ally the commonly used ferrous materials have proved to be the most economical. Copper and many of its various alloys are also used advantageously, but their use is more restricted to selected localities. It has been found that soils with high content of organic matter or alkaline soils in which the ratio of chlorides and carbonates to sulphates is high, may be corrosive to copper.[7] Copper or the commonly used ferrous metals should not be embedded directly in cinders or in tidal marshes, as they may be unduly attacked by sulphur compounds. It is also wise to avoid the embedding of any pipe materials in soils where unusually high salt contents are known to exist.

Galvanized wrought-iron pipe and steel will resist underground corrosion quite satisfactorily, particularly if the galvanized coating is 3 oz per sq ft or more. The National Bureau of Standards reports that where an underground piping material contains 3 oz of galvanizing per square foot, or more, the life of the pipe materially increased. The zinc used for galvanized coating is on the electrochemical protective side of the iron; and the zinc as it corrodes is changed to zinc compounds before the underlying base metal is attacked. This fact and the mechanical protection provided by the zinc coating account for the protection afforded by the galvanized coating. Once the galvanized coating has been destroyed, the base metal must then retard the corrosive attack, so the rate of attack depends upon the composition of such base metals. Lead-coated pipe[8] has had a limited application for underground service. It has been found that it corrodes chiefly in soils deficient in oxygen or containing cinders.

### Protective Coating

Protective coatings for buried pipe lines are in a class by themselves because of the unusual service conditions, and because it is not possible to maintain them by recoating when necessary. Buried steel pipe lines have been protected against corrosion with considerable success by the use of very thick bituminous coatings applied in molten condition. The best results are obtained by applying the bituminous coatings over a standard priming coat such as red lead or a bituminous paint, and for long service it has been found that after the bituminous coatings are applied, a wrapping of asbestos fabric saturated with bitumens will prevent movement and displacement of the bituminous coatings, and add greatly to the length of time satisfactory protection will be maintained.

### Cathodic Protection

Protection is obtained by rendering the structure cathodic to the surrounding water or soil by means of a controlled difference of potential. This method, which has proved satisfactory and economical on a number of gas and oil pipe lines underground, has also been applied with some success to the protection of the inside of water-storage tanks and other structures that are in contact continuously with water. Protective coatings that insulate a large portion of the metal surface will reduce very materially the total amount of protective current that must be impressed on bare anodic areas to arrest corrosion.

Because of differences in environmental conditions, it is necessary to determine or estimate the minimum current density required for each structure, and design the anode or anodes so that the necessary protection can be obtained most economically. In water having relatively high electrical conductivity such as in sea water, this is comparatively easy compared with fresh water. In the latter, the composition of the water is a major factor. It is therefore desirable to obtain an accurate estimate of the minimum current density required. The current is then controlled by the potential between the anode and the structure to be protected.

Rectifiers have generally proved to be the most practical means for supplying the necessary current for protection of surfaces in contact with neutral waters.[9]

## HANDLING WATER TREATING CHEMICALS

Virtually all the chemicals used in water conditioning are injurious if taken internally in large doses. Many also cause severe skin irritation. Thus, they should be handled with caution.

Caustic soda, lime, and concentrated sulfuric acid will burn the flesh. In addition, if mixed with small amounts of water, sufficient heat may be generated so that spattering occurs or the container becomes too hot to handle.

The chlorophenol compounds, even in the low concentrations used in water conditioning, have been reported[10] to produce dermatitis. Chrom-itch is not uncommon among workers handling chromates. The amines are said to be absorbed through the skin.[11] Morpholine is said to cause kidney and lung trouble when so absorbed.

Chlorine gas irritates the skin, eyes, and mucous membranes. Concentrations as low as 0.004 percent by volume in air cause dangerous illness in one-half to one hour.

