GUIDE FOR DETERMINATION OF NEEDED FIRE FLOW

545 Washington Boulevard
Jersey City, New Jersey 07310-1686
(800) 888-4ISO (4476)
www.iso.com
www.isomitigation.com

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FOREWORD

ISO has prepared this guide as an aid in estimating the amount of water that should be available for municipal fire protection. ISO calls this the needed fire flow. This publication is only a guide and requires knowledge and experience in fire protection engineering for its effective application.

INDEX

PREFACE

ISO is the premier source of information, products, and services related to property and liability risk. For a broad spectrum of types of insurance, ISO provides statistical, actuarial, underwriting, and claims information and analyses; consulting and technical services; policy language; information about specific locations; fraud-identification tools; and data processing. In the United States and around the world, ISO serves insurers, reinsurers, agents, brokers, self-insureds, risk managers, insurance regulators, fire departments, and other governmental agencies.

One of ISO's important services is to evaluate the fire suppression delivery systems of jurisdictions around the country. The result of those reviews is a classification number that ISO distributes to insurers. Insurance companies use the Public Protection Classification (PPC™) information to help establish fair premiums for fire insurance – generally offering lower premiums in communities with better fire protection.

ISO uses the Fire Suppression Rating Schedule (FSRS) to define the criteria used in the evaluation of a community's fire defenses. Within the FSRS, a section titled "Needed Fire Flow" outlines the methodology for determining the amount of water necessary for providing fire protection at selected locations throughout the community. ISO uses the needed fire flows to:

1. Determine the community's "basic fire flow." The basic fire flow is the fifth highest needed fire flow in the community. ISO uses the basic fire flow to determine the number of apparatus, the size of apparatus fire pumps, and special fire-fighting equipment needed in the community.
2. Determine the adequacy of the water supply and delivery system. ISO calculates the needed fire flow for selected properties and then determines the water flow capabilities at these sites. ISO then calculates a ratio considering the need (needed fire flow) and the availability (water flow capability). ISO uses that ratio in calculating the credit points identified in the FSRS.

ISO developed the needed fire flow through a review of actual large-loss fires. ISO recorded the average fire flow and other important factors, including construction type, occupancy type, area of the building, and exposures. Those factors are the foundation of the needed fire flow formula.

The following pages include a number of excerpts from another ISO document, the Specific Commercial Property Evaluation Schedule (SCOPES). ISO uses the SCOPES manual to weigh features of individual properties for the purpose of defining the building's vulnerability to fire loss. Insurers also use this information in their underwriting and ratemaking decisions.

CHAPTER 1

Needed Fire Flow Formula

To estimate the amount of water needed to fight a fire in an individual, nonsprinklered building, ISO uses the formula:

$$NFF = (C_i)(O_i)[(1.0+(X+P)_i]$$

where

NFF_i	=	the needed fire flow in gallons per minute (gpm)
C_i	=	a factor related to the type of construction
O_i	=	a factor related to the type of occupancy
X	=	a factor related to the exposure buildings
P	=	a factor related to the communication between buildings

To calculate the needed fire flow of a building, you will need to determine the predominant type (class) of construction, size (effective area) of the building, predominant type (class) of occupancy, exposure from the property, and the factor for communication to another building.

Here is a summary of the step-by-step process:

Step 1. Determine the predominant construction type and the associated factor (F).
Step 2. Determine the effective area (A_i).
Step 3. Substitute the values for "F" and "A" into the formula $C_i=18F(A_i)^{0.5}$ and calculate the construction factor (C_i).
Step 4. Round off the construction factor (C_i) to the nearest 250 gpm.
Step 5. Determine the predominant occupancy type and the associated factor (O_i).
Step 6. Determine if there is an exposure charge by identifying the construction type and length-height value of the exposure building as well as the distance (in feet) to the exposure building. Also make note of any openings and protection of those openings in the wall facing the subject building (the building the needed fire flow is being calculated on). The factor related to the exposure building is (X).
Step 7. Determine if there is a communication charge by identifying the combustibility of the passageway, whether the passageway is open or closed, the length, and a description of any protection provided in the passageway openings. The factor related to the communications between buildings is (P).
Step 8. Substitute the values for the factors in the formula $NFF_i = (C_i)(O_i)[1.0+(X+P)_i]$ to determine the needed fire flow.

Further details of the step-by-step process are provided in the following pages.

Note: ISO does not determine a needed fire flow for buildings rated and coded by ISO as protected by an automatic sprinkler system meeting applicable National Fire Protection Association standards. See Chapter 6, "Determining Recognition of Automatic Sprinkler Systems," for more information.

CHAPTER 2

Type of Construction (C_i) and Effective Area (A_i)

To determine the portion of the needed fire flow attributed to the construction and area of the selected building, ISO uses the formula:

$$C_i = 18F (A_i)^{0.5}$$

Where:

F = coefficient related to the class of construction
- F = 1.5 for Construction Class 1 (wood frame construction)
- = 1.0 for Construction Class 2 (joisted masonry construction)
- = 0.8 for Construction Class 3 (noncombustible construction and Construction Class 4 (masonry noncombustible construction)
- = 0.6 for Construction Class 5 (modified fire-resistive construction) and Construction Class 6 (fire-resistive construction)

A_i = effective area

Appendix A provides C_i for a range of construction classes (F) and effective areas (A_i).

1. Construction Materials and Assemblies

ISO uses the following definitions to determine the construction class for a building:

a. Combustible: Wood or other materials that will ignite and burn when subjected to fire, including materials with a listed flame-spread rating greater than 25. Also included are assemblies or combinations of combustible materials with other materials, such as the following:

(1) Metal walls or floors sheathed on either interior or exterior surfaces (with or without air space) with wood or other combustible materials (flame-spread rating over 25).

(2) Metal floors or roofs with combustible insulation or other combustible ceiling material attached to the underside of the floor or interior surface of the roof deck, or within 18" of the horizontal supports.

(3) Combustible wall materials with an exterior surface of brick, stone, or other masonry materials (commonly known as "masonry veneer").

(4) Noncombustible wall or roof construction on a skeleton wood frame (commonly known as "wood-iron clad").

(5) Combustible wall or roof construction on a noncombustible or slow burning frame.

(6) Composite assemblies of noncombustible materials with combustible materials, such as a combustible core between two noncombustible panels, or a noncombustible panel with a combustible insulation material (flame-spread rating over 25).

(7) Composite assemblies of noncombustible or slow burning materials combined with foamed plastic materials (with any flame-spread rating), unless the foamed plastic materials qualify as slow burning. (Refer to Item f, below.)

