WATER SUPPLY
FOR
PUBLIC FIRE PROTECTION

A Guide to Recommended Practice
in Canada

2020

Fire Underwriters Survey

FIRE UNDERWRITERS SURVEY is financed by the Canadian Insurance industry and utilizes technical staff of Opta Information Intelligence Corp (formerly the Insurers' Advisory Organization Inc.).

Fire Underwriters Survey's purpose is to survey fire protection conditions in Canadian communities and municipalities, providing data and advisory services to fire insurance underwriters, actuaries and public officials concerned.

Preface

The Water Supply for Public Fire Protection document is divided into two parts.

- Part 1 describes the areas Fire Underwriters Survey reviews when assessing the adequacy and reliability of water supply infrastructure for fire insurance grading purposes with the Canadian Classification Standard for Public Fire Protection (CCSPFP).
- Part 2 of the document provides guidance in calculating required fire flows for buildings in a community that are then used in the community risk assessment and corresponding review of the fire department and water distribution system for fire insurance grading purposes.

For the purposes of underwriting, the delivery, capacity and redundancy of fire protection systems is normally considered in three scenarios.

NLE (Normal Loss Expectancy): This scenario is the loss estimate expected under normal conditions, with all fire protection systems and infrastructure in place and operating as expected.

PML (Probable Maximum Loss): This scenario is the loss estimate expected with some impairment to normally only one important part of the fire protection system (ex. most important pump or water main), but not total shutdown of all infrastructure.

MFL (Maximum Foreseeable Loss): This scenario is the loss estimate expected for the worst-case fire scenario. This scenario considers multiple points of failure in key protection infrastructure and/or worst case conditions with respect to fire risk.

When measuring the fire protection capacity of water supply infrastructure, these 3 scenarios are considered.

Part 1

ASSESSEMENT OF WATER DISTRIBUTION SYSTEMS FOR PUBLIC FIRE PROTECTION IN CANADA

Fire Underwriters Survey uses the Canadian Classification Standard for Public Fire Protection (CCSPFP) to define the criteria used in the evaluation of a community's fire defenses for fire insurance grading/classification purposes for the Canadian subscribing property and casualty insurance industry.

Within the CCSPFP, a section titled "Water Supply" outlines the methodology for evaluating and crediting a public or private water distribution system for fire insurance grading purposes. Water Supply is one of a number of components evaluated by FUS in the public fire protection system.

Fire Underwriters Survey has prepared Part 1 of this document for municipal officials, consulting engineers and other stakeholders, as an aid to understanding the perspective of the underwriters with respect to effective fire protection requirements in public or private water distribution system design. This document is a guide and requires knowledge and experience in public fire protection engineering and water distribution system design for its effective application.

In the FUS assessment of a water distribution system, the major emphasis is placed upon its ability to deliver **adequate** water to control major fires throughout service area on a **reliable** basis via sufficient and suitable **hydrants**. What is ultimately available to the fire department is the critical test in this fire protection evaluation.

In order for a water distribution system to qualify for fire insurance grading recognition within the CSPFP, a water supply must surpass the following minimum requirements:

- a water delivery system must be capable of delivering not less than 1,000 LPM for two hours (for *dwellings* and *simple risks*) or 2,000 LPM for one hour (for commercial lines insured risks) in addition to any domestic consumption at the Maximum Day Demand.
- any water delivery system which cannot meet this minimum requirement shall not be recognized for fire insurance grading purposes

A water distribution supply system is considered to be fully adequate for fire insurance grading purposes if it can deliver the necessary required fire flow at any point in the distribution gridiron for the appropriate duration during a period of *Max Day Demand* on the water system.

Recommendations applying to fire departments, emergency communications and fire prevention and building code enforcement are covered in other publications of Fire Underwriters Survey. FUS local offices are prepared to assist municipal officials or their consultants with advice on special problems, as time limits permit, in accordance with the intent of this document.

GENERAL

Adequacy and Reliability

An adequate and reliable water supply for manual firefighting is an essential part of the fire protection system of a municipality or community. This is normally a piped system in common with domestic potable water service for the community.

A water distribution system is considered to be fully adequate if it can deliver the necessary fire flow at any point in the distribution gridiron for the applicable time period specified in the Table 1 Required Duration of Fire Flow with the consumption at the maximum daily rate (average rate on maximum day of past 3 years). When this delivery is also possible under certain emergency, or unusual conditions as herein specified, the water distribution system is considered to be reliable. In cities of population in excess of 250,000 (or smaller places with high fire incidents and/or severe hazard conditions) it is usually necessary to consider the possibility of two simultaneous major fires in the area served by the water distribution system.

Table 1 Required Duration of Fire Flow

Fire Flow Required (litres per minute)	Duration(hours)
2,000 or less	1.0
3,000	1.25
4, 000	1.5
5,000	1.75
6,000	2.0
8,000	2.0
10,000	2.0
12,000	2.5
14,000	3.0
16,000	3.5
18,000	4.0
20,000	4.5
22,000	5.0
24,000	5.5
26,000	6.0
28,000	6.5
30,000	7.0
32000	7.5
34,000	8.0
36,000	8.5
38,000	9.0
40,000 and over	9.5

* ***Interpolate for intermediate figures***

A water supply system is considered to be adequate for fire protection when it can supply water as indicated above with consumption at the maximum daily rate. Certain types of emergency supplies should be included where reasonable conditions for their immediate use exist. Storage on the system is credited on the basis of the normal daily minimum maintained insofar as pressure permits its delivery at the rate considered.

In order to provide reliability, duplication of some or all parts of the system will be necessary, the need for duplication being dependent upon the extent to which the various parts may reasonably be expected to be out of service as a result of maintenance and repair work, an emergency or some unusual condition. The introduction of storage, either as part if the supply works or on the water distribution system, may partially or completely offset the need for duplicating various parts of the system, the value of the storage depending upon its amount, location and availability.

Required Fire Flow

A Required Fire Flow (RFF) is the rate of water flow, at a residual pressure of 150 kPa and for a specified duration that is necessary to control a major fire in a specific structure or grouping of structures utilizing manual fire fighting measures in conjunction with built-in safety features of buildings. The method for determining required fire flows is detailed in Part 2 of this document. Water distribution system design should contemplate meeting the required fire flows existing or probable, with the possible exception of gross anomalies where there is no fire threat to the remainder of the community. In these cases, the high risk properties should be managed carefully to reduce the probability of ignition and/or fire growth as part of a coordinated fire prevention and protection system that includes the fire department, fire prevention officers, and the risk managers and loss control representatives of the risk property. When the severity of a risk is beyond the capacity of the fire department to effectively control, it is very important to take steps to reduce the probability of events escalating to a point beyond which the fire department can save the property and protect the exposures.

Basic Fire Flow

Basic Fire Flow is a statistical value based on the required fire flows calculated throughout an area selected to represent that area (ex. a community, or specific response zone). Normally the Basic Fire Flow would be selected to be adequate for 90% of risks in the area. Historically the fifth highest Required Fire Flow (RFF) in the community or response zone was used when assessing the adequacy and reliability of public fire protection in a community or response zone. Note that the use of the “fifth” highest Required Fire Flow is a rule of thumb. The objective of using the fifth highest fire flow is to provide a reasonable fire flow for almost all of the structure fires that could occur in the given area, but not to use the required fire flow for the most extreme cases. In modern survey work, the 90th percentile is used in most surveys of medium and large communities.

Automatic Sprinkler Protection

The protection of buildings by automatic sprinkler protection is a significant contribution to the fire protection of the community and should be encouraged. It is important to note that sprinkler protection is primarily considered in the private protection analysis in the underwriting process (as opposed to within the public protection analysis). However, any property that is completely protected with a sprinkler system that is designed and installed in accordance with NFPA 13, maintained and tested in accordance with NFPA 25, and which has a water supply system meeting the requirements of this document and afire department response that meets the criteria to be recognized for fire insurance grading purposes may be considered to be adequately protected even with a longer than normal response time from the fire department as the sprinkler system may effectively control the fire growth, allowing for a longer response to be more effective. (See Recognition of Automatic Sprinkler Protection).

