinkler system was required.
- A Class E fire alarm and communication system was required.
- A telephone and signaling system was required for fire department use in operating the standpipe system.
- Detectors were required in certain locations of the building and the heating, ventilating, and air conditioning system.

- Manual fire alarm boxes were required.
- Audible/visual devices were required.
- Exit signs and emergency lighting were required in selected spaces.
- An emergency power system was required.
- Smoke and heat venting was required in selected spaces.
- A smoke purge system was required.
- Stair pressurization was not directly required but could be used as an alternative to eliminate smoke and heat venting requirements.

Table E–1. Building characteristics used to determine BCNYC requirements.

Building	Height	Number of Floors Above Grade	Footprint	Primary Occupancy Classification
WTC 7	618 ft	47	48,000 ft^2	Group E (Business)

Source: PANYNJ.

Chapter 11
INTRODUCTION

11.1 PURPOSE

The purpose of this report is to summarize the fire protection (passive and active) and life safety provisions used to design and construct World Trade Center (WTC) 7.

11.2 INTRODUCTION

The regulation of building construction is a direct result of the recognition that life safety is served by the best available knowledge and practice. Codes and standards are created to establish minimum requirements. Model codes have been published throughout the United States since 1905 (Boring 1981). Through the use of technology improvements and as a result of serious incidents, such as fires, codes are developed and later revised to continually implement increased knowledge. Establishing reference standards is just as important as establishing codes. Reference standards act as a technical basis of the code and provide methods of testing, installation and maintenance. Municipalities can adopt model building codes and national standards or develop their own. Alternatively, many municipalities throughout the United States have adopted model building codes and national standards, and then amend portions as deemed necessary. New York City, however, developed their own building code and provided a technical basis with a mixture of nationally recognized standards (National Fire Protection Association, ASTM International, American National Standards Institute, etc.) and New York City developed reference standards (denoted by RS ##).

In accordance with the instructions issued by the Port Authority of New York and New Jersey (PANYNJ or Port Authority) at the start of the project, construction drawings for the WTC were to conform with the requirements of the Building Code of the City of New York (BCNYC), although as a so-called state compact under the U.S. Constitution, it was exempt from state or local laws, including the BCNYC. Based on citations in the construction documents, the 1968 edition of BCNYC, including amendments to January 1, 1985,[24] has been used for citing the design and construction requirements for WTC 7. The applicable provisions of the BCNYC given throughout this report are denoted by C26-###.

As stated previously, it was the policy of the Port Authority to follow the requirements of the BCNYC. Where documentation was identified, illustrating either conformance or deviation from the BCNYC provision, a reference has been provided. This report does not evaluate whether or not the design provisions were actually incorporated in the design of WTC 7, but merely identifies the provisions used in the design.

[24] The year is an assumption based on the years of building construction and a reference to the 1983 edition of NFPA 13 located on sprinkler drawing PFP-1 of the construction documents.

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Chapter 12
GENERAL

12.1 APPLICABLE CODES AND STANDARDS

1. Building Code of the City of New York, 1968 including amendments to January 1, 1985.[25, 26]
2. Local Law No. 5, Fire Safety Requirements and Controls, January 18, 1973.[27]
3. Local Law No. 16, March 27, 1984.[28]
4. American National Standards Institute A17.1 – Safety Code for Elevators and Escalators and Supplement A17.1-85a, 1984 (as modified by Reference Standards (RS) 18).
5. National Fire Protection Association (NFPA) 13 – Standard for the Installation of Sprinkler System, 1983 (as modified by RS 17-2).
6. NFPA 22 – Standard for Water Tanks for Private Fire Protection, 1981.
7. NFPA 72A – Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm and Supervisory Service, 1979 (as modified by RS 17).
8. NFPA 72B – Standard for the Installation, Maintenance and Use of Auxiliary, Protective Signaling Systems for Fire Alarm Service, 1982 (as modified by RS 17).
9. NFPA 72C – Standard for the Installation, Maintenance and Use of Remote Station Protective Signaling Systems for Fire Alarm and Supervisory Service, 1982 (as modified by RS 17).
10. NFPA 72D – Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems, 1979 (as modified by RS 17).
11. NFPA 72E – Standard on Automatic Fire Detectors, 1978 (as modified by RS 17).
12. NFPA 80 – Installation of Fire Doors and Windows, 1979 (RS 5-8).

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[25] Including the Building Code Reference Standards that modify national standards as deemed necessary. This edition of the BCNYC includes Local Laws No. 5 and No. 16.

[26] See footnote 1.

[27] According to Syska 1984d, the building was completely sprinklered and provided with a standpipe system, Class E fire alarm system (with voice communication), manual pull stations and smoke detection systems to comply with Local Law No. 5.

[28] According to Syska 1984a, the building was designed in compliance with Local Law No. 16.

13. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilating Systems, 1981 (as modified by RS 13-1).

14. NFPA 204 – Guide for Smoke and Heat Venting, 1968 (RS 5-11).

15. ASTM International (ASTM) E 84 – Standard Method of Test for Surface Burning Characteristics of Building Materials, 1961 (as modified by RS 3-2).

16. ASTM E 119 – Standard Methods of Fire Tests of Building Construction and Materials, 1961 (as modified by RS 3-1).

17. RS 5-15 – Minimum Covering of Pre-stressing Steel for Various Fire Resistance Ratings.

18. RS 5-17 – Standards for the Installation of Smoke Shafts.

19. RS 5-18 – Standard for the Pressurization of Stairs.

20. RS 17-1 – Standpipe System Construction.

21. RS 17-3 – Standards for the Installation of Fire, Sprinklers, Standpipe Smoke Detection…and other Alarm and Extinguishing Systems.

22. RS 17-3A – Standards for the Installation of Class E Fire Alarm Signal Systems.

23. RS 17-3B – Standards for the Installation of Modified Class E Fire Alarm Signal Systems.

12.2 BUILDING SUMMARY

Table 12–1. Building characteristics used for design development.

Building[29]	Height	Number of Floors Above Grade	Footprint	Construction Type (1968 BCNYC)	Primary Occupancy Classification
WTC 7	618 ft	47	48,000 ft^2	I-C (but some documents cite 1-B)	Group E (Business)

Source: PANYNJ.

[29] This building is located inside the Borough of Manhattan Fire District without additional restrictions imposed based on its use and occupancy (C26-402.1, C26-403.1).

Chapter 13
CONSTRUCTION

13.1 CONSTRUCTION CLASSIFICATION

The minimum construction type permitted for the building was I-C (2 h protected).[30]

13.2 BUILDING LIMITATIONS

In accordance with Table 4–2 of the Building Code of the City of New York (BCNYC) the height and area are not limited for a sprinklered Class I-C construction building housing a Group E occupancy.

- Height – No Limit
- Area – No Limit

13.3 SECONDARY/ACCESSORY OCCUPANCIES

Occupancy	Fire Index
B-1, Storage (moderate hazard)	3
B-2, Storage (low hazard, garage)	2
C, Mercantile	2
F-4, Assembly (restaurant)	1

13.4 FIRE RESISTANCE RATINGS

The minimum required fire resistance ratings listed as follows are in accordance with Table 3–4 of the BCNYC, unless noted otherwise. The fire resistance ratings are based on the test procedures of reference standard RS 3-1.

[30] All BCNYC requirements identified herein, which are dependent upon construction class, are given for Class I-C.

	Fire Resistance Rating (Hours)
1. Exterior bearing walls	2
2. Exterior non-bearing walls having an exterior separation of:[31]	
3 ft or less with 0 percent openings	2
Greater than 3 ft to less than 15 ft with ½ percent protected openings	2
15 ft to less than 30 ft with 3½ percent openings	1
30 ft or greater with unlimited openings	NC[32]
3. Interior walls:	
Walls and partitions (structurally bearing)	2
Corridors (C26-604.2(h))	1
4. Enclosure of vertical exits[33], exit passageways, hoistways and shafts	2
5. Columns, girders, trusses (other than roof trusses) and framing:	
Supporting one floor	1½
Supporting more than one floor or a floor and roof	2

[31] When two or more buildings are constructed on the same lot and the combined floor area of the buildings does not exceed the limits established by Tables 4–1 and 4–2 for any one of the buildings, no fire resistance rating shall be required for non-bearing portions of the exterior walls of those buildings facing each other, and there shall be no limitation on the permitted amount of exterior openings.

[32] Noncombustible.

[33] See Sections C26-504.6 and 26-604.8(i) for exceptions to shaft and stair enclosures requirements.

		Fire Resistance Rating (Hours)
6.	Structural members supporting a wall	Same as required fire resistance of wall supported, but not less than rating required for member by the class of construction.
7.	Floor construction including beams	1½
8.	Roof construction - Including beams, trusses, framing, arches, domes, cable supported roofs and roof decks – above floor to lowest member:	
	15 ft or less	1[34]
	15 ft to 20 ft	1[34]
	20 ft or more	1[35] or 0[36]

The minimum covering of prestressing steel shall comply with the requirements of RS 5-15 (C26-502.2(d).

[34] Materials which are not noncombustible, as defined in article 2 of the BCNYC, may be used in non-bearing construction elements if they fall into one of the following categories:

a. Materials having a structural base of noncombustible material as defined in article 2, and having a surface not over 1/8 in. thick which when tested in accordance with the provisions of reference standard RS 3-2 have a flame spread rating not higher than 50.

b. Materials which when tested in accordance with the provisions of reference standard RS 3-2 have a surface flame spread rating not higher than 25 without evidence of continued progressive combustion, and which are of such composition that surfaces which would be exposed by cutting through the material in any way would not have a flame spread rating higher than 25 without evidence of continued progressive combustion.

[35] Applies to occupancy groups: A, B-1, B-2, and D-1. See also footnote 34.

[36] Applies to all occupancy groups other than those indicated in footnote 35. Fire retardant treated wood complying with the requirements of Section C26-502.6 may be used. See also footnote 34.

13.5 OPENING PROTECTION

	Fire Resistance Rating (Hours)
1. Openings in a 3 h rated Fire Division or Fire Separation wall (C26-504.4 and Table 5–3).	3 (Class A)
2. Openings in 2 h or 1½ h rated Fire Division or Fire Separation wall or vertical communication enclosure (C26-504.4, C26-604.4(a), C26-1800.6 and Table 5–3).	1½ (Class B)
3. Openings in 1 h rated Fire Division or Fire Separation walls, corridors or partitions (C26-504.4, C26-604.4(b) and Table 5–3).	¾ (Class B)
4. Openings in 1 h rated vertical communication enclosure.	1 (Class B)
5. Required protected openings in exterior walls (Class E or Class F) (C26-503.1(b)).	¾

Noncombustible mail slots not exceeding 40 $in.^2$ may be provided in corridor doors (C26-604.4(b)).

Noncombustible louvers may be installed in corridor doors opening into toilets, service sink closets, and electrical closets (C26-604.4(b)).

Openings in Fire Divisions and Fire Separations should not exceed the size limits as follows (C26-504.4(a)):

1. In buildings that are not sprinklered no opening through a fire division or a fire separation shall exceed 120 ft^2 in area, with no dimension greater than 12 ft, and the aggregate width of all openings at any level shall not exceed 25 percent of the length of the wall.

2. Where the areas on both sides of a fire division or fire separation are sprinklered in accordance with the construction provisions of article 17, the size of the opening may be 150 ft^2 in area, with no dimension greater than 15 ft.

3. In buildings fully sprinkled in compliance with the provisions of article 17, the size and aggregate width of openings through the fire divisions or fire separations shall be unlimited.

4. When a fire division or fire separation serves as a horizontal exit also, it shall have no opening other than door openings not exceeding 56 ft^2 in area, the aggregate width of all openings at any level shall not exceed 25 percent of the length of the wall.

In shafts that contain only one opening below the roof, no opening protective is required (C26-504.6(c)).

Exterior street floor exit doors with a fire separation distance of more than 15 ft need not have a fire resistance rating (C26-604.4(a)(1)).

Openings in elevator and dumbwaiter shafts shall comply with RS 18 (C26-504.6(c)).

13.6 SEPARATION OF OCCUPANCIES

	Fire Resistance Rating (Hours)
1. Fire Divisions	
Between Group B-1 and B-2, C, E or F-4.	3
2. Fire Separations	
Between Groups E and B-2, C or F-4.	NR[37, 38]
Between tenant spaces (C26-504.3(a)).	1

Separate Building (Building Section) – Spaces classified in occupancy groups having a higher fire index than the occupancy group classification of the building shall be separated by "Fire Divisions" constructed in accordance with Section C26-504.1(a) and treated as separate buildings (C26-301.4(a)).

Separate Spaces – Spaces classified in occupancy groups having the same or lower fire index than the occupancy group classification of the building shall be separated by "Fire Separations" constructed in accordance with Section C26-504.1(b) (C26-301.4(b)).

