State of Oklahoma
Department of Transportation
Purchasing Division

Solicitation Cover Page

1. **Solicitation #:** 24-MTL-0017 2. **Solicitation Issue Date:** 5/7/2024

3. **Brief Description of Requirement:**

SOLICITATION DESCRIPTION: Laboratory Equipment: Resistance of Concrete to Rapid Freezing and Thawing. Must meet AASHTO Standards, see attached Specifications.

Vendors may submit questions until May 13th, 2024 at 1:00 pm CST by emailing stacy.welty@odot.ok.gov with ODOT's responses made available no later than May 15th, 2024 at 4:00 pm CST.

CLOSING DATE: May 20th, 2024 at 1:00 pm CST - All responses to be emailed to odotbids@odot.ok.gov with sufficient time to make sure that response is received before the 1:00 pm deadline. Please note, if you would like to have a confirmation that the bid was received, please send me a separate email with the request as I am unable to open your bid email until the closing date and time.

4. **Response Due Date**[1]: 5/20/2024 **Time**: 1:00pm CST/CDT

5. **Issued By and RETURN SEALED BID TO**[2]:

U.S. Postal Delivery Address: _____

_____

Common Carrier Delivery Address: _____

_____

Electronic Submission Address: odotbids@odot.ok.org

6. **Solicitation Type** (type "X" at one below):

- ☐ Invitation to Bid
- ☒ Request for Proposal
- ☐ Request for Quote

7. **Contracting Officer**:

Name: Stacy Welty
Phone: 405-766-0493
Email: stacy.welty@odot.ok.org

[1] Amendments to solicitation may change the Response Due Date (read GENERAL PROVISIONS, section 3, "Solicitation Amendments").
[2] If "U.S. Postal Delivery" differs from "Carrier Delivery, use "Carrier Delivery" for courier or personal deliveries.

OKLAHOMA Transportation

Responding Bidder Information

*"Certification for Competitive Bid and Contract" **MUST** be submitted along with the response to the Solicitation.*

1. **RE: Solicitation #** 24-MTL-0017

2. **Bidder General Information:**

FEI / SSN : _____ Supplier ID: _____

Company Name: _____

3. **Bidder Contact Information:**

Address: _____

City: _____ State: ____ Zip Code: _____

Contact Name: _____

Contact Title: _____

Phone #: _____ Fax #: _____

Email: _____ Website: _____

4. **Oklahoma Sales Tax Permit[3]:**

☐ YES – Permit #: _____

☐ NO – Exempt pursuant to Oklahoma Laws or Rules – Attach an explanation of exemption

5. **Registration with the Oklahoma Secretary of State:**

☐ YES - Filing Number: _____

☐ NO - Prior to the contract award, the successful bidder will be required to register with the Secretary of State or must attach a signed statement that provides specific details supporting the exemption the supplier is claiming (www.sos.ok.gov or 405-521-3911).

6. **Workers' Compensation Insurance Coverage:**

Bidder is required to provide with the bid a certificate of insurance showing proof of compliance with the Oklahoma Workers' Compensation Act.

☐ YES – Include with the bid a certificate of insurance.

☐ NO – Exempt from the Workers' Compensation Act pursuant to 85A O.S. § 2(18)(b)(1-11) – Attach a written, signed, and dated statement on letterhead stating the reason for the exempt status.[4]

[3] For frequently asked questions concerning Oklahoma Sales Tax Permit, see https://www.ok.gov/tax/Businesses/index.html

[4] **For frequently asked questions concerning workers' compensation insurance, see https://www.ok.gov/wcc/Insurance/index.html**

7. Disabled Veteran Business Enterprise Act

☐ YES – I am a service-disabled veteran business as defined in 74 O.S. §85.44E. Include with the bid response 1) certification of service-disabled veteran status as verified by the appropriate federal agency, and 2) verification of not less than 51% ownership by one or more service-disabled veterans, and 3) verification of the control of the management and daily business operations by one or more service-disabled veterans.

☐ NO – Do not meet the criteria as a service-disabled veteran business.

Authorized Signature	Date
Printed Name	Title

OKLAHOMA Transportation

Certification for Competitive Bid and/or Contract (Non-Collusion Certification)

NOTE: *A certification shall be included with any competitive bid and/or contract exceeding $5,000.00 submitted to the State for goods or services.*

Agency Name: Oklahoma Department of Transportation

Agency Number: *34500*

Solicitation or Purchase Order #: 24-MTL-0017

Supplier Legal Name: _____

SECTION I [74 O.S. § 85.22]:

A. For purposes of competitive bid,

1. I am the duly authorized agent of the above named bidder submitting the competitive bid herewith, for the purpose of certifying the facts pertaining to the existence of collusion among bidders and between bidders and state officials or employees, as well as facts pertaining to the giving or offering of things of value to government personnel in return for special consideration in the letting of any contract pursuant to said bid;
2. I am fully aware of the facts and circumstances surrounding the making of the bid to which this statement is attached and have been personally and directly involved in the proceedings leading to the submission of such bid; and
3. Neither the bidder nor anyone subject to the bidder's direction or control has been a party:
    a. to any collusion among bidders in restraint of freedom of competition by agreement to bid at a fixed price or to refrain from bidding,
    b. to any collusion with any state official or employee as to quantity, quality or price in the prospective contract, or as to any other terms of such prospective contract, nor
    c. in any discussions between bidders and any state official concerning exchange of money or other thing of value for special consideration in the letting of a contract, nor
    d. to any collusion with any state agency or political subdivision official or employee as to create a sole-source acquisition in contradiction to Section 85.45j.1. of this title.

B. I certify, if awarded the contract, whether competitively bid or not, neither the contractor nor anyone subject to the contractor's direction or control has paid, given or donated or agreed to pay, give or donate to any officer or employee of the State of Oklahoma any money or other thing of value, either directly or indirectly, in procuring this contract herein.

SECTION II [74 O.S. § 85.42]:

For the purpose of a contract for services, the supplier also certifies that no person who has been involved in any manner in the development of this contract while employed by the State of Oklahoma shall be employed by the supplier to fulfill any of the services provided for under said contract.

The undersigned, duly authorized agent for the above named supplier, by signing below acknowledges this certification statement is executed for the purposes of:

☐ the competitive bid attached herewith and contract, if awarded to said supplier;

OR

☐ the contract attached herewith, which was not competitively bid and awarded by the agency pursuant to applicable Oklahoma statutes.

Supplier Authorized Signature	Certified This Date
Printed Name	Title
Phone Number	Email
Fax Number	

A. GENERAL PROVISIONS

A.1. Definitions

As used herein, the following terms shall have the following meaning unless the context clearly indicates otherwise:

A.1.1. "Acquisition" means items, products, materials, supplies, services, and equipment a state agency acquires by purchase, lease purchase, lease with option to purchase, or rental pursuant to the Oklahoma Central Purchasing Act;

A.1.2. “Addendum” means a written restatement of or modification to a Contract Document executed by the Supplier and State.

