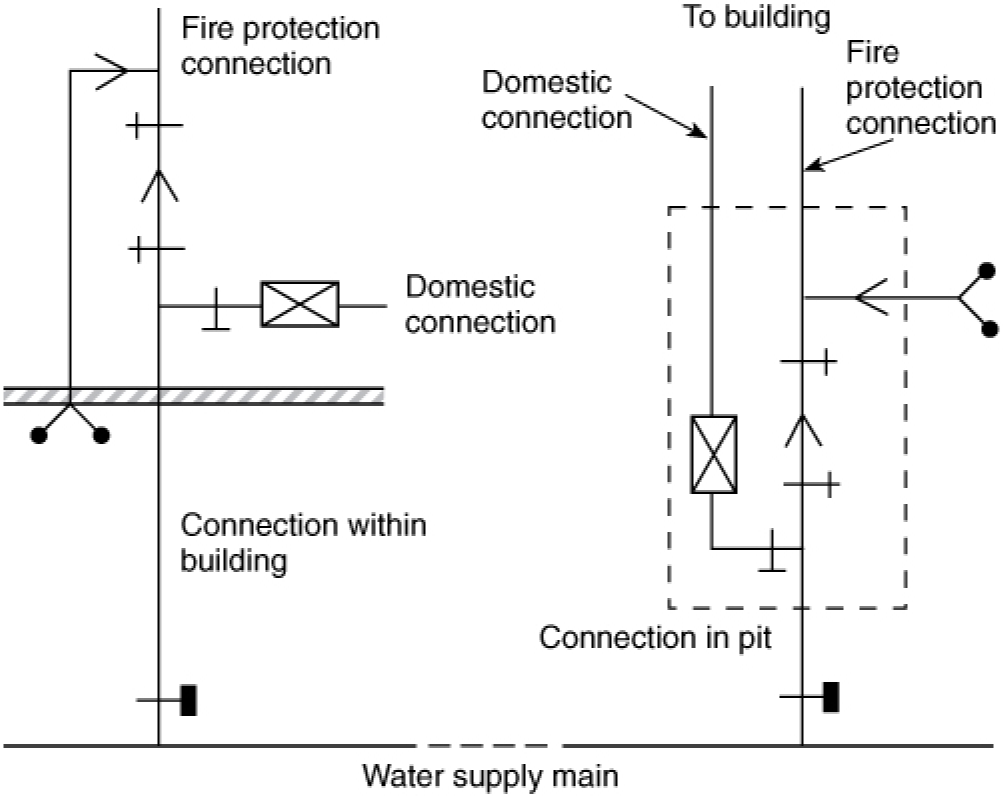
## B Miscellaneous Topics

*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*

### B.1

Figure B.1 shows acceptable methods for interconnection of the fire protection and domestic water supply.

### Figure B.1 Permitted Arrangements Between Fire Protection Water Supply and Domestic Water Supply.




### B.2 Sprinkler System Performance Criteria.

### B.2.1

Sprinkler system performance criteria have been based on test data. The factors of safety are generally small, are not definitive, and can depend on expected (but not guaranteed) inherent characteristics of the sprinkler systems involved. These inherent factors of safety consist of the following:

(1) The flow-declining pressure characteristic of sprinkler systems whereby the initial operating sprinklers discharge at a higher flow than with all sprinklers operating within the designated area.
(2) The flow-declining pressure characteristic of water supplies, which is particularly steep where fire pumps are the water source. This characteristic similarly produces higher than design discharge at the initially operating sprinklers.

The user of these standards can elect an additional factor of safety if the inherent factors are not considered adequate.

### B.2.1.1

Performance-specified sprinkler systems, as opposed to scheduled systems, can be designed to take advantage of multiple loops or gridded configurations. Such configurations result in minimum line losses at expanded sprinkler spacing, in contrast to the older tree-type configurations, where advantage cannot be taken of multiple path flows.

Where the water supply characteristics are relatively flat with pressures being only slightly above the required sprinkler pressure at the spacing selected, gridded systems with piping designed for minimal economic line losses can all but eliminate the inherent flow-declining pressure characteristic generally assumed to exist in sprinkler systems. In contrast, the economic design of a tree-type system would likely favor a system design with closer sprinkler spacing and greater line losses, demonstrating the inherent flow-declining pressure characteristic of the piping system.