Multiple occupancy or use – When a building or space is used for multiple purposes at different times, the building/space shall be given a separate occupancy group classification for each of the activities. The design and construction shall be in accordance with the most restrictive provisions that apply to any of the classifications (C26-301.6).

A minor variation of occupancy or use of a space is acceptable without multiple classifications if the variation is normally associated with the occupancy classification and no specific danger or hazard is created (C26-301.6).

Fire divisions shall be constructed of noncombustible materials or assembly of noncombustible materials to provide the fire-resistance ratings (C26-504.2). The following requirements apply:

1. Vertical fire divisions shall be continuous between foundation, roof, or horizontal fire divisions, and through any concealed space in floor or roof construction.

[37] No requirement.

[38] Separations are not required between accessory business and mercantile activities limited in area to 100 ft^2, and closets 75 ft^2 or less in area (Table 5–1 notes b and c).

2. Horizontal fire divisions shall be continuous between exterior walls and/or vertical fire divisions.

3. Fire divisions shall be made smoketight at their junction with exterior walls.

4. Fire divisions may be offset if the construction between the offset divisions, including their supports, has the same fire-resistance rating as the fire division, with all hollow spaces within the construction firestopped with noncombustible material.

5. Where combustible members such as joists, beams, or girders bear on, or frame into, vertical fire divisions, such members shall not extend through the wall and shall have at least 4 in. of solid noncombustible material below, at the sides, and at the ends of each such member.

6. Chases or recesses shall not be cut into fire divisions so as to reduce their thickness below that required for the fire-resistance rating.

7. Vertical fire divisions that are hollow shall be firestopped with at least 4 in. of noncombustible material so as to prevent passage of flame, smoke, or hot gases through the hollow spaces to the story above or below, or to hollow spaces within connecting floor or roof construction.

13.7 COMPARTMENTATION

All new buildings classified in occupancy group E (Business) having air-conditioning and/or mechanical ventilation systems that serve more than the floor on which the equipment is located, and unsprinklered floor areas[39] more than 40 ft above curb level, shall be subdivided by fire separations into spaces or compartments as indicated below (C26-504.1):

1. All unsprinklered floor areas shall be segregated by 1 h fire separations into spaces or compartments not to exceed 7,500 ft^2.

2. Where the floor area exceeds 10,000 ft^2, at least one of the subdividing fire separations shall be of 2 h construction, creating areas of refuge, complying with section C26-604.5 except that the requirement for an elevator in each area shall not apply.

3. The floor area or any subdivided area may be increased to not more than 15,000 ft^2 if complete area protection by approved devices for the detection of products of combustion other than heat is provided within such increased area and provided further that at least one of the subdividing fire separations shall be of 2 h construction where the floor area exceeds 15,000 ft^2, creating areas of refuge complying with C26-604.5 as noted in 2 above. The activation of the detectors shall have the same effect as section C26-1704.5(f).

4. Compartmentation is not required when complete sprinkler protection is provided.

[39] The floor area shall be defined as the area within exterior walls and excluding any areas enclosing stairs, corridors, elevators, and shafts. (C26-504.1)

13.8 FIRESTOPPING

All firestopping or fill materials shall consist of approved noncombustible materials that can be shaped, fitted and permanently secured in place (C26-504.7(a)).

Concealed spaces within partitions, walls, floors, roofs, stairs, furring, pipe spaces, column enclosures, etc. that would permit passage of flame, smoke, fumes or hot gases from floor to floor shall be firestopped or filled with noncombustible material in the following locations (C26-504.7):

1. Hollow partitions and furred spaces.
2. Concealed spaces within stair construction.
3. Ceiling spaces.
4. Exterior cornices.
5. Duct and pipe spaces (C26-504.5 and RS 13-1 Sec. 313 and 314).
6. Hollow spaces where combustible trim and finish is permitted.
7. Hollow vertical Fire Division (C26-504.2(i)).

The concealed space above a fire resistance rated ceiling shall be firestopped into areas not exceeding 3,000 ft^2, except where (C26-502.5):

1. Structural members within the concealed space are individually protected, or
2. The concealed space is sprinklered.

Firestopping shall not be required where (C26-502.5(a)(1)):

1. The structural members within the concealed space are individually protected with materials having the required fire resistance rating.
2. The ceiling is not an essential part of the fire resistive assembly
3. A concealed space is sprinklered in accordance with the construction requirements of article 17.

13.9 THROUGH PENETRATION PROTECTION

Noncombustible pipes and conduits may pass through fire rated construction provided the following (C26-504.5(b)):

1. Space between the pipe or conduit and its sleeve or opening does not exceed 2 in. and is packed with noncombustible material.

2. Close-fitting metal escutcheons are provided on both sides of the construction.

3. Aggregate net area of openings does not exceed 25 $in.^2$ in any 100 ft^2 of wall or floor area. Openings in excess of this limit are not permitted unless tested as part of a rated assembly and so protected.

Ceilings required to have a fire resistance rating may be pierced to accommodate noncombustible electric outlet boxes, recessed lighting fixtures, pipes and ducts as follows (C26-502.5(b)):

1. The aggregate area of outlet boxes and lighting fixtures does not exceed 16 $in.^2$ in each 90 ft^2 of ceiling area.

2. Outlet boxes and lighting fixtures are constructed of steel at least 0.022 in. thick and sealed tightly at the ceiling.

3. Additional or larger services are permitted only when tested as part of the assembly and protected as provided in the test.

The concealed space above fire rated ceilings may be used as a return air plenum if listed (tested) for that purpose provided (RS 13-1 Sec. 316):

1. All openings are tested as part of the assembly and protected in the test,

2. The integrity of firestopping is not destroyed,

3. No combustible materials are incorporated in the floor and ceiling construction, and

4. Electrical wiring is plenum rated (NFPA 70 Sec. 300-22).

13.10 FIRE AND SMOKE DAMPERS

Fire dampers shall be provided in accordance with RS 13-1 in the following locations (C26-504.5(a)):

1. Duct penetrations of walls with a 2 h fire resistance rating or greater (RS 13-1 Sec. 902(a)).

2. Each opening in required vertical shaft enclosures (RS 13-1 Sec. 902(b)).

3. Each outlet or inlet opening in vertical shaft enclosure of duct systems serving two or more floors (RS 13-1 Sec. 902(c)).

4. As an alternate, dampers may be provided at each point where the vertical duct pierces a floor it serves (RS 13-1 Sec. 902(c)).

5. Branch duct penetrations of vertical duct shaft enclosures (RS 13-1 Sec. 902(c)).

6. Fresh air intakes (RS 13-1 Sec. 902(e)).

7. Aluminum Class I duct penetrations of fire resistance rated floors (RS 13-1 Sec. 902(d)).

Fire dampers are not required at the following locations (RS 13-1 Sec. 903):

1. Non-aluminum or Class I vertical shaft branch duct penetrations with a cross-sectional area of less than 20 in.^{2} which supply only air conditioning units discharging air at not over 4 ft above the floor (RS 13-1 Sec. 903(a)).

2. Non-aluminum or Class 1 duct penetrations of a floor (at one place only) with a cross-sectional area of less than 20 in.^{2} which supply air conditioning units in one story only that discharge air at not over 4 ft above the floor (RS 13-1 Sec. 903(b)).

3. Duct penetrations in systems serving only one floor and used only for exhaust to the outside and not penetrating a fire wall or fire partition or passing entirely through the vertical shaft enclosure (RS 13-1 Sec. 903(d)).

4. Branch ducts connected to a return riser where subducts are extended at least 22 in. upward (RS 13-1 Sec. 903(e)).

Fire dampers should be automatic closing 1½ h fire rated with a fusible link or other heat actuated device rated approximately 50 °F above the maximum system operating temperature (RS 13-1 Sec. 905(a)(g)).

Duct openings permitted in fire resistance rated ceilings shall be protected with fire dampers (C26-502.5(b)).

Smoke dampers shall be installed in the main supply duct and the main return duct in systems over 15,000 cfm capacity (RS 13-1 Sec. 1003).

Smoke dampers shall be arranged to close automatically when the system is not in operation, by the operation of duct smoke detectors, and by the manual emergency fan stop (RS 13-1 Sec. 1003).

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Chapter 14
INTERIOR FINISH

14.1 INTERIOR FINISH FLAME SPREAD RATINGS

The minimum interior finish flame spread ratings below are based on Table 5–4 of the Building Code of the City of New York (BCNYC) and other sections as noted.

	Classification
1. Exits and shafts (C26-504.10(c), C26-604.8(i)(3))	Class A (0-25)
2. Corridors (C26-504.10(c), C26-604.2(k)): [40, 41]	
Group B-1	Class A (0-25)
Groups B-2, C, E, F-4	Class A or B (0-75)
3. Rooms greater than 1,500 ft^2 (C26-504.10(c)):	
Groups B-1, B-2, F-4	Class A or B (0-75)
Group E	Class A, B or C (0-225)
4. Rooms less than 1,500 ft^2 (C26-504.10(c)):	
Groups B-1, B-2, E, F-4	Class A, B or C (0-225)
5. Interior finish in kitchens, cooking spaces, pantries, repair and maintenance shops, boiler rooms and incinerator combustion rooms (Table 5–4 note f).	Class A or B (0-75)

[40] When used in corridors, Class B finish material should not extend more than 50 ft between separations of Class A finish material that are at least 2 ft wide (Table 5–4 note b).

[41] Spaces through which it is necessary for occupants of an adjacent room to pass in order to reach the only exit are considered as corridors.

14.2 SMOKE DEVELOPED RATINGS

Twenty-five or less in exits and corridors (C26-504.10(d)).

One hundred or less in rooms where the net floor area per occupant is 10 ft^2 or less (C26-504.10(d)).

No material shall be used in any interior location that upon exposure to fire will produce products that are more toxic in point of concentration than those given off by wood or paper (C26-504.10(e)).

14.3 INTERIOR TRIM

Up to 20 percent of the aggregate wall and ceiling area of any room or corridor may be finished with Class A, B, or C (0-225) materials and be exempt from the smoke developed rating requirements (C26-504.10(c)(4), C26-504.10(d)). This allowance shall include the area of doors, folding partitions, windows, glazing, skylights, luminous ceilings, trim, bases, chair rails, panels, moldings, etc.

14.4 FLOOR FINISH

Finish flooring in all exits shall be of noncombustible material (C26-504.13, C26-604.8(h)).

In all other areas, combustible finish flooring may be used when installed in accordance with Section C26-504.13(b).

Chapter 15
MEANS OF EGRESS

15.1 GENERAL

Clear width measurement is the net, unobstructed width of a means of egress without projections in such width (C26-604.2(a), C26-604.3(b)):

1. In corridors, projections up to 18 in. wide to the extent of 2 in. per unit of egress width are permitted if the total area of such projections does not exceed 5 percent of the area of the wall on which they occur (C26-604.2(a)).

2. Handrails shall project not more than 3½ in. and stringers 2 in. (each side) into the required stair width (C26-604.8(b), C26-604.8(f)).

Headroom (C26-604.2(b), 604.3(c)):

1. Corridor and exit passageway minimum height of 7 ft 6 in. for 75 percent of the floor area with no point less than 7 ft.

2. Projections from the ceiling shall be at least 7 ft above the floor and located so as not to obstruct full view of exit signs (C26-604.2(b), 604.3(c)).

Changes in level requiring less than two risers in a corridor or exit passageway shall be by a ramp (C26-604.2(e), C26-604.8(d)(2)).

Obstructions to means of egress:

1. The required width of a means of egress shall not be obstructed or reduced in any manner (C26-604.2).

2. Corridors shall be kept free of combustible contents (C26-604.2).

3. All exterior means of egress elements, including exterior corridors and stairs, shall be maintained free of ice and snow accumulation (C26-604.2, C26-604.9).

Corridors may be used as supply or return air ducts or plenums if equipped with an approved smoke detector or thermostatic device to shutdown fans (C26-604.2(j), Reference Standard [RS] 13-1 Sec. 316(d)).

Stairways connecting two or more stories shall not be used as plenums (RS 13-1 Sec. 316(e)).

15.2 EXITS

Every floor area shall be provided with at least two approved independent exits (C26-603.2).

A minimum of two exits or exit access doors shall be provided from every room or space in which the occupant load exceeds the following limits (C26-603.1):

Occupancy	Load
B (Storage)	50
C (Mercantile)	75
E (Business)	75
F (Assembly)	75

All required exits shall be located such that they are clearly visible, accessible and have unobstructed access at all times (C26-602.1).

In multi-tenant configurations, each tenant shall have access to the required numbers of exits without passing through other tenant spaces (C26-602.2).

Whenever more than one exit or exit access is required from any room, space or floor of a building, they shall be located as remote from each other as practicable (C26-602.3). The minimum distance between such doors shall be the greater of 30 ft or be one-third the maximum travel distance of the floor, provided, however, that where such distance will result in travel distances exceeding those authorized in section C26-601.1, additional vertical exits shall be provided (C26-602.3).

