CONTECH ENGINEERED SOLUTIONS

CONTECH® ENGINEERED SOLUTIONS
A QUIKRETE® COMPANY

Kansas Dam Safety Conference
March 11, 2020

Presented By: Matt McCants, P.E.

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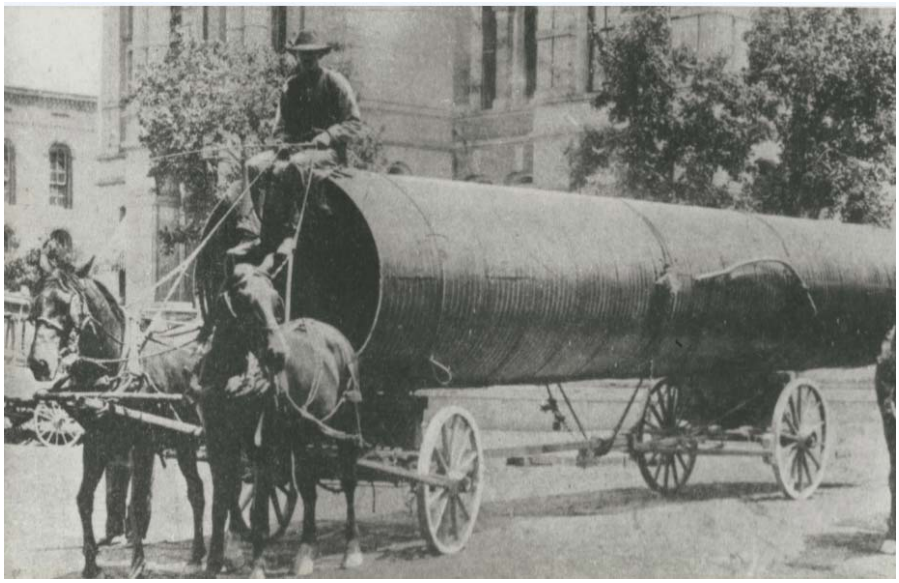
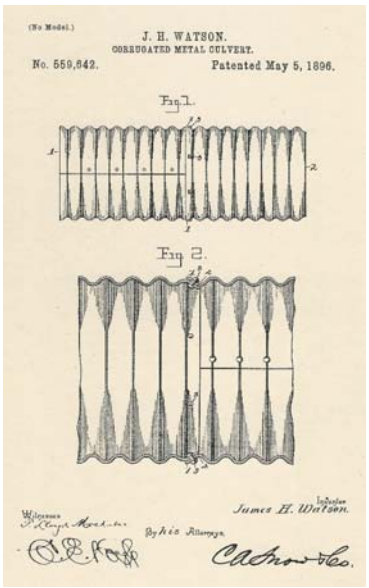




(No Model.)

J. H. WATSON.

CORRUGATED METAL CULVERT.

No. 559,842. Patented May 5, 1896.

Fig 1.

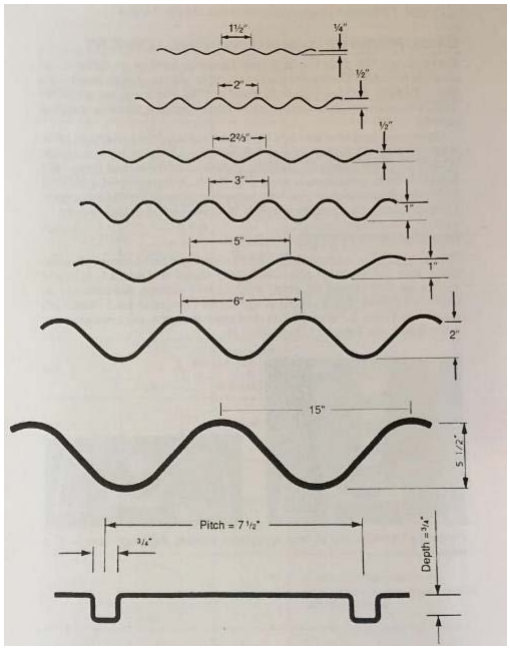
Fig 2.

