Corrosion of Aluminum Pipe

corrosion of unprotected aluminum irrigation pipe can lead to serious problem under one or more of several conditions

Martin R. Huberty

Corrosion—especially of the pitting type—of aluminum irrigation pipe has been especially severe in some areas of California.

The pitting type of corrosion is associated mainly with the establishment—through differences in composition of the metal, through stress, or other factors—of a miniature galvanic cell within the pipe-water system.

Portable aluminum irrigation pipe actually is manufactured of an alloy—aluminum plus a small amount of some alloying element such as copper, zinc, magnesium, manganese, silicon—to produce pipe with a higher tensile strength and greater rigidity than pipe made of pure aluminum.

As different alloying processes and manner of fabrication impart different physical properties to the product, much of the aluminum pipe made immediately following World War II—fabricated from scrap metal—lacked uniformity of composition. However, because many aluminum products are now manufactured with a specific purpose in mind, it is fair to assume that irrigation pipe made in recent years is—in the main—better suited to the needs than were some of the earlier lots.

Some aluminum pipe used in one area has showed no marked deterioration, but when the same pipe was used in another district corrosion was excessive.

Injury to Pipe

Observations made by various people indicated that corrosion was normally of the pitting type, often affecting only a small percentage of the total metal.

Injury was most common along straight lines indicating a possible lack of uniformity in the extruded alloy, or from scratches made by a rough edged mandrel or from other causes. Also, damage was greater usually in the main line than in the secondary lines. Couplings were found to be most heavily corroded just inward from the gasket. Pitting of the pipe was initiated on the inside surface and progressed outward.

Pipe corrosion was noticeably greater with some irrigation waters than with others and distribution of fertilizers through the pipe lines often tended to accentuate the problem.

Factors in Corrosion

When aluminum is exposed to the air an oxide coating is formed which is a deterrent against further corrosion. This dull finish can be observed on the outside of aluminum pipe that has been exposed to the weather for a considerable period of time. However, several conditions may contribute to corrosion. The higher the oxygen content of the system, the higher the corrosion potential becomes. When admixtures of metals are in contact with each other and with water containing dissolved salts, an electrical current is produced. The metal which is least noble—relatively stable—will go into solution.

Irrigation streams of high velocities tend to prevent the development of a protective oxide coating. When the oxide coating is not continuous the metal atoms in the unprotected areas of the pipe surfaces become ions and the metal will be dissolved.

Stress is also a factor in corrosion. High pumping heads can cause differences in electrical potentials between different parts of the metal, causing the equivalent of a miniature galvanic cell to be produced and anodic action results.

Temperature might be a secondary factor as chemical action would be more rapid under warm water conditions than with cold water.

Deposits Analyzed

A number of affected aluminum pipe systems were studied and chemical analyses made of the deposits found in the corrosion cavities. The deposits proved to be aluminum compounds formed in the breakdown of the pipe.

Spectographic analyses of pipe samples showed the presence of alloying metals. Microscopic examinations were made of the corroded metal and of the salt present in the cavities.

In addition, test samples were placed in solutions of different composition and concentration. Highly basic solutions caused the decomposition of the metal at a rapid rate, and strongly acid solutions were corrosive. Agitation with air increased the rate of corrosion. Solutions in which chloride was the dominant anion—negative ion—were especially effective in preventing the formation of a protective film.

To test the relative effect of the vari-

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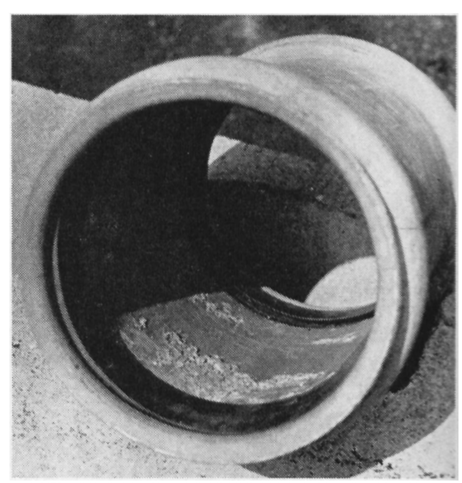
Corrosion often occurs in straight lines parallel to the axis of the pipe.

***Right*—Characteristic corrosion pattern in the pipe couplings.**



DESERTS

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field crops requiring less frequent irrigation on the fine textured soils. As a result of these conflicting requirements, and because of variations in the relationship between leaching during irrigation and the upward capillary movement of moisture between irrigations—with evaporation and salt accumulation—there is no direct relationship between tile spacing and soil texture. Frequently, more tile is required in light soils than in heavy soils.

Still another problem in tile design is the determination of what maximum flows might be expected. This information is needed so that large enough tile will be used, yet just large enough. Otherwise cost would be higher without better performance. Considerable information has been obtained on this subject in Coachella Valley, and arrangements are being made to obtain similar data elsewhere.