All vertical exits shall extend in a continuous enclosure to discharge directly to an exterior space or at a yard, court, exit passageway or street floor lobby of the required width and size to provide all occupants with a safe access to an open exterior space. Where vertical exits serving floors above grade continue in the same enclosure to serve floors below grade, the portion of such vertical exits above grade shall be separated from the portion below grade by construction having at least a 1 h fire resistance rating, with ¾ h self-closing doors opening in the direction of exit travel from the floors below grade (C26-602.4).

A maximum of 50 percent of the required number of vertical exits is permitted to discharge through a single exit passageway (C26-604.3).

One hundred percent of the number of vertical exits may discharge through a street floor lobby if egress is provided in two different directions from discharge points to open exterior spaces remote from each other (C26-604.3(h)(1)).

The clear width of an exit passageway serving two or more vertical exits shall be equal to 75 percent of the width of all vertical exits it serves (C26-604.3(b)).

The width of street floor lobbies serving as exit passageways shall be increased to accommodate the occupant load of all communicating spaces on the lobby floor that exit through them (C26-604.3(h)(2)).

No openings other than exit doors are permitted in exit passageways (C26-604.3(f)).

Openings between street floor lobbies serving as exit passageways and elevators or communicating spaces and show windows protected in accordance with Section C26-604.3(h)(3) are permitted.

Street floor lobbies serving as exit passageways may be occupied by newsstands, candy and tobacco stands, information booths or similar occupancies if constructed of noncombustible materials, occupying not more than 5 percent of the net lobby floor area, and if not reducing the required clear width at any point (C26-604.3(h)(4)).

Horizontal and Supplemental Vertical Exits (C26-604.5 to C26-604.7):

1. The occupant load capacity for vertical exits may be reduced by 50 percent when one area of refuge is provided and by 66 percent when two or more areas of refuge are provided (C26-603.3).

2. At least 3 ft^2 per person of clear public space, or space occupied by the same tenant or owner, shall be provided within the area of refuge for the occupant load received in addition to its own occupant load (C26-604.5(b)).

3. Each area of refuge shall be provided with at least one vertical exit and when located above the 11th floor, the vertical exit should be supplemented by at least one elevator (C26-604.5(c)).

4. Access to an area of refuge, on the same floor, through a horizontal exit, may consist of doors, balconies, bridges, and tunnels (C26-604.6):

    a. Doors must swing in the direction of exit travel and be self-closing having a fire resistance rating of 1½ h. Where areas of refuge are provided on both sides of a horizontal exit, two door openings shall be provided, each swinging in opposite directions (C26-604.6(b)).

    b. Balconies, bridges and tunnels serving as horizontal exits shall comply with Section C26-604.6(c).

5. Access to an area of refuge on a floor nearer to the street, through a supplemental vertical exit, may consist of enclosed interior stairs, ramps, or escalators (C26-604.7):

    a. Supplemental vertical exits shall comply with the requirements for interior stairs, and serve no other purpose than to connect a floor area with an area of refuge with no openings in the enclosure other than exit doors (C26-604.7).

    b. Every supplemental vertical exit shall have a sign at the entrance stating EXIT TO AREA OF REFUGE ON _____ FLOOR (C26-604.7).

15.3 EXIT WIDTH AND CAPACITY

Occupant load – Calculated based on the net floor area in square feet divided by the occupant load factor (square foot per person) or the actual number of occupants for whom each occupied space is designed, whichever is greater (C26-601.2):

1. Non-simultaneous Occupancy – The occupant load of toilets, locker rooms, meeting rooms, storage rooms, employee cafeterias, and similar rooms or spaces that are not occupied at the same time as other rooms or spaces on the same floor may be omitted from the occupant load calculation of the floor on which they are located (C26-601.2(c)).

2. The occupant load of any space shall include the occupant load of all spaces that discharge through it in order to gain access to an exit (C26-601.2).

Occupancy	**Occupant Load Factor**
Business (offices)	100
Conference rooms (tables)	12
Conference rooms (chairs)	10
Dining spaces	12
Mercantile:	
1st floor/basement	25
All other floors	50
Assembly (fixed seats)	No. of seats
Waiting space (standing)	4
Garages/parking	250
Storage rooms	200
Mechanical rooms	200

Where vertical exits serve more than one floor, only the occupant load of each floor considered individually is used in computing the required capacity of exits at that floor, except where one floor is used by another as a means of egress (C26-601.1).

Exit capacity (width) shall not decrease in the direction of exit travel (C26-604.8).

The width of each means of egress component shall be that computed using the appropriate egress unit factor but not less than the minimum width prescribed for the component (C26-601.1, C26-601.3):

1. Where computations give fractional results, the next larger integral number of egress units or integral number plus ½ shall be used (C26-601.3).

2. A fraction less than ½ may be neglected when constituting less than 10 percent of the total required number of egress units.

When a floor area has access to areas of refuge that comply with the requirements of section C26-604.5, the number of persons for whom vertical exits are to be provided may be reduced to 50 percent of the occupant load of the floor area when one area of refuge is provided, and may be reduce to 33 1/3 percent of the floor area when two areas of refuge are provided (C26-603.3).

Egress capacity factors – capacity per egress unit (C26-601.1, C26-601.3):

1. One unit of egress width is equal to 22 in.

2. Doors to outdoors at grade:

    a. Occupancy Group B (Storage) – 75 persons per unit

    b. Occupancy Groups C (Mercantile), E (Business), and F (Assembly) – 100 persons per unit

3. Other exit and corridor doors:

    a. Occupancy Group B (Storage) – 60 persons per unit

    b. Occupancy Group C (Mercantile), E (Business), and F (Assembly) – 80 persons per unit

4. Stairs and escalators:

    a. Occupancy Group B (Storage) – 45 persons per unit

    b. Occupancy Groups C (Mercantile), E (Business), and F (Assembly) – 60 persons per unit

5. Ramps, corridors, exit passageways, horizontal exits:

    a. Occupancy Group B (Storage) – 75 persons per unit

    b. Occupancy Groups C (Mercantile), E (Business), and F (Assembly) – 100 persons per unit

    c. When ramp slope exceeds 1 in 10, the capacity shall be reduced by 25 percent (Table 6–1 note b).

Where a door is divided by mullions into two or more door openings, each opening should be measured separately in computing the number of egress units (Table 6–1 note m).

15.4 DOORS

Minimum nominal width shall be 32 in. except for corridor and exit door openings which shall be 36 in. (C26-604.4(e)):

1. Door jambs or stops and the door thickness when open shall not reduce the required width by more than 3 in. for each 22 in. of width (C26-604.4(e)).

2. In all cases where a door opening is divided by mullions into two or more door openings, the minimum nominal width of each such opening shall be 32 in. (C26-604.4(c)).

Maximum width of leaf (C26-604.4(e)) shall be 48 in.

Minimum height (C26-604.4(f)) shall be 6 ft 8 in.

Door jambs, stops, sills, and closers should not reduce the clear opening to less than 6 ft 6 in. (C26-604.4(f)).

The floor on both sides of all exit and corridor doors shall be substantially level and have the same elevation for a distance at least equal to the width of the leaf (C26-604.4(h)).

Where doors lead out of a building, the floor level inside may be 7½ in. higher than the level outside (C26-604.4(h)).

Exit doors, corridor doors serving high hazard occupancy Group A spaces, and corridor doors from rooms required to have more than one door shall swing in the direction of egress (C26-604.4(g)).

Vertically sliding doors, rolling shutters, and folding doors shall not be used as exit doors or as corridor doors (C26-604.4(d)).

Revolving doors designed and constructed in accordance with Section C26-604.4(m) are permitted to be used as exits except that revolving doors shall not be used as interior exit access doors, at the foot of stairs, or at the head of basement stairs (C26-604.4(d)).

Turnstiles designed and constructed in accordance with Section C26-604.4(n) may also be permitted.

Power operated or power assisted manually operated doors may be used as exit or corridor doors provided they remain closed in case of power failure and are manually operable. To be credited as a required exit, power operated doors must swing in the direction of exit travel (C26-604.4(l)).

Exit doors and corridor doors shall normally be kept in the closed position (C26-604.4(i)).

Latch bolts shall be provided on all exit doors and corridor doors to hold them in a closed position against the pressure of expanding gases (C26-604.4(j)(1)(c)).

Obstruction of means of egress during door opening:

1. Doors providing access to stairways or ramps shall not block stairs/ramps or stair landings or reduce the width of landings/stairs/ramps to less than 75 percent of the required width or to less than the width of the door opening on them (C26-604.8(g), C26-604.10(c)(4)).

2. No door shall swing over the sloping portion of a ramp (C26-604.8(c)(4)).

Exit and corridor doors and doors providing access to areas of refuge shall be readily openable at all times from the side from which egress is made without the use of a key (C26-604.4(j)(1)(a), C26-604.5(d)):

1. Locks may be used in places where extra safeguards are required (banks, museums, etc.), subject to approval of the commissioner, provided the locks are equipped with electrical release devices for remote control in case of emergency (C26-604.4(j)(1)(a)(2)).

2. Doors opening into interior enclosed stairs shall not be locked from either side except that doors may be locked to prevent access to the stair from the outside at the street floor (C26-604.4(j)(1)(b).

15.5 EXIT ACCESS

Minimum clear width of corridors:

1. Occupancy Groups B (Storage), C (Mercantile) – 36 in.

2. Occupancy Groups E (Business), F (Assembly) – 44 in.

The maximum length of exit access travel shall not exceed the following limits, measured from the most remote point in an area, to the center of an exit door. Travel distance shall be measured along the natural and unobstructed path of travel. Where the path of travel is over an access stair, it shall be measured along an inclined straight line through the center of the outer edge of each tread.

Occupancy	Distance (Feet)[42]
B-1 (Storage)	150
B-2 (Storage)	175
B-2 (Parking Garage)	150
C (Mercantile)	200
E (Business)	300
F (Assembly < 75 persons)	200

[42] Distances given are for sprinklered conditions (Table 6–1).

The maximum dead-end distance shall not exceed the following limits:

Occupancy	Distance (Feet)[43]
B-1 (Storage)	50
B-2 (Storage)	NR
C (Mercantile)	50
E (Business)	50
F (Assembly)	30

Exterior corridors designed and constructed in accordance with Section C26-604.2(f) may be used as a means of egress.

15.6 STAIRWAYS

Minimum clear width shall be at least 44 in. (C26-604.8(b)):

1. The width of stairs shall be the clear width between walls, grilles, guard, or newel posts. Stair stringer projections which do not exceed two in. on each side and handrail projections of 3½ in. are permitted.

2. Vertical exits in public garages may be 36 in. wide.

3. The minimum width of landings and platforms should be at least the required width of the stairway. On a straight run stair, landing and platform widths need not be more than 44 in.

Minimum headroom shall be at least 7 ft (C26-604.8(c)).

Maximum height between landings shall be 12 ft (C26-604.8(d)).

Treads and risers (C26-604.8(e), Table 6-4):

1. Maximum riser height – 7¾ in.

   a. Occupancy Group F (Assembly) – 7½ in.

   b. All others – 7¾ in.

2. Minimum tread depth – 9½ in. plus nosing

[43] Distances given are for unsprinklered conditions. When a corridor is completely enclosed in 2 h fire resistance rated construction with ½ h fire rated doors, the permissible length of dead ends may be increased by 100 percent (C26-604.2(d)).

3. The sum of two risers plus one tread exclusive of the nosing shall not be less than 24 nor more than 25½ in.

4. Stair riser and tread dimensions shall be constant in any flight of stairs from story to story.

Curving or skewed stairs that conform to Section C26-604.8(e)(4) are permitted to be used as exits.

Where exit stairways serving floors above grade continue in the same enclosure to serve floors below grade, the above and below grade portions shall be separated by 1 h fire resistance rated construction.

Stair identification signs shall be posted on the occupancy side of the stair door indicating the letter designation of the stair.

In buildings or in building sections more than three stories or 40 ft high with roofs having a slope of less than 20 degrees, access to the roof shall be provided by at least one interior stair. Access to set back roof areas may be through a door or window opening to the roof.

No openings of any kind are permitted into stair enclosures other than windows, fire department access panels and exit doors.

Exterior stairs designed and constructed in accordance with Section C26-604.9 may be used as exits in lieu of interior stairs.

No exterior stair shall exceed 75 ft or six stories in height.

Escalators designed and constructed in accordance with Section C26-604.11 may be used as exits in lieu of interior stairs.

15.7 RAMPS

The minimum clear width of exit ramps is 44 in. (C26-604.10, C26-604.8(b)).

Level platforms or landings at least as wide as the ramp shall be provided at the top and bottom of all ramps and at intermediate levels as necessary:

1. Level platforms shall be provided on each side of door openings into or from ramps.

2. Platforms shall be at least 3 ft wide, 5 ft when a door swings onto the platform.

Minimum headroom shall be 6 ft 8 in.

