

# CAST IRON VS. PVC

## *How Much Would You Pay for Quieter Pipes?*

*by John Rattenbury, PE, CIPE*

**W**hat may be a cost-effective solution is not always what it seems. I was involved in the plumbing design for an eight-story residential assisted living facility in Cambridge, Mass., where the architect insisted on using Polyvinyl Chloride (PVC) piping throughout for the sanitary and storm systems. The architect had convinced himself that PVC piping, on a cost-per-linear foot basis, was so much cheaper than cast iron and copper that it was ludicrous to consider cast iron as a material of construction for his project. He was quite justified in his thinking given that lengths of PVC Schedule 40 piping are about one-fourth the cost of hubless cast iron.

My main concern at the time, however, was PVC's lack of sound attenuation. I finally succeeded in convincing the architect to accept cast-iron piping from the basement up to the second floor. Because the first floor contained all of the public areas and common living areas, the architect conceded that the flow noise of water cascading through the sanitary and storm piping would be unacceptable. In hindsight I've found that cast-iron piping probably could have been used for all of the vertical risers up to the eighth floor for nearly the same cost as PVC, with much quieter results. The following article is a qualitative and quantitative comparison between PVC and cast-iron installations.

### *What they want you to hear*

**P**olyvinyl Chloride is a common thermoplastic that has become the leading pipe material for both pressure and non-pressure applications. Resistant to electrolytic, chemical and biological attack, PVC piping holds a great advantage over metallic piping. The smooth inner surfaces help prevent fouling or clogging, which is very important in gravity drain applications.<sup>1</sup> Polyvinyl Chloride piping has become the predominant material of choice for plumbing in single-family

residential dwellings. It is so popular, in fact, that if you walk into many home improvement outlets, such as Home Depot, you can't even find cast iron or DWV copper next to the racks of PVC piping and boxes of PVC fittings.

The use of Polyvinyl Chloride pipe and fittings is often restricted by code. In Massachusetts, for example, the use of PVC pipe is restricted by the plumbing code (248 CMR) to residential dwellings, hotels, motels, inns, condominiums and similar buildings up to and including 10 stories in height.<sup>2</sup> Even then its application is restricted to drainage, waste and vent (DWV) piping and storm drainage. Because PVC is not fire retardant and can release noxious fumes when burned, it is not permitted for installation in return air ceiling plenums. Special conditions such as photo labs and soda fountains (carbonated water) permit the limited use of PVC.<sup>3</sup>

In all other applications, common non-plastic materials for DWV systems include service weight cast iron with poured lead or neoprene gasket joints, no-hub cast iron with stainless steel band clamps (commonly referred to as CISPI clamps), threaded galvanized steel and DWV copper with soldered joints. The most popular of these non-plastic systems appears to be no-hub cast iron and DWV copper, mostly because of the ease of installation.

Perhaps the two most attractive features of PVC, are low cost and ease of installation. A 10-foot length of 4-inch hubless cast-iron can be purchased for about \$58. A 10-foot length of 4-inch Schedule 40 PVC costs only about \$18. This amounts to a 70-percent savings. There is also a difference in fittings. A 4-inch sanitary tee, for example, costs about \$5.50 in PVC and \$11.50 in cast iron. The stainless steel band coupling required to join cast-iron fittings and pipe sections further add to the cost of cast iron. Such a coupling in 4-inch costs about \$5.10.<sup>5</sup> Because three such couplings are required to make the joints for a sanitary tee fitting, the overall cost for

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the 4-inch cast-iron sanitary tee increases to \$26.80. PVC is simply joined with socket joints and solvent cement, which at any home supply store costs about \$8 a quart.

### *The small print*

**A**t first glance, it would seem to make perfect sense to install PVC for a DWV system where the plumbing code allows. In the case of a single-family dwelling, PVC DWV is by far the least expensive plumbing package. However, there are four factors that must be considered before jumping into a complete PVC system for a large multistory residential project such as a condominium or hotel. These factors are (1) firestopping of plastic pipe penetrations through walls and floors, (2) thermal expansion relief, (3) hangers and supports, and (4) sound transmission.

