External Curing of Cast-in-Place Concrete—Specification

An ACI Standard

Reported by ACI Committee 308

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This Reference Specification provides requirements for curing concrete that the Architect/Engineer can apply to any construction project by citing it in the Project Specification. Checklists are provided to assist the Architect/Engineer in supplementing the provisions of this Reference Specification as needed by designating or specifying customized project requirements.

This Specification provides requirements for various methods for the external curing of concrete. These methods are not necessarily equal in effectiveness, cost, effect on project schedule, or impact on other aspects of the project. Provisions governing initial, final, and termination of curing are included.

This Specification addresses external curing methods applied after placement of cast-in-place concrete. While internal curing (use of saturated lightweight aggregate or other materials to provide supplemental water) and accelerated curing (heat curing) shall also use external curing methods, not all aspects of internal and accelerated curing are included.
Keywords: cold weather concreting; concrete construction; curing; curing films and sheets; hot weather concreting; insulation; membrane curing compounds; moist curing; moisture retention; sealers; water curing; water retention.

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PART 1—GENERAL

1.1—Scope

1.1.1 This Specification covers requirements for curing cast-in-place concrete elements as indicated in Contract Documents.
1.1.2 This Specification is incorporated by Contract Documents and provides requirements for the Contractor.

This draft is not final and is subject to revision. This draft is for public review and comment.
1.1.3 This Specification includes requirements for initiating curing, protection from damage, curing for unformed and formed surfaces, and curing duration.

1.1.4 This Specification governs for construction within its scope, except project-specific Contract Documents govern if there is a conflict.

1.1.5 This Specification governs if there is a conflict with referenced material and testing standards.

1.1.6 Contractor is permitted to submit written alternatives to any provision in this Specification for consideration.

1.1.7 Do not use this Specification in conjunction with ACI 301 or ACI 350.5 unless Contract Documents state that this Specification governs for Work covered by 1.1.1.

1.1.8 Ignore provisions of this Specification that are not applicable to the Work.

1.1.9 Values in this specification are stated in inch-pound units. A companion specification in SI units is available.

1.1.10 The Notes to Specifier are not part of this Specification.

1.2—Interpretation

1.2.1 Unless otherwise explicitly stated, this Specification shall be interpreted using the following principles.

1.2.1.1 Interpret this Specification consistent with the plain meaning of the words and terms used.

1.2.1.2 Definitions provided in this Specification govern over the definitions of the same or similar words or terms found elsewhere.

1.2.1.3 Whenever possible, interpret this Specification so that its provisions are in harmony and do not conflict.

1.2.1.4 Headings are part of this Specification and are intended to identify the scope of the provisions or sections that follow. If there is a difference in meaning or implication between the text of a provision and a heading, the meaning of the text governs.

1.2.1.5 Where a provision of this Specification involves two or more items, conditions, requirements, or events connected by the conjunctions “and” or “or,” interpret the conjunctions as follows:

“and” indicates that all connected items, conditions, requirements, or events apply

“or” indicates that connected items, conditions, requirements, or events apply singularly

1.2.1.6 The use of the verbs “may” or “will” indicates that the specification provision is information to the Contractor.

1.2.1.7 The phrase “as indicated in Contract Documents” means the specifier included the provision requirements in the Contract Documents.
1.2.1.8 The phrase “unless otherwise specified” means the specifier may have included an alternative to the default requirement in the Contract Documents.

1.2.1.9 The phrase “if specified” means the specifier may have included a requirement in Contract Documents for which there is no default requirement in this Specification.

1.2.1.10 Unless otherwise stated, the inch-pound system of units is applicable to combined standards referenced in this Specification.

1.3—Definitions

The following definitions shall govern in this Specification.

accepted—determined by Architect/Engineer to be in compliance with Contract Documents.