(8) Combustible assemblies which are listed as having not less than a one-hour rating.

b. **Fire-resistive:** Noncombustible materials or assemblies which have a fire-resistance rating of not less than one hour.

c. **Masonry:** Adobe, brick, cement, concrete, gypsum blocks, hollow concrete blocks, stone, tile, and similar materials with a minimum thickness of 4".

d. **Noncombustible:** Materials, no part of which will ignite and burn when subjected to fire, such as aluminum, asbestos board, glass, gypsum board, plaster, slate, steel, and similar materials. Also included are:

(1) Fire-resistive and protected-metal assemblies with a fire-resistance rating of less than one hour

(2) Materials or composite materials with a listed surface-flame-spread rating of 0 and of such composition that surfaces that would be exposed by cutting through the material in any way would not have a listed flame-spread rating greater than 0

(3) Masonry walls less than 4" thick, which are not a part of combustible walls (masonry veneer)

Note: Combustible nailing (furring) strips fastened directly to noncombustible supports shall not affect the classification of noncombustible walls, floors, or roofs.

e. **Protected metal:** Metal which is protected by materials so that the resulting assembly has a fire-resistance rating of not less than one hour.

f. **Slow burning:** Materials with a listed flame-spread rating greater than 0 but not greater than 25; except, foamed plastic materials shall be rated as slow burning if such materials or coverings meet one of the conditions in (1) or (2) below.

An acceptable thermal barrier includes those which have been tested as part of a field-fabricated or factory-manufactured composite assembly which has passed one of the acceptable wall or ceiling panel tests, when applied over foamed plastic material of a thickness and listed flame-spread rating not greater than that used in the composite assembly tested. Where any material is of a type which falls or drips to the floor of the furnace during the flame-spread test, the flame-spread rating of the material, when not protected by a thermal barrier, shall be based on the flame-spread rating of the material on the floor of the furnace, where this flame-spread is higher than the flame-spread of the material on the furnace ceiling. In all other cases, the normal flame-spread rating of the material on the furnace ceiling shall be used.

(1) An acceptable thermal barrier consisting of 1/2" or greater noncombustible material, such as plaster, cement, or gypsum board, when used over foamed plastic material having a listed flame-spread rating not greater than 25

(2) An acceptable thermal barrier which is listed with not less than a 15-minute finish rating when used over foamed plastic material having a listed flame-spread rating not greater than 25

Note 1: Combustible nailing (furring) strips fastened directly to slow burning supports shall not affect the classification of slow burning walls, floors, or roofs.

Note 2: Lumber and lumber products shall be eligible for consideration as slow burning only when all the ceilings and the walls are treated with a listed flame-retardant impregnation which meets all of the following requirements:

(1) Impregnation-treated materials shall be properly identified as having a flame-spread rating of 25 or less.

(2) Such identification shall indicate that there is no evidence of significant progressive combustion when subjected to at least 30 minutes test duration.

(3) Such identification shall indicate that the material has a permanent treatment not subject to deterioration from the effects of weathering, exposure to moisture or humidity, etc. (This requirement only applies where the treated material is exposed to the weather or moisture.) However, combustible nailing (furring) strips, doors, trim, and the top surfaces of combustible floors shall not be required to be treated.

g. **Unprotected metal:** Metal with no fire-resistive protection, or with a fire-resistance rating of less than one hour.

2. Classification of Basic Construction Types

ISO classifies construction types into six different categories:

Construction Class 6 (fire-resistive construction)
Construction Class 5 (modified fire-resistive construction)
Construction Class 4 (masonry noncombustible construction)
Construction Class 3 (noncombustible construction)
Construction Class 2 (joisted masonry construction)
Construction Class 1 (wood frame construction)

Note: In applying the rules below, ISO disregards below-grade basement walls and the construction of the lowest floor (usually concrete).

a. **Fire-resistive (Construction Class 6):** Buildings constructed of any combination of the following materials:

Exterior walls or exterior structural frame:

- Solid masonry, including reinforced concrete, not less than 4 inches in thickness
- Hollow masonry not less than 12 inches in thickness
- Hollow masonry less than 12 inches, but not less than 8 inches in thickness, with a listed fire-resistance rating of not less than two hours
- Assemblies with a fire-resistance rating of not less than two hours

Note: Panel or curtain sections of masonry may be of any thickness.

Floors and roof:

- Monolithic floors and roof of reinforced concrete with slabs not less than 4 inches in thickness
- Construction known as "joist systems" (or pan-type construction) with slabs supported by concrete joists spaced not more than 36 inches on centers with a slab thickness not less than 2 ¾ inches
- Floor and roof assemblies with a fire-resistance rating of not less than two hours

Structural metal supports:

- Horizontal and vertical load bearing protected metal supports (including prestressed concrete units) with a fire-resistance rating of not less than two hours

Note: Wherever in the SCOPES reference is made to "pre-stressed," this term shall also include "post-tensioned."

b. **Modified fire-resistive (Construction Class 5):** Buildings with exterior walls, floors, and roof constructed of masonry materials described in a., above, deficient in thickness, but not less than 4 inches; or fire-resistive materials described in a., above, with a fire-resistance rating of less than two hours, but not less than one hour.

c. **Masonry noncombustible (Construction Class 4):** Buildings with exterior walls of fire-resistive construction (not less than one hour), or of masonry, not less than 4 inches in thickness and with noncombustible or slow burning floors and roof (including noncombustible or slow burning roof decks on noncombustible or slow burning supports, regardless of the type of insulation on the roof surface).

d. **Noncombustible (Construction Class 3):** Buildings with exterior walls, floors, and roof of noncombustible or slow burning materials supported by noncombustible or slow burning supports (including noncombustible or slow burning roof decks on noncombustible or slow burning supports, regardless of the type of insulation on the roof surface).

e. **Joisted masonry (Construction Class 2):** Buildings with exterior walls of fire-resistive construction (not less than one hour), or of masonry, and with combustible floors and roof.

f. **Frame (Construction Class 1):** Buildings with exterior walls, floors, and roof of combustible construction, or buildings with exterior walls of noncombustible or slow burning construction, with combustible floors and roof.

Notes applicable to construction-type definitions above:

Note 1: Masonry or fire-resistive walls with panels composed of glass, noncombustible, slow burning, combustible, or open sections shall retain their classification as masonry or fire-resistive, provided that such panels are in or supported by a structural frame of masonry or protected metal (two hours fire resistance if in walls classed as Construction Class 6, one hour in classes 2, 4, or 5). Similarly, masonry or fire-resistive floors with wood or other combustible surfacing in buildings otherwise subject to Construction Classes 5 or 6 shall retain their classification as Classes 5 or 6.

Note 2: Noncombustible or slow burning roof deck with an exterior surface of combustible materials, such as combustible insulation, felt, asphalt, or tar, shall retain its classification as noncombustible or slow burning.

3. Crosswalk to Other Construction Types

The International Code Council (ICC) and the National Fire Protection Association (NFPA) have their own classification of construction types. These classifications are used in the codes and standards that they promulgate and are unique to their organization's publications. Below is a table that generally compares ISO's construction types to those of these other organizations.

