Protective Coatings for Steel and Concrete Bridge Components

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Content from Two Research Studies

- **KTC-16-03/SPR12-433-1F**
  Thin Film Concrete Coatings

- **KTC-16-08/SPR14-484-1F**
  Chloride Contamination Remediation On Steel Bridges

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**

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**

Result of Increased Chloride Contamination

Result of Increased Chloride Contamination

Result of Increased Chloride Contamination

Research Approach

- Identify potential thin film coatings
- Minimal system application time requirements
- User friendly
- Evaluate in laboratory (ASTM D4587) and field

Performance Criteria Evaluated

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

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 Application

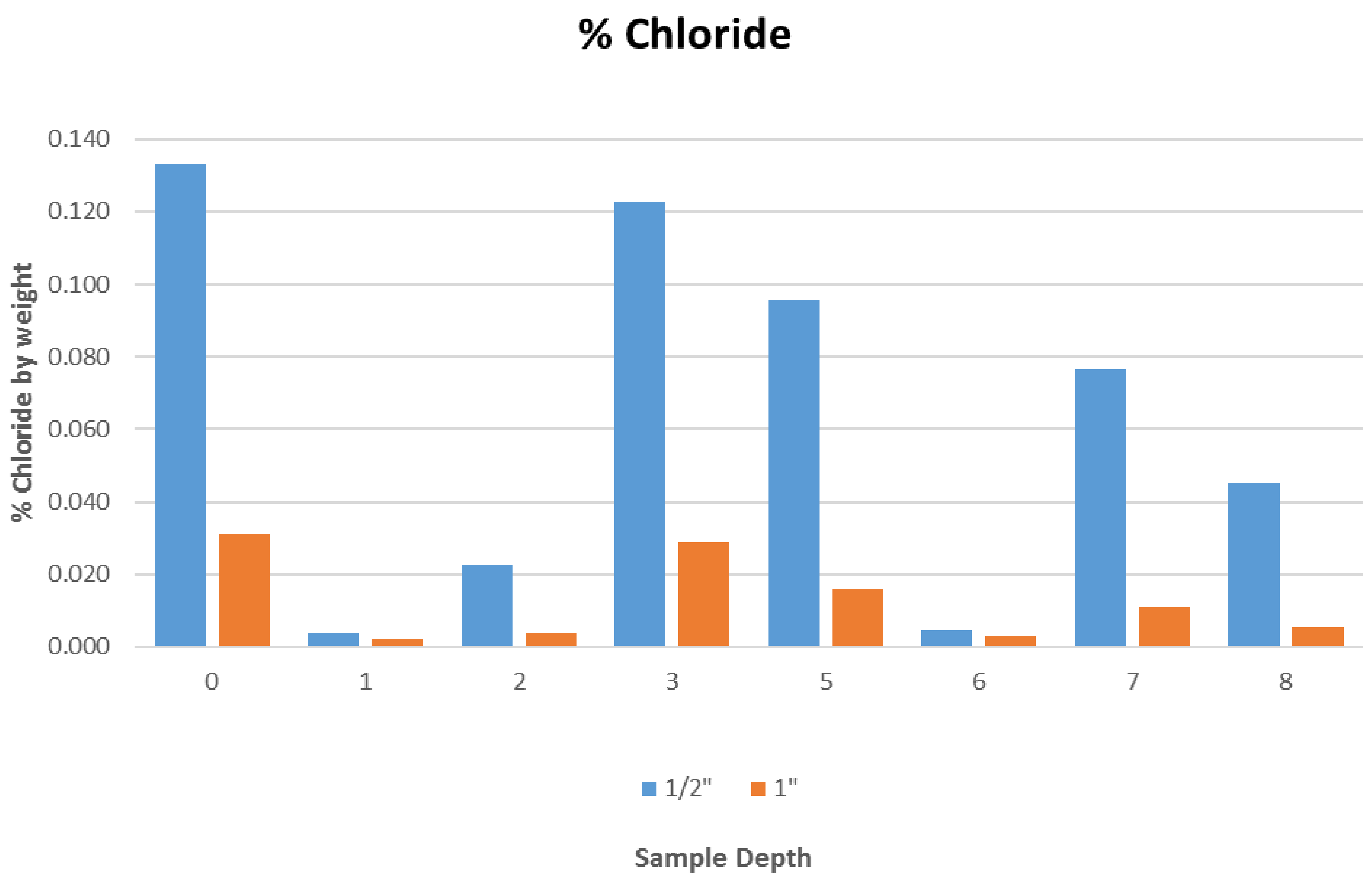
Coating Application

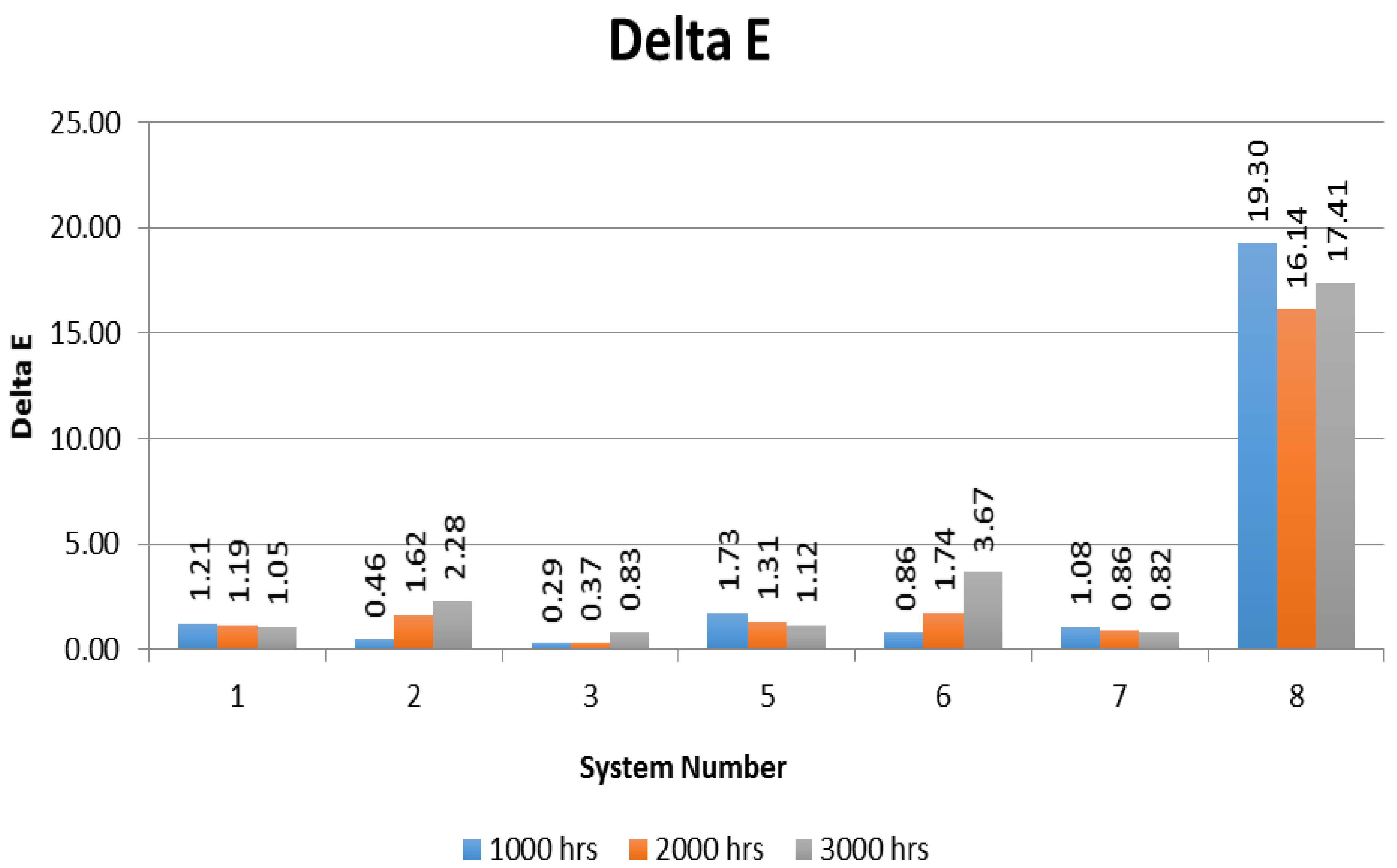
Coating Adhesion - Laboratory

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

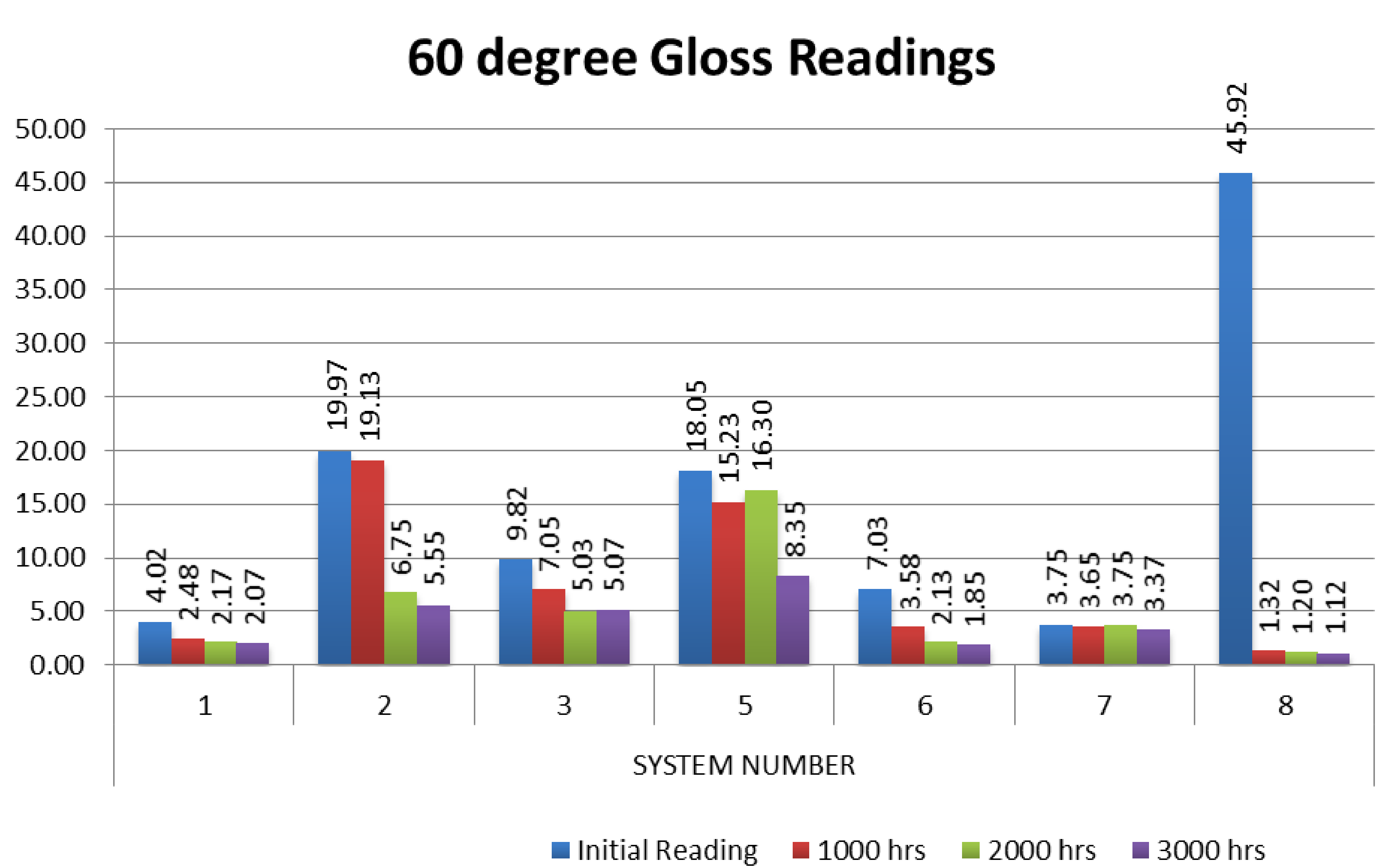
Coating Adhesion - Field

System	6 Month
	Psi
1	493
2	1452
3	549
5	1128
6	1635
7	551
8	519


% Chloride
% 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



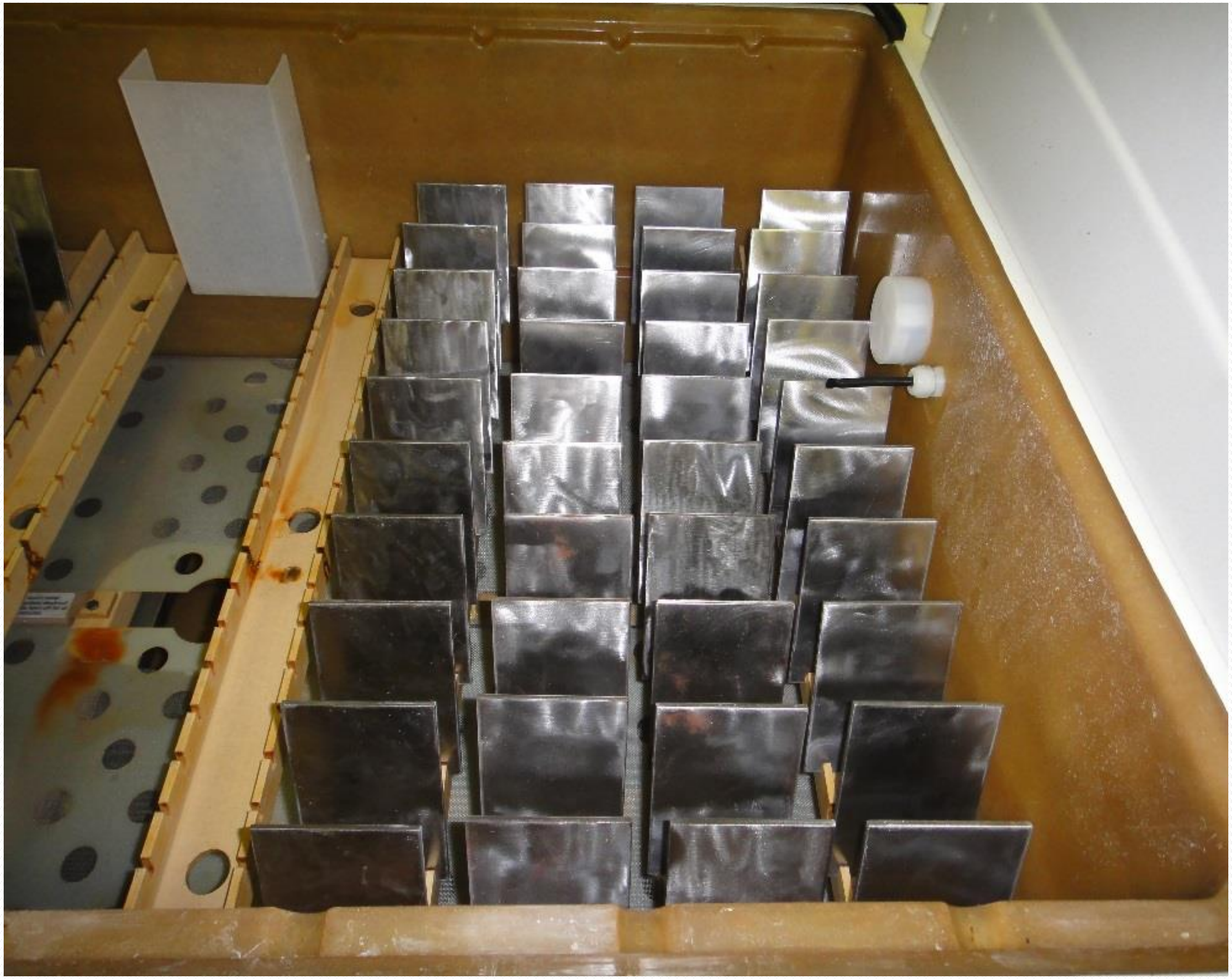
Conclusions From Thin Film Concrete Coating