Architect/Engineer—the architect, engineer, architectural firm, or engineering firm developing Contract Documents, or administering the Work under Contract Documents, or both.

cold weather—when air temperature has fallen to, or is expected to fall below, 40°F during the protection period; protection period is defined as the time recommended to prevent concrete from being adversely affected by exposure to cold weather during construction.

Contract Documents—set of documents that form the basis of a contractual relationship between and Owner and Contractor or design-builder. These documents are defined by the contractual agreement, and can contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.

Contractor—the person, firm, or entity under contract for construction of the Work.

curing period—duration during which continuous curing procedures are employed, which includes the initial and final curing stages.

dike—an embankment, ridge, berm, or other dam used to contain water.

drawings—graphic presentations that detail requirements for Work and may include written notes.

final curing—deliberate action taken between final finishing and termination of curing to reduce the loss of water from the surface of the concrete and control the temperature of the concrete.

final finishing—final treatment of fresh or recently placed concrete to produce specified surface.

hot weather—one or a combination of the following conditions that tends to impair the quality of freshly mixed or hardened concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise causing detrimental results: high ambient temperature; high concrete temperature; low relative humidity; or high wind speed.

initial curing—deliberate action taken between placement and final finishing of concrete to reduce the loss of water from the surface of the concrete.
Owner—the corporation, association, partnership, individual, public body, or authority for whom the Work is constructed.

specification—the written document that details requirements for Work.

submit—provide to Architect/Engineer for review and acceptance.

submittal—document or material provided to Architect/Engineer for review and acceptance.

testing agency—the person, firm, or entity under contract for providing testing services.

Work—the entire construction or separately identifiable parts required to be furnished under Contract Documents.

1.4—Referenced standards
Standards of ACI, ASTM, AASHTO, and ICC cited in this Specification are listed by name and designation, including year.

1.4.1 American Concrete Institute
ACI SPEC-301-20—Specifications for Concrete Construction
ACI SPEC-305.1-14(20)—Specification for Hot Weather Concreting
ACI SPEC-350.5-12—Specifications for Environmental Concrete Structures

1.4.2 ASTM International
ASTM C31/C31M-21a—Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C171-20—Standard Specification for Sheet Materials for Curing Concrete
ASTM C309-19—Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C1074-19e1—Standard Practice for Estimating Concrete Strength by the Maturity Method
ASTM C1315-19—Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

1.4.3 American Association of State Highway and Transportation Officials (AASHTO)
AASHTO M 182-05—Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

1.4.4 International Code Council (ICC)
2021 International Building Code

1.5—Submittals
Submit required information being proposed for the Work listed in 1.5.1 to 1.5.12, as applicable.

1.5.1 Liquid membrane-forming curing compound product data.
1.5.2 Liquid applied evaporation reducer product data.
1.5.3 Sheet material product data.
1.5.4 Absorbent materials product data.
1.5.5 Insulation materials, thermal protective blankets, or enclosure product data or detail.
1.5.6 Wind screen material product data, detail, and layout.
1.5.7 Curing water source.
1.5.8 Description or detail of dike material.
1.5.9 Burlap product data.
1.5.10 Fogging equipment product data and layout.
1.5.11 Heating equipment data and layout.
1.5.12 Unless otherwise specified, submit procedures for curing. If hot weather or cold weather conditions are anticipated during concrete construction, include related curing procedures.

1.6—Quality assurance and quality control
1.6.1 General—Where applicable, special inspections related to curing will be performed in accordance with the International Building Code, Chapter 17. Contractor will be notified of deviations to Contract Document’s curing requirements, and they shall be corrected upon notification.
1.6.2 Support—If termination of curing is determined by 3.4.1.2 or 3.4.1.3, provide dedicated space and source of electrical power on project site acceptable to Owner’s testing agency.

