

This document has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

ACI 515.1 R-79
(Revised 1985)

A Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete

Reported by ACI Committee 515

Byron I. Zolin, Chairman

Warner K. Babcock
Arthur E. Blackman, Sr.
Donald E. Brotherson
Robert W. Gaul

Clark R. Gunness
Kenneth A. Heffner
A. L. Hendricks
James E. Kubanick

Dorothy M. Lawrence
Stella L. Marusin
Charles J. Parise
Charles O. Pratt

Andrew Rossi, Jr.
Donald L. Schlegel
Lawrence E. Schwietz

The revising committee is listed at the end of the document.

This Guide updates and expands the scope of the committee report "Guide for the Protection of Concrete Against Chemical Attack by Means of Coatings and Other Corrosion Resistant Materials," which appeared in the December 1996 ACI JOURNAL. The previous Guide has been revised and is found in Chapter 6 of this Guide entitled "Protective Barrier Systems." In addition, there are new chapters on "Waterproofing Barrier Systems," "Dampproofing Barrier Systems," and "Decorative Barrier Systems." A separate chapter on conditioning and surface preparation of concrete is included because it is relevant to all the other chapters.

This Guide is not to be referenced as a complete unit.

Keywords: abrasive blasting; acid treatment (concrete); acid resistance; adhesion; asphalts; chemical attack; chemical cleaning; **coatings**; concrete bricks; concretes; detergents; emulsifying agents; epoxy resins; **finishes**; furan resins; glass fibers; inspection; joint sealers; latex (rubber); mortars [materials]; paints; phenolic resins; plastics; polymers, and resins; polyester resins; polyurethane resins; **protective coatings**; repairs; sealers; silicates; sulfur; surfactants; temperature; tests; vaporbarriers; **waterproofing**.

Foreword

ACI Committee 515 was organized in 1936 and published a report "Guide for the Protection of Concrete Against Chemical Attack by Means of Coatings and Other Corrosion Resistant Materials," in the De-

cember 1966 ACI JOURNAL. William H. Kuenning was chairman when this Guide was published. Albert M. Levy was chairman from 1974 to 1977 when some of the information, found in the chapters on "Waterproofing Barrier Systems" and "Dampproofing Barrier Systems," was developed.

CONTENTS

Chapter 1-Introduction, page 515.1R-2

- 1.1-General discussion
- 1.2-The systems concept for barriers
- 1.3-Barrier performance difficult to define
- 1.4-Economic factors for barrier selection
- 1.5-Inspection during application
- 1.6-Safety requirements

Chapter 2-Barrier systems: types and performance requirements, page 515.1R-3

- 2.1-Definitions of barrier systems
- 2.2-When waterproofing is used
- 2.3-When dampproofing is used
- 2.4-When protective barrier systems are used
- 2.5-Susceptibility of concrete to attack by chemicals
- 2.6-When decorative painting barrier systems are used

Chapter 3-Concrete conditioning and surface preparation, page 515.1R-12

- 3.1-General requirements
- 3.2-Repair of surface defects
- 3.3-Stopping or rerouting of water
- 3.4-Surface preparation

ACI Committee Reports, Guides, Standard Practices, and Commentaries are intended for guidance in designing, planning, executing, or inspecting construction, and in preparing specifications. Reference to these documents shall not be made in the Project Documents. If items found in these documents are desired to be part of the Project Documents, they should be incorporated directly into the Project Documents.

Copyright © 1986, American Concrete Institute. All rights reserved including rights of reproduction and use in any form or by any means, including the making of copies by any photo process, or by any electronic or mechanical device, printed or written or oral, or recording for sound or visual reproduction or for use in any knowledge or retrieval system or device, unless permission in writing is obtained from the copyright proprietors.