Witnesses

James H. Watson. Inventor

By his Attorneys

CMP corrugation profiles Sinusoidal and Ribbed



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Pipe Materials & Coatings

- Galvanized Steel Pipe
- Asphalt-Coated Corrugated Steel Pipe
- ALUMINIZED STEEL™ Type 2 (ALT2)
- Polymer-Coated Corrugated Steel Pipe
- Corrugated Aluminum Pipe

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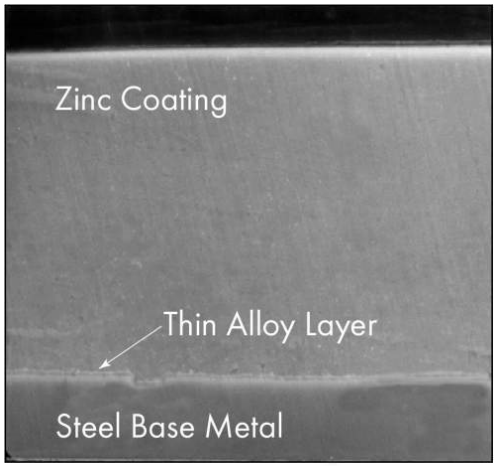
What We Know…

Galvanized



The benchmark for durability

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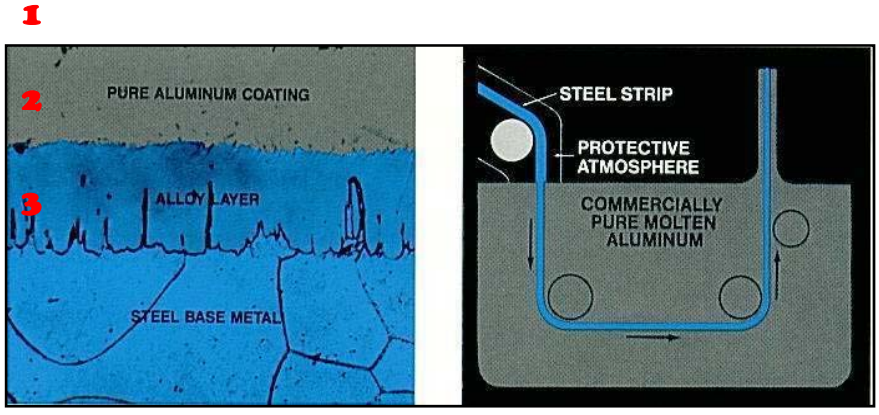
ALT2 - Multiple Layer Protection



1. Aluminum Oxide Barrier - Forms in hard & soft water
2. Aluminum Layer - Corrosion resistant / Cathodic protection
3. Thick Alloy Layer - Abrasion resistant / Pit arrestor

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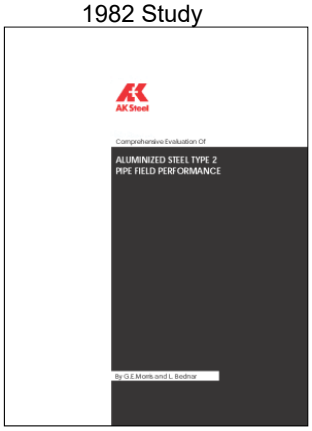
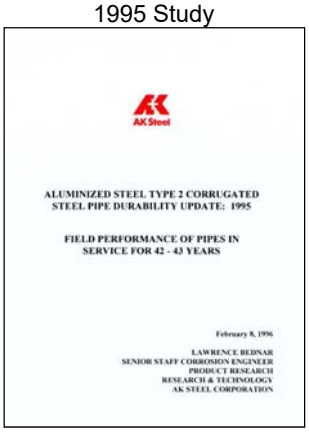
AK Steel 30 and 43 Year Reports

1982 Study



Establishes recommended environmental range (pH = 5-9; R > 1500 Ohm-cm) for a *50* year life for 16gage Aluminized Steel