Construction Types

ISO SCOPES Definition	ISO Construction Class	International Code (ICC)	NFPA 220	NFPA 5000	Standard Code 1997 (SBCCI)	National 1999 (BOCA)	Uniform Code 1997 (ICBO)
Wood frame	1	V, B	V	V	VI	5B	V
Ordinary (joisted masonry)	2	III, A	III	III	V	3	IIIV
Non-combustible (all metal)	3	II, B	II	II	IV	2C	11-N
Non-combustible (masonry)	4	II, A	II	III	IV	2B	II- 1 hr.
Modified – fire resistive	5	II, A	II	II	II	1B	II fire resistive
Fire resistive	6	I, A	I	I	I	1A	I
Heavy timber	2	IV	IV	IV	III	4	IV

4. Classification of Mixed Construction

In buildings constructed as defined in two or more classes above, ISO determines the appropriate construction class as follows:

Note: In applying these rules, ISO disregards basement walls and the lowest floor level.

a. **Fire-resistive:** Any building with 66 2/3 % or over of the total wall area and 66 2/3 % or over of the total floor and roof area constructed as defined in Construction Class 6.

b. **Modified fire-resistive:** Any building with 66 2/3 % or over of the total wall area and 66 2/3% or over of the total floor and roof area constructed as defined in Construction Class 5; or

Any building with 66 2/3% or over of the total wall area, and 66 2/3% or over of the total floor and roof area constructed as defined in Construction Classes 5 and 6, but with neither type in itself equaling 66 2/3% or over of the total area.

c. **Masonry noncombustible:** Any building with 66 2/3% or over of the total wall area and 66 2/3% or over of the total floor and roof area constructed as defined in Construction Class 4; or

Any building not qualifying under a. or b., above, with 66 2/3% or over of the total wall area and 66 2/3% or over of the total floor and roof area constructed as defined in two or more of Construction Classes 4, 5, and 6, but with no single type in itself equaling 66 2/3% or over of the total area.

d. **Noncombustible:** Any building with 66 2/3% or over of the total wall area and 66 2/3% or over of the total floor and roof area constructed as defined in Construction Class 3; or

Any building not qualifying under a. through c., above, with 66 2/3% or over of the total wall area and 66 2/3% or over of the total floor and roof area constructed as defined in two or more of Construction Classes 3, 4, 5, and 6, but with no single type in itself equaling 66 2/3% or over of the total area.

e. **Joisted masonry:** Any building not qualifying under a. through d., above, with 66 2/3% or over of the total wall area constructed as described in Construction Class 2; or

Any building not qualifying under a. through d., above, with 66 2/3% or over of the total wall area and 66 2/3% or over of the total floor and roof area constructed as defined in two or more of Construction Classes 2, 3, 4, 5, and 6, but with no single type in itself equaling 66 2/3% or over of the total area.

f. **Frame:** Any building not qualifying under a. through e., above, or any building with over 33 1/3 % of the total wall area of combustible construction, regardless of the type of construction of the balance of the building.

5. Determining Effective Area (A_i)

In the portion of the needed fire flow formula attributed to the construction and area of the subject building,

$$C_i = 18F\ (A_i)^{0.5}$$

The factor "A_i" is the "effective area" of the subject building.

a. Exempt areas:

Disregard the following in the determination of the effective area:

- In nonsprinklered buildings, or buildings which do not qualify for sprinkler credit (see Chapter 6, "Determining Recognition of Automatic Sprinkler Systems"), disregard floor areas (including basement and subbasement) where the entire floor is protected by an acceptable system of automatic sprinklers or other acceptable automatic fire protection systems, provided that there are no Combustibility Class C-5 occupancies on the floor (see "Occupancy Factor," i.e., "Rapid burning or flash burning").

- Basement and subbasement areas which are vacant, or are used for building maintenance, or which are occupied by occupancies having C-1 or C-2 contents combustibility (see "Occupancy Factor") regardless of the combustibility class applicable to the building. A basement is a story of a building which is 50% or more below grade, unless such story is accessible at grade level on one or more sides. A story which is less than 50% below grade shall also be considered a basement if such story is wholly enclosed by blank masonry foundation walls.

- In breweries, malt mills, and other similar occupancies, disregard perforated (slatted) operating decks which contain no storage.

- Roof structures, sheds, or similar attachments.

- Courts without roofs.

- Areas of mezzanines less than 25% times the square foot area of the floor immediately below.

b. Modification for division walls:

An acceptable division wall shall be constructed entirely of noncombustible materials with a fire-resistance rating of not less than one hour, or of masonry materials, and shall:

(1) Extend from one exterior wall to another (or form an enclosed area within the building).

(2) Extend from one masonry or fire-resistive floor to another masonry or fire-resistive floor, or from a masonry or fire-resistive floor to a roof of any construction.

(3) Have all openings through the wall protected by an automatic or self-closing labeled Class B (not less than one-hour) fire door.

Where division walls meet the above requirements, the maximum area on any floor used to determine the effective area shall be the largest undivided area plus 50% times the second largest undivided area on that floor.

c. Effective area calculation:

After modification for division walls as provided above, the effective area shall be the total square foot area of the largest floor in the building, plus the following percentage of the total area of the other floors:

(1) Buildings classified as Construction Classes 1 - 4: 50% of all other floors.

(2) Buildings classified as Construction Classes 5 or 6:

(a) If all vertical openings in the building are protected (see 4d., "Protection requirements," below), 25% times the remaining area not exceeding the two other largest floors.

(b) If one or more vertical openings in the building are unprotected (see 4d., "Protection requirements," below), 50% times the remaining area not exceeding 8 other floors with unprotected openings.

Note: The effective area determined under item 4c.(2)(b), above, shall not be less than the effective area that would be determined under item 4c.(2)(a), above, if all openings were protected.

d. Protection requirements:

The protection requirements for vertical openings are only applicable in buildings of Construction Class 5 or 6. The type of protection for vertical openings shall be based on the construction of the enclosure walls and the type of door or other device used for the protection of openings in the enclosure.

The following materials are acceptable for one-hour construction in enclosure walls: 4-inch brick, 4-inch reinforced concrete, 6-inch hollow block, 6-inch tile, or masonry or noncombustible materials listed with a fire-resistance rating of not less than one hour.

Protected openings:

Enclosures shall have walls of masonry or fire-resistive construction with a fire-resistance rating of not less than one hour.

Doors shall be automatic or self-closing and be labeled for Class B opening protection (not less than one-hour rating).

Elevator doors shall be of metal or metal-covered construction, so arranged that the doors must normally be closed for operation of the elevator.

Unprotected openings:

Unprotected floor openings. Also includes doors or enclosures not meeting the minimum requirements for protected openings, above.

