

SERVICE LIFE OVERVIEW

Corrugated metal pipe (CMP) has been used for more than 100 years in storm sewer and culvert applications, available only as a galvanized coated steel pipe for the first half of this period. With the addition of a number of material options over the past 50 years CMP has increased its value and usefulness in providing extended service life over a broader range of environmental conditions.

Environmental conditions can vary considerably from site to site but there are only several variables used to predict service life. The pipe interior (water-side durability) is impacted by effluent abrasion, pH and resistivity, and is typically the controlling factor in service life assignments. The pipe exterior (soil-side durability) is affected by soil pH and resistivity, and is generally not the limiting factor in estimating CMP service life.

Abrasion is a function of the bed load carried by the effluent and its velocity. Abrasion levels are correlated to the classification system developed by the Federal Highway Administration (FHWA).

FHWA ABRASION LEVELS		
Level 1	None	No bed load
Level 2	Low	Minor sand/gravel bed loads ($v \leq 5$ ft/sec)
Level 3	Moderate	Sand/gravel bed loads ($5 < v \leq 15$ ft/sec)
Level 4	Severe	Heavy gravel/rock bed loads ($v > 15$ ft/sec)

The **pH** ranges between 0 and 14 and is a measurement of acidity ($\text{pH} < 7.0$) or alkalinity ($\text{pH} > 7.0$). **Resistivity, R** [ohm-cm] is a measure of how strongly a material opposes the flow of electric current. A low resistivity indicates a material that readily allows the movement of electric charge and results in greater corrosion rates.

Normal environmental conditions have a pH range between 5.8 and 8.0 with a resistivity greater than 2000 ohm-cm. **Mildly corrosive** environments have a pH range from 5.0 to 5.8 and a resistivity between 1500 and 2000 ohm-cm. **Corrosive** environments are characterized by pH's less than 5.0 and resistivities below 1500 ohm-cm.

GALVANIZED CSP

Galvanized CSP provides a zinc coating weight of two ounces per square foot of surface area, resulting in a coating thickness of approximately 0.0017 inches (each side). Galvanized CSP has been in use longer than any other material and much has been learned about the service life of this product. A field investigation conducted in the 1960's evaluated the service life of roughly 7,000 culverts in terms of pH and resistivity alone, and was subsequently quantified in the following service life equations:

$$\text{For } \text{pH} \leq 7.3 \quad \text{Service Life (Years)} = 35.85[\text{Log}_{10} R - \text{Log}_{10} (2160 - 2490 \text{Log}_{10} \text{pH})]$$

$$\text{For } \text{pH} > 7.3 \quad \text{Service Life (Years)} = 3.82R^{0.41}$$

The equations relate the service life for 16 gage based on a 25% loss of steel in the pipe invert. Longer service life may be achieved with the heavier gages. For gages 14, 12, 10 and 8, apply factors 1.3, 1.8, 2.3 and 2.8, respectively.

For $\text{pH} \leq 7.3$ the equation should be applied to both the water-side and soil-side of the pipe. When $\text{pH} > 7.3$ the soil-side is the controlling factor.

An important factor later discovered to have a significant impact on the service life of galvanized coated CSP is the presence of soft water ($\text{CaCO}_3 < 50$ ppm). Hard water has an excess of this dissolved salt which is deposited on the pipe in the form of a scale that protects the underlying coating. Had the impact of soft water been recognized at the time of installation the resultant equations would predict longer service life for galvanized CSP installed within the environmental guidelines of today. Aluminized CSP will not be adversely affected by the presence of soft water and therefore is the recommended substitute to galvanized CSP in soft water applications (see following discussion).



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ALUMINIZED TYPE 2 (ALT2) CSP

ALT2 is a pure aluminum coating with a weight of one ounce per square foot of surface area, which produces a coating thickness of approximately 0.0019 inches (each side). The aluminum coating develops a passive aluminum oxide film that withstands a wider range of environmental conditions. The film is quite stable in neutral and acidic environments, does not break down in alkaline environments until the pH exceeds 9.0, and develops regardless of the CaCO₃ concentration. ALT2 therefore has the advantage over galvanized CSP in the lower pH and soft water environments.

POLYMER COATED CSP

The polymer coating is a laminate film applied to galvanized coils to a thickness of 10 mils (0.010 inches) on each side. The polyolefin laminate has strong adhesion characteristics with the galvanized sheet and is the most durable CSP coating available today, outperforming the other coatings in both the more abrasive and chemically aggressive environments. Installations now dating back more than 40 years show no signs of degradation.

SERVICE LIFE ASSIGNMENTS - CSP COATINGS

There have been some major research undertakings over the past couple decades to supplement the vast field surveys and related findings. Laboratory testing conducted by the primary coating suppliers along with ongoing field monitoring and other research endeavors combine to provide the following service life assignments for the principal CSP coatings:

Service Life	Environment	FHWA Abrasion	CSP Coating
Minimum 100 years	5.0 ≤ pH ≤ 9.0 R > 1500	Level 3	Polymer Coated
		Level 2	Aluminized Type 2 (14ga)
Minimum 75 Years	4.0 ≤ pH ≤ 9.0 R > 750 5.0 ≤ pH ≤ 9.0 R > 1500	Level 3	Polymer Coated
		Level 2	Aluminized Type 2
Minimum 50 Years	3.0 ≤ pH ≤ 12.0 R > 250	Level 3	Polymer Coated
Average 50 Years	6.0 ≤ pH ≤ 10.0 2000 < R < 10000 Hard Water (CaCO ₃ > 50 ppm)	Level 2	Galvanized Add-on service life of 10 yrs with asphalt coating.



Consult the NCSA Service Life Selection Guide for a fuller treatment of service life for CSP coatings (www.ncspa.org).

ALUMINUM ALLOY CMP (MINIMUM 75-YR SERVICE LIFE IN THE RECOMMENDED ENVIRONMENT)

The core material for aluminum alloy pipe is specially formulated to resist the effects of corrosion and abrasion. Corrosion resistance is further improved by cladding each surface of the core with a higher grade aluminum alloy that totals 10% of the total sheet thickness. Corrugated aluminum alloy pipe provides a minimum 75-yr service life in the recommended environment (pH 4-9, R > 500 ohm-cm). Aluminum drainage products are especially appropriate for brackish and seawater (35 ohm-cm) environments when the pipe is backfilled with a clean, free draining granular material.