Protective Coatings for Concrete Bridge Components

Bobby Meade – Greenman Pedersen Inc.
Derrick Castle – The Sherwin-Williams Co.
Sudhir Palle – University of Kentucky
Theodore Hopwood II – University of Kentucky

Content from Three Research Studies

- **KTC-14-3/SPR406-10-1F**

Evaluation of Deterioration of Structural Concrete Due to Chloride Intrusion and Other Damaging Mechanisms

- **KTC-14-4/FRT194, SPR388-12-1F.**

Sealants, Treatments and Deicing Salt Practices to Limit Bridge Deck Corrosion and Experimental Deck Sealants and Pier Cap Coating on Interstate 471

- **KTC-16-03/SPR12-433-1F**

Thin Film Concrete Coatings

The Problem

- **> 610,000 bridges in the FHWA inventory**
- **Three primary components: decks, substructures, and superstructures > 1,830,000 components**
- **~ 1,600,000 of those components are constructed of reinforced concrete**
- **Steel reinforced concrete often has corrosion issues**

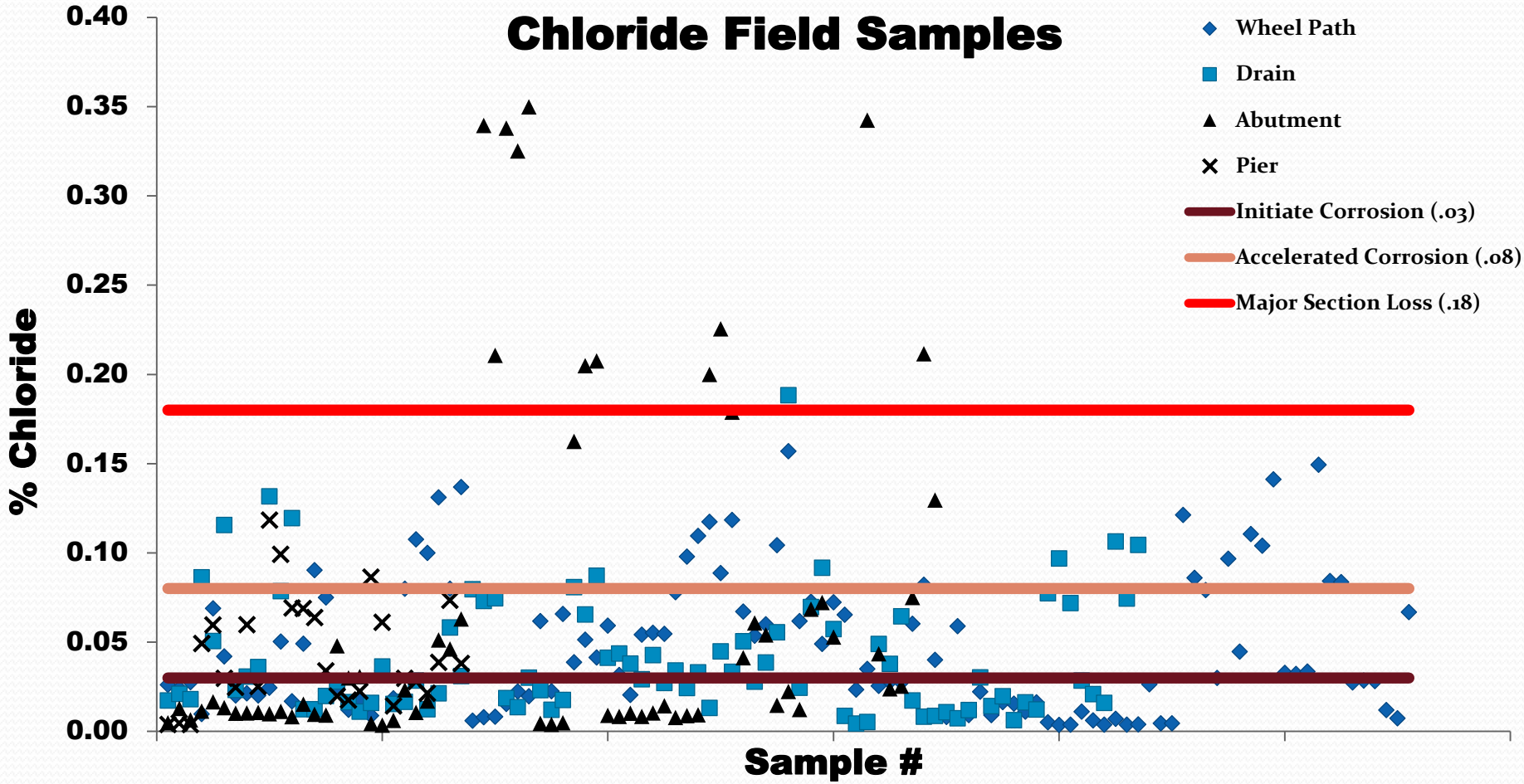
Action levels for chloride levels of concrete that result in steel corrosion