5. Maximum and Minimum Value of C_i:

The value of C_i shall not exceed

8,000 gpm for Construction Class 1 and 2
6,000 gpm for Construction Class 3, 4, 5, and 6
6,000 gpm for a 1-story building of any class of construction

The value of C_i shall not be less than 500 gpm.

ISO rounds the calculated value of C_i to the nearest 250 gpm.

CHAPTER 3

Occupancy Factor (O_i)

The factors below reflect the influence of the occupancy in the subject building on the needed fire flow:

Occupancy Combustibility Class	Occupancy Factor (O_i)
C-1 (Noncombustible)	0.75
C-2 (Limited-combustible)	0.85
C-3 (Combustible)	1.00
C-4 (Free-burning)	1.15
C-5 (Rapid burning)	1.25

1. Determining Occupancy Type

Occupancy combustibility classifications reflect the effect of the combustibility of contents on the building structure. ISO uses the following definitions to determine the combustibility classification of an occupancy:

a. **Noncombustible (C-1)** - Merchandise or materials, including furniture, stock, or equipment, which in permissible quantities does not in themselves constitute an active fuel for the spread of fire.

No occupancy shall be eligible for this classification which contains a sufficient concentration of combustible material to cause structural damage OR which contains a sufficient continuity of combustible materials so that a fire could spread beyond the vicinity of origin.

The maximum amount of combustible materials in any 10,000 square-foot section of an occupancy otherwise containing noncombustible materials shall not exceed 1000 board feet of lumber, or over 2 barrels (110 gallons) of combustible liquids or greases or equivalent amounts of other combustible materials. Further, the maximum total area containing combustible material in an occupancy otherwise containing noncombustible materials shall not exceed 5% of the total square foot area of that occupancy.

Note: In determining the applicability of C-1, combustible interior walls or partitions (including combustible finish), mezzanines, racks, shelves, bins, and similar combustible construction shall be considered combustible material.

Examples of occupancies which may (subject to survey) be eligible for C-1 classification include those storing asbestos, clay, glass, marble, stone, or metal products and some metalworking occupancies.

b. **Limited-combustible (C-2)** - Merchandise or materials, including furniture, stock, or equipment, of low combustibility, with limited concentrations of combustible materials.

Examples of occupancies classified as C-2 include banks, barber shops, beauty shops, clubs, habitational occupancies, hospitals, and offices.

Occupancies classified as C-2 in the occupancy classification list may be eligible for C-1 classification provided that such occupancy meets all of the requirements for C-1 classification.

Note: For manufacturing occupancies where over 20% of the total square foot area of the occupancy contains storage of combustible material or materials crated or wrapped in combustible containers, the combustibility class applicable to the occupancy shall not be less than C-3.

c. **Combustible (C-3)** - Merchandise or materials, including furniture, stock, or equipment, of moderate combustibility.

Examples of occupancies classified as C-3 include food markets, most wholesale and retail occupancies, etc.

Occupancies classified as C-3 in the occupancy classification list may be eligible for C-2 classification, provided that the total square foot area containing combustible material does not exceed 10% of the total square foot area of the occupancy.

Note: For the purpose of the above rule, combustible interior walls or partitions (including combustible finish), racks, shelves, bins, and similar combustible construction shall be considered combustible material.

d. **Free-burning (C-4)** - Merchandise or materials, including furniture, stock, or equipment, which burn freely, constituting an active fuel.

Examples of occupancies classified as C-4 include cotton bales, furniture stock, and wood products.

e. **Rapid burning or flash burning (C-5)** - Merchandise or materials, including furniture, stock, or equipment, which either

(1) burn with a great intensity

(2) spontaneously ignite and are difficult to extinguish

(3) give off flammable or explosive vapors at ordinary temperatures

(4) as a result of an industrial processing, produce large quantities of dust or other finely divided debris subject to flash fire or explosion

Examples of occupancies classified as C-5 include ammunition, excelsior, explosives, mattress manufacturing, matches, and upholsterers.

2. Determining Occupancy Combustibility Classification in Multiple Occupancy Buildings

In sole occupancy buildings or in multiple-occupancy buildings with occupancies subject to a single-occupancy classification, the occupancy classification applicable to the occupant(s) shall also apply to the building.

In multiple-occupancy buildings with occupancies having different occupancy classifications, the occupancy classification applicable to the building shall be determined according to the total floor area (including basements and subbasements) occupied by each occupancy, as follows:

Note: Basement and subbasement areas which are either vacant or used for building services or building maintenance shall be considered C-2 combustibility. Where such areas are used for other purposes, the combustibility class for those areas shall be determined according to the combustibility class of their occupancies.

- C-1 combustibility shall apply ONLY where 95% or more of the total floor area of the building is occupied by C-1 occupants, and there are no C-5 occupancies.

- C-2 combustibility shall apply to buildings which
  a. do not qualify as C-1 above, but where 90% or more of the total floor area of the building is occupied by C-1 and C-2 occupancies; OR
  b. are classified as CSP Construction Class 5 or 6, AND where 80% or more of the total floor area of the building is occupied by C-1 and C-2 occupancies, AND NOT MORE THAN 5% of the total floor area is occupied by C-5 occupancies.

- C-4 combustibility shall apply to any building containing C-4 occupants, where the combined total area occupied by C-4 and C-5 (if any) occupants is 25% OR MORE OF THE TOTAL FLOOR AREA of the building, provided the C-5 occupancies occupy, in total, less than 15% of the total floor area.

- C-5 combustibility shall apply to any building where 15% OR MORE OF THE TOTAL FLOOR AREA is occupied by C-5 occupancies.

- C-3 combustibility shall apply to any building not provided for above.

Occupancy Type Examples

Noncombustible (C-1) - Merchandise or materials, including furniture, stock, or equipment, which in permissible quantities do not in themselves constitute an active fuel for the spread of fire.

C-1 occupancy type examples:

- Asbestos storage
- Clay storage
- Marble storage
- Metal products storage
- Stone storage

Limited-combustible (C-2) - Merchandise or materials, including furniture, stock, or equipment, of low combustibility, with limited concentrations of combustible materials.

C-2 occupancy type examples:

- Airport, bus, railroad terminal
- Apartment
- Artist's studio
- Auto repair shop
- Auto showroom
- Aviary
- Barber shop
- Church
- Cold storage warehouse
- Day care center
- Educational institution
- Gasoline service station
- Greenhouse
- Health club
- Jail
- Library
- Medical laboratory
- Motel
- Museum
- Nursing home
- Office
- Pet grooming shop
- Photographer's studio
- Radio station
- Recreation center
- Rooming house
- Undertaking establishment

Combustible (C-3) - Merchandise or materials, including furniture, stock, or equipment, of moderate combustibility.