Storage

In general, storage reduces the requirements of those parts of the system through which supply has already passed. Since storage usually fluctuates, the normal daily minimum maintained is the amount that should be considered as available for fires. Because of the decrease in pressure when water is drawn down in standpipes, only the portion of this normal daily minimum storage that can be delivered at a residual pressure of 150 kPa at the point of use is considered as available. As well as the quantity available, the rate of delivery of water to the system from storage for the fire flow period is critical to this consideration.

Pressure

The principal requirement to be considered is the ability to deliver water in sufficient quantity to permit fire department pumpers to obtain an adequate supply from hydrants when dealing with fully involved structure fires. To overcome friction loss in the hydrant branch, hydrant and suction hose, a minimum residual water pressure of 150 kPa in the street main is required during flow. Under conditions of exceptionally low suction losses, a lower residual may be possible. This includes the use of 100 mm and larger outlets for fire department apparatus use and hydrants with large waterways.

Higher sustained pressure is of importance in permitting direct continuous supply to automatic sprinkler systems, to building standpipe and hose systems, and in maintaining a water plan so that no portion of the protection area is without water, such as during a fire at another location. Residual pressures that exceed 500 kPa during large flows are of value as they permit short hose-lines to be operated directly from hydrants without supplementary pumping.

SUPPLY WORKS

Normal Adequacy of Supply Works

The source of supply, including impounding reservoirs, and each part of the supply works should normally be able to maintain the maximum daily consumption rate plus the maximum required fire flow. Each distribution service within the system should similarly support its own requirements. In large cities where fire frequency may result in simultaneous fires, additional flow must be considered in accordance with the potential. Filters may be considered as capable of operating at a reasonable overload capacity based upon records and experience. In general, overload capacity will not exceed 25 percent, but may be higher in well designed water treatment facilities operating under favourable conditions.

The absolute minimum supply available under extreme dry weather conditions should be taken as the measure of the normal ability of the source of supply such as supply from wells. The normal or average capacity of wells during the most favourable nine-month period should be considered, or the normal sustained flow of surface supplies to the source.

Reliability of Source of Supply

The effect on adequacy must be considered for such factors as frequency, severity and duration of droughts, physical condition of dams and intakes; danger from earthquakes, floods, forest fires, and ice dams or other ice formations; silting-up or shifting of channels; possibility of accidental contamination of watershed or source; absence of watchmen or electronic supervision where needed; and injury by physical means. Where there is a risk of disruption, special precautions or alternate supplies should be arranged.

Where the supply is from wells, some consideration should be given to the absolute minimum capacity of the wells under the most unfavourable conditions; also to the length of time that the supply from the wells would be below the maximum daily consumption rate, and the likelihood of this condition recurring every year or only at infrequent intervals. It should be recognized that some water is generally available from wells and that the most extreme conditions are not as serious as a total interruption of the supply, as would be the case in the breaking of a dam or shifting of a channel. The possibility of clogging, salinity, and the need for periodic cleaning and overhauling must be considered. Dependence upon a single well, even where records are favourable, may be considered a feature of unreliability.

Frequent cleaning of reservoirs and storage tanks may be considered as affecting reliability.

Continuity of, and delay in implementing water supplies obtained from systems or sources not under the control of the municipality or utility should be considered also from these aspects.

Gravity Systems

A gravity system delivering supply from the source to distribution directly without the use of pumps is advantageous from a fire protection point of view because of its inherent reliability, but a pumping system can also be developed to a high degree if reliability.

PUMPING

Reliability of Pumping Capacity

Pumping capacity, where the water distribution system or service area is supplied by pumps, should be sufficient, in conjunction with storage when the two most important pumps are out of service, to maintain the maximum daily consumption rate plus the maximum required fire flow at required pressure for the required duration. For smaller municipalities (usually up to about 25,000 population) the relative infrequency of fires is assumed as largely offsetting the probability of a serious fire occurring at times when two pumps are out of service. (The most important pump is normally, but not always, the one of largest capacity, depending upon how vital its contribution is to maintaining flow to the distribution system.)

To be adequate, remaining pumps in conjunction with storage, should be able to provide required fire flows for the specified durations at any time during a period of five days with consumption at the maximum daily rate. Effect of normal minimum capacity of elevated storage located on the distribution system and storage of treated water above low lift pumps should be considered. The rate of flow from such storage must be considered in terms of any limitation of water main capacity. The availability of spare pumps or prime movers that can quickly be installed may be credited, as may pumps of compatible characteristics which may be valved from another service.

Power Supply for Pumps

Electric power supply to pumps should be so arranged that a failure in any power line or the repair or replacement of a transformer, switch, control unit or other device will not prevent the delivery, in conjunction with elevated storage, of required fire flows for the required durations at any time during a period of two days with consumption at the maximum daily rate.

Power lines should be underground from the station or substation of the power utility to water plants and pumping stations and have no other consumers en route. The use of the same transmission lines by other consumers introduces unreliability because of the possibility of interruption of power or deterioration of power characteristics.

Overhead power lines are more susceptible to damage and interruption than underground lines and introduce a degree of un-reliability that depends upon their location and construction. In connections with overhead lines, consideration should be given to the number and duration of lightning, wind, sleet, and snow storms in the area; the type of poles or towers and wires; the nature of the country traversed; the effect of earthquakes, forest fires, and floods; the lightning and surge protection provided; the extent to which the system is dependent upon overhead lines; and the ease of, and facilities for, repairs.

The possibility of power systems or network failures affecting large areas should be considered. In-plant auxiliary power or internal combustion driver standby pumping are appropriate solutions to these problems in many cases, particularly in small plants where high pumping capacity is required for fire protection service. When using automatic starting, prime 'movers' for auxiliary power supply and pumping should have controllers listed by Underwriters' Laboratories of Canada to establish their reliability.

Fuel Supply

At least a five-day supply of fuel for internal combustion engines or boilers used for regular domestic supply should be provided. Where long hauls, condition of roads, climatic conditions, or other circumstances could cause interruptions of delivery longer than five days, a greater storage should be provided. Gas supply should be from two independent sources or from duplicate gas-producer plants with gas storage sufficient for 24 hours. Unreliability of regular fuel supply may be offset in whole or in part by suitable provisions for the use of an alternate fuel or power supply.

BUILDINGS AND PLANT

Buildings and Structures

Pumping stations, treatment plants, control centres and other important structures should be located, constructed, arranged, and protected so that damage by fire, flooding, or other causes will be held to a minimum. They should contain no combustible material in their construction, and, if hazards are created by equipment or materials located within the same structure, the hazardous section should be suitably separated by fire-resistive partitions or fire walls.

Buildings and structures should have no fire exposures. If exposures exist, suitable protection should be provided, Electrical wiring and equipment should be installed in accordance with the Canadian Electrical Code. All internal hazards should be properly safeguarded in accordance with good practice. Private in-plant fire protection should be provided as needed.

Miscellaneous System Components, Piping and Equipment

Steam piping, boiler-feed lines, fuel-piping (gas or oil lines to boilers as well as gas, oil or gasoline lines to internal-combustion engines), and air lines to wells or control systems should be so arranged that a failure in any line or the repair or replacement of a valve, fuel pump, boiler-feed pump, injector, or other necessary device, will not prevent the delivery, in conjunction with storage, of the required fire flows for the specified duration at any time during a period of two days with consumption at the maximum daily rate.