A.1.3. ”Bid” means an offer in the form of a bid, proposal, or quote a bidder submits in response to a solicitation;

A.1.4. "Bidder" means an individual or business entity that submits a bid in response to a solicitation;

A.1.5. "Solicitation" means a request or invitation by the State Purchasing Director or a state agency for a supplier to submit a priced offer to sell acquisitions to the state. A solicitation may be an invitation to bid, request for proposal, or a request for quotation; and

A.1.6. ”Supplier” or “vendor” means an individual or business entity that sells or desires to sell acquisitions to state agencies.

A.2. Bid Submission

A.2.1. Submitted bids shall be in strict conformity with the instructions to bidders and shall be submitted with a completed Responding Bidder Information, OMES-FORM-CP-076, and any other forms required by the solicitation.

A.2.2. Bids shall be submitted to the procuring agency in a single envelope, package, or container and shall be sealed, unless otherwise detailed in the solicitation. The name and address of the bidder shall be inserted in the upper left corner of the single envelope, package, or container. SOLICITATION NUMBER AND SOLICITATION RESPONSE DUE DATE AND TIME MUST APPEAR ON THE FACE OF THE SINGLE ENVELOPE, PACKAGE, OR CONTAINER.

A.2.3. The required certification statement, "Certification for Competitive Bid and/or Contract (Non-Collusion Certification)", OMES-FORM-CP-004, must be made out in the name of the bidder and must be properly executed by an authorized person, with full knowledge and acceptance of all its provisions.

A.2.4. All bids shall be legible and completed in ink or with electronic printer or other similar office equipment. Any corrections to bids shall be identified and initialed in ink by the bidder. Penciled bids and penciled corrections shall NOT be accepted and will be rejected as non-responsive. In addition to a hard copy submittal, the bidder will also be required to submit an electronic copy. Electronic responses must be submitted in the identical format contained in the solicitation (for example Microsoft Word, Microsoft Excel, but not Adobe PDF). In the event the hard copy of the price worksheets and electronic copy of the price worksheets do not agree, the electronic copy will prevail.

A.2.5. All bids submitted shall be subject to the Oklahoma Central Purchasing Act, Central Purchasing Rules, and other statutory regulations as applicable, these General Provisions, any Special Provisions, solicitation specifications, required certification statement, and all other terms and conditions listed or attached herein—all of which are made part of this solicitation.

A.3. Solicitation Amendments

A.3.1. If an ”Amendment of Solicitation”, OMES-FORM-CP-011, is issued, the bidder shall acknowledge receipt of any/all amendment(s) to solicitations by signing and returning the solicitation amendment(s). Amendment acknowledgement(s) may be submitted with the bid or may be forwarded separately. If forwarded separately, amendment acknowledgement(s) must contain the solicitation number and response due date and time on the front of the envelope. The procuring agency must receive the amendment acknowledgement(s) by the response due date and time specified for receipt of bids for the bid to be deemed responsive. Failure to acknowledge solicitation amendments may be grounds for rejection.

A.3.2. No oral statement of any person shall modify or otherwise affect the terms, conditions, or specifications stated in the solicitation. All amendments to the solicitation shall be made in writing by the procuring agency.

A.3.3. It is the bidder's responsibility to check frequently for any possible amendments that may be issued. The procuring agency is not responsible for a bidder's failure to download any amendment documents required to complete a solicitation.

A.4. Bid Change

If the bidder needs to change a bid prior to the solicitation response due date, a new bid shall be submitted to the procuring agency with the following statement "This bid supersedes the bid previously submitted" in a single envelope, package, or container and shall be sealed, unless otherwise detailed in the solicitation. The name and address of the bidder shall be inserted in the upper left corner of the single envelope, package, or container. SOLICITATION NUMBER AND SOLICITATION RESPONSE DUE DATE AND TIME MUST APPEAR ON THE FACE OF THE SINGLE ENVELOPE, PACKAGE, OR CONTAINER.

A.5. Certification Regarding Debarment, Suspension, and Other Responsibility Matters

By submitting a response to this solicitation:

A.5.1. The prospective primary participant and any subcontractor certifies to the best of their knowledge and belief, that they and their principals or participants:

A.5.1.1. Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded by any Federal, State or local department or agency;

A.5.1.2. Have not within a three-year period preceding this proposal been convicted of or pled guilty or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) contract; or for violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

A.5.1.3. Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State, or local) with commission of any of the offenses enumerated in paragraph A.5.1.2. of this certification; and

A.5.1.4. Have not within a three-year period preceding this application/proposal had one or more public (Federal, State, or local) contracts terminated for cause or default.

A.5.2. Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to its solicitation response.

A.6. Bid Opening

Sealed bids shall be opened by the **See Page 1** located at _____ _____ at the time and date specified in the solicitation as the Response Due Date and Time.

A.7. Open Bid / Open Record

Pursuant to the Oklahoma Public Open Records Act, a public bid opening does not make the bid(s) immediately accessible to the public. The procurement or contracting agency shall keep the bid(s) confidential, and provide prompt and reasonable access to the records only after a contract is awarded or the solicitation is cancelled. This practice protects the integrity of the competitive bid process and prevents excessive disruption to the procurement process. The interest of achieving the best value for the State of Oklahoma outweighs the interest of vendors immediately knowing the contents of competitor's bids. [51 O.S. § 24A.5(5)]

Additionally, financial or proprietary information submitted by a bidder may be designated by the Purchasing Director as confidential and the procurement entity may reject all requests to disclose information designated as confidential pursuant to 62 O.S. (2012) § 34.11.1(H)(2) and 74 O.S. (2011) § 85.10. Bidders claiming any portion of their bid as proprietary or confidential must specifically identify what documents or portions of documents they consider confidential and identify applicable law supporting their claim of confidentiality. The State Purchasing Director shall make the final decision as to whether the documentation or information is confidential pursuant to 74 O.S. § 85.10. Otherwise, documents and information a bidder submits as part of or in connection with a bid are public records and subject to disclosure after contract award or the solicitation is cancelled.

A.8. Late Bids

Bids received by the procuring agency after the response due date and time shall be deemed non-responsive and shall NOT be considered for any resultant award.

A.9. Legal Contract

A.9.1. Submitted bids are rendered as a legal offer and any bid, when accepted by the procuring agency, shall constitute a contract.

A.9.2. The Contract resulting from this solicitation may consist of the following documents in the following order of precedence:

A.9.2.2. Purchase order, as amended by Change Order (if applicable);

A.9.2.3. Solicitation, as amended (if applicable); and

A.9.2.4. Successful bid (including required certifications), to the extent the bid does not conflict with the requirements of the solicitation or applicable law.

A.9.3. Any contract(s) awarded pursuant to the solicitation shall be legibly written or typed.

A.10. Pricing

A.10.1. Bids shall remain firm for a minimum of sixty (60) days from the solicitation closing date.