PART 2—PRODUCTS

2.1—Materials
2.1.1 Liquid membrane-forming curing compound—Unless otherwise specified, shall conform to ASTM C309 or ASTM C1315. Unless otherwise specified, silicate-based liquid densifiers are prohibited as curing compounds.
2.1.2 Evaporation reducers—Liquid applied evaporation reducers as indicated in Contract Documents.
2.1.3 Sheet materials for curing—Unless otherwise specified, shall conform to ASTM C171. Use dark-colored material if air temperatures are expected to be below 50°F during curing period. Use white-colored or reflective material if air temperatures are expected to be above 85°F during curing period.
2.1.4 Absorbent materials—Unless otherwise specified, absorbent materials, with or without integral vapor barrier, shall meet requirements of ASTM C171.
2.1.5 Water for curing—Unless otherwise specified, do not use seawater or water containing substances that will discolor or impair the durability of concrete, reinforcing steel, or other embedded materials.
2.1.6 Burlap—Unless otherwise specified, shall meet the requirements of AASHTO M 182.
PART 3—EXECUTION

3.1—General
3.1.1 If bleed water sheen is not visible on surface of concrete after strike-off and initial floating, provide
initial curing per 3.2.
3.1.2 Start final curing of concrete using one or more of the methods specified in 3.3 after final finishing
and once surface will not be damaged by application of selected method or methods. If start of final curing
is delayed after final finishing, use a curing method specified in 3.2 after final finishing and continue until
final curing can be started.

3.2—Initial curing
If required by 3.1.1, 3.1.2, or 3.6.1, use one or both of the methods in 3.2.1 or 3.2.2, unless otherwise
specified. Continue until final finishing, or no longer required by 3.1.1 or 3.6.1.
3.2.1 Fogging
3.2.1.1 Set up fogging equipment to allow complete and uniform coverage of surface to be cured.
3.2.1.2 Using equipment that produces fog spray from atomizing nozzles, direct fog spray above surface,
allowing fog to drift down to surface.
3.2.1.3 Continue fogging as necessary to maintain sheen on surface.
3.2.1.4 Do not allow accumulation of surface water until after final finishing is complete.
3.2.2 Evaporation reducer
3.2.2.1 Apply evaporation reducer after strike-off and between finishing operations.
3.2.2.2 Apply a uniform film of evaporation reducer to surface in accordance with manufacturer’s in-
structions.
3.2.2.3 Do not work evaporation reducer into surface. Do not use evaporation reducer as finishing aid.
Allow evaporation reducer to fully evaporate prior to subsequent finishing operations.

3.3—Final curing
3.3.1 After final finishing, and once surface will not be damaged by application of selected method or
methods, cure formed and unformed concrete using one or more of the methods in 3.3.2 through 3.3.7 until
3.4 is met.
3.3.2 Water-retention sheet material
3.3.2.1 Place sheet material on surface. Do not damage or discolor surface.
3.3.2.2 Cover all concrete surfaces to be cured.
3.3.2.3 Lap sheets to maintain contact between sheets or securely tape sheets together.
3.3.2.4 Maintain integrity and placement of sheet material throughout curing period.
3.3.2.5 Keep surface wet under sheet material. Do not allow cycles of surface drying and wetting.
3.3.3 Liquid membrane-forming curing compound

3.3.3.1 Apply a uniform continuous film at rate and pattern required by manufacturer. If no rate and pattern is required by manufacturer, apply at rate required to produce a uniform continuous film in two orthogonal directions, with half each direction and allowing first application to become tacky prior to second application.

3.3.3.2 Apply compound at completion of final finishing, after disappearance of surface water sheen, and bleeding has ceased. If specified, determine if bleeding has ceased.

3.3.3.3 Protect compound from damage and traffic as required by manufacturer.

3.3.3.4 Provide ventilation during application of membrane-forming curing compound as required by product Safety Data Sheet or manufacturer requirements.

3.3.4 Ponding

3.3.4.1 Build dike around concrete and flood surface with water.

3.3.4.2 Surface shall be continuously covered with water for the curing period.

3.3.4.3 The water temperature shall be within 20°F of concrete surface temperature when water and concrete come in contact.

