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HCRRA

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struction, and 0.6 for fire resistive construction. Interpolation is used if the type of construction does not fall into one of the four categories.

To the result obtained by application of the formula, a credit or surcharge is applied for occupancy, a credit for complete automatic sprinkler protection when provided, and a surcharge for exposures.

The maximum fire flow required is 12,000 gpm for any one location. The practical reason for this top figure is that manual fire fighting methods using men with hose streams and heavy stream appliances are not likely to develop a larger supply considering the general arrangement of buildings and the availability of hydrants. However, the possibility of a second simultaneous fire in the largest cities is considered, for which an allowance of 2,000 to 8,000 gpm additional may be made. This sets a practical maximum fire flow demand of 20,000 gpm for any city.

For groupings of one-family and small two-family dwellings not exceeding two stories in height, the short method of determining required fire flow given in Table 11-1B may

Table 11-1B. Fire Flows for Groups of Dwellings

Exposure Distances Feet	Suggested Required Fire Flow* Gallons per minute
Over 100	500
31 to 100	750-1,000
11 to 30	1,000-1,500
10 or less	1,500-2,000†

* Where wood shingles could contribute to spreading fires, add 500 gpm.

† If the buildings are continuous use a minimum of 2,500 gpm.

be used. The required fire flow should be available with consumption at the maximum daily rate (see Part B of this chapter). The number of hours during which the required fire flow should be available varies from 2 to 10 hours as indicated in Table 11-1C.

Table 11-1C. Duration of Required Fire Flow (U.S. Gallons)

Required Fire Flow			Required Fire Flow		
Gallons per minute	Million gallons per day	Duration hours	Gallons per minute	Million gallons per day	Duration hours
1,000	1.44	2	4,500	6.48	4
1,250	1.80	2	5,000	7.20	5
1,500	2.16	2	5,500	7.92	5
1,750	2.52	2	6,000	8.64	6
2,000	2.88	2	7,000	10.08	7
2,250	3.24	2	8,000	11.52	8
2,500	3.60	2	9,000	12.96	9
3,000	4.32	3	10,000	14.40	10
3,500	5.04	3	11,000	15.84	10
4,000	5.76	4	12,000	17.28	10

There are fires where quantities of water in excess of the required fire flow are used. Water supplies of 50,000 gpm or greater have been used in fire suppression, but to design systems capable of delivering flows of that magnitude in the average community for a possible unusual situation is not good economic practice.

F. Adequacy and Reliability of Supply

The adequacy of any given water system can be determined by engineering estimates. The source, including storage facilities in the distribution system, must be sufficient to furnish all the water that combined fire and domestic needs may call for at any one time. Arrangement of the supply works and details of the pumping facilities may limit the adequacy of the supply or affect its reliability. The various components of a water system are discussed in other chapters of this Section.

In a "pumping" system, a common arrangement is to have one set of pumps that takes suction from wells or from a river, lake, or other body of water. If the water does not have to be filtered, the pumps may discharge directly into the distribution system. Where filtration is necessary, the pumps take suction from the primary source and discharge the water into settling reservoirs and filter beds. After processing, the water flows to clear water reservoir from which a second set of pumps takes suction and discharges the water directly into the water main system. Unfortunately, failure of any part of the equipment may put the supply works out of commission. This is usually taken care of by duplication of units and by arrangement of the plant so as to facilitate repairs.

In considering the reliability of the supply works, features taken into account include: minimum yield, frequency and duration of droughts, condition of intakes, earthquakes, floods, forest fires, ice formations, silting up or shifting of river channels, and absence of watchmen where needed or the possibility of physical injury to them. Reliability is also affected by reservoirs out of service for cleaning and interdependence of parts of waterworks. The condition, arrangement, and reliability of individual units of plant equipment, such as pumps, engines, generators, electric motors, fuel supply, electric transmission facilities and similar items are also factors. Pumping stations of combustible construction are subject to destruction by fire unless equipped with automatic sprinklers.

Duplication of pumping units and storage facilities, and arrangement of mains and distributors so that water may be supplied to them from more than one direction, are measures that can assure continuous operation. The importance of duplicate facilities is shown by the frequency of their use.

G. Future Requirements for Determining Fire Flow

The amount of water needed to control and extinguish a fire in a given property cannot be established currently in precise terms. Differences in fire fighting tactics and variations in conditions which may exist at the time of a fire, as compared with the conditions existing when fire flow requirements were established, are variables that cannot be adequately measured at the present time. Better fire experience data basis should make it possible to tailor fire flows more specifically to conditions that might be expected at the time of a fire. Better analysis may indicate a need to increase fire flow beyond what is presently required, or it may result in a water system design based upon a balance between the risk involved and the economics of maintaining the water system.

The Role of Codes and Ordinances

Fire prevention codes can effectively limit hazards and ignition sources within buildings which in turn will not only help to limit the number of fires, but the size of fires through

the control of combustibles in a fire area. A good building code further reduces the chance for a serious fire by requiring construction materials and building assemblies which will contain a developing fire to a given area. These two factors alone will reduce considerably the amount of water needed for fire fighting. Zoning ordinances that establish distances between properties can be effective in controlling exposure situations.

The Role of Fire Detection and Extinguishing Systems

The increased use of automatic extinguishing systems, whether they use water or some other agent, will affect the quantities of water required. However, until more widespread use is made of early warning systems and automatic extinguishing systems, it will not be possible to equate the effect of these systems to required fire flow. Consideration is now given in the *ISO Guide for Determination of Required Fire Flow* for the presence of automatic sprinklers.

Water supply requirements are just one factor in a complex system that in total determines what the potential for a fire is, how extensive the fire will be, and the measures needed to suppress it. Research will someday equate all these factors and permit establishing fire flows on the basis of sound, thoroughly researched, and documented principles.

SI Units

The following conversion factors are given as a convenience in converting to SI units the English units used in this chapter.

1 ft	=	.305 m
1 psi	=	6894.757 Pa
1 gpm	=	3.785 litres/m ³

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⁴Freeman, John R., "The Arrangement of Hydrants and Water Pipes for the Protection of a City Against Fire," *Journal of the New England Water Works Association*, Vol. 7, 1892, p. 49.

⁵Metcalf, L., Huichling, E., and Hawley, W. C., "Some Fundamental Considerations in the Determination of a Reasonable Return for Public Fire Hydrant Service," *Proceedings of the American Water Works Association*, Vol. 31, 1911, p. 55.

⁶*Grading Schedule for Municipal Fire Protection*, Insurance Services Office, New York, 1974.

⁷"Fundamental Considerations in Rates and Rate Structures for Water and Sewage Works," a joint report of Committees of the American Society of Civil Engineers and the Section of Municipal Law of the American Bar Association and of Representatives of the American Water Works Association, National Association of Railroad and Utilities Commissioners, Municipal Finance Officers Association, Federation of Sewage Works Association, American Public Works Association, and Investment Bankers Association of America (reprinted from *Ohio State Law Journal*, Spring, 1951), ASCE Bulletin No. 2, American Society of Civil Engineers, New York, 1951. See also parts of the report presented in "Water Works Revenue for Fire Protection," *NFPA Quarterly*, Vol. 45, No. 1, July 1952, p. 93.

⁸Hutson, A. C., "Water Works Requirements for Fire Protection," *Journal of the American Water Works Association*, Vol. 40, No. 2, Sept. 1948, p. 936. Also reprinted in *Special Interest Bulletin No. 266*, National Board of Fire Underwriters (now American Insurance Association), New York, May 4, 1948.

⁹*Guide for Determination of Required Fire Flow*, Insurance Services Office, New York, June, 1972.

Additional Readings

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HOW THE ISO ESTIMATES FIRE-FLOW REQUIREMENTS

Insurance Services Office

Guide for Determination Of Required Fire Flow

1. An estimate of the fire flow required for a given fire area may be determined by the formula:

$$F = 18 C (A)^{0.5}$$

where

F = the required fire flow in gpm

C = coefficient related to the type of construction

C = 1.5 for wood frame construction

= 1.0 for ordinary construction

= 0.8 for noncombustible construction

= 0.6 for fire-resistive construction

Note: For types of construction that do not fall within the categories given, use a coefficient reflecting the differences. Such coefficients shall not be greater than 1.5 nor less than 0.6 and may be determined by interpolation.

A = the total floor area (including all stories, but excluding basements) in the building being considered. For fire-resistive buildings consider the 6 largest successive floor areas if the vertical openings are unprotected; if the vertical openings are properly protected, consider only the 3 largest successive floor areas.

The fire flow as determined by the above shall not exceed 8,000 gpm for wood frame construction

Source: Insurance Services Office, Guide for Determination of Required Fire Flow, New York, June 1972.

8,000 gpm for ordinary construction
6,000 gpm for noncombustible construction
6,000 gpm for fire-resistive construction
except that for a normal 1-story building of any type of
construction the fire flow shall not exceed 6,000 gpm.

The fire flow shall not be less than 500 gpm.

For 1-family and small 2-family dwellings not exceeding 2 stories
in height see note 10.

2. The value obtained in No. 1 above may be reduced by up
to 25% credit for occupancies having a light fire loading or may
be increased by up to a 25% surcharge for occupancies have a high
fire loading. As a guide for determining low or high fire loadings,
lists of light hazard and extra hazard occupancies as given in
National Fire Protection Association Standard No. 13 are included
in the Appendix.

The fire flow shall not be less than 500 gpm.

3. The value obtained in No. 2 above may be reduced by up
to 25% credit for complete automatic sprinkler protection. For
building of fire-resistive or noncombustible construction having
a light fire loading the reduction may be up to 50%. The percentage
reduction that can be made for an automatic sprinkler system will
depend upon the extent to which the automatic sprinkler system is

Source: Insurance Services Office, Guide for Determination of
Required Fire Flow, New York, June 1972.

judged to reduce the probability of fires spreading within and beyond the fire area. Normally this reduction will not exceed 25 percent.

4. To the value obtained in No. 2 above a surcharge should be added for structures exposed within 150 feet by the fire area under consideration. The degree of this charge shall depend upon the height, area, and construction of the building(s) being exposed, the separation, openings in the exposed buildings(s), the length of exposure, the provision of automatic sprinklers and/or outside sprinklers in the building(s) exposed, the occupancy of the exposed building(s), and the effect of hillside locations on the possible spread of fire.

The charge for any one side generally should not exceed the following limits for the separations shown:

<u>Separation</u>	<u>Charge</u>
0-10 feet	25%
11-30	20
31-60	15
61-100	10
101-150	5

The total percentage surcharge shall be the sum of the charges for all sides, but shall not exceed 75%.

5. The value obtained in No. 2 above is reduced by the

Source: Insurance Services Office, Guide for Determination of Required Fire Flow, New York, June 1972.

credit (if any) determined in No. 3 above and increased by the surcharge (if any) determined in No. 4 above.

The fire flow shall not exceed 12,000 gpm nor be less than 500 gpm.

- Note 1: The guide is not expected to necessarily provide an adequate value for lumber yards, petroleum storage, refineries, grain elevators, and large chemical plants but may indicate a minimum value for these hazards.
- Note 2: Judgment must be used for business, industrial, and other occupancies not specifically mentioned.
- Note 3: Consideration should be given to the configuration of the building(s) being considered and to the fire department accessibility.
- Note 4: Wood Frame structures separated by less than 10 feet shall be considered as one fire area.
- Note 5: Party Walls: Normally an unpierced party (common) wall may warrant up to a 10% exposure charge.
- Note 6: High one-story buildings: When a building is stated as 1 - 2, or more stories, the number of stories to be used in the formula depends upon the use being made of the building. For example consider a 1 - 3-story building. If the building is being used for high-piled stock, or for rack storage, an occupancy surcharge may be warranted. However, if the building is being used for steel fabrication and the extra height is provided only to facilitate movement of objects by a crane, the building would probably be considered as a 1-story building and an occupancy credit may be warranted.
- Note 7: If a building is exposed within 150 feet, normally some surcharge for exposure will be made.
- Note 8: Where wood shingle roofs could contribute to spreading fires, add 500 gpm.
- Note 9: Any noncombustible building is considered to warrant an 0.8 coefficient.

Source: Insurance Services Office, Guide for Determination of Required Fire Flow, New York, June 1972.

Note 10: Dwellings: For groupings of 1-family and small 2-family dwellings not exceeding 2 stories in height, the following short method may be used. (For other residential buildings, the regular method should be used.)

<u>Exposure distances</u>	<u>Suggested required fire flow</u>
Over 100'	500 gpm
31-100'	750-1000
11-30'	1000-1500
10' or less	1500-2000*

*If the buildings are continuous, use a minimum of 2500 gpm.

Also consider Note 8.

Outline of Procedure

- A. Determine the type of construction.
- B. Determine the ground floor area.
- C. Determine the height in stories.
- D. Using tables in Appendix, determine required fire flow to the nearest 250 gpm.
- E. Determine the credit or surcharge for occupancy and apply to the value obtained in D above. Do not round off the answer.
- F. Determine the credit, if any, for automatic sprinkler protection. Do not round off the value.
- G. Determine the total surcharge for exposures. Do not round off the value.
- H. To the answer obtained in E, subtract the value obtained in F and add the value obtained in G.

Source: Insurance Services Office, Guide for Determination of Required Fire Flow, New York, June 1972.

Round off the final answer to the nearest 250 gpm if less than 2500 gpm and to the nearest 500 gpm if greater than 2500 gpm.

Use of Tables (Steps A, B, C, D)

The tables use the GROUND AREA of the building and the height of the building in stories. Using the table corresponding to the type of construction, look under the number of stories and locate the ground area of the building(s) being considered between two ground areas given in the table. The corresponding fire flow is found in the left column.

EXAMPLES:

- a. Given: A 3-story building of ordinary construction of 7300 square feet (ground area). Using the table C = 1.0, in the 3-story column, 7300 square feet falls between 7100 and 8500 square feet and the corresponding fire flow is 2750 gpm.
- b. Given: A 3-story building of ordinary construction of 7300 square feet (ground area) communicating to a 5-story building of ordinary construction of 9700 square feet (ground area) for a total ground area of 17,000 square feet. Determine the total floor area which equals $3 (7300) + 5 (9700) = 70,400$ square feet. Using the table C = 1.0, under the one story column for 70,400 square feet the corresponding fire flow is 4750 gpm.
- c. Given: A 3-story wood frame building of 7300 square feet (ground area) communicating with a 5-story building of ordinary construction of 9700 square feet (ground area) for a total ground area of 17,000 square feet.

Determine the total floor area for each type of construction and for the fire area which is $3 (7300) = 21,900$ square feet of wood frame construction, $5 (9700) =$

Source: Insurance Services Office, Guide for Determination of Required Fire Flow, New York, June 1972.

48,500 square feet of ordinary construction, and a total area of 70,400 square feet with 31% being of wood frame construction and 69% being of ordinary construction. Under the one-story column in the wood frame construction table ($C = 1.5$), an area of 70,400 square feet has a corresponding fire flow of 7250 gpm. Similarly, under the one-story column in the ordinary construction table ($C = 1.0$), an area of 70,400 square feet has a corresponding fire flow of 4750 gpm. In this case, the fire flow will be 31% (7250) + 69% (4750) = 2250 + 5530 gpm or, to the nearest 250 gpm, = 5500 gpm.

- d. Given: A 2-story building of ordinary construction of 105,000 square feet (ground area) communicates with a 1-story building of noncombustible construction of 80,000 square feet (ground area). Normally the required fire flow would be determined by proportioning as in "c" above. This would result in a required fire flow of 7460 gpm, or 7500 gpm. However, it is to be noted that the total area of the 2-story building alone results in a fire flow of 8,000 gpm and, of course, the logical answer would be 8,000 gpm. Any time the total area results in the use of an upper limit for fire flow, the possibility of a portion of the fire area justifying the upper limit must be investigated.
- e. Given: A normal 1-story building of ordinary construction of 210,000 square feet (ground area). The table gives a required fire flow of 8,000 gpm, however, since this is a normal 1-story building, the maximum fire flow is 6,000 gpm.
- f. Given: A normal 1-story building of ordinary construction of 80,000 square feet communicates with a normal 1-story building of noncombustible construction of 85,000 square feet. Normally the required fire flow would be determined by proportioning as in "c" above. This would result in a required fire flow of 6480 gpm, or 6500 gpm. However, since these are normal 1-story buildings the maximum fire flow is 6,000 gpm.

Source: Insurance Services Office, Guide for Determination of Required Fire Flow. New York, June 1972.

A P P E N D I X

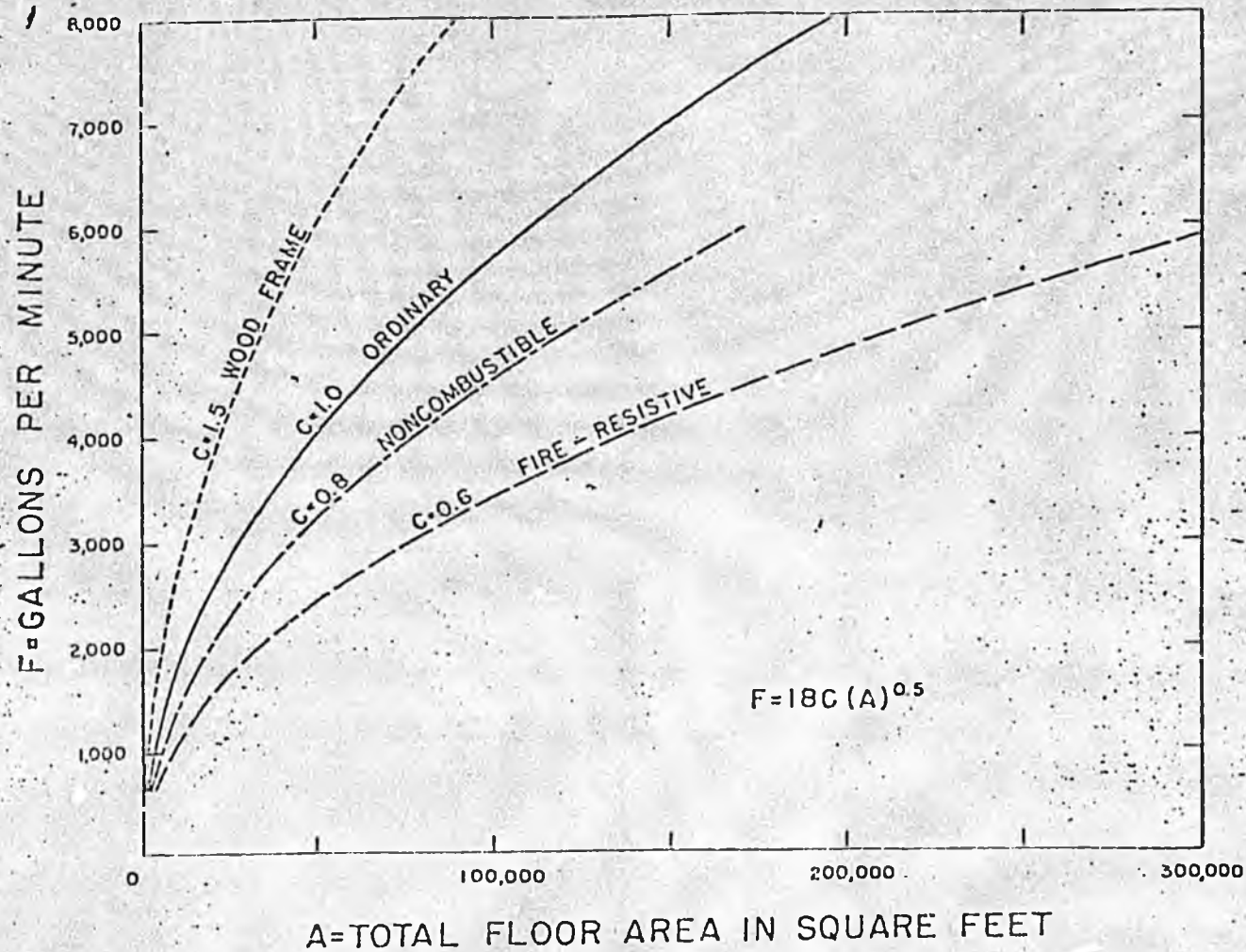
NFPA No. 13-1971, Paragraph 1311. Light Hazard Occupancies:

Apartments	Libraries, except Large Stack
Asylums	Room Areas
Churches	Museums
Clubs	Nursing, Convalescent & Care Homes
Colleges & Universities	Office Buildings
Dormitories	Prisons
Dwellings	Public Buildings
Hospitals	Rooming Houses
Hotels	Schools
Institutions	Tenements

NFPA No. 13-1971, Paragraph 1331. Extra Hazard Occupancies:

Aircraft Hangers
Chemical Works - Extra hazard
Cotton Picker and Opening Operations
Explosives and Pyrotechnics Manufacturing
High Piled Combustible Storage in excess of 21 feet high
Linoleum and Oilcloth Manufacturing
Linseed Oil Mills
Oil Refineries
Paint Shops
Pyroxylin Plastic Manufacturing & Processing
Shade Cloth Manufacturing
Solvent Extracting
Varnish Works
and other occupancies involving processing, mixing, storage
and dispensing flammable and/or combustible liquids.