First consider firestopping. The Massachusetts Building Code Chapters 6 and 7 define the requirements for firestopping and draftstopping for structures. In the case of the assisted-living facility in Cambridge previously mentioned, the plumbing risers were installed in concealed wet wall spaces between units. According to the architect, the code requires a minimum one-hour fire resistance rating between dwelling units and floors.<sup>6</sup> Cast-iron pipe is fire resistant and will not burn away or otherwise deform when exposed to fire.

To seal the penetration of a cast-iron pipe through a fire rated floor, all that is needed is some mineral wool batting and fire-resistant caulking or mortar. Firestopping assemblies from various manufacturers can be found in the Underwriters Laboratories standard UL 1479 (ASTM E814). All firestopping assemblies must be listed and approved by ASTM E814 (UL 1479) and E119 standards. The typical cost of firestopping materials for a 4-inch cast iron pipe is about \$18 and the time of installation averages about 32 units per day.

Because PVC piping is not fire resistant, it will quickly melt and burn away, leaving an opening that will permit the spread of smoke, heat and flame. To counter this, the firestopping materials for plastic piping must be intumescent.<sup>7</sup> When exposed to the heat of a fire, intumescent materials will expand more than 20 times their original volume to fill and seal the floor penetration. A test sample of a PVC pipe and firestop collar displayed by a firestopping vendor showed little evidence of the original PVC, but the intumescent material had completely sealed off the inside of the pipe penetration. A common firestopping assembly for plastic piping through concrete floors consists of a ring of intumescent material held in place around the pipe with a metal collar. This assembly is more labor intensive to install as it involves shooting in masonry anchors, clamping the collar in place and installing a smoke seal with a bead of the same type of fire-resistant

caulking or mortar used for cast-iron pipes.

Proper installation of this assembly can be further complicated due to the maximum annular space allowed between the pipe and the floor opening. In the case of a 4-inch PVC pipe, the maximum annular spacing is limited to a half-inch.<sup>8</sup> This means a 4-inch pipe penetration requires a maximum 5-inch core. This leaves little or no room for error when the contractor locates and drills floor openings through concrete slabs. This opens the door for costly errors for mis-drilled holes and misaligned piping passing through the slab. The cast-iron pipe assembly, on the other hand, is allowed to have an annulus ranging from point of contact to 2-inch maximum, allowing for some misalignment error. The cost of materials for the PVC firestopping assembly is about \$32, and the time of installation averages about 20 units per day, 12 units fewer than the cast-iron firestopping.<sup>9</sup>

The Massachusetts plumbing code requires that a Polyvinyl Chloride DWV system allow for a thermal expansion of a half-inch for every 10 feet.<sup>10</sup> Thermoplastic materials such as PVC have a rate of thermal expansion six to 10 times greater than that of metal pipe.<sup>11</sup> The stresses of expansion

are relieved in a PVC-DWV system with changes in direction or expansion fittings that are basically a pipe within a pipe that telescopes in and out as the piping expands and contracts. The joint is sealed with rubber O-rings lubricated with a water-resistant lubricant such as petroleum jelly. Expansion joints are required in vertical stacks at every other branch interval and on horizontal runs exceeding 20 feet.<sup>12</sup> According to a quote from Portland Pipe in Boston, a 4-inch expansion joint costs about \$72.60. This added expense drives up the cost of PVC piping, especially when running long waste and vent risers up a multistory building.

### *Pressure testing, hanger headaches*

**E**xpansion joints can create headaches during pressure testing. "When we tried to pressure-test the (DWV) piping, the expansion joints kept leaking," says Eric Aronson of the J.C. Higgins Corporation in reference to the Cambridge assisted-living facility. "I had guys running around trying to

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**Table A: Sch 40 PVC Stacks**

Item	Materials	Labor	Total
Pipe and Fittings	\$ 63	\$100	\$163
Expansion Joints <sup>15</sup>	\$ 52	\$ 20	\$ 72
Firestopping	\$ 56	\$ 42	\$ 98
Totals	\$171	\$162	\$333

fix leaks until the plumbing inspector finally signed off on the piping." In a system spanning eight stories with 12 vertical risers, the expansion joints caused costly man-hours to fine-tune."

