The Authoritative Source for Plumbing, Hydronics, Fire Protection and PVF

# Plumbing Engineer®

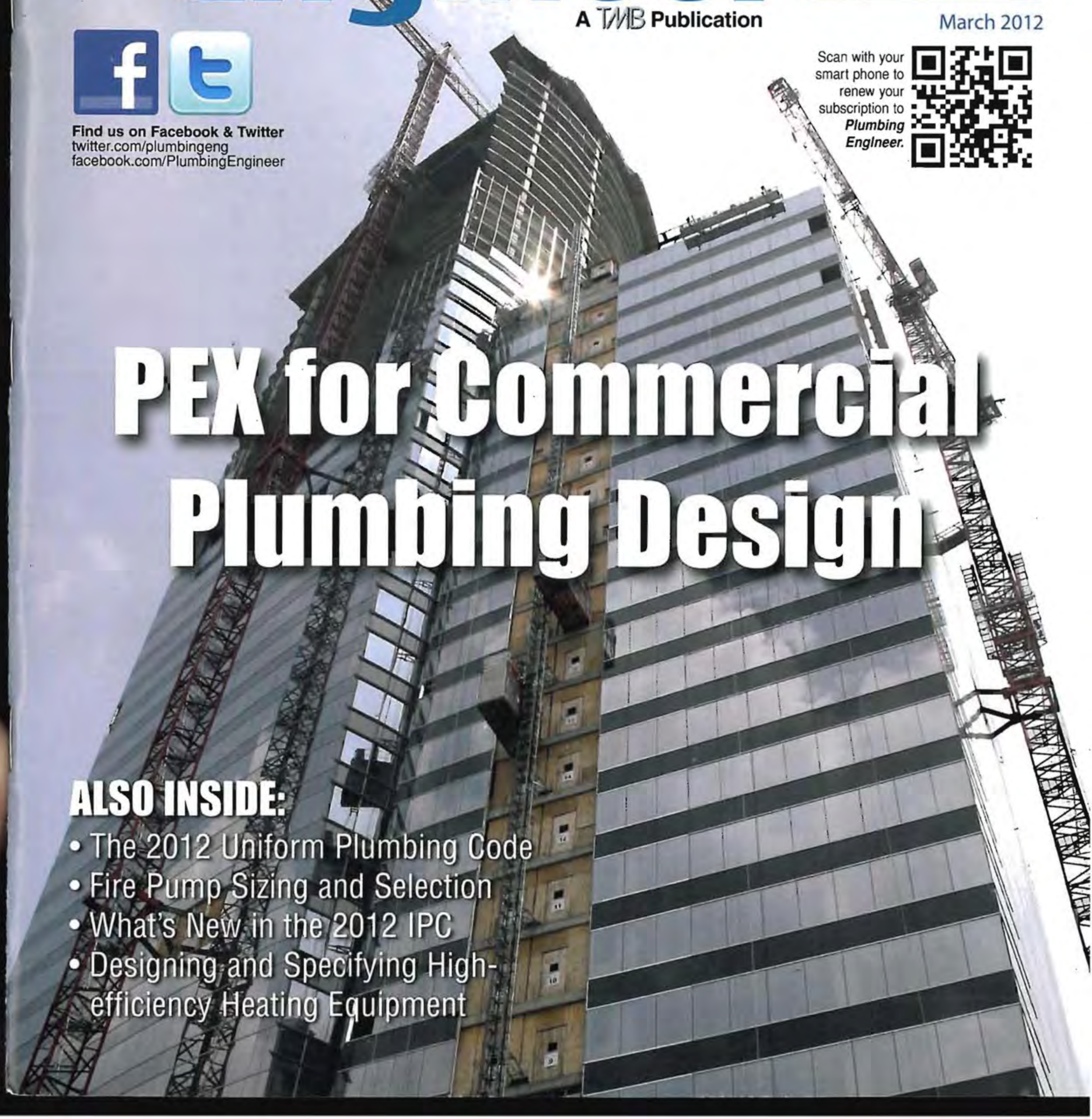
A TMB Publication

ASPE

THE OFFICIAL PUBLICATION OF THE AMERICAN SOCIETY OF PLUMBING ENGINEERS

March 2012





# PEX for Commercial Plumbing Design

## ALSO INSIDE:

- The 2012 Uniform Plumbing Code
- Fire Pump Sizing and Selection
- What's New in the 2012 IPC
- Designing and Specifying High-efficiency Heating Equipment

# Fire Pump Sizing and Selection

**By Greg Trombold**
Vice President, Membership
ASPE Cleveland Chapter

When starting a fire pump design, the most important item to consider is the water supply. If you are utilizing the city water supply as the primary source for the pump, you need to make sure that an accurate city water test is used. Some good rules to follow are:

- Make sure the water test is less than a year old.
- Make sure the water test is performed as close to the tap point as possible.
- Make sure the test is taken during the time of highest water use for the area.