Source: Insurance Services Office, Guide for Determination of
Required Fire Flow, New York, June 1972.



Source: Insurance Services Office, Guide for Determination of Required Fire Flow, New York, June 1972.

INSURANCE SERVICES OFFICE

C=1.5

FIRE FLOW VS GROUND AREA

$F=100(A)^{0.5}$

Wood Frame Construction

F-gpm; C=1.5

(ground area in square feet)

A-area in sq. ft.

SI-III

	1	2	3	4	5	6	Stories
500							
750	500	300	200	100	100	100	
1000	1,100	600	400	300	200	200	
1250	1,700	900	600	400	300	300	
1500	2,600	1,300	900	700	500	400	
1750	3,600	1,800	1,200	900	700	600	
2000	4,800	2,400	1,600	1,200	1,000	800	
2250	6,200	3,100	2,100	1,600	1,200	1,000	
2500	7,700	3,900	2,600	1,900	1,500	1,300	
2750	9,400	4,700	3,100	2,400	1,900	1,600	
3000	11,300	5,700	3,800	2,800	2,300	1,900	
3250	13,400	6,700	4,500	3,400	2,700	2,200	
3500	15,600	7,800	5,200	3,900	3,100	2,600	
3750	18,000	9,000	6,000	4,500	3,600	3,000	
4000	20,600	10,300	6,900	5,200	4,100	3,400	
4250	23,300	11,700	7,800	5,800	4,700	3,900	
4500	26,300	13,200	8,800	6,600	5,300	4,400	
4750	29,200	14,700	9,800	7,300	5,900	4,900	
5000	32,000	16,300	10,900	8,200	6,500	5,400	
5250	34,800	18,000	12,000	9,000	7,200	6,000	
5500	37,600	19,800	13,200	9,900	7,900	6,600	
5750	43,400	21,700	14,500	10,900	8,700	7,200	
6000	47,400	23,700	15,800	11,900	9,500	7,900	

WOOD FRAME

INSURANCE SERVICES OFFICE

C=1.5

FIRE FLOW VS GROUND AREA

$F=100(A)^{0.5}$

Wood Frame Construction
(ground area in square feet)

F-gpm; C=1.5

A-area in sq. ft.

FPM	1	2	3	4	5	6	Stories
6000							
6250	51,500	25,800	17,200	12,900	10,300	8,600	
6500	55,700	27,900	18,600	13,500	11,100	9,300	
6750	60,200	30,100	20,100	15,100	12,000	10,000	
7000	64,800	32,400	21,600	16,200	13,000	10,800	
7250	69,600	34,800	23,200	17,400	13,900	11,600	
7500	74,600	37,300	24,900	18,700	14,900	12,400	
7750	79,800	39,900	26,600	20,000	16,000	13,300	
8000	85,100	42,600	28,400	21,300	17,000	14,200	

INSURANCE SERVICES OFFICE

C=1.0

FIRE FLOW VS GROUND AREA
 Ordinary Construction
 (ground area in square feet)

F=18C(A)^{0.5}
 F=gpm; C=1.0
 A=area in sq. ft.

gpm	1	2	3	4	5	6	Stories
500							
750	1,200	600	400	300	200	200	
1000	2,400	1,200	800	600	500	400	
1250	3,500	2,000	1,300	1,000	800	700	
1500	5,800	2,900	1,900	1,500	1,200	1,000	
1750	8,200	4,100	2,700	2,100	1,600	1,400	
2000	10,900	5,500	3,600	2,700	2,100	1,800	
2250	13,900	7,000	4,600	3,300	2,800	2,300	
2500	17,400	8,700	5,800	4,400	3,500	2,900	
2750	21,300	10,700	7,100	5,300	4,300	3,600	
3000	25,500	12,800	8,500	6,400	5,100	4,300	
3250	30,100	15,100	10,000	7,500	6,000	5,000	
3500	35,200	17,600	11,700	8,800	7,000	5,900	
3750	40,600	20,300	13,500	10,200	8,100	6,800	
4000	46,400	23,200	15,500	11,600	9,300	7,700	
4250	52,500	26,300	17,500	13,100	10,500	8,600	
4500	59,100	29,600	19,700	14,800	11,800	9,900	
4750	66,000	33,000	22,000	16,500	13,200	11,000	
5000	73,300	36,700	24,400	18,300	14,700	12,200	
5250	81,100	40,600	27,000	20,300	16,200	13,500	
5500	89,200	44,600	29,700	22,300	17,800	14,900	
5750	97,700	48,900	32,600	24,400	19,500	16,300	
6000	106,500	53,300	35,500	26,600	21,300	17,800	

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ORDINARY

INSURANCE SERVICES OFFICE

C=1.0

FIRE FLOW VS GROUND AREA
 Ordinary Construction
 (ground area in square feet)

F=18C(A)^{0.5}
 F=gpm; C=1.0
 A=area in sq. ft.

gpm	1	2	3	4	5	6	Stories
6000							
6250	115,800	57,900	38,600	28,300	23,200	19,300	
6500	125,500	62,800	41,800	31,400	25,100	20,900	
6750	135,500	67,800	45,200	33,900	27,100	22,600	
7000	145,800	72,900	48,600	36,500	29,200	24,300	
7250	156,700	78,400	52,200	39,200	31,300	26,100	
7500	167,900	84,000	56,000	42,000	33,600	28,000	
7750	179,400	89,700	59,800	44,900	35,900	29,900	
8000	191,400	95,700	63,800	47,900	38,300	31,900	

Source: Insurance Services Office, Guide for Determination of Required Fire Flow, New York, June 1972

INSURANCE SERVICES OFFICE

C=0.8

FIRE FLOW VS GROUND AREA
Non-combustible Construction
(ground area in square feet)

$F=18C(A)^{0.5}$
F-gpm; C=0.8
A-area in sq. ft.

FEET	1	2	3	4	5	6	Stories
500	1,900	1,000	600	500	400	300	
750	3,700	1,900	1,200	900	700	600	
1000	6,100	3,100	2,000	1,500	1,200	1,000	
1250	9,100	4,600	3,000	2,300	1,800	1,500	
1500	12,700	6,400	4,200	3,200	2,500	2,100	
1750	17,000	8,300	5,700	4,100	3,400	2,800	
2000	21,800	10,900	7,300	5,500	4,400	3,600	
2250	27,200	13,600	9,100	6,800	5,400	4,500	
2500	33,200	16,600	11,100	8,300	6,600	5,500	
2750	39,700	19,900	13,200	9,900	7,900	6,600	
3000	47,100	23,600	15,700	11,800	9,400	7,900	
3250	54,900	27,500	18,300	13,700	11,000	9,200	
3500	63,400	31,700	21,100	15,900	12,700	10,600	
3750	72,400	36,200	24,100	18,100	14,500	12,100	
4000	82,100	41,200	27,400	20,500	16,400	13,700	
4250	92,400	46,200	30,800	23,100	18,300	15,400	
4500	103,100	51,600	34,400	25,800	20,600	17,200	
4750	114,600	57,300	38,200	28,700	22,700	19,100	
5000	126,700	63,400	42,200	31,700	25,000	21,100	
5250	139,400	69,700	46,500	34,900	27,600	23,200	
5500	152,600	76,300	50,900	38,200	30,500	25,400	
5750	166,500	83,300	55,500	41,600	33,300	27,800	
6000							

LT-17

NONCOMBUSTIBLE

INSURANCE SERVICES OFFICE

C=0.8

FIRE-FLOW VS GROUND AREA
Fire Resistant Construction
(ground area in square feet)

$F=18C(A)^{0.5}$
F-gpm; C=0.8
A-area in sq. ft.

FEET	1	2	3	4	5	6	Stories
500	3,300	1,700	1,100	800	700	600	
750	6,600	3,300	2,200	1,700	1,300	1,100	
1000	10,900	5,500	3,600	2,700	2,200	1,800	
1250	16,200	8,100	5,400	4,100	3,200	2,700	
1500	22,700	11,400	7,600	5,700	4,500	3,600	
1750	30,200	15,100	10,100	7,600	6,000	5,000	
2000	38,700	19,400	12,900	9,700	7,700	6,500	
2250	48,300	24,200	15,100	12,100	9,700	8,100	
2500	59,000	29,500	17,700	14,800	11,800	9,800	
2750	70,900	35,500	21,600	17,700	14,200	11,800	
3000	83,700	41,900	25,900	20,900	16,800	13,900	
3250	97,700	48,900	29,600	24,400	19,500	16,300	
3500	112,700	56,400	33,500	28,200	22,500	18,800	
3750	129,700	64,400	37,900	32,200	25,700	21,500	
4000	148,900	72,900	42,600	36,500	29,200	24,300	
4250	164,200	82,100	47,600	41,100	32,800	27,400	
4500	183,400	91,700	52,800	45,900	36,700	30,600	
4750	201,700	101,900	57,900	50,900	40,700	34,000	
5000	225,200	112,600	63,100	56,300	45,000	37,600	
5250	247,700	123,900	68,600	61,900	49,500	41,300	
5500	271,200	135,600	74,400	67,800	54,200	45,200	
5750	295,900	148,000	80,600	74,000	59,200	49,300	
6000							

FIRE-RESISTIVE

B. Insurance Grading Schedule

The "Grading Schedule for Municipal Fire Protection"²² is published and copyrighted by the Insurance Services Office.* The schedule provides a yardstick for ISO insurance grading engineers in classifying municipalities with reference to their fire defenses and physical conditions. Gradings obtained under the schedule are used throughout the United States in establishing base rates for fire insurance purposes. A similar schedule is used in Canada by the Insurers' Advisory Organization to evaluate municipal fire defenses in that country.

The Insurance Grading Schedule originally was developed by the National Board of Fire Underwriters and was continued by its successor, the American Insurance Association, prior to the organization of ISO. It has had a profound influence upon the level of municipal fire protection provided in many communities. While ISO never assumes to dictate the level of fire protection services provided by a municipality, reports of surveys made by its Municipal Survey Office generally do contain recommendations for correcting any serious deficiencies found, and over the years have been accepted as guides by many municipal officials in planning improvements in their services. It is generally appreciated that removal of deficiencies can result in a more favorable fire insurance classification which has certain economic rewards as well as a general satisfaction that the community is providing its citizens with an improved level of service, or is holding a favorable classification where already obtained. While from time to time communities may want to employ independent consultants to evaluate their fire departments, water supplies, and building regulations, the fact is that over the past sixty odd years underwriters' surveys have provided a uniform measurement of municipal fire defenses involving many millions of dollars of engineering time and talent at no cost to the local communities which may choose to follow the recommendations. It has been observed, for example, that American communities enjoy the most adequate and reliable water systems in the world. This has been due in large measure to the engineering evaluations and recommendations of underwriter survey teams.

The Municipal Grading Schedule is subject to change with the state of the art and references in this text are to the 1974 edition. With the organization of ISO, application of the Grading Schedule has tended to be more uniform throughout the country. Under NBFU and AIA the larger communities, generally those over 40,000 population, were surveyed directly by teams of engineers from the national organization while smaller communities generally were graded by state or regional rating associations some of which used their own systems of grading municipal fire defenses. Most of the latter now have been consolidated into regional ISO offices insofar as municipal surveys are concerned although state associations have essential functions in filing rates and performing other duties as may be required by law.

The Grading Schedule is based upon a deficiency point system with a possible 5,000 points of deficiency representing a community totally unprotected against fire. The 5,000

* Available from Insurance Services Office, 160 Water St., New York, N.Y. 10038.

Table 9-6B. Relative Class as Determined by Points of Deficiency

Points of Deficiency	Relative Class of Municipality
0- 500	First
501-1,000	Second
1,001-1,500	Third
1,501-2,000	Fourth
2,001-2,500	Fifth
2,501-3,000	Sixth
3,001-3,500	Seventh
3,501-4,000	Eighth
4,001-4,500	Ninth*
More than 4,500	Tenth*

* A ninth class municipality is one (a) receiving 4,001 to 4,500 points of deficiency or (b) receiving less than 4,001 points but having no recognized water supply.

* A tenth class municipality is one (a) receiving more than 4,500 points of deficiency, or (b) without a recognized water supply and having a fire department grading over 1/55 points, or (c) with a water supply and no fire department, or (d) with no fire protection.

points are divided into 10 classes, and every 500 points eliminated places the community in a more favorable class. Table 9-6B shows the relative class as determined by points of deficiency. However, a ninth class municipality may be one receiving 4,001 to 4,500 points of deficiency, or receiving less than 4,001 points but having no recognized water supply. A tenth class municipality may be one receiving over 4,500 points of deficiency, or without a recognized water supply, or with a water supply but no fire department, or without a water supply with a fire department grading over 1,755 points, or no fire protection at all. In many rural areas there are subclasses of Class 9 recognizing the value of properly organized and equipped rural fire departments serving communities without a recognized water supply. Such fire departments are required to have stipulated water tanker capacity as well as pumping engines.

The 5,000 possible deficiency points are divided between 4 main subject areas or features. Water supply and fire department each account for a possible 1,950 points, or 39 percent. Fire service communications account for another 450 points, or 9 percent. Fire safety control, including fire prevention and building regulations, counts for 650 points, or 13 percent. Where there is a divergence of more than 500 points between water supply and the fire department, additional deficiency points may be assessed on the grounds that a good water supply requires an adequate fire department to apply it in fire fighting, and a good fire department without an adequate water supply is less effective. If either of these essentials is lacking, up to 900 additional deficiency points may be charged.

Water Supply

It is important to understand that a principal basis for the Grading Schedule's evaluation of fire protection is the ability to provide needed "fire flow" of water measured in gpm. In years past schedule requirements were based largely upon population protected which, while having some validity, was not entirely equitable because some of the smaller communities may contain properties with serious fire potentials that could require large flows of water, whereas a larger community might not require as much water to control its fires. An example might be a very large unsprinklered shopping complex in a suburban residential community. In both water supply and fire department service, reliability factors get considerable attention in the schedule.

Required fire flow is the rate of flow needed for fire fighting to confine a major fire to the buildings within a block or group. The determination of this flow depends upon construction, occupancy, size of buildings, and exposure hazards. Required flow is determined for each section of a municipality and may vary from a minimum of 500 gpm to a maximum of 12,000 gpm for a single fire. Where consideration must be given to simultaneous fires, an additional 2,000 to 8,000 gpm is required. Actual flow tests are made in each section of the municipality and the results obtained are compared with the flow required in each neighborhood to deal with the hazards found.

For purposes of grading under the standard, a "basic fire flow" is used which is indicative of the quantities of water needed for handling fires in important districts. Among the items considered under water supply are: adequacy of supply works; reliability of source of supply; reliability of pumping capacity and of power supply; the condition, arrangement, operation, and reliability of system components; adequacy and reliability of mains and their installation; arrangement of the distribution system; distribution of hydrants and their size, type, installation, and condition; and various miscellaneous factors.

A minimum recognized water supply for grading purposes must be able to deliver at least 250 gpm for 2 hours, or 500 gpm for 1 hour for fire protection plus consumption of water at the maximum daily rate. Any water supply which cannot meet this requirement is not graded, and the full 1,950 deficiency points are assigned.

Fire Department

Items considered under the fire department include: pumpers, ladder trucks, distribution of companies and types of apparatus, pumper capacity, design and condition of apparatus, number of officers, manning, master and special stream devices, equipment for pumpers and ladder trucks (including elevating platforms), hose and its condition, training, response to alarms, fire operations, special protection such as fireboats, and miscellaneous factors.

A minimum recognized fire department under the schedule must have a permanent organization under applicable state and local laws, and be headed by one person responsible for the operation of the department. There must be sufficient membership to provide a response of at least 4 members to alarms, with training conducted for all active members. There must be at least one piece of suitable fire apparatus with housing and maintenance for the apparatus. Means must be provided for 24-hr receipt of alarms and immediate notification of members. Any fire department that cannot meet these requirements is not graded, and a full 1,950 deficiency points are assigned.

Under the schedule the number of engine and ladder companies must be at least equal to the number required for the basic fire flow. Engine and ladder companies must be located so that travel distances for first due, for first alarm companies, and for the maximum number of companies needed to apply required fire flows meet recommended travel distances. Structural conditions and hazards in the municipality may call for more companies than needed to apply basic fire flow. The probability of simultaneous fires, the number and extent of runs, and the need for placing additional companies in service or for relocating companies during periods of high frequency of alarms are factors considered. Consideration is given to providing protection for all areas during multiple alarms and simultaneous fires.

Where the required fire flow is 4,500 gpm or less, response

distance for the first due engine company must be not over $1\frac{1}{2}$ miles, except that it may be 2 miles in residential districts of 1- and 2-family dwellings not requiring over 2,000 gpm fire flow, and 4 miles where such dwellings have an average separation of 100 ft or more. For flows of from 5,000 to 8,500 gpm inclusive, the first due engine should be within 1 mile, and for flows of 9,000 gpm or more the distance is $\frac{3}{4}$ mile.

The first due ladder company should be within 2 miles for flows of 4,500 gpm or less, but may be 3 miles for residential districts of 1- and 2-family dwellings and 4 miles where such dwellings have an average separation of 100 ft or more. Where there are less than 5 buildings of a height equal to 3 or more stories, a ladder company may not be required. Where required fire flow is from 5,000 to 8,500 gpm, the first due response distance for ladder trucks is reduced to $1\frac{1}{2}$ miles, and where the required flow is 9,000 gpm or more the first due ladder should be within 1 mile.