1995 Study



***75* year service life**

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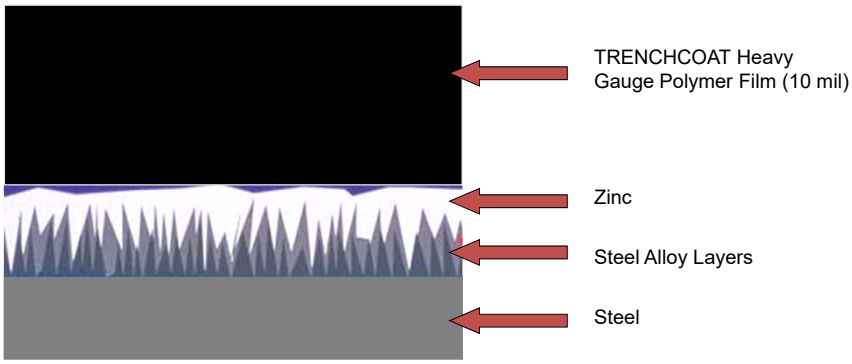
Polymer Coated Steel

TRENCHCOAT® protective film bonds to galvanized steel both chemically and physically



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What We Know

Aluminum

The aluminum alloy sheet is an aluminum core with an added cladding layer that contains a small amount of zinc

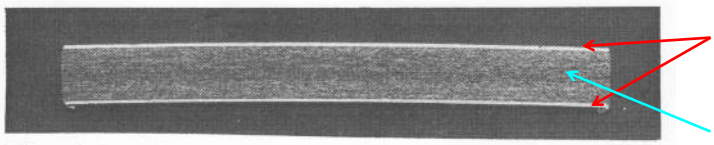

Fig. 3-1. Photomicrograph of cross section of clad aluminum alloy sheet. Designated Alcad 3004, this material combines aluminum alloys 3004 for the core and 7072 (highly corrosion resistant and anodic to alloy 3004) for the cladding. The two alloys are metallurgically bonded in the rolling mill process; cladding remains a constant 5 percent, per side, of the composite thickness of the Alclad sheet.

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What We Know

Aluminum

Service-life expectancy studies performed since the early 1960's have concluded that 16 ga. CORLIX will last 75+ years when installed in the appropriate environment

pH 4 – 9 R >= 500 ohm.cm

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What We Know

Aluminum

- **CORLIX performs exceptionally well in salt water environments with R as low as 35 ohm-cm**
- **Pipe must be backfilled with clean, granular material**

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CMP Durability?

What Impacts CMP Durability?

The service life of corrugated metal pipe is influenced by these factors:

- **pH**
- **Resistivity**
- **Water Chemistry**
- **Backfill**

Environment

- **Flow Velocity**
- **Bed Load**

Abrasion

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What Impacts CMP Durability?

Environment

pH

A measure of the activity of hydrogen ions in a solution that indicates the level of acidity

Resistivity

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 electrical current.

(water chemistry and backfill characteristics, as well)

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What Impacts CMP Durability

Water/Soil Limits:

- **Galvanized Steel**
  - $6.0 \leq pH \leq 10.0$
  - 2,000 ohm-cm < Resistivity < 8,000 ohm-cm
- **Aluminized Type 2**
  - $5.0 \leq pH \leq 9.0$
  - Resistivity > 1,500 ohm-cm
- **Aluminum**
  - $4.0 \leq pH \leq 9.0$
  - Resistivity > 500 ohm-cm
- **Polymer Coated**
  - $3.0 \leq pH \leq 12.0$
  - Resistivity > 250 ohm-cm

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Galvanized Steel
Caltrans Study

- **Investigated over 7,000 culverts in the 1950's (mostly small diameter).**
  - Majority of culverts in the northwestern part of the state
    - Heavy rainfall
    - Mountainous terrain
    - Moderately abrasive bedloads
    - Tested soil and water chemistries

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Galvanized Steel
Caltrans Study

- **Generated an empirical chart to predict "time to first perforation".**
  - First perforation defined as "service life"
  - Represents about 12% - 13% metal loss
  - Found correlation between pH and resistivity
  - Still in use in California today.

