

PVC FITTING FAILURES ON GOLF COURSE IRRIGATION SYSTEMS

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Automatic golf course irrigation systems possess unique operating characteristics that damage PVC pipe fittings that result in failures. Automatic irrigation systems incorporate many valves that open and close creating cyclic pressure surges. PVC fittings, because of their geometry and material characteristics, are uniquely unqualified to withstand the water hammer and cyclic pressure surges present in these systems.

PVC fittings used in automatic golf course irrigation systems were developed for and widely used in commercial irrigation, plumbing, waterworks, water well, and industrial markets. The quantity of PVC fittings used on golf courses represents a small percent of the total. These same fittings on golf courses account for the majority of reported failures of PVC fittings and are a significant maintenance problem for golf courses throughout the United States. The majority of these failures have been incorrectly judged to have been caused by faulty installation, defective manufacturing or incompetent design. PVC pipe used on golf course irrigation systems however, has experienced very few problems and has provided cost effective and reliable service for many years.

Automatic valve-in-head golf course irrigation systems are continuously pressurized and supply water to hundreds of valve-in-head sprinklers throughout a course. The opening and closing of these sprinklers create pressure surges that telegraph through the piping system in the vicinity of the sprinklers. A typical golf course system may experience from 40,000 to 100,000 cycles per year with magnitudes of 10 to 80 psi. (1). The attached graphs illustrate the frequency and magnitude of pressure surges on a golf course irrigation system.

Pipe fittings, defined as the intersection of two or more cylinders, are more complex geometrically than pipe. Hoop stresses of the intersecting cylinders combine at the points of intersection. The inside corner of the cylinder intersection is subjected to twice normal hoop stress. In tees, the stress at the corner is further increased because of the unsupported area defined by the overlap of the two cylinders when viewed in the horizontal plane. A cutaway of the fitting across this unsupported plane illustrates the oval shape geometry.

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Manufacturers have understood these additional stresses for years and have added material to the outside of the fittings to compensate for the additional stresses. While the additional material has increased quick burst strength, it has not increased the fitting ability to withstand pressure surges and cycles.

As PVC fittings are pressurized, the fitting deflects internally, attempting to "round up" the oval geometry of the unsupported intersection area. This creates a hinge at the internal intersection that bends in the vertical plane during every pressure surge. At this same point in the horizontal plane, additional bending is taking place created by the differential expansion of the intersection and the cylinder portions of the fittings near the bells. The extra stiffness of the intersection prevents the intersection area of the fitting from expanding to the same degree as the bell areas.

Every pressure surge "flexes" the intersection, similar to bending a hinge in two directions. The visco-elastic properties of PVC are unsuited to withstand repeated flexing and fittings fail at a number of cycles dramatically less than pipe which does not have any internal "hinges". The hinge on a plastic tackle box that fails after a short period of time is an example of a plastic "hinge failure".

The magnitude of this reduction of fatigue strength of fittings is illustrated in FATIGUE TESTING OF PVC PIPE FITTINGS. 6" schedule 40 PVC tees withstood less than 15,000 cycles of 100 psi every 2 seconds. This compares to 6" PVC pipe which withstands 1.5 million cycles of the same test parameters.

The effects of this "internal bending hinge" are greatest on full size opening tees, where the branch diameter is equal to the run diameter. 90 degree bends and first order reducing tees are the next most susceptible with 45 degree bends and service tees being susceptible to a lesser degree.

For golf course irrigation systems subjected to cyclical pressure surges, it is recommended that HARCO deep bell ductile iron fittings be used for all 4" and larger fittings and all 2", 2 ½, and 3" tees and 90 degree bends.

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1. R.D. Bliesner, "Designing, Operating and Maintaining Piping Systems Using PVC Fittings," Keller-Bliesner Engineering, Logan Utah, (1987).
2. D. B. Edwards, R. M. Cohen, B. Lehman, "Fatigue Testing of PVC Pipe Fittings," ANTEC (1992)