Standard first alarm response is 2 engines and 1 ladder company for flows not exceeding 8,500 gpm, except that for flows of less than 2,000 gpm only one engine may be required, and ladder coverage may not be required for flows of 3,500 gpm or less if there are less than 5 buildings of a height requiring such service.

For flows of 9,000 gpm and above, the first alarm response should be 3 engines and 2 ladders. Response distances for the second due engine should be within 4 miles with fire flows of under 2,000 gpm, within $2\frac{1}{2}$ miles for fire flows of from 2,000 to 4,500 gpm, 2 miles for flows from 5,000 to 6,500 gpm, and $1\frac{1}{2}$ miles for flows between 7,000 and 8,500 gpm. Where 3 engines are required, these should be within $1\frac{1}{2}$ miles. Where 2 ladders are required on first alarms, these should be within 2 miles.

Maximum multiple alarm response and response distances also are specified for the various fire flows. In general, one engine company is required for each 1,000 gpm fire flow through 7,000 gpm. At higher flows, additional engine companies are required up to 15 for 12,000 gpm. Maximum multiple alarm response distances for engines vary from 3 miles for 3 engines to 5 miles for 15 engines. In general, the response on each multiple alarm should duplicate the first alarm response.

A second ladder company within $2\frac{1}{2}$ miles is required for multiple alarms with fire flows of 5,000 to 6,500 gpm, a third ladder company should be within $3\frac{1}{2}$ miles for flows of 7,000 to 8,500 gpm, and on up to 7 ladders within 5 miles for 12,000 gpm.

It should be appreciated that these response requirements are a rather conservative minimum standard. Many fire departments will exceed these because pre-fire planning indicates need for additional companies because of life hazard or in order to run hand lines to control fires inside of buildings rather than application of maximum fire flow to merely confine fires as envisioned under the schedule. Levels of manpower on responding companies often influence the number of companies assigned to respond to various alarms. The basic purpose of the Grading Schedule is to confine fires to groups of buildings involved to avoid conflagrations, and it does not demand the same level of service that many communities choose to provide.

Under the schedule there should be at least one reserve pumper for every 8 pumpers or major fraction in service, but not less than one. This is essential to permit proper maintenance. Fully equipped reserve pumpers manned by designated off-shift or volunteer members are considered as increasing the pumpers in service and may equal up to one in-service pumper if manned on first alarms, and $\frac{1}{2}$ an

in-service pumper if manned on specified multiple alarms; however, credit cannot exceed $\frac{1}{2}$ of the required number of pumpers. Where the requirements for manning reserve pumpers have not been met, equipped reserve pumpers may be credited the same as outside aid.

Pumpers responding on automatic mutual aid within 5 miles of the municipal limits may be credited not to exceed $\frac{1}{2}$ of the pumpers required. This credit requires a detailed mutual aid system with scheduled assignments and proper training and communications. Credit allowed may not reduce the point charge by more than 75 percent, except that where there is a central communications center dispatching all companies the reduction may be up to 90 percent. Consideration also is given to outside aid available within 15 miles, and depending upon various factors deficiencies may be reduced by not more than 33 percent for such available response. Similar credits are allowed for response of ladder companies responding on scheduled mutual aid and outside aid, and for reserve ladders manned by off-shift personnel. However, deficiencies charged for an inadequate number of ladder trucks is only half that for pumpers.

Pumping capacity must be not less than the basic fire flow, and additional capacity may be needed. From the response assignments in the schedule it appears that 1,000 gpm pumpers are assumed to be standard, although credit is given for smaller capacity pumps and also for available pumps on other apparatus. Where simultaneous fires are likely, the pumper capacity must not be less than the total flow requirements for the simultaneous fires. Pumper capacity is taken as that demonstrated by test and not merely that specified in purchasing contracts. In the absence of proper test data, the credit for pumper capacity may be reduced.

Fire Department Officers

There must be a chief officer in charge of the department. For more than 2 companies there must also be an assistant or other officer above company rank who is in charge in the absence of the chief. For over 8 companies there must be sufficient battalion or district fire chiefs to provide one on duty for each 8 companies or major fraction thereof. For less than 12 companies the assistant chief may serve as a battalion or district chief. The preceding is a very conservative requirement. Many fire departments provide a district fire chief on duty for each 5 or 6 companies in order to give prompt supervision of fire companies at fires and to cover simultaneous alarms. Most fire departments with 5 or more companies provide a chief officer on each duty shift, although not required under the schedule.

There must be a company officer on duty at all times with each required engine, hose, or ladder company. The company officers are credited in the company strength. Two call or volunteer officers are considered equivalent to one full paid officer, up to $\frac{1}{2}$ the number of paid officers required.

Manning Standards

Standard manning is 6 men on duty for each required engine and ladder company, including the officer and 5 men for hose companies where pumps are not required. Where companies operate special apparatus, additional manning may be needed. Years ago from 5 to 7 men were considered standard manning, depending upon the type of company and the hazards of the district served. Today with the greater mobility of radio-equipped apparatus and the fact that serious hazards are found in all parts of the community and not just in a central district, a uniform manning is considered desirable. The 6-man standard level of com-

pany manning is a practical requirement based upon the work that must be done by engine and ladder companies. Where fewer men are provided, it is often necessary to obtain additional manpower from other companies.

While the standard calls for a 6-man level of company manning, credit is given for chiefs' aides who participate in fire fighting. Credit also is given for manpower responding on other units, such as rescue squads and fire department ambulance crews, to the extent that these assist in fire fighting, but not to exceed credit of one man per company. Credit is given also for the regular response of off-duty or volunteer fire fighters. In the schedule, 3 off-duty or volunteer members are counted as equal to one paid man on duty, up to $\frac{1}{2}$ of the required on-duty strength. Thus a fire company with 3 men on duty and 9 off-duty or volunteer members assigned to respond can be counted as a full 6-man crew. However, records of such off-duty response must be kept for both day and night alarms to substantiate the actual value of such manning. If proper records are not kept, call or volunteer response may be taken on the basis of 6 men on call equaling one on duty. In many small fire departments, small outside fires may be handled by the paid men on duty on still alarms without call assistance, but full standard response should be made immediately to all alarms for structural fires and other alarms that present a hazard to life and property.

Under the schedule a fully volunteer or call department with no paid men on duty ready to immediately answer alarms but with good call response would be charged 40 points of deficiency, as compared with an identical fire department having standard 6-man fire companies on duty or the equivalent under the schedule. This amounts to only 80 percent of all the possible deficiency points in a municipal grading. This would appear to be a small deficiency as compared with the advantage of immediate response by on-duty fire companies. If the volunteer or call department has paid apparatus operators on duty, the deficiency might be only 20 points out of 5,000 in the grading, all other things being equal.

Manpower responding on automatic mutual aid is credited up to $\frac{1}{2}$ of the required strength, but may not reduce the point charge by more than 75 percent or 90 percent as may be applicable. Credit also is given for outside aid, but may not reduce the point charge remaining after automatic aid and off-shift response credit has been applied by more than 33 percent. Credit also is given for off-shift response based upon past experience when called.

Deficiency charges are determined by comparing the total required manning of the fire companies being graded with the on-duty strength of these companies as determined by the schedule. Any deficiency divided by the number of companies equals the average deficiency per company. An average deficiency per company of one man results in only 10 points, two men 20 points, three men 40 points, four men 80 points, and five men 160 points. Thus, a fire department that maintains 5 men on each required engine and ladder company assisted by rescue squads, ambulance crews, and chiefs' aides may not be considered deficient in manpower under the standard. Likewise, a fire department that has an average on-duty manning of 3 men per required company plus response of off-duty or call men may not be considered deficient if the record of response is satisfactory. Thus, the manpower requirements are flexible and reasonable. Places that should expect poor grading on manpower are those with 2- and 3-man engine companies and 1- or 2-man ladder companies without satisfactory arrangements for prompt response of off-shift members or other men on call

and without well-scheduled automatic mutual aid. Such departments obviously are too badly undermanned to effectively apply required fire flow when serious fires occur. On the other hand, a small community requiring 2 engines and a ladder and having 6 paid men on duty supplemented by good off-shift and call response plus automatic mutual aid may have a minimum deficiency charge for manning.

Fire Service Communications

As fire service communications are an essential element in the fire defenses of any community, the Grading Schedule evaluates the following: the communications center; the communications center equipment and current supply; fire alarm boxes; alarm circuits and facilities including current supply at fire stations; material, construction, condition, and protection of circuits; fire department radio; fire department telephone service; conditions adversely affecting use and operations of facilities; fire alarm operators; and the handling of alarms. While alarm boxes are not required in residential districts, a credit of up to 20 points is given for such boxes depending upon coverage.

Determination of deficiencies under the various communications items are based upon the degree of compliance with the intent of applicable provisions of NFPA No. 71, Standard for Public Fire Service Communications. This Standard is discussed in further detail in Chapter 3 of this Section of the HANDBOOK.

Some persons in the fire service have often felt that the Grading Schedule placed undue emphasis on water supply at the expense of the fire department. In earlier editions of the schedule this may, to some extent, have been true. However, in recent editions items under fire department control including fire service communications and control of hazards amount to up to 58.5 percent of the 5,000 possible deficiency points. The one area in which water supply still has an advantage over the fire department service is the requirement that without a recognized water system, no community can have a classification better than Class 9. Hundreds of fire departments serving areas without water systems are organized to exceed the minimum requirements for fire flow from water systems by using fleets of tankers, and by the use of large diameter water supply hose supplied from pumpers at suction sources prepared and maintained by the fire department. With the water supply equipment responding with the attack pumpers, no delay is involved. Many rural fire departments believe that their ability to apply required fire flow should be recognized because it has proven successful in the control of major fires, including fires in communities recognized as having inadequate water supplies.

PART IV

INSURANCE STATISTICS AND INFORMATION
CONCERNING SPRINKLERS AND FIRE PROTECTION

INSURANCE SAVINGS CAUSED BY AUTOMATIC SPRINKLERS

Installation of automatic sprinklers reduce fire insurance premiums by an approximate average of seventy-five percent (75%) when they are installed in a building. The insurance savings will vary from this percentage by:

1. Type of construction;
2. Occupancy hazard class;
3. Quality of construction (combustible to fire resistive); and,
4. Quality of sprinkler equipment installation

In a building of fire-resistant construction, the insurance premium reduction is less since the sprinkler system is merely an addition to a building which already has fire protection qualities.

Source: Insurance Services Office, Anchorage, Alaska. The above information is subject to particular circumstances of each individual risk being evaluated, and is not conclusive or binding for any particular risk or other building.

PART V

S T A T I S T I C S

SPRINKLER WATER CONSUMPTION CHARACTERISTICS

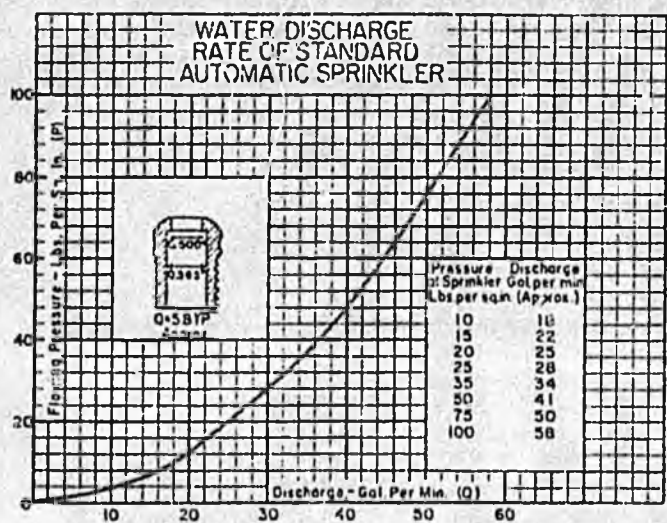


Fig. 14-3G. Water discharge rate of standard automatic sprinkler.

Source: National Fire Protection Association; Fire Protection Handbook, pp. 14-42 through 14-48 14th edition 1976

WATER SUPPLIES FOR SPRINKLER SYSTEMS

It is vital that every automatic sprinkler system have a water supply of adequate pressure, capacity, and reliability. Both the rate of flow and the total volume that may be needed must be considered.

A. Types of Supplies

Sprinkler systems may be supplied with water from one or a combination of sources, such as street mains, gravity tanks, reservoirs, fire pumps, pressure tanks, rivers, lakes, wells, etc. (see Fig. 14-1F).

In theory, a single water supply would seem to be all that is necessary for satisfactory protection. However, that single supply may at times be temporarily out of service; it may be disabled at the time of a fire or before a fire is completely extinguished; or the pressure or the capacity may be below normal during an emergency. Therefore, a secondary supply may be necessary, depending on the strength and reliability of the primary supply, the value and importance of the property, the area, height and construction of the building, the occupancy, and the outside exposures. Occasionally, three supplies are needed, especially where neither the primary nor a single secondary supply is judged wholly satisfactory or reliable.

Connections to Public Water Works Systems

A connection from a reliable public water works system of adequate capacity and pressure is the preferred single or primary supply for automatic sprinkler systems. In determining its adequacy, consideration has to be given not only to the normal capacity and pressure of the system, but also to the probable minimum pressures and flows available at unfavorable times such as during summer months, during heavy demand on the system, or during impairment caused by flood or by winter conditions.

The size and arrangement of street mains and feeders from public water supplies are also important. Connections from large mains feed two ways or from two mains on a gridiron system may provide an excellent supply. Street mains less than 6 in. in diameter are usually inadequate and unreliable. Feeds from dead-end mains are also undesirable.

Water meters, if required by the water supply authority, should be of types approved for fire service (see Sec. 11, Chap. 2).

Flow and pressure tests under varying conditions of demand are generally necessary to determine the amount of public water available for fire protection. The proper method of making such tests is described in Section 13, Chapter 5.

Cross-connections Between Public and Private Supplies

Where a secondary supply is needed to supplement the public water supply, public and private supplies can be connected so as to feed into a single fire protection system. These systems are commonly referred to as being "cross-connected."

In some localities, cross-connections may be prohibited by health authorities.

Where they are not prohibited, regulations and sound practices must be complied with in order to avoid the possi-

bility of public health being endangered by water of questionable potability entering the public system.

In general, cross-connections are permitted if carefully supervised precautions, such as a special double check valve, or other accepted devices for preventing backflow, are provided. In cases where one sprinkler supply is from public mains, health authorities usually permit, as a secondary source, either well constructed and well maintained covered steel tanks or concrete reservoirs that are filled with public water only.

Gravity Tanks

Gravity tanks of adequate capacity and elevation make a good primary supply and may be acceptable as a single supply. Details of the construction, heating, and maintenance of gravity tanks are given in NFPA No. 22, Standard for Water Tanks for Private Fire Protection, hereinafter in this chapter referred to as the NFPA Water Tank Standard (see also Sec. 11, Chap. 3 of this HANDBOOK). In determining tank size and elevation, consideration should also be given to the number of sprinklers expected to operate, duration of operation, the arrangement of underground supply piping, and the provision of hose standpipes, hydrants, and fire department connections.

Fire Pumps

A fire pump having both a reliable source of power and a reliable suction water supply provides a good secondary supply and in some instances is acceptable as a primary supply. With ample water a fire pump is capable of maintaining a high pressure over a long period of time, and may be a necessary part of some installations requiring greater water pressure than would otherwise be available.

For details of power sources, pump construction, installation, and methods of control and operation, NFPA No. 20, Standard for Centrifugal Fire Pumps, should be consulted (see also Sec. 11, Chap. 3 of this HANDBOOK).

Manually controlled pumps may be used if the primary water supply will last long enough to allow dependable starting of the fire pump, and if there is an automatic water-flow signal to make known the need for fire pump operation.

Automatic control of fire pumps is usually needed where a high water demand may occur immediately, as with a deluge system; or where a competent pump operator is not continuously present. Automatic fire pumps should have their suction under a positive head to avoid the delays and uncertainties of priming.

Under favorable circumstances of moderate property values and hazard, dependable power, and a dependable suction supply under a head, an electrically driven, automatically controlled fire pump supervised from a central station may be accepted as the primary supply for automatic sprinklers.

The automatic control of electrically driven centrifugal pumps must be arranged to prevent frequent repeated starting of the motor, either by initiating continuous running until stopped manually, or by a timing device that will stop the motor automatically only after a predetermined period of operation.

Pressure Tanks

Pressure tanks have several possible uses in automatic sprinkler protection. An important limitation is the small volume of water which can be stored in such tanks. Where a small pressure tank is accepted as the water supply, the system is classed as a Limited Supply System.

In situations where an adequate volume of water can be supplied by a public or private source but where the pressure is not sufficient to serve a sprinkler system directly, the pressure tank gives a good starting pressure for the first sprinklers that operate; the flow from it may be used while the fire pumps start automatically to increase the supply pressure.

In tall buildings where the public water pressure is too low for effective water distribution from the highest sprinklers, pressure tanks may be used to supply such sprinklers during the time required for a public fire department to begin supplying water through fire department connections.

Each proposed use of pressure tanks calls for special consideration and analysis of water capacity, location, and arrangement of the connection to the sprinkler system. Each installation is usually required to have specific approval. Details on the construction, installation, and maintenance of pressure tanks are given in the NFPA Water Tank Standard (see also Sec. 11, Chap. 3 of this HANDBOOK).

Fire Department Connections

Under fire conditions which result in a considerable number of sprinklers operating, public water or tank supplies may not provide water at sufficient pressure for effective discharge and distribution. Also, the pressure in many public water supplies to sprinkler systems may be materially reduced by hose streams from hydrants. In such cases, a connection through which the public fire department can pump water into the sprinkler system provides an important auxiliary supply. Fire department connections are therefore a standard part of sprinkler systems.

Fire department connections should be of approved type, readily accessible, and properly marked. Each connection should be fitted with a check valve, but not with a gate valve. There should be a proper drain, and an approved drip

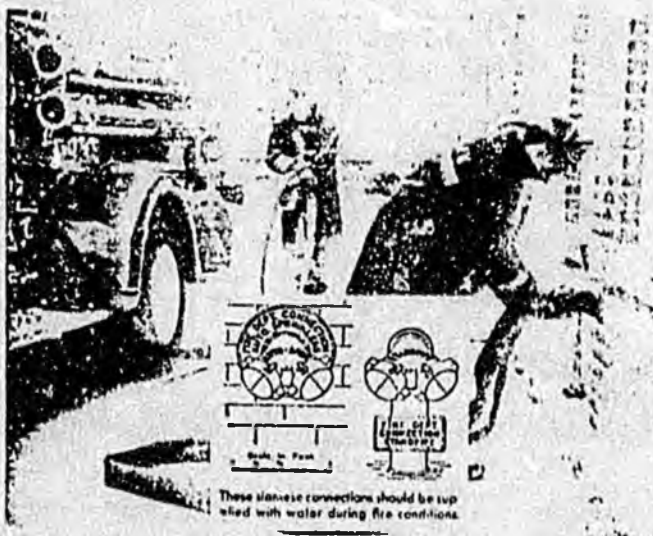


Fig. 14-4A. Fire fighters attaching hose lines to a fire department (siamese) connection supplying a sprinkler system. The inset shows typical siamese connections for sprinkler systems and standpipes. A check valve allows the use of a single hose line.