Elements that enter into the design of sprinkler systems include the following:

(1) Selection of density and area of application
(2) Geometry of the area of application (remote area)
(3) Permitted pressure range at sprinklers
(4) Determination of the water supply available
(5) Ability to predict expected performance from calculated performance
(6) Future upgrading of system performance
(7) Size of sprinkler systems

In developing sprinkler specifications, each of these elements needs to be considered individually. The most conservative design should be based on the application of the most stringent conditions for each of the elements.

### B.2.1.2 Selection of Density and Area of Application.

Specifications for density and area of application are developed from NFPA standards and other standards. It is desirable to specify densities rounded upward to the nearest 0.005 gpm/ft$^2$ (0.2 mm/min).

Prudent design should consider reasonable-to-expect variations in occupancy. This design would include not only variations in type of occupancy but also, in the case of warehousing, the anticipated future range of materials to be stored, clearance to ceiling, types of arrays, packaging, pile height, and pile stability, as well as other factors.

Design should also consider some degree of adversity at the time of a fire. To take this into account, the density and/or area of application can be increased. Another way is to use a dual-performance specification where, in addition to the normal primary specifications, a secondary density and area of application are specified. The objective of such a selection is to control the declining pressure-flow characteristic of the sprinkler system beyond the primary design flow.

A case can be made for designing feed and cross mains to lower velocities than branch lines to achieve the same result as specifying a second density and area of application.

### B.2.1.3 Geometry of Area of Application (Remote Area).

It is expected that, over any portion of the sprinkler system equivalent in size to the area of application, the system will achieve the minimum specified density for each sprinkler within that area.

Where a system is computer-designed, ideally the program should verify the entire system by shifting the area of application the equivalent of one sprinkler at a time so as to cover all portions of the system. Such a complete computer verification of performance of the system is most desirable, but unfortunately not all available computer verification programs currently do this.

This selection of the proper Hazen–Williams coefficient is important. New unlined steel pipe has a Hazen–Williams coefficient close to 140. However, it quickly deteriorates to 130 and, after a few years of use, to 120. Hence, the basis for normal design is a Hazen–Williams coefficient of 120 for steel-piped wet systems. A Hazen–Williams coefficient of 100 is generally used for dry pipe systems because of the increased tendency for deposits and corrosion in these systems. However, it should be realized that a new system will have fewer line losses than calculated, and the distribution pattern will be affected accordingly.

Conservatism can also be built into systems by intentionally designing to a lower Hazen–Williams coefficient than that indicated.

### B.2.1.4 Ability to Predict Expected Performance from Calculated Performance.

Ability to accurately predict the performance of a complex array of sprinklers on piping is basically a function of the pipe line velocity. The greater the velocity, the greater is the impact on difficult-to-assess pressure losses. These pressure losses are presently determined by empirical means that lose validity as velocities increase. This is especially true for fittings with unequal and more than two flowing ports.

The inclusion of velocity pressures in hydraulic calculations improves the predictability of the actual sprinkler system performance. Calculations should come as close as practicable to predicting actual performance. Conservatism in design should be arrived at intentionally by known and deliberate means. It should not be left to chance.

### B.2.1.5 Future Upgrading of System Performance.

It is desirable in some cases to build into the system the capability to achieve a higher level of sprinkler performance than needed at present. If this is to be a consideration in conservatism, consideration needs to be given to maintaining sprinkler operating pressures on the lower side of the optimum operating range and/or designing for low pipeline velocities, particularly on feed and cross mains, to facilitate future reinforcement.

### B.3 Effect of Clearance to Ceiling on Sprinkler Performance.

The problems with large clearances to ceiling were well recognized by the 1970s in terms of the effect both on delayed sprinkler activation and on the effect on droplet penetration through the fire plume. The work of Alpert (1972, 1975), Heskestad and Delichatsios (1979), and Beyler (1984) clearly identified the effect of clearance to ceiling on detection and activation of sprinklers. This was supplemented by the work of Heskestad and Smith (1976) in which the thermal responsiveness of sprinklers was studied and modeled. Similarly, the effect of the strong plumes resulting from large clearances to ceiling and highly challenging fires was recognized in the 1970s through the work of Yao and Kalelkar (1970), Yao (1976), and Yao (1980). This understanding was reflected in the development of large drop sprinklers in the 1970s [Yao (1997)]. The inability of $\frac{1}{2}$ in. and $\frac{17}{32}$ in. (12.7 mm and 13 mm) standard sprinklers to penetrate high-challenging fires was well understood and demonstrated in the 1970s [Yao (1976)]. The effect of excessive clearance to ceiling was also demonstrated in the testing summarized in Annex C.

This understanding of the role of clearance to ceiling on fire performance had a strong effect on the development of advanced sprinkler technologies.

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