Plants should be well arranged to provide for effective operation. Among the features to be considered are: ease of making repairs and facilities for this work, danger of flooding because of broken piping; susceptibility to damage by spray; reliability of priming and chlorination equipment; lack of semi-annual inspection of boilers or other pressure vessels; dependence upon common non-sectionalized electric bus bars; poor arrangement of piping; poor condition or lack of regular inspections of important valves; and factors affecting the operation of valves or other devices necessary for fire service such as design, operation, and maintenance of pressure regulating valves, altitude valves, air valves, and other special valves or control devices, provision of power drives, location of controls, and susceptibility to damage.

Reliability of treatment works is likely to be influenced by the removal from service of at least one filter or other treatment unit; the reduction of filter capacity by turbidity, freezing or other conditions of the water; the need for cleaning basins; and the dependability of power for operating valves, wash-water pumps, mixers and other appurtenances.

Operations

Reliability in operation of the supply system and adequate response to emergency or fire demands are essential. Instrumentation, controls and automatic features should be arranged with this in mind. Failure of an automatic system to maintain normal conditions or to meet unusual demands should result in the sounding of an alarm where remedial action will be taken.

The operating force should be competent, adequate, and continuously available as may be required to maintain both the domestic and fire services.

Emergency Services

Emergency crews, provided with suitable transportation, tools and equipment, should be continuously on duty in the larger systems and be readily available upon call in small systems. Spare pipe and fittings, and construction equipment should be readily available. Alarms for fires in buildings should be received by the utility at a suitable location where someone is always on duty who can take appropriate action as required, such as placing additional equipment in operation, operating emergency or special valves, or adjusting pressures. Receipt of alarms may be by fire alarm circuit, radio, outside alerting device, or telephone, but where special operations are required, the alarm service should be equivalent to that needed for a fire station.

Response of an emergency crew should be made to major fires to assist the fire department in making the most efficient use of the water system and to ensure the best possible service in the event of a water main break or other emergency. The increase of pressures by more than 25 percent for fires is considered to increase the possibility of breaks.

PIPING

Reliability of Supply Mains

Supply mains cut off for repair should not drastically reduce the flow available to any district. This includes all pipe lines or conduits on which supply to the distribution system is dependent, including intakes, suction or gravity lines to pumping stations, flow lines from reservoirs, treatment plant piping, force mains, supply and arterial mains, etc. Consideration should be given to the greatest effect that a break, joint separation or other failure could have on the delivery of the maximum daily consumption rate plus required fire flow at required pressure over a three-day period. Aqueducts, tunnels or conduits of substantial construction may be considered as less susceptible to failure and equivalent to good mains with a long history of reliability.

Installation of Pipe

Mains should be in good condition and properly installed. Pipe should be suitable for the service intended. Asbestos-cement, poly-vinyl chloride (PVC), cast and ductile iron, reinforced concrete and steel pipe manufactured in accordance with appropriate Canadian Standards Association or ANSI/AWWA standards, or any pipes listed by Underwriters' Laboratories of Canada for fire service are considered satisfactory. Normally, pipe rated for a maximum working pressure of 1,000 kPa is required. Service records, including the frequency and nature of leaks, breaks, joint separations, other failures and repairs, and general conditions should be considered as indicators of reliability. When mains are cleaned, they should be lined.

Mains should be so laid as not to endanger one another, and special construction should be provided to prevent their failure at stream crossings, railroad crossings, bridges, and other points where required by physical conditions; supply mains should be valved at one and one-half kilometre intervals and should be equipped with air valves at high points and blow offs at low points. Mains should not be buried extremely deep or be unusually difficult to repair, though depths to ten feet may be required because of frost conditions.

The general arrangement of important valves, of standard or special fittings, and of connections at cross-overs, intersections, and reservoirs, as well as at discharge and suction headers, should be considered with respect to the time required to isolate breaks. The need for check valves on supply or force mains and for other arrangements to prevent flooding of stations or emptying of reservoirs at the time of a break in a main should also be considered, as well as the need for relief valves or surge chambers. Accessibility of suitable material and equipment and ease of making repairs should be considered.

Arterial feeder mains should provide looping throughout the system for mutual support and reliability, preferably not more than 1,000 metres between mains. Dependence of a large area on a single main is a weakness. In general, the gridiron of minor distributors supplying residential districts should consist of mains at least 150 mm in size and arranged so that the lengths on the long sides of blocks between intersecting mains do not exceed 200 metres. Where longer lengths of 150 mm pipe are necessary 200 mm or larger intersecting mains should be used. Where initial pressures are unusually high, a satisfactory gridiron may be obtained with longer lengths of 150 mm pipe between intersecting mains.

Where dead-ends and a poor gridiron are likely to exist for a considerable period or where the layout of the streets and the topography are not well adapted to the above arrangement, 200mm pipe should be used. Both the ability to meet the required fire flows and reliability of a reasonable supply by alternate routing must be taken into account in this consideration.

Valves

A sufficient number of valves should be installed so that a break or other failure will not affect more than 400 metres of arterial mains, 150 metres of mains in commercial districts, or 250 metres of mains in residential districts. Valves should be maintained in good operating condition. The recommended inspection frequency is once a year, and more frequently for larger valves and valves for critical applications.

A valve repair that would result in reduction of supply is a liability, but because of the probable infrequency of occurrence, it might be considered as introducing only a moderate degree of unreliability even if it resulted in total interruption. The repair of a valve normally should be accomplished in two days. Valves opening opposite to the majority are undesirable and when they do occur, they should be clearly identified.

HYDRANTS

Size, Type and Installation

Hydrants should conform to American Water Works Standard for Dry Barrel Fire Hydrants or Underwriters' Laboratories of Canada listing. Hydrants should have at least two 65 mm outlets. Where required fire flows exceed 5,000 LPM or pressures are low there should also be a large pumper outlet. The lateral street connection should not be less than 150 mm in diameter. Hose threads, operating and cap nuts on outlets should conform to Provincial Standard dimensions. A valve should be provided on lateral connections between hydrants and street mains.

Hydrants that open in a direction opposite to that of the majority are considered unsatisfactory. Flush hydrants are considered undesirable because of delay in getting into operation; this delay is more serious in areas subject to heavy snow storms. Cisterns are considered unsatisfactory as an alternative to pressurized hydrants. The number and spacing of hydrants should be as indicated in Table 2-Standard Hydrant Distribution.

Inspection, Testing and Maintenance

A public or private water purveyor is recommended to review and apply NFPA 291: *Recommended Practise for Fire Flow Testing and Marking of Hydrants* and NFPA 25: *Standard for Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, regarding the frequency for inspection, testing and maintenance of public and private hydrants for fire fighting purposes.

Public and private hydrants should be inspected at least semi-annually and after each use. The maintenance regimen should include operation at least once a year. Where freezing temperatures occur, the semi-annual inspections should be made in the spring and fall of each year. Because of the possibility of freezing, hydrants should be checked frequently during extended periods of severe cold. Public or private hydrants should be kept in good condition and suitable records of inspections and repairs should be maintained by the water purveyor or private owner.

Hydrants should be painted in highly visible colours so that they are conspicuous and be situated with outlets at least twelve inches above the grade. There should be no obstruction that could interfere with their operation. Snow should be cleared promptly after storms and ice and snow accumulations removed as necessary.

Hydrant Flow Testing

Hydrant flow tests should be conducted regularly on public and private water supply systems:

1) to determine the flow rate at which water is available at various locations serviced by the water distribution system;
2) to determine where weak areas within the system exist and determine the need for booster pump applications;
3) to verify or calibrate the accuracy of water distribution system models; and
4) to determine a water flow and pressure profile where the water distribution system supplies an automatic sprinkler system.

A system of hydrant flow testing should be implemented to ensure that all service areas of the water distribution network are flow tested at least every 5 to 10 years to verify the available fire flow capacity in each area. In areas where it is not practical to conduct flow tests, hydraulic models can be used to estimate the available fire flows without flow testing.