Another factor that drives up the relative cost of PVC piping is hanger spacing. Horizontal runs of PVC piping are required by code to have supports every 4 feet on center.<sup>13</sup> Cast-iron piping, on the other hand, needs to be supported at every pipe length with an approved hanger no more than 18 inches from the joint or couplings between sections. If cast-iron piping is installed in 10-foot sections, hangers are needed every 10 feet on center. So the cost of hangers for PVC piping is about 2.5 times that of cast iron in horizontal installations. Remember the costs for 10-foot lengths of PVC and cast iron? PVC was about a third the cost of cast iron. However, for long horizontal runs (pitched according to code, of course), PVC drains can cost as much as, if not more than, cast-iron no-hub piping when expansion joints and hangers are taken into account. Even though the PVC is cheaper and lighter, it takes much longer to install and adjust the hangers and properly install the expansion joints every 20 feet. The playing field is evened out in vertical stacks, however, because both PVC and cast-iron piping need to be supported with a riser clamp at every floor.

Another negative factor associated with installing PVC piping is its unforgiving nature once a joint has been cemented. To make field alignments, cutting the piping to length and temporarily assembling the fittings dry works to a point. But have you ever pushed the end of a PVC pipe too far into the socket of a joint without cement and not been able to pull them apart? The tolerances between pipe and fitting are made to allow the solvent to act as a lubricant when setting the joint. Once the joint has set after a few seconds, there is no opportunity for adjustment. Hubless cast-iron joints are mechanical and can be assembled loose and then torqued down to specifications after critical alignments have been made. In other words, there is a higher potential for costly errors when installing PVC pipe if not done with a great deal of planning.

The last, and probably most meaningful factor to end users, is sound attenuation. Even though the light weight of PVC piping makes it easier to transport and install, it is the low density of PVC that makes it so poor at attenuating flow noise. Cast iron, on the other hand, is much quieter because

its mass absorbs far more sound energy. You can always tell who has PVC piping installed in their home when someone flushes the upstairs toilet and it sounds like a rain storm inside the living room or kitchen wall. This is probably the greatest negative against PVC piping. Some of the noises can be muffled with wrap fiberglass installation, but it doesn't compare to cast iron. The associated material and labor costs for insulating the piping only adds to the total cost of PVC.

The noise problems associated with PVC piping are well known in the plumbing trade and most plumbers insist on installing cast-iron no-hub piping in areas of a home where noise would be an issue, such as when passing through living spaces on its way down to the basement. In other areas with short runs of horizontal drains, such as the toilet discharge or shower drain, noise isn't as much as an issue, since it is localized and intermittent. But if the drain pipe is directly above the ceiling of a living room, bedroom or other living space, cast iron should be considered.

### Cost comparisons

So the question at this point is: when all factors have been taken into consideration, is it worth specifying PVC-DWV systems in multistory residential buildings in terms of cost and performance? To compare the total installed costs and PVC and cast iron, consider a single floor-to-floor section of a waste and vent riser system in a multistory building. Assume the floor-to-floor height is 12 feet, and the 4-inch waste stack receives a 4-inch horizontal waste branch through a 4-inch sanitary tee fitting and a 3-inch vent stack receives a 2-inch vent connection through a 3-inch by 2-inch sanitary tee fitting. Two separate scenarios can be compared — built completely of PVC pipe and fittings and built with PVC rough plumbing and vertical waste and vent stacks of no-hub cast iron. When comparing costs, the associated plumbing fixtures, hangers, coring and PVC branch piping are identical for both scenarios so they are not included in any cost estimating for comparison sake. Only the vertical stacks are considered. The estimated costs for both scenarios are summarized in **Tables A and B**.