- **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.**

Research Approach

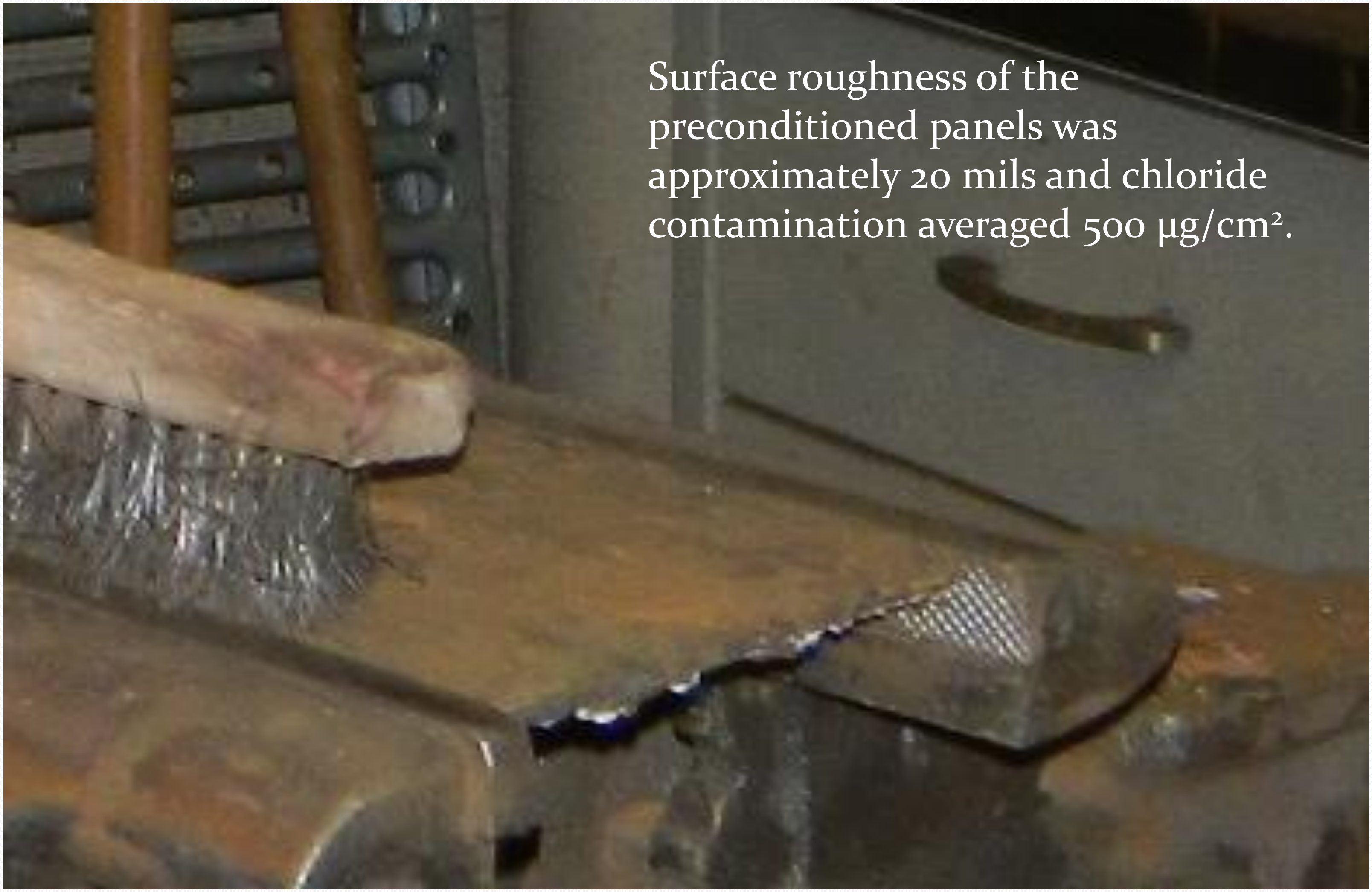
- **Precondition steel panels by cyclic salt fog exposure (ASTM B117)**
- **Clean the corroded steel panels with candidate surface preparation methods**
- **Assess the retained chlorides**
- **Recommend surface preparation methods for KYTC maintenance painting.**

