On the Waterfront

by Jim Reed

I want to thank all of you who have told me that you have enjoyed reading these articles on irrigation piping systems. Hopefully, those of you who have understood some of the concepts stressed by this article will realize the benefits when you operate your irrigation systems next year.

This month's article from the Keller-Bleisner Engineering study on "Designing, Operating, and Maintaining Piping Systems Using PVC Fittings" is on "The Dangers of Entrapped Air". Air entrapment in pressure pipelines is a much studied and discussed topic. Most designers are concerned about it, or should be, but many do not understand the full implications of the problem or the processes used to reduce the dangers associated with entrapped air. The problem of entrapped air is a complex issue. The behavior of air in a piping system is not easy to analyze, but the effects can be devastating.

There are many potential sources for air in pipelines and the sources are usually multiple in any given system. The most likely source is entrapment of air during filling, either initially or when refilled after drainage. In some systems, air re-enters each time the pumps are shut off as the pipelines drain through low lying sprinklers or open valves.

Air is often introduced at the point where water enters the system. This is an especially common problem with gravity fed pipelines, but may occur with pumped systems as well. Even water pumped from deep wells may be subject to air entrance from cascading water in the well.

A less obvious source of air comes from the release of dissolved air in the water, due to changes in temperature and/or pressure. The quantities may be small in this case, but accumulations over time can create problems.

It is also common for air to enter through air release valves or vacuum breakers when the pressure drops below atmospheric pressure. This can occur during pump shut-down or during negative surges.

Air in a piping system tends to accumulate at high points during low flow or static conditions. As the flowrate increases, the air can be forced along the pipeline by the moving water and may become lodged at the more extreme high points where it reduces the area available for flow. Thus, these pockets of air cause flow restrictions which reduce the efficiency and performance of the system.

As an air pocket grows, the velocity past that point increases until eventually the air is swept on toward an outlet. While line restrictions are problems, a more serious situation can occur when air is rapidly vented from the system under pressure. Water is about 5 times more dense than air at 100 psi, so when a pocket of compressed air reaches an outlet, such as a sprinkler head, it escapes very rapidly. As it escapes, water rushes in to replace the void. When water reaches the opening, the velocity suddenly decreases, since air escapes about 5 times faster than water at 100 psi. The result is similar to instantaneous valve closure, except that the velocity change can far exceed the normal flow velocity in the pipeline. During tests at Colorado State University, pressure surges up to 15 times the operating pressure have been recorded when entrapped air was rapidly vented under pressure. Such pressure surges can easily exceed the strength of the system components and even at lower magnitudes, repeated surges will weaken the system with time.