

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES AND
ENVIRONMENTAL CONTROL (DNREC)
DIVISION OF FISH AND WILDLIFE
CONTRACT # NAT201601/Lang.Impoundment

SPECIFICATIONS
FOR
LANG IMPOUNDMENT DIKE REHABILITATION

IN
PORT PENN
DELAWARE

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INVITATION TO BID

Sealed bids for OMB/DFM Contract No NAT201601/Lang.Impoundment, will be received by the State of Delaware, Department of Natural Resources and Environmental Control, Division of Fish and Wildlife, at the Public Auditorium, Room B172, Richardson & Robbins Building, 89 Kings Highway, Dover, Delaware 1990, after the pre-bid meeting until 2:00 PM local time on May 19, 2017, at which time they will be publicly opened and read aloud in the Conference Room. Bidder bears the risk of late delivery. Any bids received after the stated time will be returned unopened. Project involves rehabilitating and raising the dike of the Lang Impoundment, as well as repairing the water control structure.

A **MANDATORY** Pre-Bid Meeting will be held April 19, 2017, at 1:00 PM at the DFW Field Office, 303 North Congress St. Port Penn, DE 19731 for the purpose of establishing the listing of subcontractors and to answer questions. Representatives of each party to any Joint Venture must attend this meeting. **ATTENDANCE AT THIS MEETING IS A PREREQUISITE FOR BIDDING ON THIS CONTRACT.**

Sealed bids shall be addressed to Jeremy Ashe, Habitat Restoration Project Manager (Delaware Bayshore), Delaware Division of Fish & Wildlife, Office Number B261 89 Kings Highway Dover, DE 19901.

The outer envelope should clearly indicate: **CONTRACT NO. NAT201601/Lang.Impoundment_ - SEALED BID - DO NOT OPEN."**

Contract, addendums, and construction documents will be available for review at the following location:
www.bids.delaware.gov

Bidders will not be subject to discrimination on the basis of race, creed, color, sex, sexual orientation, gender identity or national origin in consideration of this award, and Minority Business Enterprises, Disadvantaged Business Enterprises, Women-Owned Business Enterprises and Veteran-Owned Business Enterprises will be afforded full opportunity to submit bids on this contract. Each bid must be accompanied by a bid security equivalent to ten percent of the bid amount and all additive alternates. The successful bidder must post a performance bond and payment bond in a sum equal to 100 percent of the contract price upon execution of the contract. The Owner reserves the right to reject any or all bids and to waive any informalities therein. The Owner may extend the time and place for the opening of the bids from that described in the advertisement, with not less than two (2) calendar days notice by certified delivery, facsimile machine or other electronic means to those bidders receiving plans.

END OF INVITATION TO BID

INSTRUCTIONS TO BIDDERS

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ARTICLE 1: GENERAL

1.1 DEFINITIONS

1.1.1 Whenever the following terms are used, their intent and meaning shall be interpreted as follows:

1.2 STATE: The State of Delaware.

1.3 AGENCY: Contracting State Agency as noted on cover sheet.

1.4 DESIGNATED OFFICIAL: The agent authorized to act for the Agency.

1.5 BIDDING DOCUMENTS: Bidding Documents include the Bidding Requirements and the proposed Contract Documents. The Bidding Requirements consist of the Advertisement for Bid, Invitation to Bid, Instructions to Bidders, Supplementary Instructions to Bidders (if any), General Conditions, Supplementary General Conditions, General Requirements, Special Provisions (if any), the Bid Form (including the Non-Collusion Statement), and other sample bidding and contract forms. The proposed Contract Documents consist of the form of Agreement between the Owner and Contractor, as well as the Drawings, Specifications (Project Manual) and all Addenda issued prior to execution of the Contract.

1.6 CONTRACT DOCUMENTS: The Contract Documents consist of the, Instructions to Bidders, Supplementary Instructions to Bidders (if any), General Conditions, Supplementary General Conditions, General Requirements, Special Provisions (if any), the form of agreement between the Owner and the Contractor, Drawings (if any), Specifications (Project Manual), and all addenda.

1.7 AGREEMENT: The form of the Agreement shall be the technical specifications of the contract where the basis of payment is a STIPULATED SUM. In the case of conflict between the instructions contained therein and the General Requirements herein, these General Requirements shall prevail.

1.8 GENERAL REQUIREMENTS (or CONDITIONS): General Requirements (or conditions) are instructions pertaining to the Bidding Documents and to contracts in general. They contain, in summary, requirements of laws of the State; policies of the Agency and instructions to bidders.

1.9 SPECIAL PROVISIONS: Special Provisions are specific conditions or requirements peculiar to the bidding documents and to the contract under consideration and are supplemental to the General Requirements. Should the Special Provisions conflict with the General Requirements, the Special Provisions shall prevail.

1.10 ADDENDA: Written or graphic instruments issued by the Owner/Architect prior to the execution of the contract which modify or interpret the Bidding Documents by additions, deletions, clarifications or corrections.

1.11 BIDDER OR VENDOR: A person or entity who formally submits a Bid for the material or Work contemplated, acting directly or through a duly authorized representative who meets the requirements set forth in the Bidding Documents.

1.12 SUB-BIDDER: A person or entity who submits a Bid to a Bidder for materials or labor, or both for a portion of the Work.

1.13 BID: A complete and properly executed proposal to do the Work for the sums stipulated therein, submitted in accordance with the Bidding Documents.

- 1.14 **BASE BID:** The sum stated in the Bid for which the Bidder offers to perform the Work described in the Bidding Documents as the base, to which Work may be added or from which Work may be deleted for sums stated in Alternate Bids (if any are required to be stated in the bid).
- 1.15 **ALTERNATE BID (or ALTERNATE):** An amount stated in the Bid, where applicable, to be added to or deducted from the amount of the Base Bid if the corresponding change in the Work, as described in the Bidding Documents is accepted.
- 1.16 **UNIT PRICE:** An amount stated in the Bid, where applicable, as a price per unit of measurement for materials, equipment or services or a portion of the Work as described in the Bidding Documents.
- 1.17 **SURETY:** The corporate body which is bound with and for the Contract, or which is liable, and which engages to be responsible for the Contractor's payments of all debts pertaining to and for his acceptable performance of the Work for which he has contracted.
- 1.18 **BIDDER'S DEPOSIT:** The security designated in the Bid to be furnished by the Bidder as a guaranty of good faith to enter into a contract with the Agency if the Work to be performed or the material or equipment to be furnished is awarded to him.
- 1.19 **CONTRACT:** The written agreement covering the furnishing and delivery of material or work to be performed.
- 1.20 **CONTRACTOR:** Any individual, firm or corporation with whom a contract is made by the Agency.
- 1.21 **SUBCONTRACTOR:** An individual, partnership or corporation which has a direct contract with a contractor to furnish labor and materials at the job site, or to perform construction labor and furnish material in connection with such labor at the job site.
- 1.22 **CONTRACT BOND:** The approved form of security furnished by the contractor and his surety as a guaranty of good faith on the part of the contractor to execute the work in accordance with the terms of the contract.

ARTICLE 2: BIDDER'S REPRESENTATIONS

- 2.1 **PRE-BID MEETING**
- 2.1.1 A pre-bid meeting for this project will be held at the time and place designated. Attendance at this meeting is a pre-requisite for submitting a Bid, unless this requirement is specifically waived elsewhere in the Bid Documents.
- 2.2 By submitting a Bid, the Bidder represents that:
- 2.2.1 The Bidder has read and understands the Bidding Documents and that the Bid is made in accordance therewith.
- 2.2.2 The Bidder has visited the site, become familiar with existing conditions under which the Work is to be performed, and has correlated the Bidder's personal observations with the requirements of the proposed Contract Documents.
- 2.2.3 The Bid is based upon the materials, equipment, and systems required by the Bidding Documents without exception.

2.3 JOINT VENTURE REQUIREMENTS

- 2.3.1 For Public Works Contracts, each Joint Venturer shall be qualified and capable to complete the Work with their own forces.
- 2.3.2 Included with the Bid submission, and as a requirement to bid, a copy of the executed Joint Venture Agreement shall be submitted and signed by all Joint Venturers involved.
- 2.3.3 All required Bid Bonds, Performance Bonds, Material and Labor Payment Bonds must be executed by both Joint Venturers and be placed in both of their names.
- 2.3.4 All required insurance certificates shall name both Joint Venturers.
- 2.3.5 Both Joint Venturers shall sign the Bid Form and shall submit a copy of a valid Delaware Business License with their Bid.
- 2.3.6 Both Joint Venturers shall include their Federal E.I. Number with the Bid.
- 2.3.7 In the event of a mandatory Pre-bid Meeting, each Joint Venturer shall have a representative in attendance.
- 2.3.8 Due to exceptional circumstances and for good cause shown, one or more of these provisions may be waived at the discretion of the State.

2.4 ASSIGNMENT OF ANTITRUST CLAIMS

- 2.4.1 As consideration for the award and execution by the Owner of this contract, the Contractor hereby grants, conveys, sells, assigns and transfers to the State of Delaware all of its right, title and interests in and to all known or unknown causes of action it presently has or may now or hereafter acquire under the antitrust laws of the United States and the State of Delaware, relating to the particular goods or services purchased or acquired by the Owner pursuant to this contract.

ARTICLE 3: BIDDING DOCUMENTS

3.1 COPIES OF BID DOCUMENTS

- 3.1.1 Bidders may obtain complete sets of the Bidding Documents from the Architectural/Engineering firm designated in the Advertisement or Invitation to Bid in the number and for the deposit sum, if any, stated therein.
- 3.1.2 Bidders shall use complete sets of Bidding Documents for preparation of Bids. The issuing Agency nor the Architect assumes no responsibility for errors or misinterpretations resulting from the use of incomplete sets of Bidding Documents.
- 3.1.3 Any errors, inconsistencies or omissions discovered shall be reported to the Architect immediately.
- 3.1.4 The Agency and Architect may make copies of the Bidding Documents available on the above terms for the purpose of obtaining Bids on the Work. No license or grant of use is conferred by issuance of copies of the Bidding Documents.

3.2 INTERPRETATION OR CORRECTION OF BIDDING DOCUMENTS

- 3.2.1 The Bidder shall carefully study and compare the Bidding Documents with each other, and with other work being bid concurrently or presently under construction to the extent that it relates to the Work for which the Bid is submitted, shall examine the site and local conditions, and shall report any errors, inconsistencies, or ambiguities discovered to the Architect.

- 3.2.2 Bidders or Sub-bidders requiring clarification or interpretation of the Bidding Documents shall make a written request to the Architect at least seven days prior to the date for receipt of Bids. Interpretations, corrections and changes to the Bidding Documents will be made by written Addendum. Interpretations, corrections, or changes to the Bidding Documents made in any other manner shall not be binding.
- 3.2.3 The apparent silence of the specifications as to any detail, or the apparent omission from it of detailed description concerning any point, shall be regarded as meaning that only the best commercial practice is to prevail and only material and workmanship of the first quality are to be used. Proof of specification compliance will be the responsibility of the Bidder.
- 3.2.4 Unless otherwise provided in the Contract Documents, the Contractor shall provide and pay for all permits, labor, materials, equipment, tools, construction equipment and machinery, water, heat, utilities, transportation, and other facilities and services necessary for the proper execution and completion of the Work.
- 3.2.5 The Owner will bear the costs for all impact and user fees associated with the project.
- 3.3 SUBSTITUTIONS
- 3.3.1 The materials, products and equipment described in the Bidding Documents establish a standard of quality, required function, dimension, and appearance to be met by any proposed substitution. The specification of a particular manufacturer or model number is not intended to be proprietary in any way. Substitutions of products for those named will be considered, providing that the Vendor certifies that the function, quality, and performance characteristics of the material offered is equal or superior to that specified. It shall be the Bidder's responsibility to assure that the proposed substitution will not affect the intent of the design, and to make any installation modifications required to accommodate the substitution.
- 3.3.2 Requests for substitutions shall be made in writing to the Architect at least ten days prior to the date of the Bid Opening. Such requests shall include a complete description of the proposed substitution, drawings, performance and test data, explanation of required installation modifications due the substitution, and any other information necessary for an evaluation. The burden of proof of the merit of the proposed substitution is upon the proposer. The Architect's decision of approval or disapproval shall be final. The Architect is to notify Owner prior to any approvals.
- 3.3.3 If the Architect approves a substitution prior to the receipt of Bids, such approval shall be set forth in an Addendum. Approvals made in any other manner shall not be binding.
- 3.3.4 The Architect shall have no obligation to consider any substitutions after the Contract award.
- 3.4 ADDENDA
- 3.4.1 Addenda will be mailed or delivered to all who are known by the Architect to have received a complete set of the Bidding Documents.
- 3.4.2 Copies of Addenda will be made available for inspection wherever Bidding Documents are on file for that purpose.
- 3.4.3 No Addenda will be issued later than 4 days prior to the date for receipt of Bids except an Addendum withdrawing the request for Bids or one which extends the time or changes the location for the opening of bids.

- 3.4.4 Each bidder shall ascertain prior to submitting his Bid that they have received all Addenda issued, and shall acknowledge their receipt in their Bid in the appropriate space. Not acknowledging an issued Addenda could be grounds for determining a bid to be non-responsive.

ARTICLE 4: BIDDING PROCEDURES

4.1 PREPARATION OF BIDS

- 4.1.1 Submit the bids on the Bid Forms included with the Bidding Documents.
- 4.1.2 Submit the original Bid Form for each bid. Bid Forms may be removed from the project manual for this purpose.
- 4.1.3 Execute all blanks on the Bid Form in a non-erasable medium (typewriter or manually in ink).
- 4.1.4 Where so indicated by the makeup on the Bid Form, express sums in both words and figures, in case of discrepancy between the two, the written amount shall govern.
- 4.1.5 Interlineations, alterations or erasures must be initialed by the signer of the Bid.
- 4.1.6 BID ALL REQUESTED ALTERNATES AND UNIT PRICES, IF ANY. If there is no change in the Base Bid for an Alternate, enter "No Change". The Contractor is responsible for verifying that they have received all addenda issued during the bidding period. Work required by Addenda shall automatically become part of the Contract.
- 4.1.7 Make no additional stipulations on the Bid Form and do not qualify the Bid in any other manner.
- 4.1.8 Each copy of the Bid shall include the legal name of the Bidder and a statement whether the Bidder is a sole proprietor, a partnership, a corporation, or any legal entity, and each copy shall be signed by the person or persons legally authorized to bind the Bidder to a contract. A Bid by a corporation shall further give the state of incorporation and have the corporate seal affixed. A Bid submitted by an agent shall have a current Power of Attorney attached, certifying agent's authority to bind the Bidder.
- 4.1.9 Bidder shall complete the Non-Collusion Statement form included with the Bid Forms and include it with their Bid.
- 4.1.10 In the construction of all Public Works projects for the State of Delaware or any agency thereof, preference in employment of laborers, workers or mechanics shall be given to bona fide legal citizens of the State who have established citizenship by residence of at least 90 days in the State.
- 4.1.11 Each bidder shall include in their bid a copy of a valid Delaware Business License.'
- 4.1.12 Each bidder shall include signed Affidavit(s) for the Bidder and each listed Subcontractor certifying compliance with OMB Regulation 4104- "Regulations for the Drug Testing of Contractor and Subcontractor Employees Working on "Large Public Works Projects." "Large Public Works" is based upon the current threshold required for bidding Public Works as set by the Purchasing and Contracting Advisory Council.

4.2 BID SECURITY

- 4.2.1 All bids shall be accompanied by a deposit of either a good and sufficient bond to the agency for the benefit of the agency, with corporate surety authorized to do business in this State, the form of the bond and the surety to be approved by the agency, or a security of the bidder assigned to the agency, for a sum equal to at least 10% of the bid plus all add alternates, or in lieu of the bid bond a security deposit in the form of a certified check, bank treasurer's check, cashier's check, money order, or other prior approved secured deposit assigned to the State. The bid bond need not be for a specific sum, but may

be stated to be for a sum equal to 10% of the bid plus all add alternates to which it relates and not to exceed a certain stated sum, if said sum is equal to at least 10% of the bid. The Bid Bond form used shall be the standard OMB form (attached).

4.2.2 The Agency has the right to retain the bid security of Bidders to whom an award is being considered until either a formal contract has been executed and bonds have been furnished or the specified time has elapsed so the Bids may be withdrawn or all Bids have been rejected.

4.2.3 In the event of any successful Bidder refusing or neglecting to execute a formal contract and bond within 20 days of the awarding of the contract, the bid bond or security deposited by the successful bidder shall be forfeited.

4.3 SUBCONTRACTOR LIST

4.3.1 As required by Delaware Code, Title 29, section 6962(d)(10)b, each Bidder shall submit with their Bid a completed List of Sub-Contractors included with the Bid Form. NAME ONLY ONE SUBCONTRACTOR FOR EACH TRADE. A Bid will be considered non-responsive unless the completed list is included.

4.3.2 Provide the Name and Address for each listed subcontractor. Addresses by City, Town or Locality, plus State, will be acceptable.

4.3.3 It is the responsibility of the Contractor to ensure that their Subcontractors are in compliance with the provisions of this law. Also, if a Contractor elects to list themselves as a Subcontractor for any category, they must specifically name themselves on the Bid Form and be able to document their capability to act as Subcontractor in that category in accordance with this law.

4.4 EQUALITY OF EMPLOYMENT OPPORTUNITY ON PUBLIC WORKS

4.4.1 During the performance of this contract, the contractor agrees as follows:

A. The Contractor will not discriminate against any employee or applicant for employment because of race, creed, sex, color, sexual orientation, gender identity or national origin. The Contractor will take affirmative action to ensure the applicants are employed, and that employees are treated during employment, without regard to their race, creed, sex, color, sexual orientation, gender identity or national origin. Such action shall include, but not be limited to, the following: Employment, upgrading, demotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Contractor agrees to post in conspicuous places available to employees and applicants for employment notices to be provided by the contracting agency setting forth this nondiscrimination clause.

B. The Contractor will, in all solicitations or advertisements for employees placed by or on behalf of the Contractor, state that all qualified applicants will receive consideration for employment without regard to race, creed, sex, color, sexual orientation, gender identity or national origin."

4.5 PREVAILING WAGE REQUIREMENT

4.5.1 Wage Provisions: For renovation and new construction projects whose costs exceed the thresholds contained in Delaware Code, Title 29, Section 6960, the minimum wage rates for various classes of laborers and mechanics shall be as determined by the Department of Labor, Division of Industrial Affairs of the State of Delaware.

4.5.2 The employer shall pay all mechanics and labors employed directly upon the site of work, unconditionally and not less often than once a week and without subsequent deduction or rebate on any account, the full amounts accrued at time of payment, computed at wage rates not less than those stated in the

specifications, regardless of any contractual relationship which may be alleged to exist between the employer and such laborers and mechanics.

4.5.3 The scale of the wages to be paid shall be posted by the employer in a prominent and easily accessible place at the site of the work.

4.5.4 Every contract based upon these specifications shall contain a stipulation that sworn payroll information, as required by the Department of Labor, be furnished weekly. The Department of Labor shall keep and maintain the sworn payroll information for a period of 6 months from the last day of the work week covered by the payroll.

4.6 SUBMISSION OF BIDS

4.6.1 Enclose the Bid, the Bid Security, and any other documents required to be submitted with the Bid in a sealed opaque envelope. Address the envelope to the party receiving the Bids. Identify with the project name, project number, and the Bidder's name and address. If the Bid is sent by mail, enclose the sealed envelope in a separate mailing envelope with the notation "BID ENCLOSED" on the face thereof. The State is not responsible for the opening of bids prior to bid opening date and time that are not properly marked.

4.6.2 Deposit Bids at the designated location prior to the time and date for receipt of bids indicated in the Advertisement for Bids. Bids received after the time and date for receipt of bids will be marked "LATE BID" and returned.

4.6.3 Bidder assumes full responsibility for timely delivery at location designated for receipt of bids.

4.6.4 Oral, telephonic or telegraphic bids are invalid and will not receive consideration.

4.6.5 Withdrawn Bids may be resubmitted up to the date and time designated for the receipt of Bids, provided that they are then fully in compliance with these Instructions to Bidders.

4.7 MODIFICATION OR WITHDRAW OF BIDS

4.7.1 Prior to the closing date for receipt of Bids, a Bidder may withdraw a Bid by personal request and by showing proper identification to the Architect. A request for withdraw by letter or fax, if the Architect is notified in writing prior to receipt of fax, is acceptable. A fax directing a modification in the bid price will render the Bid informal, causing it to be ineligible for consideration of award. Telephone directives for modification of the bid price shall not be permitted and will have no bearing on the submitted proposal in any manner.

4.7.2 Bidders submitting Bids that are late shall be notified as soon as practicable and the bid shall be returned.

4.7.3 A Bid may not be modified, withdrawn or canceled by the Bidder during a thirty (30) day period following the time and date designated for the receipt and opening of Bids, and Bidder so agrees in submitting their Bid. Bids shall be binding for 30 days after the date of the Bid opening.

ARTICLE 5: CONSIDERATION OF BIDS**5.1 OPENING/REJECTION OF BIDS**

5.1.1 Unless otherwise stated, Bids received on time will be publicly opened and will be read aloud. An abstract of the Bids will be made available to Bidders.

5.1.2 The Agency shall have the right to reject any and all Bids. A Bid not accompanied by a required Bid Security or by other data required by the Bidding Documents, or a Bid which is in any way incomplete or irregular is subject to rejection.

5.1.3 If the Bids are rejected, it will be done within thirty (30) calendar days of the Bid opening.

5.2 COMPARISON OF BIDS

5.2.1 After the Bids have been opened and read, the bid prices will be compared and the result of such comparisons will be made available to the public. Comparisons of the Bids may be based on the Base Bid plus desired Alternates. The Agency shall have the right to accept Alternates in any order or combination.

5.2.2 The Agency reserves the right to waive technicalities, to reject any or all Bids, or any portion thereof, to advertise for new Bids, to proceed to do the Work otherwise, or to abandon the Work, if in the judgment of the Agency or its agent(s), it is in the best interest of the State.

5.2.3 An increase or decrease in the quantity for any item is not sufficient grounds for an increase or decrease in the Unit Price.

5.2.4 The prices quoted are to be those for which the material will be furnished F.O.B. Job Site and include all charges that may be imposed during the period of the Contract.

5.2.5 No qualifying letter or statements in or attached to the Bid, or separate discounts will be considered in determining the low Bid except as may be otherwise herein noted. Cash or separate discounts should be computed and incorporated into Unit Bid Price(s).

5.3 DISQUALIFICATION OF BIDDERS

5.3.1 An agency shall determine that each Bidder on any Public Works Contract is responsible before awarding the Contract. Factors to be considered in determining the responsibility of a Bidder include:

- A. The Bidder's financial, physical, personnel or other resources including Subcontracts;
- B. The Bidder's record of performance on past public or private construction projects, including, but not limited to, defaults and/or final adjudication or admission of violations of the Prevailing Wage Laws in Delaware or any other state;
- C. The Bidder's written safety plan;
- D. Whether the Bidder is qualified legally to contract with the State;
- E. Whether the Bidder supplied all necessary information concerning its responsibility; and,

- F. Any other specific criteria for a particular procurement, which an agency may establish, provided however, that the criteria be set forth in the Invitation to Bid and is otherwise in conformity with State and/or Federal law.
- 5.3.2 If an agency determines that a Bidder is nonresponsive and/or nonresponsible, the determination shall be in writing and set forth the basis for the determination. A copy of the determination shall be sent to the affected Bidder within five (5) working days of said determination.
- 5.3.3 In addition, any one or more of the following causes may be considered as sufficient for the disqualification of a Bidder and the rejection of their Bid or Bids.
- 5.3.3.1 More than one Bid for the same Contract from an individual, firm or corporation under the same or different names.
- 5.3.3.2 Evidence of collusion among Bidders.
- 5.3.3.3 Unsatisfactory performance record as evidenced by past experience.
- 5.3.3.4 If the Unit Prices are obviously unbalanced either in excess or below reasonable cost analysis values.
- 5.3.3.5 If there are any unauthorized additions, interlineation, conditional or alternate bids or irregularities of any kind which may tend to make the Bid incomplete, indefinite or ambiguous as to its meaning.
- 5.3.3.6 If the Bid is not accompanied by the required Bid Security and other data required by the Bidding Documents.
- 5.3.3.7 If any exceptions or qualifications of the Bid are noted on the Bid Form.
- 5.4 ACCEPTANCE OF BID AND AWARD OF CONTRACT
- 5.4.1 A formal Contract shall be executed with the successful Bidder within twenty (20) calendar days after the award of the Contract.
- 5.4.2 Per Section 6962(d)(13) a., Title 29, Delaware Code, "The contracting agency shall award any public works contract within thirty (30) days of the bid opening to the lowest responsive and responsible Bidder, unless the Agency elects to award on the basis of best value, in which case the election to award on the basis of best value shall be stated in the Invitation To Bid."
- 5.4.3 Each Bid on any Public Works Contract must be deemed responsive by the Agency to be considered for award. A responsive Bid shall conform in all material respects to the requirements and criteria set forth in the Contract Documents and specifications.
- 5.4.4 The Agency shall have the right to accept Alternates in any order or combination, and to determine the low Bidder on the basis of the sum of the Base Bid, plus accepted Alternates.
- 5.4.5 The successful Bidder shall execute a formal contract, submit the required Insurance Certificate, and furnish good and sufficient bonds, unless specifically waived in the General Requirements, in accordance with the General Requirement, within twenty (20) days of official notice of contract award. The successful Bidder shall provide two business days prior to contract execution, copies of the Employee Drug Testing Program for the Bidder and all listed Subcontractors. Bonds shall be for the benefit of the Agency with surety in the amount of 100% of the total contract award. Said Bonds shall be conditioned upon the faithful performance of the contract. Bonds shall remain in effect for period of one year after the date of substantial completion.

- 5.4.6 If the successful Bidder fails to execute the required Contract, Bond and all required information, as aforesaid, within twenty (20) calendar days after the date of official Notice of the Award of the Contract, their Bid guaranty shall immediately be taken and become the property of the State for the benefit of the Agency as liquidated damages, and not as a forfeiture or as a penalty. Award will then be made to the next lowest qualified Bidder of the Work or readvertised, as the Agency may decide.
- 5.4.7 Each bidder shall supply with its bid its taxpayer identification number (i.e., federal employer identification number or social security number) and a copy of its Delaware business license, and should the vendor be awarded a contract, such vendor shall provide to the agency the taxpayer identification license numbers of such subcontractors. Such numbers shall be provided on the later of the date on which such subcontractor is required to be identified or the time the contract is executed. The successful Bidder shall provide to the agency to which it is contracting, within 30 days of entering into such public works contract, copies of all Delaware Business licenses of subcontractors and/or independent contractors that will perform work for such public works contract. However, if a subcontractor or independent contractor is hired or contracted more than 20 days after the Bidder entered the public works contract the Delaware Business license of such subcontractor or independent contractor shall be provided to the agency within 10 days of being contracted or hired.
- 5.4.8 The Bid Security shall be returned to the successful Bidder upon the execution of the formal contract. The Bid Securities of unsuccessful bidders shall be returned within thirty (30) calendar days after the opening of the Bids.

