Service Life of Galvanized Steel Articles in Soil Applications

High Chlorides >20 PPM

CHART 1

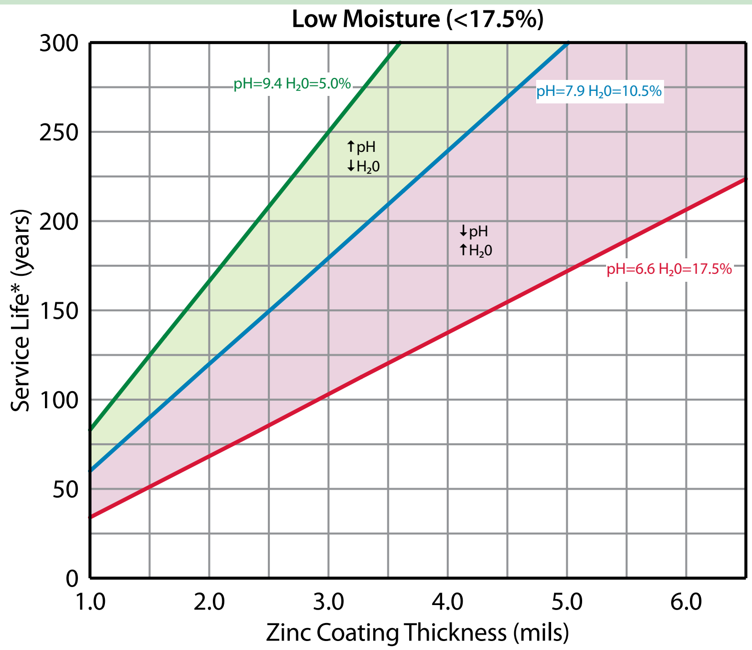
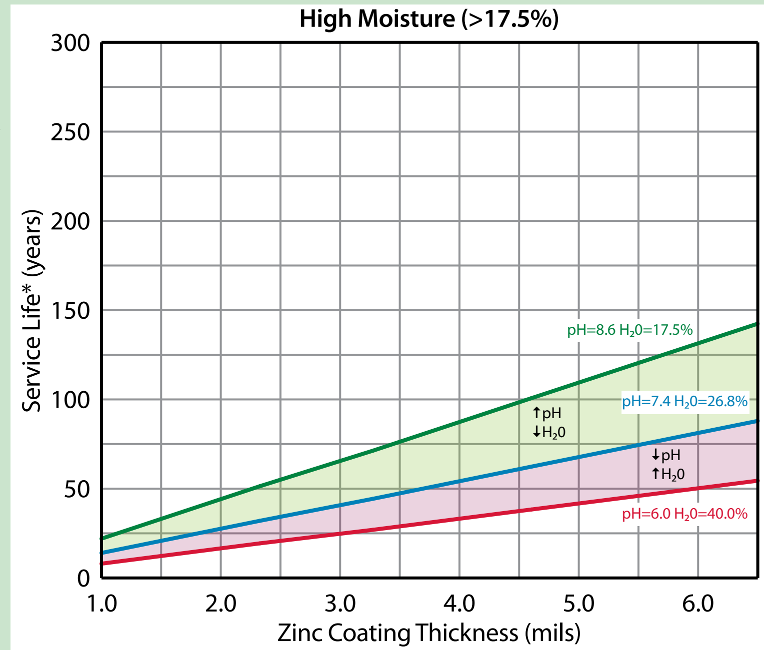