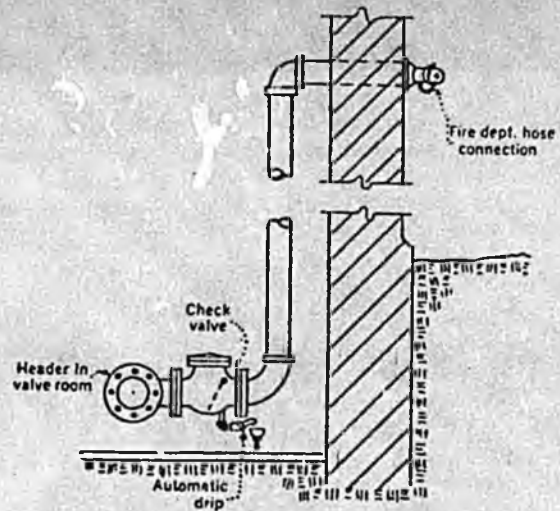


Fig. 14-4B. Typical fire department connection.

device between the check valve and the outside hose coupling. Figures 14-4A and 14-4B show the main features of a fire department connection. Other details of installation and pipe size are given in NFPA No. 13, Standard for the Installation of Sprinkler Systems, hereinafter referred to in this chapter as the NFPA Sprinkler Standard.

Where a sprinkler system has a single riser, the fire department connection should be attached to the system side of the controlling gate valve for a wet system, and between the dry-pipe valve and the gate valve for a dry system. This makes it possible to pump water into the system even if the gate valve is closed.

If there are two or more sprinkler system risers connected to a public main, each system must have its own fire department connection. If more than one riser is connected to a yard system the fire department connection should feed into the yard system on the supply side of all riser shutoff valves, and there must be a check valve in all other water supply connections into the yard system to prevent backflow and loss of water supplied through the fire department connection. If one riser is shut off, the fire department connection can still supply all other risers.

In an emergency, a fire department can pump water from public hydrants or other sources of water into a sprinkler system through its hose and a yard hydrant or other hose connection using a double female hose coupling, if other supply connections have a check valve or a gate valve that can be closed.

B. Water Supply Requirements

The water supply needed for sprinkler systems raises questions that defy specific answers except with sprinkler systems where it is planned that all sprinklers in the fire area will discharge water. Such systems include deluge and water spray systems utilizing open sprinklers where the design must provide water supply for all the sprinklers in any fire area, systems employing closed automatic sprinklers in hazardous areas where the simultaneous operation of all sprinklers is usually assumed, and multiple open sprinkler systems in a single fire area where one or more systems can be expected to operate. With such sprinkler systems (largely used for special hazard situations) the water supply requirement resolves itself mainly into a matter of hydraulic and mathematical calculations. The answer to the water supply requirement with the majority of sprinkler systems, how-

ever, is not so definite. If a water source that could supply all the sprinklers is available, there would be no problem, but such a water supply is seldom practical except in the case of small systems. The water supply requirement for any sprinkler system is directly related to the number of sprinklers expected to operate, but this depends on so many variables and uncertain factors that no exact mathematical solution is possible.

The NFPA Sprinkler Tables show that in 93 percent of all fires in sprinklered buildings, twenty or less sprinklers opened. Experience shows that with adequate water supply the percentage of unsatisfactory sprinkler performance is extremely small. Thus, water supply is a significant problem, particularly with large sprinkler systems and with systems protecting greater than ordinary hazards.

The answer to the water supply requirement for any particular sprinkler system lies mainly in experienced engineering judgment, based on consideration of the factors for or against sprinkler control. Where the cooling effect from the water discharged by sprinklers is greater than the heat liberated by the fire, the sprinklers can gain control. When the reverse situation occurs, as from an overtaxed water supply, the sprinklers cannot control the fire and the sprinkler system may fail. Where all conditions are favorable, the control of fire should be accomplished by the operation of only a small number of sprinklers. As conditions vary, however, with different classes of occupancy, areas, and types of buildings, the number of sprinklers expected to operate in order to control a fire may range up to possibly the total number in the area, and the water supply should be provided accordingly. (See Fig. 14-1D for cumulative data for the various numbers of sprinklers operating in fires.)

C. Influence of Various Factors on Water Supply Need

The primary factors affecting the number of sprinklers which might open in a fire, and therefore to be considered in determination of the water supply requirement, include the following:

Hazard of Occupancy, Including Flash Fire Hazard and Potential Rate of Heat Liberation: This is the most important factor, and one involving experienced judgment to evaluate. Where the flash fire hazard is present, it is usually necessary to provide water sufficient for the operation of all the sprinklers in any individual fire area.

Initial Water Pressure: At a pressure of 15 psi, a standard sprinkler will discharge about 22 gpm, or an average of 0.17 gal per sq ft per min on an area of 130 sq ft. At 30 psi, the discharge is 33 gpm; at 50 psi, 41 gpm, and at higher pressures the discharge is correspondingly greater, also with a greater area of coverage. With a greater discharge and greater area of coverage, there is a better chance of fire control with a small number of sprinklers, and less need for large volumes of water to supply a large number of sprinklers.

Obstructions to Distribution of Water from Sprinklers, such as High-piled Stocks, Bale Tiering, Pallets, Racks, and Shelving: With obstruction, there is less likelihood that fire will be controlled in its initial stages, and a greater chance of opening a large number of sprinklers needing large water supplies.

High Ceilings and Draft Conditions: With ceilings of unusual height, there is greater chance that drafts will carry heat away from the sprinklers immediately over a fire, resulting not only in delay in the application of water but also in the opening of sprinklers remote from the place of origin of the fire. More water is usually needed under such

conditions. The same situation exists wherever there are drafts, such as in areas open to the weather on the sides, where winds can divert heat from sprinklers over the fire.

Unprotected Vertical Openings: Sprinkler systems in multistory buildings are usually designed on the assumption that fire will be controlled on the floor of origin. Where there are unprotected openings up which heat and fire may spread, it may be expected that more sprinklers will open, particularly in the case of a fire originating near the vertical opening. In case of high combustibility, the interconnected floors may need to be considered as one fire area. This means more water and larger pipe sizes in risers and supply main.

Wet or Dry System: Owing to the delay due to exhausting air from dry-pipe systems, more sprinklers open on dry-pipe systems than on wet systems. This may call for greater water supplies.

Size of Undivided Areas: A large undivided area has a greater number of sprinklers, with a possibility of a greater maximum number of sprinklers operating, and a consequently greater water demand than with a small area.

Configuration and Type of Ceiling Construction: These influence water demand, including such factors as curtain boards, or beams affording curtain board effects to retard fire spread, and the possibility that fire may spread under a combustible ceiling out of reach of sprinklers or burn through.

Extent of Coverage and Exposures: Any fire in an un-sprinklered space extending to an area with automatic sprinklers places an abnormal demand on the sprinkler system, and requires increased water supplies for effective functioning of the system.

The preceding factors must be considered individually and collectively, and it is not feasible to derive any general formula or simple method of arriving at water supply requirements.

There are, however, certain general statements on this subject that may be made. One is that any situation may be effectively protected with much less water where the water is applied automatically rather than manually. Another is that it is good practice to provide more water, at higher pressure, than will probably be needed to extinguish any fire. Hose streams may be used to supplement sprinklers, even when not necessary, and an ample supply of water provides a margin of safety.

With a very large fire area of low to moderate hazard it is not reasonable to expect to supply all sprinklers simultaneously. Actually, the pipe sizes are not large enough to do so, except where very high supply pressures can produce a high discharge rate from sprinklers near the source of supply as well as effective discharge from the most remote sprinkler. This situation is aggravated where sprinkler supply is from an end or side of the system. The most effective piping pattern calls for sprinkler risers at the center.

The managers of large properties under sprinkler protection may, by "shopping," secure insurance coverage predicated on water supplies that are "shaded" for economy. Obtaining the desired coverage does not mean that, measured in terms of true fire safety, the property is sufficiently protected. Property owners who realize that any fire may cause indirect losses far beyond any insurance indemnity will consider full protection essential.

D. Water Supply Requirements for Pipe Schedule Sprinkler Systems

Notwithstanding the general problems involved in arriving at water supply requirements, the hazard of occupancy, being the factor of major importance, has made it

possible to establish "Guides to Water Supply Requirements for Sprinkler Systems" using this factor as the primary consideration with latitude allowed for the contributing factors.

The established "Guide" tables contained in the NFPA Sprinkler Standard divide hazards of occupancy, for the purpose of determining water supplies, into several groups with specified minimum water supplies for each group (see Table 14-4A).

Where fire pumps contribute to the water supply, standard sizes of pumps should be used to provide adequate rate of discharge, as outlined in Section 11, Chapter 4. A suction supply for the pump should preferably be large enough for continuous operation, as outlined in Section 11, Chapter 4.

Where pressure tanks furnish the water supply, the provisions for pressure tanks in Section 11, Chapter 3, should be followed.

Where a combination of different water supplies is provided in the interest of reliability, it is good practice to have the rate of supply from each source at least equal to the minimum requirement for the system.

The "Guide" should be used only with experienced judgment, but it can serve for all cases qualifying in the Light Hazard and Ordinary Hazard, Groups 1 and 2, occupancy classifications which constitute the larger percentage of sprinkler installations. The other occupancy classifications usually involve more complex factors, and therefore require special consideration.

Light Hazard Occupancies

Examples of Light Hazard Occupancies are apartment buildings, dormitories, office buildings, seating areas of restaurants, and hospitals. In these occupancies the potential rate of heat liberation is low, areas are usually subdivided, and a small number of sprinklers should normally control any fire. Under these conditions, 500 gpm should generally be sufficient, with an upward range to 750 gpm where conditions are less favorable.

Ordinary Hazard, Group 1, Occupancies

The Ordinary Hazard, Group 1 classification includes occupancies where the combustibility of contents is generally low, such as in garages, bakeries, laundries, and canneries, but is greater than for the Light Hazard classification. In this group the water supply requirement may be as low as 700 gpm where small areas, noncombustible construction, and very limited hazards are encountered; it can range up to 1,000 gpm as these conditions become more adverse.

Ordinary Hazard, Group 2, Occupancies

Ordinary Hazard, Group 2 classification includes occupancies such as clothing factories, mercantiles, pharmaceutical manufacturing, and shoe factories. With this group the features of combustibility of contents, ceiling heights, and obstruction are generally unfavorable, separately or jointly, and as indicated the water supply requirements may range as high as 1,500 gpm. It will be noted, however, that an 850 gpm minimum is retained for this group and this, of course, would be applicable only under very favorable conditions.

Water supply requirements for the three classes mentioned, as in all cases, call for a careful consideration of all factors concerned, but the figures given in Table 14-4A are of value in placing lower and upper limits for the classes concerned. While it is never advisable to provide less than the lower limit indicated, the upper limit will usually be sufficient for all situations within the group classification.

Ordinary Hazard, Group 3, Occupancies

Ordinary Hazard, Group 3, consists of occupancies where standard sprinkler spacing and pipe schedules are considered satisfactory, but where more than ordinary water supplies are advisable. This group includes certain woodworkers and other occupancies such as flour and feed mills, paper mills, piers and wharves, and tire storage.

Table 14-4A. Guide to Water Supply Requirements for Pipe Schedule Sprinkler Systems

Occupancy Classification	Residual Pressure Required (See Note 1)	Acceptable Flow at Base of Riser (See Note 2)	Duration in Minutes (See Note 4)
Light Hazard	15 psi	500-750 gpm (See Note 3)	30-60
Ordinary Hazard (Group 1)	15 psi or higher	700-1000 gpm	60-90
Ordinary Hazard (Group 2)	15 psi or higher	850-1500 gpm	60-90
Ordinary Hazard (Group 3)	Pressure and flow requirements for sprinklers and hose streams to be determined by authority having jurisdiction.		60-120
Warehouses	Pressure and flow requirements for sprinklers and hose streams to be determined by authority having jurisdiction. Also see Chapter 7 of NFPA 13, NFPA 231, and NFPA 231 C.		
High-Rise Buildings	Pressure and flow requirements for sprinklers and hose streams to be determined by authority having jurisdiction. Also see Chapter 8 of NFPA 13.		
Extra Hazard	Pressure and flow requirements for sprinklers and hose streams to be determined by authority having jurisdiction.		

NOTES:

1. The pressure required at the base of the sprinkler riser(s) is defined as the residual pressure required at the elevation of the highest sprinkler plus the pressure required to reach this elevation.
2. The lower figure is the minimum flow including hose streams ordinarily acceptable for pipe schedule sprinkler systems. The higher flow should normally suffice for all cases under each group.
3. The requirement may be reduced to 750 gpm if building area is limited by size or compartmentation or if building (including roof) is noncombustible construction.
4. The lower duration figure is ordinarily acceptable where remote station water flow alarm service or equivalent is provided. The higher duration figure should normally suffice for all cases under each group.

Extra Hazard Occupancies

Extra Hazard occupancies consist of properties where flash fires opening all the sprinklers in a fire area are probable, and call for close sprinkler spacing and larger pipe sizes. Such occupancies include explosives manufacturing, extra hazard chemical works, pyroxylin plastic manufacturing, cotton picking and opening operations, and other occupancies with a flash fire hazard.

It is not possible to lay down any general rules for these last two groups, and their water supply needs can be evaluated only on an individual basis by engineers with broad background experience. For this reason, the NFPA Sprinkler Standard refers to determination by the authority having jurisdiction as the only possible answer to the problem. It is in such occupancies that hydraulic calculations are most often needed to determine water supplies.

In any treatment of hazards by general groups of occupancy, it must be noted that individual properties differ markedly, and that buildings of the same nominal occupancy classification may show widely different individual hazards which should be considered in any determination of water supply.

E. Water Supply Requirements for Hose Stream Protection

The values given in Table 14-4A include hose stream requirements. In considering water requirements for hose streams, it should be realized that if sprinklers perform effectively little hose stream assistance is required. Although this is generally the case, a realistic viewpoint must be taken of possible contingencies and the amount of water that might be needed for hose stream protection under adverse conditions.

In evaluating hose stream requirements, possibilities should be considered such as the amount of water necessary for final extinguishment or clean-up operations, or in the event that sprinklers are retarding fire spread but are not fully effective in gaining control and extinguishment.

F. Water Supply Requirements for Hydraulically Designed Sprinkler Systems

A fire protection engineer planning new water supplies or evaluating existing supplies for sprinkler systems must have some information regarding the hydraulic behavior of sprinkler piping systems.

Hydraulic Calculations

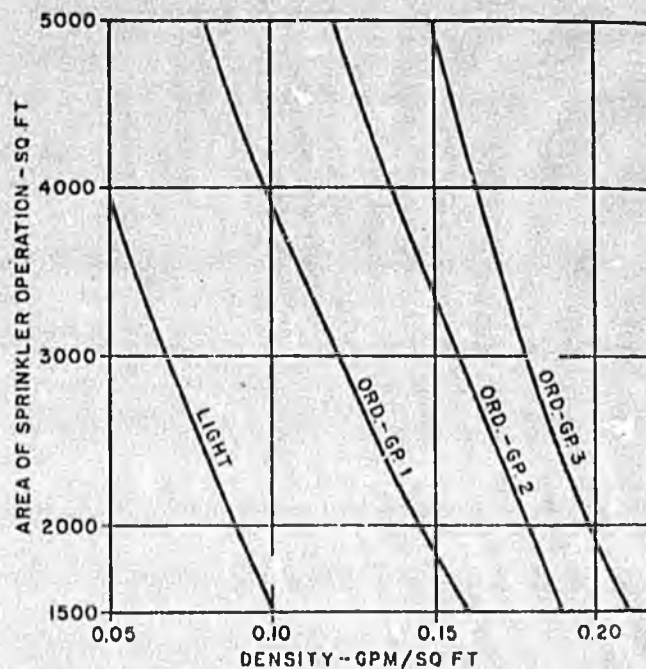
A hydraulically designed sprinkler system is one in which pipe sizes are selected on a pressure loss basis to provide a prescribed density (gallons per minute per square foot) distributed with a reasonable degree of uniformity over a specified area. This permits the selection of pipe sizes in accordance with the characteristics of the water supply available. The stipulated design density and area of application will vary with occupancy hazard.

Table 14-4B is used to determine density, area of sprinkler operation, and water supply requirements for hydraulically designed sprinkler systems. Systems must be calculated to satisfy a single point on the appropriate design curve, and interior piping must be based on this design point. It is not necessary to meet all points on the selected curve. Total water supply available to the system at the base of the riser at the residual pressure required by the design must be not less than shown in Table 14-4B; this total water supply need not be calculated through the overhead piping.

Table 14-4B. Density, Area of Sprinkler Operation, and Water Supply Requirements for Hydraulically Designed Sprinkler Systems

Hazard Classification	Minimum Water Supplies		Duration in Minutes
	Sprinklers GPM	Combined Inside & Outside Hose—GPM	
Light	150	100	30
Ord.—Gp. 1	400	250	*60-90
Ord.—Gp. 2	600	250	*60-90
Ord.—Gp. 3	750	500	*60-120

NOTES: The lower duration figure is ordinarily acceptable where remote station water-flow alarm service or equivalent is provided.



NOTES:

For dry systems increase area of sprinkler operation by 30 percent. For combustible construction with wet or dry systems the minimum area of application is 3,000 sq ft.

For hazard classifications other than those indicated see appropriate NFPA Standards for design criteria.

Calculations shall be based upon the area of sprinkler operation selected from Table 14-4B, or upon the area of the largest room being considered, whichever is smaller. Such rooms must be enclosed by construction having a fire resistance rating at least equal to the water supply duration indicated in Table 14-4B, and wall openings must be protected in an approved manner. For areas of sprinkler operation less than 1,500 sq ft, the density for 1,500 sq ft is used.

The same hazard occupancy classifications apply to hydraulically designed sprinkler systems as apply to pipe schedule sprinkler systems as mentioned in Part D of this Chapter. The recommended water supply figures are, however, somewhat lower due to the greater efficiency of a calculated system.

The water allowances for inside hose and for outside hydrants may be combined and added to the system requirement at the system connection to the underground main. The total water requirement must be calculated through the underground main to the point of supply.

With deluge systems and water spray systems having open orifices, calculations are essential. (See NFPA No. 15, Standard for Water Spray Fixed Systems.) Automatic sprinkler systems protecting high piled storage situations require a specific water density for fire control. (See NFPA No. 231, Standard for Indoor Storage, and NFPA No. 231C, Standard for Rack Storage of Materials.) Hydraulically designed systems are also used for protection of high piled storage situations.

lically calculated systems can, however, be used for all types of occupancies.

Methods of making flow calculations for sprinkler systems are given in the following: (1) the NFPA Sprinkler Standard, (2) NFPA No. 15, Standard for Water Spray Systems for Fire Protection, (3) "Automatic" Sprinkler Hydraulic Data published by "Automatic" Sprinkler Corp. of America,¹ (4) Factory Mutual Corporation's *Handbook of Industrial Loss Prevention*,² and (5) an address "Water Flow Characteristics of Sprinkler Systems" reported in the Proceedings of the 58th Annual Meeting of the NFPA.³

The design area for the system is the hydraulically most remote area, and usually includes sprinklers on both sides of the cross main. Each sprinkler in the design area must discharge at a flow rate at least equal to the stipulated minimum water application rate (density). Begin calculations at the sprinkler hydraulically farthest from the supply connection. With common system configurations this will be the end sprinkler on the end branch line. The minimum operating pressure for any sprinkler must not be less than 7 psi.