- 0.03 percent chloride to weight of concrete = initiation of corrosion
- 0.08 percent chloride to weight of concrete = accelerated corrosion
- 0.18 percent chloride to weight of concrete = major section loss of steel

KTC-14-3/SPR406-10-1F
Evaluation of Deterioration of Structural Concrete Due to Chloride Intrusion and Other Damaging Mechanisms

- 2002 – chloride content below action level in KYTC bridge decks
- Increasing concrete deterioration observed
- 2011 - evaluated 24 KYTC bridges
  - Decks, abutments, and pier caps

Chloride content of KYTC bridge components in 2011



Changes in Chloride Content in KYTC Bridge Components

- **2002 -bridge decks at the upper mat level were less than 0.01%**
- **2011 -bridge decks at the upper mat level were often 0.20% - 0.30%**
- **2011 -pier caps and abutment seats were often 0.30% to 0.40% range**

Sample Location	<0.03	>0.03 but <0.08	>0.08 but <0.18	>0.18
Wheel Path	46.8%	33.3%	19.8 %	0%
Drain	50.6%	36.8%	11.5 %	1.1%
Abutment	56.5%	18.8%	4.3%	20.3%
Pier	48.1%	40.7%	11.1%	0%

Result of Increased Chloride Contamination

KTC-14-4/FRT194, SPR388-12-1F. Sealants, Treatments and Deicing Salt Practices to Limit Bridge Deck Corrosion and Experimental Deck Sealants and Pier Cap Coating on Interstate 471

- 24 penetrating sealers evaluated
  - AASHTO T-259, “Resistance of Concrete to Chloride Ion Penetration,”
- Best performers (~1/3) reduced chloride penetration by ~75%
- Conclusion – better protection needed for non-driving surfaces

Research Approach

- **Identify potential thin film coatings**
- **Minimal system application time requirements**
- **User friendly**
- **Evaluate in laboratory and field**

Performance Criteria Evaluated

- Adhesion
- Resistance to chloride transmission
- Color stability
- Gloss retention

Types of thin film concrete coatings tested

System	Description
1	***Two component, high solids, high build, polyamide epoxy, applied in one coat***
	Two component, polyester modified, aliphatic, acrylic polyurethane, applied in one coat
2	***Two component, high solids epoxy, applied in one coat.***
	Single component, water-born acrylic, applied in one coat.
3	**Single component, water-born acrylic sealer, applied in one coat.**
	Single component, elastomeric high build acrylic, applied in one coat.
4	**Single component, waterborne blend of silanes, siloxanes and acrylics, applied in one coat**
	Single component, waterborne, silicon resin coating, applied in two coats
5	**Methyl methacrylate-ethyl acrylate copolymer sealer, applied in two coats**
6	***Two component, cycloaliphatic amine epoxy mastic, applied in one coat.***
	Two component, aliphatic acrylic-polyester polyurethane, applied in one coat.
7	**Single component, waterborne acrylic, applied in one coat.**
	Single component, modified acrylic terpolymer, applied in one coat.
8	**Two component castor oil/gypsum coating, applied in one coat.**

