THE DANGERS OF TRAPPED 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 with 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.

SOURCES OF AIR IN PIPELINES

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 shutdown or during negative surges.

WHY IS ENTRAPPED AIR A PROBLEM?

Air in a piping system tends to accumulate at high points during low flow or static conditions. As the flowrate increase, 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 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 five 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 five 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.

DEALING WITH ENTRAPPED AIR

Obviously, the best way to reduce problems caused by entrapped air would be to prevent it from entering the system. Precautions should be taken to eliminate air entrance. When systems are filled, either initially or after draining for winterization or repair, they should be filled slowly, at a velocity of 1.0 fps or less, and the air should be vented from the high points before the system is pressurized. Even with these precautions, some air can remain in the system. To deal with this remaining air or newly admitted air, continuous acting air vents contain a float mechanism which allows the air to vent through a small orifice, even when the line is pressurized. The orifice diameter should be about 1 percent of the diameter of the pipe on which it is installed to allow the entrapped air to be slowly released.

Several combination air vent/vacuum relief vents are available for control of air in systems. Air and vacuum release vents are designed to exhaust large volumes of air from pipelines during the filling process and to close positively when water reaches them. These vents operate either by a buoyant float closing the vent as the water rises or by the impact of the water against a plate or other vent closure element. The vent remains closed until the pressure drops below atmospheric pressure, as would result from draining the line. These types of vents close rapidly and will cause a significant change in velocity at closure, thus care should be used in their sizing and placement. Combination vents are manufactured to perform the functions of both continuous acting and vent/vacuum air release vents. Upon filling, a large orifice is opened. Once water reaches the vent, the large orifice closes and allows air to escape only through the smaller orifice that is actuated by a float mechanism.