Test Panel Preconditioning

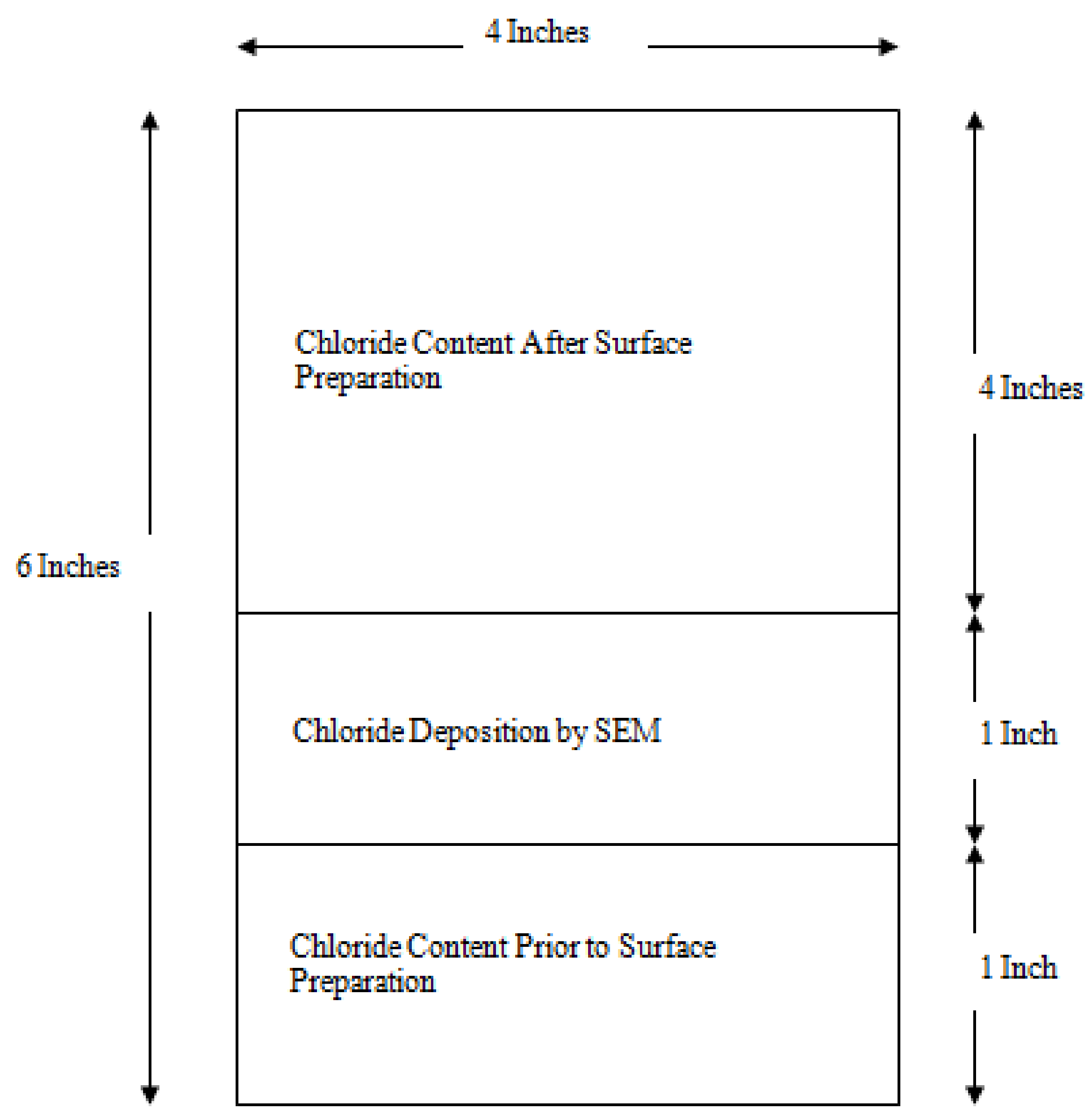


Test Panel Preconditioning

Test Panel Preconditioning



Test Panel Apportionment



Pre-surface Preparation
Boiling Extraction

Surface Preparation Methods

Thirty-two surface preparation methods.

Eight dry methods, with combinations of abrasive material (steel grit, mineral slag, glass, and aluminum oxide), abrasive size, and re-blasting (after flash rusting).

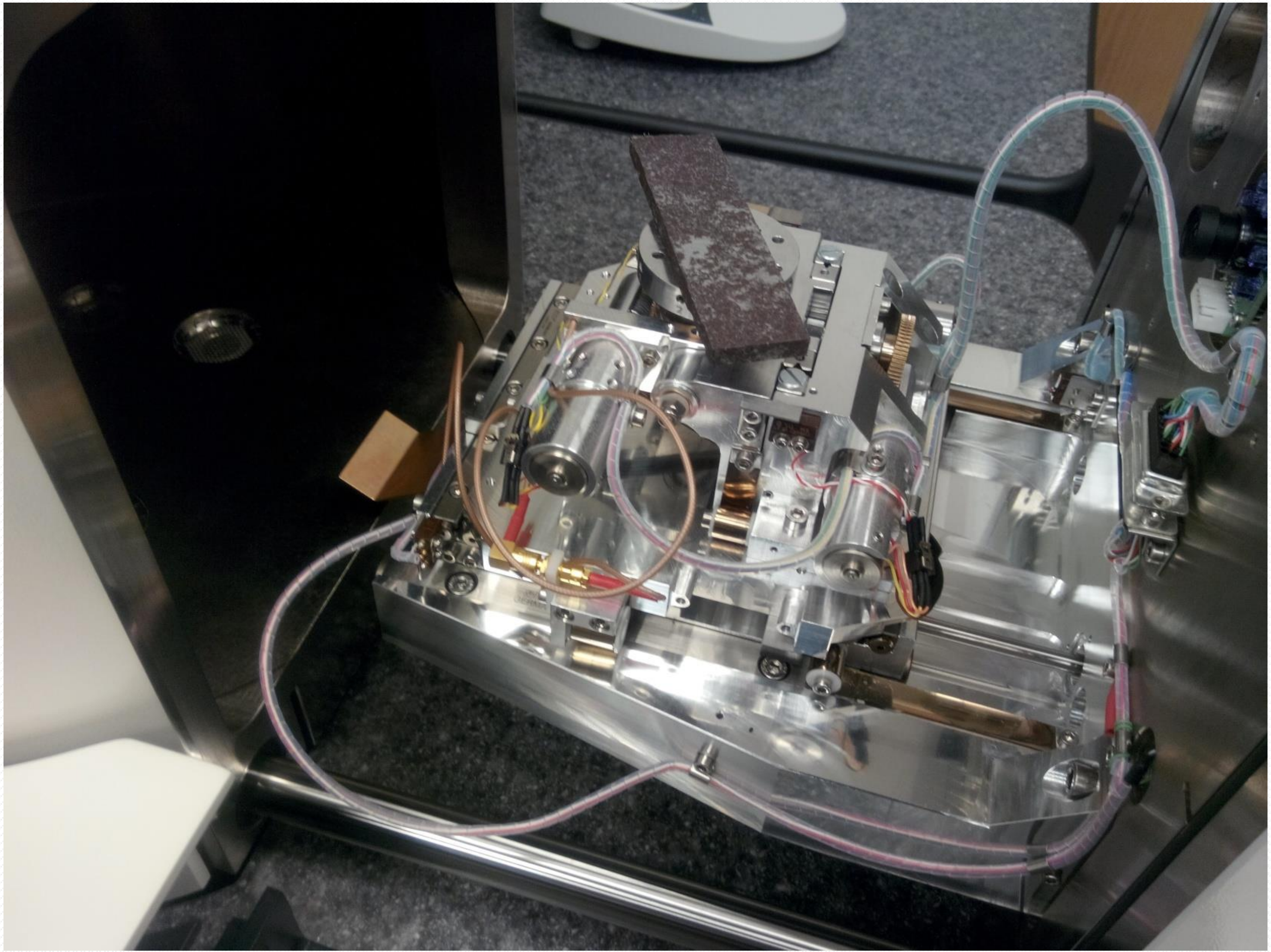
Twenty-four wet methods, with combinations of water pressure, water abrasive mixes, water temperature, and chemical additives.

