Standard Specification for Curing Concrete (ACI 308.1-98)

Reported by ACI Committee 308

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Summary: This specification provides requirements for alternative methods for curing concrete. These alternative methods are not necessarily equal in effectiveness, cost, effect on project schedule, or impact on other aspects of the project. To use this specification, the Architect/Engineer must not only include this document by reference in the project specifications, but must also identify the concrete elements that are to be cured, and must choose the method to be used to cure those elements. This specification has installed default settings that may or may not be applicable to a specific project. The Architect/Engineer is to use the Checklists included in this specification to customize the specification to a specific project. Checklists are provided in this document to guide the Architect/Engineer through these selection processes, and the selections must be included in the project specification. Alternatively, the Architect/Engineer may allow the contractor the option of using one or more of a number of permissible curing methods, subject to review and approval. Further, the Architect/Engineer must determine whether deliberate curing efforts must or may terminate after a predetermined time has elapsed, or only after specified concrete properties have developed. When deliberate efforts to cure the concrete are to be terminated only when specified concrete properties have developed, the Architect/Engineer must also select the test method used to measure those properties.

Keywords: cold-weather construction; concrete; concrete construction; curing; curing films and sheets; hot weather construction; insulating concrete; insulation; membrane-curing compounds; moist curing; moisture retention; sealers; water curing.

F2. Standard Specification ACI 308.1 is a Reference Standard which the Architect/Engineer may cite in the Project Specifications for any building project, together with supplementary requirements for the specific project.

F3. Each technical section of Standard Specification ACI 308.1 is written in the Three-Part Section Format of the Construction Specifications Institute, as adapted by ACI and modified to ACI requirements. The language is generally imperative and terse.

F4. Checklists do not form a part of Standard Specification ACI 308.1. Checklists are to assist the Architect/Engineer in properly choosing and specifying the necessary mandatory requirements for the Project Specifications.

PREFACE TO SPECIFICATIONS CHECKLIST

P1. Standard Specification ACI 308.1 is intended to be used by reference or incorporation in its entirety in the Project Specifications. Individual sections, articles, or paragraphs shall not be copied into the Project Specifications, since taking them out of context may change their meaning.
P2. If sections or parts of Standard Specification ACI 308.1 are edited into project specifications or any other document, they shall not be referred to as ACI standards, since the Standard Specification has been altered.

P3. Building codes set minimum requirements necessary to protect the public. This Standard Specification may stipulate requirements more restrictive than the minimum. Adjustments to the needs of a particular project shall be made by the Architect/Engineer by reviewing each of the items in the Specification Checklist and then including the Architect/Engineer’s decision on each item as a mandatory requirement in the Project Specifications.

P4. These mandatory requirements designate the specific qualities, procedures, materials, and performance criteria for which alternatives are permitted or for which provisions were not made in the Standard Specification. Exceptions to the Standard Specification shall be made in the Project Specifications, if required.

P5. A statement such as the following will serve to make Standard Specification ACI 308.1 a part of the Project Specifications:

Work on (Project Title) shall conform to all requirements of ACI (Standard Specification number with date suffix and title) published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by the requirements of these Contract Documents.


M. MANDATORY SPECIFICATION CHECKLIST

The specification is written to allow each method of curing to be a stand-alone specification. The specifier is to determine the desired results of the curing and select the appropriate section or sections to achieve those results. Section 1 shall be included with the selected sections. The specifier is to use ACI 308-92 Standard Practice for Curing Concrete as commentary for making decisions within the checklists. The alternative methods described in each section of this Standard Specification are not necessarily equal in effectiveness, cost, effect on project schedule, or impact on other aspects of the project. To use this specification, the Architect/Engineer must not only include this document by reference in the Project Specifications, but must also review and respond to the checklists. It is imperative that the Architect/Engineer customize this specification to meet the project requirements through the checklists. The Architect/Engineer must identify the concrete elements that are to be cured, and must choose the method to be used to cure them. Further, the Architect/Engineer must determine whether deliberate curing efforts must or may terminate after a predetermined time has elapsed, or only after particular levels of concrete properties have developed. When deliberate efforts to cure the concrete are to be terminated only when particular concrete properties have developed, the Architect/Engineer must also select the test method used to measure those properties. Checklists are provided in this document to guide the Architect/Engineer through these selection processes, and the selections must be included in the Project Specifications.

