How Potable Water Rises to the Top of Skyscrapers

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(Information compiled by Gunnar Collins, IPP, FASSE, Collins Backflow Specialists, Inc.)

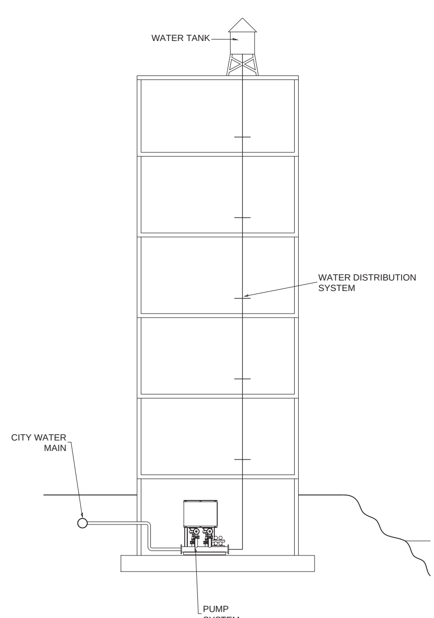
High-rise buildings decorate the landscape of our major cities across our great nation. Not only are they a challenge to build architecturally, but there are also many other challenging factors that go into each one's design, such as pumping water. Few people ever think about how the water gets to the top floors of these buildings for everyday living purposes such as drinking, bathing and mechanical uses such as cooling towers and supplying HVAC equipment. As you read, you will understand that each high-rise building's plumbing design is just as important as any other aspect of construction. No matter how big and beautiful the building, it is not habitable without water.

The Early Days

As far back as high-rise buildings existed, ways to deliver water to every floor was a necessity. The most common system used in the late 1800's and early 1900's consisted of a roof tank combined with constant speed pumps that operated by a level switch in the tank. When the level in the tank would approach a predetermined height, the pumps would either turn on to pump more water to the tank or turn off because the tank was full.

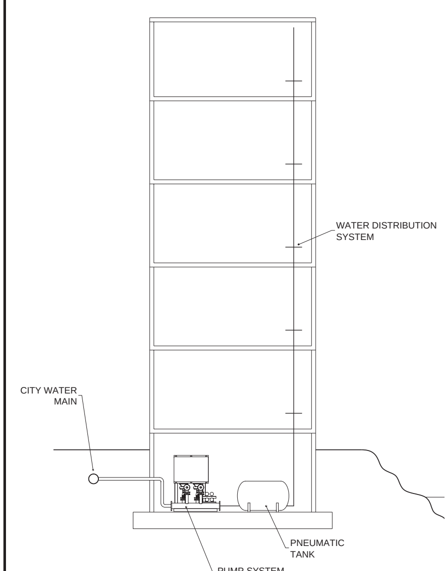
The roof tank system required heating the water during the winter to prevent freezing and during the summer months the water was hot. One inherent problem with the tank system was the vacation/resort-like atmosphere it offered pigeons, which lead to unsanitary conditions. On many of the older buildings in major cities, you can still see some of these tanks on the rooftops although they may not be in service.

Typical Commercial Building with Roof Top Tank



In the 1950's, pneumatic pressure tank systems replaced many roof tank systems. These systems put the pneumatic tank inside the building, eliminating the pigeon problem. The pumping equipment pumped water to the pneumatic tank pressurized by an air compressor that supplied water to the floors. The systems, for the most part, worked well if properly maintained, but required large areas for equipment installation and were expensive to install. In addition, these systems were big consumers of energy given they ran at a constant speed, despite low demand periods where water is hardly used.