A.10.2. Bidders guarantee unit prices to be correct.

A.10.3. In accordance with 74 O.S. §85.40, ALL travel expenses to be incurred by the supplier in performance of the Contract shall be included in the total bid price/contract amount.

A.11. Manufacturers' Name and Approved Equivalents

Unless otherwise specified in the solicitation, manufacturers' names, brand names, information and/or catalog numbers listed in a specification are for information and not intended to limit competition. Bidder may offer any brand for which they are an authorized representative, and which meets or exceeds the specification for any item(s). However, if bids are based on equivalent products, indicate on the bid form the manufacturer's name and number. Bidder shall submit sketches, descriptive literature, and/or complete specifications with their bid. Reference to literature submitted with a previous bid will not satisfy this provision. The bidder shall also explain in detail the reason(s) why the proposed equivalent will meet the specifications and not be considered an exception thereto. Bids that do not comply with these requirements are subject to rejection.

A.12. Clarification of Solicitation

A.12.1. Clarification pertaining to the contents of this solicitation shall be directed in writing to the Contracting Officer specified in the solicitation, and must be prior to the closing date of the solicitation.

A.12.2. If a bidder fails to notify the State of an error, ambiguity, conflict, discrepancy, omission or other error in the SOLICITATION, known to the bidder, or that reasonably should have been known by the bidder, the bidder shall submit a bid at its own risk; and if awarded the contract, the bidder shall not be entitled to additional compensation, relief, or time, by reason of the error or its later correction. If a bidder takes exception to any requirement or specification contained in the SOLICITATION, these exceptions must be clearly and prominently stated in their response.

A.12.3. Bidders who believe proposal requirements or specifications are unnecessarily restrictive or limit competition may submit a written request for administrative review to the contracting officer listed on the solicitation. This request must be made prior to the closing date of the solicitation.

A.13 Negotiations

A.13.1. In accordance with Title 74 §85.5, the State of Oklahoma reserves the right to negotiate with one, selected, all or none of the vendors responding to this solicitation to obtain the best value for the State. Negotiations could entail discussions on products, services, pricing, contract terminology or any other issue that may mitigate the State's risks. The State shall consider all issues negotiable and not artificially constrained by internal corporate policies. Negotiation may be with one or more vendors, for any and all items in the vendor's offer.

A.13.2. Firms that contend that they lack flexibility because of their corporate policy on a particular negotiation item shall face a significant disadvantage and may not be considered. If such negotiations are conducted, the following conditions shall apply:

A.13.3. Negotiations may be conducted in person, in writing, or by telephone.

A.13.4. Negotiations shall only be conducted with potentially acceptable offers. The State reserves the right to limit negotiations to those offers that received the highest rankings during the initial evaluation phase.

A.13.5. Terms, conditions, prices, methodology, or other features of the bidders offer may be subject to negotiations and subsequent revision. As part of the negotiations, the bidder may be required to submit supporting financial, pricing, and other data in order to allow a detailed evaluation of the feasibility, reasonableness, and

A.13.6. The requirements of the Request for Proposal shall not be negotiable and shall remain unchanged unless the State determines that a change in such requirements is in the best interest of the State Of Oklahoma.

A.14. Rejection of Bid

The State reserves the right to reject any bids that do not comply with the requirements and specifications of the solicitation. A bid may be rejected when the bidder imposes terms or conditions that would modify requirements of the solicitation or limit the bidder's liability to the State. Other possible reasons for rejection of bids are listed in OAC 260:115-7-32.

A.15. Award of Contract

A.15.1. The State Purchasing Director may award the Contract to more than one bidder by awarding the Contract(s) by item or groups of items, or may award the Contract on an ALL OR NONE basis, whichever is deemed by the State Purchasing Director to be in the best interest of the State of Oklahoma.

A.15.2. Contract awards will be made to the lowest and best bidder(s) unless the solicitation specifies that best value criteria is being used.

A.15.3. In order to receive an award or payments from the State of Oklahoma, suppliers must be registered. The vendor registration process can be completed electronically through the OMES website at the following link: https://www.ok.gov/dcs/vendors/index.php .

A.16. Contract Modification

A.16.1. The Contract is issued under the authority of the State Purchasing Director who signs the Contract. The Contract may be modified only through a written Addendum, signed by the State Purchasing Director and the supplier .

A.16.2. Any change to the Contract, including but not limited to the addition of work or materials, the revision of payment terms, or the substitution of work or materials, directed by a person who is not specifically authorized by the procuring agency in writing, or made unilaterally by the supplier, is a breach of the Contract. Unless otherwise specified by applicable law or rules, such changes, including unauthorized written Addendums, shall be void and without effect, and the supplier shall not be entitled to any claim under this Contract based on those changes. No oral statement of any person shall modify or otherwise affect the terms, conditions, or specifications stated in the resultant Contract.

A.17. Delivery, Inspection and Acceptance

A.17.1. Unless otherwise specified in the solicitation or awarding documents, all deliveries shall be F.O.B. Destination. The supplier(s) awarded the Contract shall prepay all packaging, handling, shipping and delivery charges and firm prices quoted in the bid shall include all such charges. All products and/or services to be delivered pursuant to the Contract shall be subject to final inspection and acceptance by the State at destination. "Destination" shall mean delivered to the receiving dock or other point specified in the purchase order. The State assumes no responsibility for goods until accepted by the State at the receiving point in good condition. Title and risk of loss or damage to all items shall be the responsibility of the supplier until accepted by the receiving agency. The supplier(s) awarded the Contract shall be responsible for filing, processing, and collecting any and all damage claims accruing prior to acceptance.

A.17.2. Supplier(s) awarded the Contract shall be required to deliver products and services as bid on or before the required date. Deviations, substitutions or changes in products and services shall not be made unless expressly authorized in writing by the procuring agency.

A.18. Invoicing and Payment

A.18.1. Upon submission of an accurate and proper invoice, the invoice shall be paid in arrears after products have been delivered or services provided and in accordance with applicable law. Invoices shall contain the purchase order number, a description of the products delivered or services provided, and the dates of such delivery or provision of services. An invoice is considered proper if sent to the proper recipient and goods or services have been received.

A.18.2. State Acquisitions are exempt from sales taxes and federal excise taxes.

A.18.3. Pursuant to 74 O.S. §85.44(B), invoices will be paid in arrears after products have been delivered or services provided.

A.18.4. Payment terms will be net 45. Interest on late payments made by the State of Oklahoma is governed by 62 O.S. § 34.72.

A.18.5. Additional terms which provide discounts for earlier payment may be evaluated when making an award. Any such additional terms shall be no less than ten (10) days increasing in five (5) day increments up to thirty (30) days. The date from which the discount time is calculated shall be the date of a proper invoice.

A.19. Tax Exemption

State agency acquisitions are exempt from sales taxes and federal excise taxes. Bidders shall not include these taxes in price quotes.