3.3.4.4 Start ponding on surface after final finishing and without damaging surface.

3.3.5 Sprinkling

3.3.5.1 Perform sprinkling using either soaker hoses or lawn sprinklers.

3.3.5.2 Surface shall not be eroded by running water.

3.3.5.3 If sprinkling is used on formed construction, loosen formwork until bond between form and concrete is broken, and locate soaker hoses at top of placement. Adjust water application rate to keep concrete surfaces continuously wet without excessive runoff. Do not damage surface loosening forms. Do not allow cycles of surface drying and wetting.

3.3.6 Fogging

3.3.6.1 Per 3.2.1. Do not allow cycles of surface drying and wetting.

3.3.7 Absorbent material including burlap

3.3.7.1 Verify that absorbent material is compatible with specified surface finish and will not stain or compromise finish.

3.3.7.2 Pre-dampen absorbent materials before application.

3.3.7.3 Uniformly distribute absorbent materials on surface without damaging it.

3.3.7.4 Maintain integrity and placement of absorbent materials throughout curing period. Do not allow cycles of surface drying and wetting.

3.4—Termination of curing

This draft is not final and is subject to revision. This draft is for public review and comment.
3.4.1 Maintain final curing for curing period specified in 3.4.1.1, 3.4.1.2, or 3.4.1.3.

3.4.1.1 Unless otherwise specified, duration is minimum of 7 days with a minimum surface temperature specified in Table 3.5. If minimum surface temperature is not met, follow 3.5.

3.4.1.2 Unless otherwise specified, duration is until average of two standard cured cylinders, cast in accordance with ASTM C31/C31M, attains 70% of compressive strength specified in Contract Documents tested in accordance with ASTM C39/C39M.

3.4.1.3 One of the in-place test methods from 3.4.1.3.1 through 3.4.1.3.3. Contractor shall inform Owner of selected termination method prior to start of construction.

3.4.1.3.1 Alternative In-place test method—If specified, duration is until concrete attains the specified minimum strength estimated using an alternative in-place test method, as indicated in Contract Documents.

3.4.1.3.2 Molded cylinder method—Unless otherwise specified, duration is until average of two field cured cylinders, cast in accordance with ASTM C31/C31M, attains 70% of compressive strength specified in Contract Documents tested in accordance with ASTM C39/C39M.

3.4.1.3.3 Maturity method—Unless otherwise specified, duration is until concrete attains 70% of compressive strength specified in Contract Documents estimated in accordance with ASTM C1074.

3.5—Cold weather curing

3.5.1 General—If concrete construction is subject to cold weather conditions during curing period, implement thermal protection in addition to other specified curing requirements. Protect concrete from effects of cold weather throughout curing period.

3.5.2 Monitor environmental conditions prior to start of concrete placement. If high evaporation conditions are anticipated, calculate evaporation rate in accordance with nomograph in ACI SPEC-305.1, Figure B1. If evaporation rate during concrete placement exceeds specified limit in 3.6.1, use initial curing method in 3.2.2.

3.5.3 Provide cold weather protection materials and equipment to project site before cold weather conditions exist.

3.5.4 Protect concrete surface against direct, uneven heating, and carbonation due to combustion heater exhaust exposure.

3.5.5 If a final curing method from 3.3 that uses applied water is selected, control application rate to limit runoff beyond thermally protected area.

3.5.6 If applicable, protect surface from freezing temperatures for 24 hours minimum after terminating application of water to surface.

3.5.7 Unless otherwise specified, do not expose concrete which has been wetted, either through environmental or artificial means, to repeated cycles of freezing and thawing until the average compressive strength
of a set of standard cured test cylinders, cast in accordance with ASTM C31/C31M, has reached at least
3500 psi tested in accordance with ASTM C39/C39M.