<table>
<thead>
<tr>
<th>Section/Part/Article of ACI 308.1-98</th>
<th>Notes to the Architect/Engineer</th>
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<tr>
<td>1.4</td>
<td>The Architect/Engineer shall review the referenced standards to ensure the published dates are applicable to the specific project.</td>
</tr>
<tr>
<td>1.1.1 and 1.1.2</td>
<td>Describe the work that is to be cured as required by this specification, or alternately, describe that work that is not to be cured in accordance with this specification. Specify the elements for which this specification does not apply.</td>
</tr>
<tr>
<td>1.1.3</td>
<td>Deliberate curing efforts may be terminated when either a predetermined time period has elapsed, or when specific levels of concrete properties have developed in the concrete in the field or in representative samples in the laboratory. The Architect/Engineer determines which of these criteria are to be employed in Paragraphs 1.1.7.1, 1.1.7.2, and 1.1.7.3.</td>
</tr>
<tr>
<td>1.1.5.1</td>
<td>Unless the Architect/Engineer requires otherwise in the project specifications, Section 1.1.6.1 will permit the use of any of the curing methods described in Sections 2 through 7 for unformed surfaces.</td>
</tr>
<tr>
<td>1.1.5.2</td>
<td>Unless the Architect/Engineer requires otherwise in the project specifications, Section 1.1.6.2 requires that for formed surfaces, absorbent forms be kept wet until removal, followed by the application of any of the curing methods described in Sections 2 through 7 until duration or strength requirements are met.</td>
</tr>
<tr>
<td>1.1.5.1, 1.1.5.2, and Section 5</td>
<td>Fogging, as described in Section 5, may be specified. There may be insufficient bleed water to maintain proper moisture conditions, or where little moisture loss can be tolerated. Concrete containing finely ground cements, expansive cement, fly ash, ground granulated blast furnace slag, silica fume, or other cementitious materials, or having a water-cementitious materials ratio less than 0.40 by mass, may require fogging during the initial curing period. Fogging can help to prevent plastic shrinkage cracking.</td>
</tr>
</tbody>
</table>
The Architect/Engineer is to select the curing period (Paragraph 1.1.3) and the method to be used to determine when deliberate curing measures can be terminated (Paragraphs 1.1.7.1, 1.1.7.2, and 1.1.7.3).

1.1.6.1

The Architect/Engineer must specify minimum length of time for the curing period under the non-tested criteria. The Architect/Engineer needs to consider mixture proportions, environmental conditions, and skill levels of the contractor in selecting curing duration. The default value is 7 days. The Architect/Engineer must determine acceptability of this value and must substitute a more appropriate value as necessary.

1.1.6.2 and 1.6.4.2

Under the strength testing criteria, the Architect/Engineer must specify the compressive strength that must be achieved by field-cured specimens prior to termination of deliberate curing efforts. The default compressive strength criterion for termination of deliberate curing efforts is 70 percent $f'_c$. The Architect/Engineer must determine acceptability of this value and must substitute a more appropriate value as necessary.

1.1.6.2 and 1.6.4.2

The Architect/Engineer may substitute or augment the compressive strength requirement for termination of deliberate curing measures with requirements for development of other strength-related or mechanical properties, such as flexural strength (ASTM C 496), splitting tensile strength, or modulus of elasticity. In such cases, the Architect/Engineer must specify property, test method, and test results to be achieved.

1.1.6.3 and 1.6.4.3

If curing is to be maintained until specific levels of durability related properties have been developed in the concrete, the Architect/Engineer must specify the durability related properties, test method(s) used to determine such properties, and the test results to be achieved. The Architect/Engineer is to refer to ACI 308R, “Standard Practice for Curing Concrete,” ACI 201.2R, “Guide to Durable Concrete,” and ASTM STP 169C, “Significance of Rest and Properties of Concrete and Concrete-Making Materials,” for information.

1.4


1.6.4

Any of the three methods described for determining strength is acceptable unless otherwise required by the Architect/Engineer.

