Characteristics of PVC pipe

PVC pipe is different from traditional piping materials. Understand the rating system, visco-elastic properties and potential problems of PVC before installation.

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For years there wasn't much choice in irrigation pipe material—steel was the standard of the industry. Now there's PVC pipe with its major advantages, such as installation ease, weight, chemical resistance and flow coefficient. However, steel scores higher in other properties. Neither material is better, but they are *different*. It's important for you to know these differences that require different handling in irrigation systems.

One of the most frequent causes of PVC system problems is failure to design the system to withstand the surges, shocks and other abnormalities that occur in all piping systems. The easy solution is to design the system so its normal operation pressure rating, including surges, is *two-thirds* the working pressure of the weakest component in the system. This will reduce the chance of failure due to shock.

Rating PVC pipe

If you understand the pressure ratings of PVC pipe, you're well on your way to understanding the reasoning behind certain designs.

There are two methods the industry uses to rate PVC pipe. One is the Standard Dimension Ratio (SDR) or Class

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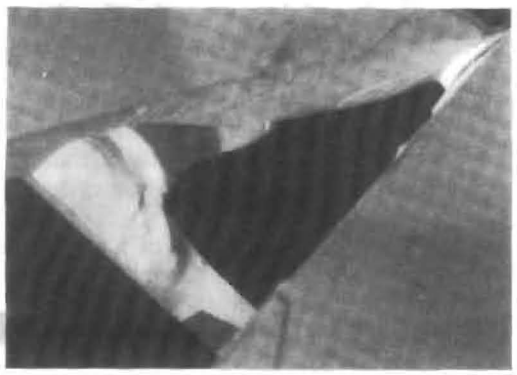
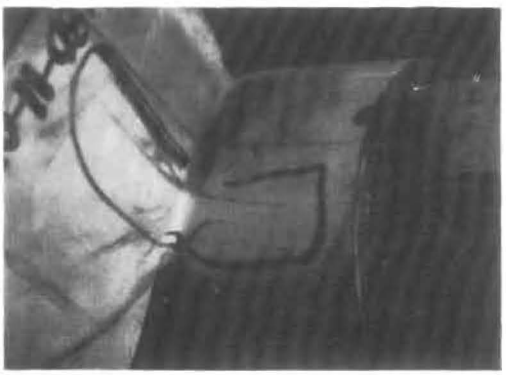
COMPARING PVC PIPE WITH STEEL

Characteristic	PVC	Steel
Solvent weldable	Yes	No
Weight (in pounds per ft.^{3})	81	455.5
Chemical resistance	Excellent	Poor
Flow coefficient	150	65 to 110
Modulus of elasticity	400,000 psi	29,000,000 psi
Maximum service temperature	140°F	1,000°F
Tensile strength	7,000 psi	60,000 psi
Maximum design stress	2,000 psi	20,000 psi
Relative impact resistance	1	6





Catastrophic burst (left) is one of the most common PVC system failures. Note the jagged edges where the fitting broke. Long term yield (right) is another common PVC system failure. The stretch marks that indicate this type of failure are commonly located in the crotch or inner corner of tees or elbows.

Cover photo: Courtesy of Weather-matic.

system. It is the ratio of the minimum wall thickness compared to the outside diameter of the pipe for an established stress or pressure level. For example, Class 200 pipe has a pressure rating of 200 psi.

The other method is the Schedule system. Schedule 40 and Schedule 80 *pipe* have specific pressure ratings for each pipe size. These ratings range from 850 psi for ½-in. Schedule 80 pipe down to 180 psi for 6-in. Schedule 40 pipe. However, the *fittings* for Schedule 40 and Schedule 80 *don't* have pressure ratings because their shapes and irregularities have made standard pressure ratings almost impossible to develop.

Years of field experience have lead to the concept that a fitting must have a wall thickness at least 25 percent heavier than its equivalent schedule and diameter pipe. This way the PVC fitting does not become the weak link in the piping system.