The Most Remote Sprinkler

Assuming a minimum pressure of 10 psi at the most remote sprinkler and a discharge coefficient of 0.75 for a standard 1-in. orifice sprinkler (the coefficient varies—0.78 is used elsewhere in this HANDBOOK), we will have a discharge of 17.7 gpm calculated from the formula $Q = 29.8 cd^2\sqrt{P}$ (see Sec. 11, Chap. 6), used in calculating flows through orifices and short tubes. The value for $29.83 cd^2$ in this instance is 5.6, a figure commonly used as the sprinkler discharge constant K in the simplified formula $Q = K\sqrt{P}$. Velocity pressure is not a factor at the more remote sprinkler, but it is considered at all the other sprinklers in the example that follows. Some organizations ignore velocity pressure in their calculations. The error introduced is on the safe side. NFPA No. 15, Standard for Water Spray Fixed Systems, recommends considering velocity only when it is more than 5 percent of the total pressure.

Assuming sprinklers 10 ft apart on branch lines, with the end section of pipe 1 in. nominal diameter, the friction loss at 17.7 gpm flow, with a Hazen and Williams formula coefficient of 120 (value for black steel pipe) will be 1.0 psi (see Fig. 11-6L in Sec. 11, Chap. 6 and change friction loss values in that graph, which are based on $C = 100$, to values based on $C = 120$ by multiplying by 0.714).

Second Sprinkler from the End

The total pressure at the second sprinkler will be $10.0 + 1.0 = 11.0$ psi. Of this, velocity pressure based on a flow of 17.7 gpm will be 0.3 psi (see Fig. 11-6A, Sec. 11, Chap. 6). The normal pressure (pressure acting perpendicular to the pipe wall) acting on the second sprinkler is the total pressure of 11.0 psi less the velocity pressure of 0.3 or 10.7 psi. On all sprinklers except the end sprinkler, only normal pressure is considered as acting on the sprinklers.

The discharge from the second sprinkler, at a pressure of 10.7 psi, will be 18.3 gpm.

The pipe between the second and third sprinkler, also 1 in. diameter, 10 ft long, and with a flow of $17.7 + 18.3 = 36.0$ gpm, will have a friction loss of 3.8 psi, and a velocity pressure of 1.2 psi. Total pressure at the third sprinkler equals $10.7 + 3.8 + 1.2$ or 15.7 psi.

Other Sprinklers on a Branch Line

Up to this point, velocity pressure has been based on flow downstream from the sprinkler being considered; this has

been confirmed by tests.³ It has also been shown by those tests that beyond the second sprinkler velocity pressure should be figured from the flow on the upstream side of the sprinkler being considered. This is done by trial and error, assuming a flow from the sprinkler, calculating the velocity pressure from the total flow, determining a normal pressure, and calculating a flow from the normal pressure. If the calculated flow is not reasonably close to the assumed flow, assume a different flow and repeat the procedure until the two are close.

Assume a flow from the third sprinkler of 19.0 gpm, and also assume that the pipe between the third and fourth sprinkler is 1½ in. Total flow is $36.0 + 19.0 = 55.0$ gpm. Velocity pressure is 0.9 psi and normal pressure at the third sprinkler is therefore $15.7 - 0.9$ or 14.8 psi. Corrected flow then becomes 21.6 gpm, which is not close enough to the 19 gpm assumed. Try an assumed flow of 21.4 gpm. Velocity pressure at 57.4 gpm is 1.0; normal pressure is 14.7 psi and the new corrected flow is 21.5 gpm. Total flow at the third head then becomes $36.0 + 21.5 = 57.5$ gpm. The calculating procedure for the other sprinklers on the branch line is the same as for the third sprinkler.

At this point it will be seen that we have exceeded the 15 psi minimum riser pressure, unless, as is quite probable, the pressure with 57.5 gpm flow is substantially higher than that with 500 gpm flow. Whether or not the pressure with 57.5 gpm flow is higher than 15 psi depends on the characteristics of the water supply. However, in any case it appears that with not many more sprinklers open the pressure at the most remote sprinkler will be less than the 10 psi selected in this example.

Branch Lines, Cross Mains, Risers, and Fittings

Cross Main Pressure at the Branch Line Connection: This is the normal pressure at the nearest open sprinkler increased by the friction loss and the velocity pressure in the intervening pipe. If the branch line is fed through a tee and nipple, additional friction loss allowances must be made except that the friction loss in nipples less than 6 in. long is customarily neglected.

Two Branches in One Line of Sprinklers: These may have the same or different numbers of sprinklers. The pressure at the entrance to the two branches will always be the same. The computations starting at the end sprinklers will be duplicated for the number of open sprinklers.

After the discharge from any number of sprinklers on a branch line has been computed and the pressure to produce the flow has been determined, the entire branch line can be considered to have the discharge characteristics of a single orifice and the discharge constant K in the formula $Q = K\sqrt{P}$ can be determined, P being the net pressure where flows are taken from tees in the cross main.

Branches on Opposite Sides of a Cross Main: These branches may have different numbers of sprinklers open, in which case the cross main pressure must be the higher of the two computed values. This increases the discharge from the branch giving the lower computed pressure, and the actual discharge must be calculated for the higher pressure using the equation:

$$\frac{Q_1}{Q_2} = \sqrt{\frac{P_1}{P_2}}$$

in which P_2 is taken as the higher pressure, Q_2 the corresponding increased discharge to be determined, and P_1 and Q_1 the pressure and corresponding discharge from the branch requiring only the lower pressure.

After the appropriate increased discharge has been deter-

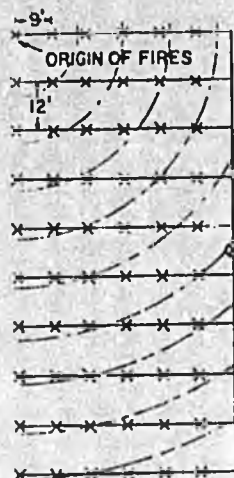
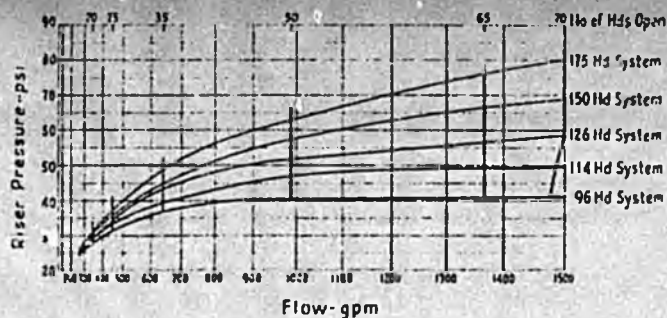


Fig. 14-4C. A flow curve for a side-central feed to sprinklers on a system having six sprinklers on each branch line is shown on the above graph. Below is the pattern of sprinklers opening on a side-central feed system. (Factory Mutual System)

mined, the two rates of flow can be combined and K for the combined branches calculated.

When sprinklers on the second branch line are assumed to have opened, starting at the cross main sprinkler, the opened sprinkler most remote from the cross main is considered as the end head in the branch line computation, the next opened is the second, etc., regardless of nonoperating sprinklers on the outer end of the branch.

Cross Main Pressures: Cross main pressures are calculated by the same procedure as used for sprinklers on a single branch line, except that it is not necessary to use the trial and error procedure for the third and additional branch lines since the effect of change in velocity pressure with flow passing through tees in the cross main is usually negligible. The net head producing the flow in successive branch lines is taken as the normal pressure at the end branch line increased by the friction loss in the pipe between the branches.

Riser Pressure: Riser pressure is taken as the normal pressure at the nearest flowing branch increased by the total friction loss between this branch and the riser and by the velocity pressure in the cross main at the riser connection.

Friction Loss in Fittings: This is generally included in calculations only when the fitting involves a change in direction of flow. An exception to this is the fitting immediately preceding the sprinkler.

Friction loss in control, gate and check valves, strainers, meters, and similar devices is always included.

The friction loss in piping between the source of supply and the opened sprinklers must obviously be included in all calculations.

Where there are differences in elevation, these must be allowed for on the basis that each foot of height represents 0.434 psi. In multistory buildings, this may be a substantial factor.

Feed mains, cross mains, and branch lines within the same system may be looped or gridded to divide the total water flowing to the design area.

Sprinkler System Water-flow Curves

To avoid repetition of laborious computation of water flows and pressures when such information is needed in cases involving standard sprinkler, spray, or open head systems, it is possible to prepare diagrams or "water-flow curves" from which riser pressures and corresponding total sprinkler flows may be determined for different numbers of opened sprinklers. One such series of curves, as developed by the Factory Mutual Engineering Corporation, and the piping arrangement and assumed pattern of opened sprinklers is shown in Figure 14-4C.

SI Units

The following conversion factors are given as a convenience in converting to SI units the English units used in this chapter.

- 1 ft² = 0.0929 m²
- 1 in. = 25.400 mm
- 1 ft = 0.305 m
- 1 psi = 6.895 kPa
- 1 gpm = 3.785 litre/min

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- ² Factory Mutual Engineering Corporation, "Hydraulics of Sprinkler Systems," *Handbook of Industrial Loss Prevention*, 2nd ed., McGraw-Hill, New York, pp. 23-1-23-13.
- ³ Nickerson, Malcolm H., "Water Flow Characteristics of Sprinkler Systems," *Proceedings of The Fifty-Eighth Annual Meeting, National Fire Protection Association*, May 17-21, 1954, Washington, D.C., pp. 140-152.

NFPA Codes, Standards, and Recommended Practices (see the latest *NFPA Publications and Visual Aids Catalog* for availability of current editions of the following documents)

- NFPA 13, Standard for the Installation of Sprinkler Systems.
- NFPA 15, Standard for Water Spray Fixed Systems.
- NFPA 20, Standard for Centrifugal Fire Pumps.
- NFPA 22, Standard for Water Tanks for Private Protection.
- NFPA 231, Standard for Indoor General Storage.
- NFPA 231C, Standard for Rack Storage of Materials.

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PART VI

S T A T I S T I C S

METERS ARE AVAILABLE WHICH CAN MEASURE WATER
CONSUMED FOR FIRE PROTECTION AND CITIES WHICH HAVE
UTILIZED METERS FOR DETERMINING PRIVATE FIRE PROTECTION CHARGES

H. Meters for Fire Connections

Fire flow meters are devices capable of measuring small and large flows with a minimum loss of head for heavy

demands. They are offered in two types: (1) detector check valve-type meters that detect only small rates of flow and (2) so-called full registration meters that measure the entire flow throughout the line in which they are installed. Meters of types other than the fire flow type have been found to be unsatisfactory for fire protection water supplies.

Detector Checks

These devices consist of a check valve with a weighted clapper in the main passage and a disc meter in a bypass around the check. In operation the smaller flows pass through the disc meter in the bypass and are accurately registered. Disc meters may be furnished up to 3 in. in size to serve specific needs. For heavy flows the check valve opens and a free unmeasured waterway is provided. Beyond the point where the weighted check valve lifts, the bypass meter registers only a small part of the flow. In many situations the detector checks should give the water works the assurance desired as to the proper use of water.

Figure 11-2BB shows a representative detector check valve.

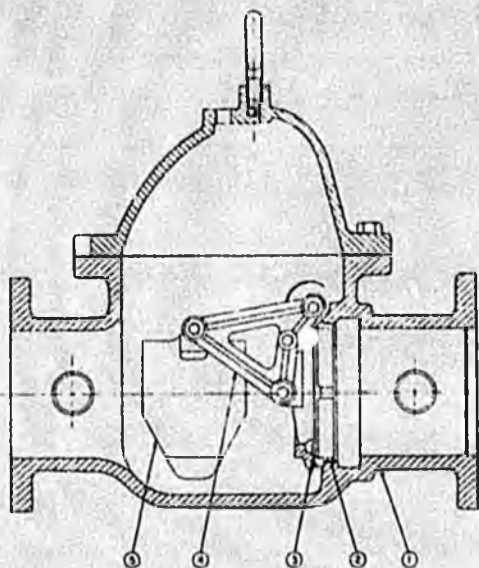


Fig. 11-2BB. A detector check valve. Photo shows view from top of weighted check valve and meter in bypass. Section view shows clapper in closed position. (The Viking Corporation)

Full Registration Meters

These devices are of three general types, each produced by a different manufacturer, and they have been designed for small friction loss with large flows and for a main passageway practically unobstructed when open. The three types are: (1) proportional type meters, (2) meters of the displacement type in a bypass and (3) turbine-type meters.

Proportional Type, Hersey Detector Meter, Model FM: This meter is a special meter of the compound type in which a "proportional meter" and an automatic valve in the main line of the meter are combined with a disc or compound meter in a bypass (see Fig. 11-2CC).

In the Model FM, the smaller flows pass through and are measured by the bypass meter. When the demand for water reaches a rate of flow which causes a difference in pressure

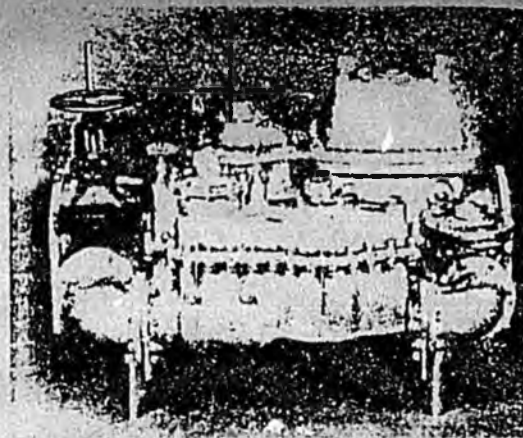


Fig. 11-2CC. A detector meter of the proportional type. (Hersey-Sparling Meter Company)

of 4 psi in the bypass, the automatic check valve opens and provides a practically free waterway through the main line. When water begins to flow through the line in which the automatic valve has opened, it is slightly retarded by a restricting orifice placed a little upstream from the automatic valve, and a part of the water is diverted through a metering unit. This diverted flow is a fixed percentage of the total flow through the restricting orifice. The metering unit is calibrated to record the total quantity through the line, the sum of the readings of the bypass meter and the main line metering unit gives the total flow.

Displacement Type, Neptune Trident Protectus Meter: This meter has all of the working parts in one casing. A disc meter is installed in a bypass on one side and a current meter on the other side of the main waterway. Small flows pass through the disc meter and are recorded when the check valve is closed. With larger flows the main check valve opens and gives a free waterway. The opening of the check valve stops the flow through the disc meter and opens the bypass to the current meter so that the flow through the open waterway is measured proportionately. The sum of the readings gives the total flow (see Fig. 11-2DD).

Turbo Type, Rockwell W-2000 Turbo Meter: This meter is based on the turbine principle of measurement. The meter is composed of two principal assemblies, the main case and the measuring chamber. The main case contains the flow straightening vane assembly. The measuring chamber includes rotor, adjusting vane, pulse amplifier chart and terminal strip for attaching the connecting cable. The function

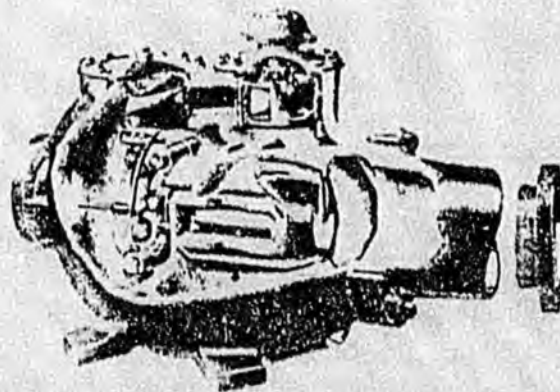


Fig. 11-2DD. A fire flow meter of the displacement type. (Neptune Meter Company)

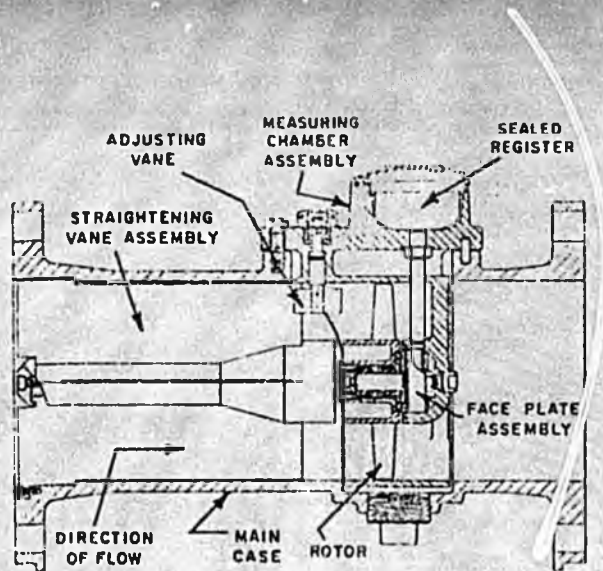


Fig. 11-2EE. A fire flow meter of the turbo type. (Rockwell Mfg. Co.)

of a printed circuit card is to electronically count revolutions and transmit intelligence to a register. The meter should be installed with a 6-in. Rockwell strainer placed immediately upstream of the meter. If the strainer is not used, a minimum of 15 diameters of straight pipe must be immediately upstream of the meter to assure valid registration (see Fig. 11-2EE).

Friction Loss in Fire Flow Meters and Detector Check Valves

The standard specifications for cold water meters adopted by both the American Water Works Association and the New England Water Works Association limit the friction loss for fire flow meters to 4 psi at rated flow capacities. Table 11-2H gives friction loss values for the three currently available types of fire flow meters.

Friction loss values for meters of the disc, current and compound type that are used commonly in waterworks systems for general purposes are relatively high and not wited for fire protection purposes. AWWA limits their friction loss values to 20 psi.

Detector Check Valves: The friction loss in detector check valves listed and approved by recognized testing laboratories is less than 3 psi for the following flows:

Size (in.)	Flow (gpm)
4	750
6	1,500
8	3,000
10	4,500
12	6,500

The pressure required to open the clapper is less than 20 psi.

Table 11-2H. Friction Loss in Fire Flow Meters
 Compiled from data supplied by manufacturers

Meter Name and Type	Size of Meter Inches	Loss of Pressure Caused by Meter Pounds per Square Inch							
		Gallons per Minute Flowing							
		250	500	750	1000	1250	1500	2000	2500
Proportional Type (Torsey-FM)	4	2.2	1.9	4.0					
	6	3.8	2.7	1.4	1.8	2.2	2.9	3.9	
	8	3.0	3.7	1.9	1.0	0.8	0.8	1.3	2.2
	10	1.6	3.6	4.0	3.7	2.6	1.4	0.8	1.1
Differential Type (Invent Protectus)	4	2.2	2.0	3.9					
	6	2.9	1.9	1.8	1.8	1.8	1.8	2.2	3.3
	8	3.2	1.8	1.5	1.5	1.5	1.6	1.8	2.2
	10	3.0	2.3	1.8	1.3	1.2	1.1	1.1	1.2
Turbo Type (Rockwell W-2000 Turbo)	6	0.2	0.3	0.6	0.85	1.2	1.6	3.5	

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AWWA C104-71, ANSI A21.4—1971, Standard for Cement-Mortar Lining for Cast Iron Pipe and Fittings for Water.

