Introduction to Water Treatment

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Corrosion Control and Regulations

Defintions

- Anion- A negatively charged ion in an electrolyte solution, attracted to the anode under the influence of a difference in electrical potential.
- Anode- The positive pole or electrode of an electrolytic system, such as a battery. The anode attracts negatively charged particles or ions (anions).
- Base Metal- A metal such as iron which reacts with dilute hydrochloric acid to form hydrogen.
- C Factor- A factor or value used to indicate the smoothness of the interior of a pipe. The higher the C Factor, the smoother the pipe, the greater the carrying capacity, and the smaller the friction or energy losses from water flowing in the pipe.
- Calcium Carbonate- An expression of the concentration of specified constituents in water in terms of their equivalent value to calcium carbonate. For example, the hardness in water which is caused by calcium, magnesium, and other ions is usually described as calcium carbonate equivalent.
- Catalysts- A substance that changes the speed or yield of a chemical reaction without being consumed or chemically changed by the chemical reaction.

Definitions

- Cathode- The negative pole or electrode of an electrolytic cell or system. The cathode attracts positively charged particles or ions (cations).
- Cathodic- An electrical system for prevention of rust, corrosion, and pitting of metal surfaces which are in contact with water or soil. A low voltage current is made to flow through a liquid (water) or a soil in contact with the metal in such a manner that the external electromotive force renders the metal structure cathodic. This concentrates corrosion on auxiliary anodic parts which are deliberately allowed to corrode instead of letting the structure corrode.
- Cation- A positively charged ion in an electrolyte solution, attracted to the cathode under the influence of a difference in electrical potential.
- Corrosion- The gradual decomposition or destruction of a material by chemical action, often due to an electrochemical reaction. Corrosion may be cause by stray current electrolysis, galvanic corrosion caused by dissimilar metals, or differential concentration cells. Corrosion starts at the surface of a material and moves inward.
- Tubercle- A protective crust of corrosion products (rust) which builds up over a pit caused by the loss of metal due to corrosion.
- Tuberculation-The development or formation of small mounds of corrosion products (rust) on the inside of iron pipe. These mounds increase the roughness of the inside of the pipe thus increasing resistance to water flow (decreases the C factor).

Flint Michigan

- What happened?
  - Switching water sources without adequate corrosion control method
  - Switch was financial based
  - No study was conducted
  - The impact is yet to be seen

Regulatory

- Lead action level: more than 10 percent of samples are above 0.015 mg/L
- Copper action level: more than 10 percent of samples are above 1.3 mg/L

Adverse effects of corrosion

- Corrosive water can cause very serious problems in both water supply facilities and water treatment plants
- Water main replacement is often required when Tuberculation reduces the carrying capacity of a main.
- Corrosive water causes materials to deteriorate and go into solution.

What causes corrosion

- Corrosion is a very complex problem
- Corrosion can occur both on the interior and exterior of metal piping and equipment.
- Corrosion is the gradual decomposition or destruction of a material as it reacts with water.

Electrochemical Corrosion: The Galvanic Cell

- Metallic corrosion in potable water is always the result of an electrochemical reaction.
- A reaction where the flow of electric current itself is an essential part of the reaction.

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- Anode-Point from which metal is lost and electric current begins
- Cathode-Point where electric current leaves the metal and flows to the anode through the electrolyte

Without getting too complicated

- Metals react to air and water
- This process is called corrosion

Factors influencing corrosion

- Physical Factors
  - Material, system pressure, soil moisture, temperature and flow
- System Construction
  - Types of coatings on the material
- System Pressure
  - High pressure systems corrode more greatly, it increases the max concentration of corrosive gases like carbon dioxide and oxygen
- Soil Moisture
  - Moisture functions as the electrolte, the same as water inside the pipe does in the case of internal corrosion
- Stray Electric Current
  - Grounding wires
- Temperature
  - Increased temperature usually increases the rate of the reaction
  - However with calcium carbonate deposition is enhanced

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- Effects of flow velocity
  - Under stagnant water flow corrosion is usually more severe.

