MIGRATING CORROSION INHIBITORS
FROM GREY TO GREEN

MCI® ADMIXTURES

Migrating Corrosion Inhibiting Admixtures for Reinforced Structures

CORTEC CORPORATION
Environmentally Safe VpCI®/MCI® Technologies

ISO/IEC-17025 LABORATORY TESTING ACCREDITED
ISO 14001 CERTIFIED
ISO 9001 CERTIFIED QUALITY SYSTEM REGISTERED

A Simple Proven Solution to Extend the Service Life of Structures

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MCI® was used to extend the service life of Terra - The Sustainability Pavilion in Dubai.

Cortec® Corporation is the global leader in corrosion inhibitor manufacturing, having been awarded more than 50 patents in corrosion inhibiting technology. Our MCI® (Migrating Corrosion Inhibitor™) Technology protects reinforcing metal in concrete from corrosion.

Corroded metal reinforcement is often the cause of deteriorated concrete, leading to costly repairs, financial losses, and safety concerns.

Cortec® offers a variety of solutions that rehabilitate existing concrete structures and extend the life span of new structures. MCI® inhibitors are unique in their ability to migrate through concrete and protect embedded ferrous metals. Our MCI® products for concrete help maintain structural integrity, repair vulnerable structures, and conserve resources.

The construction industry is a key contributor to carbon emissions due to the energy-intensive manufacturing processes for cement and steel. Increasing structures' service lives with MCI® at the time of construction reduces the need for repairs or rebuilding, thus promoting more sustainable construction practices by reducing the need for additional cement.

Corrosion in Concrete: How Does It Happen?

New concrete initially provides an excellent protective atmosphere for steel because the concrete's high alkalinity creates a protective passive oxide film on the embedded rebars. However, environmental factors such as chlorides, carbonation, and other pollutants can lower the pH or compromise the passive oxide layer, putting reinforcing steel at greater risk for corrosion.

The corrosion process itself involves an electrochemical reaction in which parts of the rebar become active "anodic" points. Ions at these points flow to "cathodic" points where they react to form rust. Once started, the corrosion rate is affected by the concrete's electrical resistivity, moisture content, temperature, chloride ions, and oxygen concentration at the steel level. As rust formation continues, it can expand to take up to six times the original volume of embedded reinforcement, causing cracking, delamination, and spalling of the concrete.

Chlorides

Chloride ions can penetrate the passive oxide film on concrete reinforcement. Once chlorides reach a certain level in the concrete, corrosion starts. Concrete can be exposed to chlorides from external sources such as deicing salts, seawater, and airborne salts. Chlorides can also be internally present in concrete early on from using seawater (for mixing), chloride-contaminated aggregates, or chloride-containing set accelerators.

Carbonation

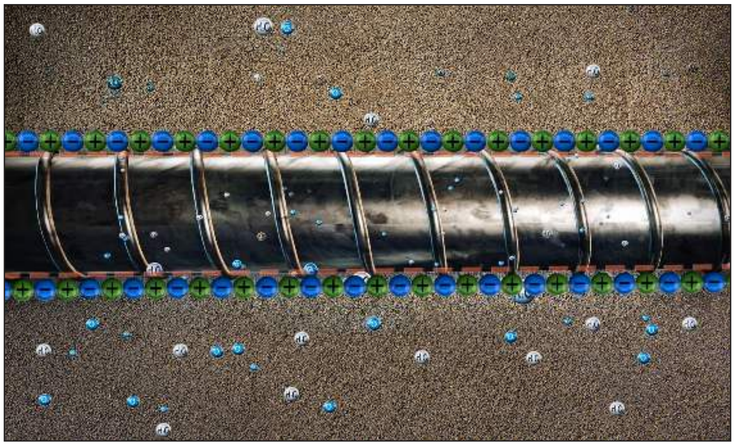
Carbonation is the process by which carbon dioxide in the air reacts with hydroxides (such as calcium hydroxide) in the concrete to form carbonates. This reaction significantly lowers concrete pH. When the pH of concrete surrounding embedded reinforcing steel drops below 12, the protective oxide layer is lost, and the corrosion process begins. Carbonation-induced corrosion may increase with exposure to higher amounts of carbon dioxide such as those in highly polluted cities, or it may happen due to prolonged carbon dioxide exposure as in the case of historical structures.