P/2

515.1R-6

MANUAL OF CONCRETE PRACTICE

Table 2.5.2. Effect of chemicals on concrete (see end of Table 2.5.2 for special notations)

Material	Effect	Material	Effect
*Acetic acid, all concentrations	Disintegrates slowly	Ashes	Harmful if wet, when sulfides and sulfates leach out (see sodium sulfate)
Acetone	Liquid loss by penetration. May contain acetic acid as impurity (which see)	Ashes, hot	Cause thermal expansion
Acid waters (pH of 6.5 or less) (a)	Disintegrates slowly. In porous or cracked concrete, attacks steel	Automobile and diesel exhaust gases (n)	May disintegrate moist concrete by action of carbonic, nitric, or sulfurous acid
*Alcohol	See ethyl alcohol, methyl alcohol	*Baking soda	See sodium bicarbonate
Alizarin	Not harmful	Barium hydroxide	Not harmful
*Almond oil	Disintegrates slowly	Bark	See tanning bark
*Alum	See potassium aluminum sulfate	*Beef fat	Solid fat disintegrates slowly, melted fat more rapidly
Aluminum chloride	Disintegrates rapidly. In porous or cracked concrete, attacks steel	*Beer	May contain, as fermentation products, acetic, carbonic, lactic, or tannic acids (which see)
*Aluminum sulfate	Disintegrates. In porous or cracked concrete, attacks steel	Benzol (benzene)	Liquid loss by penetration
*Ammonia, liquid	Harmful only if it contains harmful ammonium salts (see below)	Bleaching solution	See specific chemical, such as hypochlorous acid, sodium hypochlorite, sulfurous acid, etc.
Ammonia vapors	May disintegrate moist concrete slowly or attack steel in porous or cracked moist concrete	*Borax	Not harmful
Ammonium bisulfate	Disintegrates. In porous or cracked concrete, attacks steel	*Boric acid	Negligible effect
Ammonium carbonate	Not harmful	*Brine	See sodium chloride or other salt
*Ammonium chloride	Disintegrates slowly. In porous or cracked concrete, attacks steel	Bromine	Gaseous bromine disintegrates. Liquid bromine disintegrates if it contains hydrobromic acid and moisture
Ammonium cyanide	Disintegrates slowly	*Buttermilk	Disintegrates slowly
Ammonium fluoride	Disintegrates slowly	Butyl stearate	Disintegrates slowly
Ammonium hydroxide	Not harmful	Calcium bisulfite	Disintegrates rapidly
Ammonium nitrate	Disintegrates. In porous or cracked concrete, attacks steel	*Calcium chloride	In porous or cracked concrete, attacks steel. (b) Steel corrosion may cause concrete to spall
Ammonium oxalate	Not harmful	*Calcium hydroxide	Not harmful
*Ammonium sulfate	Disintegrates. In porous or cracked concrete, attacks steel	Calcium nitrate	Not harmful
Ammonium sulfide	Disintegrates	*Calcium sulfate	Disintegrates concrete of inadequate sulfate resistance
Ammonium sulfite	Disintegrates	Carbazole	Not harmful
Ammonium superphosphate	Disintegrates. In porous or cracked concrete, attacks steel	Carbolic acid	See phenol
Ammonium thiosulfate	Disintegrates	*Carbon dioxide	Gas may cause permanent shrinkage (see also carbonic acid)
Animal wastes	See slaughter house wastes	*Carbon disulfide	May disintegrate slowly
Anthracene	Not harmful	*Carbon tetrachloride	Liquid loss by penetration of concrete
Arsenious acid	Not harmful	*Carbonic acid	Disintegrates slowly (c)

SURFACE BARRIER SYSTEMS

515.1R-7

Table 2.5.2-(Continued)