C-3 occupancy type examples:

- Auto parts store
- Auto repair training school
- Bakery
- Boat sales (where storage≥15%)
- Book store
- Bowling establishment
- Casino
- Commercial laundry
- Contractor equipment storage
- Department store (where storage≥15%)
- Dry cleaner (no flammable fluids)
- Gift shop (where storage≥15%)
- Hardware store (where storage ≥15%)
- Leather processing
- Municipal storage building
- Nursery sales outlet store
- Pavilion or dance hall
- Pet shop
- Photographic supplies
- Printer
- Restaurant
- Sandwich shop
- Shoe repair
- Sporting goods (where storage ≥15%)
- Supermarket
- Theater
- Vacant building
- Wearing apparel factory (except furs)

Free-burning (C-4) - Merchandise or materials, including furniture, stock, or equipment, which burn freely, constituting an active fuel.

C-4 occupancy type examples:

Aircraft hangers	Packaging and crating
Cabinet making	Paper products manufacturing
Combustible metals (e.g., magnesium)	Petroleum bulk distribution center
Dry cleaner (using flammable fluids)	Stables
Feed store (with > 1/3 ton of hay)	Tire manufacturing
Fur apparel manufacturing	Tire recapping or retreading
Furniture manufacturing	Wax products (candles, etc.)
Kennels	Woodworking shop
Lumber	

Rapid burning or flash burning (C-5) - Merchandise or materials, including furniture, stock, or equipment, which either

(1) burn with a great intensity

(2) spontaneously ignite and are difficult to extinguish

(3) give off flammable or explosive vapors at ordinary temperatures

(4) as a result of an industrial processing, produce large quantities of dust or other finely divided debris subject to flash fire or explosion

C-5 occupancy type examples:

Ammunition	Matches
Feed mill (with > 7 tons of hay & straw)	Mattress factory
Fireworks	Nitrocellulose-based plastics
Flammable compressed gases	Painting with flammables or combustibles
Flammable liquids	Rag storage
Flour mill	Upholstering shop
Highly flammable solids	Waste paper storage

CHAPTER 4

Exposure and Communication Factor ($X_i + P_i$)

The factors developed in this item reflect the influence of adjoining and connected buildings on the needed fire flow. An exposure building has a wall 100 feet or less from a wall of the subject building. A communicating building has a passageway to the subject building. ISO develops a value for the exposure to another building for the side with the highest charge. Likewise, ISO develops a value for a communication to another building for the side with the highest charge. The formula is:

($X_i + P_i$), with a maximum value of 0.60

1. Exposures (Table 330.A)

The factor for X depends upon the construction and length-height value (length of wall in feet, times height in stories) of the exposure building and the distance between facing walls of the subject building and the exposure building. Table 330.A of the FSRS gives the factors. When there is no exposure on a side, $X_i = 0$.

a. Construction of facing wall of exposure – ISO considers the wall construction of the exposure. The exposure factor used considers only the side of the subject building with the highest factor.
b. Length-height value of the facing wall of the exposure – ISO determines the length-height value of the facing wall of the exposure by multiplying the length of the facing wall of the exposure in feet by the height of the exposure in stories. ISO considers buildings five stories or more in height as five stories. Each 15 feet or fraction thereof equals one story.
c. Exposure distance – The distance in feet from the subject building to the exposure building, measured to the nearest foot, between the nearest points of the buildings. Where either the subject building or the exposure is at a diagonal to the other building, ISO increases the exposure distance by 10 feet.
d. Construction of facing wall of subject building – The wall construction of the subject building.

2. Exposure exceptions

The following conditions rule out exposure charges from adjacent buildings:

- Buildings rated sprinklered (See Chapter 6, "Determining Recognition of Automatic Sprinkler Systems.")
- Buildings rated as habitational, including their appurtenant outbuildings
- Buildings of Construction Class 5 or 6
- Buildings of Construction Class 3 or 4 with C-1 or C-2 contents combustibility class applicable to the building

TABLE 330.A FACTOR FOR EXPOSURE (X_i)						
Construction of Facing Wall of Subject Building	**Distance in Feet to the Exposure Building**	**Length-Height of Facing Wall of Exposure Building**	**Construction of Facing Wall of Exposure Building Classes**			
			1,3	**2, 4, 5, & 6**		
				Unprotected Openings	**Semiprotected Openings (wired glass or outside open sprinklers)**	**Blank Wall**
Frame, Metal or Masonry with Openings	0 – 10	1-100	0.22	0.21	0.16	0
		101-200	0.23	0.22	0.17	0
		201-300	0.24	0.23	0.18	0
		301-400	0.25	0.24	0.19	0
		Over 400	0.25	0.25	0.20	0
	11 - 30	1-100	0.17	0.15	0.11	0
		101-200	0.18	0.16	0.12	0
		201-300	0.19	0.18	0.14	0
		301-400	0.20	0.19	0.15	0
		Over 400	0.20	0.19	0.15	0
	31 - 60	1-100	0.12	0.10	0.07	0
		101-200	0.13	0.11	0.08	0
		201-300	0.14	0.13	0.10	0
		301-400	0.15	0.14	0.11	0
		Over 400	0.15	0.15	0.12	0
	61 - 100	1-100	0.08	0.06	0.04	0
		101-200	0.08	0.07	0.05	0
		201-300	0.09	0.08	0.06	0
		301-400	0.10	0.09	0.07	0
		Over 400	0.10	0.10	0.08	0
Blank Masonry Wall	Facing wall of the exposure building is higher than the subject building. Use the above table EXCEPT use only the length-height of the facing wall of the exposure building ABOVE the height of the facing wall of the subject building. Buildings five stories or over in height, consider as five stories.					
	When the height of the facing wall of the exposure building is the same or lower than the height of the facing wall of the subject building, $X_i = 0$.					

3. Communications (Table 330.B)

The factor for P depends upon the protection for communicating party-wall openings and the length and construction of communications between fire divisions. Table 330.B of the FSRS gives the factors. When more than one communication type exists in any one side wall, apply only the largest factor P for that side. When there is no communication on a side, $P_i = 0$.

a. Communications with combustible construction - An open passageway must be open on top or at least one side.
b. Fire-resistive, noncombustible, or slow burning communications – ISO considers the type of construction found within the passageway.
c. Description of protection of passageway openings – The protection for the openings to the passageway by Class A or B, single or double fire door.