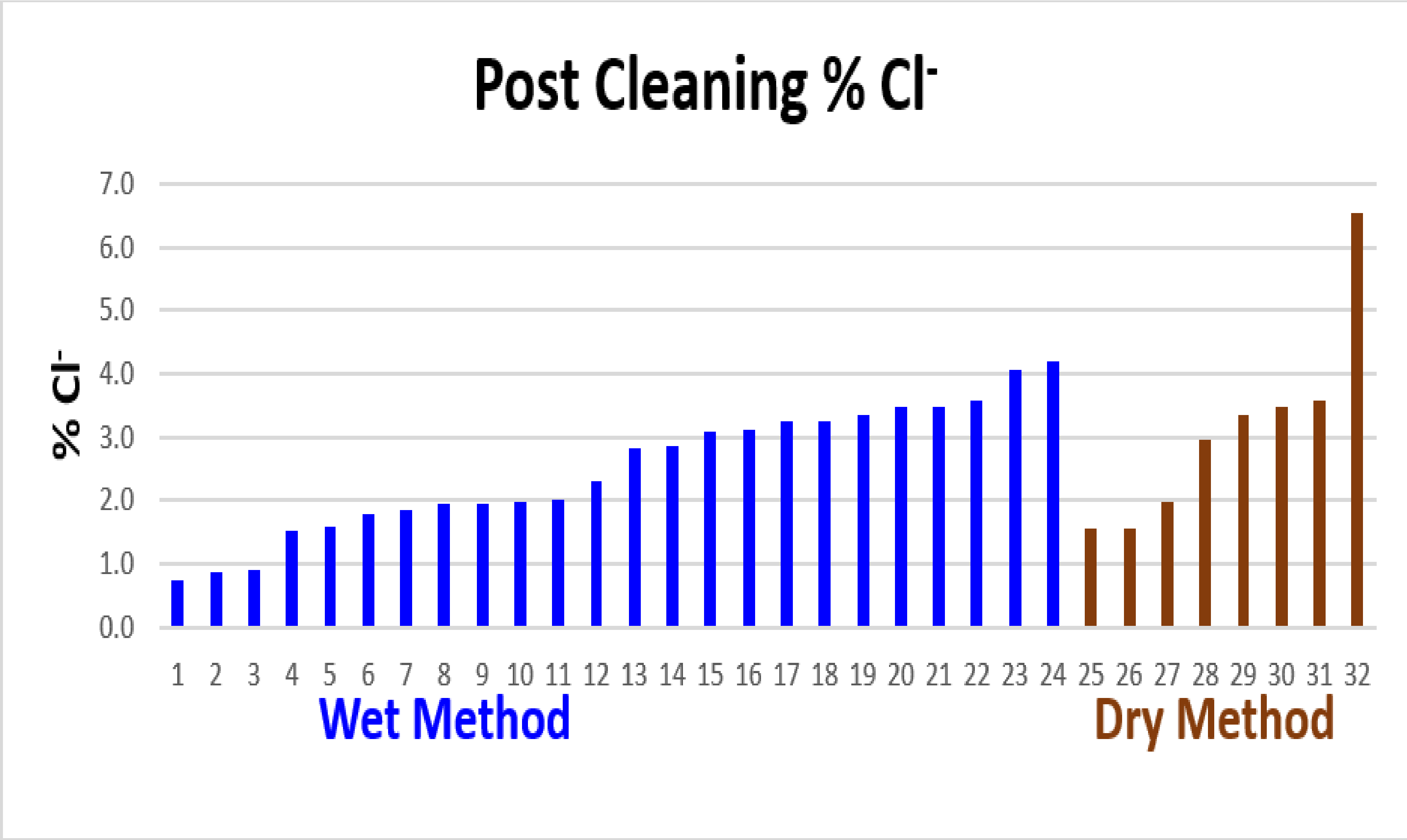
Surface Cleanliness

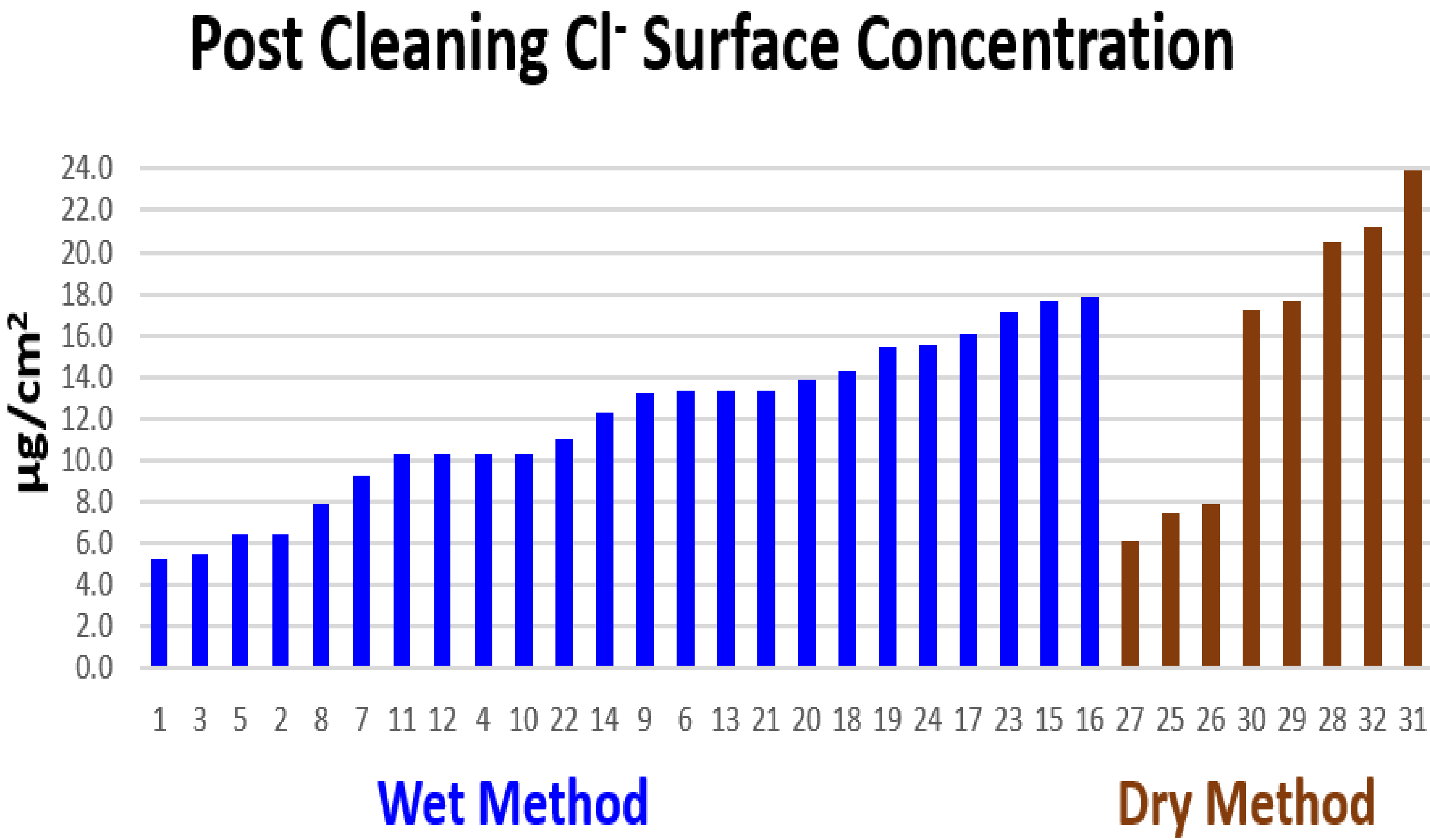
Surface Cleanliness

Post-surface Preparation SEM Assessment

Post-surface Preparation SEM Assessment



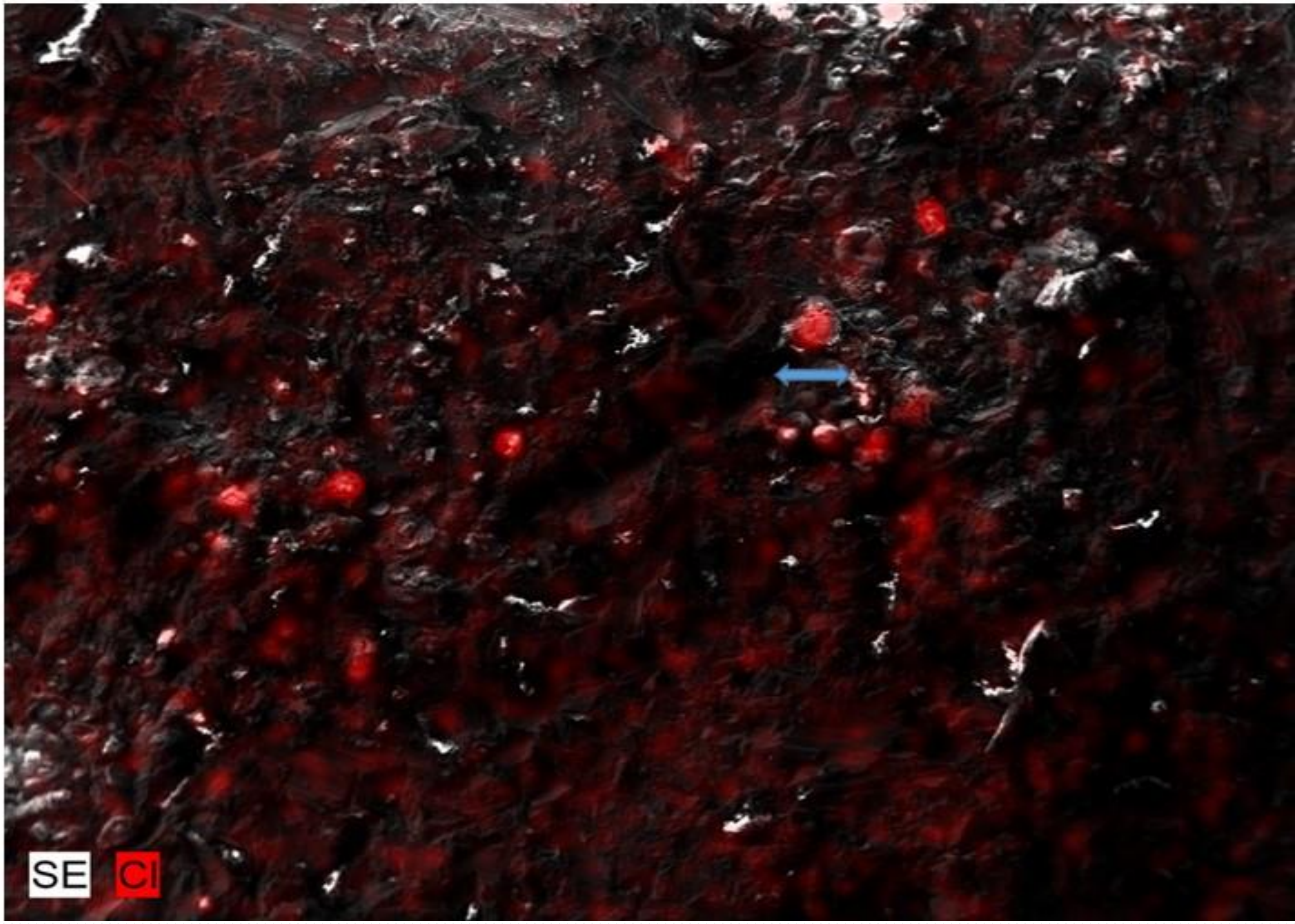

Post Cleaning % Cl-
% Cl-
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Wet Method
Dry Method



Post Cleaning Cl- Surface Concentration
µg/cm2
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1 3 5 2 8 7 11 12 4 10 22 14 9 6 13 21 20 18 19 24 17 23 15 16 27 25 26 30 29 28 32 31
Wet Method
Dry Method