Material	Effect	Material	Effect
Castor oil	Disintegrates, especially in presence of air	*Cottonseed oil	Disintegrates, especially in presence of air
Chile saltpeter	See sodium nitrate	Creosote	Phenol present disintegrates slowly
China wood oil	Liquid disintegrates slowly.	Cresol	Phenol present disintegrates slowly
Chlorine gas	Slowly disintegrates moist concrete	Cumol	Liquid loss by penetration
Chrome plating solutions (o)	Disintegrates slowly	Deicing salts	Scaling of non-air-entrained or insufficiently aged concrete (b)
Chromic acid, all concentrations	Attacks steel in porous or cracked concrete	Diesel gases	See automobile and diesel exhaust gases
Chrysen	Not harmful	Dinitrophenol	Disintegrates slowly
*Cider	Disintegrates slowly (see acetic acid)	Distiller's slop	Lactic acid causes slow disintegration
Cinders	Harmful if wet, when sulfides and sulfates leach out (see, for example, sodium sulfate)	Epsom salt	See magnesium sulfate
Cinders, hot	Cause thermal expansion	*Ethyl alcohol	Liquid loss by penetration
Coal	Sulfides leaching from damp coal may oxidize to sulfurous or sulfuric acid, or ferrous sulfate (which see)	*Ethyl ether	Liquid loss by penetration
Coal tar oils	See anthracene, benzol, carbazole, chrysen, creosote, cresol, cumol, paraffin, phenanthrene, phenol, toluol, xylol	*Ethylene glycol	Disintegrates slowly (d)
Cobalt sulfate	Disintegrates concrete of inadequate sulfate resistance	Feces	See manure
*Cocoa bean oil	Disintegrates, especially in presence of air	*Fermenting fruits, grains, vegetables, or extracts	Industrial fermentation processes produce lactic acid. (e) Disintegrates slowly (see lactic acid)
*Cocoa butter	Disintegrates, especially in presence of air	Ferric chloride	Disintegrates slowly
Coconut oil	Disintegrates, especially in presence of air	Ferric nitrate	Not harmful
*Cod liver oil	Disintegrates slowly	Ferric sulfate	Disintegrates concrete of inadequate quality
Coke	Sulfides leaching from damp coke may oxidize to sulfurous or sulfuric acid (which see)	Ferric sulfide	Harmful if it contains ferric sulfate (which see)
Copper chloride	Disintegrates slowly	Ferrous chloride	Disintegrates slowly
Copper plating solutions (p)	Not harmful	Ferrous sulfate	Disintegrates concrete of inadequate sulfate resistance
Copper sulfate	Disintegrates concrete of inadequate sulfate resistance	Fertilizer	See ammonium sulfate, ammonium superphosphate, manure, potassium, nitrate, sodium nitrate
Copper sulfide	Harmful if it contains copper sulfate (which see)	Fish liquor	Disintegrates (f)
*Corn syrup	Disintegrates slowly	*Fish oil	Disintegrates slowly
Corrosive sublimate	See mercuric chloride	Flue gases	Hot gases (400-1100 F) cause thermal stresses. Cooled, condensed sulfurous, hydrochloric acids disintegrate slowly
		Foot oil	Disintegrates slowly
		*Formaldehyde, 37 percent	Formic acid, formed in solution, disintegrates slowly
		Formalin	See formaldehyde

515.1R-8

MANUAL OF CONCRETE PRACTICE

Table 2.5.2-(Continued)