1.6.4.2.c

Unless otherwise directed by the Architect/Engineer, the contractor may request use of a nondestructive test method to demonstrate adequacy of the concrete in-place for the purpose of terminating deliberate curing efforts in accordance with the specification.

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<td>1.1.6</td>
<td>The Architect/Engineer is to select the curing period (Paragraph 1.1.3) and the method to be used to determine when deliberate curing measures can be terminated (Paragraphs 1.1.7.1, 1.1.7.2, and 1.1.7.3).</td>
</tr>
<tr>
<td>1.1.6.1</td>
<td>The Architect/Engineer must specify minimum length of time for the curing period under the non-tested criteria. The Architect/Engineer needs to consider mixture proportions, environmental conditions, and skill levels of the contractor in selecting curing duration. The default value is 7 days. The Architect/Engineer must determine acceptability of this value and must substitute a more appropriate value as necessary.</td>
</tr>
<tr>
<td>1.1.6.2 and 1.6.4.2</td>
<td>Under the strength testing criteria, the Architect/Engineer must specify the compressive strength that must be achieved by field-cured specimens prior to termination of deliberate curing efforts. The default compressive strength criterion for termination of deliberate curing efforts is 70 percent $f'_c$. The Architect/Engineer must determine acceptability of this value and must substitute a more appropriate value as necessary.</td>
</tr>
<tr>
<td>1.1.6.2 and 1.6.4.2</td>
<td>The Architect/Engineer may substitute or augment the compressive strength requirement for termination of deliberate curing measures with requirements for development of other strength-related or mechanical properties, such as flexural strength (ASTM C 496), splitting tensile strength, or modulus of elasticity. In such cases, the Architect/Engineer must specify property, test method, and test results to be achieved.</td>
</tr>
<tr>
<td>1.1.6.3 and 1.6.4.3</td>
<td>If curing is to be maintained until specific levels of durability related properties have been developed in the concrete, the Architect/Engineer must specify the durability related properties, test method(s) used to determine such properties, and the test results to be achieved. The Architect/Engineer is to refer to ACI 308R, “Standard Practice for Curing Concrete,” ACI 201.2R, “Guide to Durable Concrete,” and ASTM STP 169C, “Significance of Rest and Properties of Concrete and Concrete-Making Materials,” for information.</td>
</tr>
<tr>
<td>1.6.4</td>
<td>Any of the three methods described for determining strength is acceptable unless otherwise required by the Architect/Engineer.</td>
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<td>Unless otherwise directed by the Architect/Engineer, the contractor may request use of a nondestructive test method to demonstrate adequacy of the concrete in-place for the purpose of terminating deliberate curing efforts in accordance with the specification.</td>
</tr>
</tbody>
</table>

**O. OPTIONAL SPECIFICATION CHECKLIST**

1.6.4.3

The Architect/Engineer has the option to define when to terminate curing based on testing of the concrete surface. Refer to ACI 201.2R, “Guide to Durable Concrete,” and ASTM STP 169C, “Significance of Rest and Properties of Concrete and Concrete-Making Materials,” for information.

2.1

Do not allow the use of plastic sheets. Plastic sheets adhere to fabric or reinforced paper.

2.2.1 and 2.2.2

The Architect/Engineer may also refer to AASHTO M 182 instead of ASTM C 171.

2.3.2

The Architect/Engineer may specify the frequency of inspection.

2.3.3

If the first day high ambient temperature exceeds 20 C (68 F), it is preferable to use white or similarly reflective plastic sheets.
### Notes to the Architect/Engineer