A.20. Audit and Records Clause

A.20.1. As used in this clause, “records" includes books, documents, accounting procedures and practices, and other data, regardless of type and regardless of whether such items are in written form, in the form of computer data, or in any other form. In accepting any Contract with the State, the successful bidder(s) agree any pertinent State or Federal agency will have the right to examine and audit all records relevant to execution and performance of the resultant Contract.

A.20.2. The successful supplier(s) awarded the Contract(s) is required to retain records relative to the Contract for the duration of the Contract and for a period of seven (7) years following completion and/or termination of the Contract. If an audit, litigation, or other action involving such records is started before the end of the seven (7) year period, the records are required to be maintained for two (2) years from the date that all issues arising out of the action are resolved, or until the end of the seven (7) year retention period, whichever is later.

A.21. Non-Appropriation Clause

The terms of any Contract resulting from the solicitation and any Purchase Order issued for multiple years under the Contract are contingent upon sufficient appropriations being made by the Legislature or other appropriate government entity. Notwithstanding any language to the contrary in the solicitation, purchase order, or any other Contract document, the procuring agency may terminate its obligations under the Contract if sufficient appropriations are not made by the Legislature or other appropriate governing entity to pay amounts due for multiple year agreements. The Requesting (procuring) Agency's decisions as to whether sufficient appropriations are available shall be accepted by the supplier and shall be final and binding.

A.22. Choice of Law

Any claims, disputes, or litigation relating to the solicitation, or the execution, interpretation, performance, or enforcement of the Contract shall be governed by the laws of the State of Oklahoma.

A.23. Choice of Venue

Venue for any action, claim, dispute or litigation relating in any way to the Contract shall be in Oklahoma County, Oklahoma.

A.24. Termination for Cause

A.24.1. The supplier may terminate the Contract for default or other just cause with a 30-day written request and upon written approval from the procuring agency. The State may terminate the Contract for default or any other just cause upon a 30-day written notification to the supplier.

A.24.2. The State may terminate the Contract immediately, without a 30-day written notice to the supplier, when violations are found to be an impediment to the function of an agency and detrimental to its cause, when conditions preclude the 30-day notice, or when the State Purchasing Director determines that an administrative error occurred prior to Contract performance.

A.24.3. If the Contract is terminated, the State shall be liable only for payment for products and/or services delivered and accepted.

A.25. Termination for Convenience

A.25.1. The State may terminate the Contract, in whole or in part, for convenience if the State Purchasing Director determines that termination is in the State's best interest. The State Purchasing Director shall terminate the contract by delivering to the supplier a Notice of Termination for Convenience specifying the terms and

effective date of Contract termination. The Contract termination date shall be a minimum of 60 days from the date the Notice of Termination for Convenience is issued by the State Purchasing Director.

A.25.2. If the Contract is terminated, the State shall be liable only for products and/or services delivered and accepted, and for costs and expenses (exclusive of profit) reasonably incurred prior to the date upon which the Notice of Termination for Convenience was received by the supplier.

A.26. Insurance

The successful supplier(s) awarded the Contract shall obtain and retain insurance, including workers' compensation, automobile insurance, medical malpractice, and general liability, as applicable, or as required by State or Federal law, prior to commencement of any work in connection with the Contract. The supplier awarded the Contract shall timely renew the policies to be carried pursuant to this section throughout the term of the Contract and shall provide the procuring agency with evidence of such insurance and renewals.

A.27. Employment Relationship

The Contract does not create an employment relationship. Individuals performing services required by this Contract are not employees of the State of Oklahoma or the procuring agency. The supplier's employees shall not be considered employees of the State of Oklahoma nor of the procuring agency for any purpose, and accordingly shall not be eligible for rights or benefits accruing to state employees.

A.28. Compliance with the Oklahoma Taxpayer and Citizen Protection Act of 2007

By submitting a bid for services, the bidder certifies that they, and any proposed subcontractors, are in compliance with 25 O.S. §1313 and participate in the Status Verification System. The Status Verification System is defined in 25 O.S. §1312 and includes but is not limited to the free Employment Verification Program (E-Verify) through the Department of Homeland Security and available at www.dhs.gov/E-Verify .

A.29. Compliance with Applicable Laws

The products and services supplied under the Contract shall comply with all applicable Federal, State, and local laws, and the supplier shall maintain all applicable licenses and permit requirements.

A.30. Special Provisions

Special Provisions set forth in SECTION B apply with the same force and effect as these General Provisions. However, conflicts or inconsistencies shall be resolved in favor of the Special Provisions.

Standard Method of Test for

Resistance of Concrete to Rapid Freezing and Thawing

AASHTO Designation: T 161-22

Technically Revised: 2022

Technical Subcommittee: 3c, Hardened Concrete

ASTM Designation: C666/C666M-15

AASHTO
American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, DC 20004

Accessed by account: Oklahoma DOT | Date: Fri Mar 15 14:20:17 UTC 2024 | IP address: 204.62.22.3

Standard Method of Test for

Resistance of Concrete to Rapid Freezing and Thawing

AASHTO

AASHTO Designation: T 161-22

Technically Revised: 2022

Technical Subcommittee: 3c, Hardened Concrete

ASTM Designation: C666/C666M-15

1. SCOPE

1.1. This method covers the determination of the resistance of concrete specimens to rapidly repeated cycles of freezing and thawing in the laboratory by two different procedures: Procedure A, Rapid Freezing and Thawing in Water, and Procedure B, Rapid Freezing in Air and Thawing in Water. Both procedures are intended for use in determining the effects of variations in the properties of concrete on the resistance of the concrete to the freezing and thawing cycles specified in the particular procedure. Neither procedure is intended to provide a quantitative measure of the length of service that may be expected from a specific type of concrete.

1.2. The values stated in SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.3. All material in this test method not specifically designated as belonging to Procedure A or Procedure B applies to either procedure.

1.4. *This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 194M/M 194, Chemical Admixtures for Concrete
- M 339M/M 339, Thermometers Used in the Testing of Construction Materials

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Accessed by account: Oklahoma DOT | Date: Fri Mar 15 14:20:17 UTC 2024 | IP address: 204.62.22.3

- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 39, Making and Curing Concrete Test Specimens in the Laboratory
- R 70M/R 70, Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
- T 157, Air-Entraining Admixtures for Concrete

2.2. *ASTM Standards*:

- C215, Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens
- C295/C295M, Standard Guide for Petrographic Examination of Aggregates for Concrete
- C341/C341M, Standard Practice for Preparation and Conditioning of Cast, Drilled, or Sawed Specimens of Hydraulic-Cement Mortar and Concrete Used for Length Change Measurements
- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- C823/C823M, Standard Practice for Examination and Sampling of Hardened Concrete in Constructions
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E2877, Standard Guide for Digital Contact Thermometers
- Klieger, P., and J. Lamond, eds. *Significance of Tests and Properties of Concrete and Concrete-Making Materials*. STP169C and STP169D. ASTM International, West Conshohocken, PA, 1994. Available from https://doi.org/10.1520/STP169C-EB and https://doi.org/10.1520/STP169D-EB

2.3. *International Electrotechnical Commission Standard:*

- IEC 60584-1:2013 Thermocouples - Part 1: EMF Specifications and Tolerances

3. SIGNIFICANCE AND USE

3.1. As noted in the scope, the two procedures described in this method are intended to determine the effects of variations in both properties and conditioning of concrete in the resistance to freezing and thawing cycles specified in the particular procedure. Specific applications include specified use in M 194M/M 194, T 157, and ranking of coarse aggregates as to their effect on concrete freeze–thaw durability, especially where soundness of the aggregate is questionable.