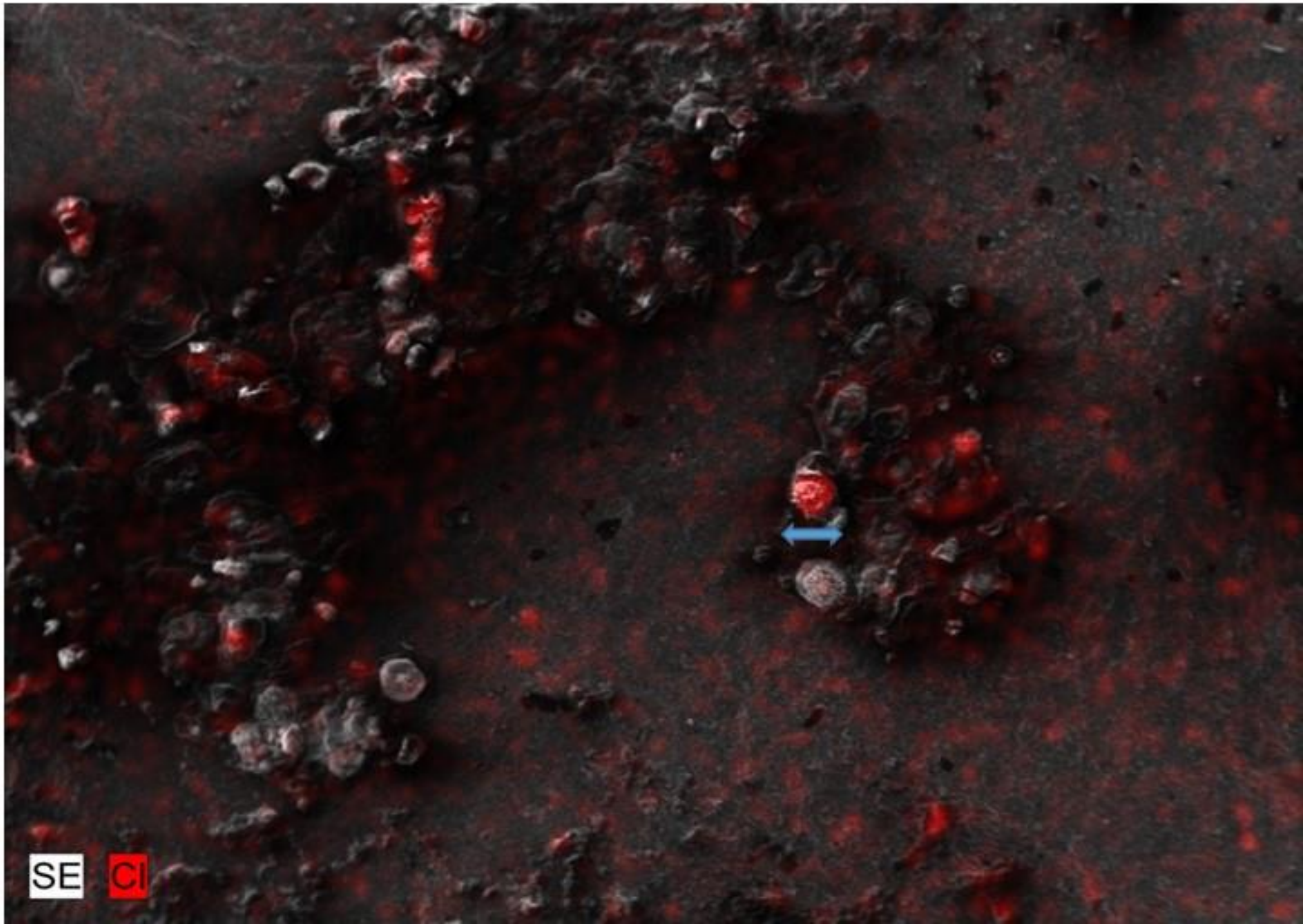
Chemical Water/Abrasive

1. Map is 73 mils x 59 mils.
2. Spot is 4.7 mils across the horizontal axis.
3. Chloride removed – 99.1%
4. Chloride – 6.4 μg/cm^2



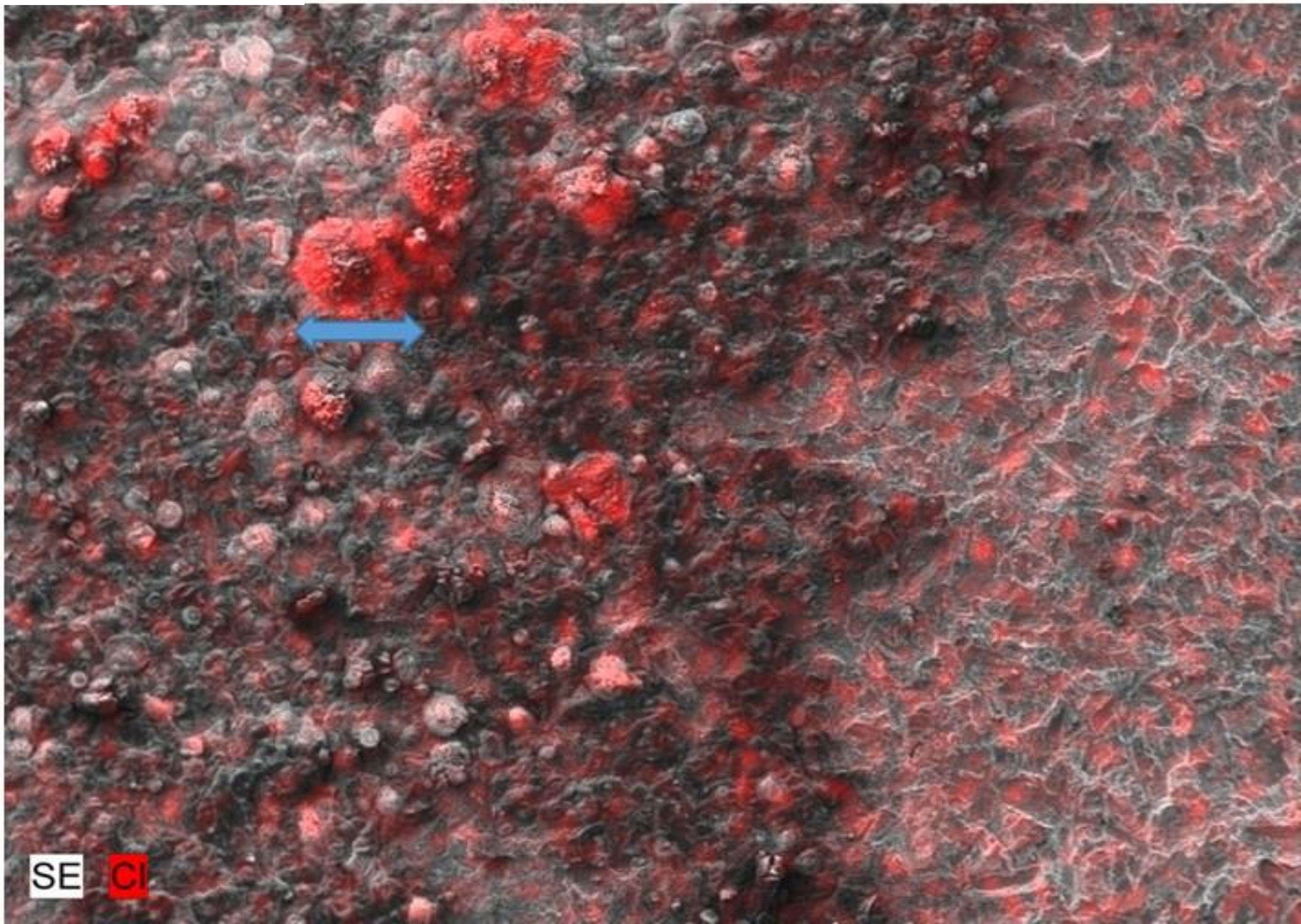
Chemical Water Jetting

1. Map is 50 mils x 37.5 mils.
2. Spot is 2.25 mils across the horizontal axis.
3. Chloride removed – 98.5%
4. Chloride – 10.3 μg/cm^2