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<td>3.1.2.1</td>
<td>The default is for all curing compound materials to be volatile organic compound (VOC) compliant. The Architect/Engineer may specify or allow non-volatile organic compound (VOC) compliant materials if they are allowed to be used by agency regulations. The Contractor may make a substitution if the compounds are allowed to be used by agency regulations.</td>
</tr>
<tr>
<td>3.2.1</td>
<td>Liquid membrane-forming curing compounds: When flooring or other surface treatments are to be installed on concrete, the Architect/Engineer should specify curing materials compatible with adhesives, paints, or sealers to be placed on concrete substrate.</td>
</tr>
<tr>
<td>3.3.1</td>
<td>The Architect/Engineer can require a heavier application of the product than recommended by the manufacturer. See note 3.2.1 above, however, concerning compatibility with subsequent surface treatments.</td>
</tr>
<tr>
<td>3.3.1</td>
<td>The Architect/Engineer may require a two-coat process. If such is the case, insert the following words at the end of the first sentence: “in a two-coat process with the second coat placed perpendicular to the first.”</td>
</tr>
<tr>
<td>3.3.1</td>
<td>The Architect/Engineer may need to specify if the curing compound is to be removed after the curing process is completed.</td>
</tr>
<tr>
<td>3.3.2</td>
<td>The Architect/Engineer may need to approve the use of a paint brush or roller on small areas.</td>
</tr>
<tr>
<td>1.8</td>
<td>Use this section when the environmental conditions are conducive to a rate of evaporation exceeding the rate of bleeding of freshly placed concrete. Protect the integrity of the concrete throughout the process of mixing, transporting, placing, finishing, and curing the concrete.</td>
</tr>
<tr>
<td>1.8.4, 5 and 1.8.4.6</td>
<td>The contractor has the option to select one of two initial curing methods, and to select the final curing method in hot weather, unless otherwise specified by the Architect/Engineer.</td>
</tr>
</tbody>
</table>

### S. SUBMITTALS CHECKLIST

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<td>1.5.2, 1.5.4, and 1.5.5</td>
<td>Written statement of curing procedure or curing method(s) that will be used. Include the data, material(s) and/or equipment to be used. State if the materials used meet the required testing criteria.</td>
</tr>
<tr>
<td>1.6.4</td>
<td>Testing criteria for the termination of the curing period are to be submitted only when the Contractor has to perform the testing.</td>
</tr>
<tr>
<td>1.5.5</td>
<td>At the present time there is not a materials specification for evaporative reducers (i.e., evaporative retarders, monomolecular films)</td>
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SECTION 1—GENERAL REQUIREMENTS

1.1 Scope
1.1.1 Work specified—This Standard Specification covers requirements for curing the cast-in-place concrete elements described in the Contract Documents.
1.1.2 Specialty concrete and special construction techniques, or other concrete elements that require the use of curing procedures not discussed in this specification are not covered by this Specification.
1.1.3 General—Immediately after placement, continuously keep concrete in moist condition, maintain specified concrete temperatures, and protect concrete from mechanical injury for the duration of the initial and final curing periods.
1.1.4 Protection from mechanical injury—Protect the concrete from damaging mechanical disturbances during the curing period. Protect finished surfaces from damage by construction equipment, materials or methods, and from damage caused by application of curing procedures, or by running water.
1.1.5 Cure the concrete as follows:
1.1.5.1 Unformed surfaces—Apply one of the curing procedures listed in Sections 2 through 7. If one of the curing procedures is used initially, it may be replaced by one of the other procedures after the concrete is 1 day old, provided that the concrete surface is not permitted to become dry at any time.
1.1.5.2 Formed surfaces—Keep absorbent wood forms wet until they are removed. After form removal, cure the concrete by one of the procedures listed in Sections 2 through 7 for the remainder of the curing period.
1.1.6 Curing period—Cure the concrete for the following time periods:
1.1.6.1 When testing is not performed to determine the curing period, cure concrete for at least 7 days provided that the concrete surface temperature is at least 10 C (50 F).
1.1.6.2 When strength basis testing is performed to determine the curing period, maintain curing procedures until test results meet or exceed requirements of Paragraph 1.6.4.2.
1.1.6.3 When durability basis testing is performed to determine the curing period, maintain curing procedures until tests meet or exceed Paragraph 1.6.4.3.