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AWWA C108—1970, ANSI A21.8—1970, Standard for Cast Iron Pipe, Centrifugally Cast in Sand-Lined Molds, for Water and Other Liquids.

AWWA C110-71, ANSI A21.10-71, Standard for Cast-Iron Fittings, 2 in. through 48 in., for Water and Other Liquids.

AWWA C111-72, ANSI A21.11-72, Standard for Rubber Gasket Joints for Cast-Iron Pressure Pipe and Fittings.

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PART VII

P L A N N I N G

FIRE PROTECTION CAN BEST BE ACHIEVED THROUGH
FORESIGHT AND COOPERATION OF ALL CITY DEPARTMENTS
INCLUDING THE FIRE DEPARTMENT AND WATER DEPARTMENT

C. Planning

The following information has been extracted in whole and in part from "America Burning," the report of the National Commission on Fire Prevention and Control¹, and is considered appropriate for inclusion in this portion of the HANDBOOK.

Planning

Fire protection has been largely a local responsibility, and for good reasons it is destined to remain so. Each community has a set of conditions unique to itself, and a system of fire protection that works well for one community cannot be assumed to work equally well for other communities. To be adequate, the fire protection system must respond to local conditions, especially to changing conditions. Planning

is the key: Without local-level planning, the system of fire protection is apt to be ill-suited to local needs and lag behind the changing needs of the community.

Excellent fire protection (for example, in the form of automatic extinguishing systems) lies within technical grasp, and certainly lies within the resources of most communities to provide. Even with considerable public support, this protection would require many years to accomplish. In the meantime, in every fire jurisdiction (whether a municipality, county, or region) standards aiming at a significant increase in fire protection must be set. Among the concepts to be defined:

Adequate Level of Fire Protection: The question of "adequacy" addressed itself not only to day-to-day normal needs, but to major contingencies that can be anticipated and to future needs as well. What is needed is a definition of "optimal" protection—in contrast to "minimal" protection, which fails to meet contingencies and future needs, and "maximal" protection, which is more than the community can afford.

Reasonable Community Costs: Fire, both as threat and reality, has its costs: property losses, deaths, injuries, hospital bills, lost tax revenues, plus the costs of maintaining fire departments, paying fire insurance premiums, and providing built-in fire protection. Each community must decide on an appropriate level of investment in fire protection. Some costs beyond the public's willingness to bear should be transferred to the private sector (as when buildings over a certain size or height or with a certain occupancy are required to have automatic extinguishing systems).

Acceptable Risk: A certain level of losses from fire must be accepted as tolerable simply because of limited resources of the community. Conditions that endanger the safety of citizens and fire fighters beyond the acceptable risk must be identified as targets for reduction.

Consideration of these matters helps to determine what functions and emphasis should be assigned to the fire department, other municipal departments, and the private sector, both now and in the future. It helps to define new policies, laws, or regulations that may be needed. Most important, consideration of these matters makes clear that fire safety is a responsibility shared by the public and private sectors. Because the fire department cannot prevent all fire losses, formal obligations fall on owners of certain kinds of buildings to have built-in fire protection. For the same reason, private citizens have an obligation to exercise prudence with regard to fire in their daily lives. But prudence also requires education in fire safety, and the obligation to provide that education appropriately falls in the public sector, chiefly the fire department. The public sector (again, chiefly the fire department) also has an obligation to see that requirements for built-in protection in the private sector are being met.

A fire department, then, has more than one responsibility. Nor are the responsibilities just mentioned exhaustive. At least 8 important functions for fire departments can be identified:

Fire Suppression: Fire fighters need proper training and adequate equipment for saving lives and putting out fires quickly, and also for their own safety.

Life Safety-paramedical Services: Capabilities needed during fires and other emergencies include first aid, resuscitation, and possibly paramedical services. (By "paramedical services" we mean emergency treatment beyond ordinary first aid, performed by fire service personnel under supervision (through radio communication, for example) of a physician.)

Fire Prevention: This includes approving building plans

and actual construction, inspecting buildings, their contents, and their fire protection equipment, public education, and investigating the causes of fires to serve as a guide to future priorities in fire prevention.

Fire Safety Education: Fire departments have an obligation to bring fire safety education not only into schools and private homes, but also into occupancies with greater than average fire potential or hazard to people, such as restaurants, hotels, hospitals, and nursing homes.

Deteriorated Building Hazards: In coordination with other municipal departments, fire departments can work to abate serious hazards to health and safety caused by deteriorated structures or abandoned buildings.

Regional Coordination: Major emergencies can exceed the capabilities of a single fire department, and neighboring fire jurisdictions should have detailed plans for coping with such emergencies. But effectiveness can also be improved through sharing of day-to-day operations—as, for example, an area-wide communication and dispatching network.

Data Development: Knowledge of how well a fire department is doing, and of how practices should change to improve performance, depends on adequate record-keeping.

Community Relations: Fire departments are representative of the local community that supports them. The impression they make on citizens affects how citizens view their government. Volunteer departments dependent on private donations must, of course, also be concerned with their community relations. Moreover, since fire stations are strategically located throughout the community, they can serve as referral or dispensing agencies for a wide range of municipal services.

As communities set out to improve their fire protection, it is not the fire department alone they must consider. The police have a role in reporting fires and in handling traffic and crowds during fires. The cooperation of the building department is needed to enforce the fire safety provisions of building codes. The work of the water department in maintaining the water system is vital to fire suppression. In the realm of fire safety education, the public schools, the department of recreation, and the public library can augment the work of the fire department. Future development and planning will influence the location of new fire stations and how they will be equipped.

These are just the obvious examples of interdependence. So seemingly trivial a matter as the manner in which house numbers are assigned and posted can affect the ability of fire departments to respond quickly and effectively to emergencies.

Master Planning

Fire protection is only one of many community services. Not only must it compete for dollars with other municipal needs, such as the education system and the police department, but, in planning for future growth, the fire protection system must take into account the changes going on elsewhere in the community. For example, if a slum area is to be torn down and replaced with high-rise apartment buildings, that will change the fire protection needs of the area. Changes in zoning maps will also change the fire protection needs in different parts of the community.

To cope with future growth, local administrators are turning increasingly to the concept of *master planning* of municipal functions. Such plans include an examination of existing programs, projection of future needs of the community, and a determination of methods to fill those needs. They seek the most cost-effective allocations of resources to help assure that the needs will be met.

A major section of a community general plan of land use should be a *Master Plan for Fire Protection*, written chiefly by fire department managers. This plan should, first of all, be consistent with and reinforce the goals of the city's overall general plan. For example, it should plan its deployment of manpower and equipment according to the kind of growth, and the specific areas of growth, that the community foresees. It should set goals and priorities for the fire department. Not only is it important to set objectives in terms of lives and property to be saved, but also to decide allocations among fire prevention inspection, fire safety education, and fire suppression as the best way to accomplish the objectives.

Having established goals, the plan should seek to establish "management by objectives" within the fire department. This operates on the principle that management is most effective when each person is aware of how his tasks fit into the overall goals and has committed himself to getting specific jobs done in a specified time.

Because fire departments exist in a real world where a variety of purposes must be served with a limited amount of money, it is important that every dollar be invested for maximum payoff. The fire protection master plan should not only seek to provide the maximum cost-benefit ratio for fire protection expenditures, but should also establish a framework for measuring the effectiveness of these expenditures.

Lastly, the plan should clarify the fire protection responsibility for other groups in the community, both governmental and private.

Devising a Fire Protection Plan

The following can serve as guidelines to fire department administrators for developing and presenting a master plan for fire protection:

Phase I

1. Identify the fire protection problems of the jurisdiction.
2. Identify the best combination of public resources and built-in protection required to manage the fire problem, within acceptable limits:
 - (a) Specify current capabilities and future needs of public resources;
 - (b) Specify current capabilities and future requirements for built-in protection.
3. Develop alternative methods that will result in trade-offs between benefits and risks.
4. Establish a system of goals, programs, and cost estimates to implement the plan:
 - (a) The process of developing department goals and programs should include maximum possible participation of fire department personnel, of all ranks;
 - (b) The system should provide goals and objectives for all divisions, supportive of the overall goals of the department;

- (c) Management development programs should strive to develop increased acceptance of authority and responsibility by all fire officers, as they strive to accomplish established objectives and programs.

Phase II

1. Develop, with the other government agencies, a definition of their roles in the fire protection process.
2. Present the proposed municipal fire protection system to the city administration for review.
3. Present the proposed system for adoption as the fire protection element of the jurisdiction's general plan. The standard process for development of a general plan provides the fire department administrator an opportunity to inform the community leaders of the fire protection goals and system, and to obtain their support.

Phase III

In considering the fire protection element the governing body of the jurisdiction will have to pay special attention to:

1. Short- and long-range goals,
2. Long-range staffing and capital improvement plans,
3. The code revisions required to provide fire loss management.

Phase IV

The fire loss management system must be reviewed and updated as budget allocations, capital improvement plans, and code revisions occur. Continuing review of results should concentrate on these areas:

1. Did fires remain within estimated limits?
2. Should limits be changed?
3. Did losses prove to be acceptable?
4. Could resources be decreased or should they be increased?

SI Units

The following conversion factors are given as a convenience in converting to SI units the English units used in this chapter.

$$\begin{aligned} 1 \text{ gal (U.S.)} &= 3.785 \text{ litres} \\ 1 \text{ gpm} &= 3.785 \text{ litres/min} \end{aligned}$$

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² *Grading Schedule for Municipal Fire Protection*, Insurance Services Office, New York, 1974.

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- NFPA No. 4A, Recommendations for Organization of a Fire Department.
- NFPA No. 73, Standard for Installation, Maintenance and Use of Public Fire Service Communications.
- NFPA No. 197, A Training Standard on Initial Fire Attack.

PART VIII

ANCHORAGE WATER UTILITY TARIFF
ON FILE WITH THE
ALASKA PUBLIC UTILITIES COMMISSION

MAR 25 1977

State of Alaska
Public Utilities Commission

I. FEES AND SPECIAL CHARGES - NONRECURRING

<u>Rule</u>	<u>Service</u>	<u>Fee or Charge</u>
10.8	Water turn-on or turn-off (per visit)	
	During business hours	\$ 12.00
	During non-business hours	50.00 (I)
5.6	Return visit necessitated by restricted access	10.00
6.2(c)	Hydrant wrench deposit	10.00
6.2(d)	Meter deposit (hydrant meters)	100.00
7.2	Fees for water connections (extending a maximum of 50 feet). This charge includes permit and inspection fees.	
	3/4"	189.60
	1"	207.56
	1-1/2"	310.29
	2"	392.04
	Larger than 2"	Cost of Construction
	3" - 4" Connection	800.00 Deposit
	6" - 8" Connection	1,000.00 Deposit
	10" Connection	Deposit determined by AWU Manager

Pursuant to Order No. 4, U-75-66

FEB 28 1977

Tariff Advice No. 8-122

Effective:

Anchorage Water Utility

Issued by:

By: Dale R. Merrell
DALE R. MERRELL, P.E.

Utility Manager

Title:

State of Alaska
 Public Utilities Commission

I. FEES AND SPECIAL CHARGES - NONRECURRING (CONTINUED)

<u>Rule</u>	<u>Service</u>	<u>Fee or Charge</u>	
7.2	Charge per foot for construction of service lines exceeding 50 feet		
	3/4"	\$ 2.70	
	1"	3.30	
	1-1/2"	4.85	
	2"	6.70	
	Larger than 2"	Cost of Construction	
7.3	Water extension permit		
	Permit administration fee	5.00	
	Inspection	10.00	
8.10	Reconnection or restoral charge	25.00	(I)
8.19	Unauthorized turn-on/turn-off	60.00	(I)
9.7	Meter test		
	3/4" through 2" meters	25.00	
	Meters larger than 2"	50.00	
10.2	Water service for test purposes	20.00	
10.9	Duplicate locate service	25.00	(I)
	Non-business hours	50.00	(I)
10.10	Private fire hydrant maintenance fee	110.00	(I)

Pursuant to Order No. 4, U-76-66

Tariff Advice No. 8-122

Effective: FEB 28 1977

Anchorage Water Utility

Issued by

 BY: DALE R. MERRELL, P.E.

 Title: Utility Manager

MUNICIPALITY OF ANCHORAGE WATER UTILITY RATES

II. SERVICE CHARGES

The rates and charges shown are the monthly service charges for water service only. Assessments, contributions in aid of construction or charges for specific services beyond the scope of normal water services (e.g., special construction of a long service line; repair of damage which was the responsibility of the customer) are in addition to the following rates.

Schedule A - Residential

One to five units;
per unit per month \$ 9.50 (I)

Schedule B - Metered commercial and industrial

This schedule applies to commercial, industrial, and multiple unit residential accounts which are metered. Metering requirements are contained in Rule 9 of this tariff.

Metered rate per 1,000 gallons \$ 1.20 (I)

Schedule C - Unmetered commercial and industrial

This schedule applies to all unmetered commercial and industrial accounts, including multiple unit residential accounts which have six or more units. The rates are for one month's service and vary by service size.

<u>Service Size</u>	<u>Monthly Rate</u>	
3/4"	\$ 14.65	(I)
1"	25.90	(I)
1 1/2"	57.70	(I)
2"	102.80	(I)
3"	232.40	(I)
4"	412.95	(I)

Pursuant to Order No. 4, U-76-66

FEB 28 1977

Tariff Advice No. 8-122 (L)

Effective: _____

Issued by _____ Anchorage-Water Utility

Utility Manager

II. SERVICE CHARGES (CONTINUED)

Schedule C - Unmetered commercial and industrial (continued)

<u>Service Size</u>	<u>Monthly Rate</u>
6"	\$ 927.85 (I)
8"	1,649.20 (I)
10"	2,576.20 (I)

Twelve inches or larger service shall be a contracted service. Additionally, any service of six inches or larger which is for mixed accounts (i.e., more than one customer class) may be contractual service at the discretion of the management of the Anchorage Water Utility subject to approval of the APUC

Schedule D - Special customers

(1) Temporary construction service charge for unmetered service using the service line that will serve the building under construction. The charge shall be a flat monthly charge for service according to the following schedule:

<u>Service Size</u>	<u>Monthly Rate</u>
3/4"	\$ 16.10 (I)
1"	21.50 (I)
1½"	32.20 (I)
2"	42.95 (I)
3"	64.40 (I)
4"	85.85 (I)
6"	128.80 (I)
8"	171.75 (I)
10"	214.65 (I)

Pursuant to Order No. 4, U-76-66
Tariff Advice No. 8-122(L)

FEB 28 1977

Effective:

Issued by: Anchorage Water Utility

By: Dale R. Merrell
Dale R. Merrell, P.E.

Title: Utility Manager

II. SERVICE CHARGES (CONTINUED)

Schedule D - Special customers (continued)

(2) Temporary construction or other use requiring a connection to a fire hydrant. The AWU reserves the right to require the customer to use a meter when an appropriate meter is available. Service shall be restricted to 2-1/2 inches diameter to 4-1/2 inches diameter. A meter deposit of \$100 will be required when the service is connected. The deposit shall be refunded when the undamaged meter is returned to the Water Utility. The monthly charges are:

<u>Service Size</u>	<u>Demand Charge</u>	<u>Commodity Charge</u>
2½"	\$250.80 per month	\$.42 per 1,000 gallons (I)
3"	300.95 per month	.42 per 1,000 gallons (I)
4"	401.25 per month	.42 per 1,000 gallons (I)
4½"	451.40 per month	.42 per 1,000 gallons (I)

(3) When an appropriate meter is not available for a temporary connection to a fire hydrant, the following monthly charges shall be effective:

<u>Service Size</u>	<u>Monthly Charge</u>
2½"	\$ 271.70 (I)
3"	321.85 (I)
4"	422.15 (I)
4½"	472.30 (I)

Schedule E - Private fire protection

This schedule shall apply to private fire services. The charges are in addition to the charge for basic water service unless the service connection is used exclusively for fire protection. The charges vary by service size.

Pursuant to Order No. 4, U-76-66

FEB 28 1977

Tariff Advice No. 8-122 (L)

Effective: _____

Issued by: Anchorage Water Utility

By: [Signature]

Title: Utility Manager

MAR 23 1977

Alaska Public Utilities Commission

I. SERVICE CHARGES (CONTINUED)

Schedule E - Private fire protection (continued)

<u>Service Size</u>	<u>Monthly Rate</u>	
2"	\$ 7.10	(N)
3"	15.90	(N)
4"	28.45	(N)
6"	63.55	(N)
8"	112.85	(N)
10"	176.40	(N)
12"	254.10	(N)

Schedule F - Bulk water sales

All bulk water sales will be handled by special contracts.

Pursuant to Order No. 4, U-76-66

Tariff Advice No. 8-122(L)

FEB 28 1977

Effective: _____

Issued by: Anchorage Water Utility

By: *[Signature]*

Utility Manager

APPENDIX A

ISO REPORT ON ANCHORAGE

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CITY MANAGER'S
OFFICE

554

ANCHORAGE,
ALASKA

Please consider this report, including the map,
as *confidential information* and exercise due care
if it becomes available only to those persons
who are entitled to this information.

April, 1969

File No. 554

REPORT

ON

ANCHORAGE, ALASKA

AMERICAN INSURANCE ASSOCIATION

Successor to National Board of Fire Underwriters

MUNICIPAL SURVEY SERVICE

85 John Street, New York, N. Y. 10038

120 South LaSalle Street, Chicago, Ill. 60603

405 California Street, San Francisco, Calif. 94104

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ANCHORAGE, ALASKA

FILE NO. 554

GENERAL

The 1960 U.S. Census showed a population of 44,320 and the present estimated population is 56,000. Area of the city is 15.1 square miles of which 4.3 square miles are included in tidelands, military reservations, and railroad right-of-way. The remaining 10.8 square miles are approximately 50% built upon. Elevations in the city range from sea level to 250 feet, with the average elevation of the principal business district 100 feet. The city is a terminus for the main supply routes serving Alaska as well as a tourist stopping point during most of the summer.

Long cold winters are common with an average snowfall of 12 inches. Prolonged low temperatures below -10 degrees are infrequent. A moderate to severe earthquake hazard exists within the city and surrounding areas. Alaska falls within the circum-Pacific belt of earthquakes which also includes coastal California and Japan. The earthquake of March 27, 1964, was centered about 75 miles from the city and reached a Richter magnitude of 8.4. Major landslides occurred in the city's downtown and residential areas, causing major damage to buildings and the water distribution system.

WATER SUPPLY

General.—The system is municipally owned and supplies nearly all of the city built-on areas and additional area to the east and south. Supervision is by an appointed director. There is no civil service but long tenure is prevalent.

Records are mainly complete, but individual valve records are not maintained.

Alarms of all fires during winter and of second alarm fires at other times are telephoned to the water treatment plant; response is made to all such fires.

Supply Works.—See map. A diversion dam on Ship Creek, elevation 530, $5\frac{1}{4}$ miles east of the city, provides 53% of the system supply capacity by gravity and is the source of water supply for Fort Richardson and Elmendorf Air Base; supply line capacity is 10.5 mgd. Seven pumped wells, total capacity 11.6 mgd, deliver the remaining supply to the distribution system. Flow in Ship Creek is a minimum during the early winter, but water has never been below the spillway. The March, 1964, earthquake disrupted casings of 2 wells, and earth slides above the diversion dam muddied gravity supply, seriously reducing the capacity of the treatment plant which can process in excess of the supply line capacity.