CHART 2



Low Chlorides <20 PPM

CHART 3

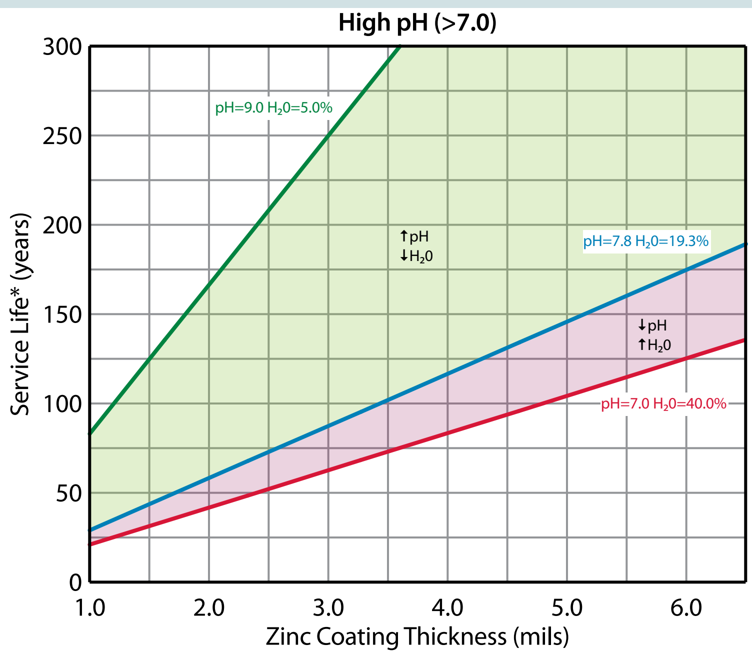
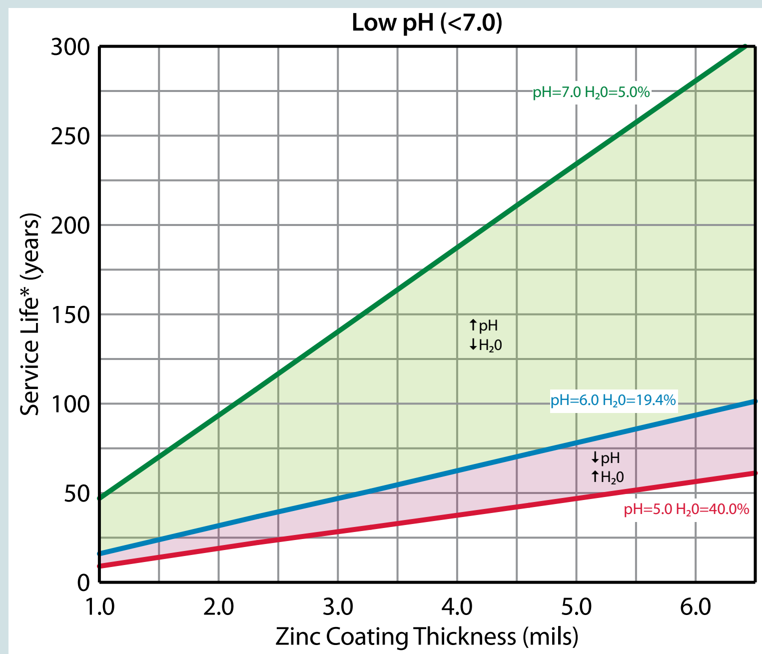


CHART 4



** Service life is defined as the time to necessary part replacement or underground maintenance.*

1 mil = 25.4 µm = 0.56 oz/ft^2

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Using the Service Life Chart

- The service life charts are separated into two sets based on chloride concentration:
  - **Charts 1 and 2**: Soils with high chloride concentration (>20 PPM)
  - **Charts 3 and 4**: Soils with low chloride concentration (<20 PPM)
- The center blue line represents the average of all of the locations covered by the chart. (Ex: ***Chart 1***'s blue line = chlorides >20 PPM, pH of 7.9, and moisture content of 10.5%).
- The green area and lines represent the soil conditions that have greater service life than the average. The pH and moisture content changes that provide the galvanized article a longer service life are shown in the green area. (Ex: ***Chart 1*** shows an increased service life if the pH is greater than the average and/or the moisture content is less.)
- The red area and lines represent conditions less ideal than the average that decrease the service life, and the affect of the pH and moisture content changes. (Ex: ***Chart 1*** shows a decreased service life if the pH is less than the average and/or the moisture content is greater.)
- The green and red lines on the outside edge of these colored areas represent the best and worst soil conditions respectively for the overall soil category.

General Observations

- Hot-dip galvanized steel performs well (service life over 75 years), in most soil conditions.
- The best soil types for hot-dip galvanized steel are sandy, coarse soils with low retained moisture levels.
- The worst soil types for hot-dip galvanized steel are dense soils with high retained moisture levels and swampy soils with high moisture and low pH values.
- Some Western soils in dry areas have very high chloride levels, as well as some other alkali materials and can be very corrosive to galvanized steel, even with very low retention of moisture.

Detailed Chart Explanations

All examples represent the performance of galvanized steel with a coating thickness of 3.5 mils.