4. Communications Exceptions

The following conditions rule out charges for communication with other separately rated buildings:

- Buildings rated sprinklered (See Chapter 6, "Determining Recognition of Automatic Sprinkler Systems.")
- Buildings rated as habitational, including their appurtenant outbuildings
- Buildings of Construction Class 5 or 6
- Buildings of Construction Class 3 or 4 with C-1 or C-2 contents combustibility class applicable to the building

TABLE 330.B FACTOR FOR COMMUNICATIONS (P_i)

	Fire-resistive, Noncombustible, or Slow burning Communications				Communications with Combustible Construction					
	Open	Enclosed			Open			Enclosed		
Description of Protection of Passageway Openings	Any Length	10 Ft. or Less	11 Ft. to 20 Ft.	21 Ft. to 50 Ft. +	10 Ft. or Less	11 Ft. to 20 Ft.	21 Ft. to 50 Ft. +	10 Ft. or Less	11 Ft. to 20 Ft.	21 Ft. to 50 Ft. +
Unprotected	0	++	0.30	0.20	0.30	0.20	0.10	++	++	0.30
Single Class A Fire Door at One End of Passageway	0	0.20	0.10	0	0.20	0.15	0	0.30	0.20	0.10
Single Class B Fire Door at One End of Passageway	0	0.30	0.20	0.10	0.25	0.20	0.10	0.35	0.25	0.15
Single Class A Fire Door at Each End or Double Class A Fire Doors at One End of Passageway	0	0	0	0	0	0	0	0	0	0
Single Class B Fire Door at Each End or Double Class B Fire Doors at One End of Passageway	0	0.10	0.05	0	0	0	0	0.15	0.10	0

\+ For over 50 feet, $P_i = 0$.

++ For unprotected passageways of this length, consider the 2 buildings as a single fire division

Note: When a party wall has communicating openings protected by a single automatic or self-closing Class B fire door, it qualifies as a division wall for reduction of area. Where communications are protected by a recognized water curtain, the value of P_i is 0.

CHAPTER 5

Separate Classifications of Buildings

ISO classifies the following as separate buildings:

a. Buildings separated by two independent walls, with no common or continuous combustible roof, that meet all of the requirements under either (1), (2), or (3) below.

(1) Where there is no communication between the two buildings

(2) Where the independent walls have communicating passageways constructed and protected as follows:

(a) A passageway open on the top or at least one side

(b) An enclosed passageway of glass, noncombustible, slow burning, or fire-resistive construction more than 10 feet in length (or, if combustible, more than 20 feet in length)

(c) An enclosed passageway of glass, noncombustible, slow burning or fire-resistive construction 10 feet or less in length (or, if combustible, 20 feet or less in length), provided that any such passageway is protected on at least one end by an automatic or self-closing labeled Class A fire door installed in a masonry wall section in accordance with standards

Where one or both of the communicating buildings qualify for sprinkler credit under ISO's Specific Commercial Property Evaluation Schedule (see Chapter 6, "Determining Recognition for Automatic Sprinkler Systems"), the above rules (including the Class A door requirement) apply. However, where acceptable sprinklers are installed over the communication in a masonry wall in the sprinklered building, such sprinklers are acceptable in lieu of the Class A door.

NOTE: A passageway is a structure providing communication between two otherwise separate buildings. Passageways must not contain contents. Enclosed passageways must not be more than 15 feet in width (least dimension). Passageways open on the top or at least one side shall not be more than 25 feet in width (least dimension). Any communicating structure that contains contents, or is more than 15 feet in width if enclosed, or is more than 25 feet in width if open, is a structure subject to all of the requirements regarding separate classification under this item.

(3) Where the independent walls have no communications, or where the two buildings have passageways constructed and protected as provided above, ISO classifies each building separately, with appropriate charges for exposure and communication (if any) under Chapter 4, "Exposure and Communication Factor."

b. Buildings separated by one continuous masonry party wall conforming to all of the following requirements:

(1) The party wall is constructed of brick or reinforced concrete not less than 6 inches in thickness; OR reinforced concrete building units (or filled blocks) with a fire-resistance rating of not less than two hours and not less than 6 inches in thickness; OR other masonry materials not less than 8 inches in thickness.

(2) The party wall rises to the underside of AND is in direct contact with a fire-resistive, masonry, or noncombustible roof; OR pierces a slow burning or combustible roof. In addition, no combustible material extends across any parapet that pierces a slow burning or combustible roof.

(3) The party wall extends to the interior surface of AND is in direct contact with a fire-resistive, masonry, or noncombustible wall OR pierces a slow burning or combustible wall. In addition, combustible cornices, canopies, or other combustible material do not extend across the party wall.

(4) All load bearing structural metal members in the party wall are protected metal (not less than one hour).

(5) At least a single automatic or self-closing labeled Class A fire door protects all access communications through the party wall. Where one or both of the communicating buildings qualify for sprinkler credit under ISO's Specific Commercial Property Evaluation Schedule (see Chapter 6, "Determining Recognition for Automatic Sprinkler Systems"), acceptable sprinklers installed over the communications are acceptable in lieu of the Class A door.

A single, labeled 1½ hour damper protects all communications caused by air conditioning and/or heating ducts piercing a party wall.

Note 1: Where unprotected metal, noncombustible, or combustible wall, floor, or roof supports are continuous through a masonry wall, such a wall is not be acceptable for separate classification.

Note 2: ISO ignores the usual openings provided for common utilities when their size is limited to that necessary to provide for normal clearances and vibration; such openings are the rule rather than the exception, and their effect is included in the overall analysis. ISO also ignores openings protected by one-hour listed firestop systems. ISO may also ignore abnormally large openings when mortar or other masonry material fills the excessive clearances.

ISO classifies all buildings not eligible for separate classification under a. or b. as a single building.

CHAPTER 6

Determining Recognition of Automatic Sprinkler Systems

ISO uses the Specific Commercial Property Evaluation Schedule (SCOPES) to evaluate sprinkler protection of a property. The criteria within the SCOPES manual permit determination of the percentage of credit for the sprinkler protection. For ISO to rate and code the property as a sprinklered property, it must score at least 10 points (out of the initial 100 points available) in ISO's automatic sprinkler grading.

A grading of 100 points represents the value of a two-source (water supply) wet-pipe or dry-pipe installation, standard in all respects, where no unusual conditions of construction or occupancy exist. In addition, the system must be installed and maintained as outlined in the National Fire Protection Association (NFPA) Standard 13 *Standard for the Installation of Sprinkler Systems*, NFPA 25 *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, and other NFPA standards as appropriate.

ISO classifies a property as a sprinklered property if it meets the following minimum conditions:

- The sprinklered building has assured maintenance. Shut down, idle, or vacant structures have acceptable watchman or waterflow and control-valve supervision (remote or central station) or a caretaker. A caretaker is a responsible person who visits the premises not less than weekly.
- The usable unsprinklered area does not exceed:
    a) 25% of the total area in buildings with an Occupancy Combustibility Class of C-1
    b) 20% of the total area in buildings with an Occupancy Combustibility Class of C-2 or C-3
    c) 10,000 square feet or 15% of the total area in buildings with an Occupancy Combustibility Class of C-4
    d) 5,000 square feet or 10% of the total square foot area in buildings with an Occupancy Combustibility Class of C-5

    See Chapter 3, "Occupancy Factor" for definitions of the occupancy combustibility classes.