3.2. It is assumed that the procedures will have no significantly damaging effects on frost-resistant concrete that may be defined as (1) any concrete not critically saturated with water (that is, not sufficiently saturated to be damaged by freezing) and (2) concrete made with frost-resistant aggregates and having an adequate air-void system that has achieved appropriate maturity and thus will prevent critical saturation by water under common conditions.

3.3. If, as a result of performance tests as described in this method, concrete is found to be relatively unaffected, it can be assumed that it was either not critically saturated or was made with "sound" aggregates, a proper air-void system, and allowed to mature properly.

3.4. No relationship has been established between the resistance to cycles of freezing and thawing of specimens cut from hardened concrete and specimens prepared in the laboratory.

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Note 1—There is no apparent reason to expect a difference in performance in these two procedures if the concrete properties are fundamentally the same. However, the fact that these two conditions may have been executed with different consolidation procedures or other procedures could affect the number and size of empty, and possibly water-filled voids, which could affect test results.

3.5. There is no specific guidance in this standard on choosing between Procedure A and Procedure B for a given application, except when contained in another standard. Standards T 157 and M 194M/M 194 both stipulate Procedure A.

3.5.1. In many instances, the choice is based on the user's determination of suitability to a specific application.

3.5.1.1. Procedure A is generally considered to be more aggressive of the two and to better reveal defective materials, although some consider the constant saturation of the test specimens to be unrealistic.

3.5.1.2. Some users prefer Procedure B as being more representative of the saturation patterns in some field applications.

3.5.2. A more complete discussion of the significance and use can be found in ASTM STP169C and STP169D.

3.6. The accuracy of testing for the purpose of verifying compliance with a quantitative specification limit, such as durability factor, can be impacted if the multi-laboratory precision of the method has not been determined or indicates poor reproducibility (Note 2).

Note 2—Multi-laboratory variation is considered to be the best estimator of the actual precision of a test method for determining specification compliance. Single-laboratory variation is a more useful indicator of precision for cases in which the user is only interested in ranking material, or in detecting changes in concrete, properties that result from variations in materials and/or mixture design.

3.7. There is no specific guidance on choosing between fundamental transverse frequency or length change, or the combination thereof, for the method of measurement.

3.7.1. Durability factor (DF) evaluates the integrity of the hardened concrete system, including the aggregates, cement, air void system, and strength.

3.7.2. Length change is usually used as an indicator of aggregate D-cracking potential.

3.7.3. Length change in percent and durability factor are inversely related. As the beam expands during freezing, the durability factor usually decreases.

3.7.4. It is recommended that the user determine the method(s) of measurement best suited for their application prior to proceeding with laboratory evaluation.

4. APPARATUS

4.1. *Freezing and Thawing Apparatus*:

4.1.1. The freezing and thawing apparatus shall consist of a suitable chamber or chambers in which the specimens may be subjected to the specified freezing and thawing cycle, together with the necessary refrigerating and heating equipment and controls to produce, continuously and automatically, reproducible cycles within the specified temperature requirements. In the event that

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the equipment does not operate automatically, provision shall be made for either its continuous manual operation on a 24-hour-a-day basis or for the storage of all specimens in a frozen condition when the equipment is not in operation.

4.1.2. The apparatus shall be so arranged that, except for necessary supports, each specimen is: (1) for Procedure A, completely surrounded by not less than 1 mm ($^1/_{32}$ in.) nor more than 3 mm ($^1/_8$ in.) of water at all times while it is being subjected to freezing and thawing cycles; or (2) for Procedure B, completely surrounded by air during the freezing phase of the cycle and by water during the thawing phase. Rigid containers, which have the potential to damage specimens, are not permitted. Length change specimens in vertical containers shall be supported in a manner to avoid damage to the gauge studs.

Note 3—Experience has indicated that ice or water pressure, during freezing tests, particularly in equipment that uses air rather than a liquid as the heat transfer medium, can cause excessive damage to rigid metal containers and possibly to the specimens therein. Results of tests during which bulging or other distortion of containers occurs should be interpreted with caution.

4.1.3. The temperature of the heat-exchanging medium shall be uniform within 3°C (6°F) throughout the specimen cabinet when measured at any given time, at any point on the surface of any specimen container for Procedure A or on the surface of any specimen for Procedure B, except during the transition between freezing and thawing and vice versa.

4.1.3.1. Support each specimen at the bottom of its container in such a way that the temperature of the heat-exchanging medium will not be transmitted directly through the bottom of the container to the full area of the bottom of the specimen, thereby subjecting it to conditions substantially different from the remainder of the specimen.

Note 4—A flat spiral of 3-mm ($^1/_8$-in.) wire placed in the bottom of the container has been found adequate for supporting specimens.

4.1.4. For Procedure B, it is not contemplated that the specimens will be kept in containers. The supports on which the specimens rest shall be such that they are not in contact with the full area of the supported side or end of the specimen, thereby subjecting this area to conditions substantially different from those imposed on the remainder of the specimen.

Note 5—The use of relatively open gratings, metal rods, or the edges of metal angles has been found adequate for supporting specimens, provided the heat-exchanging medium can circulate in the direction of the long axis of the rods or angles.

4.2. *Temperature-Measuring Equipment*—Consisting of thermometers, resistance thermometers, or thermocouples, capable of measuring the temperature at various points within the specimen chamber and at the centers of control specimens to within 1°C (2°F). The thermometer for measuring the temperature within the test chamber, on the surface of a specimen, and for embedding in a specimen, shall meet the requirements of M 339M/M 339 with a temperature range of at least –20 to 10°C (–4 to 50°F) and an accuracy of ±0.5°C (±0.9°F) (see Note 6).

Note 6—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; or IEC 60584 thermocouple thermometer, Type T, Class 1.

4.3. *Dynamic Testing Apparatus*—Conforming to the requirements of ASTM C215.