Acid Rain / Industrial Pollutants

Sulfuric and nitric acids formed from acid rain attack concrete by dissolving the cement paste and certain aggregates. They also reduce the pH of the concrete, allowing the corrosion process to begin, similarly to the workings of carbonation. Pollutants such as sulfates can also attack the concrete by reacting with hydrated compounds in the hardened cement paste. These reactions can lead to disintegration of the concrete, making embedded reinforcement more susceptible to corrosive attack.

What is MCI®?

MCIs are organic corrosion inhibitors that are amine based (amine alcohols and amine carboxylates). They are classified as mixed inhibitors, meaning they affect both anodic and cathodic portions of a corrosion cell. MCIs adsorb onto metals, forming a protective molecular layer on metal surfaces. This protective layer inhibits corrosive elements from further reacting with embedded reinforcement and reduces corrosion rates once initiated.



Why MCI® Admixtures?

Once a concrete structure is built, it is impractical to expose reinforcing steel and coat it with epoxy to protect it from corrosion. Cathodic protection systems are complicated, expensive, require steel continuity, and may need constant monitoring. Cortec® MCI®, however, can be easily added to new concrete or used for rehabilitation. It will not delay construction or increase construction costs other than the small cost of the material. Unlike standard anodic inhibitors, Cortec® MCIs do not have to be in direct contact with the reinforcing steel upon application because they can migrate to the steel and protect it. MCI® admixtures are also dosed independently of expected chloride levels.

When specified in new construction, Cortec's MCI® line of concrete admixtures offers reinforcing steel superior corrosion protection against carbonation and chloride attack.

MCI® Admixtures: Different Forms for Various Uses

MCI® admixtures come in different forms to fit different applications and industry needs. MCI®-2005, MCI®-2005 NS, and MCI®-2005 AL are liquid admixtures that can be used with ready-mix cast-in-place concrete, shotcrete, and precast concrete.

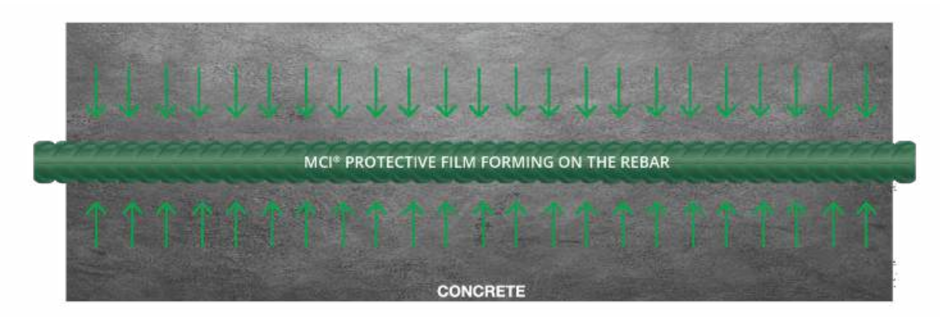
MCI®-2006 and MCI®-2006 NS are powder admixtures that can be blended with dry cementitious materials to improve their corrosion-resistant properties. They can also be used with dry shotcrete mixes.

The MCI® Grenade™, Metric MCI® Grenade™, and MCI® Grenade™ XL are pre-measured powder admixtures packaged in water-soluble bags for ease of use, storage, and on-site addition. MCI® Mini Grenades are smaller versions for easy on-site use with repair mortars.

MCI® Grenades and MCI® Mini Grenades

How Do MCI® Admixtures Move Inside the Concrete?

1. MCI® moves as a liquid within the concrete matrix. MCI® is admixed either with the batch water or directly in a mixer. With adequate mixing, the inhibitor is evenly dispersed in the concrete.
2. MCI® moves in a vapor phase throughout the concrete pore structure. This movement is governed by Fick's Law, meaning molecules move throughout the matrix from areas of high concentration to areas of low concentration.
3. When MCI® is near the steel, it has an ionic attraction to it, and forms its protective molecular layer. Independent testing has confirmed that MCI® can adsorb onto metal to a depth of 75-85 nm, forming a layer that is between 20 and 100 Å thick. In the same testing, chlorides were shown to penetrate only 60 nm deep. This confirmed the ability of MCI® to displace chlorides on the metal surface and provide protection even in their presence.