- ***Chart 1*** shows the best performance of galvanized steel in soil occurs when the moisture content of the soil is <17.5% and the chloride concentration in the soil is >20 PPM. As the pH increases and the moisture content decreases, the performance of galvanized steel becomes even better. The service life of galvanized steel in the soil conditions listed for Chart 1 is better than 120 years.
- ***Chart 2*** shows the shortest service life for galvanized steel in soil can be found when the chloride concentration in the soil is >20 PPM and the moisture content of the soil is >17.5%. The average service life for these conditions is still around 50 years in the soil, but if the pH goes below 7.4 and the moisture content is above 26.8%, then the service life degrades to a low value of 28 years. Even though this service condition for the soil has the lowest service life, it also has the lowest population with only 15% of the sites surveyed having these conditions.
- ***Chart 3*** shows an average service life for galvanized steel of 100 years. The chart shows significant improvement in service life can be seen for soil conditions where the moisture content drops below the average of 19.3% and the pH increases from the average of 7.8. There is a slight drop when the moisture content increases and the pH decreases, but this still gives a service life of 76 years at the worst condition. The service conditions on this chart represent nearly half of the actual conditions found in the Corrpro survey.
- ***Chart 4*** shows an average service life for galvanized steel of 50 years. The chart shows the performance of galvanized steel in soil under this condition can significantly improve when the pH increases above the average of 6.0 and the moisture content decreases below 19.4%. The service life can triple when the pH is 7.0 and the moisture content is at 5.0%. Like Charts 2 and 3, the service life falls off slightly at higher moisture content and lower pH.

Service Life Chart Data and Development

The primary source for information on the performance of galvanized steel articles in soil conditions was the *Condition and Corrosion Survey on Corrugated Steel Storm Sewer and Culvert Pipe: Final Report* prepared by Corrpro Companies for the National Corrugated Steel Pipe Association (NCSPA) in cooperation with the American Iron and Steel Institute (AISI).

- Examined materials from 122 U.S. sites with conditions varying from a low pH of 4.1 to a high pH of 10.3 to create a database for a statistical model.
- Statistical model was developed to accurately predict the average service life of hot-dip galvanized steel culvert based on the measured soil corrosion rate.
- The condition of the galvanized coating was evaluated by simple pipe-to-soil potential measurements using a copper-copper sulfate reference electrode.
- Measurements of pH, resistivity, moisture content in percentages, and chloride content were taken.
- Probability functions were used to predict the time to first perforation of the wall of the 16 gauge galvanized corrugated steel pipe.
- Based on previous work by Richard Stratfull of the California Department of Transportation, the predicted service life of the 16 gauge corrugated steel pipe will be twice the number of years to first perforation. Therefore, the model and analysis developed by Corrpro conservatively estimates the service life of corrugated steel pipes in soil applications to be the time to first perforation plus 50%.
- For structural hot-dip galvanized articles, a more appropriate service life is to coating consumption plus 25%, which is how the estimations for the service life charts on the opposite side of this page were developed.

Factors Affecting Corrosion

In the 1970's, Dr. Warren Rogers developed a model to determine the Mean Time to Corrosion Failure (MTCF) of Underground Storage Tanks (UST's). Using data from examinations of failed and functioning UST's, he developed a model to predict MTCF from a number of factors that could be measured at the UST site. He applied this model to over 23,000 sites. This helped refine and verify the accuracy of the model.

These are four variables in the model that affect the corrosion rate of the UST's:

- *Chlorides*- The presence of chloride ions causes the resistivity to be lower and makes the zinc coating more susceptible to corrosion. Along with high moisture levels in the soil, high chlorides will increase the rate of corrosion of the zinc coating.
- *Moisture Content*- For galvanized steel, the soil moisture content primarily affects the activity of the chloride ions. If the moisture content was below 17.5%, the chloride ion concentration does not significantly affect the corrosion rate of the zinc. If the moisture content was above 17.5%, the chloride ion concentration has a significant effect on the corrosion rate of zinc.
- *pH*- The lower pH (<7.0) values of soil have a higher corrosion rate on zinc coatings. If the pH is above 7.0, then the corrosion rate of the soil yields a longer service life of the zinc coating.
- *Resistivity*- This parameter follows the chloride ion concentration in that higher resistivity means lower chloride ion content and a lower corrosion rate of the zinc coating.