4.4. *Length Comparator*—Conforming to the requirements of R 70M/R 70. When specimens longer than the nominal 285-mm ($11^1/_4$-in.) length provided for in R 70M/R 70 are used for freeze–thaw tests, use an appropriate length reference bar, which otherwise meets the R 70M/R 70 requirements. Dial gauge micrometers for use on these longer length change comparators shall meet the gradation interval and accuracy requirements for R 70M/R 70 for the millimeter (inch) calibration requirements. Prior to the start of measurements on any specimens, fix the comparator at an appropriate length to accommodate all of the specimens to be monitored for length change.

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4.5. *Scales*—With a capacity approximately 50 percent greater than the weight of the specimens and accurate to at least 5 g (0.01 lb) within the range of ±10 percent of the specimen weight will be satisfactory.

4.6. *Tempering Tank*—With suitable provisions for maintaining the temperature of the test specimens in water, such that when removed from the tank and tested, the specimens will be maintained within –1° and +2°C (–2° and +4°F) of the target thaw temperature for specimens in the actual freezing and thawing cycle and equipment being used. The use of the specimen chamber in the freezing and thawing apparatus by stopping the apparatus at the end of the thawing cycle and holding the specimens in it shall be considered as meeting this requirement. It is required that the same target specimen thaw temperature be used throughout the testing of an individual specimen because a change in specimen temperature at the time of length measurement can affect the length of the specimen significantly.

5. FREEZING AND THAWING CYCLE

5.1. Base conformity with the requirements for the freezing and thawing cycle on temperature measurements of control specimens of similar concrete to the specimens under test in which suitable temperature-measuring devices have been imbedded. Change the position of these control specimens frequently in such a way as to indicate the extremes of temperature variation at different locations in the specimen cabinet.

5.2. A complete freezing and thawing cycle for both procedures of this method consists of two consecutive steps. The first step is to freeze the specimen by dropping the temperature of the specimen from 4 to –18°C (40 to 0°F). The second step is to thaw the specimen by raising the temperature of the specimen from –18 to 4°C (0 to 40°F). Each complete cycle shall be executed in not less than 2 nor more than 5 h. For Procedure A, not less than 25 percent of the time shall be used for thawing, and for Procedure B, not less than 20 percent of the time shall be used for thawing (Note 7). At the end of the cooling period, the temperature at the centers of the specimens shall be –18 ± 2°C (0 ± 3°F), and at the end of the heating period the temperature shall be 4 ± 2°C (40 ± 3°F), with no specimen at any time reaching a temperature lower than –20°C (–3°F) nor higher than 6°C (43°F). The time required for the temperature at the center of any single specimen to be reduced from 3 to –16°C (37 to 3°F) shall be no less than one half of the length of the cooling period, and the time required for the temperature at the center of any single specimen to be raised from –16 to 3°C (3 to 37°F) shall be not less than one half of the length of the heating period. For specimens to be compared with each other, the time required to change the temperature at the centers of any specimens from 2 to –12°C (35 to 10°F) shall not differ by more than one sixth of the length of the cooling period from the time required for any specimen and the time required to change the temperature at the centers of any specimens from –12 to 2°C (10 to 35°F) shall not differ by more than one third of the length of the heating period from the time required for any specimen.

Note 7—In most cases, uniform temperature and time conditions can be controlled most conveniently by maintaining a capacity load of specimens in the equipment at all times. In the event that a capacity load of test specimens is not available, dummy specimens can be used to fill empty spaces. This procedure also assists greatly in maintaining uniform fluid level conditions in the specimen and solution tanks.

The testing of concrete specimens composed of widely varying materials or with widely varying thermal properties, in the same equipment at the same time, may not permit adherence to the time-temperature requirements for all specimens. It is advisable that such specimens be tested at different times and that appropriate adjustments be made to the equipment.

5.3. The difference between the temperature at the center of a specimen and the temperature at its surface shall at no time exceed 28°C (50°F).

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5.4. The period of transition between the freezing and thawing phases of the cycle shall not exceed 10 min, except when specimens are being tested in accordance with Section 8.3.

6. SAMPLING

6.1. Constituent materials for concrete specimens made in the laboratory shall be sampled using applicable standard methods.

6.2. Samples cut from hardened concrete are to be obtained in accordance with ASTM C823/C823M.

7. TEST SPECIMENS

7.1. The specimens for use in this test shall be prisms or cylinders made and cured in accordance with the applicable requirements of R 70M/R 70 and R 39.

7.2. Specimens used shall not be less than 75 mm (3 in.) nor more than 125 mm (5 in.) in width, depth, or diameter and not less than 275 mm (11 in.) nor more than 405 mm (16 in.) in length.

7.3. Test specimens may also be cores or prisms cut from hardened concrete. If so, the specimens should not be allowed to dry to a moisture condition below that of the structure from which they were taken. This may be accomplished by wrapping in plastic or by other suitable means. The specimens so obtained shall be furnished with gauge studs in accordance with ASTM C341/C341M.

7.4. For this test the specimens shall be stored in saturated lime water from the time of their removal from the molds until the time freezing and thawing tests are started. All specimens to be compared with each other initially shall be of the same nominal dimensions.

8. PROCEDURE

8.1. Molded beam specimens shall be cured for 14 days prior to testing unless otherwise specified. Beam specimens sawed from hardened concrete shall be moisture-conditioned by immersing in saturated lime water at 23 ± 2°C (73 ± 3°F) for 48 h prior to testing unless otherwise specified. The thermometer for measuring the temperature of the water shall meet the requirements of M 339M/M 339 with a temperature range of at least 19 to 27°C [66.4 to 80.6°F] and an accuracy of ±0.5°C [±0.9°F] (see Note 8).

Note 8—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type T, Special; or IEC 60584 thermocouple thermometer, Type T, Class 1.

8.2. Immediately after the specified curing or conditioning period, bring the specimen to a temperature within –1° and +2°C (–2° and +4°F) of thc target thaw temperature that will be used in the freeze–thaw cycle. Protect the specimens against loss of moisture between the time of removal from curing and the start of the freezing and thawing cycles, and measure the specimens.

8.2.1. For durability factor (DF), test for fundamental transverse frequency and determine the mass, the average length, and the cross-section dimensions of the concrete specimen within the tolerance required in ASTM C215.

8.2.2. For length change, determine the initial length comparator reading for the specimen with the length change comparator.

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8.3. Start freezing and thawing tests by placing the specimens in the thawing water at the beginning of the thawing phase of the cycle. Remove the specimens from the apparatus, in a thawed condition, at intervals not exceeding 36 cycles of exposure to the freezing and thawing cycles. To ensure that the specimens are completely thawed and at the specified temperature, place them in the tempering tank or hold them at the end of the thaw cycle in the freezing and thawing apparatus for a sufficient time for this condition to be attained throughout each specimen to be tested. Measure the specimens while maintaining the specimen temperature within the temperature range specified for the tempering tank in Section 4.6. Protect the specimens against loss of moisture while out of the apparatus.

