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Studies on Residential Water Supply System through Efficient Plumbing Design

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Abstract

This study provides the information and resources necessary to for efficient plumbing design and technicalities involved in connecting residential water supply system. It includes comprehensive design concepts and guidelines to increase the acceptance and proper use of plumbing design. This study is targeted to meet the needs of home plumbers, plumbing designers, and plumbing contractors. Its purpose is to introduce potential users and to enable current users to optimize their plumbing and minimize system costs. In addition, it will allow plumbers and homeowners to become familiar with the applications, performance characteristics, and benefits of water supply systems through efficient plumbing. Cross-linking technology was first developed in Europe and has since come into use around the world for a variety of applications. The Design of plumbing with extensive testing for durability and material performance is targeted for the perpetual and hassle free residential water supply. It is feasible for potable hot and cold water supply systems as well as hydronic heating systems in all model plumbing and mechanical codes across the globe. The comparison of different piping appears to be a major obstacle to mainstream acceptance by some code officials, trade contractors, and homeowners. But not all plumbing mechanisms are the same, just as not all metals are the same. The study reveals that the polymer fittings for pipe are far more robust and reliable than those used for normal plumbing mechanism. A result of modern polymer technology, piping performs in ways that provide superior reliability, durability, and safety. Also, current testing requirements for are much more stringent than when PB piping was accepted and installed in housing.

Keywords: residential water supply, Plumbing design, hydronic, polymer,

1. Introduction

For plumbing purposes, the term “residential building” is applied to buildings that are too tall to be supplied throughout by the normal pressure in the public water mains. These buildings have particular needs in the design of their sanitary drainage and venting systems. Water main supply pressures of 8–12 metres (25– 40 feet) can supply a typical two-storey building, but higher buildings may need pressure booster systems [1]. In hilly areas, the drinking-water supply pressures will vary depending on the ground elevation. In these cases, the water authority may have to specify areas where particular supply pressures can be relied upon for the design and operation of buildings. Where a building of three or more storeys is proposed a certificate should be obtained from the drinking-water supply authority guaranteeing that the present and future public drinking-water supply pressure will be adequate to serve the building. If the public water pressure is inadequate, suitable means shall be provided within the building to boost the water pressure [2].

2. System for Boosting water Pressure

Pressure-boosting systems can be of several different types:

- pumping from a ground level or basement gravity tank to a gravity roof tank;
- pumping from a gravity storage tank or public water main into a hydro-pneumatic pressure tank that uses captive air pressure to provide adequate drinking-water supply pressure;
- installation of booster pump sets consisting of multiple staged pumps or variable speed pumps that draw water directly from a gravity storage tank or the public water main. Multistage booster pump sets typically include discharge pressure regulating valves to maintain a constant drinking-water supply pressure.

Written approval should be obtained from the appropriate authority before any pump or booster is connected to the supply. Where booster pump sets are permitted to draw directly from public water mains, the public drinking-water supply must be adequate to meet the peak demands of all buildings in the area. Otherwise, there is a high risk of backflow and subsequent contamination of the mains from buildings not equipped with a booster pump. Building booster pumps are not a solution to the problem of inadequate drinking-water supply. Where public drinking-water supply systems are overburdened and cannot pro-vide adequate pressure on a continuous basis, water must be stored on site during periods when adequate pressure is available to fill a gravity storage tank [3]. The size of the storage tank will vary according to the daily water demand of the building, and the availability of adequate pressure available in the public water mains. It should not be excessively oversized to avoid stagnation due to inadequate turnover.

Multi-storey buildings can usually be divided into zones of water pressure control. The lower two to three storeys can generally be supplied directly from the pressure in the public water main. Upper storeys, usually in groups of five to eight storeys, can be supplied from pressure-boosted main risers through a pressure reduction valve for each group. Systems can be up-fed or down-fed. Up-fed systems usually originate from a pressure booster pump set or hydro-pneumatic tank in the basement of the building. Down-fed systems usually originate from a rooftop gravity tank. Where a building is divided into water pressure zones, care must be taken not to cross-connect the piping between two or more zones. This is a particular problem when domestic hot water is recircu-lated from a central supply system.

Where hydropneumatic tanks are used for storage, the tank is filled to one third to a half full by a float level device that controls the drinking-water supply source (a well pump or pressure booster pump). The pressure is maintained at the desired operating level by an air compressor. As the building uses water from the tank, the water level and air pressure drop. When the water level drops to the “on” setting of the float level control, the well pump or booster pump starts and raises the water level in the tank to the “off” level. This restores the pressure in the tank. If some of the captive air above the water has been absorbed by the water, the air compressor starts and restores the air charge, raising the system pressure to the normal level.

Hydropneumatic tanks are typically made of steel or fibreglass and must be rated for the system operating pressure [4].

Smaller hydropneumatic tanks can also be used to help control pressure booster pumps, allowing them to be cycled on and off by a pressure switch. The captive air within the tank keeps the system pressurized while the pump is off. When the water pressure drops to the “on” pressure setting, the pump starts and raises the volume and pressure of the water in the tank. No air compressor is needed where tanks have a flexible diaphragm between the air and the water in the tank, charged with air at initial start-up. The size of pressure tanks for booster pumps must match the capacity of the pump and the peak system demand so that the pump “off” cycle is longer than the “on” cycle and the pump does not cycle too frequently[5].