ARTICLE 6: POST-BID INFORMATION

6.1 CONTRACTOR'S QUALIFICATION STATEMENT

- 6.1.1 Bidders to whom award of a Contract is under consideration shall, if requested by the Agency, submit a properly executed Contractor's Qualification Statement, unless such a statement has been previously required and submitted.

6.2 BUSINESS DESIGNATION FORM

- 6.2.1 Successful bidder shall be required to accurately complete an Office of Management and Budget Business Designation Form for Subcontractors.

ARTICLE 7: PERFORMANCE BOND AND PAYMENT BOND

7.1 BOND REQUIREMENTS

- 7.1.1 The cost of furnishing the required Bonds, that are stipulated in the Bidding Documents, shall be included in the Bid.
- 7.1.2 If the Bidder is required by the Agency to secure a bond from other than the Bidder's usual sources, changes in cost will be adjusted as provide in the Contract Documents.
- 7.1.3 The Performance and Payment Bond forms used shall be the standard OMB forms (attached).

7.2 TIME OF DELIVERY AND FORM OF BONDS

- 7.2.1 The bonds shall be dated on or after the date of the Contract.

- 7.2.2 The Bidder shall require the attorney-in-fact who executes the required bonds on behalf of the surety to affix a certified and current copy of the power of attorney.

ARTICLE 8: FORM OF AGREEMENT BETWEEN AGENCY AND CONTRACTOR

- 8.1 Unless otherwise required in the Bidding Documents, the Agreement for the Work will be according to the technical specifications of the contract. Where the Basis of Payment is a Stipulated Sum.

END OF INSTRUCTIONS TO BIDDERS

LANG IMPOUNDMENT DIKE REHABILITATION
 PORT PENN, DELAWARE
 CONTRACT # NAT201601/LANG.IMPOUNDMENT

BID FORM

For Bids Due: May 19, 2017 by 2:00 PM

To: DEPARTMENT OF NATURAL RESOURCES &
 ENVIRONMENTAL CONTROL
 98 Kings Highway
 Dover, DE 19901

Name of Bidder: _____

Delaware Business License No.: _____ **Taxpayer ID No.:** _____

(A copy of Bidder's Delaware Business License must be attached to this form.)

(Other License Nos.): _____

Phone No.: () _____ - _____ **Fax No.:** () _____

The undersigned, representing that he has read and understands the Bidding Documents and that this bid is made in accordance therewith, that he has visited the site and has familiarized himself with the local conditions under which the Work is to be performed, and that his bid is based upon the materials, systems and equipment described in the Bidding Documents without exception, hereby proposes and agrees to provide all labor, materials, plant, equipment, supplies, transport and other facilities required to execute the work described by the aforesaid documents for the lump sum base bid for raising the dike to elevation +8.5 ft. NAVD 88 between stations 0+00 and 25+00, transitioning the dike elevation from +8.5 ft. NAVD 88 to +7.00 ft. between stations 25+00 and 27+00, continuing the dike at +7.0 ft. to station 41+00, providing a cofferdam surrounding the water control structure on the Delaware River side and install a dewatering system to provide for the inspection of the subaqueous elements of the structure, replacing the water control structure, installing chain link fence, and seeding and mulching all dike slopes for the Lang Impoundment based on the quantities provided below:

<u>CONSTRUCTION ITEM</u>	<u>QUANTITY</u>
Mobilization / Demobilization	1 (Lump Sum)
Dike Fill	24,016 (Dry Tons)
Cofferdam / Dewatering System	1 (Lump Sum)
Water Control Structure	1 (Lump Sum) NOTE: Allowance of \$50,000 shall be added to the Base Bid to purchase the Weir Gates with the assistance and approval of the Owner.
Chain Link Fence	59 (Linear Feet)
Seeding and Mulching	12,500 (Square Yards)

BASE BID: \$ _____

(\$ _____)

LANG IMPOUNDMENT DIKE REHABILITATION
 PORT PENN, DELAWARE
 CONTRACT # NAT201601/LANG.IMPOUNDMENT

ALTERNATES

Alternate prices conform to applicable project specification section. Refer to specifications for a complete description of the following Alternates. These Alternates may be added to the Base Bid in any combination.

ALTERNATE No. 1: Raise the Crown elevation from 8.5' NAVD88 to 9.5' between Sta. 0+00 and Sta. 25+00, including precast concrete block walls, and additional seeding and mulching based on the quantities provided below:

<u>CONSTRUCTION ITEM</u>	<u>QUANTITY</u>
Dike Fill	7,832 (Dry Tons)
Precast Concrete Block Wall	35 (Linear Feet)
Seeding and Mulching	1,740 (Square Yards)

ALTERNATE NO. 1: _____
 (\$ _____)

ALTERNATE No. 2: Include a 14' wide, 8" thick layer of Crusher Run on the dike crown from Sta. 0+00 to Sta. 40+95 based on the quantities provided below:

<u>CONSTRUCTION ITEM</u>	<u>QUANTITY</u>
Crusher Run	2,111 (Dry Tons)

ALTERNATE NO. 2: _____
 (\$ _____)

ALTERNATE No. 3: Rehabilitation of water control structure appurtenances including design and repairs to the existing concrete cap along the wing walls, potential repairs to the concrete base, and painting of existing sheet pile wing walls based on the quantities provided below:

<u>CONSTRUCTION ITEM</u>	<u>QUANTITY</u>
Rehabilitation of Water Control Structure Appurtenances	1 (Lump Sum)

ALTERNATE NO. 3: _____
 (\$ _____)

ALTERNATE No. 4: Provide additional riprap to repair and improve the existing shore protection along the exterior of the dike between approximate Sta. 6+00 and Sta. 14+00, adjacent to the Delaware River based on the quantities provided below:

<u>CONSTRUCTION ITEM</u>	<u>QUANTITY</u>
Riprap Slope Protection	400 (Dry Tons)

ALTERNATE NO. 4: _____
 (\$ _____)

LANG IMPOUNDMENT DIKE REHABILITATION
 PORT PENN, DELAWARE
 CONTRACT # NAT201601/LANG.IMPOUNDMENT

UNIT PRICES

Unit prices conform to applicable project specification section. Refer to the specifications for a complete description of the following Unit Prices:

	ADD	DEDUCT
UNIT PRICE No. 1: <u>Dike Fill - Base Bid (Dry Tons)</u>	\$ _____	\$ _____
UNIT PRICE No. 2: <u>Dike Fill – Alternate No. 1 (Dry Tons)</u>	\$ _____	\$ _____
UNIT PRICE No. 3: <u>Crusher Run – Alternate No. 2 (Dry Tons)</u>	\$ _____	\$ _____
UNIT PRICE No. 5: <u>Riprap Slope Protection – Alternate No. 4 (Dry Tons)</u>	\$ _____	\$ _____
UNIT PRICE No. 6: <u>Chain Link Fence - Base Bid (Linear Feet)</u>	\$ _____	\$ _____
UNIT PRICE No. 7: <u>Precast Concrete Block Wall - Alternate No. 1 (Linear Feet)</u>	\$ _____	\$ _____
UNIT PRICE No. 8: <u>Seeding and Mulching – Base Bid (Square Yards)</u>	\$ _____	\$ _____
UNIT PRICE No. 9: <u>Seeding and Mulching – Alternate No. 1 (Square Yards)</u>	\$ _____	\$ _____

LANG IMPOUNDMENT DIKE REHABILITATION
PORT PENN, DELAWARE
CONTRACT # NAT201601/LANG.IMPOUNDMENT

BID FORM

I/We acknowledge Addendums numbered _____ and the price(s) submitted include any cost/schedule impact they may have.

This bid shall remain valid and cannot be withdrawn for thirty (30) days from the date of opening of bids (60 days for School Districts and Department of Education), and the undersigned shall abide by the Bid Security forfeiture provisions. Bid Security is attached to this Bid.

The Owner shall have the right to reject any or all bids, and to waive any informality or irregularity in any bid received.

This bid is based upon work being accomplished by the Sub-Contractors named on the list attached to this bid.

Should I/We be awarded this contract, I/We pledge to achieve substantial completion of all the work within _____ calendar days of the Notice to Proceed.

The undersigned represents and warrants that he has complied and shall comply with all requirements of local, state, and national laws; that no legal requirement has been or shall be violated in making or accepting this bid, in awarding the contract to him or in the prosecution of the work required; that the bid is legal and firm; that he has not, directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken action in restraint of free competitive bidding.

Upon receipt of written notice of the acceptance of this Bid, the Bidder shall, within twenty (20) calendar days, execute the agreement in the required form and deliver the Contract Bonds, and Insurance Certificates, required by the Contract Documents.

I am / We are an Individual / a Partnership / a Corporation

By _____ Trading as _____
(Individual's / General Partner's / Corporate Name)

(State of Corporation)

Business Address: _____

Witness: _____ **By:** _____
(SEAL) (Authorized Signature)

(Title)
Date: _____

ATTACHMENTS

- Sub-Contractor List
- Non-Collusion Statement
- Affidavit(s) of Employee Drug Testing Program
- Bid Security
- (Others as Required by Project Manuals)

LANG IMPOUNDMENT DIKE REHABILITATION
PORT PENN, DELAWARE
CONTRACT # NAT201601/LANG.IMPOUNDMENT

BID FORM

SUBCONTRACTOR LIST

In accordance with Title 29, Chapter 6962 (d)(10)b Delaware Code, the following sub-contractor listing must accompany the bid submittal. The name and address of the sub-contractor **must be listed for each category** where the bidder intends to use a sub-contractor to perform that category of work. In order to provide full disclosure and acceptance of the bid by the *Owner*, **it is required that bidders list themselves as being the sub-contractor for all categories where he/she is qualified and intends to perform such work.** This form must be filled out completely with no additions or deletions. **Note that all subcontractors listed below must have a signed Affidavit of Employee Drug Testing Program included with this bid.**

Subcontractor Category	Subcontractor	Address (City & State)	Subcontractors tax payer ID # or Delaware Business license #
1. Aggregate/Fill	_____	_____	_____
2. Trucking	_____	_____	_____
3. Seeding/Mulching	_____	_____	_____
4. Civil Engineer	_____	_____	_____
5. Surveyor	_____	_____	_____
6. Geotech/Compaction	_____	_____	_____

LANG IMPOUNDMENT DIKE REHABILITATION
PORT PENN, DELAWARE
CONTRACT # NAT201601/LANG.IMPOUNDMENT

BID FORM

NON-COLLUSION STATEMENT

This is to certify that the undersigned bidder has neither directly nor indirectly, entered into any agreement, participated in any collusion or otherwise taken any action in restraint of free competitive bidding in connection with this proposal submitted this date *(to the Office of Management and Budget, Division of Facilities Management)*.

All the terms and conditions of *(Project or Contract Number)* have been thoroughly examined and are understood.

NAME OF BIDDER: _____

AUTHORIZED REPRESENTATIVE

(TYPED): _____

AUTHORIZED REPRESENTATIVE

(SIGNATURE) _____

TITLE: _____

ADDRESS OF BIDDER: _____

E-MAIL: _____

PHONE NUMBER: _____

Sworn to and Subscribed before me this _____ day of _____ 20____.

My Commission expires _____ NOTARY PUBLIC _____.

THIS PAGE MUST BE SIGNED AND NOTARIZED FOR YOUR BID TO BE CONSIDERED.

LANG IMPOUNDMENT DIKE REHABILITATION
PORT PENN, DELAWARE
CONTRACT # NAT201601/LANG.IMPOUNDMENT

BID FORM

**AFFIDAVIT
OF
EMPLOYEE DRUG TESTING PROGRAM**

4104 Regulations for the Drug Testing of Contractor and Subcontractor Employees Working on Large Public Works Projects requires that Contractors and Subcontractors implement a program of mandatory drug testing for Employees who work on Large Public Works Contracts funded all or in part with public funds.

We hereby certify that we have in place or will implement during the entire term of the contract a Mandatory Drug Testing Program for our employees on the jobsite that complies with this regulation:

Contractor/Subcontractor Name: _____

Contractor/Subcontractor Address: _____

Authorized Representative (typed or printed): _____

Authorized Representative (signature): _____

Title: _____

Sworn to and Subscribed before me this _____ day of _____ 20____.

My Commission expires _____ . NOTARY PUBLIC _____.

THIS PAGE MUST BE SIGNED AND NOTARIZED FOR YOUR BID TO BE CONSIDERED.

LANG IMPOUNDMENT DIKE REHABILITATION
PORT PENN, DELAWARE
CONTRACT # NAT201601/LANG.IMPOUNDMENT

BID FORM

**STATE OF DELAWARE
OFFICE OF MANAGEMENT AND BUDGET**

BID BOND

TO ACCOMPANY PROPOSAL
(Not necessary if security is used)

KNOW ALL MEN BY THESE PRESENTS That: _____
_____ of _____ in the County of _____ and State of _____
_____ as **Principal**, and _____ of _____
_____ in the County of _____ and State of _____ as **Surety**, legally
authorized to do business in the State of Delaware ("**State**"), are held and firmly unto the **State** in the sum of _____
_____ Dollars (\$ _____), or _____ percent
not to exceed _____ Dollars (\$ _____
_____) of amount of bid on Contract No. _____, to be paid to the **State** for the use and benefit
of Delaware Division of Fish and Wildlife for which payment well and truly to be made, we do bind ourselves, our and each of
our heirs, executors, administrators, and successors, jointly and severally for and in the whole firmly by these presents.

NOW THE CONDITION OF THIS OBLIGATION IS SUCH That if the above bounden **Principal** who has submitted
to the Delaware Division of Fish and Wildlife a certain proposal to enter into this contract for the furnishing of certain material
and/or services within the **State**, shall be awarded this Contract, and if said **Principal** shall well and truly enter into and execute
this Contract as may be required by the terms of this Contract and approved by Delaware Division of Fish and Wildlife this
Contract to be entered into within twenty days after the date of official notice of the award thereof in accordance with the terms
of said proposal, then this obligation shall be void or else to be and remain in full force and virtue.

Sealed with _____ seal and dated this _____ day of _____ in the year of our Lord two thousand
and _____ (20____).

SEALED, AND DELIVERED IN THE
Presence of

Name of Bidder (Organization)

Corporate
Seal

By:

Authorized Signature

Attest _____

Title

Name of Surety

Witness: _____

By:

Title

LANG IMPOUNDMENT DIKE REHABILITATION
PORT PENN, DELAWARE
CONTRACT # NAT201601/LANG.IMPOUNDMENT

DEPARTMENT OF NATURAL RESOURCES & ENVIRONMENTAL CONTROL
89 KINGS HIGHWAY
DOVER, DE 19901
CONTRACT DOCUMENT
FOR

LANG IMPOUNDMENT DIKE REHABILITATION
CONTRACT NO. NAT2016010/LANG.IMPOUNDMENT

THIS AGREEMENT, made and executed this _____ day of _____, 2017, by and between _____ (Hereinafter designated as Contractor) party of the first part, and the Department of Natural Resources and Environmental Control, a Department created under the laws of the State of Delaware (hereinafter designated as Department) party of the second part.

WITNESSETH that the Contractor, in consideration of the covenants and agreements herein contained and made by the Department, agrees to the following:

ARTICLE ONE. The Contractor shall provide and furnish all the material, supplies, machinery, implements, appliances, tools and labor required to complete this contract in Newcastle County, State of Delaware, as shown and specified in the specifications, proposals, drawings or plans as indicated in the project manual issued for the Department, with specifications, proposals, drawings or plans entitled **LANG IMPOUNDMENT, DIKE REHABILITATION PROJECT NO. NAT201610/LANG IMPOUNDMENT** is hereby incorporated by reference as part of this contract. This contract will be binding on both parties upon receipt by the Contractor of an approved State of Delaware Purchase Order. The Contractor must prosecute the work in such order as to complete the dike rehabilitation no later than October 1, 2018.

LANG IMPOUNDMENT DIKE REHABILITATION
PORT PENN, DELAWARE
CONTRACT # NAT201601/LANG.IMPOUNDMENT

CONTRACT DOCUMENT (CONTINUED)

IN WITNESS WHEREOF, the said parties have duly executed this agreement in triplicate the day and year first above written.

IN WITNESS WHEREOF, the parties below have hereunto set their hands on the _____ day of _____, 2017.

Contractor
By: _____
Witness Title

State of _____
County of _____

Sworn and subscribed before me this _____ day of _____, 2017.

Notary Public

IN WITNESS WHEREOF, the parties below have hereunto set their hands on the _____ day of _____, 2017.

Witness

Project Manager
Division of Fish and Wildlife

State of _____
County of _____

Sworn and subscribed before me this _____ day of _____, 2017.

Notary Public

LANG IMPOUNDMENT DIKE REHABILITATION
PORT PENN, DELAWARE
CONTRACT # NAT201601/LANG.IMPOUNDMENT

CONTRACT DOCUMENT (CONTINUED)

IN WITNESS WHEREOF, the parties below have hereunto set their hands on the _____
day of _____, 2017.

Witness

Director, Division of Fish and Wildlife

State of _____

County of _____

Sworn and subscribed before me this _____ day of _____, 2017.

Notary Public

Witness

Secretary, Department of
Natural Resources &
Environmental Control

State of _____

County of _____

Sworn and subscribed before me this _____ day of _____, 2017.

Notary Public

STATE OF DELAWARE
OFFICE OF MANAGEMENT AND BUDGET

PERFORMANCE BOND

Bond Number: _____

KNOW ALL PERSONS BY THESE PRESENTS, that we, _____, as principal (“**Principal**”), and _____, a _____ corporation, legally authorized to do business in the State of Delaware, as surety (“**Surety**”), are held and firmly bound unto the _____ (“**Owner**”) Delaware Division of Fish and Wildlife, in the amount of _____ (\$_____), to be paid to **Owner**, for which payment well and truly to be made, we do bind ourselves, our and each and every of our heirs, executors, administrations, successors and assigns, jointly and severally, for and in the whole, firmly by these presents.

Sealed with our seals and dated this _____ day of _____, 20__.

NOW THE CONDITION OF THIS OBLIGATION IS SUCH, that if **Principal**, who has been awarded by **Owner** that certain contract known as Contract No. _____ dated the _____ day of _____, 20__ (the “Contract”), which Contract is incorporated herein by reference, shall well and truly provide and furnish all materials, appliances and tools and perform all the work required under and pursuant to the terms and conditions of the Contract and the Contract Documents (as defined in the Contract) or any changes or modifications thereto made as therein provided, shall make good and reimburse **Owner** sufficient funds to pay the costs of completing the Contract that **Owner** may sustain by reason of any failure or default on the part of **Principal**, and shall also indemnify and save harmless **Owner** from all costs, damages and expenses arising out of or by reason of the performance of the Contract and for as long as provided by the Contract; then this obligation shall be void, otherwise to be and remain in full force and effect.

Surety, for value received, hereby stipulates and agrees, if requested to do so by **Owner**, to fully perform and complete the work to be performed under the Contract pursuant to the terms, conditions and covenants thereof, if for any cause **Principal** fails or neglects to so fully perform and complete such work.

Surety, for value received, for itself and its successors and assigns, hereby stipulates and agrees that the obligation of **Surety** and its bond shall be in no way impaired or affected by any extension of time, modification, omission, addition or change in or to the Contract or the work to be performed thereunder, or by any payment thereunder before the time required therein, or by any waiver of any provisions thereof, or by any assignment, subletting or other transfer thereof or of any work to be performed or any monies due or to become due thereunder; and **Surety** hereby waives notice of any and all such extensions, modifications, omissions, additions, changes, payments, waivers, assignments, subcontracts and transfers and hereby expressly stipulates and agrees that any and all things done and omitted to be done by and in relation to assignees, subcontractors, and other transferees shall have the same effect as to **Surety** as though done or omitted to be done by or in relation to **Principal**.

Surety hereby stipulates and agrees that no modifications, omissions or additions in or to the terms of the Contract shall in any way whatsoever affect the obligation of **Surety** and its bond.

Any proceeding, legal or equitable, under this Bond may be brought in any court of competent jurisdiction in the State of Delaware. Notices to **Surety** or Contractor may be mailed or delivered to them at their respective addresses shown below.

IN WITNESS WHEREOF, **Principal** and **Surety** have hereunto set their hand and seals, and such of them as are corporations have caused their corporate seal to be hereto affixed and these presents to be signed by their duly authorized officers, the day and year first above written.

PRINCIPAL

Name: _____

Witness or Attest: Address: _____

By: _____ (SEAL)

Name:

Name:

Title:

(Corporate Seal)

SURETY

Name: _____

Witness or Attest: Address: _____

By: _____ (SEAL)

Name:

Name:

Title:

(Corporate Seal)

STATE OF DELAWARE
OFFICE OF MANAGEMENT AND BUDGET

PAYMENT BOND

Bond Number: _____

KNOW ALL PERSONS BY THESE PRESENTS, that we, _____, as principal (“**Principal**”), and _____, a _____ corporation, legally authorized to do business in the State of Delaware, as surety (“**Surety**”), are held and firmly bound unto the Delaware Division of Fish and Wildlife (“**Owner**”), in the amount of _____ (\$ _____), to be paid to **Owner**, for which payment well and truly to be made, we do bind ourselves, our and each and every of our heirs, executors, administrations, successors and assigns, jointly and severally, for and in the whole firmly by these presents.

Sealed with our seals and dated this _____ day of _____, 20__.

NOW THE CONDITION OF THIS OBLIGATION IS SUCH, that if **Principal**, who has been awarded by **Owner** that certain contract known as Contract No. _____ dated the _____ day of _____, 20__ (the “Contract”), which Contract is incorporated herein by reference, shall well and truly pay all and every person furnishing materials or performing labor or service in and about the performance of the work under the Contract, all and every sums of money due him, her, them or any of them, for all such materials, labor and service for which **Principal** is liable, shall make good and reimburse **Owner** sufficient funds to pay such costs in the completion of the Contract as **Owner** may sustain by reason of any failure or default on the part of **Principal**, and shall also indemnify and save harmless **Owner** from all costs, damages and expenses arising out of or by reason of the performance of the Contract and for as long as provided by the Contract; then this obligation shall be void, otherwise to be and remain in full force and effect.

Surety, for value received, for itself and its successors and assigns, hereby stipulates and agrees that the obligation of **Surety** and its bond shall be in no way impaired or affected by any extension of time, modification, omission, addition or change in or to the Contract or the work to be performed thereunder, or by any payment thereunder before the time required therein, or by any waiver of any provisions thereof, or by any assignment, subletting or other transfer thereof or of any work to be performed or any monies due or to become due thereunder; and **Surety** hereby waives notice of any and all such extensions, modifications, omissions, additions, changes, payments, waivers, assignments, subcontracts and transfers and hereby expressly stipulates and agrees that any and all things done and omitted to be done by and in relation to assignees, subcontractors, and other transferees shall have the same effect as to **Surety** as though done or omitted to be done by or in relation to **Principal**.

Surety hereby stipulates and agrees that no modifications, omission or additions in or to the terms of the Contract shall in any way whatsoever affect the obligation of **Surety** and its bond.

Any proceeding, legal or equitable, under this Bond may be brought in any court of competent jurisdiction in the State of Delaware. Notices to **Surety** or Contractor may be mailed or delivered to them at their respective addresses shown below.

IN WITNESS WHEREOF, **Principal** and **Surety** have hereunto set their hand and seals, and such of them as are corporations have caused their corporate seal to be hereto affixed and these presents to be signed by their duly authorized officers, the day and year first above written.

PRINCIPAL

Name: _____

Witness or Attest: Address: _____

Name:

(Corporate Seal)

By: _____(SEAL)
Name:
Title:

SURETY

Name: _____

Witness or Attest: Address: _____

Name:

(Corporate Seal)

By: _____(SEAL)
Name:
Title:

GENERAL REQUIREMENTS

TABLE OF ARTICLES

1. GENERAL
2. OWNER
3. CONTRACTOR
4. ADMINISTRATION OF THE CONTRACT
5. SUBCONTRACTORS
6. CONSTRUCTION BY OWNER OR BY SEPARATE CONTRACTORS
7. CHANGES IN THE WORK
8. TIME
9. PAYMENTS AND COMPLETION
10. PROTECTION OF PERSONS AND PROPERTY
11. INSURANCE AND BONDS
12. UNCOVERING AND CORRECTION OF WORK
13. MISCELLANEOUS PROVISIONS
14. TERMINATION OR SUSPENSION OF THE CONTRACT

ARTICLE 1: GENERAL

1.1 CONTRACT DOCUMENTS

1.1.1 The intent of the Contract Documents is to include all items necessary for the proper execution and completion of the Work by the Contractor. The Contract Documents are complementary and what is required by one shall be as binding as if required by all. Performance by the Contractor shall be required to an extent consistent with the Contract Documents and reasonably inferable from them as being necessary to produce the intended results.

1.1.2 Work including material purchases shall not begin until the Contractor is in receipt of a bonafide State of Delaware Purchase Order. Any work performed or material purchases prior to the issuance of the Purchase Order is done at the Contractor's own risk and cost.

1.2 EQUALITY OF EMPLOYMENT OPPORTUNITY ON PUBLIC WORKS

1.2.1 For Public Works Projects financed in whole or in part by state appropriation the Contractor agrees that during the performance of this contract:

1. The Contractor will not discriminate against any employee or applicant for employment because of race, creed, sex, color, sexual orientation, gender identity or national origin. The Contractor will take positive steps to ensure that applicants are employed and that employees are treated during employment without regard to their race, creed, sex, color, sexual orientation, gender identity or national origin. Such action shall include, but not be limited to, the following: employment, upgrading, demotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Contractor agrees to post in conspicuous places available to employees and applicants for employment notices to be provided by the contracting agency setting forth this nondiscrimination clause.
2. The Contractor will, in all solicitations or advertisements for employees placed by or on behalf of the Contractor, state that all qualified applicants will receive consideration for employment without regard to race, creed, sex, color, sexual orientation, gender identity or national origin."

ARTICLE 2: OWNER

(NO ADDITIONAL GENERAL REQUIREMENTS – SEE SUPPLEMENTARY GENERAL CONDITIONS)

ARTICLE 3: CONTRACTOR

3.1 Schedule of Values: The successful Bidder shall within twenty (20) days after receiving notice to proceed with the work, furnish to the Owner a complete schedule of values on the various items comprising the work.