1.2 Definitions
Cold weather—A period when, for more than 3 successive days, the average daily temperature drops below 4 C (40 F). (Note: Average daily temperature is the average of the highest and lowest temperature from midnight to midnight. When ambient temperatures are above 10 C (50 F) or more in 12 hr in 1 day, the period shall not be regarded as cold weather.)
Concrete, fresh—Unhardened concrete that can be consolidated by the intended method.
Curing—Maintenance of a satisfactory moisture content and temperature in concrete during its early stages so that desired properties may develop.
Curing compound—A liquid that can be applied as a coating to the surface of newly placed concrete to retard the loss of water or, in the case of pigmented compounds, to reflect heat so as to provide an opportunity for the concrete to develop its properties in a favorable temperature and moisture environment. (Note: In accordance with the requirements of ASTM C 309, such products, when applied as specified by ASTM, restrict the loss of water from the concrete surface, but may not prohibit moisture loss entirely.)
Curing, final—Deliberate action taken between the final finishing and termination of curing.
Curing, initial—Deliberate action taken between placement and final finishing of concrete to reduce the loss of moisture from the surface of the concrete.
Curing period—Duration of time in which continuous curing procedures are employed. (Note: The curing period includes initial and final curing stages.)
Daily—Occurring each day with the standard of 24 hr to the day.
Dry—A surface not covered with visible free moisture.
Evaporation reducer—A material that generates a continuous thin film when spread over water on the surface of fresh concrete and thus retards the evaporation of bleed water.
Hot weather—A combination of high ambient temperature, high concrete temperature, low relative humidity, wind velocity, and solar radiation that may cause excessive evaporation.
Volatile organic compounds (VOC)—Volatile organic compounds that vaporize under stated conditions. (There are legal limits in some areas on the nature or concentration of such compounds in products such as membrane-forming compounds for curing concrete.)
Wet—Covered with visible free moisture; not dry.

1.3 Reference organizations
Abbreviations for and complete names and addresses of organizations issuing documents referred to in this Standard Specification are listed:
American Concrete Institute (ACI)
P.O. Box 9094
Farmington Hills, MI 48333-9094
Phone: 248-848-3700; Fax: 248-848-3701
1.4—Reference standards

1.4.1 Reference standards—Standards of ACI, ASTM, and AASHTO referred to in this Standard Specification are listed, with serial designation including year of adoption or revision, and are part of this Standard Specification.

1.4.1.1 ACI standards
306.1-90 Standard Specification for Cold Weather Concreting

1.4.2 ASTM standards
C 31-91 Standard Method for Making and Curing Concrete Test Specimens in the Field.
C 94-95 Standard Specification for Ready-Mixed Concrete
C 171-92 Standard Specification for Sheet Materials for Curing Concrete
C 309-94 Standard Specification for Liquid Membrane—Forming Compounds for Curing Concrete
C 1074-93 Practice for Estimating Concrete Strength by the Maturity Method
C 1077-95a Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

1.4.3 AASHTO materials standards
M 182-91 Specification for Burlap Cloth Made from Jute or Kenaf

1.5—Submittals

1.5.1 Submit data in this Standard Specification as required by the Architect/Engineer for review and acceptance. Submit data for approval prior to execution and with sufficient time for the review process.

1.5.2 Submit procedure for curing method(s) to be employed and data demonstrating that materials meet specifications.

1.5.3 If a nondestructive test method is proposed to estimate the strength of the concrete in-place, the Contractor shall obtain the Architect/Engineer’s approval for the test method, and provide test data correlating strength of concrete determined by proposed nondestructive test method with the compressive strength of laboratory-cured molded cylinders or drilled cores.

1.5.4 Submit cold weather curing procedures at least 1 month prior to cold weather concreting.

1.5.5 Submit hot weather curing procedures at least 1 month prior to use, and data demonstrating that proposed materials meet specification requirements, including the following:
   a. Evaporation reducer product technical data
   b. Fogging procedures
   c. Other protective measures to be used

1.6—Quality assurance

1.6.1 Concrete curing materials and procedures may be tested and inspected by the Owner as work progresses to verify adequacy.

1.6.2 Agencies—Testing agencies that perform testing services on concrete materials shall meet the requirements of ASTM C 1077. Tests of concrete shall be made by an ACI Concrete Field Technician, Grade 1 or equivalent. Testing agency shall report results of tests and inspections performed during the course of the work to the Owner, Architect/Engineer, and Contractor within 3 days of testing.

1.6.3 The Contractor has to provide, for the use of the testing agency, adequate area for safe storage of field-cured specimens until time of test.