Hydrant flow tests should be completed in accordance with NFPA 291. Note that results may vary substantially, depending on the time of day, season and associated demands on the water distribution system.

Hydrant Distribution

Hydrant locations and spacing should be convenient for fire department use. Hydrants should be located at intersections, in the middle of long blocks, at the end of long dead-end streets, and on both sides of busy and wide roadways where it may be impractical to run hose lines across traffic. To allow for convenient utilization of water supplies, distribution density of hydrants should be in accordance with the required fire flows indicated in Table 2 Standard Hydrant Distribution. The maximum recommended spacing of hydrants in commercial, industrial, institutional and multi-family residential areas is 90 metres; in single family residential areas, a maximum spacing of 180 metres is recommended. In areas where fire apparatus have access (e.g. large properties, private developments, etc.), hydrants should be required by bylaw. The planning of hydrant locations should be a cooperative effort between the water utility and fire department and should take into account the types of apparatus and probable set up arrangements that will be used by the fire department as well as the accessibility of the structure with respect to application of hose streams.

Table 2 Standard Hydrant Distribution

Fire Flow Required (LPM)	Average Area per Hydrant (m^2)	Maximum Recommended Spacing Between Hydrants (m) [a,b,c,e,f,g]	Maximum Distance from Any Point on Street or Road Frontage to a Hydrant (m) [d,f,g]	Minimum Number of Hydrants (total available)
1,800	16,000	180	90	1
2,000	16,000	180	90	1
4,000	15,000	180	90	1
6,000	14,000	150	75	1
8,000	13,000	135	70	2
10,000	12,000	135	70	3
12,000	11,000	120	70	3
14,000	10,000	105	65	4
16,000	9,500	90	55	5
18,000	9,000	90	55	5
20,000	8,500	90	55	6
22,000	8,000	90	55	6
24,000	7,500	75	45	6
26,000	7,000	75	45	7
28,000	6,500	60	35	8
30,000	6,000	60	35	8
32,000	5,500	60	35	9
34,000	5,250	60	35	9
36,000	5,000	50	30	10
38,000	4,750	50	30	10
40,000	4,500	50	30	11
42,000	4,250	45	27	11
44,000	4,000	45	27	12
46,000	3,750	45	27	12
48,000	3,500	40	25	13

Table 2 Footnotes

a. Reduce by 30 m for dead-end streets or roads.
b. Where streets are provided with median dividers that cannot be crossed by fire fighters pulling hose lines, or where arterial streets are provided with four or more traffic lanes and have a traffic count of more than 30,000 vehicles per day, hydrant spacing shall average not greater than 150 m on each side of the street and be arranged on an alternating basis up to a fire flow requirement of 26,000 LPM and 122 m for fire flow requirements exceeding 26,000 LPM.
c. Where new water mains are extended along streets where hydrants are not needed for protection of structures or similar fire problems, fire hydrants shall be provided at spacing not to exceed 300 m to provide for transportation hazards.
d. Reduce by 15 m for dead-end streets or roads.
e. Hydrant spacing may be increased in gridded municipal areas if there are adequate (accessibly positioned) hydrants to deliver required fire flows using the following hydrant flow rates:
    - for each hydrant within 75m of the building credit 95 LPS;
    - for hydrants between 76-150m of the building credit 63 LPS;
    - for hydrants 151-300m of the building credit 47 LPS
    - for hydrants greater than 300m from the building, do not credit.
f. A 50-percent spacing increase shall be permitted where the building is equipped throughout with an approved automatic sprinkler system designed and installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems.
g. A 25-percent spacing increase shall be permitted where the building is equipped throughout with an approved automatic sprinkler system designed and installed in accordance with NFPA 13R: Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies; or NFPA 13D: Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured

RECORDS

Plans and Records

Complete, up-to-date plans and records essential for the proper operation and maintenance of the system should be available in a convenient form, suitably indexed and safely filed. These should include plans of the source as well as records of its yield and a reliable estimate of the safe yield; plans of the supply works including dams, intakes, wells, pipelines, treatment plants, pumping stations, storage reservoirs and tanks; and a map of the distribution system showing mains, valves, and hydrants. Plans and maps should be in duplicate and stored so as to be readily available during an emergency even if some facilities are inaccessible.

Detailed distribution system plans, in a form suitable for field use, should be available for maintenance crews. Records of consumption, pressures, storage levels, pipes, valves, hydrants, and of the operations of the supply works and distribution system, including valve and hydrant inspections and repairs should be maintained.

Part 2

GUIDE FOR DETERMINATION OF REQUIRED FIRE FLOWS FOR PUBLIC FIRE PROTECTION IN CANADA

Risk Quantification with Required Fire Flows

Fire Underwriters Survey uses the Classification Standard for Public Fire Protection to define the criteria used in the evaluation of a community's fire defenses for fire insurance grading/classification purposes for the Canadian subscribing property and casualty insurance industry.

Within the Classification Standard for Public Fire Protection, a section titled "Required Fire Flow" outlines the methodology for determining the amount of water necessary for providing effective public fire protection at selected locations throughout the community based on buildings currently built, or expected to be built in the community.

Fire Underwriters Survey uses required fire flows in the community evaluation process to determine the relative fire risk level of each community or zone within each community which is referred to as the "Basic Fire Flow (BFF)". Normally the Basic Fire Flow is selected to be adequate for the vast majority (90%) of risks in the area. Historically the fifth highest Required Fire Flow (RFF) in the community or response zone was used when assessing the adequacy and reliability of public fire protection in a community or response zone. Note that the use of the "fifth" highest Required Fire Flow is a rule of thumb. The objective of using the fifth highest fire flow is to provide a reasonable fire flow for almost all of the structure fires that could occur in the given area, while not using the most severe risks as a benchmark for design.

FUS uses the Required Fire Flows (RFF) to measure risk and response capacities at specific locations. FUS uses the Basic Fire Flow (BFF) as a benchmark of the risk in a zone or community (aggregation of required fire flows). For example;

a. when assessing **fire departments** for fire insurance grading purposes, FUS uses the Basic Fire Flows to determine the number of fire apparatus, associated staffing, equipment and timeframe for interventions required to provide an effective level of response fire suppression response across the community. The fire department benchmark requirements are detailed in the Fire Underwriters Survey Table of Effective Response, which provides a benchmark standard of response cover (for maximum credit in fire insurance grading) for each range of required fire flows and the Basic Fire Flows.
b. when assessing **water distributions systems** for fire insurance grading purposes, FUS uses the Basic Fire Flows to review the reliability and adequacy of the water distribution system to consistently deliver the required fire flows across the zone or community.

Fire Underwriters Survey has prepared this guide to aid individuals in estimating the amount of water that should be available for effective public fire protection relative to any structure in the built environment or any structure being designed, with the intent of providing an adequate volume of water, and at a flow rate effective for use by fire departments, and considering the possibility of a fully involved structure fire and the need for manual hose streams. The guide to calculate required fire flows is made available to municipal officials, consulting engineers and other interested stakeholders as an aid in estimating water supply requirements for public fire protection. This document is a guide and requires specialized knowledge and experience in public fire protection engineering for its effective application.

In areas where the authority having jurisdiction determines that adequate and reliable water supply systems for effective fire-fighting purposes do not otherwise exist, consideration should be given to planning for alternative water supplies for structural fire-fighting purposes. The recommended approach for alternative water supply design and delivery is described in NFPA 1142, Standard on Water Supplies for Suburban and Rural Fire Fighting. Note that compliance with NFPA 1142 may or may not be recognized for fire insurance grading purposes depending on the measured effectiveness and reliability of the system created, with respect to delivering appropriate flow rates and volumes of water in time frames that would be effective.