3.2 Subcontracts: Upon approval of Subcontractors, the Contractor shall award their Subcontracts as soon as possible after the signing of their own contract and see that all material, their own and those of their Subcontractors, are promptly ordered so that the work will not be delayed by failure of materials to arrive on time.

3.3 Before commencing any work or construction, the General Contractor is to consult with the Owner as to matters in connection with access to the site and the allocation of Ground Areas for the various features of hauling, storage, etc.

- 3.4 The Contractor shall supervise and direct the Work, using the Contractor's best skill and attention. The Contractor shall be solely responsible for and have control over construction means, methods, techniques, sequences and procedures and for coordinating all portions of the Work under the Contract, unless the Contract Documents give other specific instructions.
- 3.5 The Contractor shall enforce strict discipline and good order among the Contractor's employees and other persons carrying out the Contract. The Contractor shall not permit employment of unfit persons or persons not skilled in tasks assigned to them.
- 3.6 The Contractor warrants to the Owner that materials and equipment furnished will be new and of good quality, unless otherwise permitted, and that the work will be free from defects and in conformance with the Contract Documents. Work not conforming to these requirements, including substitutions not properly approved, may be considered defective. If required by the Owner, the Contractor shall furnish evidence as to the kind and quality of materials and equipment provided.
- 3.7 Unless otherwise provided, the Contractor shall pay all sales, consumer, use and other similar taxes, and shall secure and pay for required permits, fees, licenses, and inspections necessary for proper execution of the Work.
- 3.8 The Contractor shall comply with and give notices required by laws, ordinances, rules, regulations, and lawful orders of public authorities bearing on performance of the Work. The Contractor shall promptly notify the Owner if the Drawings and Specifications are observed to be at variance therewith.
- 3.9 The Contractor shall be responsible to the Owner for the acts and omissions of the Contractor's employees, Subcontractors and their agents and employees, and other persons performing portions of the Work under contract with the Contractor.
- 3.10 The Contractor shall keep the premises and surrounding area free from accumulation of waste materials or rubbish caused by operations under the Contract. At completion of the Work the Contractor shall remove from and about the Project all waste materials, rubbish, the Contractor's tools, construction equipment, machinery and surplus materials. The Contractor shall be responsible for returning all damaged areas to their original conditions.
- 3.11 STATE LICENSE AND TAX REQUIREMENTS
- 3.11.1 Each Contractor and Subcontractor shall be licensed to do business in the State of Delaware and shall pay all fees and taxes due under State laws. In conformance with Section 2503, Chapter 25, Title 30, Delaware Code, "the Contractor shall furnish the Delaware Department of Finance within ten (10) days after entering into any contract with a contractor or subcontractor not a resident of this State, a statement of total value of such contract or contracts together with the names and addresses of the contracting parties."
- 3.12 The Contractor shall comply with all requirements set forth in Section 6962, Chapter 69, Title 29 of the Delaware Code.
- 3.13 During the contract Work, the Contractor and each listed Subcontractor, shall implement an Employee Drug Testing Program in accordance with OMB Regulation 4104- "Regulations for the Drug Testing of Contractor and Subcontractor Employees Working on "Large Public Works Projects". "Large Public Works" is based upon the current threshold required for bidding Public Works as set by the Purchasing and Contracting Advisory Council.

ARTICLE 4: ADMINISTRATION OF THE CONTRACT

4.1 CONTRACT SURETY

4.1.1 PERFORMANCE BOND AND LABOR AND MATERIAL PAYMENT BOND

4.1.2 All bonds will be required as follows unless specifically waived elsewhere in the Bidding Documents.

4.1.3 Contents of Performance Bonds – The bond shall be in the form approved by the Office of Management and Budget. The bond shall be conditioned upon the faithful compliance and performance by the successful bidder of each and every term and condition of the contract and the proposal, plans, specifications, and bid documents thereof. Each term and condition shall be met at the time and in the manner prescribed by the Contract, Bid documents and the specifications, including the payment in full to every person furnishing material or performing labor in the performance of the Contract, of all sums of money due the person for such labor and material. (The bond shall also contain the successful bidder's guarantee to indemnify and save harmless the State and the agency from all costs, damages and expenses growing out of or by reason of the Contract in accordance with the Contract.)

4.1.4 Invoking a Performance Bond – The agency may, when it considers that the interest of the State so require, cause judgement to be confessed upon the bond.

4.1.5 Within twenty (20) days after the date of notice of award of contract, the Bidder to whom the award is made shall furnish a Performance Bond and Labor and Material Payment Bond, each equal to the full amount of the Contract price to guarantee the faithful performance of all terms, covenants and conditions of the same. The bonds are to be issued by an acceptable Bonding Company licensed to do business in the State of Delaware and shall be issued in duplicate.

4.1.6 Performance and Payment Bonds shall be maintained in full force (warranty bond) for a period of two (2) years after the date of the Certificate for Final Payment. The Performance Bond shall guarantee the satisfactory completion of the Project and that the Contractor will make good any faults or defects in his work which may develop during the period of said guarantees as a result of improper or defective workmanship, material or apparatus, whether furnished by themselves or their Sub-Contractors. The Payment Bond shall guarantee that the Contractor shall pay in full all persons, firms or corporations who furnish labor or material or both labor and material for, or on account of, the work included herein. The bonds shall be paid for by this Contractor. The Owner shall have the right to demand that the proof parties signing the bonds are duly authorized to do so.

4.2 FAILURE TO COMPLY WITH CONTRACT

4.2.1 If any firm entering into a contract with the State, or Agency that neglects or refuses to perform or fails to comply with the terms thereof, the Agency which signed the Contract may terminate the Contract and proceed to award a new contract in accordance with this Chapter 69, Title 29 of the Delaware Code or may require the Surety on the Performance Bond to complete the Contract in accordance with the terms of the Performance Bond. Nothing herein shall preclude the Agency from pursuing additional remedies as otherwise provided by law.

4.3 CONTRACT INSURANCE AND CONTRACT LIABILITY

4.3.1 In addition to the bond requirements stated in the Bid Documents, each successful Bidder shall purchase adequate insurance for the performance of the Contract and, by submission of a Bid, agrees to indemnify and save harmless and to defend all legal or equitable actions brought against the State, any Agency, officer and/or employee of the State, and Gahagan and Bryant Associates, Inc. (Engineer) for and from all claims of liability which is or may be the result of the successful Bidder's actions during the performance of the Contract.

4.3.2 The purchase or nonpurchase of such insurance or the involvement of the successful Bidder in any legal or equitable defense of any action brought against the successful Bidder based upon work performed pursuant to the Contract will not waive any defense which the State, its agencies and their respective officers, employees and agents might otherwise have against such claims, specifically including the defense of sovereign immunity, where applicable, and by the terms of this section, the State and all agencies, officers and employees thereof shall not be financially responsible for the consequences of work performed, pursuant to said contract.

4.4 RIGHT TO AUDIT RECORDS

4.4.1 The Owner shall have the right to audit the books and records of a Contractor or any Subcontractor under any Contract or Subcontract to the extent that the books and records relate to the performance of the Contract or Subcontract.

4.4.2 Said books and records shall be maintained by the Contractor for a period of seven (7) years from the date of final payment under the Prime Contract and by the Subcontractor for a period of seven (7) years from the date of final payment under the Subcontract.

ARTICLE 5: SUBCONTRACTORS

5.1 SUBCONTRACTING REQUIREMENTS

5.1.1 All contracts for the construction, reconstruction, alteration or repair of any public building (not a road, street or highway) shall be subject to the following provisions:

1. A contract shall be awarded only to a Bidder whose Bid is accompanied by a statement containing, for each Subcontractor category, the name and address (city or town and State only – street number and P.O. Box addresses not required) of the subcontractor whose services the Bidder intends to use in performing the Work and providing the material for such Subcontractor category.
2. A Bid will not be accepted nor will an award of any Contract be made to any Bidder which, as the Prime Contractor, has listed itself as the Subcontractor for any Subcontractor unless:
 - A. It has been established to the satisfaction of the awarding Agency that the Bidder has customarily performed the specialty work of such Subcontractor category by artisans regularly employed by the Bidder's firm;
 - B. That the Bidder is duly licensed by the State to engage in such specialty work, if the State requires licenses; and
 - C. That the Bidder is recognized in the industry as a bona fide Subcontractor or Contractor in such specialty work and Subcontractor category.

5.1.2 The decision of the awarding Agency as to whether a Bidder who list itself as the Subcontractor for a Subcontractor category shall be final and binding upon all Bidders, and no action of any nature shall lie against any awarding agency or its employees or officers because of its decision in this regard.

5.1.3 After such a Contract has been awarded, the successful Bidder shall not substitute another Subcontractor for any Subcontractor whose name was set forth in the statement which accompanied the Bid without the written consent of the awarding Agency.

- 5.1.4 No Agency shall consent to any substitution of Subcontractors unless the Agency is satisfied that the Subcontractor whose name is on the Bidders accompanying statement:
- A. Is unqualified to perform the work required;
 - B. Has failed to execute a timely reasonable Subcontract;
 - C. Has defaulted in the performance on the portion of the work covered by the Subcontract; or
 - D. Is no longer engaged in such business.
- 5.1.5 Should a Bidder be awarded a contract, such successful Bidder shall provide to the agency the taxpayer identification license numbers of such subcontractors. Such numbers shall be provided on the later of the date on which such subcontractor is required to be identified or the time the contract is executed. The successful Bidder shall provide to the agency to which it is contracting, within 30 days of entering into such public works contract, copies of all Delaware Business licenses of subcontractors and/or independent contractors that will perform work for such public works contract. However, if a subcontractor or independent contractor is hired or contracted more than 20 days after the Bidder entered the public works contract the Delaware Business license of such subcontractor or independent contractor shall be provided to the agency within 10 days of being contracted or hired.
- 5.2 PENALTY FOR SUBSTITUTION OF SUBCONTRACTORS
- 5.2.1 Should the Contractor fail to utilize any or all of the Subcontractors in the Contractor's Bid statement in the performance of the Work on the public bidding, the Contractor shall be penalized in the amount of (project specific amount*). The Agency may determine to deduct payments of the penalty from the Contractor or have the amount paid directly to the Agency. Any penalty amount assessed against the Contractor may be remitted or refunded, in whole or in part, by the Agency awarding the Contract, only if it is established to the satisfaction of the Agency that the Subcontractor in question has defaulted or is no longer engaged in such business. No claim for the remission or refund of any penalty shall be granted unless an application is filed within one year after the liability of the successful Bidder accrues. All penalty amounts assessed and not refunded or remitted to the contractor shall be reverted to the State.
- *one (1) percent of contract amount not to exceed \$10,000
- 5.3 ASBESTOS ABATEMENT
- 5.3.1 The selection of any Contractor to perform asbestos abatement for State-funded projects shall be approved by the Office of Management and Budget, Division of Facilities Management pursuant to Chapter 78 of Title 16.
- 5.4 STANDARDS OF CONSTRUCTION FOR THE PROTECTION OF THE PHYSICALLY HANDICAPPED
- 5.4.1 All Contracts shall conform with the standard established by the Delaware Architectural Accessibility Board unless otherwise exempted by the Board.
- 5.5 CONTRACT PERFORMANCE
- 5.5.1 Any firm entering into a Public Works Contract that neglects or refuses to perform or fails to comply with its terms, the Agency may terminate the Contract and proceed to award a new Contract or may require the Surety on the Performance Bond to complete the Contract in accordance with the terms of the Performance Bond.

ARTICLE 6: CONSTRUCTION BY OWNER OR SEPARATE CONTRACTORS

- 6.1 The Owner reserves the right to simultaneously perform other construction or operations related to the Project with the Owner's own forces, and to award separate contracts in connection with other portions of the Project or other Projects at the same site.
- 6.2 The Contractor shall afford the Owner and other Contractors reasonable opportunity for access and storage of materials and equipment, and for the performance of their activities, and shall connect and coordinate their activities with other forces as required by the Contract Documents.

ARTICLE 7: CHANGES IN THE WORK

- 7.1 The Owner, without invalidating the Contract, may order changes in the Work consisting of Additions, Deletions, Modifications or Substitutions, with the Contract Sum and Contract completion date being adjusted accordingly. Such changes in the Work shall be authorized by written Change Order signed by the Professional, as the duly authorized agent, the Contractor and the Owner.
- 7.2 The Contract Sum and Contract Completion Date shall be adjusted only by a fully executed Change Order.
- 7.3 The additional cost, or credit to the Owner resulting from a change in the Work shall be by mutual agreement of the Owner, Contractor and the Architect. In all cases, this cost or credit shall be based on the 'DPE' wages required and the "invoice price" of the materials/equipment needed.
- 7.3.1 "DPE" shall be defined to mean "direct personnel expense". Direct payroll expense includes direct salary plus customary fringe benefits (prevailing wage rates) and documented statutory costs such as workman's compensation insurance, Social Security/Medicare, and unemployment insurance (a maximum multiplier of 1.35 times DPE).
- 7.3.2 "Invoice price" of materials/equipment shall be defined to mean the actual cost of materials and/or equipment that is paid by the Contractor, (or subcontractor), to a material distributor, direct factory vendor, store, material provider, or equipment leasing entity. Rates for equipment that is leased and/or owned by the Contractor or subcontractor(s) shall not exceed those listed in the latest version of the "Means Building Construction Cost Data" publication.
- 7.3.3 In addition to the above, the General Contractor is allowed a fifteen percent (15%) markup for overhead and profit for additional work performed by the General Contractor's own forces. For additional subcontractor work, the Subcontractor is allowed a fifteen (15) percent overhead and profit on change order work above and beyond the direct costs stated previously. To this amount, the General Contractor will be allowed a mark-up not exceeding seven and one half percent (7.5%) on the subcontractors work. These mark-ups shall include all costs including, but not limited to: overhead, profit, bonds, insurance, supervision, etc. No markup is permitted on the work of the subcontractors subcontractor. No additional costs shall be allowed for changes related to the Contractor's onsite superintendent/staff, or project manager, unless a change in the work changes the project duration and is identified by the CPM schedule. There will be no other costs associated with the change order.

ARTICLE 8: TIME

- 8.1 Time limits, if any, are as stated in the Project Manual. By executing the Agreement, the Contractor confirms that the stipulated limits are reasonable, and that the Work will be completed within the anticipated time frame.
- 8.2 If progress of the Work is delayed at any time by changes ordered by the Owner, by labor disputes, fire, unusual delay in deliveries, abnormal adverse weather conditions, unavoidable casualties or other causes beyond the Contractor's control, the Contract Time shall be extended for such reasonable time as the Owner may determine.
- 8.3 Any extension of time beyond the date fixed for completion of the construction and acceptance of any part of the Work called for by the Contract, or the occupancy of the building by the Owner, in whole or in part, previous to the completion shall not be deemed a waiver by the Owner of his right to annul or terminate the Contract for abandonment or delay in the matter provided for, nor relieve the Contractor of full responsibility.
- 8.4 **SUSPENSION AND DEBARMENT**
- 8.4.1 Per Section 6962(d)(14), Title 29, Delaware Code, "Any Contractor who fails to perform a public works contract or complete a public works project within the time schedule established by the Agency in the Invitation To Bid, may be subject to Suspension or Debarment for one or more of the following reasons: a) failure to supply the adequate labor supply ratio for the project; b) inadequate financial resources; or, c) poor performance on the Project."
- 8.4.2 "Upon such failure for any of the above stated reasons, the Agency that contracted for the public works project may petition the Director of the Office of Management and Budget for Suspension or Debarment of the Contractor. The Agency shall send a copy of the petition to the Contractor within three (3) working days of filing with the Director. If the Director concludes that the petition has merit, the Director shall schedule and hold a hearing to determine whether to suspend the Contractor, debar the Contractor or deny the petition. The Agency shall have the burden of proving, by a preponderance of the evidence, that the Contractor failed to perform or complete the public works project within the time schedule established by the Agency and failed to do so for one or more of the following reasons: a) failure to supply the adequate labor supply ratio for the project; b) inadequate financial resources; or, c) poor performance on the project. Upon a finding in favor of the Agency, the Director may suspend a Contractor from Bidding on any project funded, in whole or in part, with public funds for up to 1 year for a first offense, up to 3 years for a second offense and permanently debar the Contractor for a third offense. The Director shall issue a written decision and shall send a copy to the Contractor and the Agency. Such decision may be appealed to the Superior Court within thirty (30) days for a review on the record."
- 8.5 **RETAINAGE**
- 8.5.1 Per Section 6962(d)(5) a.3, Title 29, Delaware Code: The Agency may at the beginning of each public works project establish a time schedule for the completion of the project. If the project is delayed beyond the completion date due to the Contractor's failure to meet their responsibilities, the Agency may forfeit, at its discretion, all or part of the Contractor's retainage.
- 8.5.2 This forfeiture of retainage also applies to the timely completion of the punchlist. A punchlist will only be prepared upon the mutual agreement of the Owner, Architect and Contractor. Once the punchlist is prepared, all three parties will by mutual agreement, establish a schedule for its completion. Should completion of the punchlist be delayed beyond the established date due to the Contractor's failure to meet their responsibilities, the Agency may hold permanently, at its discretion, all or part of the Contractor's retainage.

ARTICLE 9: PAYMENTS AND COMPLETION

9.1 APPLICATION FOR PAYMENT

9.1.1 Applications for payment shall be made according to the technical specifications of the contract. There will be a five percent (5%) retainage on all Contractor's monthly invoices until completion of the project. This retainage may become payable upon receipt of all required closeout documentation, provided all other requirements of the Contract Documents have been met.

9.1.2 A date will be fixed for the taking of the monthly account of work done. Upon receipt of Contractor's itemized application for payment, such application will be audited, modified, if found necessary, and approved for the amount. Statement shall be submitted to the Owner.

9.1.3 Section 6516, Title 29 of the Delaware Code annualized interest is not to exceed 12% per annum beginning thirty (30) days after the "presentment" (as opposed to the date) of the invoice.

9.2 PARTIAL PAYMENTS

9.2.1 Any public works Contract executed by any Agency may provide for partial payments at the option of the Owner with respect to materials placed along or upon the sites or stored at secured locations, which are suitable for use in the performance of the contract.

9.2.2 When approved by the agency, partial payment may include the values of tested and acceptable materials of a nonperishable or noncontaminative nature which have been produced or furnished for incorporation as a permanent part of the work yet to be completed, provided acceptable provisions have been made for storage.

9.2.2.1 Any allowance made for materials on hand will not exceed the delivered cost of the materials as verified by invoices furnished by the Contractor, nor will it exceed the contract bid price for the material complete in place.

9.2.3 If requested by the Agency, receipted bills from all Contractors, Subcontractors, and material, men, etc., for the previous payment must accompany each application for payment. Following such a request, no payment will be made until these receipted bills have been received by the Owner.

9.3 SUBSTANTIAL COMPLETION

9.3.1 When the building has been made suitable for occupancy, but still requires small items of miscellaneous work, the Owner will determine the date when the project has been substantially completed.

9.3.2 If, after the Work has been substantially completed, full completion thereof is materially delayed through no fault of the Contractor, and without terminating the Contract, the Owner may make payment of the balance due for the portion of the Work fully completed and accepted. Such payment shall be made under the terms and conditions governing final payment that it shall not constitute a waiver of claims.

9.3.3 On projects where commissioning is included, the commissioning work as defined in the specifications must be complete prior to the issuance of substantial completion.

9.4 FINAL PAYMENT

- 9.4.1 Final payment, including the five percent (5%) retainage if determined appropriate, shall be made within thirty (30) days after the Work is fully completed and the Contract fully performed and provided that the Contractor has submitted the following closeout documentation (in addition to any other documentation required elsewhere in the Contract Documents):
- 9.4.1.1 Evidence satisfactory to the Owner that all payrolls, material bills, and other indebtedness connected with the work have been paid,
 - 9.4.1.2 An acceptable RELEASE OF LIENS,
 - 9.4.1.3 Copies of all applicable warranties,
 - 9.4.1.4 As-built drawings,
 - 9.4.1.5 Operations and Maintenance Manuals,
 - 9.4.1.6 Instruction Manuals,
 - 9.4.1.7 Consent of Surety to final payment.
 - 9.4.1.8 The Owner reserves the right to retain payments, or parts thereof, for its protection until the foregoing conditions have been complied with, defective work corrected and all unsatisfactory conditions remedied.

ARTICLE 10: PROTECTION OF PERSONS AND PROPERTY

- 10.1 The Contractor shall be responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the performance of the Contract. The Contractor shall take all reasonable precautions to prevent damage, injury or loss to: workers, persons nearby who may be affected, the Work, materials and equipment to be incorporated, and existing property at the site or adjacent thereto. The Contractor shall give notices and comply with applicable laws ordinances, rules regulations, and lawful orders of public authorities bearing on the safety of persons and property and their protection from injury, damage, or loss. The Contractor shall promptly remedy damage and loss to property at the site caused in whole or in part by the Contractor, a Subcontractor, or anyone directly or indirectly employed by any of them, or by anyone for whose acts they may be liable.
- 10.2 The Contractor shall notify the Owner in the event any existing hazardous material such as lead, PCBs, asbestos, etc. is encountered on the project. The Owner will arrange with a qualified specialist for the identification, testing, removal, handling and protection against exposure or environmental pollution, to comply with applicable regulation laws and ordinances. The Contractor and Architect will not be required to participate in or to perform this operation. Upon completion of this work, the Owner will notify the Contractor and Architect in writing the area has been cleared and approved by the authorities in order for the work to proceed. The Contractor shall attach documentation from the authorities of said approval.
- 10.3 As required in the Hazardous Chemical Information Act of June 1984, all vendors supplying any materials that may be defined as hazardous, must provide Material Safety Data Sheets for those products. Any chemical product should be considered hazardous if it has a warning caution on the label relating to a potential physical or health hazard, if it is known to be present in the work place, and if employees may be exposed under normal conditions or in any foreseeable emergency situation. Material Safety Data Sheets must be provided directly to the Owner along with the shipping slips that include those products.

10.4 The Contractor shall certify to the Owner that materials incorporated into the Work are free of all asbestos. This certification may be in the form of Material Safety Data Sheet (MSDS) provided by the product manufacturer for the materials used in construction, as specified or as provided by the Contractor.

ARTICLE 11: INSURANCE AND BONDS

11.1 The Contractor shall carry all insurance required by law, such as Unemployment Insurance, etc. The Contractor shall carry such insurance coverage as they desire on their own property such as a field office, storage sheds or other structures erected upon the project site that belong to them and for their own use. The Subcontractors involved with this project shall carry whatever insurance protection they consider necessary to cover the loss of any of their personal property, etc.

11.2 Upon being awarded the Contract, the Contractor shall obtain a minimum of two (2) copies of all required insurance certificates called for herein, and submit one (1) copy of each certificate, to the Owner, within 20 days of contract award.

11.3 Bodily Injury Liability and Property Damage Liability Insurance shall, in addition to the coverage included herein, include coverage for injury to or destruction of any property arising out of the collapse of or structural injury to any building or structure due to demolition work and evidence of these coverages shall be filed with and approved by the Owner.

11.4 The Contractor's Property Damage Liability Insurance shall, in addition to the coverage noted herein, include coverage on all real and personal property in their care, custody and control damaged in any way by the Contractor or their Subcontractors during the entire construction period on this project.

11.5 Builders Risk (including Standard Extended Coverage Insurance) on the existing building during the entire construction period, shall not be provided by the Contractor under this contract. The Owner shall insure the existing building and all of its contents and all this new alteration work under this contract during entire construction period for the full insurable value of the entire work at the site. Note, however, that the Contractor and their Subcontractors shall be responsible for insuring building materials (installed and stored) and their tools and equipment whenever in use on the project, against fire damage, theft, vandalism, etc.

11.6 Certificates of the insurance company or companies stating the amount and type of coverage, terms of policies, etc., shall be furnished to the Owner, within 20 days of contract award.

11.7 The Contractor shall, at their own expense, (in addition to the above) carry the following forms of insurance:

11.7.1 Contractor's Contractual Liability Insurance

Minimum coverage to be:

Bodily Injury	\$500,000	for each person
	\$1,000,000	for each occurrence
	\$1,000,000	aggregate
Property Damage	\$500,000	for each occurrence
	\$1,000,000	aggregate

11.7.2 Contractor's Protective Liability Insurance

Minimum coverage to be:

Bodily Injury	\$500,000	for each person
	\$1,000,000	for each occurrence
	\$1,000,000	aggregate

Property Damage	\$500,000	for each occurrence
	\$500,000	aggregate

11.7.3 Automobile Liability Insurance

Minimum coverage to be:

Bodily Injury	\$1,000,000	for each person
	\$1,000,000	for each occurrence
Property Damage	\$500,000	per accident

11.7.4 Prime Contractor's and Subcontractors' policies shall include contingent and contractual liability coverage in the same minimum amounts as 11.7.1 above.

11.7.5 Workmen's Compensation (including Employer's Liability):

11.7.5.1 Minimum Limit on employer's liability to be as required by law.

11.7.5.2 Minimum Limit for all employees working at one site.

11.7.6 Certificates of Insurance must be filed with the Owner guaranteeing fifteen (15) days prior notice of cancellation, non-renewal, or any change in coverages and limits of liability shown as included on certificates.

11.7.7 Social Security Liability

11.7.7.1 With respect to all persons at any time employed by or on the payroll of the Contractor or performing any work for or on their behalf, or in connection with or arising out of the Contractor's business, the Contractor shall accept full and exclusive liability for the payment of any and all contributions or taxes or unemployment insurance, or old age retirement benefits, pensions or annuities now or hereafter imposed by the Government of the United States and the State or political subdivision thereof, whether the same be measured by wages, salaries or other remuneration paid to such persons or otherwise.

11.7.7.2 Upon request, the Contractor shall furnish Owner such information on payrolls or employment records as may be necessary to enable it to fully comply with the law imposing the aforesaid contributions or taxes.

11.7.7.3 If the Owner is required by law to and does pay any and/or all of the aforesaid contributions or taxes, the Contractor shall forthwith reimburse the Owner for the entire amount so paid by the Owner.

ARTICLE 12: UNCOVERING AND CORRECTION OF WORK

12.1 The Contractor shall promptly correct Work rejected by the Owner or failing to conform to the requirements of the Contract Documents, whether observed before or after Substantial Completion and whether or not fabricated, installed or completed, and shall correct any Work found to be not in accordance with the requirements of the Contract Documents within a period of two years from the date of Substantial Completion, or by terms of an applicable special warranty required by the Contract Documents. The provisions of this Article apply to work done by Subcontractors as well as to Work done by direct employees of the Contractor.