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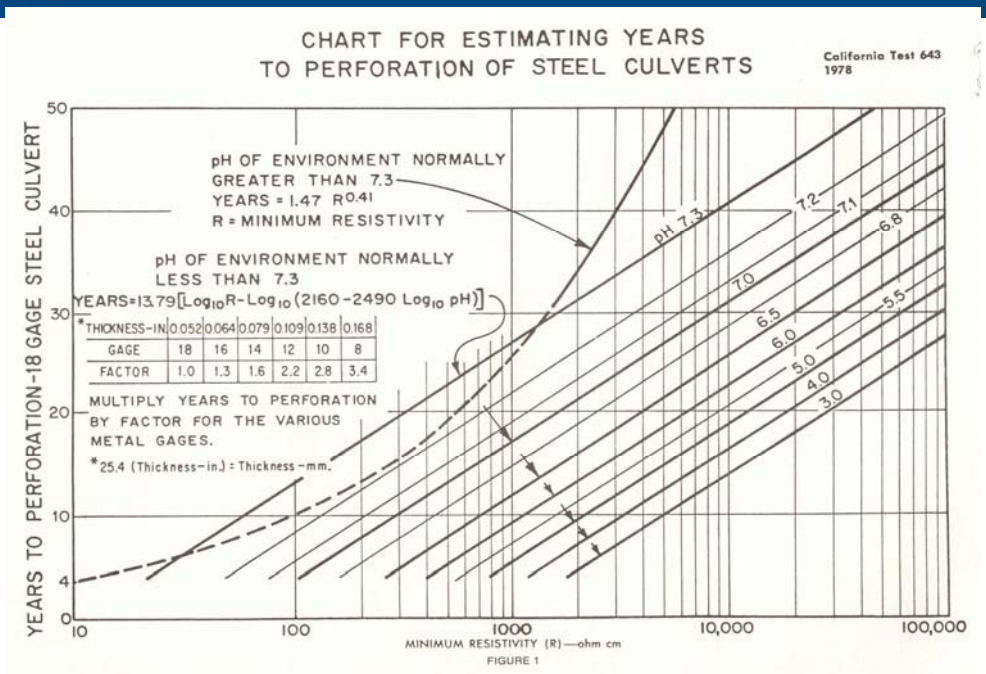
Caltrans Chart



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Galvanized Steel
U.S. Dept. of Weights & Measures

- **Refined the Caltrans study - 1983**
  - The Caltrans method underestimated the actual service life of most culverts.
    - Culverts with less than “moderate” abrasion
    - Culverts with intermittent flow
    - Culverts with lower velocity flows

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Galvanized Steel
U.S. Dept. of Weights & Measures

- **Invert metal loss of 25% more accurately predicts service life**
  - Maintain a factor of safety of at least 1.5 for cross-sectional area.
  - Adequate invert metal left to begin maintenance.
  - Still conservative for soilside corrosion.
- **Effort resulted in development of the A.I.S.I chart.**

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Galvanized Steel
US Army Corps of Engineers

- **Developed a rational method to determine which service life chart is appropriate - 1988**
  - Type of flow: gravity or pressure?
  - Type of bedding and backfill material?
  - Anticipated abrasion level?
  - Invert protection?
- See flow chart

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US Army Corps of Engineers
Galvanized Steel