Changes in direction of travel shall be made only at landings (or platforms) (C26-604.10(c)).

Ramps with a slope not greater than 1 in 12 at any place may be curved.

Ramps shall not have a slope steeper than 1 in 8 and sloping portions shall be at least 3 ft but not more than 30 ft long between platforms or landings.

Level and ramped moving walkways designed and constructed in accordance with Section C26-604.12 may be used as exits.

15.8 HANDRAILS AND GUARDRAILS

Continuous handrails are required on both sides of all stairs, and all ramps with a slope exceeding 1 in 12:

1. Stairs less than 44 in. wide may have a handrail on one side only.
2. Intermediate handrails shall be provided to divide stairs more than 88 in. wide into widths that maintain nominal multiples of 22 in. and widths not greater than 88 in. nor less than 44 in.
3. Handrail height shall be 30 to 34 in. measured vertically above the nosing of treads.
4. Handrail ends shall be returned to walls and posts when terminated.
5. Handrails shall provide a finger clearance of 1½ in. and shall project not more than 3½ in. into the required stair width.

Stair landings and platforms shall be enclosed on sides by walls, grilles, or guards at least 3 ft height.

15.9 EXIT SIGNS

In all buildings, the location of every exit on every floor shall be clearly indicated by approved EXIT signs (C26-606.1).

EXIT signs shall be placed at an angle with the exit opening if such placement is required for the signs to serve their purpose.

In areas where the location of the exit may not be readily visible or understood (including long corridors and open floor areas), directional signs shall be provided to serve as guides from all portions of the corridor or floor.

The size, color and illumination of EXIT signs shall conform to Section C26-606.3. Directional signs shall conform to Section C26-606.4.

All EXIT signs shall be illuminated at all times when the building is occupied.

Where a total of more than four signs (exit and/or directional) are required, all EXIT signs shall be connected to circuits that are separate from the general lighting and power circuits. These circuits shall be taken off ahead of the main switch or connected to an emergency lighting power source when such source is provided.

Any door, passageway, stair, or other means of communication that is not an exit shall be so identified with a NOT AN EXIT sign and a sign indicating its use or purpose or a directional exit sign shall be provided.

15.10 MEANS OF EGRESS LIGHTING

Corridors and exits shall be equipped with artificial lighting facilities to provide at least 2 ft candle intensity floor lighting continuously during the time that conditions of occupancy of the building require that the exits be available (C26-605.1(a)).

Lighting shall be provided to illuminate changes in direction in and intersections of corridors, balconies, exit passageways, stairs, ramps, escalators, bridges, tunnels, landings, and platforms.

Illumination shall be arranged so that failure of any one light does not leave any area in darkness.

Where a total of more than four lights are required, exit lighting shall be connected to an emergency power source or to approved storage battery equipment (C26-605.2(a)).

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Chapter 16
FIRE SUPPRESSION

16.1 AUTOMATIC SPRINKLER PROTECTION

Automatic sprinkler protection shall be designed and installed in accordance with Section C26-1703.1 and Reference Standard (RS) 17-2 in the following areas:

1. Spaces in group B-1 > 500 ft^2.
2. Spaces in group B-1 < 500 ft^2 when required by the commissioner.
3. Spaces in group B-2 > 5,000 ft^2 or 75 ft in height.
4. Spaces in high-rise buildings classified as mercantile occupancy group C > 7,500 ft^2 in floor area or with an unenclosed stair or escalator between any two or more floors.
5. Showroom spaces exceeding 7,500 ft^2 in area located more than 40 ft above curb level in new and existing buildings classified in occupancy group E, 100 ft or more in height having air-conditioning and/or mechanical ventilation systems that serve more than the floor in which the equipment is located.
6. Regardless of occupancy, any story above grade and the 1st story below grade without required ventilation:
    a. All other stories below grade.
    b. Sprinklers may be omitted in toilets, shower rooms, stair, and mechanical and electrical rooms.
7. Catering establishments and banquet halls with an occupancy load of 300 or more persons.
8. Spaces in occupancy group F-4 located more than 75 ft above curb level.
9. Notwithstanding the requirement of other sections, new high rise buildings in occupancy group E (Business).

A wet-pipe sprinkler system should be provided throughout all areas requiring automatic sprinkler protection (C26-1703.13). In areas subject to freezing the sprinkler system shall be protected (insulation, heat trace, antifreeze) or a dry-pipe system shall be provided (C26-1703.13).

A sprinkler alarm system shall be provided in accordance with RS 17-2 and RS 17-3 or in accordance with RS 17-3A or RS 17-3B if a class E or modified class E fire alarm system is provided (C26-1703.4).

A sprinkler alarm system shall be provided when more than 36 heads are installed in any fire area or section.

16.2 STANDPIPES

Wet standpipes designed and installed in accordance with Section C26-1702.1 and RS 17-1 shall be provided (C26-1702.1(a)(1)).

The number and location of standpipes shall be such that every point of every floor can be reached by a 20 ft stream from a nozzle attached to not more than 125 ft of hose connected to a riser outlet valve (C26-1702.4):

1. Standpipe risers and 2½ in. hose valves shall be located within stairway enclosures (C26-1702.5(a)).

2. When stairway enclosures are not available within the 125 plus 20 ft distance (145 ft total), risers and valves shall be located as near to the enclosure as practicable (C26-1702.5(a)).

The highest riser shall be extended above the roof with a 3-way manifold with 2½ in. hose valves (C26-1702.11(a)(2)).

A 2½ in. hose outlet shall be provided at each standpipe riser on each floor served, and on the entrance floor above the riser control valve, located between 5 and 6 ft above the landing or floor (C26-1702.11(a)(1)).

Hose stations shall be located at the standpipe risers, either inside or adjacent to the entrance of stairway enclosures (C26-1702.11(b)):

1. Hose stations shall be located to satisfy the 125 plus 20 ft (145 ft total) requirement (C26-1702.11(b)(1)).

2. Hose shall be (C26-1702.11(c)):

   a. 1½ in. unlined (flax-line) linen hose in Groups C, E, and F.

   b. 2½ in. (unlined) in Group B.

3. Auxiliary hose stations equipped with 1½ inch (unlined) hose are permitted in Groups C, E, and F (C26-1702.11(c)(4), C26-1702.11(d)).

Standpipe systems that include more than one riser shall have all risers cross-connected at, or below, the street entrance floor level (C26-1702.10(a)).

Standpipe systems having more than one zone shall be arranged such that the risers supplied from each zone are cross-connected below, or in the story of the lowest hose outlets from the water source in each zone (C26-1702.10(b)).

Standpipe risers shall be at least 4 in. in diameter where the riser height is 150 ft or less from the highest hose outlet to the level of the entrance floor, 6 in. in diameter where greater than 150 ft (C26-1702.7, Table 17–1).

16.3 WATER SUPPLY

Standpipe systems shall have a primary water supply available at all times to every hose outlet or made available automatically when the hose valve at any outlet is opened (C26-1702.14).

Combinations of two or more of the following sources shall serve as the primary water supply (C26-1702.14(b)):

1. Direct connection to city water system.
2. Direct connection to a private yard main.
3. Gravity tank(s).
4. Pressure tank(s).
5. Automatic fire pump (C26-1702.14(b)(5)):
    a. In buildings higher than 300 ft, the automatic fire pump shall be used only for the lower 300 ft.
    b. Zones above 300 ft shall be supplied by either a gravity or pressure tank.
6. An additional standpipe system water supply shall be provided for standpipes in buildings over 300 ft high (C26-1702.15(a)). The primary water supply to the standpipe system should be supplemented by one or more manually operated fire pumps (C26-1702.15(a)).

At least one of the following automatic sources of water supply shall be provided for sprinklers (C26-1703.8(a):

1. Gravity tank(s).
2. Pressure tank(s).
3. Automatic fire pump.
4. Direct connection to public water system.

Domestic water supply may be used to supply cooling tower sprinklers and sprinklers installed in buildings classified in Occupancy Group E (Business) in accordance with Section C26-1703.9(e) (C26-1703.9 (c) and (d)).

Auxiliary sources of water supply for sprinkler systems may include a manually actuated fire pump or siamese connection (C26-1703.8(b)).

Combined Water Supplies:

1. Fire pumps may simultaneously serve as the required auxiliary water supply for standpipe and sprinkler systems in accordance with Section C26-1702.15(d).

2. Tanks used to provide the required primary water supply to a standpipe system may also be used as a supply for an automatic sprinkler system (C26-1703.8(c)).

One standpipe system and one sprinkler system siamese connection shall be provided for each 300 ft of exterior building wall or fraction thereof facing each street or public space (C26-1702.9(a), C26-1703.6(a)(1)):

1. Modifications based on street frontage as permitted by Sections C26-1702.9(b)-(f).

2. Each siamese connection shall be connected to a riser or to a cross connection connecting other siamese connections or risers (C26-1702.10(f)).

3. In below grade sprinkler systems for garage occupancies, a sprinkler siamese connection shall be provided within 50 ft of every exit or entrance used by motor vehicles (C26-1703.6(a)(2)).

4. Siamese connections for partial sprinkler systems shall be in accordance with Section C26-1703.6(a)(3).

Chapter 17
FIRE DETECTION AND ALARM

17.1 FIRE ALARM SYSTEM

New buildings classified in occupancy group E 75 ft or more in height and existing buildings in occupancy group E 100 or more ft in height are required to be provided with a Class E (or modified Class E) fire alarm and communication system including loud speakers, two-way voice, and a fire command station. (C26-1704.1(a)(9), C26-1704.4(g)(h), C26-1704.5(f)(g), C26-1704.8)

A sprinkler alarm system shall be provided when more than 36 heads are installed in any fire area or section (C26-1703.4).

A local water flow alarm unit shall be provided (outdoor water motor or electric alarm gongs) where there is no watchman with watch service (Reference Standard [RS] 17-2 Sec. 3721).

Central station water flow alarm service is desirable, but does not waive the local alarm requirement (RS 17-2 Sec. 3721).

17.2 SMOKE AND HEAT DETECTOR LOCATIONS

Heating, Ventilating, and Air Conditioning (HVAC) Systems (C26-1300.7(a), RS 13-1):

1. In HVAC systems over 2,000 cfm capacity, approved smoke detectors shall be provided for automatic fan shut-down in (RS 13-1 Sec. 4-3 and 4-4):

    a. The main supply duct on the downstream side of the filters.

    b. The return air stream, prior to exhausting from the building or being diluted by outside air.

        Exception 1: The smoke detector in the return air stream may be omitted in systems of less than 15,000 cfm capacity.

        Exception 2: Both detectors may be omitted provided that the system is less than 15,000 cfm capacity, the entire system is within the space served and such space is protected by an area smoke detection system.

2. In HVAC systems serving more than the floor on which the equipment is located, an approved product of combustion ionization detecting device or a combination of an approved smoke detecting device and an approved fixed temperature thermostatic device shall be located at the return shaft at each floor and so located as to monitor each inlet to the air return shaft (RS 13-1 Sec. 4-3.2(c)).

3. In HVAC systems utilizing recirculated air, smoke detectors shall be provided for automatic fan shut-down when any of the following conditions exists (RS 13-1 Sec. 4-5.4):

    a. System supplies an exit passageway, or a space leading from elevators to a street or to the exterior.

    b. System supplies spaces on more than one story or spaces in different fire areas in the same story.

    c. Where the area of a building or space served is over 15,000 ft^2 in mercantile or indoor assembly occupancies.

    d. Where there is a duct opening in a required 2 h fire resistance rated interior fire division.

    e. Where a duct passes through a firewall.

    f. Where a corridor is used as a plenum.

Specific occupancy requirements:

1. In a Class E fire alarm system, ceiling mounted ionization smoke detectors or combination smoke/heat detectors shall be installed at each elevator landing immediately above a call button (C26-1704.5(f)(8)). A building equipped throughout with an automatic sprinkler system including a water flow alarm shall be exempt from the installation of the detectors provided the water flow alarm has the same effect mentioned below (C26-1704.5(f)(10)).

2. The activation of a smoke detector in any elevator lobby shall only annunciate at the fire command station. The activation of both smoke detectors in any elevator lobby shall cause selected elevators to return non-stop to the designated level (RS 18-1, Rule 211.3b(6)(a and b)).

3. Activation of an elevator landing detector shall (C26-1704.5(f)(8)):

    a. Sound continuously throughout the floor of alarm and floor above.

    b. Sound fire alarm signal at the fire command station, mechanical control center and regularly assigned location of the fire safety director.

    c. Operate the information display system.

    d. Stop the air supply into and air return from the floor where activated by approved remote control reversible fire shutters or by automatically shutting down supply and return air fans.

    e. Activate air exhaust fans and dampers in smoke shafts and/or pressurizing fans in stair enclosures.