Cortec® Admixture Dispensing Equipment

Cortec® Corporation can provide both portable and direct-feed dispensing systems for precise dosing of MCI® admixtures into ready-mix concrete.

Portable MCI® Admixture Dispensing Unit

Direct-Feed MCI®
Admixture Dispensing Unit

Can You Confirm the Presence of MCI® in Concrete?

Different methods are available to verify the presence of MCI® admixtures in fresh or hardened concrete. Please contact your Cortec® rep regarding the best method for your application.

How Do MCI® Admixtures Perform?

MCI® admixtures have been tested and evaluated as per industry standards. Also, they have been assessed and approved by many DOTs. Test methods for evaluating MCI® performance include (but are not limited to) the following:

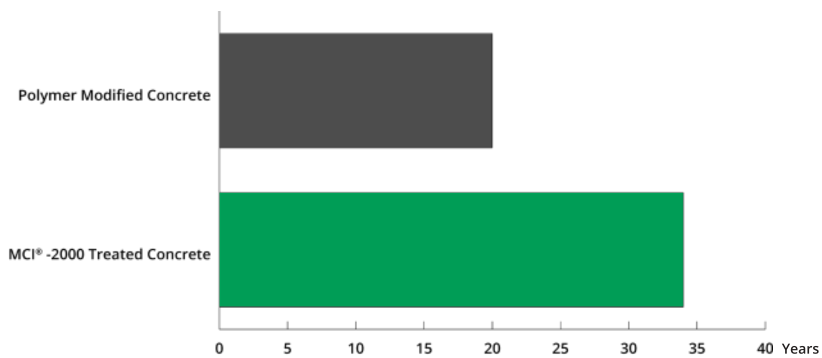
- ASTM G109: Standard Test Methods for Determining Effects of Chemical Admixtures on Corrosion of Embedded Steel Reinforcement in Concrete Exposed to Chloride Environments
- ASTM G180: Standard Test Method for Corrosion Inhibiting Admixtures for Steel in Concrete by Polarization Resistance in Cementitious Slurries
- On-Site Polarization Resistance Testing
- ASTM C494 Standard Specification for Chemical Admixtures for Concrete

The SHRP Program

The SHRP Program involved both lab testing and actual field installation on bridges throughout the USA.

In comparison to polymer-modified concrete overlays, MCI®-treated concrete overlays demonstrated a dramatic extension of predicted service life.

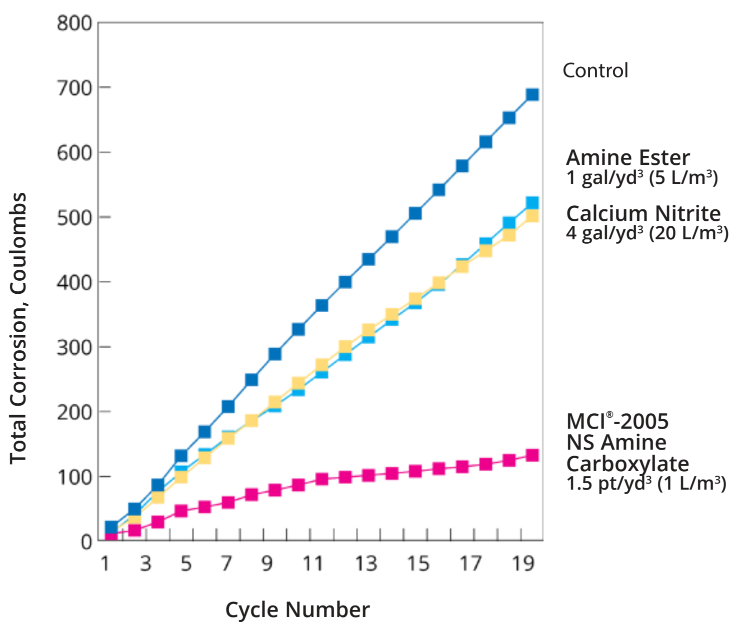
Predicted Service Life of Bridge Decks



ASTM C1582

It is an industry practice to use corrosion inhibiting admixtures that meet requirements of ASTM C1582, a standard specification for corrosion inhibiting admixtures in chloride environments. To meet the specification requirements, the corrosion inhibiting admixture needs to meet certain ASTM C494 criteria for physical concrete properties and pass one of two corrosion tests: ASTM G109 or ASTM G180.