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- Effects of chemical factors
- Various chemical factors greatly influence corrosion
  - pH
  - Alkalinity
  - Chlorine residual
  - Levels of dissolved solids
  - Dissolved gases

Alkalinity

- The simplest form of corrosion control in any system is increasing alkalinity

pH

- The hydrogen ion is extremely active at pH values below 4
- Low pH water is more corrosive (less than 7)
- Water higher than pH 7.5 is less corrosive

Dissolve oxygen

- Oxygen is often considered the most corrosive component of water chemistry.

Dissolved Solids

- Solids dissolved in water are present as ions that increase the electric conductivity of the water.
- Higher the dissolved solids, higher the salt content, the greater the potential for corrosion to occur due to the increased conductivity.

Hardness

- Planned deposition of calcium carbonate film is one of the most common corrosion control measures used in water systems.

Phosphate and Silicate

- These compounds have a tendency to form protective films in water systems when present in high enough concentrations and when in the correct chemical form for the particular conditions of the water

Biological Factors

- Two types of microorganisms that can play an important role in corrosion of water distribution system are iron bacteria and sulfate reducing bacteria.
- Both can increase the rate of corrosion and the formation of undesirable corrosion by products

Iron Bacteria

- Iron bacteria are often present in a filamentous form, resulting in slimy, reddish or brown colored masses.
- An unpleasant musty odor is often associated with the presence of iron bacteria.

How to determine if corrosion problems exist

- Lead and Copper Rule requires water systems to control corrosion to protect the public from the harmful effects of lead, copper, or other toxic metals in drinking water.
- Leaks in the system indicate corrosion
- Red water complaints
- Taste and odor complaints

Langelier Index

- A water is considered stable when it is just saturated with calcium carbonate, in this condition it will neither dissolve nor deposit calcium carbonate.
- If the pH is raised from the equilibrium point, the water becomes scale forming and will deposit calcium carbonate.
- If the pH is lowered from the equilibrium point, the water turns corrosive

Langelier Index

- The langelier index is the most common index used to indicate how close a water is to the equilibrium point, or the corrosiveness of the water.
- This index reflects the equilibrium pH of a water with respect to calcium and alkalinity. The Langelier Index can be determined by using equation:

Langelier Index = pH – pHS

Where pH = actual pH of the water and

pHS = pH at which water having the same alkalinity and calcium content is just saturated with calcium carbonate.

Pg 390

Methods of controlling corrosion

- Calcium Carbonate Saturation
  - Reducing corrosive water is almost always accomplished by treating the water with chemicals so that the water is saturated or slightly supersaturated with calcium carbonate.
  - These chemicals should be fed after filtration

Determination of chemicals

- Depends on water quality goals and ultimately price.
- Quicklime
  - Added to waters that have a low hardness and low alkalinity in order to form calcium carbonate barrier in distribution mains.
- Caustic Soda
  - Added to waters with high levels of hardness and alkalinity because there is already sufficient calcium alkalinity to form calcium carbonate, but the pH must be increased to reach saturation conditions.

Lime

- Difficult to handle (powder)
- Messy
- Cakes
- Inhalation hazards
- Requires a lime tower or gravity feed

Caustic Soda

- Accurate Feed
- Liquid
- Dangerous chemical
- Expensive

Chemical dose is dependent on pH desired

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- pH desired is based on the Langelier Saturation Index.

Cathodic Protection Systems

- Used to reduce or inhibit corrosion of metal exposed to water or soil.
- Key to the system is the use of an auxiliary anode of expendable metal that is immersed or buried in the soil or water.
- All cathodic protection systems pass current through the soil or water from anodes connected to the structure that is to be protected. (pg 398)

Protection of flocculators, clarifiers, and filters

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- Automatic cathodic protection control devices can provide precise corrosion control under nearly all conditions

Lead and Copper Rule

- Lead is a common, natural and often useful metal found throughout the environment in lead-based paint, air, soil, household dust, food, certain types of pottery etc.
- Lead in drinking water, although rarely the sole cause of lead poisoning can significantly increase a person's total lead exposure
- When water stands in lead pipes or plumbing systems containing lead for several hours or more, the lead may dissolve into your drinking water.