When relatively large amounts of the non-gaseous chemicals are to be handled, protective clothing, including goggles, should always be provided, and a shower head or its equivalent provided at or very near the point where the chemicals are mixed. *Chemicals should always be washed from the skin with large volumes of water.*

For the handling of chlorine and chlorinators, the U. S. Public Health Service[12] stipulates the following safety requirements:

1. Suitable gas masks and a small bottle of ammonia for testing for leaks should be kept at convenient points immediately outside the room or enclosure in which chlorine is being stored or is in use. Gas masks should be inspected at regular intervals and kept in serviceable condition. Note:—All-purpose masks offer adequate protection only when the concentration of acid gases does not exceed two percent—see *Safe Practices Pamphlet* #64 National Safety Council.
2. Chlorinating equipment and cylinders of chlorine should be housed preferably in separate buildings above the ground level.
3. The room or building housing chlorinators in service should be maintained at a temperature above 60 F, but never in excess of the normal summer temperature. The cylinders of chlorine should be shielded, where necessary, from excessive heat or cold. Direct heat should not be applied to cylinders of chlorine, nor should hot water be poured over them or come in contact with the cylinder valve.
4. Adequate ventilation should be provided for all enclosures in which chlorine is being fed or stored.
5. All joints of tubing connecting chlorine cylinder and chlorinators should be kept absolutely tight and inspected frequently to insure tightness. Tubing should slope upward from the cylinder.

## LEGAL REGULATIONS

In a number of states, the water used for humidification, even in industrial plants, is required to meet drinking water standards insofar as bacteriological quality is concerned. A ruling of the U. S. Department of Agriculture, Meat Inspection Division, *prohibits* the use of chromate in water used for air washing when the air later contacts foodstuffs.[13]

There is an ever growing consciousness on the part of public health officials, of the necessity for regulations to *protect* potable water supplies. Attesting this is an ordinance[14] now in effect in Detroit, Michigan, which stipulates in part:

"No physical connection shall be maintained between lines carrying city water and pipes, pumps, or tanks supplied from any other source. Where dual supplies are necessary or desired, lines carrying city water must be protected against back flow of polluted water by an *atmospheric gap*. Secondary supplies and emergency sources shall include: surface waters from rivers, lakes, ponds, lagoons, and reservoirs; well waters both deep and shallow; any supply of water which has been stored, held, or reserved after being used for industrial purposes; cooling water, or water which has in any way been treated, processed, or has been subjected or exposed to any contamination of a bacteriological or chemical nature; and water from any other source than the city supply."

The U. S. Public Health Service stipulates:

"Salts of barium, hexavalent chromium, heavy-metal glucosides, or other substances with deleterious physiological effects, shall not be allowed in the water supply system."

Table 7 . . . . Recommended Maximum Allowable Content in Water Supply[a]

| Substance | Max. Concentration, ppm |
|---|---|
| Copper | 3.0 |
| Iron & Manganese (Total) | 0.3 |
| Magnesium | 125.0 |
| Zinc | 15.0 |
| Lead | 0.1 |
| Fluorine | 1.0 |
| Arsenic | 0.05 |
| Selenium | 0.05 |
| Phenols (Total) | 0.001 |
| Polyphosphate of Sodium | 10.0 |
| *pH* Value @ 25C | 10.6 |

[a] U. S. Public Health Service.

The same agency recommends that the concentration of the substances listed be held below the values cited in Table 7. The Board of Directors of the American Water Works Association has accepted these values as standard for *all* public water supplies in the United States.[15] While their action is not binding, prudence dictates that no form of treatment should be used that will result in raising the concentration of the substances listed above the value cited.

Since virtually all of the permissible chemicals used for scale, slime, and corrosion control have deleterious physiological effects if taken internally in *relatively large doses*, they should always be carefully *proportioned*. To insure this, the Detroit ordinance stipulates that the chemical feeding device must have the following major characteristics:

"1. There shall be a visible means of checking the quantity of material being applied by the feeding device.
2. A water metering device, sealed to prevent tampering, shall be installed to measure the flow of water being treated.
3. The device shall be constructed so that in the event of back-flow or vacuums, the maximum amount of material that may be possibly back-siphoned from the device or any of its attachments or parts shall not exceed one fluid ounce.
4. Should there be a failure of the water metering device or the water supply, the feeding device shall automatically cease operating."



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