8.3.1. For durability factor (DF), determine the fundamental transverse frequency and mass of the specimen.

8.3.2. For length change, determine the length comparator reading for the specimen with the length change comparator.

8.3.3. For Procedure A, rinse out the container and add clean water prior to returning the specimen to the apparatus.

8.4. Return the specimens, turning them end-to-end, either to random positions in the apparatus or to positions according to some predetermined rotation scheme that will ensure that each specimen that continues under test for any length of time is subjected to conditions in all parts of the freezing apparatus. Continue each specimen in the test until it has been subjected to 300 cycles or until its relative dynamic modulus of elasticity reaches 60 percent of the initial modulus, whichever occurs first, unless other limits are specified (Note 9). For the length change test, 0.10 percent expansion may be used as the end of test. Whenever a specimen is removed because of failure, replace it for the remainder of the test by a dummy specimen. Each time a specimen is tested for fundamental frequency (Note 10) and length change, make a note of its visual appearance and make special comment on any defects that develop (Note 11). When it is anticipated that specimens may deteriorate rapidly, they should be measured at intervals not exceeding 10 cycles when initially subjected to freezing and thawing.

Note 9—It is not recommended that specimens be continued in the test after their relative dynamic modulus of elasticity has fallen below 50 percent.

Note 10—It is recommended that the fundamental longitudinal frequency be determined initially and as a check whenever a question exists concerning the accuracy of determination of fundamental transverse frequency and that the fundamental torsional frequency be determined initially and periodically as a check on the value of Poisson's ratio.

Note 11—In some applications, such as airfield pavements and other slabs, popouts may be defects that are a concern. A popout is characterized by the breaking away of a small portion of the concrete surface due to internal pressure, thereby leaving a shallow and typically conical spall in the surface of the concrete through the aggregate particle. Popouts may be observed as defects in the test specimens. Where popouts are a concern, the number and general description should be reported as a special comment. The aggregates causing the popout may be identified by petrographic examination as in ASTM C295/C295M.

8.5. When the sequence of freezing and thawing cycles must be interrupted, store the specimens in a frozen condition.

Note 12—If, because of equipment breakdown or for other reasons, it becomes necessary to interrupt the cycles for a protracted period, store the specimens in a frozen condition in such a way as to prevent loss of moisture. For Procedure A, maintain the specimens in the containers and surround them by ice, if possible. If it is not possible to store the specimens in their containers, wrap and seal them, in as wet a condition as possible, in moisture-proof material to prevent dehydration and store in a refrigerator or cold room maintained at $-18 \pm 2°C$ ($0 \pm 3°F$). Follow the latter procedure when Procedure B is being used. In general, for specimens to remain in a thawed

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condition for more than two cycles is undesirable, but a longer period may be permissible if this occurs only once or twice during a complete test.

9. CALCULATIONS

9.1. *Relative Dynamic Modulus of Elasticity*—Calculate the numerical values of relative dynamic modulus of elasticity as follows:

$$P_c = (n_1^2/n^2) \times 100 \quad (1)$$

where:

P_c = relative dynamic modulus of elasticity, after c cycles of freezing and thawing, percent;
n = fundamental transverse frequency at 0 cycles of freezing and thawing; and
n_1 = fundamental transverse frequency after c cycles of freezing and thawing.

Note 13—This calculation of relative dynamic modulus of elasticity is based on the assumption that the mass and dimensions of the specimen remain constant throughout the test. This assumption is not true in many cases because of disintegration of the specimen. However, if the test is to be used to make comparisons between the relative dynamic moduli of different specimens or of different concrete formulations, P_c as defined is adequate for the purpose.

9.2. *Durability Factor*—Calculate the durability factor as follows:

$$DF = PN/M \quad (2)$$

where:

DF = durability factor of the test specimen;
P = relative dynamic modulus of elasticity at N cycles, percent;
N = number of cycles at which P reaches the specified minimum value for discontinuing the test or the specified number of cycles at which the exposure is to be terminated, whichever is less; and
M = specified number of cycles at which the exposure is to be terminated.

9.3. *Length Change in Percent*—Calculate the length change as follows:

$$L_c = \frac{(l_2 - l_1)}{L_s} \times 100 \quad (3)$$

where:

L_c = length change of the test specimen after c cycles of freezing and thawing, percent;
l_1 = length comparator reading at 0 cycles;
l_2 = length comparator reading after c cycles; and
L_s = the effective gauge length between the innermost ends of the gauge studs as shown in the mold diagram in R 70M/R 70.

10. REPORT

10.1. *Report the following data such as are pertinent to the variables or combination of variables studied in the tests*:

10.1.1. *Properties of Concrete Mixture*:

10.1.1.1. Type and proportions of cement, fine aggregate, and coarse aggregate, including maximum size and grading (or designated grading indices), and ratio of net water content to cement.

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10.1.1.2. Kind and proportion of any addition or admixture used.

10.1.1.3. Air content of fresh concrete.

10.1.1.4. Unit mass of fresh concrete.

10.1.1.5. Consistency of fresh concrete.

10.1.1.6. Air content of the hardened concrete when available.

10.1.1.7. Indicate if the test specimens are cut from hardened concrete, and if so, state the size, shape, orientation of the specimens in the structure, and any other pertinent information available.

10.1.1.8. Curing period.

10.1.2. *Mixing, Molding, and Curing Procedures*—Report any departures from the standard procedures for mixing, molding, and curing as prescribed in Section 7.

10.1.3. *Procedure*—Report which of the two procedures was used.

10.1.4. *Characteristics of Test Specimens*:

10.1.4.1. Dimensions of specimens at zero cycles of freezing and thawing,

10.1.4.2. Mass of specimens at zero cycles of freezing and thawing,

10.1.4.3. Nominal gauge length between embedded ends of gauge studs, and

10.1.4.4. Any defects in each specimen present at zero cycles of freezing and thawing.

10.1.5. *Results*:

10.1.5.1. Values for the durability factor of each specimen, calculated to the nearest whole number, and for the average durability factor for each group of similar specimens, also calculated to the nearest whole number, and the specified values for minimum relative dynamic modulus and maximum number of cycles (Note 14);

10.1.5.2. Values for the percent length change of each specimen and for the average percent length change for each group of similar specimens (Note 14);

10.1.5.3. Values of loss or gain of mass for each specimen and average values for each group of similar specimens; and

10.1.5.4. Any defects in each specimen that develop during testing, and the number of cycles at which such defects were noted.

Note 14—It is recommended that the results of the test on each specimen and the average of the results on each group of similar specimens be plotted as curves showing the value of relative modulus of elasticity or percent length change against time expressed as the number of cycles of freezing and thawing.

11. PRECISION

11.1. *Dynamic Modulus*:

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11.1.1. *Within-Laboratory Precision (Single Beams)*—Criteria for judging the acceptability of durability factor results obtained by the two procedures in the same laboratory on concrete specimens made from the same batch of concrete or from two batches made with the same materials are given in Table 1. Precision data for length change are not available at this time.