Coating Application

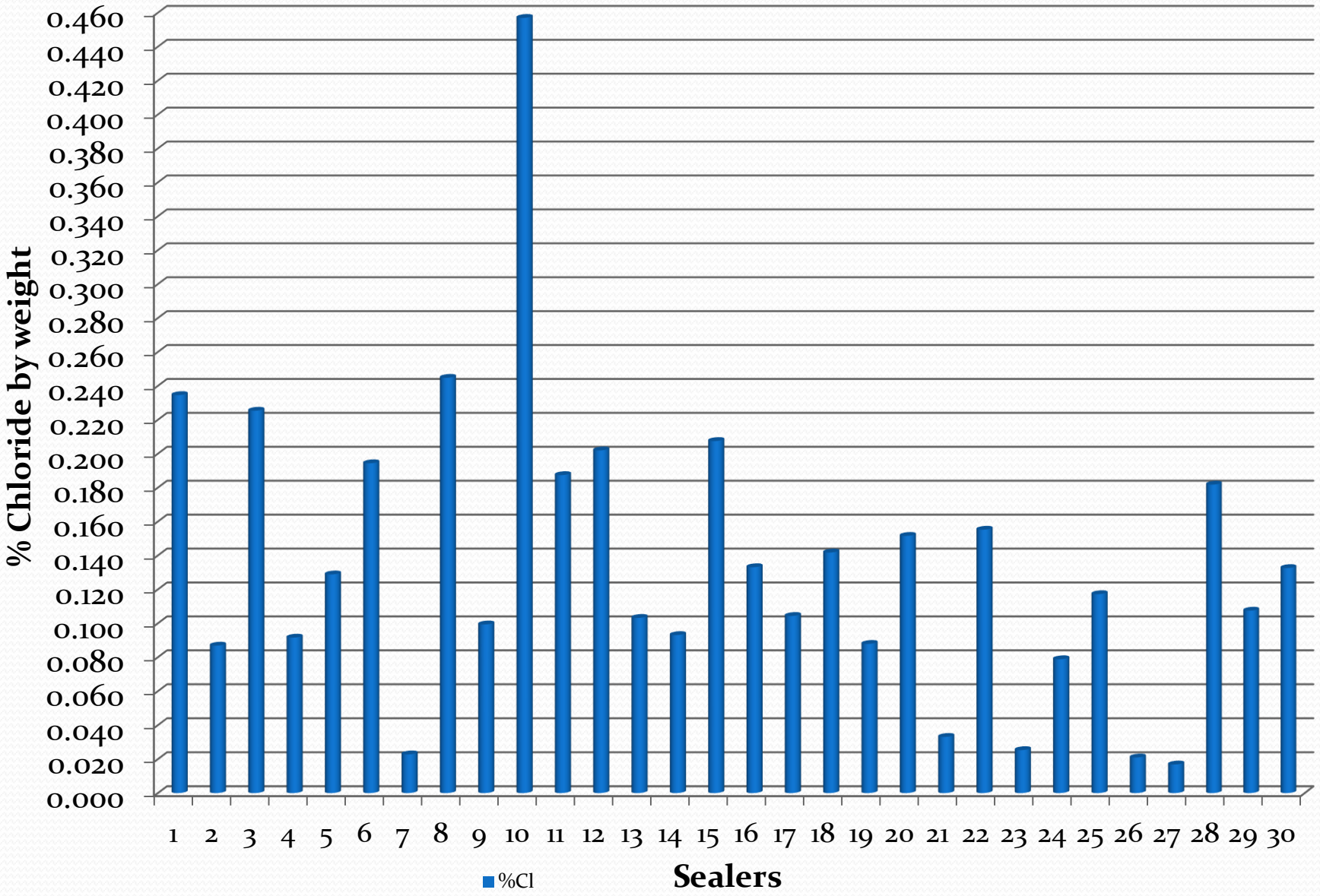
Coating Adhesion - Field

System	6 Month	Failure Mode
	Psi	
1	493	100% Cohesive Concrete
2	1452	100% Cohesive Concrete
3	549	100% Cohesive Coating
5	1128	90% Adhesive Concrete/Coating 10% Cohesive Concrete
6	1635	100% Cohesive Coating
7	551	90% Adhesive Concrete/Coating 10% Cohesive Concrete
8	519	100% Cohesive Coating