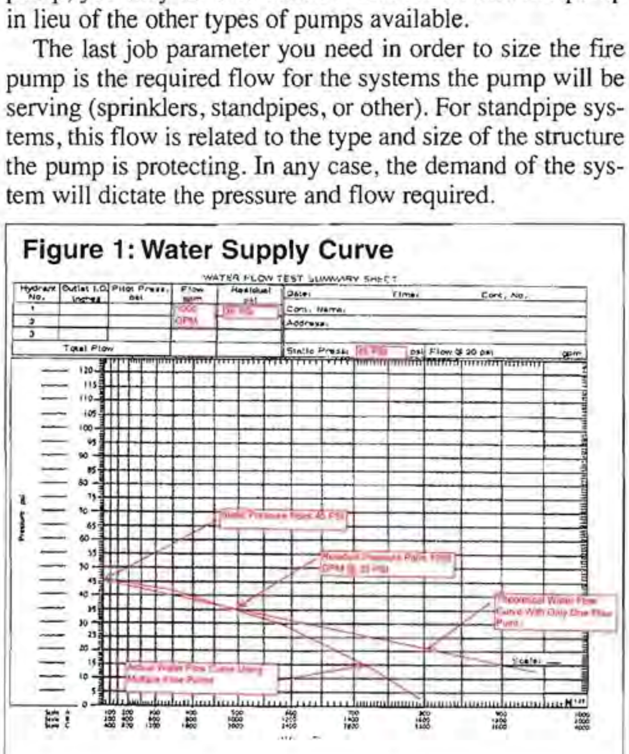
In a cold climate, testing during the summer may be a better choice, since residents are watering their lawns and commercial properties are using more water for cooling. Additionally, in highly residential areas, peak morning use typically occurs early in the day, between 6:30 and 9 a.m., so that may be the best time for the test.

Another consideration regarding the water test is this: Did the city flow enough water to meet 150 percent of the fire pump design point? This will ensure that the municipal supply will provide enough volume to meet the system demand. If not, request a new test using more hydrants or plot a water supply curve (see Figure 1).

If you are using a private water supply, lake, or ground-level storage tank, you must remember that you are not permitted to use a suction lift with a fire pump. Thus, if the water supply is located below the suction inlet to the fire pump, you may have to utilize a vertical turbine fire pump in lieu of the other types of pumps available.

The last job parameter you need in order to size the fire pump is the required flow for the systems the pump will be serving (sprinklers, standpipes, or other). For standpipe systems, this flow is related to the type and size of the structure the pump is protecting. In any case, the demand of the system will dictate the pressure and flow required.

**Figure 1: Water Supply Curve**




### Calculating standpipe system pressure

Two types of structure calculations for pressure are available. One is for high-rise structures (buildings greater than 75 feet in height, measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story) and one is for non-high-rise structures. This is a factor because any high rise requires a pressure of 100 pounds per square inch (psi) at the top of the structure while flowing the rated gallons per minute (gpm) of the fire pump. This discussion concentrates on high rises because the pressure calculations for most non-high-rise buildings are determined through the use of software specifically designed for fire sprinkler hydraulic calculations. These programs are used by sprinkler contractors to keep their pipes as small as possible, which controls the cost of the job.

When calculating the water pressure for a high rise, it is a good idea to use a calculation sheet such as the one shown in Figure 2. If you use a calculation sheet, a few variables need to be filled in:

- Pressure drop in the backflow prevention device and water meter
- Friction loss in the most remote standpipe when flowing 500 gpm
- Elevation change

*Continued on page 66*

**Figure 2: Water Pressure Calculation Sheet**

Trombold

The Trombold Equipment Company
Cleveland • Columbus • Cincinnati

1/24/12

**Pressure calculation sheet fire pumps**

Engineer: ______________ Job: Example

City water test: Date: 6-5-11 Static pressure: 45 PSI
Residual pressure: 35 PSI GPM flowing: 1250

**Pump #1**

| | | |
|---|---|---|
| Pressure required at top of structure | 100 | |
| Height of building 212 / 2.31 = | + 92 | |
| Friction loss in building piping | + 10 | |
| **Total pressure required for system** | 202 PSI | (1) |
| Residual pressure at street | 35 | |
| Backflow loss | - 7 | |
| Water meter | - 3 | |
| Elevation change | - 0 | |
| Friction loss in suction piping | - 3 | |
| **Available suction pressure at pump** | 22 PSI | (2) |
| Subtract (2) from (1) **Pump discharge pressure** | 180 PSI | |

# Fire Pumps

*Continued from page 64*

For the example in Figure 2, the parameters are:

- Building height: 212 feet
- City water pressure: 45 psi static; 35 psi residual
- Required flow rate: 1,250 gpm

Assume that the pump is 1,250 gpm for this example. As you can see, the calculated required pump psi is 180 psi.