4. In addition to the smoke detector requirement, in a building equipped throughout with an automatic sprinkler system, a waterflow alarm when activated shall initiate Phase I emergency recall operation (RS 18-1, Rule 211.3).

17.3 MANUAL FIRE ALARM BOXES

The boxes shall be installed in accordance with NFPA 72.

At least one fire alarm sending station shall be provided in each story located in each path of escape with additional stations installed so that no point on any floor is more than 200 ft from the nearest station (RS 17-3A, Sec. 7(a)).

Operation of a manual station shall automatically transmit a fire alarm signal to the fire department via a central station and sound an alarm continuously on the floor where activated and the floor above (C26-1704.5(f)(4)).

Fire alarm (Class E) sending stations shall be painted red with a diagonal white stripe painted or applied to sending stations which transmit a fire alarm signal to the fire department via a central station (C26-1704.6(e)).

17.4 AUDIBLE/VISUAL ALARM NOTIFICATION APPLIANCES

In a Class E fire alarm system, loudspeakers capable of being operated from the fire command station should be provided on each floor, and in each elevator and stair enclosure (C26-1704.8(a)).

Loudspeakers shall be located so that their operation will be heard clearly above ambient noise (C26-1704.5(f)(5)).

The loudspeaker amplifier system shall be so designed and installed that approximately 50 percent of the system shall remain operable for the transmission and audibility of signal and intelligibility of voice communication over the loudspeaker system throughout the building, in the event the other 50 percent becomes inoperable (C26-1704.5(f)(7)).

Recessed speakers shall be located not more than 10 ft from the entrance to each required exit (RS 17-3A, Sec. 8(b)).

17.5 COMMUNICATION SYSTEMS

In every building more than 300 ft high, a telephone and signaling system shall be provided for fire department use in operating the standpipe system (C26-1702.21, C26-1704.7(a)).

Standpipe Telephone System:

1. System shall permit communication by permanent telephones in the following locations (C26-1704.7(b)):

    a. Pump rooms.

    b. Entrance floor.

    c. Gravity tank rooms.

d. Each floor near main standpipe riser.

2. The system shall be a selective ringing, common talking system supplied by a 24-volt direct current power source (C26-1704.7(b)).

3. Permanent wall telephones shall be provided with 6 inch gongs except in the pump room where a loud speaking receiver should be provided (C26-1704.7(c)).

4. The telephones in the pump room shall be equipped with a loudspeaking receiver so that a voice can be distinctly heard at a distance of at least 15 ft from the receiver.

5. Where portable phones are used, jacks protected by break-glass boxes shall be provided (C26-1704.7(c)):

   a. At least three portable phones shall be provided for each standpipe installation, kept in a dedicated, locked cabinet located in the main hall of the entrance floor (C26-1704.7(d)).

   b. A pilot light shall be provided over the cabinet to indicate if the system is in use or a receiver is off the hook (C26-1704.7(e)).

Standpipe Signaling Devices:

1. Manual, individually coded sending stations shall be located in the main corridor of the building arranged to transmit a signal to alarm sounding devices (C26-1704.7(f)(1)). System shall be installed in accordance with RS 17-3 (C26-1704.7(f), C26-1704.8).

2. An 8 inch gong shall be provided in the pump rooms and in elevator shafts at intervals not exceeding 10 floors (C26-1704.7(f)(1)).

3. Adjacent to each telephone station and near the main standpipe riser, a closed circuit strap key connected in series with the box circuit of the signal sending station shall be provided (C26-1704.7(f)(2)).

In a Class E fire alarm signal system, the standpipe fire line telephone and signaling system may be combined with the fire alarm system provided (C26-1704.7(g)):

1. The alarms and two-way voice communication with the fire command station include the pump and gravity tank rooms.

2. A designated floor station of the Class E system is located at or near the main standpipe riser on every floor.

A two-way communication capability shall be provided between the fire command station and the following locations (C26-1704.8(a)(2)):

1. A designated floor warden station on each floor.

2. Mechanical control center.

3. Elevators.

4. Air-handling control rooms.

5. Elevator machine rooms.

A floor warden station shall be located between required stairways, vertical exits or other exits (RS 17-3B 7.b):

1. System shall include a telephone type handset at the floor warden station with integral signaling to the fire command station.

2. Warden stations may be part the speaker system.

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Chapter 18
ELEVATORS AND HOISTWAYS

18.1 GENERAL

Elevators or escalators shall be provided in accordance with Section C26-1800.1 and RS 18-1 in all new buildings exceeding four stories in height (C26-604.1(a), C26-1800.6(d)):

1. When Areas of Refuge are provided above the 11th floor of a building, they shall be served by at least one elevator (C26-604.5(c)).

2. Escalators may be used as exits in lieu of interior stairs (C26-604.11 and C26-1800.6(g)).

In every building exceeding 175 ft in height, at least one elevator shall be kept available for immediate use by the fire department during all hours (C26-1702.22, C26-1800.8).

In buildings exceeding 150 ft in height, there shall be an operator available at all times (C26-1800.8).

Automatic passenger elevators shall be equipped with emergency controls for fire department use (Reference Standard [RS] 18-1 Rule 210.13):

1. A two-position keyed switch shall be provided at a main floor of each elevator or group of elevators for recall to the main floor in accordance with RS 18-1 Rule 210.13.a.

2. A keyed switch shall be provided in or adjacent to an operating panel of each elevator to initiate emergency service in accordance with RS 18-1 Rule 210.13.b.

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Chapter 19
EMERGENCY, ELECTRICAL, AND STANDBY POWER SYSTEMS

19.1 EMERGENCY POWER SYSTEMS

An emergency power system shall be provided in high-rise buildings in occupancy group E and have capacity to operate equipment such as (C26-610.1, C26-610.3):

1. Fire pumps.
2. At least three elevators at one time, with manual transfer to other elevators.
3. Alarm systems.
4. Communications systems.
5. Emergency lighting, if battery packs are not available.
6. Ventilating systems used for smoke venting or control.
7. Stair pressurization.

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Chapter 20
SPECIAL FEATURES

20.1 SMOKE AND HEAT VENTING

Elevator and dumbwaiter shafts shall be vented in accordance with Reference Standard (RS) 18-1.

Other closed shafts shall be vented as follows:

1. All closed shafts having an area exceeding 4 ft^2 shall be provided with a smoke vent having an area of at least 3½ percent of the maximum shaft area at any floor but not less than ½ ft^2 (C26-504.6(d)).

2. Smoke vents may be windows, louvers, skylights, vent ducts, or similar devices (C26-504.6(d)).

3. Vent ducts shall be enclosed by construction having the same fire resistance rating as required for the shaft and extend vertically, diagonally, or horizontally in accordance with Sections C26-504.6(d)(1 and 2).

4. Of the total required vent area for shafts at least one-third shall be clear to the outdoors either in the form of fixed louvers, ridge vents, or hooded or goose-necked openings (C26-504.6(e)).

5. As an alternate, skylights or trap doors may be used arranged to open automatically by fusible link or other mechanical device when subjected to 160 °F fixed temperature or 15 °F to 20 °F per min temperature rise (C26-504.6(e)).

6. The remaining portion of the required vent area may be a window or skylight glazed with plain glass not more than 1/8 in. thick or slow burning plastic (C26-504.6(e)).

Machine Rooms:

1. Any compartment containing machinery that communicates with a shaft enclosure shall comply with all requirements for shafts (C26-504.6(f)).

2. The required louver or glazing shall not be located in any door leading into such compartment (C26-504.6(f)).

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Chapter 21
INSPECTIONS

21.1 INSPECTION REQUIREMENTS

The following requirements shall apply to the inspection of all materials which, in their use, are regulated by the provisions of the code:

1. Controlled inspection – All such materials which are designated for "controlled inspection" under the provisions of the code shall be inspected and/or tested to verify compliance with code requirements. Unless otherwise provided by code provisions, all required inspection and test of materials designated for "controlled inspection" shall be made and witnessed by or under the direct supervision of an architect or engineer retained by or on behalf of the owner or lessee, who shall be, or shall be acceptable to, the architect or engineer who prepared or supervised the preparation of the plans; and the architect or engineer by whom, or under whose direct supervision, the required inspections and tests are made and witnessed shall file with the department signed copies of all required inspection and test reports, together with his signed statement that the material and its use or incorporation into the work comply with code requirements, unless the filing of such reports and statements is specifically waived by code provisions (C26-106.3(a)).

2. Semi-controlled inspection – All such materials that are not designated for controlled inspection under the provisions of the code shall be subject to semi-controlled inspection and, as such, shall be inspected and/or tested to verify compliance with code requirements by the person superintending the use of the material or its incorporation into the work, except that all required inspections and tests may, at the option of the owner or lessee, be made and witnessed by or under the direct supervision of any architect or engineer retained by or on behalf of the owner or lessee, who shall be, or shall be acceptable to, the architect or engineer who prepared or supervised the preparation of the plans. The person superintending the use of the material or its incorporation into the work, or the architect or engineer by or under whose direct supervision the required inspections and tests are made and witnessed, as the case may be, shall file with the department signed copies of all required inspection and test reports, together with his signed statement that the material and its use or incorporation into the work comply with code requirements, unless the filing of such reports and statement is specifically waived by code provisions (C26-106.3(b)).

3. Off-site inspection – In all cases where code provisions require that the inspection and/or test of materials be made off-site, or prior to actual use or incorporation into the work, the inspector shall mark or cause to be marked for identification all units (or packages of units) of the material inspected; and the reported results of such inspection shall state that the material was so marked for identification (C26-106.3(c)).

21.2 MATERIALS REQUIRING INSPECTION

The installation of all required sprayed-on fire protection of structural members except those encased in concrete shall be subject to the controlled inspection requirements (C26-502.2(f)).

The installation of all required firestopping shall be subject to the controlled inspection requirements (C26-504.7(h)).

Chapter 22
REFERENCES

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SECTION III
POST-CONSTRUCTION FIRE PROTECTION AND LIFE SAFETY PROVISIONS FOR WORLD TRADE CENTER 1, 2, AND 7

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EXECUTIVE SUMMARY

As part of the analysis of building and fire codes and standards of the National Institute of Standards and Technology (NIST) World Trade Center (WTC) Investigation, this report supports the effort to document the change in building code regulations that occurred after the construction of WTC 1, 2, and 7. The purpose of this report is to summarize the applicable fire protection (both passive and active) and life safety provisions that were adopted after the design and construction of the WTC 1, 2, and 7.

The WTC complex was a network of buildings constructed and maintained under the jurisdiction of the Port Authority of New York and New Jersey (PANYNJ). Facilities of the PANYNJ are not subject to the requirements of the local building codes, although the PANYNJ voluntarily followed the New York City codes where applicable. In accordance with the instructions issued by the Port Authority at the start of the WTC project, construction drawings for the WTC were to conform to the requirements of the Building Code of the City of New York (BCNYC).

The City of New York does not use a national model building code. Since the first published model building code in the United States in 1905, municipalities have been given the opportunity to adopt a model building code(s) or develop their own code(s). New York City has taken the approach to develop their own building code while incorporating technical and installation requirements by referencing nationally recognized standards (National Fire Protection Association, ASTM International, American National Standards Institute, etc.) and New York City developed reference standards (denoted by RS).

As time passed and experience was gained, the provisions of the BCNYC changed. Depending on the requirements of the changes in the BCNYC, new buildings (and some existing buildings) were required to meet the revised design and construction provisions. Generally, changes to the building code effect new buildings and only affect existing buildings when a major alteration or a change in occupancy occurs. However, some of the provisions of the BCNYC were made retroactive, thus, effecting existing buildings. The revised provisions in the BCNYC that were applicable to WTC 1, 2, and 7 are summarized in this report.

Determination of the applicable building provisions was a multi-step task. First, documentation, such as drawings, memorandums and New York City building regulations, were analyzed to identify the initial construction provisions at the times of construction of WTC 1, 2, and 7. Second, New York City building regulations, published since the times of construction, were analyzed to identify the new and amended building provisions. Third, the building provisions were analyzed to determine their applicability to the building characteristics of WTC 1, 2, and 7.

The revised provisions of the building code affect WTC 1 and WTC 2 differently from WTC 7. All of the requirements that were adopted by the City of New York subsequent to the 1968 edition of the Building Code should have been implemented in the original design of WTC 7 since the local laws containing the revised construction provisions all predate the time of construction (1985) of WTC 7. However, all of the code provisions that were passed subsequent to the 1968 edition of the Building Code were not required to be implemented in WTC 1 and WTC 2 since the local laws came into effect after the time of

construction (1971) of WTC 1 and WTC 2. Only the applicable retroactive provisions were required to be implemented.