Method for Determining Required Fire Flows

Fire Underwriters Survey defines **Required Fire Flow** as the amount and rate of water application required in firefighting to confine and control the fires possible in a building or group of buildings which comprise essentially the same fire area by virtue of immediate exposure. This may include as much as a city block.

To determine the estimated amount of water required to confine and control a fire in a building or group of buildings, Fire Underwriters Survey uses the following base formula:

$$RFF = 220C\sqrt{A}$$

Where:

RFF	= the Required Fire Flow in litres per minutes (LPM)
C	= the Construction Coefficient is related to the type of construction of the building
A	= the Total Effective Floor Area (effective building area) in square metres of the building

To calculate the required fire flow of a building the first step is to determine the predominate type of construction (and associated Construction Coefficient) and Total Effective Area. The required fire flow of an individual building should then be adjusted based on the following additional factors:

- Occupancy and Contents Adjustment Factor,
- Automatic Sprinkler Protection, and
- Exposure Adjustment Charge

The following procedure is recommended to be followed to determine the Required Fire Flow.

A. Determine the Construction Coefficient (C)
B. Determine Total Effective Floor Area (A)
C. Using values obtained in A and B with the base Required Fire Flow formula ($RFF = 220C\sqrt{A}$), to determine the Required Fire Flow to the nearest 1,000 LPM.
D. Determine the increase or decrease for the Occupancy Contents Adjustment Factor and apply to the value obtained in C above. Do not round off the answer.
E. Determine the decrease if warranted for having Automatic Sprinkler Protection. Do not round off the value.
F. Determine the total Exposure Adjustment Charge for exposures if warranted. Do not round off the value.
G. To the answer obtained in D, subtract the value obtained in E and add the value obtained in F. The final figure is rounded off to the nearest 1,000 LPM.

Construction Coefficient (C)

Note that the construction typology used by the insurance industry and public fire protection differs from the terms of reference in the National Building Code of Canada (NBC).

The following Construction Types and Coefficients are used in the required fire flow formula:

C	=	1.5 for **Type V** Wood Frame Construction
	=	0.8 for **Type IV-A** Mass Timber Construction
	=	0.9 for **Type IV-B** Mass Timber Construction
	=	1.0 for **Type IV-C** Mass Timber Construction
	=	1.5 for **Type IV-D** Mass Timber Construction
	=	1.0 for **Type III** Ordinary Construction
	=	0.8 for **Type II** Noncombustible Construction
	=	0.6 for **Type I** Fire Resistive Construction

When determining the predominate Construction Coefficient of a building, the following reference terms are used by fire underwriters and fire departments.

Wood Frame Construction (Type V)
A building is considered to be of Wood Frame construction (Type V) when structural elements, walls, arches, floors, and roofs are constructed entirely or partially of wood or other material.

Note: Includes buildings with exterior wall assemblies that are constructed with any materials that do not have a fire resistance rating that meets the acceptance criteria of CAN/ULC-S114. May include exterior surface brick, stone, or other masonry materials where they do not meet the acceptance criteria.

Mass Timber (Type IV)
Mass timber construction, including Encapsulated Mass Timber, Heavy Timber and other forms of Mass Timber are considered as one of the following sub-types relating to the fire resistance ratings of assemblies as follows:

- Type IV-A (Encapsulated Mass Timber)
    - A building is considered to be of Mass Timber Type IV-A (Encapsulated Mass Timber) construction when structural elements, walls, arches, and floors have a minimum 2-hour fire resistance rating and the roof has a minimum 1 hour fire resistance rating. Additionally all elements of the building must meet the requirements set out for Encapsulated Mass Timber Construction within the 2020 National Building Code of Canada . For types of mass timber construction that do not fully meet these criteria, treat as Type IV-B, Type IV-C or Type IV-D.
- Type IV-B (Rated Mass Timber)
    - A building is considered to be of Mass Timber Type IV-B (Rated Mass Timber) construction when the building assemblies include mass timber construction elements and all structural elements, exterior walls, interior bearing walls and roof have a minimum 1-hour fire resistance rating.

- Type IV-C (Ordinary Mass Timber)
    - A building is considered to be of Mass Timber Type IV-C (Partially Rated Mass Timber) construction when exterior walls are of Mass Timber construction with a minimum 1-hour fire resistance rating. Other structural elements, interior bearing walls and the roof may not have a fire resistance rating.
- Type IV-D (Un-Rated Mass Timber)
    - A building is considered to be of Mass Timber Type IV-D (Un-Rated Mass Timber) construction when exterior walls do not have a minimum 1-hour fire resistance rating, regardless of the fire resistance rating of other structural elements, interior bearing walls and the roof.

Ordinary Construction (Type III also known as joisted masonry)
A building is considered to be of Ordinary construction (Type III) when exterior walls are of masonry construction (or other approved material) with a minimum 1-hour fire resistance rating, but where other elements such as interior walls, arches, floors and/or roof do not have a minimum 1 hour fire resistance rating.

Noncombustible Construction (Type II)
A building is considered to be of Noncombustible construction (Type II) when all structural elements, walls, arches, floors, and roofs are constructed with a minimum 1-hour fire resistance rating and are constructed with noncombustible materials.

Fire-Resistive Construction (Type I)
A building is considered to be of Fire-resistive construction (Type I) when all structural elements, walls, arches, floors, and roofs are constructed with a minimum 2-hour fire resistance rating, and all materials used in the construction of the structural elements, walls, arches, floors, and roofs are constructed with noncombustible materials.

Items of Note Regarding Construction Coefficients

i. Unprotected noncombustible construction (example unprotected steel) should be considered within ordinary construction or noncombustible construction based on the minimum fire resistance rating of the structural elements, exterior walls, and interior bearing walls;
    - If minimum fire resistance rating of exterior walls is 1 hr, apply Ordinary Construction Coefficient (1.0)
    - If minimum fire resistance rating of all structural elements, walls, arches, floors, and roofs is 1 hr, apply Noncombustible Construction Coefficient (0.8).

ii. If a building cannot be defined within a single Construction Coefficient, the Construction Coefficient is determined by the predominate Construction Coefficient that makes up more than 66% or over of the Total Floor Area.

Total Effective Area (A)

To determine a required fire flow for an individual building, the Total Effective Area that would be affected during the design fire must be determined. The Total Effective Area is the largest Floor Area (in square metres) plus the following percentages of the total area of the other floors:

1) For a building classified with a Construction Coefficient from 1.0 to 1.5:
   a) 100% of all Floor Areas are considered in determining the Total Effective Area to be used in the formula.
2) For a building classified with a Construction Coefficient below 1.0:
   a) if any vertical openings in the building (ex. interconnected floor spaces, atria, elevators, escalators, etc.) are unprotected, consider the two largest adjoining floor areas plus 50% of all floors immediately above them up to a maximum of eight; or
   b) if all vertical openings and exterior vertical communications are properly protected in accordance with the National Building Code, consider only the single largest Floor Area plus 25% of each of the two immediately adjoining floors.

Protection requirements:

The protection requirements for vertical openings are only applicable in buildings with a Construction Coefficient below 1.0. The type of protection for vertical openings shall be based on the construction of the enclosure walls and the type of opening or other device used for the protection of openings in the enclosure. See also NBC Division B, Section 3.5. Vertical Transportation.

Protected openings:

i. Enclosures shall have walls of masonry or other limited or noncombustible construction with a fire resistance rating of not less than one hour.
ii. Openings including doors shall be provided with automatic closing devices
iii. Elevator doors shall be of metal or metal-covered construction, so arranged that the doors must normally be closed for operation of the elevator.

Unprotected openings:

i. Any opening through horizontal separations that are unprotected or otherwise have closures that do not meet the minimum requirements for protected openings, above.