Material	Effect	Material	Effect
*Formic acid, 10 percent	Disintegrates slowly	Lignite oils	If fatty oils are present, disintegrates slowly
*Formic acid, 30 percent	Disintegrates slowly	*Linseed oils	Liquid disintegrates slowly. Dried or drying films are harmless
*Formic acid, 90 percent	Disintegrates slowly	Locomotive gases (r)	May disintegrate moist concrete by action of carbonic, nitric or sulfurous acids (see also automobile and diesel exhaust gases)
*Fruit juices	Hydrofluoric, other acids, and sugar cause disintegration (see also fermenting fruits, grains, vegetables, extracts)	Lubricating oil	Fatty oils, if present, disintegrate slowly
Gas water (g)	Ammonium salts seldom present in sufficient quantity to disintegrate	Lye	See sodium hydroxide
Gasoline	Liquid loss by penetration	Machine oil	Fatty oils, if present, disintegrate slowly
*Glucose	Disintegrates slowly	*Magnesium chloride	Disintegrates slowly. In porous or cracked concrete, attacks steel
*Glycerine	Disintegrates slowly	Magnesium nitrate	Disintegrates slowly
*Grain	See fermenting fruits, grains, vegetables, extracts	*Magnesium sulfate	Disintegrates concrete of inadequate sulfate resistance
*Honey	Not harmful	Manganese sulfate	Disintegrates concrete of inadequate sulfate resistance
Horse fat	Solid fat disintegrates slowly, melted fat more rapidly	Manure	Disintegrates slowly
Humic acid	Disintegrates slowly	*Margarine	Solid margarine disintegrates slowly, melted margarine more rapidly
*Hydrochloric acid, all concentrations	Disintegrates rapidly, including steel	Mash, fermenting	Acetic and lactic acids, and sugar disintegrate slowly
Hydrofluoric acid, all concentrations	Disintegrates rapidly, including steel	Mercuric chloride	Disintegrates slowly
Hydrogen sulfide	Not harmful dry. In moist, oxidizing environments converts to sulfurous acid and disintegrates slowly	Mercurous chloride	Disintegrates slowly
Hypochlorous acid, 10 percent	Disintegrates slowly	Methyl alcohol	Liquid loss by penetration
Iodine	Disintegrates slowly	Methyl ethyl ketone	Liquid loss by penetration
Kerosene	Liquid loss by penetration of concrete	Methyl isobutyl ketone	Liquid loss by penetration
*Lactic acid, 5-25 percent	Disintegrates slowly	*Milk	Not harmful. However, see sour milk
*Lamb fat	Solid fat disintegrates slowly, melted fat more rapidly	Mine water, waste	Sulfides, sulfates, or acids present disintegrate concrete and attack steel in porous-or cracked concrete
*Lard and lard oil	Lard disintegrates slowly, lard oil more rapidly	*Mineral oil	Fatty oils, if present, disintegrate slowly
Lead nitrate	Disintegrates slowly	Mineral spirits	Liquid loss by penetration
Lead refining solutions (q)	Disintegrates slowly	*Molasses	At temperatures ≥ 120 F, disintegrates slowly
Leuna saltpeter	See ammonium nitrate and ammonium sulfate	Muriatic acid	See hydrochloric acid
		*Mustard oil	Disintegrates, especially in presence of air
		Nickel plating solutions (v)	Nickel ammonium sulfate disintegrates slowly

SURFACE BARRIER SYSTEMS

515.1R-9

Table 2.5.2-(Continued)