    Note: the area limitations above do not include unused, unsprinklered areas such as underfloor areas, attic areas, etc. However, ISO classifies usable vacant areas as used areas. ISO considers areas with obstructed sprinkler protection as unsprinklered.
- Installation has evidence of flushing and hydrostatic tests of both the underground and overhead piping in accordance with NFPA Standard 13.
- A full flow main drain test has been witnessed within the last 48 months.
- Dry-pipe installations have evidence of a satisfactory or partly satisfactory dry-pipe trip test conducted within the last 48 months.
- Fire-pump installations have evidence and results of a fire-pump test conducted within the last 48 months.

Where all 1- and 2-family dwellings in an entire subdivision or other definable area are protected with a residential sprinkler system meeting the requirements of NFPA 13D, *Standard for Sprinkler Systems in One- and Two- Family Dwellings and Mobile Homes*, a reduction in the needed fire flow may be appropriate. Where evidence is available to document the installation of these systems, the needed fire flow for such installations may be reduced to 500 gpm at 20 psi. No allowance will be made for

individual 1- and 2-family dwellings provided with residential sprinkler systems when interspersed with similar non-sprinklered 1- and 2-family dwellings.

Where residential occupancies up to and including four stories in height are protected with an automatic fire sprinkler system installed in accordance with NFPA 13R, *Standard for the Installation of Sprinkler Systems in residential Occupancies up to and including Four Stories in Height*, a reduction of the needed fire flow may be appropriate. Where evidence is available from local fire or building officials to document the installation, approval, testing and maintenance of these systems as defined in Chapter 6 of the Standard, the needed fire flow shall be the greater of the base of riser demand or 1,000 gpm at 20 psi, whichever, is greater, except when the calculated nonsprinklered needed fire flow is less than 1,000 gpm, the lesser demand should be used. Residential occupancies are as specified in NFPA 101 *Life Safety Code*® include (1) Apartment buildings, (2) Lodging and rooming houses, (3) Board and care facilities, and (4) Hotels, motels, and dormitories.

CHAPTER 7

Other Considerations for Determining Needed Fire Flow (NFF_i)

- When the subject building or exposure buildings have a wood-shingle roof covering and ISO determines that the roof can contribute to spreading fires, ISO adds 500 gpm to the needed fire flow.
- The maximum needed fire flow is 12,000 gpm. The minimum is 500 gpm.
- ISO rounds the final calculation of needed fire flow to the nearest 250 gpm if less than 2,500 gpm and to the nearest 500 gpm if greater than 2,500 gpm.
- For 1- and 2-family dwellings not exceeding 2 stories in height, ISO uses the following needed fire flows:

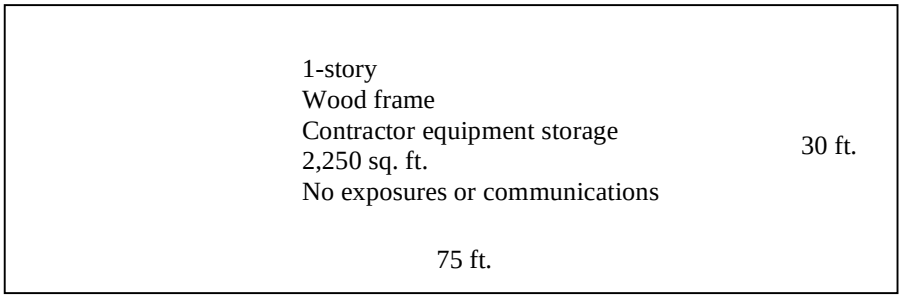
DISTANCE BETWEEN BUILDINGS	NEEDED FIRE FLOW
More than 100'	500 gpm
31-100'	750 gpm
11-30'	1,000 gpm
10' or less	1,500 gpm

- For other types of habitational buildings, the maximum needed fire flow is 3,500 gpm.

CHAPTER 8

Examples

Example 1.



CONSTRUCTION TYPE

Construction Class 1 (wood frame construction)
Construction type coefficient (F) = 1.5
Effective area (A_i) = 2,250

$C_i = 18F\ (A_i)^{0.5}$
$C_i = 18(1.5)\ (2,250)^{0.5}$
$C_i = 27\ (47.43)$
$C_i = 1,280.72$
C_i = 1,250 (rounded to the nearest 250 gpm)

OCCUPANCY TYPE

Contractor equipment storage
Occupancy combustibility class C-3 (Combustible)
Occupancy factor (O_i) = 1.00

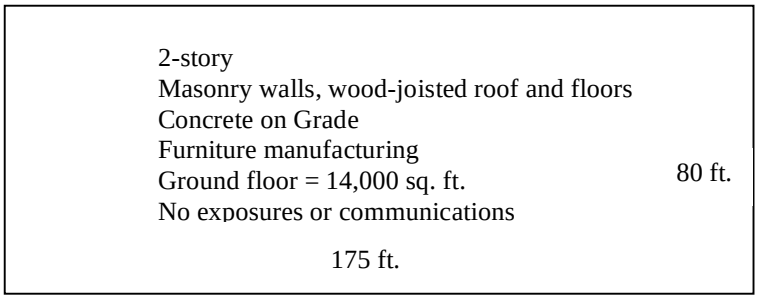
EXPOSURES AND COMMUNICATIONS

None
Exposure and communication factor $(X + P)_i = 0.00$

CALCULATION

$NFF_i = (C_i)(O_i)[1.0+(X+P)_i]$
$NFF_i = (1,250)(1.00)[1.0+(0.00)]$
$NFF_i = (1,250)(1.00)(1.00)$
NFF_i = 1,250 gpm

Example 2



CONSTRUCTION TYPE

Construction Class 2 (joisted masonry construction)
Construction type coefficient (F) = 1.0
Effective area (A_i) = 21,000 (ground floor + ½ of second floor area)

$C_i = 18F\ (A_i)^{0.5}$
$C_i = 18(1.0)\ (21{,}000)^{0.5}$
$C_i = 18\ (144.91)$
$C_i = 2{,}608.45$
C_i = 2,500 (rounded to the nearest 250 gpm)

OCCUPANCY TYPE

Furniture manufacturing
Occupancy combustibility class C-4 (free-burning)
Occupancy factor (O_i) = 1.15