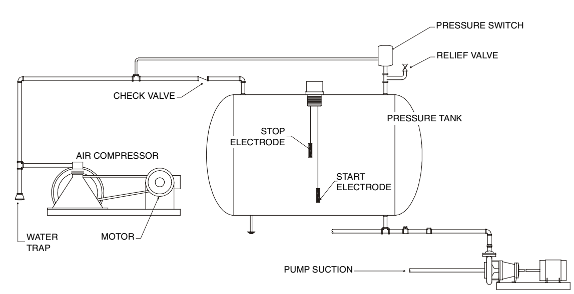
Typical Commercial Building with Pneumatic Tank System



The Present

Today, water pressure systems, or booster systems, have come a long way since the early

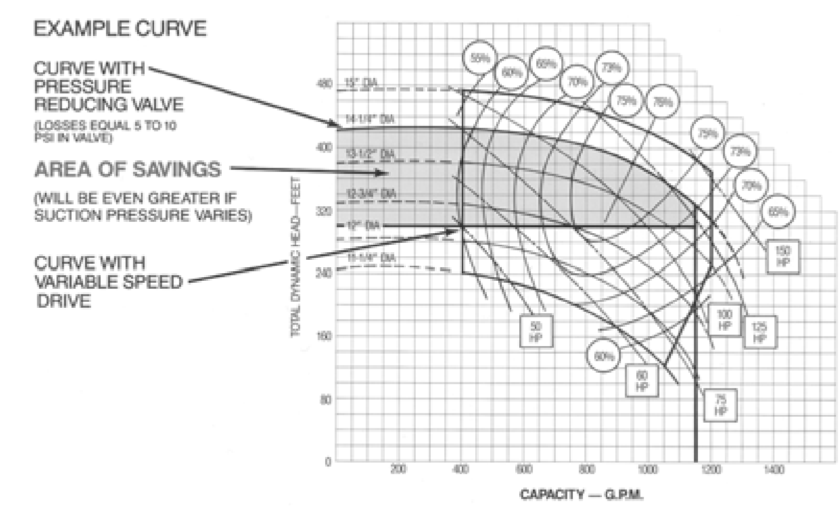
Typical Pneumatic Tank Pump System



days of pigeon-infested roof tanks. Now building owners have many control and pumping options that solve any pumping application while saving on energy costs and space.

Booster systems, such as the one marketed by Metropolitan Industries in Romeoville, now come prefabricated and skid-mounted, which allows for ease of installation and provides many design solutions to meet constrictive space requirements. Building owners can now choose from state-of-the-art variable speed control, which cuts energy bills in half over the life of the system while increasing system life by years. Other advances in technology include touch-screen panels allowing operators to make system adjustments with the touch of a finger, ability to interface into existing building automation systems and "smart pump technology" that allows booster systems to continually self-diagnose itself and alert the operator to any problems.

Constant Speed with PRV vs. Variable Speed

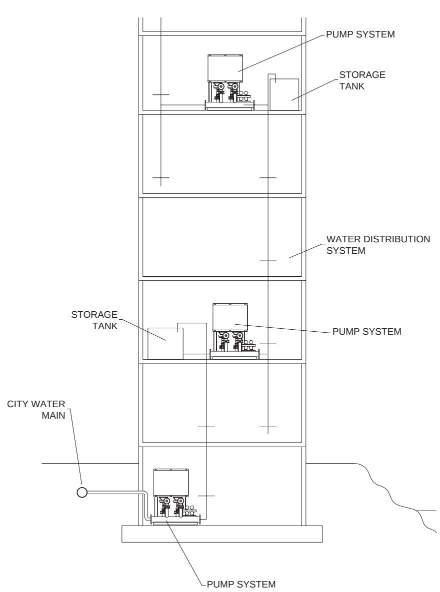


The Joy of Variable Speed Systems

Variable speed pressure systems are fast becoming the first choice for both operating and designing engineers due to the advantage of reduced equipment and energy costs, the elimination of water hammer/surges found with most constant speed systems and variable speed's ability to maintain accurate pressure settings.