- 12.2 At any time during the progress of the work, or in any case where the nature of the defects shall be such that it is not expedient to have them corrected, the Owner, at their option, shall have the right to deduct such sum, or sums, of money from the amount of the contract as they consider justified to adjust the difference in value between the defective work and that required under contract including any damage to the structure.

ARTICLE 13: MISCELLANEOUS PROVISIONS**13.1 DIMENSIONS**

- 13.1.2 All dimensions shown shall be verified by the Contractor by actual measurements at the project site. Any discrepancies between the drawings and specifications and the existing conditions shall be referred to the Owner for adjustment before any work affected thereby has been performed.

13.2 LABORATORY TESTS

- 13.2.1 Any specified laboratory tests of material and finished articles to be incorporated in the work shall be made by bureaus, laboratories or agencies approved by the Owner and reports of such tests shall be submitted to the Owner. The cost of the testing shall be paid for by the Contractor.
- 13.2.2 The Contractor shall furnish all sample materials required for these tests and shall deliver same without charge to the testing laboratory or other designated agency when and where directed by the Owner.

13.3 ARCHAEOLOGICAL EVIDENCE

- 13.3.1 Whenever, in the course of construction, any archaeological evidence is encountered on the surface or below the surface of the ground, the Contractor shall notify the authorities of the Delaware Archaeological Board and suspend work in the immediate area for a reasonable time to permit those authorities, or persons designated by them, to examine the area and ensure the proper removal of the archaeological evidence for suitable preservation in the State Museum.

13.4 WARRANTY

- 13.4.1 For a period of two (2) years from the date of substantial completion, as evidenced by the date of final acceptance of the work, the contractor warrants that work performed under this contract conforms to the contract requirements and is free of any defect of equipment, material or workmanship performed by the contractor or any of his subcontractors or suppliers. However, manufacturer's warranties and guarantees, if for a period longer than two (2) years, shall take precedence over the above warranties. The contractor shall remedy, at his own expense, any such failure to conform or any such defect. The protection of this warranty shall be included in the Contractor's Performance Bond.

ARTICLE 14: TERMINATION OF CONTRACT

- 14.1 If the Contractor defaults or persistently fails or neglects to carry out the Work in accordance with the Contract Documents or fails to perform a provision of the Contract, the Owner, after seven days written notice to the Contractor, may make good such deficiencies and may deduct the cost thereof from the payment then or thereafter due the Contractor. Alternatively, at the Owner's option, and the Owner may terminate the Contract and take possession of the site and of all materials, equipment, tools, and machinery thereon owned by the Contractor and may finish the Work by whatever method the Owner may deem expedient. If the costs of finishing the Work exceed any unpaid compensation due the Contractor, the Contractor shall pay the difference to the Owner.
- 14.2 "If the continuation of this Agreement is contingent upon the appropriation of adequate state, or federal funds, this Agreement may be terminated on the date beginning on the first fiscal year for which funds are not appropriated or at the exhaustion of the appropriation. The Owner may terminate this Agreement by providing written notice to the parties of such non-appropriation. All payment obligations of the Owner will cease upon the date of termination. Notwithstanding the foregoing, the Owner agrees that it will use its best efforts to obtain approval of necessary funds to continue the Agreement by taking appropriate action to request adequate funds to continue the Agreement."

END OF GENERAL REQUIREMENTS

EMPLOYEE DRUG TESTING REPORT FORM

Period Ending: _____

4104 Regulations for the Drug Testing of Contractor and Subcontractor Employees Working on Large Public Works Projects requires that Contractors and Subcontractors who work on Large Public Works Contracts funded all or in part with public funds submit Testing Report Forms to the Owner no less than quarterly.

Project Number: _____

Project Name: _____

Contractor/Subcontractor Name: _____

Contractor/Subcontractor Address: _____

Number of employees who worked on the jobsite during the report period: _____

Number of employees subject to random testing during the report period: _____

Number of Negative Results _____ Number of Positive Results _____

Action taken on employee(s) in response to a failed or positive random test:

Authorized Representative of Contractor/Subcontractor: _____
(typed or printed)

Authorized Representative of Contractor/Subcontractor: _____
(signature)

Date: _____

**EMPLOYEE DRUG TESTING
REPORT OF POSITIVE RESULTS**

4104 Regulations for the Drug Testing of Contractor and Subcontractor Employees Working on Large Public Works Projects requires that Contractors and Subcontractors who work on Large Public Works Contracts funded all or in part with public funds to notify the Owner in writing of a positive random drug test.

Project Number: _____
Project Name: _____
Contractor/Subcontractor Name: _____
Contractor/Subcontractor Address: _____

Name of employee with positive test result: _____

Last 4 digits of employee SSN: _____

Date test results received: _____

Action taken on employee in response to a positive test result:

Authorized Representative of Contractor/Subcontractor: _____
(typed or printed)

Authorized Representative of Contractor/Subcontractor: _____
(signature)

Date: _____

This form shall be sent by mail to the Owner within 24 hours of receipt of test results.

Enclose this test results form in a sealed envelope with the notation "Drug Testing Form – DO NOT OPEN" on the face thereof and place in a separate mailing envelope.

STATE OF DELAWARE
DEPARTMENT OF LABOR
DIVISION OF INDUSTRIAL AFFAIRS
OFFICE OF LABOR LAW ENFORCEMENT
PHONE: (302) 451-3423

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NEWARK, DE 19702

Located at:
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PREVAILING WAGES FOR HEAVY CONSTRUCTION EFFECTIVE MARCH 15, 2017

CLASSIFICATION	NEW CASTLE	KENT	SUSSEX
ASBESTOS WORKERS	22.10	19.44	42.27
BOILERMAKERS	77.62	32.12	58.92
BRICKLAYERS	47.02	23.20	24.91
CARPENTERS	53.81	53.81	42.77
CEMENT FINISHERS	43.59	24.35	18.14
ELECTRICAL LINE WORKERS	73.65	28.24	64.65
ELECTRICIANS	66.85	66.85	66.85
GLAZIERS	20.42	17.73	12.00
INSULATORS	55.48	55.48	55.48
IRON WORKERS	60.95	60.95	58.31
LABORERS	44.70	44.70	44.70
MILLWRIGHTS	69.18	69.18	55.75
PAINTERS	79.76	79.76	79.76
PILEDRIVERS	75.27	39.35	30.63
PLASTERERS	19.23	16.70	11.29
PLUMBERS/PIPEFITTERS/STEAMFITTERS	82.03	77.84	17.89
POWER EQUIPMENT OPERATORS	67.29	62.96	67.29
SHEET METAL WORKERS	30.73	19.06	17.90
SPRINKLER FITTERS	33.11	12.54	10.38
TRUCK DRIVERS	31.96	20.62	22.27

CERTIFIED

03/24/2017

BY:

[Signature]
ADMINISTRATOR, OFFICE OF LABOR LAW ENFORCEMENT

NOTE: THESE RATES ARE PROMULGATED AND ENFORCED PURSUANT TO THE PREVAILING WAGE REGULATIONS ADOPTED BY THE DEPARTMENT OF LABOR ON APRIL 3, 1992.

CLASSIFICATIONS OF WORKERS ARE DETERMINED BY THE DEPARTMENT OF LABOR. FOR ASSISTANCE IN CLASSIFYING WORKERS, OR FOR A COPY OF THE REGULATIONS OR CLASSIFICATIONS, PHONE (302) 451-3423.

NON-REGISTERED APPRENTICES MUST BE PAID THE MECHANIC'S RATE.

PROJECT: NAT201701 Broad.Dune Broadkill Beach Dune Enhancements- Dune Grass Planting Sand Fencing and Post and Rail Fence, Sussex County

STATE OF DELAWARE
DEPARTMENT OF LABOR
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NEWARK, DE 19702

PREVAILING WAGES FOR HIGHWAY CONSTRUCTION EFFECTIVE MARCH 15, 2017

CLASSIFICATION	NEW CASTLE	KENT	SUSSEX
BRICKLAYERS	51.99	51.99	15.17
CARPENTERS	53.48	53.81	42.77
CEMENT FINISHERS	33.91	34.12	27.13
ELECTRICAL LINE WORKERS	23.52	45.39	22.22
ELECTRICIANS	66.85	66.85	66.85
IRON WORKERS	62.35	24.95	26.50
LABORERS	43.30	39.85	39.12
MILLWRIGHTS	16.84	16.34	14.11
PAINTERS	67.07	67.07	67.07
PILEDRIVERS	69.44	24.83	28.17
POWER EQUIPMENT OPERATORS	42.91	41.41	37.92
SHEET METAL WORKERS	23.79	21.23	19.23
TRUCK DRIVERS	35.73	29.51	35.95

CERTIFIED:

03/24/2017

BY:

[Signature]
ADMINISTRATOR, OFFICE OF LABOR LAW ENFORCEMENT

NOTE: THESE RATES ARE PROMULGATED AND ENFORCED PURSUANT TO THE PREVAILING WAGE REGULATIONS ADOPTED BY THE DEPARTMENT OF LABOR ON APRIL 3, 1992.

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NON-REGISTERED APPRENTICES MUST BE PAID THE MECHANIC'S RATE.

PROJECT: NAT201701 Broad.Dune Broadkill Beach Dune Enhancements- Pedestrian Crossover ADA Crossover and Vehicle Crossover, Sussex County

**TECHNICAL SPECIFICATIONS
FOR
LANG IMPOUNDMENT REHABILITATION PROJECT
CONTRACT #NAT201601**

**STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL (DNREC)
DIVISION OF FISH AND WILDLIFE**

Submitted by:

Gahagan & Bryant Associates, Inc.

9008 Yellow Brick Rd., Unit O

Baltimore, MD 21237

(410) 682-5595

Dennis C. Urso

DE PE No. 19938

March 2017



DE Engineering Certificate
of Authorization No. 637

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APPENDICES

A	Permits
B	Protective Coatings
C	Weir Gates Specifications
D	Concrete Repair Technical Guidelines

01 11 00 SUMMARY OF WORK

1.0 GENERAL

Administration and performance of the work shall be subject to the terms of the Contract Documents. Should it be discovered that information within these Technical Specifications conflicts with the terms or conditions within other sections of the Contract Documents, the Owner and Engineer shall be notified immediately. Additional and/or supplemental requirements shown herein shall not be considered as conflicting.

1.1 PROJECT DESCRIPTION

1.1.1 REHABILITATION OF DIKE AND REFURBISHMENT OF WATER CONTROL STRUCTURE

The existing Lang Impoundment dikes were constructed in the 1950's and are approximately 4,095 feet in length, with existing centerline elevations ranging from approximately 6' to 9' NAVD 88. The site is bounded by the Augustine Wildlife Area to the north, the Delaware River to the east, Rt. 9 To the west, and the town of Port Penn to the south.

The Lang Impoundment Rehabilitation Project consists of improvements to the existing Lang Impoundment perimeter dike from Station 0+00 to Sta. 40+95 as shown on the plans. Fill for construction will be provided from offsite borrow sources to be determined by the Contractor and approved by the Engineer. The base bid dike construction template will provide for a dike with a crown width of 20' and a crown elevation of 8.5' NAVD 88 from Sta. 0+00 to Sta. 25+00, transition to a crown elevation of 7.0' between Sta. 25+00 and Sta. 27+00, and a crown elevation of 7.0' between Sta. 27+00 and Sta. 40+50. From Sta. 40+50 to Sta. 40+95, the dike crown will transition to meet the existing Rte. 9 grade. Interior side slopes will be constructed on a 1V:3H angle. Exterior side slopes will be constructed on a 1V:2.5H angle to tie into existing grade where required. The base bid will also include installation of a cofferdam surrounding the water control structure on the Delaware River side and a dewatering system to provide for the inspection of the subaqueous elements of the structure, replacing the water control structure, installing chain link fence, and seeding and mulching all dike slopes as shown on the drawings for the Lang Impoundment.

Alternate pay items that may be awarded include:

- Alternate No. 1 - Raise the Crown elevation from 8.5' NAVD88 to 9.5' between Sta. 0+00 and Sta. 25+00, including precast concrete block walls, and additional seeding and mulching.
- Alternate No. 2 - Include a 14' wide, 8" thick layer of Crusher Run on the dike crown from Sta. 0+00 to Sta. 40+95.
- Alternate No. 3 - Refurbish the water control structure appurtenances including design and repairs to the existing concrete cap along the wing walls, potential repairs to the concrete base, and cleaning and application of a protective coating to the existing steel sheet pile wing walls.
- Alternate No. 4 – Provide additional riprap to repair and improve the existing slope protection along the exterior of the dike between approximate Sta. 6+00 and Sta. 14+00, adjacent to the Delaware River.

The work herein consists of furnishing all labor, materials, tools, equipment, plant, supplies, superintendence, insurance, incidentals, and other services necessary or required; and performing all excavation, transportation, and placement of materials, into the designated placement areas to the lines and grades shown on the Plans. The work also includes the procurement, transportation and installation of the water control structure as shown on the Plans.

1.2 TECHNICAL DEFINITIONS

Clearing: Clearing shall mean the removal and appropriate disposal of all above ground and below ground vegetation, debris, and other items existing in designated areas to be cleared.

Contractor: The term Contractor means the independent contractor which is named in the Contract agreement and is responsible for the work.

Demobilization: The term demobilization shall include the work in connection with demobilization of the plant utilized to perform work under the various bid items. The Contract price shall include transportation and other costs incidentals for the removal of the plant and equipment from the work sites, and final cleanup of the premises.

Dike: This term shall mean the earth fill portions of the existing dike structure, or the new dike structure, and all other fills within the limits of the dike system.

Dike Fill: Dike fill shall mean any material delivered to the site, and placed using mechanical means and methods including, but not limited to, drag lines, dozers, loaders, backhoes, dump trucks, or other machinery.

Engineer: The Engineer shall mean the engineer or engineers, or the firm, or firms, employed to provide professional engineering services. The Engineer is the Owner's Design Consultant, for matters concerning the work as defined in the Contract Documents.

Excavation: Excavation shall mean the removal of existing material to the lines and grades shown in the Plans and specified in the Technical Specifications herein.

Final Grade: Final grade shall mean the constructed lines and elevations, shown by cross sections, after completion of final shaping and grading.

Foundation Preparation: The term shall include all or a portion of the following: stripping, clearing, and grubbing of the site; scarifying, mixing, compaction, and excavation of unsatisfactory material.

Grubbing: Grubbing shall mean the removal and appropriate disposal of stumps, roots larger than 1 inch in diameter, and matted roots from the designated grubbing areas. Grubbing shall include the back filling of holes created from the removal of said materials.

Miscellaneous Equipment: Scarifiers, disks, motorized graders, spreaders, and other equipment shall be suitable for construction of dikes. Trucks, scrapers, and other types of earth-hauling equipment, if used, shall be suitable for construction. Matting, if used or required, shall be of sufficient size, quantity, and strength for the types of equipment that will work from or cross over the mats and for the types of foundation on which matting will be placed upon during the period of construction that the matting is used. Additional equipment used to grading and shaping of dikes, shall be of suitable horse-power, track configuration, tread pressure, blade size, bucket size, and other attachments where applicable, to accommodate the varying types of terrain and foundation conditions where work will be performed.

Mobilization: The term mobilization shall include the work in connection with mobilization of the plant, equipment, and personnel necessary to perform the work under various bid items. The Contract price will include transportation and other costs incidental to delivery of the plant and other equipment to the general work area in condition ready for operation.

Owner: The Owner is the State of Delaware, Department of Natural Resources and Environmental Control (DNREC), Division of Fish and Wildlife.

Permit: The term permit shall mean all permits obtained by the Owner, and shall include any other permits required for work, whether obtained by the Owner or the Contractor.

Plans: The Plans shall mean the drawings included as part of the contract documents.

Power-Driven Tampers: Compaction of material in areas where it is impracticable to use a crawler-type tractor shall be performed by the use of approved power-driven tampers of the rammer type having a static weight of at least 70 pounds or by approved hydraulic actuated tractor-mounted tampers.

Slope Protection (or Shore Protection): The terms slope protection and shore protection shall mean the placement of materials and construction of features as shown on the plans for the purposes of wave abatement and erosion control.

Stripping: The term stripping shall mean the removal and appropriate disposal of crops, weeds, grass, and other vegetative materials from the ground surface and/or topsoil.

1.3 SPECIAL SCHEDULING REQUIREMENTS

1.3.1 ORDER OF WORK

In general, and depending upon the options awarded, the order of work shall be performed as follows:

- (Base bid) - Installation of cofferdams and dewatering system, and inspection and evaluation of the Water Control Structure elements
- Alternate No. 3 (if awarded) - Design of water control structure repairs and refurbishment of structure
- (Base bid) - Rehabilitation of Dike at Lang Impoundment, including Alternate No. 1 and Alternate No. 2 (if awarded)
- Alternate No. 4 (if awarded) – Riprap replacement and repair

Construction work may commence on dike simultaneously with water control structure activities. Construction shall be continuous from start to finish with no appreciable shut down periods.

1.4 PERMITS

The Contractor shall comply with all applicable permits and/or other obligations required by law. Permits obtained by the Owner are included in Appendix A.

1.4.1 PERMIT COMPLIANCE

The Contractor shall comply with all local, Federal, State and municipal laws, rules regulations, and ordinances applicable to the work of this Contract, and shall obtain and/or pay for any other permits required in connection with the execution of the work and not furnished in the Contract Documents.

1.4.2 PERMIT PRECEDENCE WITH OTHER CONTRACT DOCUMENTS

The Contractor shall comply with all provisions contained in the permits. Where dimensions or configurations conflict between the Contract Documents and the permit drawings, the dimensions or configurations shown on the Contract Documents shall govern. If as defined in the permits, any laws, rules, regulations or ordinances conflict with the Contract Documents, then such laws, rules, regulations, or ordinances shall govern instead of the Contract Documents, except in such cases where the Contract Documents exceed them in quality of materials or labor, then the Contract Documents shall be followed. Any conflicts between the permit and the Contract Documents shall be immediately brought to the attention of the Engineer prior to the commencement of work. It shall be expressly understood that the Owner and Engineer shall not be responsible for such conflicts.

1.4.3 CONTRACTOR OBTAINED PERMITS

Any necessary permits not provided by the Owner shall be the responsibility of the Contractor. The Contractor shall make application for and pay for any necessary permit fees, temporary or permanent utility interruption(s) and/or re-location fees, transportation, and temporary staging areas.

1.5 WORK ACCORDANCE

All work shall be accomplished in accordance with the Contract Documents, including these Technical Specifications, the Plans, appendices, and other parts of the Contract Documents, including any addenda. Any changes made to the Technical Specifications or appendices therein, or variances in construction from the work defined in the Contract Documents, without written authorization by the Engineer, shall become the express responsibility of the Contractor at its own risk and cost.

1.6 LOCAL CONDITIONS AND SITE PHYSICAL DATA

Information furnished is for the Contractor's review. However, it is expressly understood that the Engineer is not responsible for any interpretation or conclusion drawn by the Contractor. The Owner and Engineer are also not responsible for any lack of information herein pertaining to physical conditions at the site. Likewise, the Owner and Engineer will not be responsible for any information provided to the Contractor by any information agency or other party other than the Engineer. The Contractor shall make every effort possible to familiarize itself with and research the conditions to be expected at the site.

1.6.1 SUBSURFACE MATERIAL AND GENERAL SITE CONDITIONS

The Contractor is expected to examine the Technical Specifications, Plans, and the site, and after investigation, decide for itself the character, quality, and quantity of any material to be removed; and the characteristics, whether surface, subsurface, or otherwise, at the dike and water control structure locations. The Contractor is expressly encouraged to perform its own investigations to determine the character of materials and satisfy itself as to the means and methods required to perform the work herein specified. In particular, the Contractor shall evaluate the soft foundation conditions within the dike construction footprint (especially between Sta. 1+00 to 17+00) in regards to heavy equipment utilization, access and dump truck routing. Matting or other means of providing firm support for heavy equipment shall be the responsibility of the Contractor. The Engineer must be immediately notified of any site conditions that may affect the performance of the work.

1.6.2 DEBRIS

Other materials including but not limited to scrap rope, wire cable, scrap metal, anchors, anchor chains, timbers, snags, stumps, metal, buoys, buoy anchors, timbers, or other rubbish or other obstructive materials encountered during construction activities shall be disposed of in accordance with any and all applicable Federal, State, or local requirements. No separate payment will be made for removal and disposal of debris.

1.6.3 GROUNDWATER

Subsurface groundwater conditions and elevations may change. Changes in groundwater elevations shall not be just cause for increased compensation.

1.6.4 WEATHER CONDITIONS

The site may be affected by tropical storms and hurricanes primarily from June through November, and by stormy and/or rainy weather, including severe thunderstorms, during any time of the year. The Contractor shall be responsible for obtaining information concerning rain, wind, and water level conditions that could influence safety and work operations. A list of publications containing climatological and meteorological observations and data for the site is provided below. Other publications or information sources are available in addition to the following:

- Monthly climate summary provided by the National Oceanic and Atmospheric Administration (NOAA);
- National Weather Service Forecast Office.

1.7 PRESERVATION OF PUBLIC AND PRIVATE PROPERTY

Fences, roads, signs, ditches, private or public grounds, and other structures or improvements damaged as a result of the Contractor's operations shall be repaired or replaced by the Contractor at its expense. The areas used by the Contractor shall be restored to the same or better condition as existed prior to commencement of the work. All damages by or as a result of the Contractor's operations, either to surface or sub-surface structures, shall be repaired or replaced by the Contractor at its own expense.

1.8 UTILITY LOCATIONS

Locations of underground utilities have not been field verified. The Contractor is notified that uncharted utilities and/or obstructions may be present within the site. Prior to commencement of work, the Contractor shall verify in the field the location of any known, unknown, or suspected underground utilities or other obstructions to the satisfaction of the Contractor. The Contractor shall investigate existing conditions and satisfy itself as to the existence of additional construction which may interfere with work described herein.

THE CONTRACTOR SHALL CALL "MISS UTILITY OF DELMARVA" @ (811) OR @ 1-800-282-8555 A MINIMUM OF 2 DAYS AND A MAXIMUM OF 5 DAYS PRIOR TO THE COMMENCEMENT OF ANY EXCAVATION (DIGGING, DREDGING, JETTING, ETC.) OR ANY DEMOLITION ACTIVITY IN ACCORDANCE WITH DELAWARE CODE (TITLE 26, CHAPTER 8). THE PROTECTION OF UTILITIES SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR.

The Engineer assumes no responsibility for failure to show any or all these structures on the Plans or to show them in their exact location. Failure to show will not be considered sufficient basis for claims for additional compensation for extra work in any manner whatsoever, unless the obstruction encountered is such as to necessitate substantial changes in the lines or grades, or requires the building of special work for which no provision is made. It is assumed that the Contractor has thoroughly inspected the site, is informed as to the correct location of surface and subsurface structures, and has considered and allowed for all foreseeable incidental work due to variable subsurface conditions, whether such conditions and such work are fully and properly described in the Contract Documents or not. Minor changes and variations of the work specified and shown on the drawings shall be expected by the Contractor and allowed for as incidental to the satisfactory completion of a whole and functioning work or improvement.

1.8.1 PROTECTION OF EXISTING UTILITIES AND SUBSURFACE STRUCTURES

Existing utilities that are shown or the locations of which are made known to the Contractor prior to excavation or fill placement and that are to be retained, as well as utilities encountered during excavation operations or transportation of materials, shall be protected from damage during construction and, if damaged, shall be repaired at the expense of the Contractor. The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Excavation made with power-driven equipment is not permitted within two feet of known utilities or subsurface structures. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Engineer. Report damage to any utilities or subsurface structures immediately to the Engineer. In the event that the Contractor damages existing utilities that are not shown or the locations of which are not known to the Contractor, report of this damage shall be made immediately MISS UTILITY OF DELMARVA (811) and the Owner. If it is determined that repairs shall be required, these repairs will be ordered in accordance with provisions of the Contract Documents.

1.9 UNAUTHORIZED PLACEMENT OF MATERIAL

1.9.1 MISPLACED MATERIAL

Excavated material that is deposited elsewhere than in places designated or approved will not be paid for, and the Contractor may be required to remove the misplaced excavated material and deposit it where directed by the Engineer at no cost to the Owner.

1.9.2 DEBRIS DISPOSAL

During the progress of the work, the Contractor shall not deposit pipe, wire rope, scrap metal, timbers, or other rubbish or obstructive material into the dike construction areas. This material, together with scrap, rope, wire cable, pipe, or other obstructive material which may be encountered during excavation or fill operations, shall be disposed of by the Contractor at locations in accordance with any and all applicable Federal, State, or local requirements.

1.10 USE OF OWNER PREMISES AND WORK AREA CONDITIONS

1.10.1 CONTRACTOR FACILITIES

The Contractor's field offices, staging areas, stockpile storage, and temporary buildings shall be placed in areas approved by the Owner. Temporary movement or relocation of Contractor facilities shall be made only on approval by the Owner. The Contractor shall fuel and lubricate equipment in a manner that protects against spills and evaporation, and the Contractor shall provide a berm or suitable secondary containment basin around fuel and liquid chemical storage tanks to contain the tank contents in the event of a leak or spill.

1.10.2 SANITARY FACILITIES

Sanitary sewage services will not be furnished by the Owner. The Contractor shall provide and maintain in neat, sanitary condition toilets and other necessary accommodations for employees' use to comply with the regulations of the State Department of Health or other jurisdictions.

1.10.3 SITE MAINTENANCE

Trash or debris shall not be allowed to accumulate on the site. The Contractor shall clean the entire area of any litter resulting from the Contractor's operations on a daily basis. The Contractor shall maintain the premises as clean and presentable, as good construction practices will allow, at all times.

1.10.4 EXCLUSION OF THE PUBLIC

The Contractor will be permitted to exclude the public from the work areas in the immediate vicinity of its excavation, transporting, and placement operations. Enforcement shall be the Contractor's responsibility at no additional cost to the Owner. Should enforcement be required, it shall be - coordinated with local enforcement agencies, and notification shall be provided to the Owner in the event of such occurrence.

1.11 FIRE PROTECTION

The Contractor shall take stringent precautions against fire. Open fires are not allowed unless approved in writing by the Owner.

1.12 ACCESS AND STAGING

The Owner will provide staging areas for the Contractor's use for the duration of the contract as shown on the plans. The construction entrances shall be stabilized in accordance with DeIDOT Standard Specifications for Road and Bridge Construction Section 268. The Contractor shall be responsible for maintaining staging and access necessary for its equipment and plant to and from the site. The Contractor shall ascertain the environmental conditions that can affect the access such as climate, winds and existing dike conditions. The Contractor shall provide hay bales, straw material and watering as necessary to minimize dust and sediments from leaving the site. The Contractor shall be responsible for providing access to the site for their employees as well as the Owner and/or the Engineer and other Owner authorized representative(s) when requested, to include daily inspection of the sites, at no additional cost to the Owner. No separate payment shall be made for site access or staging areas.