3. Testing and Certification of Plumbing Pipes

Since piping is used to transport potable water, it must comply with federal regulations for public safety. Plumbing materials should be inert (not chemically reactive) and cannot contaminate the potable water passing through them. The fittings are mechanical and do not require the use of solvents or chemicals that might leach into the water when the system is first used.

Testing and certification must comply with NSF/ANSI Standard Drinking Water System Components - Health Effects, and Standard Plastic Pipe System Components and Related Materials. The primary focus of plumbing pipe Standard is to establish minimum health effect requirements for chemical contaminants and impurities that are indirectly imparted into drinking water from products, components, and materials used in potable water systems. PEX piping systems are tested at water pH levels from 5.0 to 10.0, both excessive acidity and alkalinity, beyond levels encountered in potable water systems. Plumbing pipe should not corrode, and it is resistant to mineral build-up. NSF/ANSI Standard that covers physical, performance, and health effect requirements for plastic piping system components used in potable hot- and cold-water distribution systems.

Nominal Diameter	OD inches[1]	Wall inches[2]	ID inches	Weight lb/ft
3/8”	0.500	0.075	0.350	0.05
1/2”	0.625	0.075	0.475	0.06
3/4”	0.875	0.102	0.671	0.10
1”	1.125	0.130	0.865	0.16
1 1/4”	1.375	0.160	1.055	0.25
1 1/2”	1.625	0.190	1.245	0.35
2”	2.125	0.248	1.629	0.60

Table 1: Piping Dimensions and Flow Characteristics

Flow Rate	ft/sec							
GPM	3/8”	1/2”	5/8”	3/4”	1”	1 1/4”	1 1/2”	2”
0.2	0.67	0.36	0.25	0.18	0.11	0.07	0.05	0.03
0.3	1.00	0.54	0.37	0.27	0.16	0.11	0.08	0.05
0.4	1.33	0.72	0.50	0.36	0.22	0.15	0.11	0.06
0.5	1.67	0.91	0.62	0.45	0.27	0.18	0.13	0.08
0.6	2.00	1.09	0.74	0.54	0.33	0.22	0.16	0.09
0.7	2.33	1.27	0.87	0.64	0.38	0.26	0.18	0.11
0.8	2.67	1.45	0.99	0.73	0.44	0.29	0.21	0.12
0.9	3.00	1.63	1.12	0.82	0.49	0.33	0.24	0.14
1.0	3.33	1.81	1.24	0.91	0.55	0.37	0.26	0.15
1.1	3.67	1.99	1.36	1.00	0.60	0.40	0.29	0.17
1.2	4.00	2.17	1.49	1.09	0.66	0.44	0.32	0.18
1.3	4.34	2.35	1.61	1.18	0.71	0.48	0.34	0.20
1.4	4.67	2.53	1.74	1.27	0.76	0.51	0.37	0.22
1.5	5.00	2.72	1.86	1.36	0.82	0.55	0.40	0.23

Table 2: Flow Velocity

4. Water storage vessels

Separate water storage vessels are an integral part of many dual supply systems. This section deals with requirements for the storage of water supplied from the water main or other drinking-water sources. In the design of these systems, it is important to ensure that the required air gap is established between the drinking-water supply inlet and the overflow spill level of the fixture. Water storage tanks are appropriate for use in the following circumstances:

- sanitary flushing
- supply of drinking-water
- firefighting
- air-conditioning
- refrigeration
- ablutions
- prevention of cross-connections
- make-up water
- contingency reserve.

Requirements relating to installation and protection of water storage tanks:

- Tanks must be installed on bases, platforms or supports designed to bear the weight of the tank when it is filled to maximum capacity, without undue distortion taking place.
- Metal tanks (and other tanks when similarly specified) should be installed with a membrane of non-corrosive insulating material between the support and the underside of the tank.
- Tanks must be supported in such a manner that no load is transmitted to any of the attached pipes.
- Tanks must be accessible for inspection, repairs, maintenance and replacement.
- Tanks must be provided with a cover, designed to prevent the entry of dust, roof water, surface water, groundwater, birds, animals or insects.
- Insulation from heat and cold should also be provided.
- Tanks storing potable water should not be located directly beneath any sanitary plumbing or any other pipes conveying non-potable water.

Requirements relating to access to water storage tanks:

- Adequate headroom and side access must be provided to enable inspection, cleaning and maintenance of the interior and exterior of the tank.
- Where the interior depth of any storage tank exceeds 2 metres, access ladders of standard design should be installed and entry safety codes complied with.

5. Plumbing Methodology

This type of fitting requires that the piping, with a reinforcing ring placed over the end of the pipe, is expanded before the fitting is inserted into the pipe end. The expanded pipe end is allowed to retract onto the fitting to form the seal—the "memory" of the pipe allows it to tighten over the fitting. An expander tool is required to expand the pipe and the ring together. ASTM F 1960 is applicable to fittings that use a reinforcing ring.