3.5.8 Maintain concrete surface temperature in accordance with Table 3.5 throughout curing period.

3.5.9 Maximum decrease in concrete surface temperature during any 24-hour period shall not exceed
Table 3.5.

3.5.10 Thermal protection removal method shall not decrease the surface temperature faster than 5°F/hr.

<table>
<thead>
<tr>
<th>Table 3.5 Concrete temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least dimension of section, inches</td>
</tr>
<tr>
<td>Less than 12</td>
</tr>
<tr>
<td>12 to less than 36</td>
</tr>
<tr>
<td>36 to 72</td>
</tr>
<tr>
<td>Greater than 72</td>
</tr>
</tbody>
</table>

3.6—Hot weather curing

3.6.1 General—If concrete construction is subject to hot weather conditions during placement or finishing, or evaporation rate is anticipated to exceed limit as indicated in Contract Documents, implement additional protection and curing requirements per 3.6.2 and 3.6.3.

3.6.2 Initial curing—Use one or more initial curing methods specified in 3.2 unless otherwise specified.

3.6.3 Final curing—Use one or more final curing methods specified in 3.3 unless otherwise specified.

(non-mandatory portion follows)

NOTES TO SPECIFIER

General notes

G1. ACI Specification SPEC-308.1 is to be used by reference in the technical specifications of the Contract Documents. Do not copy individual parts, articles, or paragraphs into the technical specifications of the Contract Documents because taking them out of context may change their meaning.

G2. If parts of ACI Specification SPEC-308.1 are copied into the technical specifications of the Contract Documents or any other document, do not refer to them as an ACI specification.

G3. A statement such as the following will serve to make ACI Specification SPEC-308.1 a part of the technical specifications of the Contract Documents:

This draft is not final and is subject to revision. This draft is for public review and comment.
“Work on (Project Title) shall conform to all requirements of ACI SPEC-308.1-22 External Curing of Cast-in-Place Concrete—Specification published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by these Contract Documents.”

G4. ACI Specification SPEC-308.1 is written in the three-part section format of the Construction Specifications Institute, as adapted for ACI requirements. The language is imperative and terse.

G5. If ACI Specification SPEC-308.1 is referenced in Contract Documents along with another ACI specification that contains overlapping provisions, identify which requirements are in conflict and state in Contract Documents which requirements govern.

Forward to checklists

F1. This foreword is included for explanatory purposes only; it is not a part of ACI Specification SPEC-308.1.

F2. ACI Specification SPEC-308.1 may be referenced by the specifier in the technical specifications of the Contract Documents for any project, together with supplementary requirements for the specific project. Responsibilities for project participants must be defined in the technical specifications of the Contract Documents. ACI Specification SPEC-308.1 cannot and does not address responsibilities for any project participant other than Contractor.


F4. The Mandatory Requirements Checklist indicates work requirements regarding specific qualities, procedures, materials, and performance criteria that are not defined in ACI Specification SPEC-308.1. The specifier must include these requirements in the technical specifications of the Contract Documents.

F5. The Optional Requirements Checklist identifies specifier alternatives or additions. The checklist identifies the parts, and articles of ACI Specification SPEC-308.1 and the action required or available to the specifier. The specifier should review each of the items in the checklist and make adjustments to the needs of a particular project by including those selected alternatives or additions as mandatory requirements in the technical specifications of the Contract Documents.

F6. Cited references—Documents and publications that are referenced in the checklists of ACI Specification SPEC-308.1 are listed below. These references provide guidance to the specifier and are not considered to be part of ACI Specification SPEC-308.1.

American Concrete Institute
ACI SPEC-305.1-14(20)—Specification for Hot Weather Concreting

ASTM International

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### MANDATORY REQUIREMENTS CHECKLIST