A similar calculation can be used for a non-high rise, by changing the 100 psi to the end head pressure (15 – 50 psi, depending on the head). However, the friction loss and pipe sizing become an issue when doing this calculation, which is why most contractors and sprinkler designers use software.

**A note about pressure**

One thing that some engineers forget is that the pump will discharge at a much higher pressure at churn (no flow) than at the design point. Per NFPA 20 (2010): Standard for the Installation of Stationary Pumps for Fire Protection, fire pumps are allowed to have a 40 percent rise in pressure from rated flow to churn. This is almost never the case, but different pumps and speeds affect the churn pressure, so you should always look at a curve to determine the shutoff pressure. The reason for reviewing this is typically to understand what the maximum pressure (no-flow churn) will be in the system to determine whether high-pressure fittings are needed.

**Calculating pump gpm**

To calculate pump gpm, two sizing methods are available, the standpipe method and the sprinkler area calculation. In a fully sprinklered structure with standpipes, NFPA 14 (2010): Standard for the Installation of Standpipes and Hose Systems says that the first standpipe requires 500 gpm and each additional standpipe requires 250 gpm, up to a maximum of 1,000 gpm.

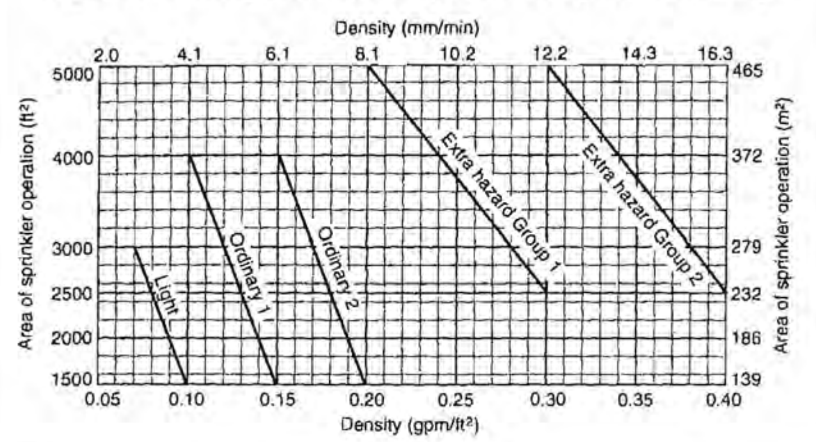
For example, a building with two standpipes would require a 750-gpm pump (500 gpm for the first standpipe and 250 for the second), and a building with five standpipes would require a 1,000-gpm pump because that is the maximum allowed by NFPA 14. (Note that the local code or the insurance carrier may require more than the maximum allowed by NFPA 14.)

Area calculations are more difficult. You need to know the sprinkler hazard classifications of the building and its contents to determine the design density, and the square footage (area of operation) of each hazard must be calculated. The five types of hazard classifications from NFPA 13 (2010): Standard for the Installation of Sprinkler Systems are:

- Light hazard: Low quantity of combustibles with low heat release (e.g., churches, hospitals, museums)
- Ordinary hazard 1: Moderate quantity of combustibles with moderate heat release and eight-foot stockpiles (e.g., mechanical rooms, restaurant kitchens, laundry facilities)
- Ordinary hazard 2: Moderate quantity of combustibles with moderate heat release and 12-foot stockpiles (e.g., stages, large library stack rooms, repair garages)
- Extra hazard 1: High quantity of combustibles with high heat release and no flammable or combustible liq-

*Continued on page 68*

**Figure 3: Density/area curves (NFPA 13 Figure 11.2.3.1.5)**



# Fire Pumps

*Continued from page 66*

uids (e.g., aircraft hangers, saw mills)

- Extra hazard 2: High quantity of combustibles with high heat release and flammable and combustible liquids (e.g., plastics processing, flammable liquids spraying)

Refer to NFPA 13 for a more thorough definition of the classifications.

Once the hazards have been determined, you next take the most remote 1,500-square-foot area of sprinkler operation and multiply it by the density found in NFPA 13 Figure 11.2.3.1.5 (see Figure 3). Then you must add the inside and outside hose stream demand to the area calculation. This information can be found in NFPA 13 Table 11.2.3.1.1 (see Table 1). Hose stream demand is the amount of water that must be added to the sprinkler system hydraulic calculation to fill the hoses as well as ensure enough supply to operate the sprinklers. Inside hoses are generally 1- to 1½-inch standpipe hoses that may be connected to the sprinkler system for initial fire attack.