The applicable local laws that provided changes to fire protection and life safety provisions in the BCNYC are as follows:

- Local Law No. 5, Fire Safety Requirements and Controls (effective date immediately except as noted), January 18, 1973.
- Local Law No. 16, Local Laws of the City of New York for the Year 1984 (effective date immediately except as noted), March 27, 1984.
- Local Law No. 33, Local Laws of the City of New York for the Year 1978 (effective date immediately), October 6, 1978.
- Local Law No. 54, Local Laws of the City of New York for the Year 1970 (effective date immediately), November 17, 1970.
- Local Law No. 55, Local Laws of the City of New York for the Year 1976 (effective date immediately), November 1, 1976.
- Local Law No. 84, Fire Safety Pressurization Requirements in Certain Office Buildings (effective date immediately), December 13, 1979.
- Local Law No. 86, Dates for Compliance with the Local Laws Enacted for Fire Safety Requirements and Controls in Certain Buildings (effective date immediately), December 13, 1979.

The following is a summary of the post construction (retroactive) provisions that were required to be implemented in WTC 1 and WTC 2. These provisions should have been implemented in the initial construction of WTC 7.

- Compartmentation of floor areas creating areas of refuge, unless complete sprinkler protection is provided. The commissioner may waive the compartmentation provision and accept an alternative measure fulfilling the intent of the code. One-third of the total floor area must be in compliance by February 7, 1973, with at lest two-thirds of the total floor area in compliance by August 7, 1984. Full compliance must be provided by February 7, 1988.
- Stair and elevator signs are required to be provided for by October 1, 1985.
- Emergency lighting shall be provided with secondary power by April 1, 1987.
- Exit signs shall be provided with secondary power by April 1, 1987.
- Provide sprinklers for showroom spaces over 7,500 ft^2 in area and located more than 40 ft above curb level.

- Provide sprinklers for catering establishments and banquet halls with an occupant load of 300 or more persons.

- Provide sprinklers for spaces in occupancy group F-4 (Assembly) located more than 75 ft above curb level.

- Install a Class E or modified Class E fire alarm and communication system including loud speakers, two-way voice, manual fire alarm boxes and a fire command station.

- Provide the appropriate number of elevators ready for immediate use by the fire department.

- Provide a fire safety plan.

- Remove locks from elevator and hoistway doors, except elevators used exclusively for freight, by April 1, 1987.

- Provide at least one smoke shaft by which smoke and heat can be mechanically vented to the outdoors by September 13, 1982. In lieu of the smoke shaft, a stair pressurization system(s) can be installed in all interior enclosed stairs. Or, provide a sprinkler system throughout. One-third of the sprinkler system must be installed by December 13, 1981, with two-thirds of the system completed by December 13, 1982. Full compliance must be provided by December 13, 1983. The commissioner may extend the time requirements upon approval.

In addition to the retroactive provisions incorporated since the 1968 BCNYC, Local Laws added requirements for new construction that were applicable to the design and construction of WTC 7, but were not applicable to the design and construction of WTC 1 and WTC 2. These requirements are identified below:

- Class I-B, unsprinklered, occupancy group E (Business) was changed from allowing unlimited height and area to limiting Class I-B unsprinklered buildings to 75 ft in height with an unlimited area.

- All hollow spaces shall be firestopped or filled with noncombustible materials, where combustible trim and finish is permitted.

- Only wool carpet assemblies are permitted to be installed in lobby areas, exit passageways and convenient stairs.

- Flammability requirements of carpets and carpet assemblies were changed.

- Provisions for adequate means of egress in the opinion of the commissioner or fire protection as the commissioner shall direct. Provisions include:

  – Stair doors may be locked on the stair side above the street floor except that at intervals of four stories or less, the doors shall be openable from the stair side without the use of a key. Doors with automatic unlocking systems that are activated by the fire alarm system, are deemed as openable from the stair side.

- The minimum distance between vertical exits shall be the greater of 30 ft or one-third the maximum travel distance of the floor.
- New high-rise buildings in occupancy group E (Business) shall be sprinklered.
- An emergency power system shall be provided in all group E (Business) high-rise buildings.
- A smoke control system shall be provided for in all group E (Business) occupancies.
- A smoke purge system shall be provided for in all group E (Business) occupancies.
- All sprayed-on fire protection shall be subject to the controlled inspection requirements of the BCNYC.

The PANYNJ and various consultants continuously evaluated the life safety and fire protection features of the WTC. Chapter 12 of this report contains a summary of how the local law provisions were complied with. Some of the local law provisions were complied with prior to the passage of the local law requirements. During the time of the 1975 WTC fire, the New York Board of Fire Underwriters stated, "The Fire Safety Program of the World Trade Center is an excellent one" and "In the overall, these towers may be considered as among the safest buildings in New York City" (refer to Appendix A in NIST NCSTAR 1-1H). However, the same report cites problem areas such as , "… fireproofing of the steel may be missing in places; … fire rating of shafts is just above minimum requirements; wiring ducts under the floor (as in many other buildings), have questionable fire resistance and construction hazards and deficiencies due to incomplete construction are still present."

Chapter 23
INTRODUCTION

The regulation of building construction results from the recognition that life safety is served by the best available knowledge and practice. As technology changes and serious incidents occur, such as fires, building codes are developed and revised. Model codes have been published throughout the United States since 1905 (Boring 1981). Referenced standards adopted by the codes provide a technical basis for implementation of the code requirements and provide detailed methods of testing, installation, and maintenance. Municipalities can either adopt a model building code(s) or develop their own code(s). Additionally, many municipalities throughout the United States adopt model building codes and amend the code as deemed necessary. New York City, however, has taken the approach to develop their own building code while providing technical support and installation requirements from a mixture of nationally recognized standards (National Fire Protection Association, ASTM International, American National Standards Institute, etc.) and New York City developed reference standards (denoted by RS).

The World Trade Center (WTC) complex was constructed under the jurisdiction of the Port Authority of New York and New Jersey (PANYNJ or Port Authority). Facilities of the PANYNJ are not technically subject to the requirements of the local building codes, although the PANYNJ voluntarily followed the New York City codes where applicable. In accordance with the instructions issued by the Port Authority at the start of the WTC project, construction drawings for the WTC were to conform to the requirements of the Building Code of the City of New York (BCNYC) (Solomon 1975).

New technology and serious incidents, such as fires, bring about the need for change in the provisions of the BCNYC. As the years pass, the building code becomes outdated and requires revisions. In the city of New York, local laws are passed to address the changes and are later incorporated in the BCNYC. The requirements in the local laws generally affect only new construction and major alteration projects. However, in some cases, requirements include retroactive provisions that are applicable to existing buildings within the effective date. The effective date of a local law is a crucial piece of information that will determine how a local law will affect a building.

WTC 1, 2, and 7 were affected differently by the local laws presented herein since the buildings were constructed under different editions of the BCNYC. WTC 1 and WTC 2 were constructed under the 1968 edition of the BCNYC. The 1968 edition of the BCNYC, including amendments to January 1, 1985, was used to provide the fire protection and life safety provisions during the design and construction phases (base building) of WTC 7. It is important to understand that all of the local laws in this report dated before the amended date above have already been included in the base building construction of WTC 7. In contrast, there are certain local laws in this report, with retroactive requirements, that are applicable to the base building of WTC 1 and WTC 2. Without an applicable retroactive effective date, existing conditions are permitted to remain, even if a new provision has changed the requirements of the BCNYC. However, when tenant modifications or major alterations to the base building are performed, the modification (or major alteration) is required to meet the most current provision at the time of installation.

The reference standards within the BCNYC have been dealt with differently throughout the years and are complex to summarize. Amendments, deletions, and additions to the reference standards of the BCNYC have been adopted through Local Laws, Board of Standards and Appeals calendar numbers, and Building Department amendments. As previously stated, reference standards within the BCNYC contain both nationally recognized standards and New York City developed reference standards. Due to the complex manner with which reference standards are dealt with in the BCNYC, a complete detail of the revised provisions within the BCNYC reference standards cannot be detailed in this report. Where a specific section of the New York City developed reference standard has been amended, deleted, or added, it shall be noted in this report. Otherwise, it is understood that the reference standard of the BCNYC refers to a nationally recognized standard and has merely been updated to a more recent edition of the national standard. Since nationally recognized standards do not contain retroactive effective dates, an updated edition of a nationally recognized standard would therefore only affect major renovations or tenant modifications.

Chapters 3 through 11 present a summary of the minimum requirements of the revised BCNYC provisions that have been added or amended by the Local Laws. Chapter 12 is a brief summary of how the revised provisions were implemented in WTC 1 and WTC 2.

Chapter 24
GENERAL

24.1 LOCAL LAWS WITH APPLICABLE FIRE PROTECTION/LIFE SAFETY PROVISIONS

1. Local Law No. 5, Fire Safety Requirements and Controls (effective date immediately except as noted), January 18, 1973.

2. Local Law No. 16, Local Laws of the City of New York for the Year 1984 (effective date immediately except as noted), March 27, 1984.

3. Local Law No. 33, Local Laws of the City of New York for the Year 1978 (effective date immediately), October 6, 1978.

4. Local Law No. 54, Local Laws of the City of New York for the Year 1970 (effective date immediately), November 17, 1970.

5. Local Law No. 55, Local Laws of the City of New York for the Year 1976 (effective date immediately), November 1, 1976.

6. Local Law No. 84, Fire Safety Pressurization Requirements in Certain Office Buildings (effective date immediately), December 13, 1979.

7. Local Law No. 86, Dates for Compliance with the Local Laws Enacted for Fire Safety Requirements and Controls in Certain Buildings (effective date immediately), December 13, 1979.

24.2 BUILDING SUMMARIES

Table 24–1. Building characteristics.

Building	Height	Number of Floors Above Grade	Footprint	Construction Type (1968 BCNYC)	Primary Occupancy Classification
WTC 1	1,368 ft	110	42,900 ft^2	I-B	Group E (Business)
WTC 2	1,362 ft	110	42,900 ft^2	I-B	Group E (Business)
WTC 7	618 ft	47	48,000 ft^2	I-C (some documents cite 1-B)	Group E (Business)

Source: Merrit 2000a, 2000b; PANYNJ.

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Chapter 25
CONSTRUCTION

25.1 CONSTRUCTION CLASSIFICATION

The Building Code of the City of New York (BCNYC) of December 16, 1968, did not limit the height or area of a construction Class I-B, unsprinklered, occupancy group E (Business) building. However, Local Law No. 16 amended Table 4–1, Area and Height Limitations of Unsprinklered Buildings and Spaces, and limited the height (of the previously mentioned characteristics) to 75 ft while the area remained unlimited.

25.2 COMPARTMENTATION

All new buildings classified in occupancy group E (Business),[44] and existing office buildings, 100 ft or more in height having air-conditioning and/or mechanical ventilation systems that serve more than the floor on which the equipment is located, unsprinklered floor areas,[45] more than 40 ft above curb level, shall be subdivided by fire separations into spaces or compartments as required (C26-504.1, added by Local Law [LL] 5, Sec. 6):

1. All unsprinklered floor areas shall be segregated by 1 h fire separations into spaces or compartments not to exceed 7,500 ft^2.

2. Where the floor area exceeds 10,000 ft^2, at least one of the subdividing fire separations shall be of 2 h construction, creating areas of refuge, complying with section C26-604.5 except that the requirement for an elevator in each area shall not apply.

3. The floor area or any subdivided area may be increased to not more than 15,000 ft^2 if complete area protection by approved devices for the detection of products of combustion other than heat is provided within such increased area and provided further that at least one of the subdividing fire separations shall be of 2 h construction where the floor area exceeds 15,000 ft^2, creating areas of refuge complying with C26-604.5 as noted in 2 above. The activation of the detectors shall have the same effect as section C26-1704.5(f).

4. In existing building, existing 1 h fire separations may be accepted in lieu of the 2 h fire separation provided all of the requirements of 2 and 3 above are complied with.

5. Compartmentation is not required when complete sprinkler protection is provided.

[44] LL 16/1984 removed 'all new buildings classified in occupancy group E (Business)' leaving the compartmentation requirements of C26-504.1 to existing office buildings 100 ft or more in height due to sprinkler requirements.

[45] The floor area shall be defined as the area within exterior walls and excluding any areas enclosing stairs, corridors, elevators, and shafts.

6. Existing office buildings 100 ft or more in height shall comply with the requirements as follows:

    a. At least one-third of the total floor area of the building not in compliance with the requirements above on February 7, 1973, shall comply with the requirements above by December 13, 1981. Complete plans showing such compliance shall be filed with, and a permit secured from the commissioner, by September 13, 1980 (LL 5, Sec. 6, dates revised by LL 86, Sec. 1).

    b. At least two-thirds of the total floor area of the building not in compliance with the requirements above on February 7, 1973, must be in compliance on or before August 7, 1984 (LL 5, Sec. 6, dates revised by LL 86, Sec. 1).

    c. Full compliance must be provided on or before February 7, 1988 (LL 5, Sec. 6, dates revised by LL 86, Sec. 1).