1.13 PROTECTION OF EXISTING WATERWAYS

The Contractor shall conduct its operations in such a manner that material or other debris are not deposited in the river or other areas adjacent to the site. Should the Contractor, during the progress of the construction, lose, dump, throw overboard, sink, or misplace any material, plant, machinery or appliance, the Contractor shall recover and remove the same with the utmost dispatch. The Contractor shall give immediate notice to the Owner, with description and location of such obstructions, until the same are removed. Should the Contractor refuse, neglect, or delay compliance with the above requirements, such obstructions may be removed by the Owner, and the cost of such removal may be deducted from any money due or to become due to the Contractor, or may be recovered under its bond.

1.14 ADJACENT PROPERTY AND STRUCTURES

The Contractor is notified that construction will occur adjacent to active facilities, private property, and environmentally sensitive areas. The Contractor is hereby notified that adverse working conditions may exist, and the necessary allowances and precautions shall be made to avoid damaging public and private property and sensitive vegetation. The Contractor shall take extreme care when working adjacent to structures. Any damage to structures as a result of the Contractor's negligence will result in suspension of construction activities and require prompt repair at the Contractor's expense prior to continuation of work. Unauthorized damage to any existing utilities, building facilities, structures, or plant life shall be repaired by the Contractor at no expense to the Owner.

1.15 PROGRESS MEETINGS AND MINUTES

The Contractor shall attend a weekly progress meeting with the Owner or Owner's representative at the site or an appropriate meeting place set forth by the Owner to discuss the Schedule of work, construction problems, coordination issues, or other topics that may be of mutual interest. The Contractor shall provide minutes of all weekly meetings to the Engineer within 48 hours of the meeting.

1.16 QUALITY CONTROL INSPECTIONS

The Contractor shall conduct daily quality control inspections of the construction activities for compliance with the Contract requirements and record the information as specified herein. A copy of the records of quality control inspections, as well as corrective action taken, shall be filed daily and submitted as directed. The daily quality control reports shall be submitted on an approved daily quality control report form.

The Contractor shall inspect for compliance with Contract requirements and record the inspection of operations including, but not limited to the items specified within this Section. A copy of the records of the compliance inspections, tests, and corrective action taken shall be submitted with the daily quality control report.

END OF SECTION

01 20 00 PRICE AND PAYMENT PROCEDURES

The following sections encompass the bid items required for the work covered by the Contract price.

1.0 MEASUREMENT AND PAYMENT

1.1 MOBILIZATION AND DEMOBILIZATION

1.1.1 GENERAL

The Contract fixed price for mobilization will include the costs in connection with mobilization of the equipment necessary to perform work under the various bid items. The Contract price will include transportation and other costs incidental to delivery of the equipment to the general work area in condition ready for operation.

Demobilization shall include the costs in connection with demobilization of the equipment utilized to perform work under the various bid items. The Contractor price shall include transportation and other costs incidental to removal of the equipment from the work sites.

The Owner may require the Contractor to furnish cost data to justify this portion of the bid if the Owner believes that the Contractor's bid for this item does not bear a reasonable relationship to the cost of the work in this Contract. Failure to justify such price to the satisfaction of the Owner will result in payment, as determined by the Owner, and the cost as determined by the Owner will not be subject to appeal.

1.1.2 MEASUREMENT

This item shall not be measured for payment.

1.1.3 PAYMENT

Payment for mobilization and demobilization shall be made at the contract lump sum price for this item as follows:

- Sixty percent of the lump sum price upon completion of the Contractor's mobilization at the work site.
- The remaining 40 percent upon completion of demobilization.

1.2 DIKE CONSTRUCTION

1.2.1 GENERAL

Dike fill material shall be furnished by the Contractor and subject to the approval of the Owner in accordance with Section 6 of the Technical Specifications. The contract unit price for Dike Construction shall include the costs for sampling and testing of material for moisture content, compaction, and gradation; associated cost with staging and storage areas; project site preparation, cleanup, and disposal; purchasing, furnishing, and transporting the fill material to the project site; dewatering surface of impoundment basin, foundation preparation, silt fence installation, placing fill, compacting, shaping, and grading of material and labor and equipment required to complete the

Work as specified in Section 6 of the Technical Specifications.

1.2.2 MEASUREMENT

The method of determining fill material weight when transportation of fill material is from the borrow source directly to the project site using trucks shall be conducted using the Truck Weight Ticket Method. Dike fill material shall be measured in short tons of 2,000 pounds each. Truck weight tickets from a certified scale will be accepted for determination of the weight of fill placed in the dike alignment template. Determination of tonnage will be by actual weight as determined by certified weigh bills or carrier displacement and adjusted by the Owner for the moisture content of the fill material as described in paragraph 3.2.2.2 of this specification. To determine the load, measurements will be taken before each truck is loaded and directly after it is loaded with acceptable dike fill material. Measurement specifications for dike fill material only provide the process for measuring the hauled fill for pay purposes and are not a representation of accessibility of the site.

1.2.2.1 Truck Weight Ticket Method

Trucks shall be weighed with public weight master certified weigh bills provided by the Contractor at the job site. A weighing record shall accompany each delivery. The weighing record shall indicate the name of the shipper, date, trailer, number, material weighed, gross, tare and net weights. The weigher shall sign each weight record. The weight delivery ticket and weigh records will be submitted to the Engineer at the placement site prior to unloading. The Engineer reserves the right to reject delivery if any required information is missing or incomplete from the delivery tickets. Other methods of establishing weights, if used for determination of weights for payment purposes, shall be subject to the approval of the Engineer. Weigh bills and the scales used for weighing of trucks and material contained therein shall, unless otherwise approved by the Engineer, conform to the requirements set forth in the following paragraphs:

Scales shall conform to the requirements of the U.S. Department of Commerce National Bureau of Standards Handbook H-44. The tolerance applications of the Handbook, as application to under-registration and over- registration and to tests involving digital indications or representations, shall apply. A scale shall not be used for weighing a load totaling more than the natural capacity marked on the scale by the manufacturer. Any portion of the load in excess of the nominal scale capacity will not be considered for payment.

The accuracy of the scale will be checked. When a state scale inspector is not immediately available for checking the scale, the Contractor may, at his own expense, secure a check from the local official sealer of weights and measures. The Engineer may give tentative approval based on check truckloads weighed on other scales that bear an official seal placed in the current calendar year.

The total weight of a single highway vehicle shall be weighed as a single draft and shall not be determined by adding together the results obtained by separately weighing each end of such vehicle except that weighing of a coupled combination may be determined with uncoupling under the following conditions:

- The brakes are released;
- There is no tension or compression of the drawbar;
- The approaches are straight and in the same level plane as the scale platform;

- The approaches are paved at least fifty (50) feet in each direction with a seal coat or high type surfacing;
- The approaches are of sufficient width and length to endure level positioning of vehicles during the weighing operations.

Print-Out Weigh Tickets: When a print-out system is employed on a platform or surge bin scale, it shall be equipped with a printer which shall print out the following information on a triplicate ticket for each truckload. The system shall be so interlocked as to allow printing only when the scale has come to a complete rest.

- Time;
- Date;
- Sequential ticket number (may be pre-printed on ticket);
- Material weighed;
- Gross weight;
- Tare weight (truck shall be tare weighted at least twice daily);
- Net weight;
- Truck identification number (or license plate number).

Weigh Bills: For scales not equipped with a printout system, weigh bills shall contain the same or equivalent data as specified for the printout system. Weigh bills, including printouts, shall be certified by the signature of the scale operator. The scale operator shall attest that the information shown on the weigh bill and the weight(s) observed on the scale at the time the weigh bill was signed are correct. Each truck shall be plainly marked by a distinctive number, letter, or name, which shall not be changed or given to any other truck during the Contract Period. The Owner reserves the right to periodically inspect the weighing operations at the scales.

Verification of Weights: The Owner reserves the right to have loaded and unloaded trucks re-weighed at another certified weigh scale, at no additional expense to the Owner.

1.2.2.2 Adjustment for Moisture Content

The weights of the Dike Fill material delivered and placed at the project site will be adjusted for moisture content. Moisture content shall be determined in the laboratory in accordance with ASTM D2216. All moisture content testing shall be by the Contractor's hired independent laboratory and the test results shall be reported to the Owner at the time they become available to the Contractor. The Contractor shall take a representative sample of the Dike Fill material in the delivered material for laboratory determination of moisture content. The moisture contents determined by each test will be averaged separately for each source and for each day's deliveries. The total dry weight tons of dike fill material delivered each day, from each source, will be determined in accordance with the formula below, using the average moisture content for each day's deliveries from each source.

$$\text{Total dry weight tons} = \frac{TW}{2,000 \text{ lbs.} * [1 + (\frac{\% \text{ Moisture}}{100})]}$$

Total dry weight tons calculated for each day's deliveries from each respective source.

TW = Total weight of material delivered from each respective source for the day, in pounds (Dike Fill material plus moisture)

2,000 lb. = one (1) ton

% Moisture = Average moisture content for each respective source, and each day's delivered material

1.2.3 PAYMENT

Payment for Dike Construction will be made at the Contract unit price per dry ton (dry-weight).

The quantity of material computed to have been misplaced outside of specified lines and grades, lost during offloading, and lost during re-handing processes will be deducted from the total volume of material delivered to the project site for payment.

1.3 REFURBISHMENT OF WATER CONTROL STRUCTURE

1.3.1 GENERAL

The Contract price per unit for the water control structure will include design, specifications, installation and operation of dewatering measures (such as cofferdams, pumping system, etc.), removal and disposal of the existing structure components, concrete base repair, concrete weir wall construction, wing wall concrete cap removal and replacement, structure concrete cap repair, wing wall concrete cap repair, painting of both steel sheet pile wing walls, installation of the new structure components, and removal of the cofferdams and dewatering system, as specified in Section 1.5 of the Technical Specifications.

1.3.2 MEASUREMENT

Refurbishment of the Water Control Structure shall be measured for payment at the Contract unit price (Lump Sum).

1.3.3 PAYMENT

Payment shall be made at the Contract unit price.

1.4 RIPRAP SLOPE PROTECTION

1.4.1 GENERAL

Installation of slope protection including stone (riprap) will be required as shown on the Plans. Stone shall be furnished by the Contractor and subject to the approval of the owner in accordance with Section 31 35 00 of the Technical Specifications. The unit price shall include delivery and placement of the stone slope protection; slope preparation required for the placement of stone; delivery and installation of geotextile material; stone relocation; all costs applicable for pre-placement activities; gradation and laboratory testing; associated cost with staging and storage areas; project site preparation, cleanup, and disposal; purchasing, furnishing, transporting material to the project site; and labor and equipment required to complete the work as specified herein and shown on the Plans.

1.4.2 MEASUREMENT

Stone required to complete the slope protection as shown shall be measured by the short ton (dry ton) or 2,000 pounds for payment by the Truck Weight Ticket Method. Measurement for payment of the stone work as specified in this Section will be based on the number of tons, placed within the lines and grades shown on the Plans and as specified, herein. Stone acceptably delivered and placed to the specified lines and grades as indicated on the Plans by Contractor will be measured for acceptance. Determination of tonnage of stone will be by actual weight as determined by certified weigh bills.

Where a loss of material due to removing, stockpiling, relocating, re-installing or hauling is possible, the Engineer shall have the discretion to require re-measurement prior to placement. Each truck load shall only be comprised of one type of stone gradation.

1.4.2.1 Truck Weight Ticket Method

Method of determining stone material weight when transportation of stone material is from the rock quarry directly to the project site using trucks shall be conducted using Truck Weight Ticket Method. Trucks shall transport only one material type. Combined truck shipments are prohibited.

Stone shall be measured in short tons of 2,000 pounds each. Truck weight tickets from a certified scale will be accepted for determination of the weight of stone placed in the finished section. To determine the load, measurements will be taken before each truck is loaded and directly after it is loaded with acceptable stone.

Trucks shall be weighed with public weight master certified weigh bills provided by the Contractor at the job site. A weighing record shall accompany each delivery. The weighing record shall indicate the name of the shipper, date, trailer, number, material weighed, gross, tare and net weights. The weigher shall sign each weight record. The weight delivery ticket and weigh records will be submitted to the Engineer at the placement site prior to unloading. The Engineer reserves the right to reject delivery if any required information is missing or incomplete from the delivery tickets. Other methods of establishing weights, if used for determination of weights for payment purposes, shall be subject to the approval of the Engineer. Weigh bills and the scales used for weighing of trucks and material contained therein shall, unless otherwise approved by the Engineer, conform to the requirements set forth in the following paragraphs:

Scales shall conform to the requirements of the U.S. Department of Commerce National Bureau of Standards Handbook H-44. The tolerance applications of the Handbook, as application to under-registration and over-registration and to tests involving digital indications or representations, shall apply. A scale shall not be used for weighing a load totaling more than the natural capacity marked on the scale by the manufacturer. Any portion of the load in excess of the nominal scale capacity will not be considered for payment.

The accuracy of the scale will be checked. When a state scale inspector is not immediately available for checking the scale, the Contractor may, at his own expense, secure a check from the local official sealer of weights and measures. The Engineer may give tentative approval based on check truckloads weighed on other scales that bear an official seal placed in the current calendar year.

The total weight of a single highway vehicle shall be weighed as a single draft and shall not be determined by adding together the results obtained by separately weighing each end of such

vehicle except that weighing of a coupled combination may be determined with uncoupling under the following conditions:

- The brakes are released;
- There is no tension or compression of the drawbar;
- The approaches are straight and in the same level plane as the scale platform;
- The approaches are paved at least fifty (50) feet in each direction with a seal coat or high type surfacing;
- The approaches are of sufficient width and length to endure level positioning of vehicles during the weighing operations.
- Print-Out Weigh Tickets: When a print-out system is employed on a platform or surge bin scale, it shall be equipped with a printer which shall print out the following information on a triplicate ticket for each truckload. The system shall be so interlocked as to allow printing only when the scale has come to a complete rest.
 - Time;
 - Date;
 - Sequential ticket number (may be pre-printed on ticket);
 - Material weighed;
 - Gross weight;
 - Tare weight (truck shall be tare weighted at least twice daily);
 - Net weight;
 - Truck identification number (or license plate number).

Weigh Bills: For scales not equipped with a printout system, weigh bills shall contain the same or equivalent data as specified for the printout system. Weigh bills, including printouts, shall be certified by the signature of the scale operator. The scale operator shall attest that the information shown on the weigh bill and the weight(s) observed on the scale at the time the weigh bill was signed are correct. Each truck shall be plainly marked by a distinctive number, letter, or name, which shall not be changed or given to any other truck during the Contract Period. The Owner reserves the right to periodically inspect the weighing operations at the scales.

Verification of Weights: The Owner reserves the right to have loaded and unloaded trucks re-weighed at another certified weigh scale, at no additional expense to the Owner.

1.4.3 PAYMENT

Payment shall be made at the Contract unit price per dry ton.

The quantity of material computed to have been misplaced outside of specified lines and grades, lost during offloading, and lost during re-handing processes will be deducted from the total volume of material delivered to the project site for payment.

1.5 SEEDING AND MULCHING

1.5.1 GENERAL

Seeding and Mulching shall be completed for the dike slopes as shown on the plans, including placement of 4" topsoil, seeding, mulching, fertilizing, and watering as needed to establish the grass; and all materials, labor and equipment required to complete the work as specified herein.

1.5.2 MEASUREMENT

Seeding and Mulching shall be measured for payment at the Contract unit price per square yard of seeded dike slope.

1.5.3 PAYMENT

Payment shall be made at the Contract unit price per square foot.

1.6 CRUSHER RUN

1.6.1 GENERAL

An 8" layer of Crusher Run shall be completed for the dike crown as shown on the plans, including all materials, labor and equipment required to complete the work as specified herein.

1.6.2 MEASUREMENT

Crusher Run shall be measured for payment at the Contract unit price per dry ton of Crusher Run placed on the dike crown.

1.6.3 PAYMENT

Payment shall be made at the Contract unit price per ton.

END OF SECTION

01 32 00 CONSTRUCTION PROGRESS DOCUMENTATION

1.0 SUBMITTALS AND GENERAL REQUIREMENTS

1.1 GENERAL

The Contractor is responsible for providing all Contractor required submittals outlined in the Contract Documents and additional submittals requested by the Engineer. The submittals listed herein are additional to other submittals required within the Contract Documents. The Engineer may request submittals in addition to those specified when deemed necessary to adequately describe the work covered in the respective Sections. Units of weights and measures used on all submittals are to be the same as those used in the Contract Documents. Each submittal is to be complete and in sufficient detail to allow ready determination of compliance with Contract requirements.

1.2 SUBMITTAL PROCEDURES

All submittals shall be transmitted to the Engineer in accordance with the following:

- All submittals required for each item shall be transmitted to the Engineer in electronic format. Handwritten logs, reports and checklists can be scanned and submitted in .pdf format;
- The Engineer will review the submittal data and notify the Contractor who shall then make any necessary revisions to the report prior to re-submission. The Contractor must keep one copy at the site at all times.

1.3 SUBMITTALS AFTER AWARD

The items listed below are required within twenty (20) days of Contract award and shall be submitted to the Engineer.

1.3.1 SCHEDULE OF VALUES

Submit no later than twenty (20) days within award of the Contract a schedule of values (Contract price breakdown, itemizing material and labor for each classification of work. The schedules of values shall be in accordance with the Contract Documents.

1.3.2 PLAN

Submit no later than twenty (20) days within award of the Contract a safety plan. The safety plan shall be consistent with the requirements of the General Conditions. The plan shall additionally be in conformance with the following unless otherwise specified:

- OSHA Safety and Health Standards 29 CFR 1910 (General Industry), US Department of Labor, Occupational Safety and Health Administration. Hereafter referred to as "29 CFR 1910". Available by calling (513)533-8236;
- OSHA 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response, Interim Final Rule, U.S. Department of Labor, Occupational Safety and Health Administration, December 1986. Hereafter referred to as "29 CFR 1910.120";
- OSHA Safety and Health Standards 29 CFR 1926 (Construction Industry), US Department of Labor, Occupational Safety and Health Administration, 1985. Hereafter referred to as "29 CFR

1926”;

1.3.3 QUALITY CONTROL PLAN

Submit no later than twenty (20) days within award of the Contract a quality control plan to ensure the work complies with the Contract Documents. Include, as a minimum, the following to cover all operations, both onsite and offsite, including work by subcontractors, fabricators, suppliers, and purchasing agents, designers of record, consultants, architect/engineers (AE), fabricators, suppliers, and purchasing agents:

- A description of the quality control organization, including a chart showing lines of authority and acknowledgment;
- The names, responsibilities, and authorities of each person on the quality control organization chart;
- Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors.

1.3.3.1 Quality Control Daily Report Form

A quality control daily report form, containing blanks for required information shall be developed by the Contractor for use during this Contract. A copy of the daily quality control report form shall be submitted with the quality control plan, no later than twenty (20) days within award of the Contract, for approval.

1.3.3.2 Work Plan and Schedule

For the work plan and schedule of work, the Contractor shall include its means and methods for performing all work. The plan shall detail the proposed means and methods the Contractor will use to meet the minimum requirements of the work, while complying with these Technical Specifications. The Contractor shall evaluate the physical conditions of the existing dike and adjacent areas within the dike construction footprint towards developing the work plan, including consideration of the soft foundation conditions.

The work plan shall include, but not necessarily be limited to, the following:

- A work schedule outlining all start and completion dates for major construction activities;
- A complete list of plant and equipment, with accompanying specification information to be used for the work at each dike to be constructed;
- Means and methods for stripping, clearing, and grubbing existing dikes within the new dike construction limits and other activities required for foundation preparation;
- Material source(s) and methodology to be used for construction of dikes, including dump truck and heavy equipment routing within the site;
- Means and methods for removal and disposal of the existing water control structure components;
- Means and methods for installation of the new water control structure components;
- Estimated start and completion dates for construction of the dike;
- A description of the proposed execution of required monitoring of the mechanical fill placement and compaction to ensure compliance with specifications.

1.3.4 SLOPE PROTECTION SUBMITTALS

For the work plan and schedule of work, the Contractor shall submit the following for review:

1.3.4.1 Stone Work and Plan Schedule

The Contractor shall submit a stone work plan and schedule that describes the equipment, stockpiling, loading and unloading, transportation, placement methods, and sequences planned to be used in stone placement. This plan shall also include quality control procedures and a list of the major pieces of equipment that are to be used for performing the stone work. This plan and schedule shall be submitted for review prior to shipment of the stone. The Contractor shall not commence stone work until the plan has been reviewed and approved by the Engineer. This information may be combined with the Work Plan and Schedule, above, or may be provided separately.

1.3.4.2 Stone Quality

Before stone is produced from a source for completion of the work under this contract, the source of stone shall be approved. Stone source documentation including certificates that demonstrate compliance with the stone quality and gradation shall be submitted a minimum of twenty (20) days before the stone is required in the work. Approval of a stone source shall not be construed as a waiver of the right of the Owner to require the Contractor to furnish stone that complies as specified herein.

1.3.4.3 Geotextiles Submittals

For the work plan and schedule of work, the Contractor shall submit its means and methods for installing geotextile fabric and shall submit at least two geotextile pins, 3-foot by 3-foot geotextile fabric samples, and a certificate of compliance for the geotextile attesting that the geotextile meets the chemical, physical, and manufacturing requirements specified herein. Engineer approval is required for all submittals.

1.3.5 ENVIRONMENTAL PROTECTION PLAN

Seven (7) calendar days prior to the preconstruction conference, the Contractor shall submit in writing an environmental protection plan conforming to the requirements of the Contract documents including these Technical Specifications. Approval of the Contractor's plans will not relieve the Contractor of its responsibility for adequate and continuing control of pollutants and other environmental protection measures. The environmental protection plans shall include, but not be limited to, the following:

- Methods for protection of features to be preserved within authorized work areas. The Contractor shall prepare a listing of methods to protect resources needing protection (i.e., trees, shrubs, vines, grasses and ground cover, landscape features, air and water quality, fish and wildlife, soil, historic, archeological, and cultural resources);
- Procedures to be implemented to provide the required environmental protection and to comply with the applicable laws and regulations. The Contractor shall provide written assurance that immediate corrective action will be taken to prevent pollution of the environment due to accident, natural causes, or failure to follow the procedures set out in accordance with the environmental protection plan;

- Drawings showing locations of any proposed temporary excavations or embankments for haul roads, stream crossing, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials;
- Methods of protecting surface and ground water during construction activities;
- Descriptions of the methods and measures for the prevention of oil spills (i.e., ground cover, containment, absorbent, etc.);
- Work area plans showing the proposed activity in each portion of the area and identifying the areas of limited use or nonuse. The plan should include measures for marking the limit.
- The environmental protection plans shall also address specific measures and information requested to be submitted in Technical Specifications Section 5. The Contractor shall train its personnel in the elements of the environmental protection plans.

1.4 SUBMITTALS DURING CONSTRUCTION

1.4.1 DAILY QUALITY CONTROL REPORTS

The Contractor shall supply daily quality control reports to document construction progress and ensure compliance with Contract Documents for each project under this Contract. The daily quality control reports shall start on the first day of mobilization and end on the last day of demobilization, and shall be furnished to the Engineer by 2:00 PM the following day. The daily quality control report shall be filled out every day, regardless of whether any portion of the work is accomplished and regardless of whether requested by the Engineer.

All compliance and quality control inspections will be recorded on the daily quality control reports including, but not limited to, the specific items required in each technical section of the Contract Documents. Daily quality control reports shall include a description of the work completed each day including, but not limited to, the operating hours of equipment and personnel, estimated quantity of material excavated and placed, surveys conducted, water quality tests conducted, shoreline protection installation progress, stone tests, weather observed, times and reasons for work stoppages and/or delays, any problems in compliance with permit or other laws, corrective actions taken, and personnel and visitors on site. Failure to provide daily quality control reports to the Engineer shall result in delay of payments to the Contractor until the daily quality control reports are received.

1.4.1.1 Report of Environmental Issues

The Contractor shall submit, as specified, logs and final summary report of sightings and incidents with endangered species and other environmental issues. Environmental issues shall be submitted with the daily quality control report.

1.4.1.2 Material Transportation and Disposal Fees

Logs or records, including receipts or tickets, for material transportation, disposal fees, and the like shall be provided.

1.4.1.3 Weigh Bills

Certified weigh bills shall be provided to the Engineer at the time the weighted material is delivered. Certified weigh bills for each load of dike fill material or riprap for slope protection delivered to the project site shall include certification of weight, the time of weighing, time of

delivery, and serial number and description of delivery truck.

1.4.1.4 Fill Material Shipment Log Sheets

On the work day following fill material shipment, the Contractor shall submit a copy of the log of all shipments from the Dike Fill or Riprap stone material source(s). The log sheets shall include information regarding placement or stockpiling of the shipments, what shipments were sampled, quantities of fill material shipped, and copies of weigh bills. The Daily Log sheet and its format shall be approved by the Owner prior to the shipment of any Dike Fill material.

1.4.1.5 Water Control Structure Certifications

Upon delivery of water control structure components, including concrete and steel materials, certified copies of test reports demonstrating conformance to applicable specifications (Technical Specifications Section 35 00 80) shall be submitted to the Owner for approval before the water control structure is refurbished.

1.5 POST CONSTRUCTION SUBMITTALS AND NOTICES

1.5.1 RECORD DRAWINGS

The Contractor shall maintain, on a separate set of the Plans, a record of all changes made during construction. The Contractor shall be responsible for keeping these records and neatly noting with colored pencil or ink all changes. These "Record Drawings" shall be turned over to the Engineer at the completion of the project. Final payment will not be made until "Record Drawings" have been received and accepted by the Engineer.

1.5.2 FINAL SUBMITTALS

At the time of Contractor's request for final acceptance, the Contractor shall provide to the Engineer the following material, which the Contractor shall have accumulated and retained during the course of work:

- One set of all project submittals and all equipment and material warranties/guarantees as provided by all appropriate suppliers or manufacturers;
- One set of "Record Drawings" showing all revisions to the original Contract Documents;
- Any and all other documents, manuals, etc. required by the Contract Documents.

1.5.3 APPLICATION FOR FINAL PAYMENT

After the Contractor has completed corrections as mutually agreeable to the Engineer and Contractor and has delivered any required daily quality control reports, data requests, guarantees, bonds, certificates of inspection, marked-up record documents, or other documents as required, and has completed demobilization, the Contractor may submit the application for final payment to the Engineer for submittal to the Owner.