High One Storey Buildings

When a building has large single storey spaces (ex. warehouses, atria, etc.) exceeding 3 m in height, the number of storeys to be used in determining the total effective area depends upon the use being made of the building. For example, consider a 1=3 storey building. If the building is being used for high piled stock, or for rack storage, the building would be considered as 3 storeys. 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 should be considered as a one storey.

Each normal height (3m) storey included in the formula provides for additional fire loading. In the case of normal height storeys this fire loading comes from the structure, walls, floors, ceilings/roofs as well as the contents.

Subdividing Buildings (Vertical Firewalls)

In determining Total Effective Area, a building may be subdivided if a vertical firewall with a fire-resistance rating of not less than 2 hours, and meeting the requirements of the National Building Code exists. If the firewall is properly constructed and all openings are properly protected in accordance with the NBC, then the boundary can be treated as protected with no exposure charge.

Notes:

1. If there is a severe risk of fire on the exposed side of the firewall due to hazard conditions, a charge of up to 10% may be applied at the discretion of the Authority Having Jurisdiction or design engineer determining required fire flows.
2. If there are unprotected openings (or improperly protected) in the firewall, then the severity of the exposure in relation to the subject building should be considered (ex. percentage of openings, distance to exposure, combustibility of exposure, etc.) and an exposure charge of up to 10% may be applied.

Basements

Basement floor area is excluded from the Total Effective Area when the basement is at least 50% below grade in the building being considered.

Open Parking Garages

For open parking garages, use the area of the largest floor as the Total Effective Area.

Occupancy and Contents Adjustment Factor

The required fire flow may be reduced by as much as -25% for occupancies having contents with a very low fire hazard or may be increased by up to 25% for occupancies having contents with a high fire hazard. The Occupancy and Contents Adjustment Factor should not be made at greater than 25% or less than -25%.

- *Noncombustible Contents* *-25%*
  - Includes merchandise or materials, including stock, or equipment, which in permissible quantities does not in themselves constitute an active fuel for the spread of fire.
  - May include limited or controlled amounts of combustible material, not exceeding 5% of the Total Effective Area of the occupancy. Combustible components of construction (ex. interior walls, finishes, etc.) should be included in the limit on combustible materials.
- *Limited Combustible Contents* *-15%*
  - Includes merchandise or materials, including furniture, stock, or equipment, of low combustibility, with limited concentrations of combustible materials.
- Combustible Contents 0% no adjustment
  - Includes merchandise or materials, including furniture, stock, or equipment, of moderate combustibility.
- *Free Burning Contents* *+15%*
  - Includes merchandise or materials, including furniture, stock, or equipment, which burn freely, constituting an active fuel.
- *Rapid Burning Contents* *+25%*
  - Includes merchandise or materials, including furniture, stock, or equipment, which either
    - Burn with great intensity
    - spontaneously ignite and are difficult to extinguish
    - give off flammable or explosive vapors at ordinary temperatures
    - as a result of an industrial processing, produce large quantities of dust or other finely divided debris subject to flash fire or explosion

Items of Note for the Occupancy and Contents Adjustment Factor

i. Table 3 provides recommended Occupancy and Contents Adjustment Factors for example Major Occupancies from the National Building Code of Canada (NBC).
ii. In applying the Occupancy and Contents Adjustment Factor, charges should be adjusted accordingly to the specific fire loading and situation that exists in the subject building.
iii. Values can be interpolated from the examples given considering fire loading and expected combustibility of contents of the subject building if not listed.
iv. Values provided can be modified by up to 10% percent positively or negatively depending on the extent to which the fire loading is unusual for the building.
v. Buildings with multiple major occupancies should use the most restrictive Occupancy and Contents Adjustment Factor or can interpolate based on the percentage of each occupancy and its associated fire loading.

Table 3 Recommended Occupancy/Contents Charges by Major Occupancy Examples[1]

Group	Division	Description of Major Occupancies	Occupancy and Contents	Adjustment Factor
A	**1**	***Assembly*** *occupancies* intended for the production and viewing of the performing arts	Combustible	0%
A	**2**	***Assembly*** *occupancies* not elsewhere classified in Group A	Limited to Combustible	-15% to 0%
A	**3**	***Assembly*** *occupancies* of the arena type	Limited to Combustible	-15% to 0%
A	**4**	***Assembly*** *occupancies* in which occupants are gathered in the open air	Limited to Combustible	-15% to 0%
B	**1**	**Detention** occupancies	Noncombustible to Limited	-25% to -15%
B	**2**	**Care** and treatment occupancies	Noncombustible to Limited	-25% to -15%
B	**3**	**Care** occupancies	Limited	-15%
C	**---**	**Residential** occupancies	Limited	-15%
D	**---**	**Business** and personal services occupancies		
D	**---**	• *Police stations without detention quarters*	Non-combustible	-20%
D	**---**	• *Banks, Barber and hairdressing shops, Beauty parlours, Dental offices, Laundries (self-service), Medical offices, Offices, Radio stations*	Limited	-15%
D	**---**	• *Dry cleaning establishments (self-service, not using flammable or explosive solvents or cleaners), Small tool and appliance rental and service establishments*	Combustible	0%
E	**---**	**Mercantile** occupancies		
E	**---**	• *Exhibition halls*	Limited	-15%
E	**---**	• *Supermarkets*	Limited	-15%
E	**---**	• *Shops/Stores*	Limited to Combustible	-15% to 0%
E	**---**	• *Markets*	Combustible	0
E	**---**	• *Department stores*	Free Burning	15%
F	**1**	**High hazard industrial** occupancies	Rapid Burning	+25%
F	**2**	**Medium hazard industrial** occupancies		
F	**2**	• *Television studios not admitting a viewing audience*	Limited	-15%
F	**2**	• *Cold storage plants*	Combustible	0%
F	**2**	• *Electrical substations*	Combustible	0%
F	**2**	• *Helicopter landing areas on roofs*	Limited	-15%

[1] The values presented in this table are intended as a guideline and the occupancy/contents adjustment should be based on the actual severity of conditions within the risk structure.

Group	Division	Description of Major Occupancies	Occupancy and Contents	Adjustment Factor
F	**2**	• *Salesrooms*	Combustible	0%
F	**2**	• *Service stations*	Combustible	0%
F	**2**	• *Wholesale rooms*	Combustible	0%
F	**2**	• *Aircraft hangars (Medium Hazard)*	Free to Rapid Burning	15% to 25%
F	**2**	• *Box factories*	Free to Rapid Burning	15% to 25%
F	**2**	• *Candy plants*	Free to Rapid Burning	15% to 25%
F	**2**	• *Factories (Medium Hazard)*	Free to Rapid Burning	15% to 25%
F	**2**	• *Mattress factories*	Free to Rapid Burning	15% to 25%
F	**2**	• *Planing mills*	Free to Rapid Burning	15% to 25%
F	**2**	• *Printing plants*	Free to Rapid Burning	15% to 25%
F	**2**	• *Warehouses (Medium Hazard)*	Free to Rapid Burning	15% to 25%
F	**2**	• *Woodworking factories*	Free to Rapid Burning	15% to 25%
F	**2**	• *Dry cleaning establishments not using flammable or explosive solvents or cleaners*	Combustible to Free burning	0% to 15%
F	**2**	• *Freight depots*	Combustible to Free burning	0% to 15%
F	**2**	• *Laboratories (Medium Hazard)*	Combustible to Free burning	0% to 15%
F	**2**	• *Laundries, except self-service*	Combustible to Free burning	0% to 15%
F	**2**	• *Workshops (Medium Hazard)*	Combustible to Free burning	0% to 15%
F	**2**	• *Repair garages*	Combustible to Free burning	0% to 15%
F	**2**	• *Storage rooms (Medium Hazard)*	Combustible to Free burning	0% to 15%
F	**3**	**Low hazard industrial** occupancies		
F	**3**	• *Power plants*	Combustible	0%
F	**3**	• *Salesrooms*	Combustible	0%
F	**3**	• *Sample display rooms*	Combustible	0%
F	**3**	• *Storage garages, including open air parking garages*	Combustible	0%
F	**3**	• *Workshops (Low Hazard)*	Limited to Combustible	-15% to 0%
F	**3**	• *Factories (Low Hazard)*	Combustible to Free burning	0% to 15%
F	**3**	• *Laboratories (Low Hazard)*	Limited to Combustible	-15% to 0%
F	**3**	• *Light-aircraft hangars (Low Hazard - storage only)*	Combustible to Free burning	0% to 15%
F	**3**	• *Storage rooms (Low Hazard)*	Limited to Combustible	-15% to 0%
F	**3**	• *Warehouses (Low Hazard)*	Combustible to Free burning	0% to 15%
F	**3**	• *Creameries*	Free to Rapid Burning	15% to 25%