A small section, with 7 hydrants, in the southern part of the city is served by the Romig Water Company which has an emergency connection from an 8-inch city main for fire supply.

Distribution Storage.—See map. System storage is limited to the 0.5-mg treatment plant clear well, elevation 366.

Consumption.—The average daily consumption for the 12 months ending July 31, 1968, was 11.01 mgd with a maximum of 16.56 mg on July 24, 1968.

Pressures.—The average pressure during fire flow tests was 57 psi, with a maximum of 87 psi and minimum of 38 psi.

Distribution System.—See map. From the Control House, 1400 feet west of the treatment plant, a 24-inch wood-stave pipe line extends well into the distribution system furnishing the main supply to the more important northern section of the system. The southern portion of the system is supplied by a 36-, 30-inch reinforced concrete steel-cylinder-type pipe the capacity of which is greatly restricted by a 16-inch branch supplying 2 lines of 10- and 8-inch pipe. New mains are of cement-lined cast iron with older

ANCHORAGE, ALASKA

pipe of tar-coated cast iron. Of the total pipe in the system, 28% is asbestos-cement pipe, and 9% is wood-stave pipe in 6-, 8-, and 10-inch sizes. Of the 154.85 miles of 4-inch and larger mains, only 0.32 mile is 4-inch and 59.97 miles are 6-inch. Dead ends of 6-inch mains total 4.21 miles.

The average valve spacing is 4340 feet on supply mains, 910 feet on arterial mains, 440 feet in the principal business district, and 810 feet in representative residential districts. There is no regular valve inspection program.

There are 869 public and 16 private hydrants. Of the public hydrants, 31 have 4-inch connections to mains, and 148 lack a large pumper outlet; others are of satisfactory size and type with a pumper and 2 or 3 hose outlets, and all have valved connections.

The average hydrant spacing is 125,500 square feet in the principal business district, 173,000 square feet in other high-value districts, and 214,400 square feet in representative residential districts; hydrants are inspected 2 or more times a year and after every use during freezing weather.

Fire Flow Tests.—See map with table. Tests were witnessed on August 8 and 14, 1968, under normal conditions. The consumption rate during the tests in the principal business district was about 15.8 mgd, and daily consumption was 13.05 and 12.70 mg, respectively. The principal business district tests were repeated the second day, after regulator valves and important line valves were checked, and were made at a time when consumption did not materially exceed the maximum daily rate. Test 9, on the Romig Water System, was made with the city emergency connection open. Tests 24, 25, and 26 were repeated on October 2 after a regulator by-pass valve, found open, was closed and a 16-inch valve, found closed, was opened.

Proposed Improvements.—See map. The 36-, 30-inch southern section supply main was being extended to a 5-mg reservoir under construction for completion in 1969. A gridiron of 12- and 16-inch mains, being installed in the northern section of the port and industrial area, was nearly complete at the time of the survey.

FIRE DEPARTMENT

In addition to the city, the department provides fire protection for the Spenard and Muldoon Public Utility Districts outside the city with an estimated population of 30,000 and an area of 24 square miles. One ladder and 5 engine companies, and an ambulance are in service in 4 fire stations in the city; the 2 engine companies in one station in the Spenard District and the one engine company in the Muldoon

District are under the jurisdiction of the city fire chief according to written contracts, although the fire stations and the fire apparatus are owned by the districts.

There are 93 full-paid members (including 20 assigned to the 3 companies outside the city) as follows:

Fire Force:		
Officers:	Chief and	
	Senior Captains	5
	Company	28
Fire fighters and Engineers:		52
Non-fire force:		10

Members work an average of 64 hours per week. The number normally on duty is 18 with the engine and ladder companies within the city and 7 with the 3 companies outside the city. Some of the off-shift members are called on second alarm fires, and all of the off-shift on fifth alarm fires. Some outside aid is readily available.

All apparatus and vehicles in service and reserve are equipped with radio transmitter-receivers on a frequency shared with 3 small fire departments.

Pumper capacity is adequate. Repairs to apparatus are made by a full-time department mechanic; the shop area is at the rear of the apparatus floor at Engine 3 quarters. The preventive maintenance program includes annual tests of pumps, but no 200-psi pressure tests have been conducted in many cases. Service tests, at draft, of 5 pumpers were witnessed during the survey; 2 did not deliver rated capacities at required pressures.

Hose drying facilities are provided at each fire station, and hose tests are conducted annually; 15% is over 10 years old.

Rules and regulations, adopted in 1968, have been distributed to each fire station.

Training is under the part-time supervision of a lieutenant who is assisted by other officers. An 80-foot drill tower with basement, attached to Engine 1 quarters, is of reinforced concrete construction and is equipped with a standpipe system. Grounds are paved but somewhat congested; a pumper test pit is provided, but no hydrants are available. There is no regular schedule for drills at the tower, but most companies average about one 3-hour drill per month on each shift; few of the drills are combined company drills. Each company conducts 2 hours of training daily at quarters; about 25% are drills. New members normally receive some training before appointment; after appointment, the company officer is responsible for the new man's training. Some officer schools have been conducted, and

monthly staff officer meetings are held. Most members have received some instruction in the hazards of radioactive materials; some have had advanced training.

There has been no regularly scheduled building inspection program by companies for pre-fire planning purposes. A few of the more important occupancies are inspected once or twice a year, but most notes and sketches are incomplete or lacking. A more complete inspection program has been recently started but is progressing slowly.

Within the city response to all box alarms and telephone alarms for fires in buildings is 2 engine companies, one ladder company, and a chief officer, except that no ladder company is dispatched to some outlying high value districts and many residential districts; outside the city 2 engine companies and a chief officer normally are dispatched to box alarms and telephone alarms for fires in buildings. During the fiscal year 1967-1968 there were 3757 alarms of which 238 were for building fires and 2444 were ambulance calls; 1430 of the alarms were outside the city of which 916 were ambulance calls.

Fire methods include the extensive use of 1½-inch hose lines, spray nozzles, and breathing equipment. Back-up lines are laid if fire is evident or upon orders. Pumpers connect to hydrants on most fires, but occasionally direct hydrant streams are used in areas with higher pressures. The first company to arrive connects to sprinkler or standpipe systems if fire is evident or upon orders. Ladder, ventilation, and salvage work is performed by the ladder company or engine companies but is hindered by lack of adequate manpower.

FIRE ALARM

The telegraph-type fire alarm system is maintained by a technician from the municipal electronics laboratory.

Alarm headquarters is in a room on the first floor of the public safety building, a 2-story building of fire-resistive construction; the room contains some combustible materials and is not properly cut off from other operations in the building. Headquarters equipment, installed in 1962, with emergency ground return facilities, is of automatic type and is mainly complete. Current is supplied by individual circuit rectifiers with a common battery. Each fire station has a punch register and tapper, a radio receiver, and voice alarm facilities.

There are 117 boxes in service, all of which are accessible; 12 are located outside the city limits in contract districts. Fifteen boxes are provided with

indicating lights; the condition of paint on boxes and on bands on poles is generally good. Of the 47 miles of box and alarm circuits, 4 miles are in underground cable, 35 miles in messenger supported aerial cable, and the remainder is of aerial wire construction. Four box and one alarm circuits are in service; moderate to considerable ground readings were noted on 2 of the circuits.

Five telephone trunk lines extend to a switchboard in alarm headquarters; 4, arranged for progressive operation, are reserved for emergency calls for the city and contract districts, and one additional is for emergency calls from a small nearby fire department; 4 trunks for business calls extend to instruments with switching facilities at the department secretary's desk and in alarm headquarters. Voice amplification circuits extend to 5 fire stations and are used in lieu of fire telephone extension lines.

One operator is on duty at all times. Telephone alarms for fires in buildings are confirmed over the alarm system. Tests and records are fairly good.

FIRE PREVENTION

Hazardous Materials.—The city has adopted the 1965 edition of the Fire Prevention Code of the American Insurance Association along with a few additional ordinances. An amendment has eliminated the requirement for most permits. The gas code contains generally good requirements for gas piping and gas appliances.

Fire prevention activities are under the direction of the chief of the fire department and include the outlying districts adjacent to the city. The fire prevention bureau consists of a fire marshal, a deputy fire marshal, 2 inspectors, and 1 clerk. All are appointed by the chief of the fire department.

The bureau makes inspections of most occupancies every 1 to 2 years. Many businesses are required to have approval from the bureau before their annual business license is issued. Some inspections are made of small businesses by fire department companies. Most conditions found during the survey were fair or fairly good.

Electricity.—A city ordinance adopts the 1965 edition of the National Electrical Code along with some other requirements. Electrical regulations are enforced by the city electrical inspector. Fairly good procedures are in effect for inspections during construction, and each job site is visited at least 3 times. Because the city-owned power and light company also supplies surrounding districts outside the city limits, the inspector spends much of his time on inspections outside the city. There is no

ANCHORAGE, ALASKA

reinspection program. Most new work was fairly good, and existing installations were found to be in fair condition.

BUILDING DEPARTMENT

The city has adopted the 1964 Uniform Building Code, with the appendix and some amendments. The 1964 Uniform Housing Code, which provides minimum requirements for new and existing places of habitation as well as some provisions for fire protection, has also been adopted. Fire Zone 1 covers all of the principal business district, some adjoining blocks, and most other commercial districts throughout the city. Fire Zone 2 includes some of the areas bounding the high-value districts which should be in Fire Zone 1; some of the principal business district is adjacent to a variable zone that allows some types of wood frame construction. Restrictions within Fire Zone 1 are satisfactory; restrictions within Fire Zone 2 are inadequate. Wood shingle or shake roofs are permitted outside of Fire Zones 1 and 2.

The department is under supervision of the building official, assisted by 1 plan check engineer, 1 zone enforcement officer, 2 building inspectors, 1 mechanical inspector, and 1 clerk. All personnel are selected by examination and appointed by the building official. Procedures are fairly good. Plans are checked by the plan checker; review of fire safety features is coordinated with the fire prevention bureau. Records are consolidated although somewhat incomplete. Major plans except for most residential occupancies are kept indefinitely; most plans are fairly well stored and filed.

STRUCTURAL CONDITIONS

Principal Business District.—See map. The district includes 16 blocks or part blocks and covers 38.9 acres. Streets cover 35% of the district and are between 60 and 80 feet in width. Of the total block area, 55% is built upon, with individual blocks ranging from 15% to 84%. Buildings average 1 and 2 stories although 5 buildings are over 8 stories. The tallest building is a 14-story building that joins several older wood frame structures to form a large hotel complex. Wood frame construction covers 21%, fire-resistive construction covers 41%, and automatic sprinklers protect 17% of the built-on area. Exposures to the district are mild from all directions.

Shopping Centers.—The one large shopping center in the city limits, Northern Lights Shopping Center, occupies approximately 9 acres at the south city limits along Northern Lights Boulevard between Spenard Road and Minnesota Drive. Con-

struction is of ordinary type, and the entire area is mutually exposed along a front enclosed mall. Automatic sprinkler protection is provided throughout.

Other Business Districts.—Along the principal streets of the city, namely, 5th Avenue, Gambell Street, Fireweed Lane, and Spenard Road, are smaller commercial districts. Construction in these districts is mostly ordinary or wood frame. Heights vary from 1 to 3 stories. The closely built sections of these districts are confined to narrow strips along both sides of the street.

Industrial Districts.—Practically all of the industrial occupancies are located near or along the railroad right-of-way and the waterfront. This district consists of several large bulk oil storage plants, a large number of warehouse facilities, a few light manufacturing plants, and a variety of small businesses. Most of the buildings are widely separated and have relatively low heights. Some of the larger buildings have automatic sprinkler protection.

Waterfront District.—A portion of the city-owned pier is being reconstructed. Upon completion, the waterfront will have facilities for loading and unloading of cargo, a separate dock for transfer of fuel and oils to the various bulk plants, and several smaller piers to handle fishing boats. The new piers are all of concrete pile and deck construction while the remaining older wharves are mostly timber and wood frame.

Institutional Districts.—Along Providence Drive in the southeast portion of the city, an institutional district is developing. It presently contains the Alaska Youth Correctional Institute, the Alaska Psychiatric Institute, the Providence Hospital, and Alaska Methodist University. All of the buildings are well separated and of new construction. The hospital is a 5-story structure and also the tallest building in the district. Areas are mainly large, and the basement portions of some buildings are sprinklered.

Residential.—Residential districts consist mainly of detached, 1- and 2-story wood frame dwellings with a few apartment house districts and government housing projects. Composition roofs predominate in most sections. Current urban renewal projects are aimed at eliminating the substandard houses along the Seward Highway between 17th and 19th Avenues.

Earthquakes.—The city has felt many earthquakes prior to the severe shock of 1964; for example, the moderate shock of October 3, 1954, caused minor damage to the tall buildings in Anchorage (the same buildings were severely damaged or collapsed in the 1964 shock).

Further details on the 1964 earthquake and nature of the earthquake hazard in Anchorage may be obtained from the following publications:

"The Alaska Earthquake", published by the American Insurance Association and the Pacific Fire Rating Bureau, 465 California Street, San Francisco, California

"The Prince William Sound, Alaska, Earthquake of 1964 and Aftershocks", Volume II part A, available from Superintendent of Documents, Washington, D. C.

RECOMMENDED IMPROVEMENT PROGRAM

The following program has been prepared to assist the City of Anchorage in providing better protection to life and property from fire and may be used as a guide for future planning. In general, recommendations under each heading are listed in the order of their importance. The areas in which the City of Anchorage provides fire protection services under contract have not been analyzed as to their specific fire protection needs, and recommendations for these areas are not included in this program.

WATER SUPPLY

1. That additional hydrants be provided so that:
 - a. In the principal business district there will be one hydrant at each street intersection.
 - b. In other high-value districts there will be one or 2 hydrants at each street intersection, depending upon the character of the district, with intermediate hydrants so that they are not over 300 feet apart.
 - c. In residential districts there will be one hydrant at each street intersection with intermediate hydrants so that they are not over 500 feet apart.
2. That the 5-mg reservoir be completed as soon as possible.
3. That the distribution system be strengthened by the installation of mains shown in red on the map, that 6-inch dead ends be eliminated wherever possible, and that the following be adopted as the minimum size of mains used for hydrant supply for all future construction:
 - a. In high value districts, 8- and 12-inch; the former to be used where it completes a close gridiron and the latter for longer lines, not closely interconnected.
 - b. In residential districts, 8-inch; 6-inch to be used only where it completes a close gridiron and in no case for runs of over 600 feet between interconnections.
4. That the 24-inch wood-stave supply line be replaced by pipe conforming to an appropriate American Water Works Association standard.
5. That comprehensive indexed records and maps suitable for use in the field be compiled for all system valves; that valves be inspected annually and large and important valves more frequently; that valves be maintained in good condition; and that

inspections, operations, and conditions be recorded.

6. That hydrants be maintained in good operating condition at all times.

7. That all alarms of fire be received and recorded over the fire alarm system at the water treatment plant.

FIRE DEPARTMENT

1. That at least 4 members be on duty at all times with each engine and ladder company.

NOTE: Seven members on duty at all times with each high-value engine and ladder company, 6 with other ladder companies, and 5 with other engine companies is considered standard manning.

2. That a ladder company, equipped with an aerial ladder truck, be established in Engine 3 quarters.

3. That a full-time training officer be appointed; that more suitable training facilities, including a structure in which fires may be built, be provided in an area where the use of smoke and water will not be restricted; and that the training program be expanded to include supervised combined company drills at the training grounds, regularly scheduled schools for all officers, and additional training for pump operators.

4. That company members make more frequent inspections of buildings in their respective districts for pre-fire planning purposes; inspection data to be recorded on suitable forms, augmented by appropriate notes and sketches, and used as subjects for discussion in the training program.

5. That the apparatus replacement program be continued, and that the repair facilities be ex-

ANCHORAGE, ALASKA

panded, including additional tools and equipment, and that a more complete preventive maintenance program be adopted.

6. That a ladder company be included in the response to all box alarms and all telephone alarms for fires in buildings.

7. That the rules and regulations be expanded, to include complete fire ground rules, and be distributed to each member.

8. That all fire stations be of noncombustible construction (preferably fire-resistive), of good design, and suitably located, and that proper refueling facilities be provided at each fire station.

9. That if the city continues to provide protection outside the city, an additional ladder company be established.

FIRE ALARM

1. That 2 qualified operators be on duty at all times in alarm headquarters.

2. That additional boxes be installed so that one will be visible from and be within 500 feet of every building in high-value districts and be within 800 feet of buildings elsewhere; and that the conspicuousness of boxes be improved by installing indicating lights over all boxes in high-value districts.

3. That the reliability of the system be improved by:

- a. Providing additional box circuits so that none will serve an excessive area.
- b. Repairing circuits to remove high ground readings.
- c. Providing emergency power facilities at each fire station and for local circuits at alarm headquarters.
- d. Installing circuits underground or in messenger supported aerial cable, wherever possible.
- e. Providing automatic recording devices for radio and voice amplification facilities.

Report based on survey made during July, and August, 1968, by engineers R. I. Eby, M. J. Myrick, and R. E. Boudon, in cooperation with Karl Steinbrugge and other personnel of the Pacific Fire Rating Bureau. Acknowledgment is made of the assistance rendered by the mayor, city manager, and other officials.

EVERETT W. FOWLER, *Manager and
Chief Engineer*

KENNETH J. CARL, *Director of Municipal Surveys
and Assistant Chief Engineer*

FIRE PREVENTION

1. That additional qualified personnel be appointed to the fire prevention bureau so that adequate control can be maintained over hazardous materials, processes, and occupancies including regular and systematic inspections of all commercial and industrial buildings at suitable intervals, and that adequate records be kept of such inspections.

2. That a complete inspection of old wiring be made and defects corrected, and that all wiring be subsequently reinspected at suitable intervals.

BUILDING DEPARTMENT

1. That the building code be amended to include those structural features necessary to restrict the spread of fire. It is recommended that the National Building Code of the American Insurance Association be used as a guide in framing these amendments.

2. That only roof coverings of class C or better be permitted within the city limits.

3. That Fire Zone 1 be revised to include all closely built business and commercial areas. It is suggested that the Recommended Method for Laying Out Fire Limits by the American Insurance Association (National Board of Fire Underwriters) be used as a guide in determining these revisions.

STRUCTURAL CONDITIONS

1. That owners of existing defectively constructed buildings which involve serious life hazard or are so located as to form conflagration breeders be required to protect floor, fire wall, and exposed window openings.

2. That approved automatic sprinkler equipment be required in all basements exceeding 2500 square feet in area used for storage or for mercantile purposes and in all buildings which by reason of their size, construction, or occupancy involve serious life hazard or might act as conflagration breeders.

REDUCE ESCALATING INFLATION OF LOCAL GOVERNMENT COSTS

SAVE LIVES AND PROPERTY

ENCOURAGE SUSTAINED RESPONSIBLE BUSINESS
AND ECONOMIC ACTIVITY IN ALASKAN COMMUNITIES

SUPPORT COMMUNITY FIRE PROTECTION
INCENTIVE PROGRAM

A Legislative Incentive Program
Which Will Save Your Taxes,
Provide Low Interest
Capitalization Loans and
Reduce Fire Department and
Your Water Utility Costs
and, at the same time,
Increase Fire Safety

Prepared For
Alaska Fire Chiefs Association
and
Alaska State Firefighters' Association
by
Brian R. Shute
Attorney At Law

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I. THE PROBLEM: ALASKA'S EXPANDING AND DEVELOPING COMMUNITIES WITH UNDERDEVELOPED PUBLIC SERVICES ARE PARTICULARLY VULNERABLE TO CATASTROPHIC FIRE LOSSES.