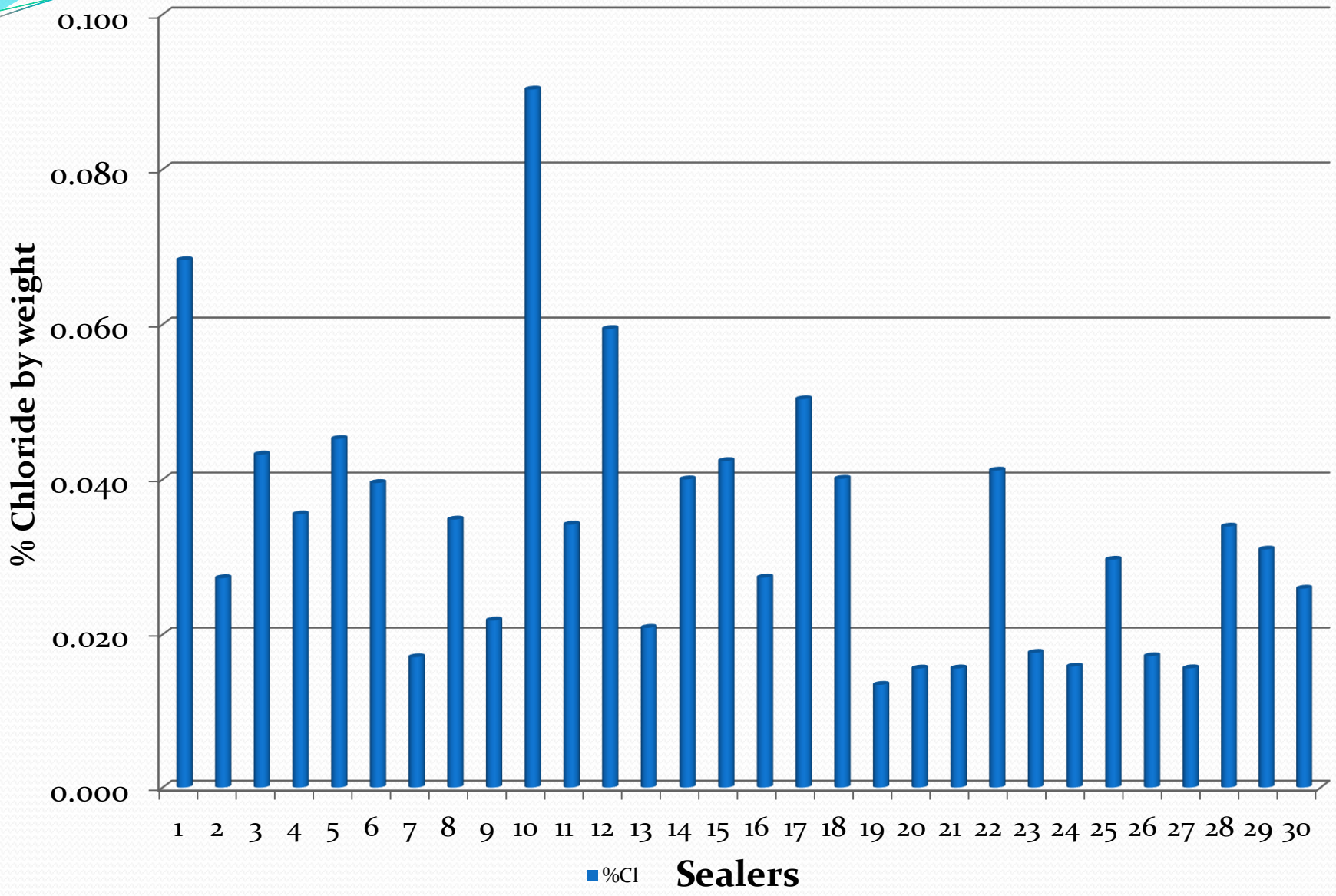
Coating Adhesion - Laboratory

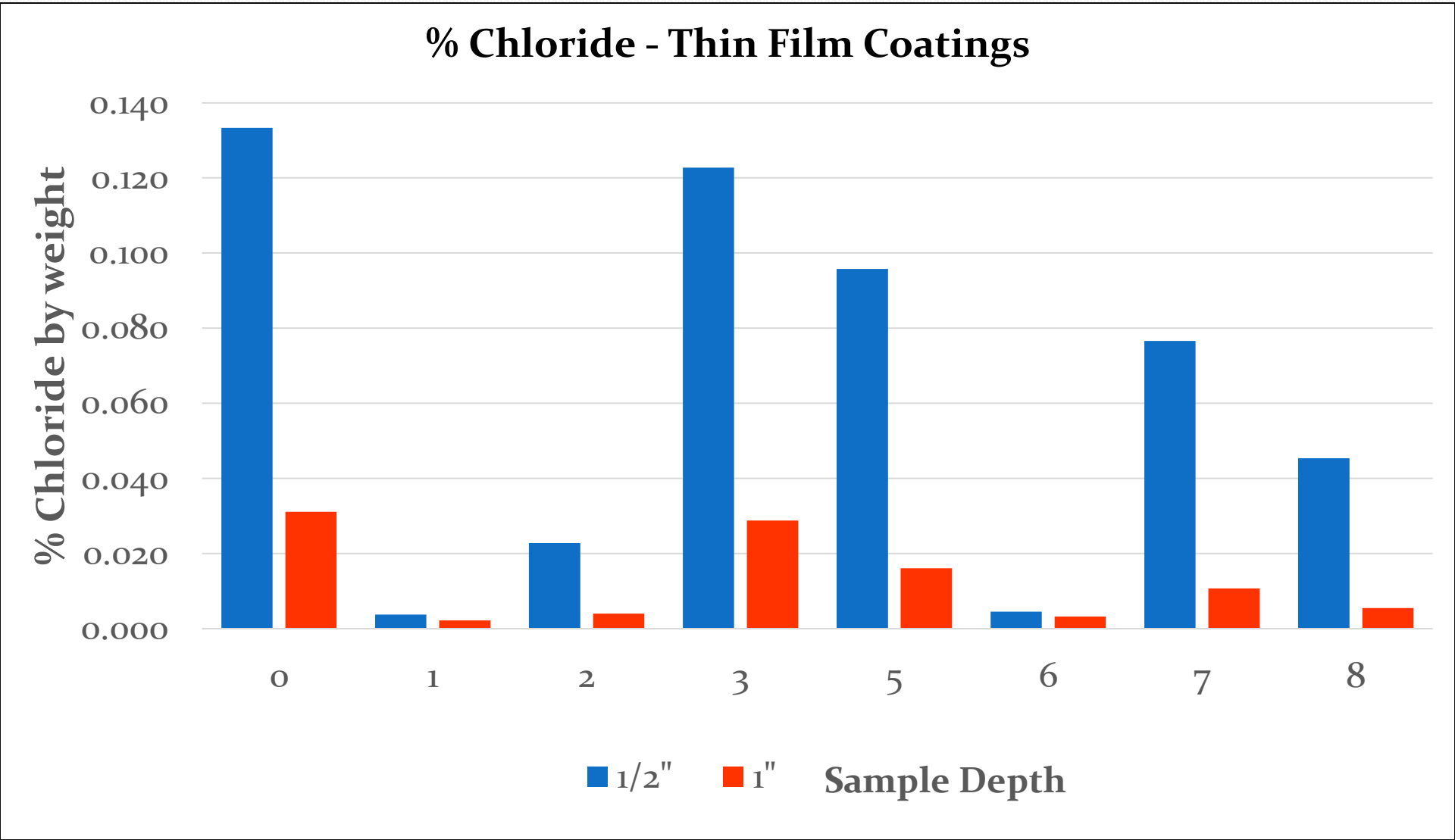
System	Pre-exposure	1,000 hr exposure	2,000 hr exposure	3,000 hr exposure
	Psi	Psi	Psi	Psi
1	738	798	811	1005
2	1029	915	1120	860
3	288	640	707	636
5	798	697	746	810
6	1150	723	858	754
7	505	625	758	767
8	283	255	230	619