Automatic Sprinkler Protection

The required fire flow may be reduced by up to 50 percent for complete Automatic Sprinkler Protection depending upon adequacy of the system. Where only part of a building is protected by Automatic Sprinkler Protection, credit should be interpolated by determining the percentage of the Total Floor Area being protected by the automatic sprinkler system.

To be able to apply the full 50 percent reduction, the following areas should be reviewed to determine the appropriate level of credit for having Automatic Sprinkler Protection as per the table below:

Table 4 Sprinkler Credits

Automatic Sprinkler System Design	Credit	
	With complete building coverage	With partial building coverage of X%
Automatic sprinkler protection designed and installed in accordance with NFPA 13	30%	30% × Percentage of Total Floor Area Serviced by Sprinkler System
Water supply is standard for both the system and Fire Department hose lines	10%	10% × Percentage of Total Floor Area Serviced by Sprinkler System
Fully supervised system	10%	10% × Percentage of Total Floor Area Serviced by Sprinkler System

Automatic Sprinkler Protection Designed and Installed in Accordance with Applicable NFPA Standards (30%)

The initial credit for Automatic Sprinkler Protection is a maximum of 30% based on the system being designed and installed in accordance with the applicable criteria of NFPA 13, *Standard for Installation of Sprinkler Systems,* NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential* Occupancies, or NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes* and being maintained in accordance with the applicable criteria of NFPA 25, *Standard for the Inspections, Testing and Maintenance of Water-Based Fire* (see Recognition of Automatic Sprinkler Protection).

Water Supply is Standard for both the Sprinkler System and Fire Department Hose Lines (10%)

To qualify to apply an additional 10% reduction, a water supply that is standard for both the sprinkler system and fire department hose lines is required, to qualify the following conditions should be satisfied:

a) Sprinkler system is supplied by a pressurized water supply system (public or private) that is designed and built with no major non-conformance issues (i.e. water supply system is designed in accordance with Part 1 of the Water Supply for Public Fire Protection to qualify for fire insurance grading recognition).
b) Calculated demand for maximum sprinkler design area operation in addition to hose stream requirements are below the available water supply curve (at the corresponding flow rate and pressure). An appropriate safety margin is used to take into account the difference between the available water supply curve at the time of hydrant flow testing as compared to the available water supply curve during Maximum Day Demand.

c) Volume of water available is adequate for the total flow rate including the maximum sprinkler design area operation plus required hose streams plus Maximum Day Demand for the full duration of the design fire event.
d) Residual pressure at all points in the water supply system can be maintained at not less than 150 kPa during the flowing of the sprinkler and required hose streams (plus Maximum Day Demand).

Fully Supervised System (10%)

To qualify to apply an additional 10% reduction, an automatic sprinkler system should be fully supervised. The purpose of the supervisory signal is to ensure that malfunctions of the automatic sprinkler system will be discovered and corrected promptly, while the water flow alarm serves to notify emergency services of the fire as soon as the automatic sprinkler system activates.

- a distinctive supervisory signal to indicate conditions that could impair the satisfactory operation of the sprinkler system (a fault alarm), which is to sound and be displayed, either at a location within the building that is constantly attended by qualified personnel (such as a security room), or at an approved remotely located receiving facility (such as a monitoring facility of the sprinkler system manufacturer); and
- a water flow alarm to indicate that the sprinkler system has been activated, which is to be transmitted to an approved, proprietary alarm-receiving facility, a remote station, a central station or the fire department.

Additional Reductions for Community Level Automatic Sprinkler Protection of Area

Buildings located within communities or subdivisions that are completely sprinkler protected may apply up to a maximum additional 25% reduction in required fire flows beyond the normal maximum of 50% reduction for sprinkler protection of an individual building.
This additional reduction may be applied where all the following conditions are met:

a) the community has a bylaw requiring all buildings that may be built within 30 m of the subject building to be fully sprinkler protected. I.e. future development will not create unsprinklered buildings within 30 m of the subject building, and
b) all buildings within 30 meters of the subject building are fully sprinkler protected with systems that are designed and installed in accordance with the applicable criteria of NFPA 13, *Standard for Installation of Sprinkler Systems,* NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential* Occupancies, or NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* and
c) the community has in place a Fire Prevention Program that provides a system of ensuring that installed fire sprinkler systems are inspected, tested, and maintained in accordance with NFPA 25: *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, and
d) the community maintains the pressure and flow rate requirements for fire sprinkler installations. I.e. the community does not make significant reductions to the operating pressures or flows across the distribution network.

Adjustment of Sprinkler Reductions for Community Level Oversight of Sprinkler Maintenance, Testing and Water Supply Requirements

The reduction in required fire flows for sprinkler protection may be reduced or eliminated if

a) the community does not have a Fire Prevention Program that provides a system of ensuring that installed fire sprinkler systems are inspected, tested, and maintained in accordance with NFPA 25: *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, or
b) the community does not maintain the pressure and flow rate requirements for fire sprinkler installations, or otherwise allows the flow rates and pressure levels that were available during sprinkler system design to significantly degrade, increasing the probability of inadequate water supply for effective sprinkler operation.

Recognition of Automatic Sprinkler Protection

A property should be considered as "sprinkler protected" for the purposes of determining required fire flows, if the building has an automatic fire sprinkler system:

- designed and installed throughout all areas in accordance with NFPA 13, *Standard for Installation of Sprinkler Systems*, and maintained in accordance with the NFPA 25, *Standard for the Inspections, Testing and Maintenance of Water-Based Fire Protection Systems*, and
- supplied by water infrastructure capable of meeting all pressure and flow requirements of the sprinkler system concurrently with Max Day Demand (if connected to a domestic system)

Evidence of the sprinkler system design, installation should be acquired from the party responsible for the building (the owner, building engineer or property manager) or the municipal fire prevention office.

On site, the sprinkler system should carry test tags verifying that a qualified person has conducted tests including:

- flushing and hydrostatic tests of both the underground and overhead piping in accordance with NFPA 13;
- full-flow main drain test within the previous 48 months.
- dry-pipe trip test (if applicable) conducted within the last 48 months
- fire-pump test (if applicable) conducted within the last 48 months

Items of Note for Sprinkler Systems

i. It is important to note that installation of automatic sprinkler systems provides a highly effective and reliable system of fire protection however, this does not preclude the need for manual fire flows entirely as some fires, for various reasons, grow beyond the capability of sprinkler protection to be effective, and in these cases, manual fire fighting intervention is required.

Exposure Adjustment Charge

A percentage of water for the exposures should be added to the required fire flow for the subject building to provide adequate flow rates for hose streams used to reduce the spreading of fire from the subject building to exposed risks (ex. structures, stored materials, forest, etc.). The required fire flow of a subject building may be increased depending on the severity of exposed risks to the subject building and the distance between the exposed risks and the subject building. This charge considers the usage of water supplies to prevent exposed risks from igniting or being damaged during a major fire incident in the subject building.