1.6.4 Tests for determining time for termination of curing methods:

1.6.4.1 General—Tests to determine time of termination for curing measures may be performed by a testing agency acceptable to the Architect/Engineer.

1.6.4.2 Strength basis—When termination of curing measures is based on the development of strength, curing measures shall not be terminated before the compressive strength of the concrete has reached 70 percent of $f_c'$ as determined by one of the following methods:

1.6.4.2.a Compressive strength basis—Mold cylinders in accordance with ASTM C 31 and test in accordance with ASTM C 39. Maintain curing until tests of at least two cylinders, field-cured alongside the concrete they represent, have reached the compressive strength specified for termination of curing.

1.6.4.2.b Maturity method basis—Maintain curing methods until concrete attains the compressive strength specified for termination of curing, as estimated in accordance with ASTM C 1074.

1.6.4.2.c Nondestructive test methods—Maintain curing methods until testing indicates that the specified compressive strength has been reached.

1.6.4.3 Durability basis—Maintain curing methods until specified results are achieved.

1.7—Curing in cold weather

1.7.1 This covers protection and additional curing requirements that are to be implemented during cold weather. Protect the concrete from the effects of cold weather throughout the process, placing, finishing, and curing the concrete. Use initial curing method or methods defined in Paragraph 1.8 to avoid plastic shrinkage cracks.

1.7.1.1 Maintain concrete temperature as required by ACI 306.1 during the curing period.

1.7.1.2 Terminate the addition of water to the surface and allow the concrete surface to dry prior to exposure of the concrete to freezing temperatures. Protect the concrete against direct uneven heating and carbonation due to the ex-
posure to combustion heater exhaust. Do not initiate the addition of water if freezing weather is to occur during the curing period. Do not expose saturated concrete to cycles of freezing and thawing.

1.7.1.3 When the concrete is to be subjected to freezing conditions, change the addition of water-curing procedure, and employ a moisture retention curing procedure in accordance with Section 2, use a membrane-forming curing compound in accordance with Section 3 or heat the adjacent concrete environment to a temperature above freezing.

1.7.1.4 Do not permit the concrete to cool faster than the rate of 3 C (5 F) per hour or more for the first 24 hr.

1.7.1.5 Use black plastic sheets for curing when the daily high ambient air temperature is less than 15 C (60 F).

1.7.1.6 Provide required materials and equipment to protect the concrete at the project site before cold weather concreting.

1.8—Curing in hot weather

1.8.1 This covers protection and additional curing requirements that are to be implemented during hot weather. Use initial curing method or methods to avoid plastic shrinkage cracks.

1.8.2 During the initial curing period use evaporation reducers, fogging, or shade (individually or in combination) to control the rate of bleed water evaporation and subsequent drying of the concrete.

1.8.3 Products

1.8.3.1 Use evaporation reducer materials that form a thin continuous film and prevent rapid moisture loss of the bleed water from the concrete surface. Apply the evaporation reducer materials in accordance with manufacturer’s recommendations.

1.8.3.2 Fog spray equipment shall produce fog spray from an atomizing nozzle with sufficient velocity to cover the concrete surface. Higher operating pressures and flow rates may be necessary to deliver the fog spray over long distances.

1.8.3.3 The temperature of the curing water shall not be more than 10 C (20 F) cooler than the surface temperature of the concrete at the time the water and concrete come in contact. Water shall be potable, meet the requirements of ASTM C 94, and be free of materials that have the potential to stain concrete.

1.8.4 Execution

1.8.4.1 Prepare to implement hot weather curing procedures prior to hot weather conditions.

1.8.4.2 Provide sufficient human resources to properly execute the hot weather concreting procedures while continuously placing and finishing the concrete.

1.8.4.3 Wet subgrade, forms, reinforcing, and other embedded steel and previously placed surfaces immediately before placing concrete.

1.8.4.4 Prevent drying of the concrete prior to the application of final curing methods by using the appropriate initial curing method. When necessary to prevent drying of the concrete surface, further reduce the loss of moisture from the concrete by shading the concrete mixers, formwork, reinforcing steel, and concrete from direct sunlight, and by erecting windbreaks, or a combination of such methods. Place and finish concrete at night when loss of moisture from the concrete cannot be controlled by the above measures, and when evaporative conditions are less severe than in the daytime.