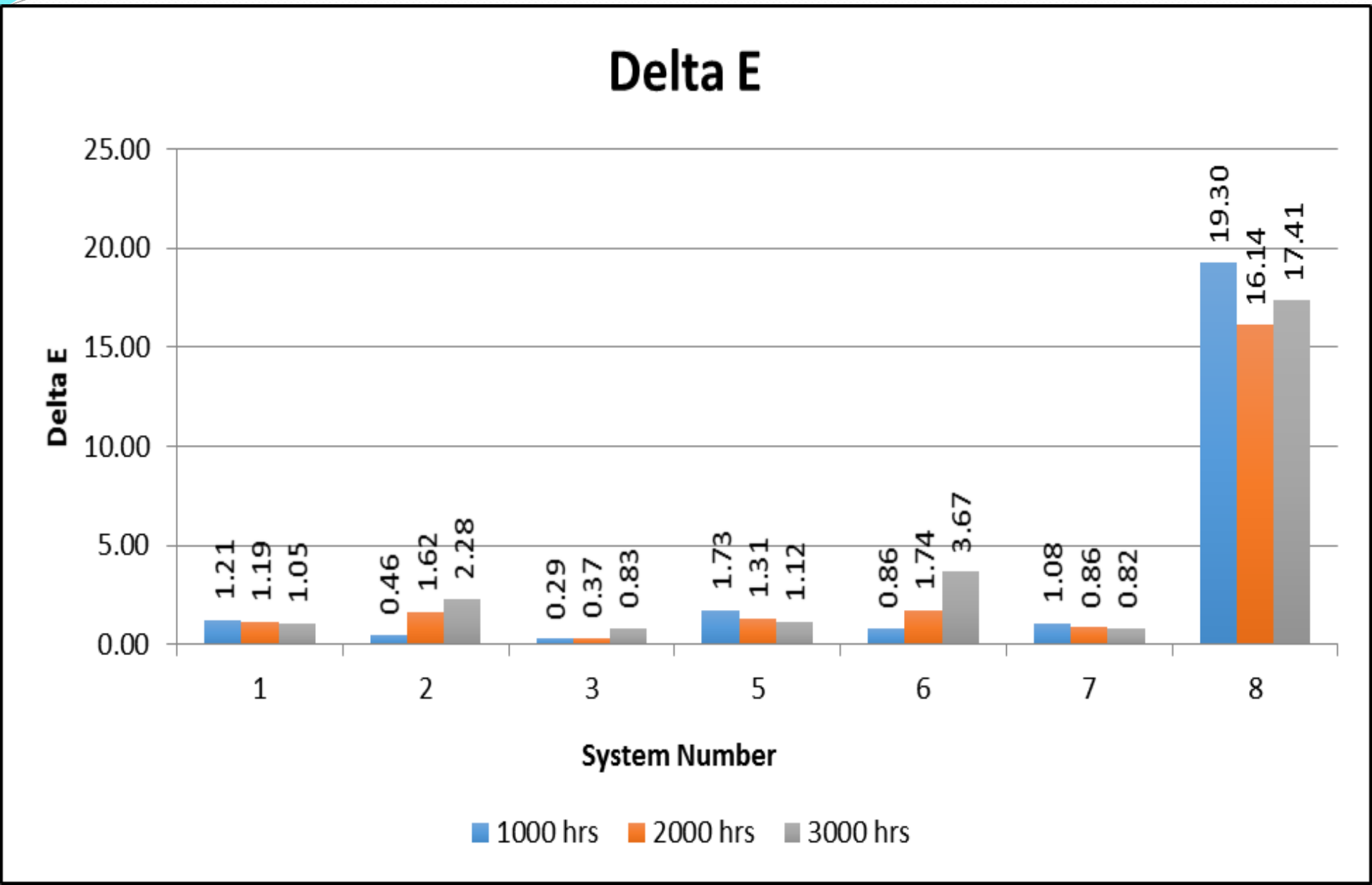
% Cl at 1/2 Inch Depth



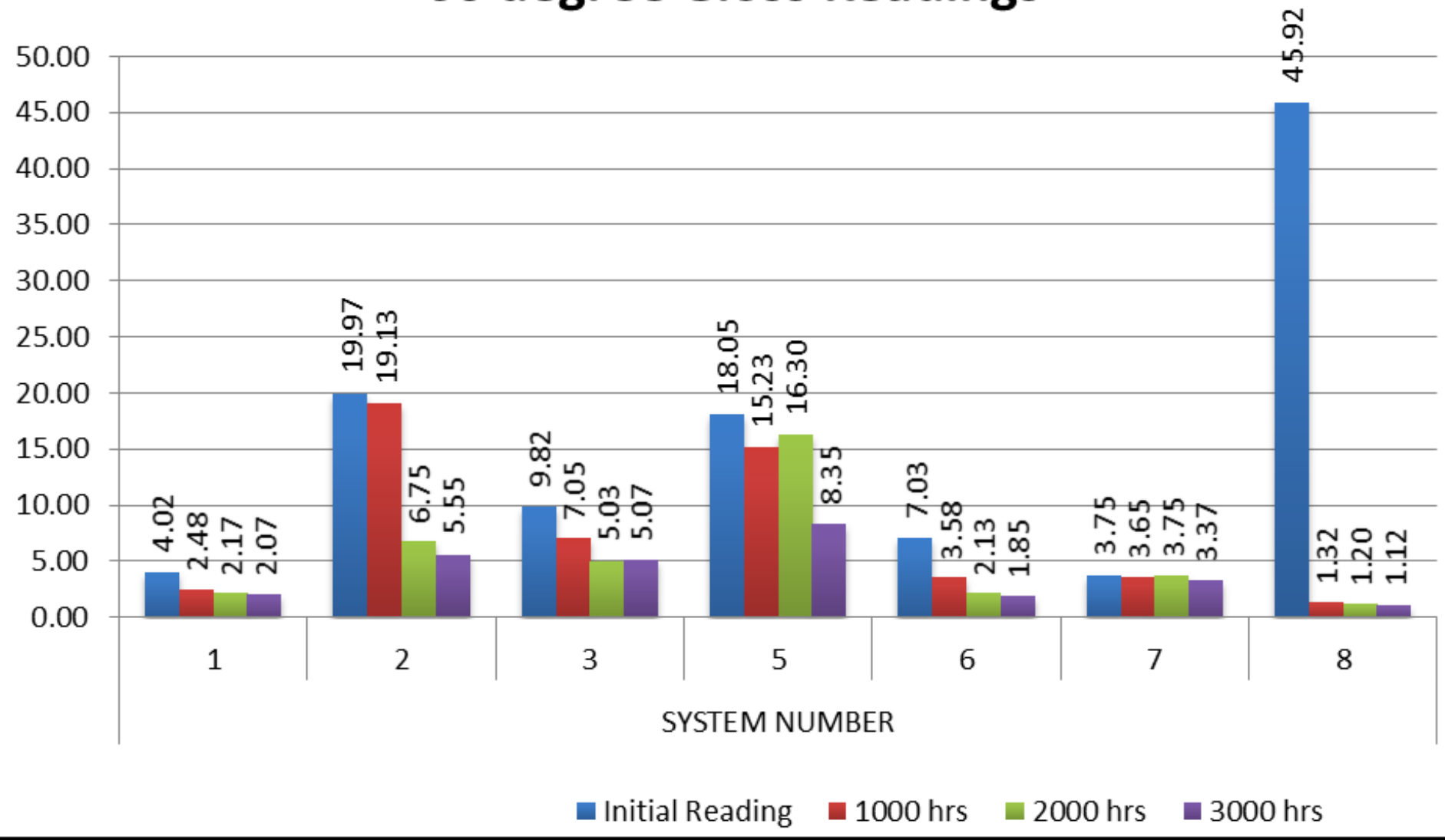
% Cl at 1" Depth


0.100
0.080
0.060
0.040
0.020
0.000
% Chloride by weight
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
%Cl
Sealers