Material	Effect	Material	Effect
Nickel sulfate	Disintegrates concrete of inadequate sulfate resistance	Potassium hydroxide, 25 percent or over	Disintegrates concrete
Niter	See potassium nitrate	*Potassium nitrate	Disintegrates slowly
Nitric acid, all concentrations	Disintegrates rapidly	Potassium permanganate	Harmless unless potassium sulfate present (which see)
*Oleic acid, 100 percent	Not harmful	Potassium persulfate	Disintegrates concrete of inadequate sulfate resistance
Oleum	See sulfuric acid, 110 percent	Potassium sulfate	Disintegrates concrete of inadequate sulfate resistance
*Olive oil	Disintegrates slowly	Potassium sulfide	Harmless unless potassium sulfate present (which see)
Ores	Sulfides leaching from damp ores may oxidize to sulfuric acid or ferrous sulfate (which see)	Pyrites	See ferric sulfide, copper sulfide
Oxalic acid	Not harmful. Protects tanks against acetic acid, carbon dioxide, salt water. Poisonous. Do not use with food or drinking water	*Rapeseed oil	Disintegrates, especially in presence of air
Paraffin	Shallow penetration not harmful, but should not be used on highly porous surfaces like concrete masonry (u)	Rock salt	See sodium chloride
*Peanut oil	Disintegrates slowly	Rosin	Not harmful
Perchloric acid, 10 percent	Disintegrates	Rosin oil	Not harmful
Perchloroethylene	Liquid loss by penetration	Sal ammoniac	See ammonium chloride
Petroleum oils	Liquid loss by penetration. Fatty oils, if present, disintegrate slowly	Sal soda	See sodium carbonate
Phenanthrene	Liquid loss by penetration	Salt for deicing roads	See text. Also calcium chloride, magnesium chloride, sodium chloride
Phenol, 5-25 percent	Disintegrates slowly	Saltpeter	See potassium nitrate
*Phosphoric acid, 10-85 percent	Disintegrates slowly	*Sauerkraut	Flavor impaired by concrete. Lactic acid may disintegrate slowly
*Pickling brine	Attacks steel in porous or cracked concrete	Sea water	Disintegrates concrete of inadequate sulfate resistance. Attacks steel in porous or cracked concrete
Pitch	Not harmful	Sewage	Usually not harmful (see hydrogen sulfide)
*Poppy seed oil	Disintegrates slowly	Silage	Acetic, butyric, lactic acids (and sometimes fermenting agents of hydrochloric or sulfuric acids) disintegrate slowly
*Potassium aluminum sulfate	Disintegrates concrete of inadequate sulfate resistance	Slaughter house wastes (w)	Organic acids disintegrate
*Potassium carbonate	Harmless unless potassium sulfate present (which see)	Sludge	See sewage, hydrogen sulfide
*Potassium chloride	Magnesium chloride, if present, attacks steel in porous or cracked concrete	Soda water	See carbonic acid
Potassium cyanide	Disintegrates slowly	*Sodium bicarbonate	Not harmful
Potassium dichromate	Disintegrates	Sodium bisulfate	Disintegrates
Potassium hydroxide, 15 percent	Not harmful (h)	Sodium bisulfite	Disintegrates
		Sodium bromide	Disintegrates slowly

515.1R-10

MANUAL OF CONCRETE PRACTICE

Table 2.5.2-(Continued)

Material	Effect	Material	Effect
Sodium carbonate	Not harmful, except to calcium aluminate cement	Sulfurous acid	Disintegrates rapidly
*Sodium chloride	Magnesium chloride, if present, attacks steel in porous or cracked concrete. (b) Steel corrosion may cause concrete to spall	Tallow and tallow oil	Disintegrates slowly
Sodium cyanide	Disintegrates slowly	Tannic acid	Disintegrates slowly
Sodium dichromate	Dilute solutions disintegrate slowly	Tanning bark	May disintegrate slowly if damp (see tanning liquor)
*Sodium hydroxide, 1-10 percent	Not harmful (h)	Tanning liquor	Disintegrates, if acid
*Sodium hydroxide, 20 percent or over	Disintegrates concrete	*Tartaric acid solution	Not harmful
Sodium hypochlorite	Disintegrates slowly	Tobacco	Organic acids, if present, disintegrate slowly
*Sodium nitrate	Disintegrates slowly	Toluol (toluene)	Liquid loss by penetration
Sodium nitrite	Disintegrates slowly	*Trichloroethylene	Liquid loss by penetration
Sodium phosphate (monobasic)	Disintegrates slowly	*Trisodium phosphate	Not harmful
Sodium sulfate	Disintegrates concrete of inadequate sulfate resistance	Tung oil	Liquid disintegrates slowly. Dried or drying films are harmless
Sodium sulfide	Disintegrates slowly	Turpentine	Mild attack. Liquid loss by penetration
*Sodium sulfite	Sodium sulfate, if present, disintegrates concrete of inadequate sulfate resistance	*Urea	Not harmful
Sodium thiosulfate	Slowly disintegrates concrete of inadequate sulfate resistance	Urine	Attacks steel in porous or cracked concrete
*Sour milk	Lactic acid disintegrates slowly	Vegetables	See fermenting fruits, grains, vegetables, extracts
*Soybean oil	Liquid disintegrates slowly. Dried or drying films harmless	Vinegar	Disintegrates slowly (see acetic acid)
Strontium chloride	Not harmful	Walnut oil	Disintegrates slowly
*Sugar	Disintegrates slowly	*Whey	Disintegrates slowly (see lactic acid)
Sulfite liquor	Disintegrates	*Wine	Not harmful. Necessary to prevent flavor contamination
Sulfite solution	See calcium bisulfite	Wood pulp	Not harmful
*Sulfur dioxide	With moisture forms sulfurous acid (which see)	Xylol (xylene)	Liquid loss by penetration
*Sulfuric acid, 10-80 percent	Disintegrates rapidly	*Zinc chloride	Disintegrates slowly
*Sulfuric acid, 80 percent oleum	Disintegrates	Zinc nitrate	Not harmful
		Zinc refining solutions (x)	Hydrochloric or sulfuric acids, if present, disintegrate concrete
		Zinc slag	Zinc sulfate (which see) sometimes formed by oxidation
		Zinc sulfate	Disintegrates slowly