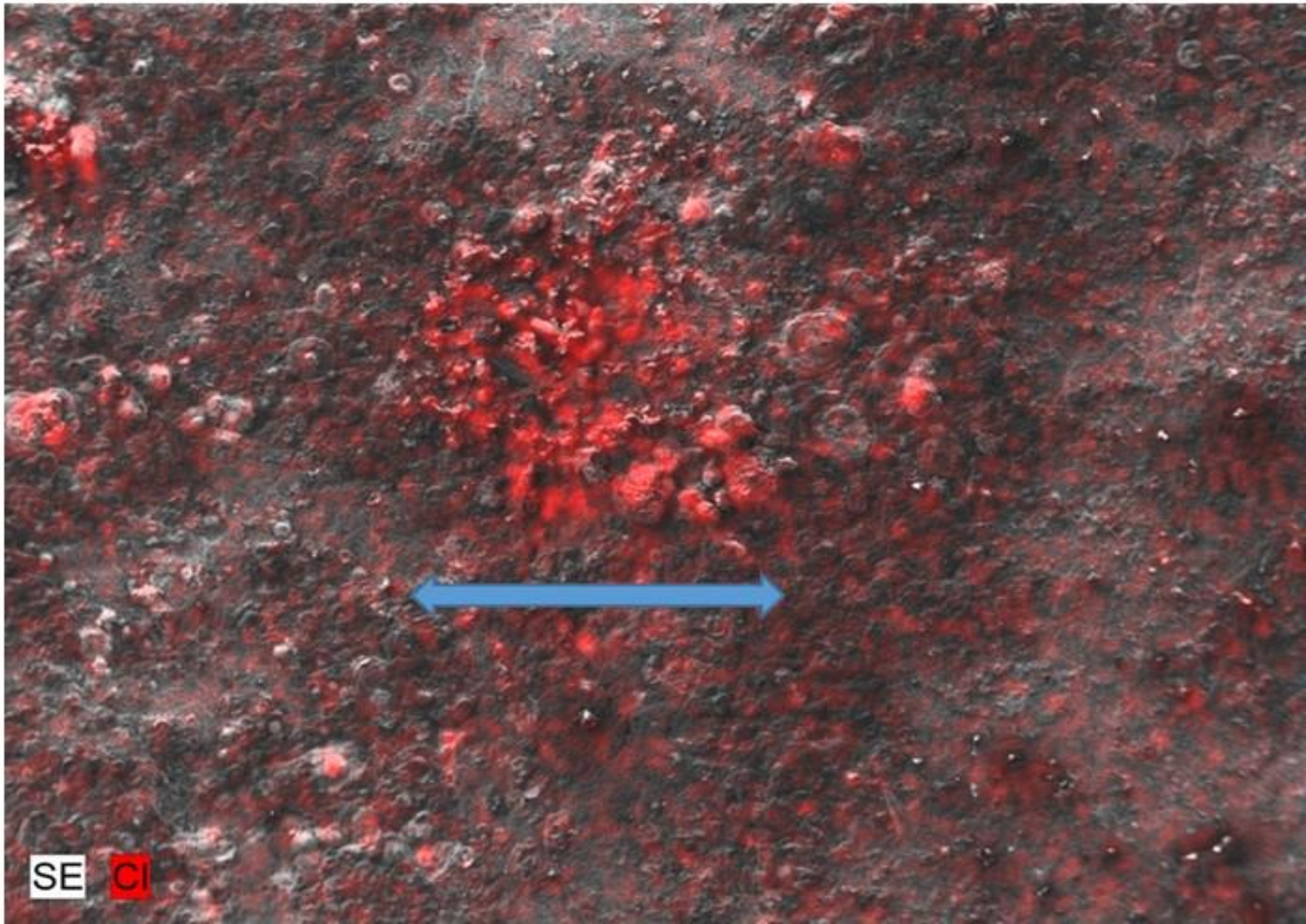
Chemical Steel Grit 40/50

1. Map is 49 mils x 37 mils.
2. Spot is 3.6 mils across the horizontal axis.
3. Chloride removed – 98.1%
4. Chloride – 7.9 μg/cm^2



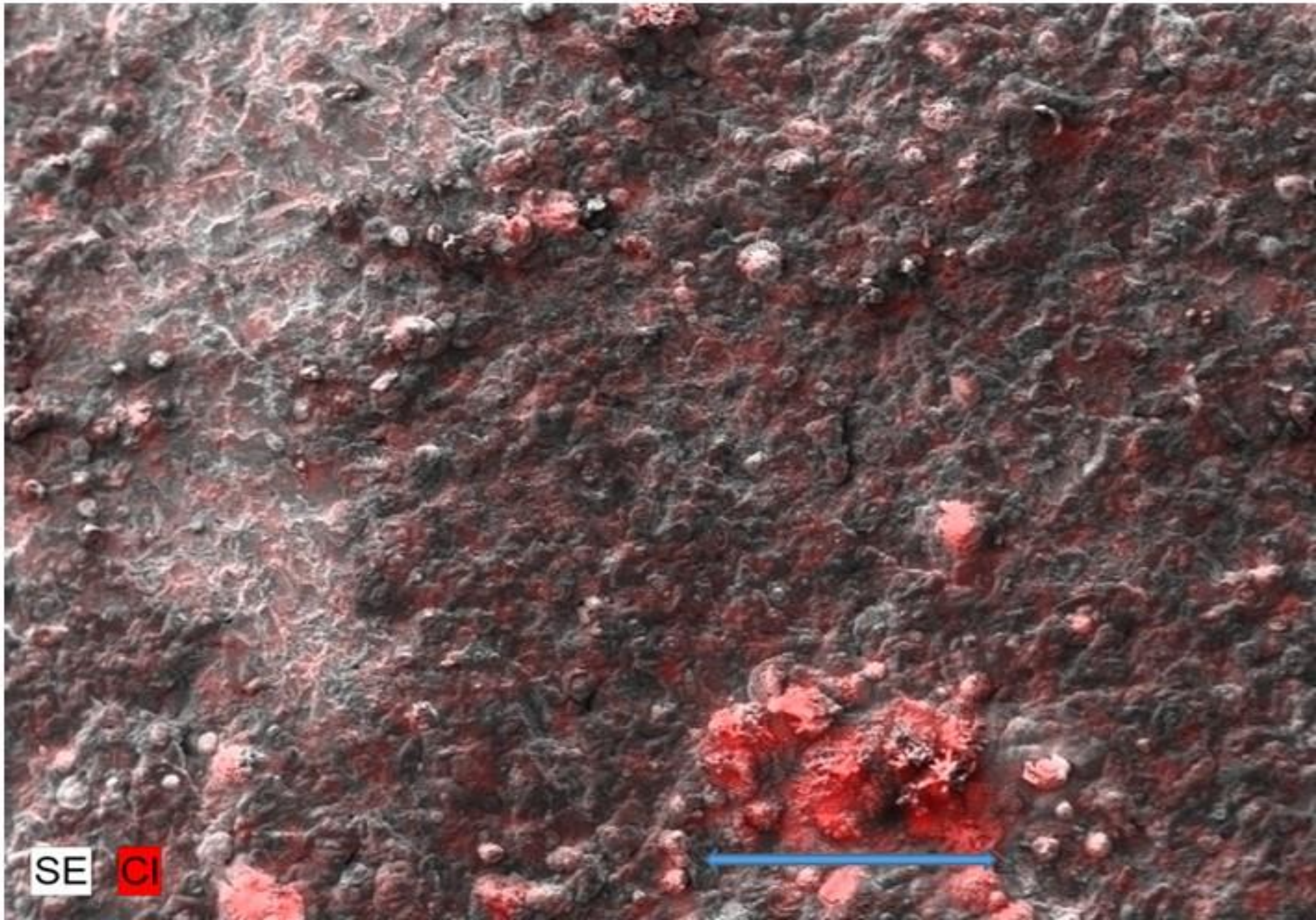
Chemical Mineral Slag

1. Map is 117 mils x 88 mils.
2. Spot is 30.0 mils across the horizontal axis.
3. Chloride removed – 98.0%
4. Chloride – 10.3 µg/cm^2



4.8K psi wash, Steel Grit 40/50

1. Map is 86 mils x 60 mils.
2. Spot is 18.1 mils across the horizontal axis.
3. Chloride removed – 95.9%
4. Chloride – 17.1 μg/cm²



Conclusions

- **Wet surface preparation methods are most effective in remediating chlorides**
- **Repeated dry abrasive blast cleaning is nearly as effective**
- **No method tested cleaned to less than 5 µg/cm^2 chloride**
- **Remaining chlorides are deposited in "hot spots"**

Thank You

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