END OF SECTION

01 40 00 QUALITY REQUIREMENTS

1.0 SCOPE OF WORK

1.1 SURVEYING

The Owner shall conduct final dike acceptance surveys for measurement and payment of the completed dikes, and final acceptance surveys following installation of slope protection. All survey data used for purposes of final acceptance shall be available to the Contractor upon request.

The Contractor shall conduct its own daily construction surveying required in conjunction with the work. The Contractor shall furnish copies of all field notes and all other records relating to the survey or to the layout of the work to the Engineer. The Contractor shall retain copies of all such material furnished to the Engineer.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

U.S. Army Corps of Engineers Publications:

- EM 1110-1-1002 Survey Markers and Monumentations;
- EM 1110-1-1003 NAVSTAR Global Positioning System Surveys;
- EM 1110-1-1005 Control and Topographic Surveying;
- EM 1110-2-1003 Hydrographic Surveying.

1.3 QUALITY ASSURANCE/QUALITY CONTROL STANDARDS

Surveys shall follow the quality assurance/quality control standards and methods set forth in EM 1110-1-1002, EM 1110-1-1003, EM 1110-1-1005, EM 1110-2-1003, and these Technical Specifications.

1.3.1 DELAWARE LICENSED PROFESSIONAL SURVEYOR OR ENGINEER

Layout of work and interim construction surveys for dike construction and slope protection installation shall be performed under the supervision of a qualified Delaware licensed Professional Surveyor or Professional Engineer. Prior to commencing surveying activities, the Contractor shall provide the name of the qualified professional land surveyor or engineer to be used on the project. If a professional engineer is used for the survey work, the engineer shall have documented experience and responsible charge of surveys of the same type being performed under this Contract, and the documentation of the engineer's experience shall be provided to the Engineer prior to conducting the work. The Engineer reserves the right to approve or disapprove of the Contractor's surveyor or engineer.

1.3.2 REAL TIME KINEMATIC GLOBAL POSITIONING SYSTEM

Topographic surveys shall be conducted using RTK GPS and the horizontal and vertical control shown on the Plans.

1.4 PROJECT DATUM

The Project vertical datum shall be referenced to the North American Vertical Datum (NAVD 88). Horizontal positions shall be referenced to NAD83 U.S. State Plane Delaware (0700). All units shall be U.S. survey feet.

1.5 SURVEY CONTROL

The Contractor shall use the survey control shown on the Plans.

1.6 SURVEY ACCURACY

GPS-based systems shall not be applied without establishing a local RTK base station using the project control monumentation. Project control monumentation and vertical datum relationships are shown on the Plans in the Contract Documents. Required survey accuracies shall be within +/- 1 Foot horizontally and within +/- 0.2 Foot vertically. The Contractor is responsible for providing all applicable RTK equipment for surveying operations.

1.7 LAYOUT OF WORK

All baselines, temporary bench marks, and survey control shall be established and maintained by the Contractor for the duration of work. The Contractor shall also be responsible for all measurements that may be required for the execution of the work to the lines and grades specified in the Contract Documents. If such marks are destroyed by the Contractor through the Contractor's negligence prior to their authorized removal, they shall be replaced by the Contractor at its own expense.

Temporary bench marks and controls established by the Contractor to layout the work and to perform the surveys shall be verified by Real Time Kinematic Global Positioning Systems on a weekly basis, at a minimum. Ground control and temporary benchmarks established by the Contractor shall be in conformance with Corps of Engineers EM 1110-1-1002.

The Contractor shall perform its own daily construction surveying as required to complete the work in this Contract to the required lines and grades shown in the Plans. The Contractor shall lay out its work from the coordinates, distances, stationing, ranges, and control shown in the Plans, and shall be responsible for the measurements in connection therewith. The Contractor shall furnish, at its expense, stakes, templates, platforms, equipment, range markers, and labor as may be required to lay out any part of the work. The Contractor shall be responsible for executing the work to the lines and grades that may be established or indicated by the Engineer. The Contractor shall also be responsible for maintaining and preserving the stakes and other marks established by the Engineer until authorized to remove them. If these marks are destroyed by the Contractor or through its negligence before their removal is authorized, they may be replaced by the Engineer at its discretion. The expense of replacement will be deducted from the amounts due or to become due, to the Contractor.

1.8 DIKE CONSTRUCTION SURVEYS

The Contractor shall conduct pre-fill surveys of the dike footprint following foundation preparation and excavation of unsatisfactory materials. The Owner shall conduct final dike acceptance surveys for measurement and payment of the completed dikes. Additionally, the Contractor shall provide its own interim construction surveys as necessary to complete the work of the Contract.

Dike cross-sections shall be taken at 50-foot intervals along the dike alignment. The distance between elevation readings shall be not more than 5 feet, with additional readings at break points or abrupt changes in grade.

1.8.1 PRE-FILL SURVEY

Following foundation preparation and excavation of unsatisfactory materials and prior to commencing fill placement into the site, the Contractor shall perform a pre-fill survey of the placement area. The limits of the survey shall include all limits of work including the footprints of the dikes and the water control structure.

1.8.2 INTERIM CONSTRUCTION SURVEYS

During the course of dike construction operations, the Contractor shall perform daily topographic surveys to monitor dike fill progress and assure compliance with the technical specifications. Interim construction surveys will be used to determine the layout of work, the conformance of fill layers to the thickness specified, and to verify the shaping of the completed dike to the lines and grades shown on the Plans.

Contractor's survey data and deliverables shall be submitted with the daily quality control report. Submittals shall include hard copy plots and electronic files.

1.8.3 FINAL ACCEPTANCE SURVEY

The Owner shall conduct the survey for final acceptance of the completed work for the dike. The limits of the survey shall cover the entire limits of work.

The Contractor shall provide five (5) days advance notice to the Engineer of its intent to request Final Acceptance Survey. Final acceptance of the whole or a part of the work and the deductions or corrections of deductions made thereon will not be reopened after having once been made, except on evidence of collusion, fraud or obvious error, and the acceptance of a completed section shall not change the time of payment of the retained percentages of the whole or any part of the work.

If any slumps, slides, scarps, mounds, failures, or other features not in conformance to the lines and grades shown on the Plans be disclosed by this examination, the Contractor will be required to repair the deficiencies as mutually agreeable to the Engineer and Contractor. The repair of any deficiencies may be waived at the discretion of the Owner. The Contractor or its authorized representative will be notified when surveys are to be made. When the area is found to be in a satisfactory condition by the Owner, it will be finally accepted. The Engineer reserves the right to perform check surveys during any phase of dike construction. If discrepancies are found between the Contractor's surveys and the surveys performed by the Engineer, the surveys performed by the Engineer shall govern.

The dike construction final acceptance survey shall serve as the before slope protection installation survey.

1.9 SLOPE PROTECTION SURVEY

The Owner shall conduct the survey for final acceptance of the completed slope protection installation. The Contractor shall conduct interim construction surveys for slope protection installation. Additionally, the Contractor shall provide its own construction surveys as necessary to complete the

work of the Contract.

1.9.1 INTERIM CONSTRUCTION SURVEYS

Interim construction surveys shall be performed by the Contractor and shall be taken during slope protection installation. Interim construction surveys shall be taken over the same stationing as the dike construction final acceptance survey. Cross-sections shall be taken at 25-foot intervals along the entire dike alignment shown in the Plans and shall extend beyond the top of the filter fabric and beyond the toe of slope. The distance between elevation readings shall be not more than 10 feet, with additional readings at break points or abrupt changes in grade. The surveys shall encompass the previous day's construction to the maximum extent practicable.

Contractor's survey data and deliverables shall be submitted with the daily quality control report. Submittals shall include hard copy plots and electronic files.

1.9.2 FINAL ACCEPTANCE SURVEY

The final acceptance survey shall be performed by the Owner and shall be taken after slope protection installation is complete. The final acceptance survey shall be taken over the same stationing as the before stone installation survey. Cross-sections shall be taken at 25-foot intervals along the alignment shown in the Plans and shall extend beyond the top of the geotextile fabric and beyond the toe of slope. The distance between elevation readings shall be not more than 10 feet, with additional readings at break points or abrupt changes in grade. The Contractor shall provide the Engineer a minimum of three days' notice of its intent to request a final acceptance survey.

Final acceptance of the whole or a part of the work and the deductions or corrections of deductions made thereon will not be reopened after having once been made, except on evidence of collusion, fraud or obvious error, and the acceptance of a completed section shall not change the time of payment of the retained percentages of the whole or any part of the work.

If any features not in conformance to the lines and grades shown on the Plans be disclosed by this examination, the Contractor will be required to repair the deficiencies as mutually agreeable to the Engineer and Contractor. The repair of any deficiencies may be waived at the discretion of the Owner. The Contractor or its authorized representative will be notified when surveys are to be made. When the area is found to be in a satisfactory condition by the Owner, it will be finally accepted. The Engineer reserves the right to check surveys during any phase of dike construction. If discrepancies are found between the Contractor's surveys and surveys performed by the Engineer, the surveys performed by the Engineer shall govern.

END OF SECTION

01 57 00 TEMPORARY CONTROLS

1.0 ENVIRONMENTAL PROTECTION

The environmental resources within the project boundaries and those affected outside the limits of permanent work under this contract shall be protected during the entire period of this contract. The Contractor shall confine its activities to areas defined by the Technical Specifications and Plans. Environmental protection shall be as stated in the following subparagraphs.

1.1 PROTECTION OF LAND RESOURCES

Prior to the beginning of construction, the Contractor shall identify the land resources to be preserved within the Contractor's work area. The Contractor shall not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, top soil, and land forms without special direction from the Owner. Ropes, cables, or guys shall not be fastened to or attached to trees for anchorage unless specifically authorized. Where such special emergency use is permitted, the Contractor shall provide effective protection for land and vegetation resources as follows. Trees, shrubs, vines, grasses, land forms, and other landscape features identified by the Owner to be preserved for removal by others shall be clearly identified by marking, fencing, or wrapping with boards, or other approved techniques.

The Contractor shall clean up areas used for construction.

The Contractor shall restore landscape features damaged or destroyed during construction operations outside the limits of the approved work areas. This work will be accomplished at the Contractor's expense.

1.2 LOCATION OF FIELD OFFICES, STORAGE, AND OTHER CONTRACTOR FACILITIES

The Contractor's field offices, staging areas, stockpile storage, and temporary buildings shall be placed in approved areas. Temporary movement or relocation of Contractor facilities shall be made only on approval by the Owner.

1.3 TEMPORARY EXCAVATIONS AND EMBANKMENTS

Temporary excavations and embankments for plant or work areas shall be controlled to protect adjacent areas from despoilment.

1.4 PLACEMENT OF SOLID WASTES

Solid wastes, excluding clearing debris, shall be placed in containers which are emptied on a regular schedule. Handling and disposal shall be conducted to prevent contamination.

1.5 PLACEMENT OF SOLID WASTE BY REMOVAL FROM OWNER PROPERTY

The Contractor shall transport solid waste off Owner property and dispose it in compliance with federal, state, and local requirements for solid waste placement.

1.6 PLACEMENT OF DISCARDED MATERIALS

Discarded materials, other than those which can be included in the solid waste category, will be handled as directed.

1.7 SANITATION FACILITIES

The Contractor shall provide and operate sanitation facilities that will adequately treat or dispose sanitary wastes in conformance with Federal, State, and local health regulations.

1.8 MAINTENANCE OF POLLUTION CONTROL FACILITIES

The Contractor shall maintain constructed facilities and portable pollution control devices for the duration of the contract or for that length of time construction activities create the particular pollutant.

2.0 TURBIDITY AND WATER QUALITY

The Contractor shall conduct its excavation, disposal, and fill operations in a manner to minimize turbidity and shall conform to all water sampling and water quality standards prescribed herein and by any permit or other water quality requirements included in the contract documents. Upland stockpiles and work areas shall be surrounded by silt fences to prevent erosion, turbidity, and disturbance of the adjacent waters. Floating or staked turbidity curtains shall be installed on both sides of the dike to contain turbidity generated by excavation and fill operations. Turbidity curtains shall extend to within 1 foot of the bottom.

2.1 COMPLIANCE INSPECTION

The Owner may take its own samples at any time to assure compliance with the Technical Specifications and permits. The Contractor shall provide assistance necessary to the Owner.

2.1.1 RECORDS

A copy of the records of inspections and tests, as well as records of corrective action taken, shall be submitted as directed.

3.0 AIR QUALITY

3.1 GENERAL REQUIREMENTS

The Contractor shall keep construction activities under surveillance, management, and control to minimize pollution of air resources. Activities, equipment, processes, and work operated or performed by the Contractor in accomplishing the specified construction shall be in strict accordance with the laws of the State of Delaware, and the Federal emission and performance laws and standards. The measures below shall be implemented to control air pollution by the construction activities included in the contract.

3.1.1 PARTICULATES

Dust particles, aerosols, and gaseous byproducts from construction activities, processing and

preparation of materials, such as from asphaltic batch plants, shall be constantly controlled, including weekends, holidays, and hours when work is not in progress.

3.1.2 HYDROCARBONS AND CARBON MONOXIDE EMISSIONS

Hydrocarbon and carbon monoxide emissions from equipment shall be controlled to Federal and State allowable limits, and in accordance with the applicable engine emission standards.

3.1.3 ODORS

Odors shall be constantly controlled for construction activities, processing, and preparation of materials.

4.0 FISH AND WILDLIFE RESOURCES

The Contractor shall keep construction activities under surveillance, management, and control to minimize interference with, disturbance to, and damage of fish and wildlife. The Contractor will take all appropriate measures to comply with wildlife resource protection laws. Some specific considerations for work under this solicitation are as follows: Obtain and abide by a state wildlife special use permit which will be provided by the contract manager free of charge.

4.1 ENDANGERED SPECIES ACT (ESA)

The Contractor shall be aware that the proposed activities will take place in an environment that may be host to protected animals under the Endangered Species Act. No known nesting areas are directly within the construction areas, but nesting areas may be evidenced during construction operations, and the Contractor shall take all appropriate action to avoid disturbing or otherwise impacting them. Contractor to coordinate with all Owner's permit requirements.

END OF SECTION

31 00 00 EARTHWORK

1.0 DIKE WORK

1.1 SCOPE OF WORK

The Lang Impoundment Rehabilitation Project requires the rehabilitation of the existing Lang Impoundment dikes. The base bid dike construction template will provide for a dike with a crown width of 20' and a crown elevation of 8.5' NAVD 88 and from Sta. 0+00 to Sta. 25+00, transition to a crown elevation of 7.0' between Sta. 25+00 and Sta. 27+00, and a crown elevation of 7.0' between Sta. 27+00 and Sta. 40+50. From Sta. 40+50 to Sta. 40+95, the dike crown will transition to meet the existing Rte. grade. Interior side slopes will be constructed on a 1V:3H angle. Exterior side slopes will be constructed on a 1V:2.5H angle to tie into existing grade where required. The work is to be done in accordance with the Proposal and Contract and at the Contract price or prices, subject to the provisions of the Technical Specifications.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

American Society for Testing and Materials (ASTM) Standards & Publications:

- C136 - Standard Method for Sieve Analysis of Fine and Coarse Aggregates;
- D422 - Standard Test Method for Particle-Size Analysis of Soils;
- D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³));
- D2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass;
- D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System);
- D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils;
- D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.3 GENERAL

The work consists of furnishing all plant, labor, equipment, supplies, and materials for performing the operations to construct the dikes to the lines and grades as shown in the Plans. Preliminary investigations, including topographic surveys and borings, have been performed to estimate the character of existing materials, and are included in these specifications.

The Contractor is expected to examine the Technical Specifications, Plans, and the site, and after investigation, decide for itself the character, quality, and quantity of the existing materials on site, and the characteristics, whether surface, subsurface, or otherwise, at the existing upland areas, adjacent water bodies, and existing dikes. The Contractor is expressly encouraged to perform its own investigations to determine the character of materials and satisfy itself as to the means and methods

required to perform the work herein specified. In particular, the Contractor shall evaluate the soft foundation conditions within the dike construction footprint (especially between Sta. 1+00 to 17+00) in regards to heavy equipment utilization, access and dump truck routing. The Engineer must be immediately notified of any site conditions that may affect the performance of the work.

1.3.1 MATERIALS

Material shall be selected to meet the specified requirements for satisfactory material for dike fill. Fill material for dike construction shall be obtained from approved (by Engineer) sources. On-site borrow pits are not available for this Contract. The Contractor is responsible for obtaining fill material from the permitted source, delivery and placement of fill material that meet the specifications herein.

The Contractor shall coordinate with the borrow source(s) to ensure sufficient quantities exist to complete the project prior to submitting its proposal. It is the Contractor's responsibility to develop the appropriate site use agreements with the facilities prior to responding for conducting operations at the site. Any shutdown of operations, whether controlled by the Contractor or not, at the borrow site will not constitute a change in project completion date or increase in cost to the Owner.

The Contractor is responsible for the cost of acquiring the fill material from the borrow source and is responsible for paying any fees associated with the use of this facility, if applicable. The Contractor is responsible for conducting ongoing communication and coordination with the facilities, their tenants and other facility users throughout the duration of the contract.

The Contractor is responsible for evaluating any load restrictions located at the borrow source facility, haul route, or project site(s) and to incorporate those restrictions into his work plan.

1.3.1.1 Satisfactory Materials

Satisfactory materials may consist of available non-organic soils (classified as GW, GP, GM, SP, SM in accordance with ASTM D2487) from approved borrow sources, and shall require the approval of the Engineer. Satisfactory materials shall have a percentage passing the No. 200 sieve of between 5% to 30%. Materials that otherwise meet gradation requirements but have a composition which may cause excessive turbidity when placed as dike fill, may be rejected by the Engineer. Satisfactory material shall be free of organic materials and rocks greater than 2.0 inches in size.

1.3.1.2 Unsatisfactory Materials

Unsatisfactory materials shall consist of materials such as roots, brush, sod, or other perishable materials and debris, peat and other highly organic soils, and soil materials of any classification that have a moisture content, at the time of compaction, beyond the range of 1 percentage point below and 3 percentage points above the optimum moisture content of the soil material as determined by moisture density relations test.

Soils classified as SW, CH, CL, SC, MH, ML, GP, GW, GM, GC, OL, OH, and PT in accordance with ASTM D2487 are also considered unsatisfactory for dike construction.

1.3.1.3 Material Quality

The Contractor will be responsible for performing any material processing required to ensure the fill material is free from deleterious substances. The fill material shall be free of deleterious

substances including, but not limited to wood, organic waste, coal, charcoal, shale, alkali, mica, coated grains of soft and flaky particles, clay lumps, or lignites. In addition, the fill material shall be clean and free of sod, roots, brush, wood, tires, plastic, rubbish, oil, metal, chemical contaminants and other waste materials. The material shall not contain organic or non-organic substances that may be leached from the material in amounts sufficient to be deleterious or harmful.

1.3.1.4 Gradation

The character of the fill material furnished by the Contractor shall have a final composite gradation curve that meets the requirement of Section 6.3.1.1. Dike fill material shall be tested in accordance with ASTM D422.

Material that has gradation characteristics that will cause the composite gradation to not comply with the required gradation band shall become the property of the Contractor and shall be set aside and removed from the project site and disposed of in accordance with applicable Federal, State, and local laws and regulations, and shall be deducted from pay quantities.

1.3.1.5 Sediment Sampling

The Contractor will be responsible for the collection and testing of samples of proposed fill material and samples taken at the material delivery site during construction. Fill material samples for laboratory testing shall be collected at the material delivery site prior to offloading.

1.3.1.6 Test for Proposed Fill Materials

Samples of soil materials proposed as dike fill shall be provided to the Engineer prior to testing. Approximately one-half cubic foot of each proposed material shall be provided for evaluation. Soil materials proposed as dike fill shall be tested by a licensed Professional Engineer or Certified Geologist and shall be approved by the Engineer prior to the start of work as follows:

Material	Requirement	Test Method	Number of Tests
Satisfactory Soil Materials	Mechanical analysis of soils	ASTM D422	One for each source of proposed fill material to determine conformance to definition of satisfactory material
	Moisture-density relations of soil	ASTM D1557 Modified Proctor	

1.3.2 QUALITY CONTROL TESTING DURING CONSTRUCTION

Soil Material shall be tested during construction as follows:

Material	Requirement	Test Method	Number of Tests
Soil material in-place after compaction	Density of soil-in-place	ASTM D6938 Nuclear Method	One (1) sample representing 500 tons of fill material delivered or one (1) sample per lift, whichever is greater, to determine field compaction and moisture content
Dike Fill material delivered to site	Gradation and moisture content	ASTM D422 and ASTM D2216	One (1) sample representing 500 tons of fill material delivered

Fill material samples shall be collected at the rate of one (1) sample representing 500 tons of fill material delivered or one (1) sample per lift, whichever yields the greater amount of material testing. Samples shall be periodically taken throughout the workday as material is delivered to the site. The Engineer shall be present during the collection of all samples taken for testing unless otherwise approved by the Engineer. Every sample shall be tested for gradation and moisture in accordance with ASTM D422 and ASTM D2216, respectively. All sample testing shall be certified by a licensed Professional Engineer or Geologist.

1.3.2.1 Evaluation of Test Results

Soil materials of any classification shall not have a moisture content at the time of compaction that would be classified as unsatisfactory materials.

Results of density of soil in place tests shall be considered satisfactory if the average of any group of four consecutive density tests which may be selected is in each instance equal to or greater than the specified density, and if no density test has a value more than 2 percentage points below the specified density.

1.3.2.2 Sampled Material Gradation Testing

The gradation of material shall be determined in accordance with ASTM D422. Every sample shall be tested using the mechanical method.

In addition to the percentage passing, the test results shall also include percentage retained on each sieve. The gradation and moisture test on a sample collected at the job site shall be completed within two (2) working days after the date of sample collection. Test results shall be submitted to the Owner on the workday following the day of the test.

1.3.2.3 Grain Size Reporting

Each sample test results shall be represented by a gradation curve and a frequency curve. All title information shall be filled out with project name, date sampled, sample number, delivery vessel/truck number sample obtained from, unified soil classification, percent passing the No. 200

sieve (0.074 mm). Gradation curves shall show percent retained on vertical axis and grain size on horizontal axis.

Gradation curves shall be identified by sample number and date and accompany the gradation curve. A tabulation of the laboratory results of weight retained, percent retained and cumulative percent retained on each sieve, by weight, shall be provided with each gradation curve.

Tabulated grain size laboratory results shall be reported in digital format in a Microsoft Excel Spreadsheet. Digital data shall be supplied to the engineer with the following day Daily Report. Samples from the Dike Fill material source shall be numbered consecutively and the sample and testing date identified. Samples from the project site shall be identified with the name or designation number assigned to the delivery vessel or truck.

1.3.3 WEIGH SCALE CERTIFICATION

Prior to the use of any scale under this Contract, the Contractor shall submit details on the location and construction of the scale and a copy of the certification of the scale's accuracy from the local weights and measures regulating agency.

1.3.4 QUALITY CONTROL

The Contractor shall establish and maintain a quality control system for all operations performed under this Section to assure compliance with the Contract requirements and maintain records of its quality control for all operations performed, including, but not limited to the following:

- Quality and gradation of Dike Fill material;
- Access roadway improvements and restoration;
- Construction surveys;
- Placement and stockpiling of material.

1.3.5 CHANGES IN DIKE TEMPLATE OR ALIGNMENT

The Engineer reserves the right to make changes in the dike templates and/or alignment, as may be found necessary before completion of the work. The Engineer reserves the right to increase or decrease the foundation widths and slopes of the dikes or make changes in the final templates as may be deemed necessary. Should such changes be necessary, a mutually agreed upon adjustment to the Contract shall be made in accordance with the Contract Documents. Should it become necessary, through no fault of the Contractor, to abandon a location where work has been done, payment for materials placed shall be made in accordance with the Contract Documents.

1.3.6 ORDER OF WORK FOR DIKE CONSTRUCTION

The Contractor shall perform the work in the following order and in accordance with these Technical Specifications and Plans:

- 1) Foundation Preparation
 - a. Surface dewatering of impoundment basin;
 - b. Clearing, grubbing and stripping;
 - c. Preparation of ground surface for dike fill, including degrading crown and slope of existing

dike where needed.

- 2) Placement of dike fill (and crusher run if awarded);
- 3) Seeding

1.4 FOUNDATION PREPARATION

All work items under this Section shall be completed in their entirety prior to commencement of dike fill.

1.4.1 PROTECTION

Appropriate measures shall be taken to protect the existing dikes and water control structure from damage as a result of activities specified herein and other construction activities for this project. Prior to any earthwork operations, staked silt fences shall be installed in the interior of the dike construction template as shown on the plans. The silt fences shall conform to DeDOT Standard Specifications for Road and Bridge Construction Section 251.

1.4.2 CLEARING, GRUBBING, AND STRIPPING

Prior to start of construction the Owner will draw down as much of the surface water as reasonably possible using the existing water control structure. Clearing, grubbing, and stripping shall be carried out to the extent needed to prepare the footprint for dike construction free from objectionable materials such as trees, brush, vegetation, stumps, grass, roots, and trash. Clearing and grubbing and stripping shall be performed within the entire dike construction footprint.

Clearing and grubbing shall consist of the removal of all trees, brush, and heavy vegetation within the dike construction template, including the crown and interior slopes of the existing dikes. Stripping shall include the removal of the top 4" of existing dike soil on the crown and interior dike slopes within the dike construction template. Cleared, grubbed and stripped materials may be disposed of outside the limits of required dike construction locations in a manner and at locations approved of by the Owner.

The Contractor shall include its means and methods for clearing, grubbing, and stripping with its work plan for review and approval by the Engineer.

1.4.3 REMOVAL OF DEBRIS AND DISPOSAL OF MATERIALS

The Contractor shall remove debris from the work area, excavation area, foundation areas, cut and fill areas, or shoreline protection areas. Debris removal shall include removal of tires, concrete rubble, trash, and other objectionable material. All debris and other materials shall become the property of the Contractor and shall be disposed in appropriate off-site locations.

1.4.4 DEGRADING

Degrading shall consist of removal and replacement of material in preparing for the dike construction to the lines and grades shown in the Plans. Portions of the existing dike above the dike construction template shall be degraded to the lines and grades shown in the plans. The slope of the existing dike shall be degraded as needed for the operation of the dump trucks and the earthwork equipment, with slopes not steeper than 1V:3H. The degraded material shall be utilized within the dike construction template. Degrading shall not be performed until stripping has been completed. The

Contact work plan shall take into account the means and methods required to complete the degrading.

1.4.5 PREPARATION OF GROUND SURFACE FOR DIKE FILL

The ground surface of the existing dikes shall be adequately prepared prior to fill placement. The degraded and prepared ground surface shall be scarified and moistened or aerated just prior to placement of dike fill materials to ensure adequate bond between fill material and the prepared ground surface.