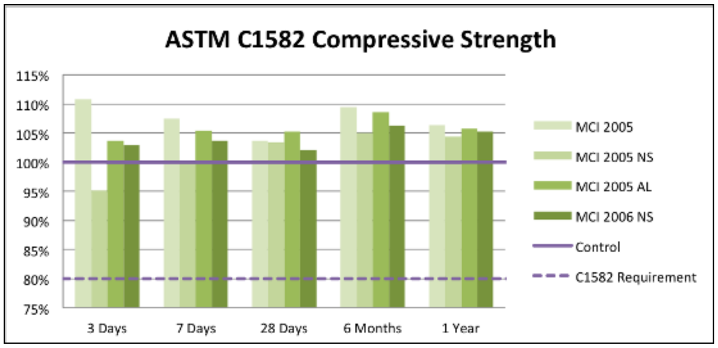
MCI®-2005, MCI®-2005 NS, and MCI®-2005 AL meet this standard specification for chloride corrosion inhibiting admixtures.

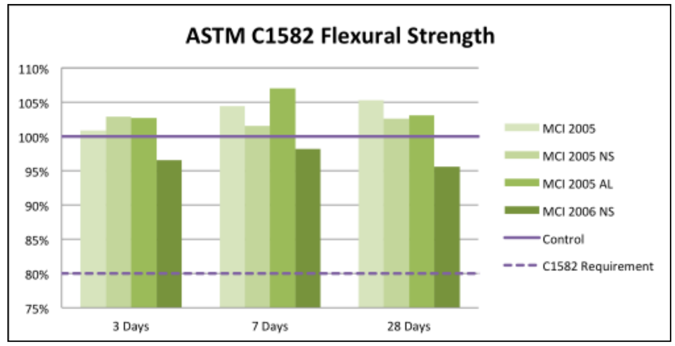


Cracked Beam Testing

Cracked beam testing is a modified version of ASTM G109 in which the concrete specimens are cracked to accelerate the corrosion process.

Despite the small dose, MCI®-2005 NS outperformed other commercially available admixtures in slowing corrosion rates in cracked concrete





MCI®-2005					
	Control	MCI®-2005	Relative to Control	ASTM C1582 Requirements	Result
Initial Set (Minutes)	312	431	119	+/- 210 minutes of control	Meets requirement
Final Set (Minutes)	404	524	120	+/- 210 minutes of control	Meets requirement
Compressive Strength (PSI) - 3 Days, 28 Days, 1 Year	3290, 5143, 6463	3647, 5330, 6877	111%, 104%, 106%	Min 80% of control	Meets requirement
Freeze Thaw Durability	99.1	98.8	99.80%	RDF 80%	Meets requirement

MCI®-2005 NS					
	Control	MCI®-2005 NS	Relative to Control	ASTM C1582 Requirements	Result
Initial Set (Minutes)	308	318	10	+/- 210 minutes of control	Meets requirement
Final Set (Minutes)	406	419	13	+/- 210 minutes of control	Meets requirement
Compressive Strength (PSI) - 3 Days, 28 Days, 1 Year	3297, 5167, 6463	3137, 5340, 6773	95%, 103%, 105%	Min 80% of control	Meets requirement
Freeze Thaw Durability	98.5	97.1	98.60%	RDF 80%	Meets requirement