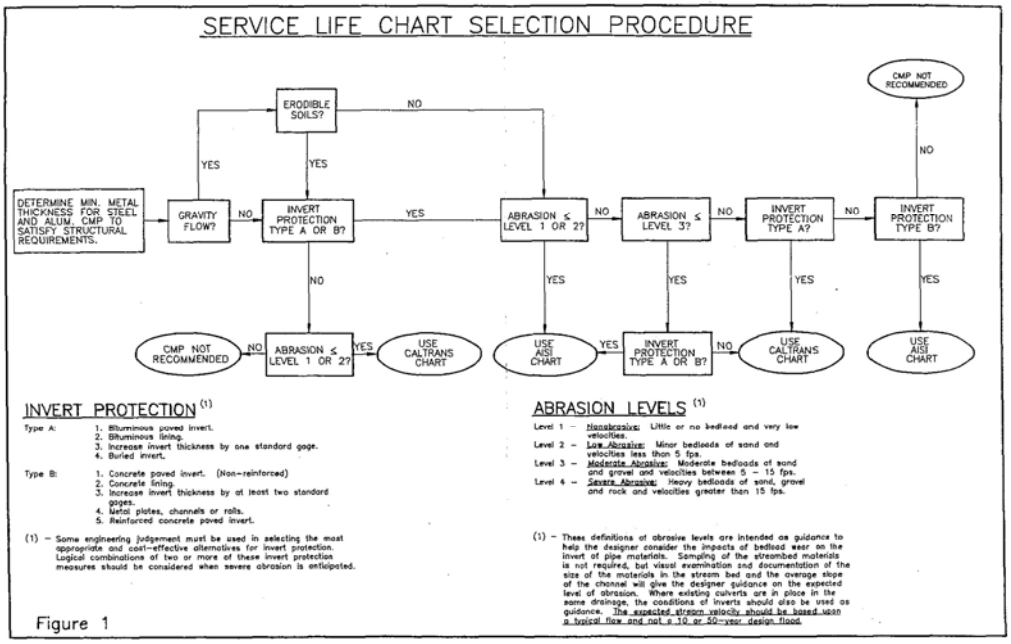

Figure 1

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AISI Chart

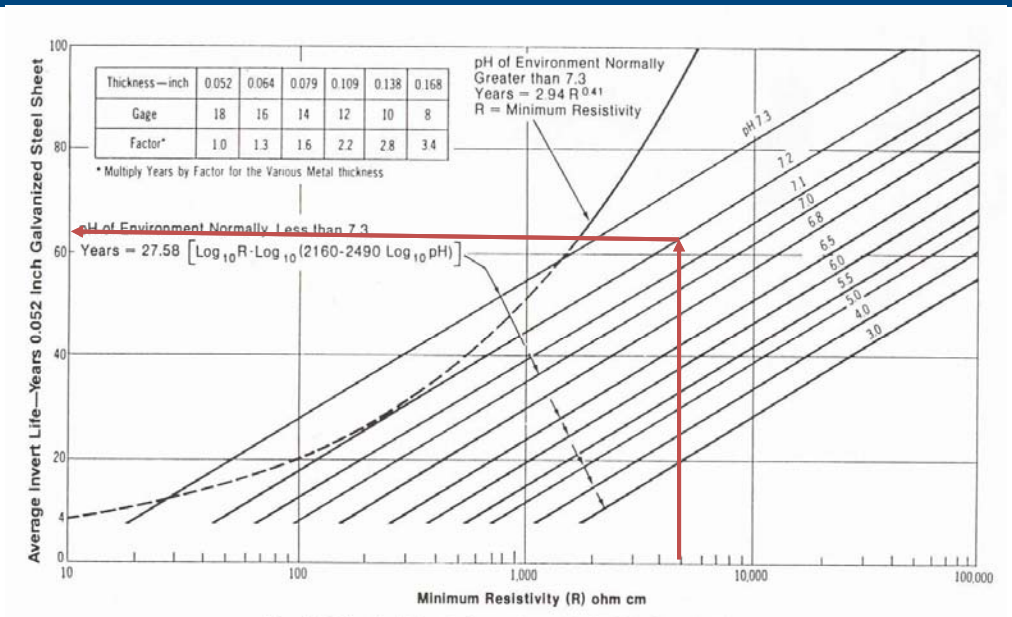

Figure 6.7 Chart For Estimating Average Invert Life For Plain Galvanized Culverts.

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Abrasion

Abrasion is a function of flow velocity AND bed load. In the absence of bed load, abrasion is *not* a factor.

FHWA abrasion guidelines:

Abrasion Level	Abrasion Condition	Bed Load	Flow Velocity (fps)
Level 1	Non – Abrasive	None	Low
Level 2	Low Abrasive	Minor (sand)	< 5
Level 3	Moderate Abrasive	Moderate (sand & gravel)	5 - 15
Level 4	Severe Abrasive	Heavy (sand, gravel & rock)	> 15

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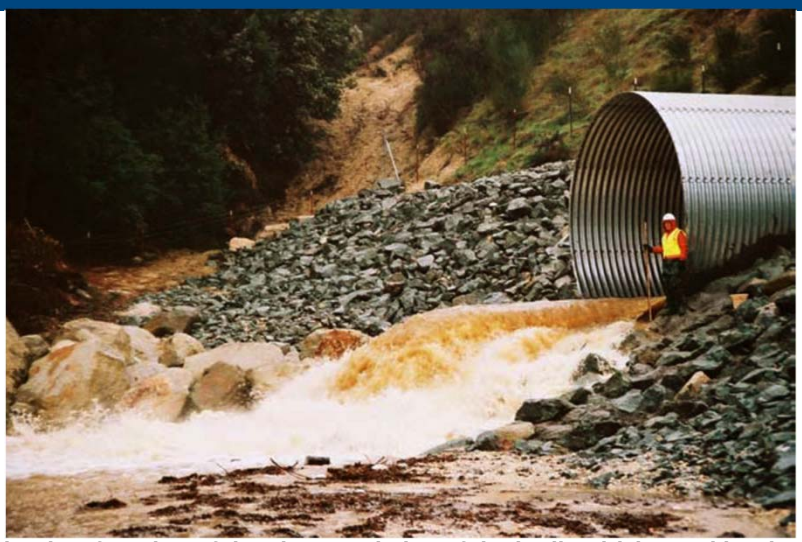
Abrasion Considerations