1.5 ESTIMATED FILL QUANTITIES

The following lengths and neat-line volumes are based on limited surveys taken in March 2016 and a NOAA Lidar survey taken in 2014 as shown on the plans. The volumes are estimates only and the Contractor shall make its own determination regarding the quantities necessary to achieve the lines and grades as shown in order to prepare its estimates using its proposed means and methods of construction. The percentage for items including, but not limited to, overbuilding, compaction, settlement, foundation displacement, and construction waste is the responsibility and decision of the Contractor. The estimated volumes for the dike alignment are as follows:

Table 1: Estimated Fill Quantities for Dike Construction

Item	Net Fill (cy)	Net Fill (dry tons)
Base Bid	18,725	24,016
Alternate No. 1	6,107	7,832

1.6 PLACEMENT OF FILL

Fill for dikes shall be placed to the lines and grades shown on the drawing. Compaction shall be accomplished by successive passes of dozers, crawler-type tractors, vibratory pneumatic-tired rollers or steel-wheeled rollers, or other approved equipment capable of obtaining the required density throughout the entire layer. Compaction adjacent to structures shall be done with power-driven hand tampers.

Fill shall not be placed until the required excavation and preparation of the underlying foundation soils is completed and inspected, and surveyed by the Engineer. Fill shall be placed in approximately horizontal layers beginning at the lowest elevation of the foundation. The first layer shall be 2.0 feet thick. Material placed below the water surface elevation, or on soft foundation areas, shall be placed in a loose lift and compacted by passes of a crawler-type tractor, or other approved equipment, to the greatest extent possible across the entire dike footprint. The material shall be placed in successive horizontal layers of loose material for the full width of the cross section. The placement of fill shall commence at Sta. 0+00 and continue through Sta. 40+95 for each layer. Subsequent layers may not be added until the entire previous layer has been completed and accepted by the Engineer.

The thickness of each subsequent layer of fill placed above the initial 2.0 foot layer prior to compaction

shall be as specified in Table 1. Materials placed by dumping in piles or windrows shall be spread uniformly to not more than the specified layer thickness prior to compaction. Each layer shall be spread uniformly on a prepared surface, i.e., a soil surface that has been moistened or aerated and scarified plowed, disked, or otherwise broken up in such a manner that the fill will bond with the surface on which it is placed, and shall be compacted with multiple overlapping passes of the compaction equipment. The compacted fill shall have a minimum density of 95% of the modified proctor maximum dry density as determined by ASTM D1557. The in-place density of the compacted fill shall be determined using test procedures ASTM D6938 "In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)".

The distribution of materials throughout each zone shall be essentially uniform, and the fill shall be free from lenses, pockets, streaks, or layers of material differing substantially in texture, moisture content, or gradation from the surrounding material. The top of fill shall be maintained approximately level during construction. Dikes shall be constructed in continuous layers from abutment to abutment, except where openings to facilitate construction or to allow installation of outfall pipes during construction are specified. If the surface of any layer becomes too hard and smooth to achieve a suitable bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth of not less than 2 inches before the next layer is placed.

The contractor shall provide a quality control system to verify that placed fill has achieved adequate compaction and moisture content, per laboratory test data. As a minimum, the quality control system shall include one (1) field test for every lift of fill or 500 tons placed. The contractor is responsible for obtaining and testing soil samples for determination of modified proctor maximum dry density and optimum moisture content of soil to be used as fill. All sample testing shall be certified by a licensed Professional Engineer or Geologist.

Table 2: Equipment Compaction Requirements

Equipment Type	Applicable Soils ¹	Maximum Layer Thickness ² (inches)	Minimum Passes ³
Track-type crawler (standard tracks) 30,000 lbs. min.	SP	12	4
	SP-SM	6	4
Less than 30,000 lbs.	SP, SP-SM	6	4
Steel drum Vibratory roller (10,000 lbs. min.)	SP, SP-SM	12	4

¹ Unified Soil Classification System

² Prior to Compaction

³ The Engineer shall determine if adequate compaction is being achieved. Additional passes may be required.

1.6.1 MOISTURE CONTROL

Water may be applied by sprinkling the material after placement on the dike fill. Uniform moisture distribution shall be obtained by disking. Material that is too wet when deposited on the dike fill shall either be removed or be dried to the specified moisture content prior to compaction.

If the top surface of the preceding layer of compacted dike fill or a foundation or abutment surface in the zone of contact with the dike fill becomes too dry to permit suitable bond, it shall either be removed or scarified and moistened by sprinkling to acceptable moisture content before placement of the next layer of dike fill.

Dike fill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content, shall be reworked to meet the requirements or removed and replaced by acceptable dike fill. The replacement dike fill and the foundation, abutment, and dike fill surfaces upon which it is placed shall conform to all requirements of this specification for foundation preparation, approval, placement, moisture control, and compaction. Contractor is responsible for all additional costs, time and materials associated with reworking placed dike fill.

During the course of the work, the Engineer may perform quality assurance tests to identify material; determine compaction characteristics; determine moisture content; and determine density of dike fill in place. Tests performed by the Engineer will be used to verify that the dike fill conforms to compaction and moisture requirements, and is not a replacement for the contractor's quality control system. Where the moisture content of a layer of soil material is below optimum before compaction, the required amount of water shall be uniformly applied to the surface of the layer of soil material and the layer of soil disked or otherwise mixed until a uniform moisture content is reached.

Moisture content for the compacted fill shall be determined by one of the following methods: ASTM D2216 "Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass", or D6938 "In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)". Acceptable moisture content shall be within the range of +/- 2% of the optimum moisture as determined using ASTM D6938, or as specified on the drawings.

1.6.2 GRADE TOLERANCES

For acceptance, dikes shall be constructed, as a minimum, to the grades and elevations shown on the Plans. Tolerances for dike construction shall include 0.0 to +0.5 feet on the dike crown elevation and slopes. Tolerance on slope shall be measured perpendicular to slope.

1.6.3 DAMAGES OR FAILURES

1.6.3.1 Conduct of Work

The Contractor shall maintain and protect the dikes in a satisfactory condition until completion and acceptance of the work in this Contract. If the Contractor's equipment causes shears, rutting, quaking, heaving, cracking or excessive deformation of the dikes, the Contractor shall limit the type, load, or travel speed of the equipment on the dikes and make necessary repairs at no additional cost to the Owner.

1.6.3.2 Erosion, Slides, and Settlement

If erosion, sliding, or settlement occurs in any part of the dikes during its construction or after its completion but prior to its acceptance, the Contractor shall rebuild that portion of the dike at the bid price per unit ton of fill.

Sections not conforming to the minimum acceptance template shall be corrected at no additional cost to the Owner. The Contractor shall be responsible for repair of damages to the dikes resulting from construction equipment operation, settlement, subsidence, slides, displacement and handling of foundation materials; normal seasonal weather related damage; and Contractor negligence until acceptance. After acceptance, the Contractor shall be responsible for damages to the dikes resulting from its operations or negligence at no additional cost to the Owner.

1.6.4 ACCEPTANCE OF COMPLETED DIKE

If erosion, sliding, or settlement occurs in any part of the dikes during its construction or after its completion but prior to its acceptance, the Contractor shall rebuild that portion of the dike at the bid price per unit ton of fill.

Sections not conforming to the minimum acceptance template shall be corrected at no additional cost to the Owner. The Contractor shall be responsible for repair of damages to the dikes resulting from construction equipment operation, settlement, subsidence, slides, displacement and handling of foundation materials; normal seasonal weather related damage; and Contractor negligence until acceptance. After acceptance, the Contractor shall be responsible for damages to the dikes resulting from its operations or negligence at no additional cost to the Owner.

END OF SECTION

31 35 00 SLOPE PROTECTION

1.0 SCOPE OF WORK

The work in this Section consists of providing labor, material, and equipment for stockpiling stone, preparing the dike slopes for stone installation, and installing stone (riprap) as required for slope protection as shown on the plans, and in areas needing repair as directed by the Engineer. The work covered in this Section also consists of installation of geotextile under the stone slope protection, which includes the labor, material, and equipment to perform the operations required to furnish, haul, place, and maintain the geotextile, complete as specified herein and as shown until placement of the stone slope protection is completed and accepted. The stone (riprap) and geotextile materials and installation shall conform to DelDOT Specifications for Road and Bridge Construction, August 2001, Sections 712 and 713.

1.1 ESTIMATED SLOPE PROTECTION QUANTITIES

The following quantities are based on limited surveys taken in March 2016 and a NOAA Lidar survey taken in 2014 as shown on the plans. The quantities are estimates only and the Contractor shall make its own determination regarding the quantities necessary to achieve the lines and grades as shown in order to prepare its estimates using its proposed means and methods of construction. The percentage for items including, but not limited to, overbuilding, compaction, settlement, foundation displacement, and construction waste is the responsibility and decision of the Contractor. The estimated quantities of slope protection riprap are as follows:

Table 3: Estimated Slope Protection Quantities

Riprap Slope Protection [DRY TONS]
400

1.2 MATERIALS

1.2.1 STONE

The Contractor shall make arrangements, pay royalties, and secure the permits for procurement, furnishing, and transporting stone. The Contractor shall vary the quarrying, processing, loading, and placing operations to produce the sizes and quality of stone specified. If the stone being furnished by the Contractor does not meet the requirements as specified herein, the Contractor shall furnish, at no additional cost to the Owner, other stone meeting these requirements. Riprap shall be Delaware Department of Transportation (DelDOT) Class R-6 conforming to the requirements of DelDOT Specifications Section 712.04. Prior to placement, stone shall be subject to approval by the Engineer. Approval of stone shall not constitute acceptance of all stone from a source. Stone of unsatisfactory quality or size distribution as specified will be rejected and shall be promptly removed from the project at no expense to the Owner.

1.2.2 WEIGH SCALE CERTIFICATION

Prior to the use of any scale under this Contract, the Contractor shall submit details on the location and construction of the scale and a copy of the certification of the scale's accuracy from the local weights and measures regulating agency.

1.2.3 GEOTEXTILE

New nonwoven geotextile shall be placed prior to placement of stone. The geotextile shall meet the requirements of DelDOT Specifications Section 827.06. The geotextile material must be accepted by the Engineer prior to installation.

1.3 EXECUTION

1.3.1 PROTECTION OF EXISTING DIKES AND ACCESS AREAS

Once on the site, individual locations may be accessed by travel over the existing roads and adjacent areas, and dikes. If the dikes are used for travel, the Contractor shall be responsible for stabilizing them as a haul road. The Contractor shall exercise extreme care if heavy construction loads are placed on the existing dikes. The Contractor shall repair the damage caused by its activities, direct or indirect, at Contractor's expense. Excavation below the existing dike grade, except as shown, shall not be permitted without approval.

Access areas used on or to the site shall be repaired to their pre-project condition.

1.3.2 SLOPE PREPARATION

Slope preparation to receive stone slope protection shall be undertaken following the completion of dike fill and the performance of the dike construction final acceptance survey. Slope protection installation shall generally conform to the required lines and grades shown on the Plans. Some field fitting may be required. Miscellaneous areas requiring slope protection repair shall be identified by the Engineer and shall be repaired by the Contractor in conformance with these specifications.

1.3.3 INSTALLATION OF GEOTEXTILES

Before placement of stone, the Contractor shall demonstrate that the placement technique for each application shall prevent damage to the geotextile. The geotextile shall be placed at the locations as specified. At the time of installation, the geotextile shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation, or storage. Geotextile shall be laid smooth and free of tension, stress, folds, wrinkles or creases. The geotextile strips shall be placed longitudinally along slope, parallel to dike alignment with up-slope strips overlapping down-slope strips. The strips shall be placed to provide a minimum width of 18 inches of overlap for each joint after stone is placed. Temporary pinning of the textile to help hold it in place until the stone is placed shall be allowed on the slopes. Securing pins shall be inserted through both strips of overlapping geotextile along the line passing through midpoints of the overlap. The geotextile shall be protected during construction from contamination by surface runoff. If the geotextile becomes contaminated, it shall be removed and replaced with uncontaminated geotextile at no expense to the Owner. Geotextile damaged during its installation or during placement of the stone shall be replaced by the Contractor at no cost to the Owner. The slope protection work shall be scheduled so

that covering the geotextile with a layer of the stone is accomplished within two (2) days after placement of the geotextile. Failure to comply shall require replacement of the geotextile at Contractor's expense. The geotextile shall be protected from damage prior to and during the placement of stone. Equipment shall not be allowed on unprotected geotextile. The soil surface on the slopes to receive the geotextile shall be prepared to a relative smooth condition free of obstructions, depressions, debris, and soft or low-density pockets of material. Erosion features, including rills or gullies, shall be graded out of the surface before geotextile placement.

1.3.4 INSTALLATION OF STONE

Stone shall be placed so that a reasonably well-graded mass is produced with a minimum practicable percentage of voids. Stone shall be constructed to the lines and grades shown. Stone shall be placed evenly and to the full course thickness of each stone type in one operation, using a method that shall avoid damage to the geotextile, when present. Stone shall be allowed to fall no more than 2 feet from the bottom of the clam or bucket to the placement surface. For underwater work, the maximum drop shall be 3 feet. In no case shall the drop be greater than that which may cause damage to the geotextile when present. An otherwise allowable height, using the Contractor's approved placement method, will not be permitted if it is shown to cause segregation of stone sizes, breakage of individual stone, or damage to the filter fabric when present. The Contractor shall maintain the stone layer until accepted and if material is displaced or the surface damaged, replacement shall be made to the indicated lines and grades, at the Contractor's expense. Protruding rock shall be removed and the void filled with smaller rock. The stone work shall be finished smooth.

1.3.5 COMPLIANCE INSPECTION

The Contractor shall inspect for compliance with the contract requirements and record the inspection of operations. The Contractor, at Contractor's expense, shall perform inspections in accordance with the following schedule:

- Stone quality - one (1) set of quality tests, for each new stone type provided;
- Gradation - one (1) gradation test to be performed per stone type;
- Specific gravity - one (1) specific gravity test per stone type;
- Placement - continuous check of placement to ensure proper size and compliance with grade lines shown;
- Excavation and placement - Lines and grades, disposition of material.

1.3.6 TOLERANCES

Stone work for slope protection shall be carried to the lines and grades shown, the tolerances as specified herein, and as directed. Final surfaces of the finished course shall be reasonably even, uniform, and shall follow with reasonable variation the indicated lines and grades without continuous under or overbuilding. Deviations in slope protection thickness and elevation from the design value shall be within +/-0.3 foot.

1.3.7 MISPLACED MATERIALS

Material that escapes or is lost while loading, transporting or placing stone, or which is deposited other than in the area shown or a change approved in writing, shall be removed and re-deposited

where directed at Contractor's expense.

1.4 ACCEPTANCE

Slope protection will be accepted for the portion of completed dike alignment that requires slope protection as shown on the plans. Acceptance will be based on the topographic surveys performed as specified in Technical Specifications Section 4. The Engineer reserves the right to check surveys during any phase of slope protection installation. If discrepancies be found between the Contractor's survey and surveys performed by the Engineer, the survey performed by the Engineer shall govern.

The geotextile fabric will be accepted in-place and in conjunction with acceptance of the slope protection. Its presence and condition will be observed daily by the Engineer while being installed and covered. The Contractor shall refrain from covering the fabric without giving the Engineer sufficient opportunity for inspection.

END OF SECTION

32 11 23 AGGREGATE BASE COURSE

1.0 CRUSHER RUN

Crusher Run shall conform to DeIDOT Standard Specifications for Road and Bridge Construction Sections 302 and 821 for Graded Aggregate Base Course - Type B (Crusher Run). An 8" thick layer of Crusher Run shall be placed and compacted on the dike to the lines and grades as shown in the Plans. Crusher Run materials shall be subject to approval by the Engineer prior to placement. The Contractor shall provide certifications from the suppliers that the materials meet the requirements of these specifications.

Table 4: Estimated Crusher Run Quantities

Crusher Run [DRY TONS]
2,111

END OF SECTION

32 31 13 CHAIN LINK FENCE AND GATES

1.0 GENERAL

1.1 SUMMARY

This Section includes industrial/commercial chain link fence and gates specifications:

1. Galvanized steel coated chain link fabric
2. Aluminum coated steel chain link fabric
3. Polymer coated steel chain link fabric
4. Zinc 5% Aluminum alloy coated steel chain link fabric
5. Galvanized steel framework and fittings
6. Polymer coated galvanized steel framework and fittings
7. Gates: swing and cantilever slide
8. Barbed wire
9. Barbed tape
10. Installation

1.2 REFERENCES

- A. ASTM A121 Specification for Metallic-Coated Carbon Steel Barbed Wire
- B. ASTM A392 Specification for Zinc-Coated Steel Chain-Link Fence Fabric
- C. ASTM A491 Specification for Aluminum-Coated Steel Chain-Link Fabric
- D. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- E. ASTM A817 Specification for Metallic-Coated Steel Wire for Chain Link Fence Fabric and Marcellled Tension Wire
- F. ASTM A824 Specification for Metallic-Coated Steel Marcellled Tension Wire for use with Chain Link
- G. ASTM F552 Standard Terminology Relating to Chain Link Fencing
- H. ASTM F567 Standard Practice for Installation of Chain Link Fence
- I. ASTM F626 Specification for Fence Fittings
- J. ASTM F668 Specification for Polymer Coated Chain Link Fence Fabric
- K. ASTM F900 Specification for Industrial and Commercial Swing Gates
- L. ASTM F934 Specification for Standard Colors for Polymer-Coated Chain Link
- M. ASTM F1043 Specification for Strength and Protective Coatings of Steel Industrial Chain Link Fence Framework
- N. ASTM F1083 Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
- O. ASTM F1184 Specification for Industrial and Commercial Horizontal Slide Gates

- P. ASTM F1345 Specification for Zinc-5% Aluminum-Mischmetal Alloy-Coated Steel Chain-Link Fence Fabric
- Q. ASTM F1664 Specification for Poly (Vinyl Chloride) (PVC) and Other Conforming Organic Polymer-Coated Steel Tension Wire Used with Chain-Link Fence
- R. ASTM F1665 Specification for Poly (Vinyl Chloride) (PVC) and Other Conforming Organic Polymer-Coated Steel Barbed Wire Used with Chain-Link Fence
- S. ASTM F1910 Specification for Long Barbed Tape Obstacles
- T. ASTM F1911 Standard Practice for Installation of Barbed Tape
- U. ASTM F2200 Specification for Automated Vehicular Gate Construction
- V. UL325 Automatic operators: Door, Drapery, Gate, Louver and Window

1.3 SUBMITTALS

- A. Shop drawings: Site plan showing layout of fence location with dimensions, location of gates and opening size, cleared area, elevation of fence, gates, footings and details of attachments.
- B. Certifications: Manufacturers material certifications in compliance with the current ASTM specifications.
- C. Domestic certifications: Material certifications, Made in U.S.A., Buy American Act or Buy America when required.
- D. Material samples: When required, provide representative samples of chain link fabric, framework and fittings.
- E. Specification Changes: May not be made after the date of bid.

1.4 QUALITY ASSURANCE

- A. Manufacturer: Company headquartered in the United States having U.S. manufacturing facility/facilities specializing in manufacturing chain link fence products with at least 5 years experience.
- B. Tolerances: Current published edition of ASTM specifications tolerances apply. ASTM specification tolerances supersede any conflicting tolerance.

2.0 PRODUCTS

2.1 MANUFACTURERS

None Specified

2.2 CHAIN LINK FABRIC

Steel Chain Link Fabric: Height as indicated on drawings; Zinc-Coated Steel Fabric: ASTM A392 hot dipped galvanized before or after weaving; Class 1 - 1.2 oz/ft² (366 g/m²); 2" Mesh; 9 gauge wire; standard (K&T) selvage; top rail required.

2.3 ROUND STEEL PIPE FENCE FRAMEWORK

Round steel pipe and rail: Schedule 40 standard weight pipe, in accordance with ASTM F1083, 1.8 oz/ft² (550 g/m²) hot dip galvanized zinc exterior and 1.8 oz/ft² (550 g/m²) hot dip galvanized zinc interior coating

Regular Grade: Minimum steel yield strength 30,000 psi (205 MPa)

1. Line post 2.375" OD, 3.65 lb/ft
2. End, Corner, Pull post; 2.875" OD, 5.79 lb/ft
3. Top, brace, bottom and intermediate rails, 1.660" OD

2.4 TENSION WIRE

Metallic Coated Steel Marcellled Tension Wire: 7 gauge (0.177 in.) (4.50 mm) marcellled wire complying with ASTM A824. Match coating type to that of the chain link fabric.

2.5 FITTINGS

- A. Tension and Brace Bands: Galvanized pressed steel complying with ASTM F626, minimum steel thickness of 12 gauge (0.105 in.) (2.67 mm), minimum width of 3/4 in. (19 mm) and minimum zinc coating of 1.20 oz/ft² (366 g/m²). Secure bands with 5/16 in. (7.94 mm) galvanized steel carriage bolts.
- B. Terminal Post Caps, Line Post Loop Tops, Rail and Brace Ends, Boulevard Clamps, Rail Sleeves: In compliance to ASTM F626, pressed steel galvanized after fabrication having a minimum zinc coating of 1.20 oz/ft² (366 g/m²).
- C. Truss Rod Assembly: In compliance with ASTM F626, 3/8 in. (9.53 mm) diameter steel truss rod with a pressed steel tightener, minimum zinc coating of 1.2 oz/ft² (366 g/m²), assembly capable of withstanding a tension of 2,000 lbs. (970 kg).
- D. Tension Bars: In compliance with ASTM F626. Galvanized steel one-piece length 2 in. (50 mm) less than the fabric height. Minimum zinc coating 1.2 oz. /ft² (366 g/m²). [

2.6 TIE WIRE AND HOG RINGS

Tie Wire and Hog Rings: Galvanized minimum zinc coating 1.20 oz/ft² (366 g/m²) 9 gauge (0.148) (3.76 mm) steel wire in compliance with ASTM F626

2.7 SWING GATES

Swing Gates: Galvanized steel pipe welded fabrication in compliance with ASTM F900. Gate frame members 1.900 in. OD (48.3 mm) ASTM F 1083 schedule 40 galvanized steel pipe. Frame members spaced no greater than 8 ft. (2440 mm) apart vertically and horizontally. Welded joints protected by applying zinc-rich paint in accordance with ASTM Practice A780. Positive locking gate latch, pressed steel galvanized after fabrication. Galvanized malleable iron or heavy gauge pressed steel post and frame hinges. Provide lockable drop bar and gate holdbacks. Match gate fabric to that of the fence system. Gateposts per ASTM F1083 schedule 40 galvanized steel pipe, 2.875 in OD.

2.8 CONCRETE

Concrete for post footings shall have a 28-day compressive strength of 2,500 psi. (17.2 MPa).

3.0 EXECUTION

3.1 CLEARING FENCE LINE

Clearing: Surveying, clearing, grubbing, grading and removal of debris for the fence line or any required clear areas adjacent to the fence

3.2 FRAMEWORK INSTALLATION

- A. Posts: Posts shall be set plumb in concrete footings in accordance with ASTM F567. Minimum footing depth, 36 in. Minimum footing diameter four times the largest cross section of the post up to a 4.00" dimension and three times the largest cross section of post greater than a 4.00" dimension. Modify post footings to maintain a maximum 3" distance from existing concrete wall to exterior edge of post. Top of concrete footing to be at grade, crowned to shed water away from the post. Line posts installed at intervals not exceeding 10 ft. (3.05 m) on center.
- B. Top rail: Install continuous thru the line post. Splice rail using top rail sleeves minimum 6 in. (152 mm) long. Rail shall be secured to the terminal post by a brace band and rail end. Bottom rail or intermediate rail shall be field cut and secured to the line posts using boulevard clamps or brace band with rail end.
- C. Terminal posts: End, corner, pull and gate posts shall be braced and trussed for fence 6 ft. (1.8 m) and higher and for fences 5 ft. (1.5 m) in height not having a top rail. The horizontal brace rail and diagonal truss rod shall be installed in accordance with ASTM F567.
- D. Tension wire: Shall be installed 4 in. (101.6 mm) up from the bottom of the fabric. Fences without top rail shall have a tension wire installed 4 in. (101.6 mm) down from the top of the fabric. Tension wire to be stretched taut, independently and prior to the fabric, between the terminal posts and secured to the terminal post using a brace band. Secure the tension wire to each line post with a tie wire.

3.3 CHAIN LINK FABRIC INSTALLATION

Chain Link Fabric: Install fabric to inside of the framework. Attach fabric to the terminal post by threading the tension bar through the fabric; secure the tension bar to the terminal post with tension bands and 5/16 in. (7.94 mm) carriage bolts spaced no greater than 12 inches (304.8mm) on center. Small mesh fabric less than 1 in. (25 mm), attach to terminal post by sandwiching the mesh between the post and a vertical 2 in. wide (50mm) by 3/16 in. (4.76 mm) galvanized steel strap using carriage bolts, bolted thru the bar, mesh and post spaced 15 in. (381 mm) on center. Chain link fabric to be stretched taut free of sag. Fabric to be secured to the line post with tie wires spaced no greater than 12 inches (304.8 mm) on center and to horizontal rail spaced no greater than 18 inches (457.2 mm) on center. Secure fabric to the tension wire with hog rings spaced no greater than 18 inches (457.2 mm) on center. Excess

wire shall be cut off and bent over to prevent injury. The installed fabric shall have a ground clearance on no more than 2 inches (50 mm).

3.4 BARBED WIRE INSTALLATION

None

3.5 GATE INSTALLATION

Swing Gates: Installation of swing gates and gateposts in compliance with ASTM F 567. Direction of swing shall be inward. Gates shall be plumb in the closed position having a bottom clearance of 3 in. (76 mm), grade permitting. Hinge and latch offset opening space shall be no greater than 3 in. (76 mm) in the closed position. Double gate drop bar receivers shall be set in a concrete footing minimum 6 in. (152 mm) diameter 24 in. (609.6 mm) deep. Gate leaf holdbacks shall be installed for all double gates.

3.6 BARBED TAPE INSTALLATION

None

3.7 NUTS AND BOLTS

Bolts: Carriage bolts used for fittings shall be installed with the head on the secure side of the fence. All bolts shall be peened over to prevent removal of the nut.