Along with drainage need there is the accompanying problem of removing excessive accumulations of salt. It has been found that there is no good alternative to the construction of essentially level basins with large borders on all sides, and to holding water to a depth of 6″ or so on the surface for considerable periods of time. This leaches the salt downward, and to such depth that it will not later return to the surface.

Other plot work is under way to evaluate effects of deep plowing of a stratified soil on leachability, and when soil amendments are required to correct a sodic soil.

Also, work is under way which will provide better information on the mechanical characteristics of various types of tile, and how those characteristics affect drainage performance. In some instances the effectiveness of tile appears to be decreasing, and studies are in progress to determine why this is so, and how effectiveness can be restored. Fortunately, the problem does not appear to be important at this time.

So far as is known, almost every problem concerned with the drainage of irrigated desert lands of California is under study, has been studied, or will be studied soon.

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Agencies cooperating in the drainage research in one or more of the areas include the Coachella Valley County Water District, the Imperial Valley Irrigation District, the United States Salinity Laboratory, the United States Bureau of Reclamation, the Soil Conservation Service, the United States Department of Agriculture Southwest Irrigation Field Station, the Agricultural Extension Service, the Eastern Municipal Water District, and the Palo Verde Irrigation District.

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ous fertilizers that farmers would likely distribute through their irrigation system, sections of pipe were placed in aerated solutions containing the following nitrogen bearing fertilizers: Calcium nitrate, potassium nitrate, ammonium sulphate, sodium nitrate, ammonium hydroxide and urea. Two levels of nitrogen, roughly 100 and 200 pounds per acre foot, were used. The calcium and sodium solutions remained clear, while the ammonium compounds tended to become murky.

Protective Coatings

Although a protective film of aluminum oxide can form—under favorable conditions—on the pipe surface, aluminum irrigation pipe manufacturers have taken steps to make a more corrosion resistant product. In addition—at times —a protective inner coating of pure aluminum is added. Protective coatings —usually containing zinc or chromate or both—have often been applied to pipe that has already shown a considerable amount of corrosion. When the coatings are applied to old pipe great care must be used to properly clean the pipe prior to the application of the protective material. Any cracks in the coating, or failure to completely cover the entire inner surface of the pipe are potential areas of excessive corrosion.

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RIVER SEEPAGE

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eight days during March 1956. A maximum discharge of 590 gallons per minute was obtained for limited periods of time until the pumping water level reached the bottom of the suction pipe, 62′ below the ground surface.

Artesian Pressure Reduced

Operation of the well was quite effective in reducing the pressure in the artesian aquifer as shown in the graph on page 34. There was an immediate response in water pressure both at the start and stopping of pumping. While it is encouraging to get a pressure relief in the artesian aquifer, of primary importance is what happens in the surface soils where the crops are to be grown. Records obtained from a continuous water level recorder on shallow observation well No. 3—located in the region of the poorest drainage conditions — show that the water table dropped 1.5′ during the pumping period. This is almost directly proportional to the pressure relief recorded in the piezometers about the same distance from the pumped well. The downward trend of the water table of the shallow well was reversed soon after the pumped well stopped. In the next four days the water table rose approximately 0.5′ above the lowest level obtained during the pumping test. There seems no doubt that if the pumping test had been continued for a longer period of time the water level in the surface would have continued to decline. Responses to the pumping in other areas in the field as observed in surface observation wells were not as immediate nor as pronounced as in observation well No. 3. For example, very little change in the surface water levels was recorded in some areas. This is explained by the fact that less permeable layers lie between the surface soil and the artesian aquifer so the relief in artesian pressure was not felt immediately at the surface of the soil because it takes quite a while for the water to drain down out of the surface layers.

The 8″ well was successful in draining an area to a distance of approximately 200′ from the well, and a larger well probably would have done a better job of drainage. However, in this particular case, it is not economical to operate a pumped well for drainage because the water must be pumped again—out of the drainage ditches into the river.

Because the test drainage well was feasible but not economical, a subsurface drainage system was designed and installed. To develop the subsurface drainage system, soil permeability tests were made by sinking a shallow auger hole beneath the soil surface to at least 1′ below the water table. After some initial flushing of the hole it was pumped and the rate of rise of water in the hole was measured.

The rate of water rise is proportional to the soil permeability and a suitable chart can be used to calculate the soil permeability from this rate of rise. The soil permeability can be used to determine the depth and spacing of drains required to drain an area.

Several auger hole tests were made on the test farm and calculations indicated that a spacing of 100′ and an average depth of 5′ for drainage tile would be adequate.

Although the subsurface drainage system was installed on the farm it has not been in operation during periods of high water in the river so it has not been possible to judge the effectiveness of the system.

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