Abrasion is a function of the characteristics of the bedload (size and hardness of aggregates), flow velocity, and frequency of flow

Abrasion Considerations

If abrasion is not considered during initial design, then inspection and maintenance are crucial to prevent catastrophic damage to the invert of the culvert

This CSP culvert had a reinforced concrete paved invert placed during installation in order to accommodate abrasive flows up to 45 fps

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Table 1 – Recommended Environments

Material Type	Soil* and Water pH										Resistivity (ohm-cm)	
	3	4	5	6	7	8	9	10	11	12	Minimum	Maximum
Galvanized Steel*											2000	8000
Aluminized Steel Type 2 (ALT2)											1500	N/A
Polymer Coated											250	N/A
Aluminum Alloy											500	N/A

*Appropriate pH range for Galvanized Steel is 6.0 to 10

Table 2 – FHWA Abrasion Guidelines

Abrasion Level	Abrasion Condition	Bed Load	Flow Velocity (fps)
1	Non-Abrasive	None	Minimal
2	Low Abrasion	Minor	< 5
3	Moderate Abrasion	Moderate	5 - 15
4	Severe Abrasion	Heavy	> 15

"Interim Direct Guidelines on Drainage Pipe Alternative Selection." FHWA, 2005.

Table 3 – Drainage Product Usage Guide

Application	Culverts, Storm Drain, Cross Drain, Median Drain, Side Drain											
Roadway Classification	Rural	Minor	Major	Urban	Rural	Minor	Major	Urban	Rural	Minor	Major	Urban
Design Service Life	25	50	75	100	25	50	75	100	25	50	75	100
Abrasion Level	Abrasion Level 1 & 2				Abrasion Level 3				Abrasion Level 4			
CMP (1/2" & 1" deep corrugations), ULTRA FLO® & Smooth Cor™ Minimum gage required to meet design service life, assuming that structural design has been met.												
Galvanized (2 oz.)	16	12	10	8[4]	14	10	8	N/A	14[5]	10[5]	8[5]	N/A
Galvanized and Asphalt Coated	16	14	10	8	14	12	8	N/A	14[5]	12[5]	8[5]	N/A
Galv., Asphalt Coated & Paved Invert	16	16	14	10	16	14	12	8	14	12	10	N/A
Aluminized Type 2 (ALT2)	16	16	16	14	14	14	14	12	14[6]	14[6]	14[6]	12[6]
Polymer Coated	16	16	16[8]	16[9]	16	16	16[8]	16[9]	14[7]	14[7]	14[7,8]	14[7,9]
Aluminum Alloy	16	16	16	16	14	14	14	14	14[5]	14[5]	14[5]	14[5]

1. Based on Table 1 - Recommended Environments.
2. Smooth Cor™ Steel Pipe combines a corrugated steel exterior shell with a hydraulically smooth interior liner.
3. Service life estimates for ULTRA FLO® and Smooth Cor™ Pipe assume a storm sewer application. Storm sewers rarely achieve abrasion levels 3 or 4. For applications other than storm sewers or abrasion conditions above Abrasion Level 2, please contact your Contech Sales Representative for gage and coating recommendations.
4. Design service life for 8 GA galvanized is 97 years.
5. Invert protection to consist of velocity reduction structures.
6. Asphalt coated and paved invert or velocity reduction structures are needed.
7. Requires a field applied concrete paved invert with minimum thickness 1" above corrugation crests.
8. 75 year service life for polymer coated is based on a pH range of 4-9 and resistivity greater than 750 ohm-cm.
9. 100 year service life for polymer coated is based on a pH range of 5-9 and resistivity greater than 1500 ohm-cm.

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