1.8.4.5 Use one of the two following methods for initial curing:

a. Use fog spray as specified in Section 5 of this Specification.

b. Use entrapment of the bleed water on the concrete surface under a uniform distribution of an evaporation-retardant film. Place the evaporation-retardant film between the different finishing operations. Do not work the liquid film material into the paste during subsequent finishing operations. Do not work water to the surface of the concrete in the finishing process.

1.8.4.6 Perform final curing methods immediately upon completion of the final finishing operation. Final curing may be performed using any of the methods described in this Specification.

1.8.4.6.a Use a white pigmented (ASTM C 309 Type 2) liquid membrane-forming curing compound.

1.8.4.6.b Use white, or reflective, plastic.

1.8.4.6.c Do not use evaporative-retardant material as a curing compound.

SECTION 2—MOISTURE RETENTION

2.1—General

2.1.1 Description—This section covers methods and procedures for curing concrete using plastic sheets, plastic sheets bonded to water-absorbent fabric, or reinforced paper.

2.2—Products

2.2.1 Plastic sheets shall be polyethylene with a minimum thickness of 0.1 mm (0.004 in.) or 4 mil plastic sheets bonded to water-absorbent fabric shall have a minimum thickness of 0.1 mm (0.004 in.) or 4 mil polyethylene film bonded to a layer of cotton, burlap, manufactured fabric, or other absorptive material. Sheets shall meet the requirements of ASTM C 171.

2.2.2 Reinforced paper shall consist of two layers of kraft paper bonded with a layer of bituminous adhesive, reinforced with non-asbestos fibers. Reinforced paper shall comply with ASTM C 171.

2.3—Execution

2.3.1 Place material on the concrete surface as soon as possible without marring the surface. Cover all exposed concrete surfaces and beyond the edge of the concrete surface. Securely tape sheets together or lap them. Maintain the integrity of the material and the ability to contain the water on the concrete surface throughout the curing period.

2.3.2 Verify that the concrete is continuously wet under the sheets; otherwise, add water through soaker hoses under the sheets.

2.3.3 Use black or dark colored plastic sheets when the daily high ambient temperature is below 15 C (60 F). Use white or similarly reflective plastic sheets when the daily high ambient temperature is above 30 C (85 F). Use any color or transparency of plastic sheet at temperatures between 15 and 30 C (60 and 85 F).
SECTION 3—MOISTURE RETENTION: LIQUID MEMBRANE-FORMING CURING COMPOUNDS

3.1—General
3.1.1 Description—This section covers methods and procedures for curing concrete using liquid membrane-forming curing compounds.
3.1.2 Submittals
3.1.2.1 Submit description of curing procedure to be used, and data demonstrating that proposed materials meet specification requirements, to include the following:
   a. Manufacturer’s technical data including rate of moisture loss at stated application rate and material safety data sheets (MSDS).
   b. Manufacturer’s certification verifying product compliance to volatile organic compound (VOC) limits.

3.2—Products
3.2.1 Liquid membrane-forming compounds shall meet the requirements of ASTM C 309. White or gray compounds shall be used for light reflectance.

3.3—Execution
3.3.1 Apply liquid membrane-forming compounds uniformly and at the rate recommended by the manufacturer, but at a rate as tested using ASTM C 309. Apply liquid membrane-forming compounds immediately after final finishing and as soon as the free water has disappeared, no water sheen is visible, and bleeding has essentially ceased. Keep the concrete surface moist without standing water. Protect the membrane from damage for the duration of the curing period. Provide adequate ventilation during the formation of the membrane.
3.3.2 Place curing compounds with an electrical or gasoline-powered sprayer. The use of a hand pump sprayer, brush, or paint roller for areas less than 200 m² (2000 ft²) is permissible or if overspray from powered sprayers could damage adjacent materials.

SECTION 4—ADDITION OF WATER: PONDING

4.1—General
4.1.1 Description—This section covers concrete curing methods and procedures for addition of water to the concrete surface by ponding or immersion.