The maximum Exposure Adjustment Charge to be applied to a subject building is 75% when summing the percentages for all sides of the building. Table 5 outlines the maximum Exposure Adjustment Charge to apply for any one side of the subject building based on the following separation distances between the subject building and the exposed risk (aka. exposure):

Table 5 Exposure Charges

Separation Distance	Maximum Exposure Adjustment Charge
0 m to 3 m	25%
3.1 m to 10 m	20%
10.1 m to 20 m	15%
20.1 m to 30 m	10%
Greater than 30	0%

The Exposure Adjustment Charge percentage shall depend upon the height, area, and construction of the building(s) being exposed, the separation distance, unprotected openings in the exposed risk(s), the length and height of exposed risk, and the provision of automatic sprinkler protection in the risk(s) exposed.

When determining the appropriate Exposure Adjustment Charge to apply to a single side of the subject building the following items should be reviewed:

- Exposure distance
  - The distance in metres from the subject building facing wall to the exposed building facing wall, measured to the nearest metre, between the nearest points of the buildings. Where either the subject building or the exposed building is at a diagonal to the other building, the shortest distance should be increased by 3 metres and this adjusted value used as exposure distance.
- Construction types of facing walls and protection of openings
  - the wall construction of the exposed building facing wall
  - whether or not there are unprotected openings (including glazing, eaves, etc.)
- Length-height value of the exposed building facing wall
  - a length-height value of the exposed building facing wall should be determined by multiplying the length of the exposed building facing wall in metres by the height of the exposed building in stories. (Each 4 metres or fraction thereof equals one story for this determination).

Using the exposure distance, construction type, status of unprotected openings, and the length-height value, look up the recommended charge from Table 6. Review the notes after the table and adjust the exposure charge if appropriate.

Table 6 Exposure Adjustment Charges for Subject Building considering Construction type of Exposed Building Face

Distance (m) to the Exposure	Length-height factor of exposing building face	Type V	Type III-IV[2]	Type III-IV[3]	Type I-II[2]	Type I-II[3]
0 to 3	0-20	20%	15%	5%	10%	0%
	21-40	21%	16%	6%	11%	1%
	41-60	22%	17%	7%	12%	2%
	61-80	23%	18%	8%	13%	3%
	81-100	24%	19%	9%	14%	4%
	Over 100	25%	20%	10%	15%	5%
3.1 to 10	0-20	15%	10%	3%	6%	0%
	21-40	16%	11%	4%	7%	0%
	41-60	17%	12%	5%	8%	1%
	61-80	18%	13%	6%	9%	2%
	81-100	19%	14%	7%	10%	3%
	Over 100	20%	15%	8%	11%	4%
10.1 to 20	0-20	10%	5%	0%	3%	0%
	21-40	11%	6%	1%	4%	0%
	41-60	12%	7%	2%	5%	0%
	61-80	13%	8%	3%	6%	1%
	81-100	14%	9%	4%	7%	2%
	Over 100	15%	10%	5%	8%	3%
20.1 to 30	0-20	0%	0%	0%	0%	0%
	21-40	2%	1%	0%	0%	0%
	41-60	4%	2%	0%	1%	0%
	61-80	6%	3%	1%	2%	0%
	81-100	8%	4%	2%	3%	0%
	Over 100	10%	5%	3%	4%	0%
Over 30 m	all sizes	0%	0%	0%	0%	0%

[2] *with unprotected openings*
[3] *without unprotected openings*

Items of Note for Exposures Charge

i. Automatic Sprinkler Protection in Exposed Buildings

If the exposed building is fully protected with an automatic sprinkler system (see note Recognition of Automatic Sprinkler Protection), the Exposure Adjustment Charge determined from Table 6 may be reduced by up to 50% of the value determined.

ii. Automatic Sprinkler Protection in both Subject and Exposed Buildings

- If both the subject building and the exposed building are fully protected with automatic sprinkler systems (see note below regarding recognition of sprinkler protection), no Exposure Adjustment Charge should be applied.

iii. Exposure protection of Area Between Subject and Exposed Buildings

- If the exposed building is fully protected with an automatic sprinkler system (see note below regarding recognition of sprinkler protection), and the area between the buildings is protected with an exterior automatic sprinkler system, no Exposure Adjustment Charge should be applied.

iv. Reduction of Exposure Charge for Type V buildings

- If the exposed building face of a Type V building has an exterior cladding assembly with a minimum 1 hour FRR, then the exposure charge may be treated as a Type III/IV building for the purposes of looking up the appropriate exposure charge in Table 6.

Additional Items of Note

i. The required fire flow calculation guide is not expected to provide an adequate required fire flow for complex and unusual risks such as lumber yards, petroleum storage, refineries, grain elevators, and large chemical plants, but may indicate a minimum value for these hazards. Applicable industry standards and guidelines should be consulted when reviewing fire flows and emergency response needs for complex and high consequence risks.

ii. Judgment must be used for business, industrial, and other occupancies not specifically mentioned.

iii. Consideration should be given to the configuration of the building(s) being considered and accessibility by the fire department with respect to applying hose streams.

iv. Consideration should be given to carefully reviewing closely spaced, wood frame construction and the potential for fire spread beyond the building of origin. There are many risk factors that may contribute to the risk of these types of fires, one of which is spacing of structures. If the designer or the Authority Having Jurisdiction determines there to be a high potential for fire spread between closely spaced combustible buildings, the designer should consider the maximum probable fire size involvement when determining the Total Effective Area of the design fire.

v. Where wood shingle or shake roofs contribute to risk of fire spread in the subject building, an additional charge of 2,000 L/min to 4,000 L/min should be added to the required fire flow in accordance with the extent and condition of the risk.

vi. For one and two-family dwellings not exceeding two storeys in height and having Total Effective Area of not more than 450 m^2, the following short method may be used in determining a required fire flow:

Table 7 Simple Method for One and Two Family Dwellings Up To 450 sq.m

Exposure distances	Suggested Required Fire Flow (LPM) [4,5,6]	
	Wood Frame	Masonry or Brick
Less than 3m	8,000	6,000
3 to 10m	4,000	4,000
10.1 to 30m	3,000	3,000
Over 30m	2,000	2,000

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4 For sprinkler protected risks, 50% of the value from this table may be used, to a minimum required fire flow of 2,000 LPM

5 If all exposures within 30m of subject building are sprinkler protected, a minimum required fire flow of 2,000 LPM may be used

6 If all exposing building faces within 10m have protected openings (or blank walls) and a minimum 1 hr FRR, the required fire flow may be reduced by 2,000 LPM to a minimum of 2,000 LPM.

vii. For one and two-family dwellings not exceeding two storeys but having a Total Effective Area of more than 450 m^2, and for row housing, the following short method may be used in determining a required fire flow:

Table 8 Simple Method for One and Two Family Dwellings Exceeding 450 sq.m, and Row Housing Exposure distances

Exposure distances	Suggested Required Fire Flow [4,5,6]	
	Wood Frame	Masonry or Brick
Less than 3m	12,000	9,000
3 to 10m	8,000	8,000
10.1 to 30m	6,000	6,000
Over 30m	4,000	4,000

Note that for larger and more complex developments, a full calculation of required fire flows is recommended.

viii. Special hazards

a. In areas where there is a significant hazard of wildfires and a significant level of exposure to fuels, further investigation into adequate water supplies for public fire protection should be made and may consider alternative fire suppression strategies including, but not limited to, exterior exposure protection fire sprinkler systems, structure protection units and other methods of protection of the built environment from wildland fires in the interface areas. For further information see the National Research Council publication National Guide for Wildland-Urban Interface Fires.

b. In areas where there is a significant hazard of seismic events, consideration should be given to the need for redundancy in water supplies both for manual fire fighting and for building sprinkler systems, particularly in areas where there is a significant life safety hazard.

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