Lead and Copper Rule

- 1991
- Maximum contaminant level goals, actions levels are established for lead and copper
- Lead and copper monitoring
- Treatment technique for lead and copper, included optimal corrosion control techniques
- Public notification and education

Monitoring Requirements

- Lead and Copper monitoring must be taken from high risk areas
  - Homes with lead solder installed after 1982
  - Homes with lead pipes
  - Homes with lead service lines

  (pg 404)

Maximum Contaminant Level Goals

- 10 percent of samples taken in the system cannot exceed the action level:

- Lead- Action level of 0.015 mg/L
- Copper- Action level of 1.3 mg/L

Treatment Requirements

- pH and alkalinity adjustment
- Calcium adjustment (to form protective calcium carbonate films inside plumbing)
- Phosphate- or silica based inhibitor addition

Lead service line replacement

- All public water systems that continue to exceed the lead action level after installing optimal corrosion control treatment
- Replacement of seven percent of their lead service lines per year
- Total replacement of the entire lead service line unless it can demonstrate that it does not control the entire line.
- A maximum of 15 years to complete the lead service line replacement.

Public Education

- Mail out notices
- Announcements in major local daily and weekly newspapers, distribution, of pamphlets to schools, health care, and day care facilities, and submittal of public service announcements to at least five of the largest radio and television stations in the area.
- Flushing taps before use
- Cooking with cold rather than hot tap water
- Checking new plumbing for lead solder
- Testing their water for lead

Public Notification

- Tier I (24 hours)
  - Acute disease outbreak with potential to do immediate harm to the public health
    - Fecal coliform repeat positive
- Tier II (30 days)
  - MCL violations
  - Monitoring violations
- Tier III (Annual-Consumer Confidence Report)
  - Monitoring violations
  - Failure to comply

§64400.10. Community Water System.
"Community water system" means a public water system which serves at least 15 service connections used by yearlong residents or regularly serves at least 25 yearlong residents.

§64400.38. Enhanced Coagulation.
"Enhanced coagulation" means the addition of sufficient coagulant for improved removal of disinfection byproduct precursors by conventional filtration treatment.

§64400.80. Nontransient-noncommunity Water System.
"Nontransient-noncommunity water system" means a public water system that is not a community water system and that regularly serves at least the same 25 persons over 6 months per year.

§64400.70. MCL.
"MCL" means maximum contaminant level.

§64401.82. Total Organic Carbon or TOC.
"Total organic carbon" or "TOC" means total organic carbon reported in units of milligrams per liter (mg/L), as measured using heat, oxygen, ultraviolet irradiation, chemical oxidants, or combinations of these oxidants that convert organic carbon to carbon dioxide, rounded to two significant figures.

§64401.85. Transient-noncommunity Water System.
"Transient-noncommunity water system" means a public water system that is not a community water system or a nontransient-noncommunity water system.

Table 64533-A
Maximum Contaminant Levels and Detection Limits for Purposes of Reporting
Disinfection Byproducts

Disinfection Byproduct	Maximum Contaminant Level (mg/L)	Detection Limit for Purposes of Reporting (mg/L)
Total trihalomethanes (TTHM)	0.080	
Bromodichloromethane		0.0010
Bromoform		0.0010
Chloroform		0.0010
Dibromochloromethane		0.0010
Haloacetic acids (five) (HAA5)	0.060	
Monochloroacetic Acid		0.0020
Dichloroacetic Acid		0.0010
Trichloroacetic Acid		0.0010
Monobromoacetic Acid		0.0010
Dibromoacetic Acid		0.0010
Bromate	0.010	0.0050 0.0010[1]
Chlorite	1.0	0.020

[1] For analysis of samples using EPA Method 317.0 Revision 2.0, 321.8, or 326.0

MCL's

- Nitrate (as nitrogen) – 10 mg/L
- Nitrite (as nitrogen) – 1 mg/L
- Perchlorate – 0.006 mg/L
- Arsenic – 0.010 mg/L
- Fluoride – 2.0 mg/L

Questions or Comments

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