Variable speed water pressure systems use a transducer to sense pressure and automatically adjust the speed of the pump in order to maintain a constant discharge pressure, regardless of demand or flow. The result is that the pump energy used is reduced as the flow demand decreases. On the other hand, constant speed systems maintain the same pump speed, regardless of flow, and depend on pressure reducing valves (PRV) to adjust building pressure. This is similar to pressing the gas pedal in your car to the floor and controlling the speed of your vehicle by depressing or pressing the brake pedal based on driving conditions.

Typical Commercial Building with Multiple Pump Systems

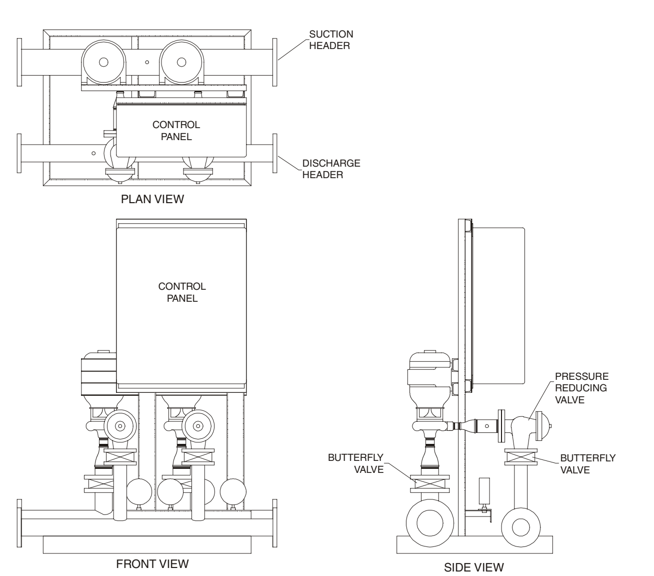


Sizing a Booster System

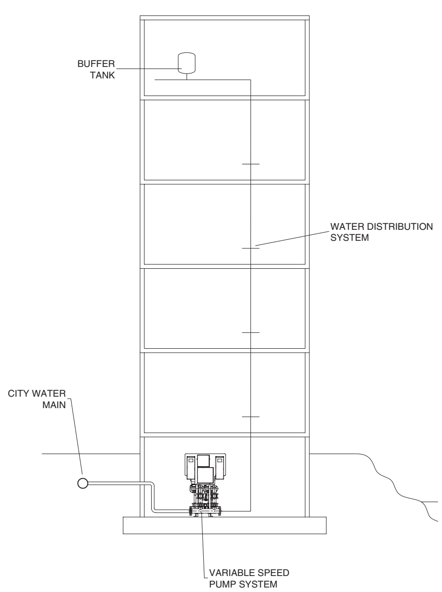
The first item to consider when sizing a booster system is to calculate the flow rate, or gallons per minute (GPM). The "Fixtures Unit" method created by the American Society of Plumbing Engineers determines this figure. This approach assigns a relative value to each fixture or group of fixtures normally encountered. A fixture is any item that uses water such as a sink, dishwasher, hose spigot, water fountain, etc. Once the number of fixtures is determined, the ASPE table assigns the necessary GPM based on the probability that multiple fixtures will be used at the same time.

The second item to consider is your Total Dynamic Head (TDH). Every floor in a high-rise building translates into pressure loss from the city water supply. Friction losses and vertical losses are considered here for water to reach higher floors. Every booster pump system is sized to