<table>
<thead>
<tr>
<th>Section/Part/Article</th>
<th>Notes to Specifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1</td>
<td>Specify cast-in-place elements that shall be cured.</td>
</tr>
<tr>
<td>2.1.2</td>
<td>There is no ASTM standard governing the formulation or use of evaporation reducers. Specify the material to be used as required for the Work.</td>
</tr>
<tr>
<td>3.4.1.3.1</td>
<td>If 3.4.1.3.1 is specified in Optional Checklist, specify the in-place test method and minimum strength required for termination of curing. It may be method specific and not necessarily compressive strength. If 3.4.1.3.1 is not specified in Optional Checklist, this item is not mandatory.</td>
</tr>
<tr>
<td>3.6.1</td>
<td>Specify the allowable evaporation rate specific to the type of structure, anticipated mixture design, and environment pertaining to the Work. A lower allowable evaporation rate may be required for mixtures containing silica fume or admixtures which limit bleed rate.</td>
</tr>
</tbody>
</table>

### OPTIONAL REQUIREMENTS CHECKLIST

<table>
<thead>
<tr>
<th>Section/Part/Article</th>
<th>Notes to Specifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5.12</td>
<td>Specify if Contractor is not required to submit procedures for curing.</td>
</tr>
<tr>
<td>2.1.1</td>
<td>Specify alternative curing compounds if allowed, and if silicate based liquid densifiers are allowed as curing compounds.</td>
</tr>
<tr>
<td>2.1.3</td>
<td>Specify alternative sheet material if allowed. Other types of sheet materials are available that are not covered by ASTM C171.</td>
</tr>
<tr>
<td>2.1.4</td>
<td>Specify alternative absorbent materials for curing if allowed. Other types of absorbent materials, such as cotton mats, straw, washed sand, and fibrous paper mats, are available and not covered by ASTM C171.</td>
</tr>
<tr>
<td>2.1.5</td>
<td>Specify alternative requirements for water used in curing concrete if allowed. Consider expected service conditions if allowing seawater, or chloride and/or sodium laden water, with presence of ferrous items such as reinforcement or embedments. Consider aesthetic impact if allowing water that may stain concrete.</td>
</tr>
<tr>
<td>2.1.6</td>
<td>Specify alternative burlap for curing if allowed.</td>
</tr>
<tr>
<td>3.2</td>
<td>Specify alternative initial curing method if allowed.</td>
</tr>
<tr>
<td>3.3.3.2</td>
<td>Specify how to determine if bleeding has ceased if required. In high evaporation environments, such as dry and windy conditions, it may be difficult to visually determine if bleeding has ceased. Trapped bleed water is detrimental to the concrete surface and yet delaying final curing application is risky. While no ASTM standard exists, placing a clear 18-inch square plastic sheet on the surface prior to application of compound and observing if water is accumulating under the sheet due to bleeding or dewatering can help determine compound application timing.</td>
</tr>
<tr>
<td>3.4.1.1</td>
<td>Specify minimum duration, if other than 7 days, for the curing period.</td>
</tr>
<tr>
<td>3.4.1.2, 3.4.1.3.2, and 3.4.1.3.3</td>
<td>Specify compressive strength required for termination of curing, if not 70% of compressive strength which has been specified in Contract Documents. A higher strength may be desired.</td>
</tr>
</tbody>
</table>
for more severe exposure conditions or for mixtures which use supplementary cementitious materials.

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
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<tbody>
<tr>
<td>3.4.1.3.1</td>
<td>Specify if alternative in-place test method may be used. Durability, instead of compressive strength, is sometimes more critical and alternative testing such as pull-off or impact may be preferred. If specified, see Mandatory Checklist for requirement to then specify test method and strength.</td>
</tr>
<tr>
<td>3.5.7</td>
<td>Specify alternative compressive strength if allowed. Some concrete elements may be designed for a specified compressive strength less than 3500 psi and require an alternative strength.</td>
</tr>
<tr>
<td>3.6.2</td>
<td>Specify alternative requirements for curing during hot weather conditions if needed. Alternatively, reference ACI SPEC-305.1 and address the mandatory requirements checklist items in ACI SPEC-305.1 in Contract Documents.</td>
</tr>
<tr>
<td>3.6.3</td>
<td>Specify alternative final curing method if not already in 3.3.</td>
</tr>
</tbody>
</table>

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