A high fire death rate is peculiarly an American problem. No other industrialized nation comes close to the American fire death rate. Fire deaths and injuries per million population in the United States are nearly three times that of Sweden which has the next highest death and injury rate by fire.

In 1974 nearly 3 million fires caused nearly \$4 billion worth of fire losses. The dollar value of the damage and destruction by fire does not even begin to approximate the actual losses because serious fires create indirect business and community losses such as:

- (a) Loss of customers
- (b) Loss of profits
- (c) Cost of retaining key personnel during shutdown
- (d) Loss of taxes on destroyed property.

Finally, there are indirect losses of a personal nature. These may be even more difficult to estimate, yet their importance should not be neglected. In addition to financial losses incurred through temporary unemployment and expenses incurred in finding and moving to new housing, there is the destruction of irreplaceable personal belongings. With its vast expanses and small communities with

underdeveloped public services, Alaska has a particularly dismal experience with fire losses. Tragic reminders of this are the New England Fish Company and Alaska Steamship dock fire in Cordova, the fires in Sitka which destroyed the priceless Russian cathedral, and the Sitka Cold Storage Company and dock facility. Perhaps most tragic are the cannery fires in small communities (most recently in Craig, Alaska, in 1980). Most often the canneries have not been rebuilt, and in some cases, the communities, which relied on the canneries as their sole means of economic support have ceased to exist. Canneries have plenty of water by virtue of the business they are in, and private fire protection would have eliminated the monetary losses, and in some cases, assured the continued existence of the community itself.

Water is an indispensable commodity when it comes to fighting fire. Fires cause billions of gallons of water to be consumed putting them out. Providing adequate water supplies constitutes a major community expense. Residents of the Anchorage and Matanuska-Susitna boroughs are certainly aware of the Susitna hydroelectric project, as part of the ongoing efforts to assure that area with adequate and safe water supplies. The residents of Juneau learned of the exigencies of having adequate water supplies in January of 1980, when climatic conditions temporarily depleted their water supply.

The State of Alaska will undergo rapid growth in population as development of its resources progresses. The oil industry is expanding, other industrial plants associated with the oil industry are planned and coming on line. The fishing industry is expanding into new products and plants. This is bringing increasing population and business to many of our communities. The growth is impacting the fire protection and water supplies of these growing areas. Communities are being faced with providing additional fire protection services, and with the costs of providing these services. See, Shirnberg, Robert R., Community Fire Protection Incentive Program, October 20, 1979.

Consequently, given the compelling social goal of avoiding catastrophic fire losses, together with the absolute necessity to provide water for basic human existence, a community must develop policies which maximize its ability to provide both fire protection and adequate water supplies.

II. THE SOLUTION: MAXIMUM UTILIZATION OF PRIVATE FIRE PROTECTION SYSTEMS MINIMIZES FIRE LOSSES AND MINIMIZES COSTS OF OPERATING FIRE DEPARTMENTS AND WATER UTILITIES.

Private fire protection systems (the backbone of which are automatic sprinkler systems) are the most effective means of controlling fires in buildings. Not only do private fire protection systems put out fires, they do not require nearly as much water to extinguish fires as would be required for the Fire Department to put out the same fire. Nor do sprinkler systems require as much or as expensive equipment to fight a given fire as a Fire Department. Where private fire protection systems are deployed the expense and cost of the Fire Department are much less, and the chance for injury to firemen as a result of fire is almost negligible in sprinklered buildings. Sprinkler systems are the most technologically advanced fire fighting weapon, and their use should be maximized to reduce and hold down costs of the Fire Department.

We must accept the fact that public fire departments can control a fire only in its early development stages. For the most part, fire departments can only combat fire by directly overwhelming it with massive amounts of expensive equipment, manpower and water. When the fire is small, the fire department is still on the way. Even with the best response time, it is fact that many small fires are out of control by the time the fire departments arrive.

By contrast, the private fire protection system has no response time. It is on scene before the fire starts, and usually has put out the fire before the fire department even arrives.

III. LEGISLATION CREATING INCENTIVES FOR THE INSTALLATION OF PRIVATE FIRE PROTECTION SYSTEMS WILL ENCOURAGE A STATEWIDE SHIFT TOWARD MAXIMIZING UTILIZATION OF MORE EFFICIENT, LESS COSTLY FIREFIGHTING TECHNOLOGY, THEREBY HOLDING DOWN OR REDUCING COSTS OF WATER UTILITIES AND FIRE DEPARTMENTS.

Private fire protection is an alternative. Its technology is ready to be implemented, and, through legislative incentive, it will reduce the increasing burden of fire protection costs. Within a few short years of implementing legislative incentives, private fire protection systems will become increasingly prevalent in communities statewide. As Alaskan communities expand and grow, the legislative incentives will alleviate the necessity to expand the manpower, equipment, and water supplies for the fire department as in the past. Fire departments won't need to open as many new stations, buy as much firefighting equipment, or hire as many firefighters to meet the fire protection needs of the state's expanding communities. Costs of water supplies will be reduced as existing supplies go farther as a result of the water conservative propensities of private fire protection systems are realized. By moving now to take advantage of proven fire protection technology huge savings in property loss, jobs, insurance costs, building costs, life, and indeed even entire communities (in cases of unprotected cannery fires) will result and those savings will continue to accrue and continue to accelerate as the incentives prompt more and more property

to be protected. (For a hypothetical case study of savings a community can realize as a result of widespread sprinkler installation see, Hackey, Associate Professor, Univ. Maryland, Built In Fire Protection and Fire Department Manning (Appendix A).

IV THE SAVINGS IN LIFE, PROPERTY, CONSERVATION OF WATER, AND REDUCED COST OF LOCAL GOVERNMENT SERVICES FROM WIDESPREAD INSTALLATION OF PRIVATE FIRE PROTECTION SYSTEMS.

Statistics showing the effectiveness of automatic sprinkler systems are phenomenal. Only in rare instances do automatic sprinkler systems fail to control fires in sprinklered buildings. The failures are seldom due to the sprinklers, but rather, the lack of water, often because the system has been turned off, either unintentionally, intentionally, or by vandals. A complete record of fires in sprinklered buildings would show that their efficiency probably approaches 100%. National Fire Protection Association, Fire Protection Handbook, pp. 14-1 through 14-48, 14th edition, 1976. Given the billions of dollars in fire losses, the potential for savings resulting from widespread installation of sprinklers cannot be ignored. Of all the fires controlled by sprinklers, more than 90% of them are controlled by three or less sprinkler heads. Fire Protection Handbook, supra.

The effectiveness of automatic sprinklers stems from their presence at the scene of a potential fire before it starts. They can apply water immediately where it is needed because there are not problems of access to the seat of the fire, or interference with visibility for fire fighting due to smoke. Fire Protection Handbook, supra. Sprinklers extinguish fires much earlier than a fire department could

ever respond to an alarm. Automatic sprinklers are particularly effective for life safety because they give warning of the existence of fire, and at the same time apply water to the burning area.

The only fatalities in fully sprinklered properties reported to the National Fire Protection Association were caused by explosions or flash fires; by ignition of the bedding or clothing of a person who was too young, too old, too intoxicated, or too handicapped in some other way to protect himself properly. . . .

In those isolated instances of fatalities to sleeping, handicapped, or intoxicated persons, ignition of clothing or bedding caused fatal burns or asphyxiation either because the small fire did not generate sufficient heat to fuse the sprinkler, or because the victim had suffered fatal injuries before the sprinkler operated. In these later instances, however, the sprinklers protected the lives of persons in adjoining areas. Fire Protection Handbook, supra.

See, also, Horne, B.G., Fire Chief, Controlling the Cost of Fire Protection in the City of San Buenaventura.

Water necessary to put out a fire in its beginning stages is nowhere near the water required for the fire department to put it out after it once gets blazing. Performance characteristics of sprinklers indicate that standard automatic sprinklers discharge anywhere from 18 to 58 gallons of water per minute, depending on the pressure at

the sprinkler head. Fire Protection Handbook, supra, at pp. 14-42 through 14-48. By comparison, a heavy-attack two and one-half inch mobile fire department hose line in operation can consume as much as 250 gallons of water per minute. If the fire is not put out in its infant stages (as occurs over 90% of the time when automatic sprinklers are deployed), it may take a number of heavy-attack lines hours to control the fire - if the water supply holds out that long.

Sprinklers do not cause excessive water damage. Damage by sprinklers is negligible compared to that caused by fighting the same fire with a hose stream. Most fires are controlled by a small number of sprinklers, while many hose streams are required to combat a fire which is out of control. Sprinklers, in most cases, control the fire immediately. The water damage which does occur is negligible compared to the damage which would have resulted if the building should have been completely or substantially consumed by a fire fought by conventional means. See, Horne, B. G., Fire Chief, Controlling the Cost of Fire Protection in the City of San Buenaventura.

V. THE SIZE OF A COMMUNITY'S WATER SYSTEM CAN BE REDUCED BY WIDESPREAD INSTALLATION OF PRIVATE FIRE PROTECTION SYSTEMS IN THE COMMUNITY.

A major part of the cost of the developing community's water supply is the additional reservoir of water which must be on hand for major fires, and the high pressure distribution lines from the reservoir to assure the fire department will have enough water pressure to project many hose streams onto a raging major fire. Nowhere near the same quantity of water or water pressure would be required for automatic sprinklers to do the same job.

The traditional method for estimating the water supply required to serve a community's fire protection needs is by computing fire flow requirements. The criteria to estimate fire flow requirements are found in the Guide for Determination of Required Fire Flow, Insurance Service Organization, 1972. The fire flow formula reflects significant water conservation propensities of private fire protection. Depending on the flammability of a given building, the fire flow required is reduced by 25% to 75% when a sprinkler system is present in a building. Fire Protection Handbook, supra, at pp. 11-2 through 11-6.

The fire flow formula developed by ISO can be utilized to determine the community-wide fire flow requirements. This procedure is more fully described in ISO's Municipal Grading Schedule, copies of which are available in many

community Fire Department and Fire Department Protection offices.

Although the methodology in the Municipal Grading Schedule does not enable a precise computation of the reduction in community fire flow requirements caused by widespread sprinkler installation, it is significant. Anchorage, Alaska, is a specific case in point, where ISO engineers indicate installation of sprinklers in the Central Business District, alone, made Anchorage a more fireworthy community, and caused a reduction in fire flow requirements.

VI. PRIVATE FIRE PROTECTION REDUCES THE COST OF OTHER PUBLIC SERVICES.

In addition to the water conserving properties of automatic sprinkler systems, and the significant savings in life and property, there are other public benefits from widespread installation of private fire protection systems.

Among these are:

1. Both the economic and physical burden of the Fire Department are decreased since private fire protection generally puts out the fire before the fire department even arrives. This also decreases the hazards of fighting fire.
2. The cost of manpower and time fighting the fire is reduced and therefore the money necessary to operate the Fire Department can be reduced, stabilized, and diverted to other essential Fire Department or community expenditures.
3. Private fire protection decreases fire insurance costs not only for the person installing it, but also for an entire community where the installations are widespread. Many rural communities have little or no fire protection. These communities may not be able to afford the expensive fire-fighting equipment more urbanized communities have. Commercial construction moneys are also difficult to obtain because insurance rates are too high. By installing private fire protection, great reductions in insurance premiums can be achieved, which will enable property owners to get reasonable insurance premiums needed to obtain financing for construction.

4. Construction without sprinklers imposes higher insurance costs and imposes on the architect more stringent rules governing compartmentalization, fire proofing, exit distance spacing, travel distance, and exterior design requirements. It costs more to construct without sprinklers. 242 News Bulletin, Automatic Sprinkler Fire Control Association, Inc., pp. 1316 (1973). Providing incentives to construct with sprinklers will lower construction costs and then insurance costs, enabling construction to go forward that otherwise would have been too costly. The resulting stabilization and expansion of a community's economic base, not to mention expanded tax base, is obvious.
5. Private fire protection increases municipal tax revenues by encouraging property development.
6. Private fire protection increases a community's total fire protection security, preventing conflagrations and exposure fires.
7. Private fire protection results in lessening the cost of capital improvements to the community's water supply since widespread installation of private fire protection decreases the required fire flow necessary for adequate municipal fire protection.
8. Private fire protection saves billions of gallons of water, which is in chronic short supply in many communities.
9. Encouragement of private fire protection is consistent with the State policy of encouraging installation of fire protection devices (smoke alarms).
10. Since private fire protection can reduce the cost of the Fire Department and the water utility, Municipal tax

dollars and State revenue sharing monies can be expended for other essential services, making more efficient use of government dollars.

These benefits are substantial and should be encouraged by the incentive legislative programs hereinafter described.

VII. TAX CREDITS, LOW INTEREST LOANS FOR PRIVATE FIRE PROTECTION, INSTALLATION, AND ELIMINATION OF WATER STANDBY CHARGES WILL PROVIDE THE LEGISLATIVE INCENTIVE TO MOVE TOWARD UTILIZATION OF THE BEST AND MOST ECONOMICAL FIRE SAFETY TECHNOLOGY - PRIVATE FIRE PROTECTION.

A. Why Legislative Incentives?

The decision to install or not to install private fire protection hinges on two variables. First, the Uniform Building Code requires building materials with a higher fire rating for higher fire rating for higher risk occupancies. If construction is without sprinkler systems the construction costs may be too high, and the increased cost could prevent the decision to construct from even being made. Second, the reduction in insurance rates for buildings with sprinklers will be greater for some kinds of buildings than for others. The size of the reduction is largely determinative of how long it will take the property owner to amortize the cost of the sprinkler system. If the insurance reduction is too small, it will take too long to amortize the cost of installing the system, and the decision to install it may not be made, with the resultant loss in fire safety. Legislative incentives in the form of low interest loans which can be obtained to finance sprinkler installation, additional tax credits to buildings that have sprinklers, and legislative elimination of water standby charges will make the decision to install private protection economical and, thus, voluntary. A significant trend would develop

wherein water guzzling fire companies would be replaced by water efficient sprinkler systems, reducing both losses caused by fire and costs to local government.

B. Low Interest Loans Will Cause Financing to be Available so that Sprinklers can be Installed in Both New and Pre-existing Construction.

Funds for low interest loans to finance installation of private fire protection systems should be available in amounts that will allow for a rapid implementation and installation of private fire protection systems by those who qualify for the loans. Many small businesses in our state do not have access to financing at reasonable rates. The current level of interest rates simply does not make it economical for the property owner to consider the installation of private fire protection. Loan qualifications should be established on the basis of need similar to that required for small business loans. But, in addition, loans should also be made available to property owners who are required to install private fire protection by the community building codes, with some consideration given to those property owners desiring to install a system in a pre-existing structure. Making funds available to owners of pre-existing structures will accelerate the move towards utilizing private fire protection technology instead of the more costly and riskier Fire Department.

C. Tax Credits for Installation of Private Fire Protection Will Encourage, not Penalize the Owner who Adopts Better Fire Safety Technology, and Will Not Cause Cities to Lose Tax Revenue.

Installation of private fire protection systems causes property valuations to increase. Up to now the increase has been included in the property's assessed and the community's mill rate has been applied accordingly, thus raising the owner owner's taxes. This penalizes the property owner for installing fire protection systems. A property owner who does not install such a system is the one to penalize, because he increases the potential for disastrous fires in the community, and causes escalating costs for the Fire Department and Water System. Enacting State legislation will remove from tax rolls the penalizing assessment against private fire protection systems. This approach does away with counterproductive taxing practices, and maximizes the cost savings of better fire safety technology.

Local governments will not lose tax revenue as a result of the tax credit for fire protection systems. First, as the incentives induce increasing numbers of fire protection systems to be installed, fire departments will save literally millions of dollars because their requirements for manpower, equipment, and additional fire stations will be drastically reduced, to maintain a given level of fire safety. Attached as Appendix II is an actual case study of great savings which resulted in fire department costs in

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the City of Fresno, California. By inducing widespread installation on of private fire protection systems, the City of Fresno's fire department saved literally millions of dollars, according to the study. Reilly and Viniello, Sprinklers Cut Fresno's Fire Losses and Budget, Fire Journal, November 1979 (See Appendix ID). Appendix I empirically documents the huge savings which will result to the Fire Department from a program of this sort.

Second, the assessed value of a sprinkler system, when compared to the value of the rest of a building, is minimal. Without the sprinkler system a fire will destroy the building, and the corresponding loss from municipal tax rolls of the entire valuation of the building will be many-fold greater than the minimum value of the sprinkler system. The City's tax base will grow more rapidly if it is not being consumed by destructive fires, which will not occur when a City's property tax base is protected by sprinklers. It is a certainty that the loss of tax-assessable property will be many times greater in a community that does not have widespread sprinkler installation.

Third, the major component of a City's water supply cost is the necessity to have water available to combat fire. Widespread installation of private fire protection systems will drastically reduce the fire flow demand, with a correspondent cost reduction to the water

utility. In sum, then, the savings to the fire department and the water utility, together with the increased tax base that will result from the increased fire safety, induced by exemption of fire protection systems from the tax base, all culminate to provide increased, rather than decreased, revenue to municipalities. The tax credit incentive in Senate Bill 370 and House Bill 648 will insure this result.

D. Elimination Of Water Standby Charges

One of the most invidious disincentives to the installation of private fire protection systems has been the water standby charge levied by water utilities. The charge is levied when a private fire protection system is connected to the water system, regardless of whether it consumes water or not. The theory of the charge is that the connection of the system creates demand that the Utility must meet. Nothing can be further from the truth, however. By connection to the water supplies, the required fire flow, and, therefore, demand, is reduced. Sprinklers simply do not demand anywhere near as much water to fight fires as do Fire Departments. See, p. 6, supra; see, also, Fire Protection Handbook, supra, at 14-42 through 14-48. The cumulative effect if widespread spinkler installation is reservoir requirements which are stablized or reduced when compared to the requirements without the sprinklers.

Water demand charges eat up or completely eliminate any

insurance savings to the property owner which would otherwise go towards amortizing the cost of installing the system. The demand charge makes it uneconomical to install the sprinklers. The water demand charge eliminates the only source of cost saving to be realized by installation of the sprinkler system. The demand charge should be exposed for what it is--a disincentive to installation of private fire protection that is counter productive to the goal of having adequate water supplies, and to the goal of making our communities safe from destructive fires. In the interests of conserving scarce water resources and maximizing the public fire protection dollar, then, legislation banning imposition of water demand charges on private fire protection systems should be enacted.

VIII. CONCLUSION

For the foregoing reasons support of this legislative program is urgently solicited. Senators, Representatives, local governments, and the public are urged to support these legislative incentives. The Alaska State Firefighter's Association and the Alaska State Fire Chiefs Association believe it's time to stop utilizing expensive, dangerous, and outmoded fire safety technology to protect our communities. These legislative incentives promote utilization of the best firefighting technology, while at the same time saving money. It will save the public and local government