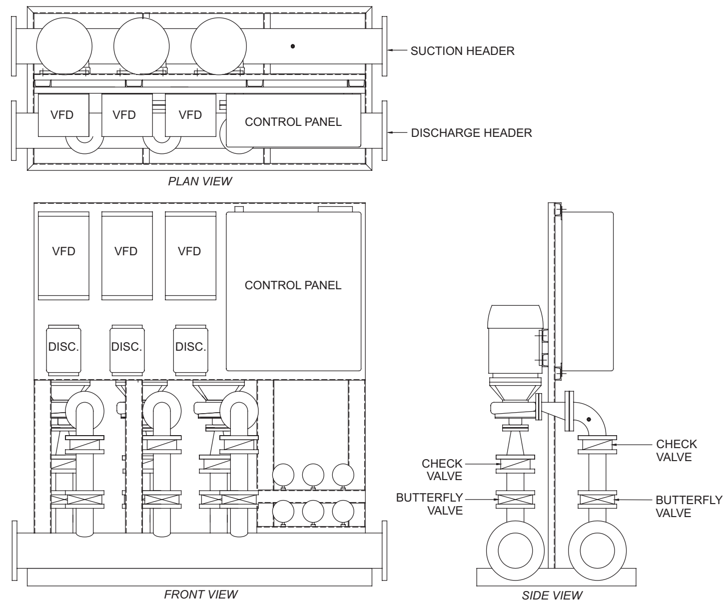
Typical Duplex Constant Speed Booster System



Typical Commercial Building Variable Speed System with Buffer Tank



Typical Duplex Variable Speed Booster System



overcome static head and friction losses at a given GPM or flow rate. By combining the static head (vertical distance or lift) and friction head (resistance to flow within various components such as pipes) your TDH is determined.

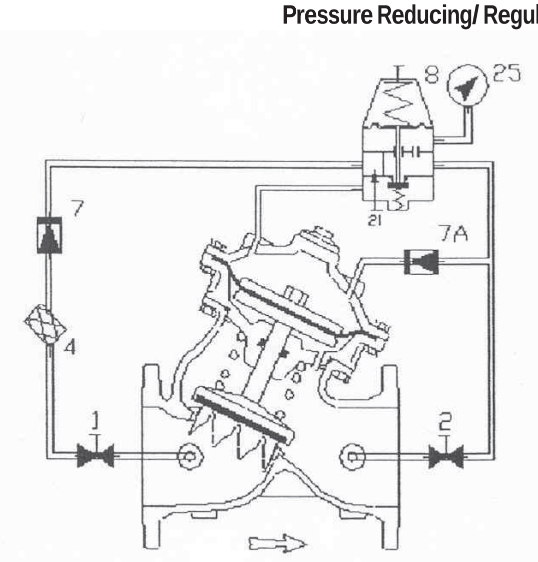
As large city water mains age, their ability to deliver water pressure to buildings reduces, which is why most multi-story buildings need a booster pump system to pressurize water on upper floors. In Chicago, much of the city has 20 psi in the street, ranking it among the lowest compared with other major cities. Typically, a pressure of 40 psi at the top of a building is ideal.

Once your GPM and TDH are determined, it is time to choose the number of pumps your systems will utilize. For a small system below approximately 150 GPM, two pumps will suffice. Typically, a system is designed with a minimum of two pumps. This allows for the pumps to alternate, which extends the life of both. Should one pump need service, the system can continue to supply water to the building without a total system shutdown.

Applications over 150 GPM should consider three pump installations for greater dependability. For systems with extremely variable demands, such as a stadium application, where the demand can range from the highest peak possible, such as during a halftime intermission when fans utilize the washrooms all at once, to the lowest flow in a short period, additional pumps should be considered.

For extremely tall buildings, such as the John Hancock Building in Chicago, water distribution is divided into pressure zones in order to meet high flow demands due to large heads. This allows for workable pressure throughout the entire building. If the system requires 250 psi to get water to the top of the building, this pressure cannot be transmitted to the fixtures on lower floors. Pressure zones are created by using pressure reducing valves or having dedicated pump systems for each zone. L

Pressure Reducing/ Regulating Valves



CONTROL LIST

1 Cock Valve
2 Cock Valve
7 Check Valve
7A Check Valve
25 Pressure Valve
4 Control Y-Filter
8 Press. Reducing Pilot Valve #2

These valves are used to control downstream pressure by utilizing an upstream pressure pilot line feeding a regulating valve. The regulating valve controls pressure supplied to the top of the main valve bonnet. By regulating the pressure on the valve bonnet, the downstream pressure can be regulated. Additional PRVs installed at high energy costs can be added for stability and reponse times.