MCI®-2005 AL					
	Control	MCI®-2005 AL	Relative to Control	ASTM C1582 Requirements	Result
Initial Set (Minutes)	300	344	44	+/- 210 minutes of control	Meets requirement
Final Set (Minutes)	396	438	42	+/- 210 minutes of control	Meets requirement
Compressive Strength (PSI) - 3 Days, 28 Days, 1 Year	3270, 5080, 6453	3390, 5240, 6823	104%, 103%, 106%	Min 80% of control	Meets requirement
Freeze Thaw Durability	98.8	98.1	99.20%	RDF 80%	Meets requirement

MCI®-2006 NS					
	Control	MCI®-2006 NS	Relative to Control	ASTM C1582 Requirements	Result
Initial Set (Minutes)	239	257	18	+/- 210 minutes of control	Meets requirement
Final Set (Minutes)	318	329	11	+/- 210 minutes of control	Meets requirement
Compressive Strength (PSI) - 3 Days, 28 Days, 1 Year	4340, 6190, 7380	4780, 6710, 8150	110%, 108%, 110%	Min 80% of control	Meets requirement
Freeze Thaw Durability			96%	RDF 80%	Meets requirement

Product Selection Guide

Category	Subcategory	Product	Description	Approximate Dosage Rate	Packaging
Admixtures	Amine Carboxylate Based	MCI®-2005	Liquid, amine carboxylate based concrete admixture. Can retard concrete setting time 3-4 hours at 70 ºF (21 ºC). Patented.	1 pt/yd^3 (0.6 L/m^3)	5 gal (19 L) pails 55 gal (208 L) drums 275 gal (1040 L) totes
		MCI®-2005 NS	Liquid, normal set version of MCI®-2005. Can not be frozen. Patented.	1.5 pts/yd^3 (1 L/m^3)	5 gal (19 L) pails 55 gal (208 L) drums 275 gal (1040 L) totes
		MCI®-2005 AL	Liquid, normal set version of MCI®-2005 with less ammonia odor. Patented.	1.5 pts/yd^3 (1 L/m^3)	5 gal (19 L) pails 55 gal (208 L) drums 275 gal (1040 L) totes
		MCI®-2006	Powder, amine carboxylate based concrete admixture. Can retard concrete setting time 3-4 hours at 70 ºF (21 ºC). Patented.	1 lb/yd^3 (0.6 kg/m^3)	5 lb (2.3 kg) boxes 50 lb (22.7 kg) drums 100 lb (45.4 kg) drums
		MCI®-2006 NS	Powder, normal set version of MCI®-2006. Patented.	1 lb/yd^3 (0.6 kg/m^3)	5 lb (2.3 kg) boxes 50 lb (22.7 kg) drums 100 lb (45.4 kg) drums
	Amino Alcohol Based	MCI®-2000	Liquid, amino alcohol based concrete admixture. Patented.	1 pt/yd^3 (0.6 L/m^3)	5 gal (19 L) pails 550 gal (208 L) drums
		MCI®-2001	Powder, fumed silica /MCI®-2000 combination. Patented.	3 lb/yd^3 (1.8 kg/m^3)	5 lb (2.3 kg) boxes 50 lb (22.7 kg) drums 100 lb (45.4 kg) drums
	Specialty	MCI® Grenade™	MCI®-2006 NS powder pre-measured into water-soluble bags for admixing into concrete. Patented.	1 grenade/yd^3	40 grenades/drum
		MCI® Grenade™ XL	MCI®-2006 NS powder pre-measured into water-soluble bags for admixing into concrete. Patented.	1 grenade/5 yd^3 (3.8 m^3)	10 grenades/drum
		Metric MCI® Grenade™	MCI®-2006 NS powder pre-measured into water-soluble bags for admixing into concrete. Patented.	1 grenade/m^3	32 grenades/drum
		MCI® Mini Grenade™	MCI®-2006 NS powder pre-measured into water-soluble bags for admixing into concrete. Patented.	1 grenade/0.5-0.6 ft^3 (1 grenade/0.015 m^3)	100 grenades/carton
		MCI®-2012	Concrete waterproofing admixture that is enhanced with MCI® for added corrosion protection.	1.7 quarts/yd^3 (2.1 L/m^3)	5 gal (19 L) pails 55 gal (208 L) drums 275 gal (1040 L) totes

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