For example, if you have a 40,000-square-foot building that is all ordinary group 1, the calculation would be 1,500 x 0.15 (density) = 225 + 250 (hose demand) = 475 gpm total for the fire pump.

If the structure has multiple hazards, the hazard with the highest gpm calculation dictates the pump size. Make sure you touch base with the insurance carrier for a particular project, as they may require higher square footage or density requirements, depending on the job.

**Table 1 Hose stream demand and water supply duration requirements for hydraulically calculated systems (NFPA 13 Table 11.2.3.1.1)**

| Occupancy | Inside hose, gpm | Total Combined Inside and Outside Hose, gpm | Duration, minutes |
|---|---|---|---|
| Light hazard | No hose: 0 | 100 | 30 |
| Ordinary hazard | One hose: 50 | 250 | 60–90 |
| Extra hazard | Two or more hoses: 100 | 500 | 90–120 |

For SI units, 1 gpm = 3.785 L/min.

### Selecting the pump

Once you have calculated the gpm and psi requirements for the pump, you need to determine the type of pump that works best for the job. The three most widely used pumps are horizontal split case, inline and vertical turbine.

Horizontal split case pumps are also called double-suction fire pumps, because the water pathways direct water to both sides of the impeller. They are the most common type of fire pump on the market, partly because of the ratings available in this style of pump, typically 250 through 5,000 gpm. This was the first type of pump used for fire protection systems.

Inline fire pumps offer several benefits:

- Their size and design offer space savings.
- They offer the ability to increase the ratings allowed by NFPA 20 from a maximum of 499 gpm, to 750 gpm, to today's unlimited rating. (The largest currently available is 1,500 gpm.)
- They offer a low cost of installation because they don't require a base plate that needs grouting.

Vertical turbine pumps are used in situations where the water supply is below the suction flange of the fire pump, because NFPA 20 requires a positive suction pressure to a fire pump.

The other item that needs to be determined is the type of drive: diesel or electric. Once that is determined, you can find the appropriate pump model and horsepower in a manufacturer's catalog. I don't recommend using pump curves to select fire pumps, as every selection must be UL approved, which might lead to picking the wrong horsepower for a particular selection.

One other note on fire pump selection is that selecting pumps that have a higher rpm is not necessarily a misstep, because fire pumps only run once a week for a limited amount of time, so the length of life will be about the same for a 1,750 rpm pump as for a 3,500 rpm pump.

### Power supply

If a generator is going to be used as

*Continued on page 70*

# Fire Pumps

*Continued from page 68*

a secondary power supply, the fire pump will require a transfer switch, which must be dedicated to the fire pump. A typical design would be to use a combination controller and transfer switch in a cabinet to avoid the need for additional requirements laid out in NFPA 20. A reduced-voltage start also should be considered when connecting to a generator to potentially reduce the size of the generator. This is true even for normal power considerations, as large-horsepower fire pumps with across-the-line starting put significant strain on power systems. The two most commonly used by designers are solid state soft start and wye-delta closed transition. These two have the best starting characteristics of the approved options on the market.

### Code issues

Following are some code requirements for fire pumps that you should factor into pump selection and system design.

- Horizontal elbows or tees upstream of a fire pump must be 10 pipe diameters from the suction flange on a split-case fire pump.
- Pumps must maintain a positive suction pressure at the suction flange.
- Electrical feeds to fire pump controllers must have a two-hour fire rating.
- Fire pumps can't be used as pressure-maintenance pumps.
- Variable-speed pumps are allowed by the code.
- Fire pumps need to be installed in a 2-hour rated room.

### Avoiding trouble

To avoid problems during the design and installation process, you should always do your homework and consult with the authority having jurisdiction and insurance representative before you begin.

Some jurisdictions have special requirements for fire pumps. For instance, New York City requires a manual round rotor fire pump with every automatic fire pump, and the Ohio EPA requires suction control valves on every fire pump to prevent going below 20 psi in the main. Insurance companies also may have unique requirements that go above and beyond the code. FM Global, for example, requires diesel fuel tanks to be double wall and have a spill basin, and every pump room must have a low pump room temperature alarm.

Knowing these location-specific and unique issues before starting your design will help the process go more smoothly and be more successful. ■

*__Greg Trombold__ has been involved with the plumbing and fire protection industry for more than 20 years, including working with engineers on sizing and selecting equipment, designing the pump and piping layouts for packaged systems, supplying new fire pumps to contractors, assisting contractors with installation of this equipment, starting up the equipment once it is installed, and repairing and servicing all types of pumps in the field. He graduated from Ohio State with a degree in business administration and started with the Trombold Equipment Co. in 1989. He is currently Vice President, Membership of ASPE's Cleveland Chapter.*