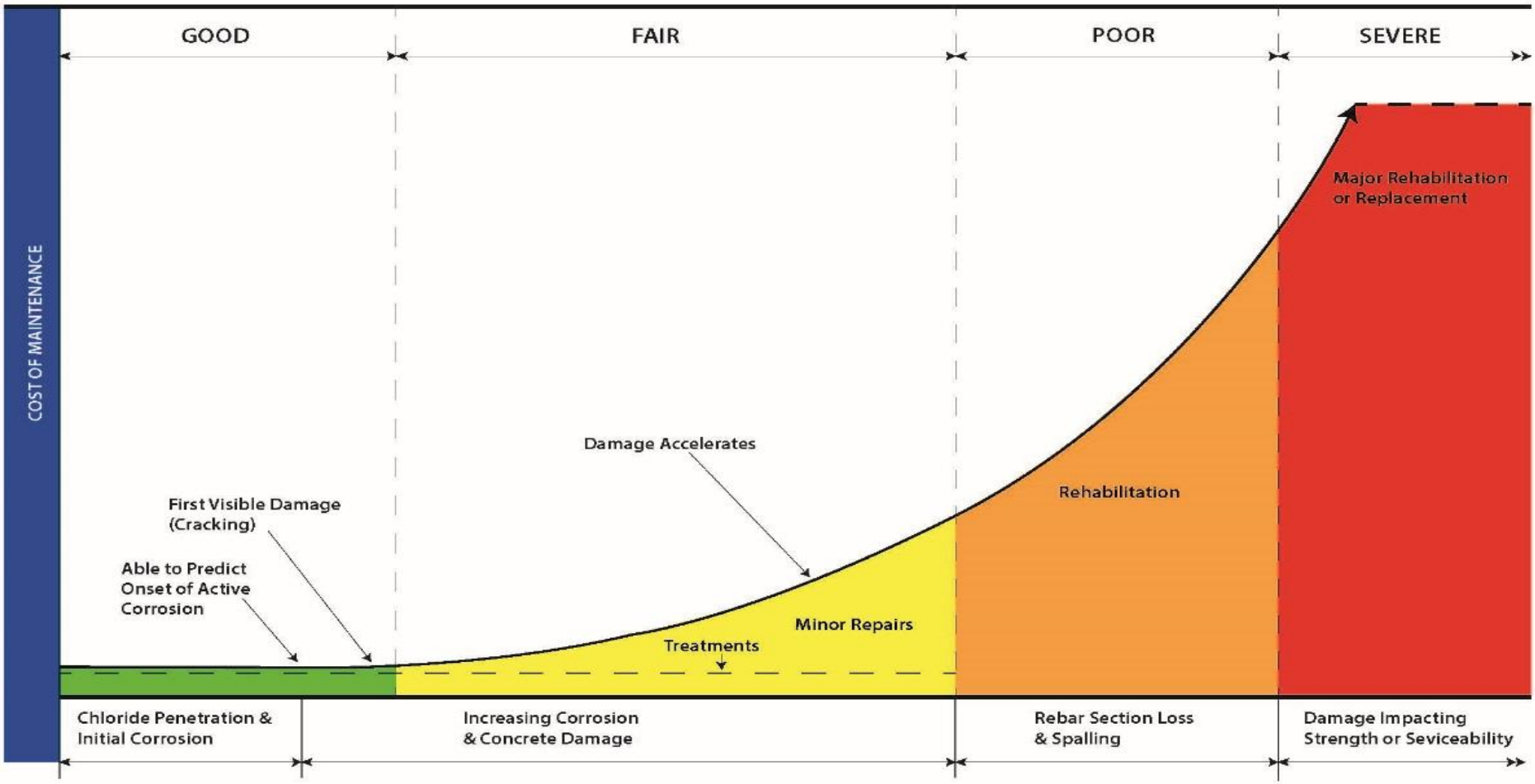

% Chloride - Thin Film Coatings
% Chloride by weight
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0
1
2
3
5
6
7
8
1/2"
1"
Sample Depth


Delta E
25.00
20.00
15.00
10.00
5.00
0.00
Delta E
1.21
1.19
1.05
0.46
1.62
2.28
0.29
0.37
0.83
1.73
1.31
1.12
0.86
1.74
3.67
1.08
0.86
0.82
19.30
16.14
17.41
1
2
3
5
6
7
8
System Number
1000 hrs
2000 hrs
3000 hrs

60 degree Gloss Readings



NBI CONDITION RATINGS



Thin Film Coatings applied in 2004

Conclusions From Thin Film Concrete Coating

- **Adhesion of coatings and the ability to resist chloride penetration are two characteristics very important for concrete coating performance.**
- **Systems 1, 2 and 6 perform better in these characteristics than other systems tested.**
- **Each of these are two-coat systems with epoxy primers. Two systems have urethane top coats and the third has an acrylic top coat.**

Thank You

- Contact information for authors
  - Bobby.meade@uky.edu
  - Derrick.Castle@Sherwin.com
  - Sudhir.palle@uky.edu
  - Ted.hopwood@uky.edu