Figure 1 – Cold Expansion Polymer Fitting with Reinforced Ring

Figure 2 – Cold Expansion Metal Fitting with Reinforced Ring

This type of fitting requires that the piping with a reinforcing ring placed over the end of the pipe, is expanded before the fitting is inserted into the pipe end. The expanded pipe end is allowed to retract onto the fitting to form the seal—the "memory" of the pipe allows it to tighten over the fitting. An expander tool is required to expand the pipe and the ring together. ASTM F 1960 is applicable to fittings that use a reinforcing ring.

5.1 Cold Expansion Fittings with Metal Compression Sleeves

This type of fitting requires that the PEX piping is expanded before it is placed over the oversized fitting. The pipe shrinks down over the fitting insert, then a metal compression sleeve is pulled over the connection, compressing the pipe over the fitting. A tool is required to expand the pipe and to pull the sleeve over the pipe. ASTM F 2080 is applicable to cold expansion fittings that use a metal compression sleeve.

Figure 3 – Cold Expansion Fitting with Metal Compression Sleeve

5.2 Copper Crimp Ring

The copper ring is crimped equally around the fitting. The go-no-go gauge ensures a proper crimp. Some manufacturers use o-rings on their metal fittings to make the seal with the pipe. ASTM F 1807 is the applicable standard for metal insert fittings. ASTM F 2159 is the applicable standard for plastic fittings. ASTM 2434 is the applicable standard for metal insert fittings with o-rings.

Figure 4 – Metal Insert Fitting with Copper Crimp Ring

6.0 Performance and Conclusions

The system performance with simultaneous flows was very similar to the previous 100-foot test but with slightly lower pressure drops. A static pressure of 40 psi is considered to be a minimum supply pressure. A summary of the results for the simultaneous flow system performance at 60 and 80 psi source static pressure is shown in Appendix A.

Comparing the flow pressure and flow rate is a good way to determine the performance of a plumbing system. The limitation is that the pressure at the base of the riser is dependent on the size of the service line, meter, and water utility supply pressure. In order to describe and compare the performance of each type of system, the pressure drop from the base of the riser to the farthest outlet (including elevation losses) can be evaluated. Figures 5 show the comparison of pressure drop based on various outlets in the system flowing with the resultant pressure drop at the farthest fixture.

Both figures indicate that the home-run system, while having a higher pressure drop to the TF, has a more consistent pressure drop during simultaneous flow. The other systems, based on the trunk line feeding branch lines, continued to show increasing pressure drop as more fixtures were added to the system. In fact, when the full set of fixtures was operating simultaneously, the trunk and branch system pressure drop exceeded that of the home-run and the remote manifold configurations. (The remote manifold system is highly dependent on the system design, i.e., the location of the manifolds and the number of fixtures connected to the manifold).

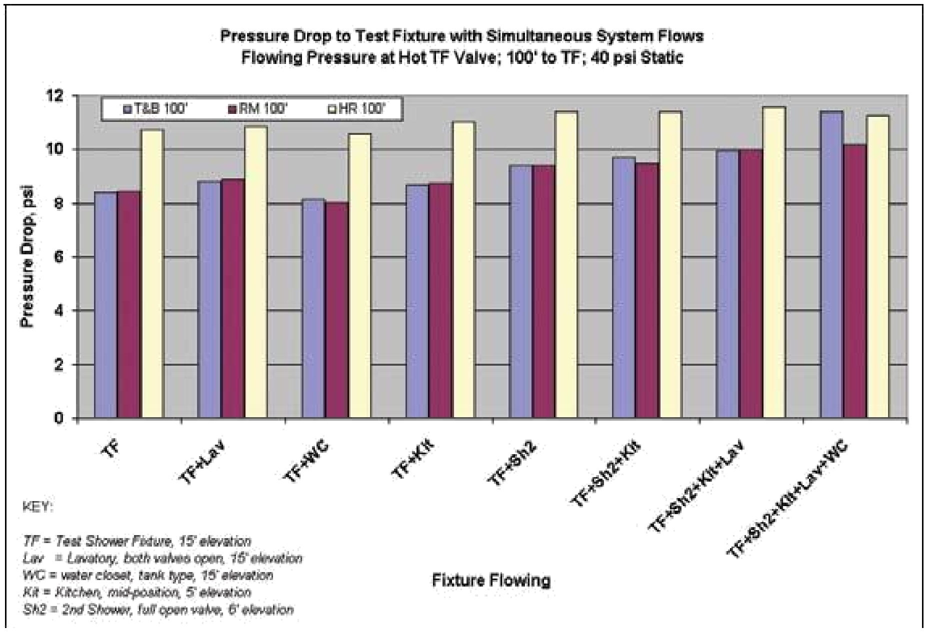

Figure 5 – Performance of Fixture flowing of water trough pipes

In conclusion, this review indicates the need for better use of existing knowledge as well as for some research and test development work particularly in the areas of plumbing, response to building water flow technologies and resistance to water hammer.

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