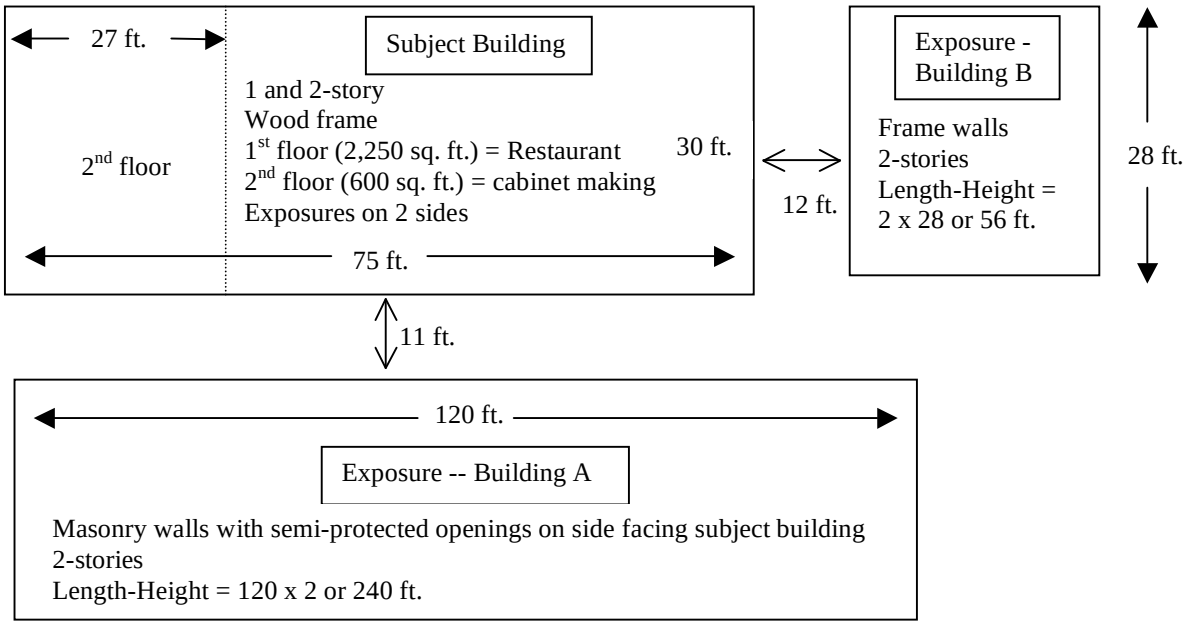
EXPOSURES AND COMMUNICATIONS

None
Exposure and communication factor $(X + P)_i = 0.00$

CALCULATION

$NFF_i = (C_i)(O_i)[1.0+(X+P)]$
$NFF_i = (2{,}500)(1.15)[1+(0.00)]$
$NFF_i = (2{,}500)(1.15)(1.00)$
$NFF_i = 2{,}875$
NFF_i = 3,000 gpm (because it is greater than 2,500 ISO rounds the NFF to the nearest 500 gpm)

Example 3



CONSTRUCTION TYPE

Construction Class 1 (wood-frame construction)
Construction type coefficient (F) = 1.5
Effective area (A_i) = 2,655 (ground floor + ½ of second floor area)

$C_i = 18F\ (A_i)^{0.5}$
$C_i = 18(1.5)\ (2{,}655)^{0.5}$
$C_i = 27(51.53)$
$C_i = 1{,}391.31$
C_i = 1,500 (rounded to the nearest 250 gpm)

OCCUPANCY TYPE

Cabinet making (occupies over 25% of the total floor of the building)
Occupancy combustibility class C-4 (free-burning)
Occupancy factor (O_i) = 1.15

EXPOSURES AND COMMUNICATIONS

Exposure charge for Building A = 0.14
Exposure charge for Building B = 0.17
The building with the highest charge is Building B.
Exposure factor (X_i) = 0.17
Communication (P_i) charge = none
Exposure and communication factor $(X + P)_i$ = 0.17

CALCULATION

$NFF_i = (C)(O)[1.0+(X+P)]$
$NFF_i = (1{,}500)(1.15)[1+(0.17)]$
$NFF_i = (1{,}500)(1.15)(1.17)$
$NFF_i = 2{,}018$
NFF_i = 2,000 gpm

APPENDIX A

Needed Fire Flow/Effective Area Table

TYPE OF CONSTRUCTION FACTOR AS DETERMINED BY RANGE IN EFFECTIVE AREA

Class	1		2		3,4		5,6	
Factor (F)	1.5		1.0		0.8		0.6	
	Effective Area (A_i)		Effective Area (A_i)		Effective Area (A_i)		Effective Area (A_i)	
(C_i)	At Least	Not Over	At Least	Not Over	At Least	Not Over	At Least	Not Over
500	0	535	0	1,205	0	1,883	0	3,348
750	536	1,050	1,206	2,363	1,884	3,692	3,349	6,564
1,000	1,051	1,736	2,364	3,906	3,693	6,103	6,565	10,850
1,250	1,737	2,593	3,907	5,835	6,104	9,117	10,851	16,209
1,500	2,594	3,622	5,836	8,150	9,118	12,734	16,210	22,639
1,750	3,623	4,822	8,151	10,852	12,735	16,954	22,640	30,140
2,000	4,823	6,194	10,853	13,937	16,955	21,776	30,141	38,714
2,250	6,195	7,737	13,938	17,409	21,777	27,202	38,715	48,359
2,500	7,738	9,452	17,410	21,267	27,203	33,230	48,360	59,076
2,750	9,453	11,338	21,268	25,511	33,231	39,861	59,077	70,864
3,000	11,339	13,395	25,512	30,140	39,862	47,095	70,865	83,724
3,250	13,396	15,624	30,141	35,156	47,096	54,931	83,725	97,656
3,500	15,625	18,025	35,157	40,557	54,932	63,374	97,657	112,659
3,750	18,026	20,597	40,558	46,344	63,375	72,413	112,660	128,734
4,000	20,598	23,341	46,345	52,517	72,414	82,058	128,735	145,881
4,250	23,342	26,256	52,518	59,076	82,059	92,306	145,882	164,100
4,500	26,257	29,342	59,077	66,020	92,307	103,156	164,101	183,390
4,750	29,343	32,600	66,021	73,350	103,157	114,610	183,391	203,751
5,000	32,601	36,029	73,351	81,066	114,611	126,666	203,752	225,185
5,250	36,030	39,630	81,067	89,168	126,667	139,325	225,186	247,690
5,500	39,631	43,402	89,169	97,656	139,326	152,587	247,691	271,267
5,750	43,403	47,346	97,657	106,529	152,588	166,452	271,268	295,915
6,000	47,347	51,461	106,530	115,788	166,453		295,916	
6,250	51,462	55,748	115,789	125,434				
6,500	55,749	60,206	125,435	135,464				
6,750	60,207	64,836	135,465	145,881				
7,000	64,837	69,637	145,882	156,684				
7,250	69,638	74,609	156,685	167,872				
7,500	74,610	79,753	167,873	179,446				
7,750	79,754	85,069	179,447	191,406				
8,000	85,070		191,407					