SURFACE BARRIER SYSTEMS

515.1R-11

Key to special notations-Table 2.5.2

*	Sometimes used in food processing or as food or beverage ingredient. Ask for advisory opinion of Food and Drug Administration regarding coatings for use with food ingredients.
a	Waters of pH higher than 6.5 may be aggressive if they also contain bicarbonates. (Natural waters are usually of pH higher than 7.0 and seldom lower than 6.0, though pH values as low as 0.4 have been reported. For pH values below 3, protect as for dilute acid.)
b	Frequently used as a deicer for concrete pavements. If the concrete contains too little entrained air or has not been aged more than one month, repeated application may cause surface scaling. For protection under these conditions, see "deicing salts."
c	Carbon dioxide dissolves in natural waters to form carbonic acid solutions. When it dissolves to extent of 0.9 to 3 parts per million it is destructive to concrete.
d	Frequently used as deicer for airplanes. Heavy spillage on runway pavements containing too little entrained air may cause surface scaling.
e	In addition to the intentional fermentation of many raw materials, much unwanted fermentation occurs in the spoiling of foods and food wastes, also producing lactic acid.
f	Contains carbonic acid, fish oils, hydrogen sulfide, methyl amine, brine, other potentially reactive materials.
g	Water used for cleaning coal gas.
h	However, in those limited areas of the United States where concrete is made with reactive aggregates, disruptive expansion may be produced.
n	Composed mostly of nitrogen, oxygen, carbon dioxide, carbon monoxide, and water vapor. Also contains unburned hydrocarbons, partially burned hydrocarbons, oxides of nitrogen, and oxides of sulfur. Nitrogen dioxide and oxygen in sunlight may produce ozone, which reacts with some of the organics to produce formaldehyde, peracylnitrates, and other products.
o	These either contain chromium trioxide and a small amount of sulfate, or ammonium chromic sulfate (nearly saturated) and sodium sulfate.
p	Many types of solutions are used, including (a) Sulfate-Contain copper sulfate and sulfuric acid. (b) Cyanide-Contain copper and sodium cyanides and sodium carbonate. (c) Rochelle-Contain these cyanides, sodium carbonate, and potassium sodium tartrate. (d) Others such as fluoborate, pyrophosphate, amine, or potassium cyanide.
q	Contains lead fluosilicates and fluosilicic acid.
r	Reference here is to combustion of coal, which produces carbon dioxide, water vapor, nitrogen, hydrogen, carbon monoxide, carbohydrates, ammonia, nitric acid, sulfur dioxide, hydrogen sulfide, soot, and ashes.
u	Porous concrete which has absorbed considerable molten paraffin and then been immersed in water after the paraffin has solidified has been known to disintegrate from sorptive forces.
v	Contains nickelous chloride, nickelous sulfate, boric acid, and ammonium ion.
w	May contain various mixtures of blood, fats and oils, bile and other digestive juices, partially digested vegetable matter, urine, and manure, with varying amounts of water.
x	Usually contains zinc sulfate in sulfuric acid. Sulfuric acid concentration may be low (about 6 percent in "low current density" process) or higher (about 22-28 percent in "high current density" process).