The PVC nipple is a unique component in the PVC piping system. Although nipples should be made only from Schedule 80 pipe stock or the equivalent, both nipples and Schedule 40 threaded fittings will have a wall thickness in the *threaded* portion that is equal to the *minimum* wall thickness of a Schedule 80 threaded *pipe*. The nipple's pressure rating is *half* that of the Schedule 80 pipe because of cuts in the wall thickness made by the threads.

Recent studies show that molded threads are substantially stronger than machined or cut threads because of the natural flow of molten material around the thread profile during the molding process. This is similar to metallic fasteners that are stronger if they have rolled threads rather than machined threads.

Visco-elasticity problems

All plastics and specifically PVC are visco-elastic materials. A children's plaything called Silly Putty is an example of a visco-elastic material. Visco-elasticity allows a material, like Silly Putty, to be stretched greatly if you pull it slowly. However, if you pull quickly, the material will break with a snap.

Visco-elasticity has both advantages and disadvantages in piping systems. The ability of PVC pipe to deform or "creep" is a major benefit when you install a sprinkler system along a curved sidewalk or when you need to compensate for changes in elevation or grades. Also, a visco-elastic material can more easily tolerate temperature-related expansion and contraction.

The two most common types of system failures related to visco-elasticity are *catastrophic burst* and *long-term yield* (stretch). You can identify burst failures by the sharp, jagged breaks that almost always leave the system in multiple pieces. Pressure surges, especially those caused by water hammer, produce burst failures. It is not uncommon for the failure to spread away from the origin and travel into adjacent components, such as pipe or fittings.

Long-term yield failure will remain localized and often result in areas of plastic erosion around the point of origin. You can see in a magnified examination of these areas that the pipe has "stretch marks" and a very glossy surface. These long-term failures usually will be located in the most highly stressed area of a fitting or component. In typical PVC tees and elbows, these areas can be the crotch or inner corner of the direction change.

Sometimes the failure of a female threaded socket seems to contradict this scenario. Here, the failure is almost always found to originate and follow the knitline, bondline or weldline. The

knitline can be the weakest link in the chain and, with the high wedging loads induced by tapered pipe threads, the wall may fail.

PVC pipe and water hammer

The elastic or non-rigid nature of PVC greatly reduces the pressure wave or surge pressure that travels through the piping system. This is partly because some of the energy is dissipated by causing the PVC pipe and fittings to swell or grow slightly while the pressure wave travels through the system.

The maximum surge pressure generated in a 2-in. Schedule 40 PVC system flowing at 5 feet per second is about a third as great as the surge pressure generated in a steel or copper system. However, the *wave velocity* is also very slow—about the same 3:1 ratio. This can produce water hammer in a system with quick-closing valves. Therefore, the valve closing times in a PVC system must be that much longer than the closing times in a metal system in order to help prevent water hammer.

An air slug is a common cause of water hammer that you often overlook. An air slug is nothing more than a bubble or air pocket within the system. When this bubble travels through the piping at the velocity of water, there is no real problem. But when the air slug gets to the sprinkler, the air escapes through a sprinkler nozzle approximately five times faster than water, so the upstream water velocity suddenly increases. When the air slug is gone, the system velocity suddenly drops to the original value.

For example, if the normal velocity is 3 feet per second, the system can increase to 15 feet per second during air escape, and it can be instantly reduced by 12 feet per second to the original speed. That 12-ft.-per-second change will create an additional pressure of more than 200 psi in that 2-in. system. This 200-psi surge, added to the working pressure of 100 psi, *exceeds* the 280 psi ratng of Schedule 40 pipe.

The 200-psi surge will only last about a third of a second, but remember, PVC pipe is visco-elastic and the pipe cannot tolerate sudden changes or forces. That size of surge, even for that brief time, may result in broken piping and components. □

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