4.2—Products
4.2.1 The temperature of the curing water shall not be lower than 10 C (20 F) cooler than the surface temperature of the concrete at the time the water and concrete come in contact. Water shall be potable or shall meet the requirements of ASTM C 94, and shall be free of materials that have the potential to stain concrete.

4.3—Execution
4.3.1 Execute ponding by building a ridge of earth, sand, or other material around the concrete and flooding the surface with water.
4.3.2 Start ponding on the concrete surface as soon as possible without marring the surface.
4.3.3 Replace water lost due to evaporation or leakage at a rate sufficient to maintain the pond. Do not allow alternate wetting and drying of the concrete surfaces. Keep concrete surfaces continuously wet.

SECTION 5—ADDITION OF WATER: FOG SPRAY

5.1—General
5.1.1 Description—This section covers curing methods and procedures for addition of water to concrete surfaces by fog spray.

5.2—Products
5.2.1 The temperature of the curing water shall not be lower than 10 C (20 F) cooler than the surface temperature of the concrete at the time the water and concrete come in contact. Water shall be potable or shall meet the requirements of ASTM C 94, and shall be free of materials that have the potential to stain concrete.
5.2.2 Equipment shall produce fog spray from an atomizing nozzle with sufficient velocity to cover the concrete surface. Higher operating pressures and flow rates may be necessary to deliver the fog spray over long distances. Lower pressure devices are acceptable for final curing.

5.3—Execution
5.3.1 Initial curing procedure—Direct atomized water spray above the concrete surface to allow the fog to drift down to the concrete surface. Direct discharge of the atomized water spray onto the surface of the concrete is unacceptable. Generate sufficient velocity of the atomized water droplets to reach the extreme edges of the concrete surface. Continue fogging as necessary to maintain the reflective appearance of the damp concrete. Do not allow the surface to dry, or to undergo cycles of drying and wetting. Keep the concrete surface damp, but do not accumulate water until after final set has occurred.
5.3.2 Final curing procedure—Keep the concrete surface continuously wet. Do not allow alternate wetting and drying of concrete surfaces.

SECTION 6—ADDITION OF WATER: SPRINKLING

6.1—General
6.1.1 Description—This section covers concrete curing methods and procedures by sprinkling.

6.2—Products
6.2.1 The temperature of the curing water shall not be lower than 10 C (20 F) cooler than the surface temperature of the concrete at the time the water and concrete come in contact. Water shall be potable or shall meet the requirements of ASTM C 94, and shall be free of materials that have the potential to stain concrete.

6.2.2 Equipment shall consist of soaker hoses, lawn sprinklers, or a combination thereof.

6.3—Execution
6.3.1 Perform sprinkling for final curing by using either soaker hoses or lawn sprinklers. Exercise care so the surface of the concrete is not eroded.
6.3.2 Use soaker hoses for initial curing of concrete walls and columns after time of initial setting and prior to the
forms being removed. Place hoses at the top of walls and columns so water will enter between concrete and form work.

6.3.3 Keep the concrete surfaces continuously wet.

SECTION 7—ADDITION OF WATER: WATER-ABSORBENT MATERIALS

7.1—General
7.1.1 Description—This section covers curing methods and procedures for addition of water to the concrete surface by absorbent materials.

7.2—Products
7.2.1 The temperature of the curing water shall not be lower than 10°C (20°F) cooler than the surface temperature of the concrete at the time the water and concrete come in contact. Water shall be potable or shall meet the requirements of ASTM C 94, and shall be free of materials that have the potential to stain concrete.

7.2.2 Use sand, hay, straw, burlap, cotton mats, rugs, or earth free of materials that could cause staining of the concrete surface.

7.2.3 Earth materials shall be free of organic matter and particles larger than 25 mm (1 in.).

7.2.4 Burlap shall meet the requirements of AASHTO M 182-91.

7.3—Execution
7.3.1 Uniformly distribute absorbent materials across the concrete surface. Apply water to the materials so that the materials are not displaced. Keep the concrete surfaces continuously wet. Do not allow concrete surfaces to dry or alternate with wetting and drying cycles. Do not place the materials during the initial curing period. Do not stain the concrete.