7. In existing office building 100 ft or more in height, the commissioner may waive or modify the above requirements and accept alternatives fulfilling the intent of the requirements if compliance would cause practical difficulty or undue hardship. Where compliance with the time requirements above would cause undue hardship, the commissioner, with the approval of the fire commissioner, may extend the time for compliance (LL 5, Sec. 6, revised by LL 86, Sec. 1).

25.3 FIRESTOPPING

Where combustible trim and finish is permitted, all hollow spaces shall be firestopped at 10 ft intervals or shall be solidly filled with noncombustible materials (C26-504.7(f), added by LL 16, Sec. 28).

Chapter 26
INTERIOR FINISH

26.1 FLOOR FINISH

Carpets and carpet assemblies shall not be installed in required exits, except that wool carpeting may be installed in lobby areas, exit passageways and convenient stairs (C26-504.13(d), added by LL 16, Sec. 32).

The flammability requirements of carpets and carpet assemblies, when used as a floor covering, shall be as follows (C26-504.13(d), added by LL 16, Sec. 32):

1. All carpets and underlayments shall pass a methanine pill test in accordance with RS 5-20.

2. Carpets and carpet assemblies shall be tested for at least a 15 min critical radiant flux exposure in accordance with RS 5-20:

    a. Where carpets and carpet assemblies are installed in corridors, the minimum critical radiant flux shall be 0.5 W/cm^2.

    b. Where carpets and carpet assemblies are installed in other general areas, the minimum critical radiant flux shall be 0.4 W/cm^2.

3. Carpets and carpet assemblies shall be tested for smoke development ratings in accordance with RS 5-20 and shall not exceed 300 within the first 4 min for the flaming or no-flaming mode.

4. The manufacturer of the carpets and carpet assemblies shall submit a certificate from an independent laboratory acceptable to the commissioner showing the complete test data results, prior to final acceptance.

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Chapter 27
MEANS OF EGRESS

27.1 GENERAL

Every structure existing on December 6, 1968, that does not provide exit facilities in accordance with the Building Code of the City of New York (BCNYC) provisions and contain, in the opinion of the commissioner, inadequate means of egress shall be provided with such means of egress or fire protection as the commissioner shall direct (C26-600.3, added by Local Law [LL] 54, Sec. 5).

27.2 EXITS

The minimum distance between vertical exit doors shall be the greater of 30 ft or one-third the maximum travel distance of the floor, provided, however, that where such distance will result in travel distances exceeding those authorized in section C26-601.1, additional vertical exits shall be provided (C26-602.3 amended by LL 16, Sec. 35).

27.3 DOORS

Doors opening into interior stair enclosures shall not be locked from either side with the following exceptions (C26-604.4(j)(1)(b), amended by LL 5, Sec. 9):

1. Doors may be locked to prevent access to the stair at the street floor.

2. In buildings classified in occupancy group E, 100 ft or more in height and existing office buildings 100 ft or more in height, the doors may be locked on the stair side above the street floor except that at intervals of four stories or less, doors shall be openable from the stair side without the use of a key to permit reentry at such floors.

3. The door on every floor where a keyed switch is required by the provisions of article 18 shall be openable from the stair side without the use of a key to permit reentry at such floors.

4. When a locked door is provided with an automatic fail safe system for opening such door in the event of the activation of any automatic fire detecting device or when any elevator in readiness as provided in section C26-1800.8 is activated, such door shall be deemed as openable from the stair side. Stair reentry signs required by C26-608.5 shall specify that reentry is provided only during fire emergencies.

27.4 STAIR AND ELEVATOR SIGNS

Buildings classified in occupancy group E (Business), occupied or arranged to be occupied for an occupant load of more than 100 persons above or below the street level or more than a total of

500 persons in the entire building and any existing office building with an occupant load more than 100 persons shall be provided with signs as follows (C26-608.1, added by LL 5, Sec. 11):

1. A sign shall be posted and maintained on every floor at the elevator landing. The sign shall read "IN CASE OF FIRE, USE STAIRS UNLESS OTHERWISE INSTRUCTED". (C26-608.2, added by LL 5, Sec. 11).

2. Floor numbering signs on every floor (C26-608.3, added by LL 5, Sec. 11).

3. Stair and elevator identification signs (C26-608.4, added by LL 5, Sec. 11).

4. Stair reentry signs (C26-608.5, added by LL 5, Sec. 11).

5. All existing buildings not already subject to the requirements of this section as of January 18, 1973 shall comply with these requirements by October 1, 1985 (C26-608.7(c), amended by LL 16, Sec. 49).

27.5 MEANS OF EGRESS LIGHTING

Where a total of more than four lights are required, exit lighting shall be connected to an emergency power source or to storage battery equipment. The exit lighting may be on circuits that are separate from the general lighting and power circuits, taken off ahead of the main switch. The requirements of this section shall be provided by April 1, 1987 (C26-605.2, added by LL 16, Sec. 45).

Where a total of more than four exit signs are required, the signs shall be connected to an emergency power source or to storage battery equipment. The exit lighting may be on circuits that are separate from the general lighting and power circuits, taken off ahead of the main switch. The requirements of this section shall be provided by April 1, 1987 (C26-606.2(b), added by LL 16, Sec. 46).

Chapter 28
FIRE SUPPRESSION

28.1 AUTOMATIC SPRINKLER PROTECTION

New automatic sprinkler system requirements were added to section C26-1703.1 of the Building Code of the City of New York (BCNYC) as follows (Local Law [LL] 5, Sec. 15 and LL 16, Sec. 64). Automatic sprinklers are required in the following locations:

1. Showroom spaces exceeding 7,500 ft^2 in area located more than 40 ft above curb level in new and existing buildings classified in occupancy group E (Business), 100 ft or more in height having air-conditioning and/or mechanical ventilation systems that serve more than the floor in which the equipment is located (LL 5, Sec. 15). This existing condition must be corrected by January 18, 1976.

2. Catering establishments and banquet halls with an occupancy load of 300 or more persons (LL 16, Sec. 64).

3. Spaces in occupancy group F-4 (Assembly) located more than 75 ft above curb level (LL 16, Sec. 64).

4. Notwithstanding the requirements of showrooms above, new high-rise buildings in occupancy group E (Business) (LL 16, Sec. 64).

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Chapter 29
FIRE DETECTION AND ALARM

29.1 FIRE ALARM SYSTEM

New buildings classified in occupancy group E (Business), 75 ft or more in height and existing buildings in occupancy group E (Business) 100 or more ft in height are required to be provided with a Class E fire alarm and communication system including loud speakers, two-way voice and a fire command station in accordance with RS 17-3A. (C26-1704.1(a)(9), C26-1704.4(g), C26-1704.5 (f), added by Local Law [LL] 5, Sec. 21, 23, and 25, amended by LL 16, Sec. 72):

1. It shall be a special electrically supervised approved direct wire, radio or combination thereof fire alarm system consisting of an interior fire alarm and voice communicating system so arranged that the operation of any station will identify its location at the fire command station, at the mechanical control center and at the regularly assigned location of the fire safety director (C26-1704.5(f)(1), added by LL 5, Sec. 25).

2. Audible signal devices indicating operation of the fire alarm signal system shall be provided at the fire command station, mechanical control center and the regularly assigned location of the fire safety director (C26-1704.5(f)(3), added by LL 5, Sec. 25).

3. The fire alarm system may be sounded over loud speakers in accordance with RS 17-3A so located that their operation will be heard clearly above any ambient noise, and shall be controlled from the fire command station in such a manner that the fire alarm signal can be sounded on the individual floors or throughout the building (C26-1704.5 (f)(5), added by LL 5, Sec. 25).

4. Provision shall be made whereby the fire command station may permit the floor station to make announcements over the loud speaker system (C26-1704.5(f)(6), added by LL 5, Sec. 25).

5. Existing office buildings 100 ft or more in height shall comply with the requirements of this section by September 13, 1981 (C26-1704.5(f)(12), added by LL 5, Sec. 25, amended by LL 86, Sec. 3).

6. In existing office buildings 100 ft or more in height where compliance would cause practical difficulty or undue hardship, the commissioner may waive or modify the requirements of C26-1407.5(f)(1-9) and accept alternatives fulfilling the intent of the requirements (C26-1704.5(f)(11), added by LL 5, Sec. 25).

Fire alarm or communication systems installed prior to December 13, 1980, in existing office buildings 100 ft or more in height, may be incorporated or installed in a modified Class E fire alarm signal system in accordance with RS 17-3B (C26-1704.5(g), added by LL 5, Sec. 25). The requirements of the modified Class E system are the same as the Class E system mentioned above except:

1. The provision whereby the fire command station may permit the floor station to make announcements over the loud speaker system is not required.

2. Other differences mentioned below.

A fire command station shall be located in the lobby of the building on the entrance floor as part of the elevator control panel or immediately adjacent thereto. The fire command station shall contain the following (C26-1704.8(b), added by LL 5, Sec. 30):

1. The loud speaker and communication capability described in section C26-1704.8(a).

2. The audible alarm signal required in section C26-1704.5(f)(g).

3. Manually reset information display system to indicate the floor where the alarm was activated.

4. Means to control the sounding devices on any floor or throughout the building.

5. Means to manually transmit a fire alarm signal to the fire department.

6. Means for silencing the audible alarm signals when the loud speakers are in use and for activating the audible alarm systems automatically when use of the loud speakers are terminated.

7. Display lamps to include on/off condition of air-handling systems unless such lamps are provided in the mechanical control center.

8. Existing office buildings 100 ft or more in height shall comply with the requirements by September 13, 1981 (C26-1704.8(c), added by LL 5, Sec. 30, amended by LL 86, Sec. 3).

29.2 SMOKE AND HEAT DETECTOR LOCATIONS

An approved products of combustion ionization detecting device or a combination of an approved smoke detecting device and an approved fixed temperature thermostatic device shall be installed at each elevator landing. The device shall be located in the ceiling immediately above a call button (C26-1704.4(h), C26-1704.5(f)(8), added by LL 5, Sec. 25).

Activation of an elevator landing detector should (C26-1704.5(f)(9), added by LL 5, Sec. 25):

1. Sound continuously throughout the floor of alarm and floor above.

2. Cause a fire alarm signal to be transmitted to the fire department.

3. Sound fire alarm signal at the fire command station, mechanical control center and regularly assigned location of the fire safety director.

4. Operate the information display system.

5. Stop the air supply into and air return from the floor where activated by approved remote control reversible fire shutters or by automatically shutting down supply and return air fans.

6. Activate air exhaust fans and dampers in smoke shafts and/or pressurizing fans in stair enclosures.

An approved products of combustion ionization detecting device or a combination of an approved smoke detecting device and an approved fixed temperature thermostatic device shall be located at the air return shaft at each floor and so located as to monitor each inlet to the air return shaft (RS 13-1 Sec. 1006, added by LL 5, Sec. 34).

A building equipped throughout with an automatic sprinkler system including a water flow alarm shall be exempt from the installation of any detectors required at each elevator landing and return air shaft, as mentioned above, provided (C26-1704.5(f)(10), added by LL 5, Sec. 25):

1. The water flow alarm has the same effect specified for the elevator landing detector mentioned above.

2. In addition to the smoke detector requirement, in a building equipped throughout with an automatic sprinkler system, a waterflow alarm when activated shall initiate Phase I (Rule 211.3a) emergency recall operation (RS18-1, Rule 211.3b(2)).

Approved and operational smoke detecting devices shall be installed in mechanical rooms, electrical switch gear rooms and electric and telephone closets over 75 ft^2 in all buildings in all occupancy groups (C26-1705.2(b), added by LL 16, Sec. 78).

29.3 MANUAL FIRE ALARM BOXES

At least one fire alarm sending station shall be provided in each story located in each path of escape with additional stations installed so that no point on any floor is more than 200 ft from the nearest station (RS 17-3A and B, Sec. 7(a), added by LL 5, Sec. 39 and 40).

Operation of a manual station shall automatically transmit a fire alarm signal to the fire department via a central station and sound an alarm continuously on the floor where activated and the floor above (C26-1704.5(f)(4), added by LL 5, Sec. 25).

Fire alarm (Class E) sending stations shall be painted red with a diagonal white stripe painted or applied to sending stations which transmit a fire alarm signal to the fire department via a central station (C26-1704.6(e), amended by LL5, Sec. 27).

All fire alarm stations installed or relocated after April 1, 1984, shall be installed so that the handle is approximately 4 ft from the floor (C266-1704.6, amended by LL 16, Sec. 76).

A designated station on each floor shall have the capability of operating the loud speakers for that floor (RS 17-3A, Sec. 7(i), added by LL 5, Sec. 39). This is not a requirement of the modified class E fire alarm system.

29.4 AUDIBLE/VISUAL NOTIFICATION APPLIANCES

In a Class E fire alarm system, loudspeakers capable of being operated from the fire command station shall be provided on each floor, and in each elevator and stair enclosure (C26-1704.8(a), added by LL 5, Sec. 30).