According to the estimates, the lower cost of PVC pipe and fittings is offset by the higher cost for expansion joints and firestopping. The only uncertain variable in these estimates is the labor cost. Equal costs were assumed for installing a straight, 12-foot section of risers. But when working with rough plumbing in walls where there are many cuts, bends and fittings, the overall labor cost for installing PVC should be significantly lower because of the ease of installation. "When you just consider the vertical risers," Aronson says, "you're not looking at a big difference in labor costs for just the vertical piping."

Also, the time and expense for rigging bundles of piping up several stories has not been taken into account, but this has to be factored in for a specific project. These cost estimates, of course, do not address the sound attenuation issue. In a multistory apartment or condominium building, the

**Table B: Hubless Cast-Iron Stacks**

Item	Materials	Labor	Total
Pipe and Fittings	\$170	\$100	\$270
Firestopping	\$ 33	\$ 28	\$ 61
Totals	\$203	\$128	\$331

accumulated water flow can be significant on lower floors and make noise levels higher and nearly continuous. If fiberglass wrap insulation is considered to cut down the noise for the PVC stacks, the overall cost of installation is increased. Therefore, given the fact that the installed cost of uninsulated PVC and cast-iron riser sections is nearly equal, a DWV system consisting of PVC branch piping with cast-iron vertical risers and offsets would be the better choice. It offers both the labor and material savings that PVC provides and minimizes flow noise through the use of more massive cast iron while minimizing the cost of firestopping and thermal expansion fittings.

#### *The bottom line*

There are no exact costs for each material, and everyone's estimates will vary. But it seems clear that the 70-percent to 75-percent savings people see at first glance when buying PVC piping and fittings isn't always realized in the final installed cost. When installing vertical waste, vent and rainwater stacks down several stories or when there are long horizontal runs to be installed, the PVC/cast-iron combination described has the following advantages:

- 1** It offers material and labor savings for branch piping built with PVC in areas where firestopping, thermal expansion fittings and flow noise are not issues.
- 2** It minimizes flow noise as the main stacks pass through floors.
- 3** It minimizes thermal expansion in the straight vertical runs of waste and vent stacks.
- 4** It minimizes the cost of firestopping between floors without having to build fire rated shafts.

Of course, each individual situation must be assessed to find the factors that will be significant. Even if PVC comes out ahead on a particular project, how much is an owner willing to pay for quieter plumbing? Or are the savings worth sacrificing comfort levels? You will have to discuss with your clients. So when an architect on one of your projects insists on PVC piping to save money, you can discuss at least four important factors that make PVC waste and vent stacks less attractive.

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#### **ENDNOTES:**

1. Nayyar, Mohinder L., *Piping Handbook*, McGraw-Hill, 6th ed., 1992, pp. D.9-D.11
2. 248 CMR 2.06 (2) (n) (1).
3. *Ibid.*
4. *Means Plumbing Cost Data*, 1996.  
Costs exclude hangers and couplings.
5. *Ibid.*
6. 780 CMR, Table 602.
7. **in-tu-mesce** (in'ti-més, tyi-) *verb, intransitive* **In-tu-mesced, In-tu-mesc-ing, In-tu-mesc-es** a. To swell or expand; enlarge. b. To bubble up, especially from the effect of heating.
8. This would appear to be in conflict with 248 CMR 2.06 (2) (n) (1 1), which requires a 1-inch annular space between pipe and sleeve for PVC piping (although this section does not address fire rated penetrations of floors).
9. Cost estimates for firestopping of both PVC and cast-iron piping provided by J.C. Higgins Corporation of Randolph, Mass.
10. 248 CMR 2.06 (2) (n) (8).
11. Nayyar, Mohinder L., *Piping Handbook*, McGraw-Hill, 6th ed., 1992, p.D.9.
12. *Ibid.*
13. 248 CMR 2.06 (2) (n) (7).
14. *Cast Iron Soil Pipe & Fittings Handbook*, McGraw-Hill, Volume 1, 1992, Cast Iron Soil Pipe Institute (CISPI), Chapter IV, Section GI, p. 65.
15. When estimating costs for expansion joints, 50 percent of the labor and materials is carried to account for the fact that they are installed on every other floor in a multistory installation.

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