Table 1—Within-Laboratory Durability Factor Precision for Single Beams

Range of Average Durability Factor	Procedure A		Procedure B	
	Standard Deviation[a]	Acceptable Range of Two Results[a]	Standard Deviation[a]	Acceptable Range of Two Results[a]
0 to 5	0.8	2.2	1.1	3.0
5 to 10	1.5	4.4	4.0	11.4
10 to 20	5.9	16.7	8.1	22.9
20 to 30	8.4	23.6	10.5	29.8
30 to 50	12.7	35.9	15.4	43.5
50 to 70	15.3	43.2	20.1	56.9
70 to 80	11.6	32.7	17.1	48.3
80 to 90	5.7	16.0	8.8	24.9
90 to 95	2.1	6.0	3.9	11.0
Over 95	1.1	3.1	2.0	5.7

[a] These numbers represent the (1s) and (d2s) limits as described in ASTM C670.

Note: The values given in Columns 2 and 4 are the standard deviations that have been found to be appropriate for Procedures A and B, respectively, for tests for which the average durability factor is in the corresponding range given in Column 1. The values given in Columns 3 and 5 are the corresponding limits that should not be exceeded by the difference between the results of two single test beams.

Note 15—The between-batch precision of durability factors has been found to be the same as the within-batch precision. Thus, the limits given in this precision statement apply to specimens from different batches made with the same materials and mix design and having the same air content, as well as to specimens from the same batch.

Note 16—The precision of this method for both procedures has been found to depend primarily on the average durability factor and not on the maximum N or minimum P specified for terminating the test nor on the size of the beams within limits. The data on which these precision statements are based cover maximum N_s from 100 to 300 cycles and minimum P_s from 50 to 70 percent of E_o. The indexes of precision are thus valid at least over these ranges.

11.1.1.1. The different specimen sizes represented by the data include the following: 75 by 75 by 405 mm; 75 by 75 by 420 mm; 75 by 100 by 405 mm; 90 by 115 by 405 mm; 75 by 75 by 280 mm; 90 by 100 by 405 mm; and 100 by 75 by 405 mm (3 by 3 by 16 in.; 3 by 3 by $16^1/_4$ in.; 3 by 4 by 16 in.; $3^1/_2$ by $4^1/_2$ by 16 in.; 3 by 3 by 11 in.; $3^1/_2$ by 4 by 16 in.; and 4 by 3 by 16 in.). The first dimension given represents the direction in which the specimens were vibrated in the test for fundamental transverse frequency. The most commonly used size was 75 by 100 by 405 mm (3 by 4 by 16 in.).

11.1.1.2. *Within-Laboratory Precision (Averages of Two or More Beams)*—Specifications sometimes call for comparisons between averages of two or more beams. Tables 2 and 3 give appropriate standard deviations and acceptable ranges for the two procedures for two averages of the number of test beams shown.

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Table 2—Within-Laboratory Durability Factor Precision for Averages of Two or More Beams—Procedure A

Range of Average Durability Factor	Number of Beams Averaged									
	2		3		4		5		6	
	Standard Deviation[a]	Acceptable Range[a]	Standard Deviation[a]	Acceptable Range[a]	Standard Deviation[a]	Acceptable Range[a]	Standard Deviation[a]	Acceptable Range[a]	Standard Deviation[a]	Acceptable Range[a]
0 to 5	0.6	1.6	0.5	1.3	0.4	1.1	0.4	1.0	0.3	0.9
5 to 10	1.1	3.1	0.9	2.5	0.8	2.2	0.7	2.0	0.6	1.8
10 to 20	4.2	11.8	3.4	9.7	3.0	8.4	2.7	7.5	2.4	6.8
20 to 30	5.9	16.7	4.8	13.7	4.2	11.8	3.7	10.6	3.4	9.7
30 to 50	9.0	25.4	7.4	20.8	6.4	18.0	5.7	16.1	5.2	14.7
50 to 70	10.8	30.6	8.8	25.0	7.6	21.6	6.8	19.3	6.2	17.6
70 to 80	8.2	23.1	6.7	18.9	5.8	16.4	5.2	14.6	4.7	13.4
80 to 90	4.0	11.3	3.3	9.2	2.8	8.0	2.5	7.2	2.3	6.5
90 to 95	1.5	4.2	1.2	3.5	1.1	3.0	0.9	2.7	0.9	2.4
Above 95	0.8	2.2	0.6	1.8	0.5	1.5	0.5	1.4	0.4	1.3

[a] These numbers represent the (1s) and (d2s) limits as described in ASTM C670.

Table 3—Within-Laboratory Durability Factor Precision for Averages of Two or More Beams—Procedure B

Range of Average Durability Factor	Number of Beams Averaged									
	2		3		4		5		6	
	Standard Deviation[a]	Acceptable Range[a]	Standard Deviation[a]	Acceptable Range[a]	Standard Deviation[a]	Acceptable Range[a]	Standard Deviation[a]	Acceptable Range[a]	Standard Deviation[a]	Acceptable Range[a]
0 to 5	0.8	2.1	0.6	1.8	0.5	1.5	0.5	1.4	0.4	1.2
5 to 10	2.9	8.1	2.3	6.6	2.0	5.7	1.8	5.1	1.7	4.7
10 to 20	5.7	16.2	4.7	13.2	4.1	11.5	3.6	10.3	3.3	7.4
20 to 30	7.4	21.0	6.1	17.2	5.3	14.9	4.7	13.3	4.3	12.2
30 to 50	10.9	30.8	8.9	25.1	7.7	21.8	6.9	19.5	6.3	17.8
50 to 70	14.2	40.2	11.6	32.9	10.1	28.5	9.0	25.5	8.2	23.2
70 to 80	12.1	34.2	9.9	27.9	8.5	24.2	7.6	11.6	7.0	19.7
80 to 90	6.2	17.6	5.0	14.4	4.4	12.5	3.9	11.1	3.6	10.2
90 to 95	2.8	7.8	2.3	6.4	2.0	5.5	1.7	4.9	1.6	4.5
Above 95	1.4	4.1	1.2	3.3	1.0	2.9	0.9	2.6	0.8	2.3

[a] These numbers represent the (1s) and (d2s) limits as described in ASTM C670.

11.1.2. *Multilaboratory Precision*—No data have been available for evaluation of multilaboratory precision.

11.2. *Length Change*:

11.2.1. *Within-Laboratory Precision*—The single operator coefficient of variation has been determined to be 29.9 percent. Therefore results of two properly conducted tests by the same operator on samples from the same batch of concrete, using the same freeze-thaw apparatus and the same length comparator, should not differ from each other by more than 84.6 percent of the average.

11.2.2. *Multilaboratory Precision*—No data have been available for multilaboratory precision.

11.3. *Bias*—This test method has no bias because the values determined can be defined only in terms of this test method.

12. KEYWORDS

12.1. Accelerated testing; concrete-weathering tests; conditioning; freezing and thawing; resistance-frost.

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