The loudspeaker amplifier system shall be so designed and installed that approximately 50 percent of the system shall remain operable for the transmission and audibility of signal and intelligibility of voice communication over the loudspeaker system throughout the building, in the event the other 50 percent becomes inoperable (C26-1704.5(f)(7), added by LL 5, Sec. 25). This is not a requirement of the modified Class E fire alarm system.

Loudspeakers shall be located so that their operation will be heard clearly above ambient noise (C26-1704.5(f)(5), added by LL 5, Sec. 25).

Recessed and surface mounted speakers shall be located not more than 10 ft from the entrance to each required exit (RS 17-3A and B, Sec. 8(b), added by LL 5, Sec. 39 and 40).

The alarm sounding devices may be utilized for other audio purposes including building security if means are provided to insure fire alarm priority (RS 17-3A and B, Sec. 8(c), added by LL 5, Sec. 39 and 40).

29.5 COMMUNICATION SYSTEM

In a Class E fire alarm signal system, the standpipe fire line telephone and signaling system may be combined with the fire alarm system provided (C26-1704.7(g), added by LL 5, Sec. 28):

1. The alarms and two-way voice communication with the fire command station include the pump and gravity tank rooms.

2. A designated floor station of the Class E system is located at or near the main standpipe riser on every floor.

New and existing buildings classified in occupancy group E (Business), 100 ft or more in height shall be provided with the following (C26-1704.8, added by LL 5, Sec. 30):

1. Loudspeakers on each floor of the building, in each elevator and each stair enclosure, which shall be capable of being operated from the fire command station.

2. A two-way communication with capability between the fire command station and the following locations:

    a. A designated floor warden station on each floor.

    b. Mechanical control center.

    c. Elevators.

    d. Air-handling.

    e. Elevator machine rooms.

A floor warden station shall be located between required stairways, vertical exits, or other exits (RS 17-3A and B, Sec. 7(b), added by LL 5, Sec. 39 and 40):

1. System shall include a telephone type handset at the floor warden station with integral signaling to the fire command station.

2. Warden station may be part of the speaker system.

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Chapter 30
ELEVATORS AND HOISTWAYS

30.1 ELEVATOR IN READINESS

In buildings classified in occupancy group E (Business), 100 ft or more in height, and in existing office buildings 100 ft or more in height, the number of elevators that shall be kept available for immediate use by the fire department is as follows (C26-1800.8, added by Local Law [LL] 5, Sec. 31):

1. Where a floor is serviced by three or less elevator cars, every car shall be kept available.

2. Where a floor is serviced by more than three elevator cars, at least three elevator cars with a total rated load capacity of not less than 6,000 lb shall be kept available for every floor. Such cars shall include not more than two cars which service all floors and at least one other car in another bank servicing that floor. If the total load capacity of all cars servicing the floor is less than 6,000 lb, all cars shall be kept available.

3. Elevators which have automatic or continuous pressure operation shall be controlled by keyed switches meeting the requirements of RS 18-1.

4. In high-rise buildings classified in occupancy group E (Business), all other automatically operated cars shall have manual operation capability.

Notwithstanding the retroactive provisions in C26-1801.1, existing office buildings 100 ft or more in height shall comply with the requirements of this section by September 13, 1981.

30.2 LOCKS

In high-rise buildings and existing high-rise buildings, no switch, lock, or device of any kind shall be installed on any floor on or above the street floor on any elevator car or elevator hoistway door, except elevators used exclusively for freight, that shall prevent opening of such doors by anyone not having a key, unless fire department access to cars and hoistways is provided for by a city-wide standard key. Existing high-rise buildings shall comply with this requirement by April 1, 1987 (C26-1801.4, added by LL 16, Sec. 80).

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Chapter 31
EMERGENCY, ELECTRICAL, AND STANDBY POWER SYSTEMS

31.1 EMERGENCY POWER SYSTEMS

An emergency power system shall be provided in high-rise buildings in occupancy group E (Business) (C26-610.3, added by Local Law [LL] 16, Sec. 50).

Emergency power shall be provided having the capacity to operate the following equipment, where such equipment is installed (C26-610.1, added by LL 16, Sec. 50):

1. Fire pumps.
2. At least three elevators at one time, with manual transfer to other elevators.
3. Alarm systems.
4. Communications systems.
5. Emergency lighting, if battery packs are not provided.
6. Ventilating systems used for smoke venting or control.
7. Stair pressurization.

Emergency power generation equipment shall be registered with the Department of Environmental Protection, Bureau of Air Resources in accordance with the requirements of Section 1403.2-3.09 of the Administrative Code (C26-610.2, added by LL 16, Sec. 50).

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Chapter 32
SPECIAL FEATURES

32.1 SMOKE AND HEAT VENTING

Buildings classified in occupancy group E (Business), 100 ft or more in height, having air-conditioning and/or mechanical ventilation systems that serve more than the floor on which the equipment is located, shall be provided with at least one smoke shaft by means of which smoke and heat shall be mechanically vented to the outdoors as provided in RS 5-17 (C26-504.15(b)) (Local Law [LL] 5, Sec. 7). RS 5-17 was added by LL 5, Sec. 32.

Existing office buildings, 100 ft or more in height, having air-conditioning and/or mechanical ventilation systems that serve more than the floor on which the equipment is located, shall be provided with at least one smoke shaft by means of which smoke and heat shall be mechanically vented to the outdoors as provided in RS 5-17 or in lieu of such smoke shaft(s), all interior enclosed stairs other than a fire tower or access stairs may be provided with a system of pressurization for fire emergency use (C26-504.15(c)) (LL 5 Sec. 7, revised by LL 86, Sec. 2):

1. Where the pressurization system(s) option has been chosen, the system(s) shall be provided in accordance with RS 5-18.

2. The smoke and heat venting requirements shall be completed by September 13, 1982.

New Buildings that are sprinklered throughout shall be exempt from the smoke shaft requirements (C26-504.15(b)) (LL 5, Sec 7).

Existing buildings that are sprinklered throughout shall be exempt from the smoke shaft and optional stair pressurization requirements under the following conditions (C26-504.15(b)) (LL 86, Sec 2):

1. The installation shall proceed in conformance with a schedule acceptable to the commissioner.

2. At least one-third of the total floor area of the building, including but not limited to the entrance lobby, corridors and elevator landing areas, is sprinklered by December 13, 1981.

3. At least two-thirds of the total floor area of the building is sprinklered by December 13, 1982.

4. The building is sprinklered throughout by December 13, 1983.

5. Where compliance with the time requirements would cause undue hardship, the commissioner, with approval of the fire commissioner, may extend the time for compliance.

32.2 SMOKE CONTROL

Smoke control shall be installed in all buildings classified in occupancy group E (Business) as follows (C26-1300.8(a), added by LL 16, Sec. 53):

1. Ventilation systems supplying different occupancy groups shall not be interconnected, provided however that a ventilation system may serve two occupancy groups located on the same floor when the accessory use occupies less than 20 percent of the floor area occupied by the principal use.

2. Ventilation systems supplying corridors shall not be interconnected with systems serving other spaces, except that this requirement shall not apply to floors used exclusively as office space in buildings classified in occupancy group E (Business) which are fully sprinklered.

3. A ventilation system supplying any part of a means of egress shall not be interconnected with any other ventilation system.

4. A ventilation system supplying public areas and assembly spaces shall have smoke detecting devices that will shut down the system upon detecting smoke.

5. Either a combined heat and smoke damper or independent heat and smoke dampers shall be installed at any penetration of construction required to have a fire resistance rating., unless otherwise provided by section C26-504.5.

32.3 SMOKE PURGE

In all buildings classified in occupancy group E (Business), there shall be provided a system of mechanical means of sufficient capacity to exhaust 6 air changes per hour or 1 cfm/ft^2, whichever is greater, from the largest floor in the building, using either dedicated fan equipment or the building ventilation system arranged to shut down automatically with manual override capability to exhaust one floor at a time through a roof or an approved location on an exterior wall other than a lot line wall (C26-1300.8(b), added by LL 16, Sec. 53).

32.4 STAIR PRESSURIZATION

Stair pressurization is not directly required by code in an occupancy classified as group E (Business). As previously stated in Section 32.1 of this report, stair pressurization can be used to eliminate the requirement of smoke and heat venting. If stair pressurization is provided, each stair shall be protected in accordance with RS 5-18 (RS 5-18 added by LL 5, Sec. 33, amended by LL 84, Sec. 3).

32.5 FIRE SAFETY PLAN

A fire safety plan for fire drill and evacuation procedures shall be submitted to the commissioner. The applicable parts of the fire safety plan shall be distributed to the tenants and service employees. All occupants of the building shall participate and cooperate in carrying out the provisions of the fire safety plan (C19-161.2, added by LL 5, Sec. 1).

One employee (of the building owner) shall be designated as fire safety director and one or more employees as deputy fire safety director. Such employees shall each have a certificate of fitness, qualifying him to conduct fire drills, evacuations, and related activities such as organizing, training and supervising a fire brigade.

During fire emergencies, the primary responsibility of the fire safety director shall be the supervision and manning of a fire command station and the direction and execution of the evacuation as provided in the fire safety plan. Such activities shall be subject to fire department control.

A fire brigade consisting of qualified building service employees shall be selected by the fire safety director.

Fire drills shall be conducted in accordance with the fire safety plan at least once every 3 months for existing building during the first 2 years. Thereafter, fire drills shall be conducted at least once every 6 months. The occupants of the building, other than building service employees, shall not be required to leave the floor or use the exits during the drill.

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Chapter 33
INSPECTIONS

33.1 MATERIALS REQUIRING INSPECTION

The installation of all required sprayed-on fire protection of structural members except those encased in concrete shall be subject to the controlled inspection requirements in C26-106.3(a), C26-502.2(f), added by Local Law No. 55.

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Chapter 34
RESPONSE TO RETROACTIVE PROVISIONS

The Port Authority of New York and New Jersey (PANYNJ) and various consultants continuously evaluated the life safety and fire protection features of the World Trade Center (WTC). In response to the Local Laws of New York City, a fire in 1975, a bombing in 1993, and many other fires, the life safety and fire protection features of WTC 1 and WTC 2 were enhanced. Throughout the years, numerous studies and plans were created. The reports generated by the studies gave recommendations with numerous alternatives to equivalently comply with the intent of the code. Eventually, for one reason or another, the provisions of these Local Laws were addressed, and in many instances were exceeded (see Table 12–1). Additionally, since the PANYNJ did not merely comply with the minimum requirements, some of the local law provisions were complied with prior to the development of the Local Law requirements. During the time of the 1975 WTC fire, the New York Board of Fire Underwriters stated, "The Fire Safety Program of the World Trade Center is an excellent one" and "In the overall, these towers may be considered as among the safest buildings in New York City" (stated in a document contained in Appendix A of NIST NCSTAR 1-1H).

Table 34–1. Life safety and fire protection provisions required by Local Laws.

Provision	Approach adopted by PANYNJ
Compartmentation	No (sprinkler alternative was chosen)[a]
Stair and elevator signs	Yes
Secondary power supply for exit signs and lights	Exceeded[b]
Smoke and heat shaft or stair pressurization	Exceeded[c] (not required since building was sprinklered)
Elevators in readiness	Exceeded[d]
Class E fire alarm system	Exceeded[e]
Fire command station	Yes[f]
Removal of locks on elevators and hoistway doors	Yes
Fire protection and fire safety plans	Yes
Emergency power	Exceeded[g]

a. In 1976, a plan to vertically compartmentalize WTC 1 and WTC 2 was chosen. But, in the mid-1980s, a program to fully sprinkler WTC 1 and WTC 2 was initiated, eliminating the compartmentation requirements. Documentation indicates that in 1993, WTC 1 was approximately 95 percent completed and approximately 85 percent complete in WTC 2. By 2000, the office floors of WTC 1 and WTC 2 were sprinklered except for electric and telephone closets, most toilet rooms, the main lobby and the B-6 Level Mechanical Equipment Room (Merritt 2000a, 2000b).
b. Provided with separate feeders and emergency generators.
c. Smoke purge and pressurization of corridors with 100 percent fresh air was provided.
d. All passenger elevators are capable of being recalled and makes the car available for manual operation by the Fire Department.
e. Many components of the fire alarm system were above code requirements at the time of Local Law No. 5. After the 1993 bombing, a completely new system was installed complying with the most current provisions at the time of installation.
f. Each tower did not have an individual fire command station at the time of the 1993 bombing. Part of the enhancement after the bombing included providing Fire Command Stations in the lobby of each building.
g. Was not retroactively required, but was provided.

Sources: PANYNJ; Appendix A, NIST NCSTAR 1-1H; Rivera 1993; Merritt 2000a, 2000b.

Chapter 35
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