Table 5: Estimated Chain Link Fence Quantities

Chain Link Fence [Linear Feet]
59

END OF SECTION

32 92 19 SEEDING AND MULCHING

1.0 GENERAL

Seeding and Mulching shall conform to DeIDOT Standard Specifications for Road and Bridge Construction Sections 732, 734, and 735. Seed shall be the mix specified for Permanent Crown Vetch Seeding. Seeding shall include placement of a minimum thickness of 4" of topsoil on all constructed slopes as shown on the plans following acceptance of the completed dike construction. Alternate No. 1 will require seeding and mulching both the inside and outside raised slopes. Seeding operations shall include seeding, applying fertilizer and inoculant, mulching, tracking, and watering as necessary to establish the grass in accordance with the DeIDOT Standard Specifications. Seeding operations shall be completed within 7 days for accepted sections of the constructed dike, in order to minimize slope erosion and rutting. Upon completion of seeding operations, the staked silt fences shall be removed. Seeding materials shall be subject to approval by the Engineer prior to placement. The Contractor shall provide certifications from the suppliers that the materials meet the requirements of these specifications.

Table 6: Estimated Seeding and Mulching Quantities

Item	Seeding and Mulching [SQUARE YARDS]
Base Bid	12,500
Alternate No. 1	1,740

END OF SECTION

35 00 80 WATERWAY AND MARINE CONSTRUCTION

1.0 REFURBISHMENT OF THE WATER CONTROL STRUCTURE

This section covers the refurbishing of the existing water control structure at the location shown on the Plans. The work in this section consists of evaluation of the existing structure, design of repairs and refurbishment, and furnishing all plant, labor, materials and supplies and performing all operations in connection with refurbishment of the water control structure. This work shall be accomplished in complete and strict accordance with the Technical Specifications and applicable Plans, and shall be subject to the terms and conditions of the Contract.

1.1 QUALITY/ASSURANCE/QUALITY CONTROL

The Contractor shall establish and maintain quality control for all construction activities involved in the refurbishment of the water control structure. The Contractor shall maintain records of its quality control for all construction operations and certify compliance with applicable sections of the Technical Specifications. The Contractor's records shall include the following:

- Equipment Type: size, and suitability for construction of the prescribed work;
- Construction of cofferdams and dewatering operations;
- Construction: layout, maintaining impoundment water control;
- Steel certifications;
- Concrete certifications;
- Concrete patching material and equipment certifications;
- Steel sheet pile paint certifications.

1.2 HANDLING AND STORAGE

Materials delivered to the site shall be inspected for damage, unloaded, and stored with minimum handling. Upon delivery of gates, certified copies of test reports demonstrating conformance to applicable specifications shall be submitted for approval by the Owner before installation. Materials shall be handled using a method that will ensure delivery to the installation locations in sound undamaged condition. Gates and all materials shall be carried to the installation location, not dragged.

1.3 MATERIALS

1.3.1. SATISFACTORY BACKFILL MATERIAL

Satisfactory soils for backfill shall be as described in Section 31 00 00.

1.3.2. COMPACTION EQUIPMENT

Power driven tampers shall be used in the compaction of structural fill within three feet of the structure and near structure where vehicular equipment cannot be used. These tampers should be a power driven, hand operated type.

1.3.3. WING WALL CONCRETE CAP AND CONCRETE WEIR DESIGN/CONSTRUCTION

The work under this section includes the design and construction of the wing wall concrete cap and the concrete weir wall.

1.3.3.1. DESIGN

The wing wall concrete cap and concrete weir shall be designed by a licensed professional engineer. The wing wall concrete cap shall be designed to replace the existing cap in kind, including removal of the existing cap and secure attachment of the new cap to the existing sheet pile wing wall. The concrete weir shall be designed as a replacement of the existing weir timbers within the H-beam channels. The design shall include a full set of plans and specifications, and signed and sealed, to be submitted to the Engineer for approval prior to the start of construction. The specifications shall include appropriate safety, quality control, testing and inspection protocols. All aspects of the design shall conform to the DelDOT Standard Specifications for Road and Bridge Construction unless otherwise justified by the design engineer. Note that approval of submittals by the Engineer shall not be construed as relieving the design engineer or the Contractor from responsibility for compliance with the specifications nor from responsibility of errors of any sort in the submittals.

1.3.3.2. CONSTRUCTION

The wing wall concrete cap and concrete weir shall be constructed in accordance with the approved design plans and specifications and in accordance with these specifications.

1.3.4. WING WALL CONCRETE CAP, WATER CONTROL STRUCTURE CONCRETE CAP, AND CONCRETE BASE PATCHING

The work under this section includes the patching of cracks in the wing wall concrete cap and the water control structure concrete cap. All cracks and spalls 1/16" wide or wider shall be patched. Cracks and spalls shall be cleaned by high pressure water jetting with fresh water prior to application of the patching mortar. The pressure washer shall have a minimum capability of producing 5,000 psi and be fitted with a variety of nozzles suitable for cleaning the various sizes and shapes of the cracks. The Engineer shall be notified at least 7 days prior to the day the Contractor proceeds with pressure washing operations. The patching mortar shall be sprayed into the cleaned cracks and spalls and hand troweled to a smooth finish. The work shall be performed in accordance with the International Concrete Repair Institute (ICRI) guidelines and the patching material manufacturer's specifications, guidelines and safety recommendations. The patching mortar shall be SikaRepair 224 manufactured by Sika Corporation. The ICRI Guidelines and the Sika specifications, product data sheet, and safety data sheet are included in Appendix B. Alternate patching mortar with equivalent properties to SikaRepair 224 may be proposed by the Contractor but will be subject to the Engineer's approval. Evidence of previous experience using the proposed alternate product under similar conditions shall be submitted to the Engineer to aid in the evaluation of the Contractor's proposal.

1.3.5. PAINTING OF WING WALL STEEL SHEET PILES

The work under this section includes the painting of the steel sheet piles of both existing wing walls. This work shall not begin until replacement and patching of the concrete caps have been completed and accepted by the Engineer. The steel sheet piles shall be prepared for painting by high pressure

hydro washing using a minimum 5,000 psi pressure washer with fresh water. The pressure washing shall proceed in a methodical and continuous manner, ensuring complete and thorough coverage of the entire exposed surfaces. The Engineer shall be notified at least 7 days prior to the day the Contractor proceeds with pressure washing operations.

Following completion of the pressure washing and at least 1 day to allow for thorough drying, the steel sheet piles shall be painted. The paint to be used shall be Sherwin Williams MIL-24441 Type IV, Epoxy Polyamide, Dark Gray. The paint shall be applied in a methodical and continuous pattern ensuring complete and even coating of the prepared steel surface, and in accordance with the manufacturer's specifications and safety recommendations. Two coats shall be applied to the steel. The second coat shall not be applied until the first coat has dried sufficiently (minimum 24 hours) and has been accepted by the Engineer. The Sherwin Williams specifications, product data sheet, and safety data sheet are included in Appendix B. Alternate paint with equivalent properties to Sherwin Williams MIL-24441 Type IV, Epoxy Polyamide, Dark Gray may be proposed by the Contractor but will be subject to the Engineer's approval. Evidence of previous experience using the proposed alternate product under similar conditions shall be submitted to the Engineer to aid in the evaluation of the Contractor's proposal.

1.3.6. GATES

Specifications for the gates are provided by the manufacturer and are included in Appendix C.

1.4 EXECUTION

The Contractor shall submit his work plan for approval by the Engineer prior to start of construction. The work plan shall include a schedule of activities, means and methods of construction, and all labor, materials and equipment to be used to complete the work.

1.4.1. COFFERDAMS AND DEWATERING

The Contractor shall install a steel sheet pile cofferdam on the river side of the water control structure and utilize sufficient pumps to dewater the surface of the impoundment basin on the inside of the water control structure and perform continuous dewatering in the immediate vicinity of the water control structure on both sides. Prior to construction of the cofferdam a floating turbidity curtain shall be installed and anchored as shown in the Plans. The turbidity curtain shall conform to DelDOT Standard Specifications for Road and Bridge Construction Section 269. Temporary sheet piling shall be designed by a licensed Professional Engineer and shall be carried to adequate depths and braced as necessary for proper and safe performance of the work. A set of signed and sealed plans shall be provided to the Engineer for approval prior to construction of the cofferdam. Construction shall be such as to permit all repairs to the water control structure as required, and shall give sufficient clearance for inspection. An earthen or steel sheet pile cofferdam may also be constructed on the impoundment side of the structure to aid in maintaining dewatering efforts. Excavation of a sump or ditch will likely be required to keep the surface area dewatered within the impoundment basin and in the immediate vicinity of the water control structure on both sides. Upon approved completion of all work under this contract, the cofferdams and turbidity curtain shall be removed.

The Contractor shall provide a pumping system capable of removing virtually all surface water from the impoundment basin and in the vicinity of the water control structure on both sides. The water

shall be discharged to the Delaware River within the area protected by the turbidity curtain.

1.4.2. INSPECTION AND EVALUATION

Upon attainment of a dewatered surface around the water control structure, the Owner and the Engineer will complete an inspection and evaluation of the entire water control structure and all of its components. The Contractor shall be required to participate in the inspection and evaluation. A report will be prepared by the Owner and Engineer describing the rehabilitation efforts to be performed by the Contractor, as well as what Bid Options will be awarded. Any rehabilitation efforts beyond what are described in these specifications may be requested as a Change Order by the Owner to be negotiated with the Contractor.

1.4.3. DESIGN OF REPAIRS AND REFURBISHMENT

Upon written notice from the Owner, the Contractor shall proceed with retaining a design engineer to design the wing wall cap replacement and/or the concrete weir. Following acceptance of the plans and specifications by the Engineer, the Contractor will be given written notice by the Owner to proceed with the repairs.

1.4.4. PROCUREMENT OF GATES AND MATERIALS

An allowance of \$50,000 will be added to the base bid for the Contractor to purchase and deliver to the site the gates for this project. The contractor and the owner will purchase gates manufactured by Mechanical Associates or of like kind with this allowance. The allowance does not cover installation or other necessary materials. The installation and all necessary materials shall be the Contractor's responsibility based on the base bid lump sum including the replacement of the water control structure. All hardware and materials necessary for the installation and repairs shall be the Contractor's responsibility.

1.4.5. INSTALLATION OF GATES AND COMPLETE REFURBISHMENT

The contractor shall remove the existing water control structure and install the new gates and complete the rehabilitation of the water control structure and appurtenances as described herein and in accordance with these specifications. All removed materials shall be disposed of offsite at the Contractor's expense. None of the existing hardware and materials shall be reused.

1.4.6. TESTING AND INSPECTION OF REFURBISHED WATER CONTROL STRUCTURE

The Owner and Engineer will test and inspect the rehabilitated water control structure and appurtenances to ensure successful operation and acceptance that all repairs were completed in accordance with these specifications.

1.4.7. REMOVAL OF COFFERDAMS

Upon written notice of acceptance by the Owner, the Contractor shall remove the cofferdams and turbidity curtain.

END OF SECTION

APPENDIX A

PERMITS



STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES &
ENVIRONMENTAL CONTROL
DIVISION OF WATER
89 KINGS HIGHWAY
DOVER, DELAWARE 19901

WETLANDS & SUBAQUEOUS
LANDS SECTION

TELEPHONE (302) 739-9943
FAX (302) 739-6304

DNREC Division of Fish & Wildlife
Attention: Jeremy Ashe
89 Kings Hwy
Dover, DE 19901
Tax Parcel: 130100009

Subaqueous Lands Permit: SP-327/16
Associated Permit(s):
Date of Issuance: 11/10/2016
Construction Expiration Date: 11/10/2019
Amended Date: N/A

SUBAQUEOUS LANDS PERMIT

GRANTED TO:

DNREC Division of Fish & Wildlife

TO RESTORE/REPAIR:

Approximately 4,000 linear feet of existing dikes consisting of approximately
47,000 cubic yards of material by raising the elevation
New flap gates directly attached to the existing concrete headwall/frame
Approximately 750 feet of shoreline by replenishing 400 tons of rip rap

TO TEMPORARILY INSTALL:

A coffer dam around the existing water control structures

LOCATED ON PUBLIC SUBAQUEOUS LANDS:

In the Lang Impoundment
Within the Augustine Wildlife Management Area
Between Port Penn Road & Thorntown Road on Route 9 North
New Castle County, Delaware

Pursuant to the provisions of 7 Del. C., §7205, and the Department's Regulations Governing the Use of Subaqueous Lands, permission is hereby granted on this 10th day of November A.D. 2016, to construct the above-referenced project in accordance with the approved plans (16 sheets), as approved on November 9, 2016; and the application dated September 6, 2016, and received by this Division on September 7, 2016.

WHEREAS, DNREC Division of Fish & Wildlife, owner of certain adjoining lands to Augustine Wildlife Management Area, has applied for permission to install the indicated structures for private use; and;

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WHEREAS, pursuant to the provisions of 7 Del. C., §7203, the Secretary of the Department of Natural Resources and Environmental Control through his duly authorized representative finds that it is not contrary to the public interest if this project is approved subject to the terms and conditions herein set forth.

NOW THEREFORE, this Permit is issued subject to the attached Subaqueous Lands Permit General Conditions and the following special conditions:

SPECIAL CONDITIONS

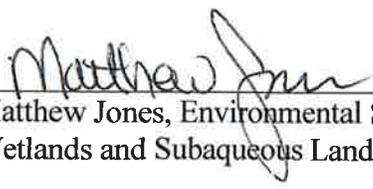
1. This approval is in accordance with the plans and application submitted to the Department of Natural Resources and Environmental Control, a copy of which is attached hereto and made a part hereof.
2. To avoid impacts to anadromous species, no work shall take place between March 15th and June 30th for the construction activities associated with the temporary coffer dam and the repair of the water control structures of any given year. If this time of year restriction cannot be met, please contact fisheries biologists Ed Hale (302-735-2969) and Ian Park (302-735-8663) for further consideration and guidance.
3. All fill materials associated with the proposed project shall be clean and free from oils, grease, asphalt and other contaminants.
4. The repair and improvement of the water control structures shall be planned for periods of low waterway base flows. In the event that sediment and erosion controls are damaged or destroyed due to storm events, such controls shall be repaired and/or replaced immediately.
5. There shall be no stockpiling of construction material or equipment staging in regulated wetlands or subaqueous lands.
6. The permittee shall employ measures during construction to prevent spills of fuels or lubricants. In the event of a spill, efforts shall be taken to prevent its entry into wetlands and aquatic areas. Any spills entering wetlands and aquatic areas shall be removed immediately. This office shall be notified of any spill(s) within six hours of occurrence. This office will determine the effectiveness of spill and contamination removal and specify remediation as necessary.
7. All equipment and machinery utilized in construction shall arrive on-site in a clean condition and shall be maintained free of fluid leaks. An emergency spill kit shall be available on-site to handle any fluid leaks or spills from machinery.
8. This permit is granted for the purpose of restoring and stabilizing the shoreline, as stated in the application. Any other use without prior approval shall constitute reason for this Permit being revoked.

10. The work authorized by this permit is subject to the terms and conditions of the appropriate Department of the Army Permit.

IN WITNESS WHEREOF, I, Steven M. Smailer, the duly authorized representative of David S. Small, Secretary of the Department of Natural Resources and Environmental Control, have hereunto set my hand this 10th day of November, 2016.



By Steven M. Smailer, Section Manager
the duly authorized representative of the Secretary of the
Department of Natural Resources and Environmental Control



Matthew Jones, Environmental Scientist
Wetlands and Subaqueous Lands Section



STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES &
ENVIRONMENTAL CONTROL
DIVISION OF WATER
89 KINGS HIGHWAY
DOVER, DELAWARE 19901

GENERAL CONDITIONS

1. The permittee and contractor shall at all times comply with all applicable laws and regulations of the Department of Natural Resources and Environmental Control.
2. The activities authorized herein shall be undertaken in accordance with the Permit conditions, the final stamped and approved plans, and with the information provided in the Permit application.
3. A copy of this Permit and the stamped approved plans shall be available on-site during all phases of construction activity.
4. The conditions contained herein shall be incorporated into any and all construction contracts associated with the construction authorized herein. The permittee and contractor are responsible to ensure that the workers executing the activities authorized by this Permit have full knowledge of, and abide by, the terms and conditions of this Permit.
5. No portion of the structure shall be constructed using creosote treated lumber.
6. No portion of the structure(s) authorized by this Permit shall exceed the dimensions for that structure identified on Page One of this Permit.
7. The activities authorized herein shall be conducted so as not to violate the State of Delaware's Surface Water Quality Standards in effect at the date of Permit authorization.
8. The issuance of this Permit does not constitute approval for any activities that may be required by any other local, state or federal government agency.
9. The issuance of this Permit does not imply approval of any other part, phase, or portion of any overall project the permittee may be contemplating.
10. This Permit authorizes only the activities described herein. Modifications to the project may require a supplemental approval from this office prior to the initiation of construction. A determination of the need for a supplemental approval will be made by this office pursuant to the permittee submitting written notification and revised plans indicating project changes. Failure to contact the Department prior to executing changes to the project shall constitute reason for this Permit being revoked.
11. The Contractors Completion Report shall be filled out and returned within 10 days of completion of the authorized work.
12. The permittee shall protect and hold the State of Delaware harmless from any loss, cost or damage resulting from the activities authorized herein.
13. Representatives of the Department of Natural Resources and Environmental Control shall be allowed to access the property to inspect all work during any phase of the construction and may conduct pre and post-construction inspections, collect any samples or conduct any tests that are deemed necessary.
14. The permittee shall maintain all authorized structures and activities in a good and safe condition.

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STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES &
ENVIRONMENTAL CONTROL
DIVISION OF WATER
89 KINGS HIGHWAY
DOVER, DELAWARE 19901

WETLANDS & SUBAQUEOUS
LANDS SECTION

TELEPHONE (302) 739-9943
FAX (302) 739-6304

**SUBAQUEOUS LANDS PERMIT
CONTRACTOR'S COMPLETION REPORT
POST-CONSTRUCTION**

Subaqueous Lands Permit Number: SP-327/16

Name: DNREC Division of Fish & Wildlife

Address: 89 Kings Hwy
Dover, DE 19901

Parcel #: 130100009

I hereby certify that I have constructed the project authorized by the above-referenced Subaqueous Lands Permit in accordance with the approved plans for the project.

Printed Name of Contractor

Name of Company

Contractor's Signature

Date

Telephone Number

Upon completion of construction, this form shall be completed, signed by the contractor, and mailed to the Wetlands and Subaqueous Lands Section at:

**DNREC
Wetlands and Subaqueous Lands Section
89 Kings Highway
Dover, Delaware 19901**

Or faxed to the Wetlands and Subaqueous Lands Section at: **302-739-6304**

This form must be received by the Department within ten days of the date that construction is completed.

=====
For official use only

Compliance inspection date _____ *Built in accordance with plans* Yes No

Scientist: _____

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APPENDIX B

PROTECTIVE COATINGS



Protective & Marine Coatings

MIL-DTL-24441D, TYPE IV EPOXY POLYAMIDE

N10-450 SERIES

Revised 7/10

PRODUCT INFORMATION

9.33

PRODUCT DESCRIPTION

MIL-24441, TYPE IV is a low VOC, epoxy polyamide system, formulated for immersion service and to protect surfaces from environmental attack. For use where air pollution regulations for marine coatings are restricted to a maximum of 340 g/L or 2.8 lb/gal.

PRODUCT CHARACTERISTICS

Finish:	Low sheen	
Color:	Volume Solids:	
Primer:	Formula 150 Green	67.3 ± 1%
Finish:	Formula 151 Haze Gray	66.2 ± 1%
	Formula 152 White	67.2 ± 1%
	Formula F153 Dark Gray	67.0 ± 1%
	Formula F154 Dark Gray	67.0 ± 1%
	Formula F155 Dark Gray	67.0 ± 1%
	Formula F156 Red	67.0 ± 1%
VOC (EPA Method 24):	340 g/l; 2.8 lb/gal, maximum, mixed	
Mix Ratio:	1:1 by volume	

Recommended Spreading Rate per coat:

	Minimum	Maximum
Wet mils (microns)	6.0 150	9.0 225
Dry mils (microns)	4.0 100	6.0 150
~Coverage sq ft/gal (m²/L)	175 4.3	265 6.5
Theoretical coverage sq ft/gal (m²/L) @ 1 mil / 25 microns dft	1072 26.3	

NOTE: Brush or roll application may require multiple coats to achieve maximum film thickness and uniformity of appearance.

Drying Schedule @ 6.0 mils wet (150 microns):

	35-40°F (1.6-4.5°C)	41-60°F (4.5-16°C)	61-80°F (16-27°C) 50% RH	81-100°F (27-38°C)
Dry to touch:	12 hours	8 hours	6 hours	4 hours
To recoat:				
minimum (epoxy):	24 hours	18 hours	12 hours	8 hours
minimum (non-epoxy)*:	12 hours	8 hours	6 hours	4 hours
maximum:	14 days	12 days	10 days	7 days
Cure to service:	6 days	5 days	4 days	64 hours

*An anti-foulant topcoat must be applied before the previous epoxy topcoat has hardened and while the epoxy is in a slightly tacky condition. This overcoat period is mainly dependent on the existing environmental conditions. If the epoxy is not tacky, an additional coat of epoxy must be applied to provide the required tacky condition.

Pot Life:	5 hours at 77°F/25°C, 50% RH
Sweat-in-Time:	None required

Shelf Life:	36 months, unopened Store indoors at 40°F (4.5°C) to 100°F (38°C)
Flash Point:	100°F (38°C), PMCC, mixed
Reducer/Clean Up:	Reducer #130, R7K130

RECOMMENDED USES

For use over prepared substrates such as steel and aluminum in industrial and marine environments where a hard, durable, chemical resistant coating is desired, such as:

- Marine vessels - bilges, tanks, underwater hulls
- Off shore platforms

PERFORMANCE CHARACTERISTICS

Complies with Military Specification MIL-DTL-24441, Type IV and is listed on NAVSEA QPL-24441.

Color Product Rex Number

Primer:		
Green - 150, Part A		N10G450
Hardener for Primer 150, Part B		N10V450

Finishes:		
Haze Gray - 151, Part A		N10A451
White - 152, Part A		N10W452
Dark Gray - 153, Part A		N10A453
Dark Gray - 154, Part A		N10A454
Dark Gray - 155, Part A		N10A455
Red - 156, Part A		N10R456
Yellow- 158, Part A		N10Y458
Hardener for 151-155, Part B		N10V451
Hardener for 156, Part B		N10V456
Hardener for 158, Part B		N10V458



Protective & Marine Coatings

MIL-DTL-24441D, TYPE IV EPOXY POLYAMIDE

N10-450 SERIES

PRODUCT INFORMATION

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RECOMMENDED SYSTEMS

	Dry Film Thickness / ct.	
	Mils	(Microns)
Steel:		
1 ct. MIL-24441, Type IV Primer	4.0-6.0	(100-150)
1 ct. MIL-24441, Type IV Epoxy	4.0-6.0	(100-150)
Steel:		
2 cts. MIL-24441, Type IV Epoxy	4.0-6.0	(100-150)
Steel, Non-Immersion (exterior):		
1 ct. MIL-24441, Type IV Primer	4.0-6.0	(100-150)
1 ct. MIL-PRF-24635	1.5-2.0	(40-50)
Steel, Non-Immersion (exterior):		
1 ct. MIL-24441, Type IV Primer	4.0-6.0	(100-150)
2 cts. DOD-E-24607	1.5-2.0	(40-50)
Aluminum:		
1 ct. MIL-24441, Type IV Primer	4.0-6.0	(100-150)
1 ct. MIL-24441, Type IV Epoxy	4.0-6.0	(100-150)

The systems listed above are representative of the product's use, other systems may be appropriate.

SURFACE PREPARATION

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Refer to product Application Bulletin for detailed surface preparation information.

Minimum recommended surface preparation:

Iron & Steel	
Atmospheric:	SSPC-SP6/NACE 3, 2.0 mil (50 micron) profile
Immersion:	SSPC-SP10/NACE 2, 1.0-3.0 mil (25-75 micron) profile
Aluminum: SSPC-SP7 or Power Wire Brush	

Surface Preparation Standards

Condition of Surface	ISO 8501-1 BS7079:A1	Swedish Std. SIS055900	SSPC	NACE
White Metal	Sa 3	Sa 3	SP 5	1
Near White Metal	Sa 2.5	Sa 2.5	SP 10	2
Commercial Blast	Sa 2	Sa 2	SP 6	3
Brush-Off Blast	Sa 1	Sa 1	SP 7	4
Hand Tool Cleaning	C St 2	C St 2	SP 2	-
Pitted & Rusted	D St 2	D St 2	SP 2	-
Rusted	C St 3	C St 3	SP 3	-
Power Tool Cleaning	Pitted & Rusted D St 3	D St 3	SP 3	-

TINTING

Do not tint.

APPLICATION CONDITIONS

Temperature:	
air and surface:	35°F (1.6°C) minimum, 100°F (38°C) maximum
material:	60°F (16°C) minimum
	At least 5°F (2.8°C) above dew point
Relative humidity:	85% maximum

Refer to product Application Bulletin for detailed application information.

ORDERING INFORMATION

Packaging:	1 gallon (3.78L) and 5 gallon (18.9L) containers
Weight:	10.9 - 11.8 ± 0.2 lb/gal ; 1.3-1.4 Kg/L, mixed, depending on color

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

WARRANTY

The Sherwin-Williams Company warrants our products to be free of manufacturing defects in accord with applicable Sherwin-Williams quality control procedures. Liability for products proven defective, if any, is limited to replacement of the defective product or the refund of the purchase price paid for the defective product as determined by Sherwin-Williams. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY SHERWIN-WILLIAMS, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

DISCLAIMER

The information and recommendations set forth in this Product Data Sheet are based upon tests conducted by or on behalf of The Sherwin-Williams Company. Such information and recommendations set forth herein are subject to change and pertain to the product offered at the time of publication. Consult your Sherwin-Williams representative to obtain the most recent Product Data Information and Application Bulletin.



Protective & Marine Coatings

MIL-DTL-24441D, TYPE IV EPOXY POLYAMIDE

N10-450 SERIES

Revised 7/10

APPLICATION BULLETIN

9.33

SURFACE PREPARATIONS

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Iron & Steel (immersion service)

Remove all oil and grease from surface by Solvent Cleaning per SSPC-SP1. Minimum surface preparation is Near White Metal Blast Cleaning per SSPC-SP10/NACE 2. Blast clean all surfaces using a sharp, angular abrasive for optimum surface profile (1-3 mils / 25-75 microns). Remove all weld spatter and round all sharp edges. Prime any bare steel the same day as it is cleaned or before flash rusting occurs.

Iron & Steel (atmospheric service)

Remove all oil and grease from surface by Solvent Cleaning per SSPC-SP1. Minimum surface preparation is Commercial Blast Cleaning per SSPC-SP6/NACE 3. For better performance, use Near White Metal Blast Cleaning per SSPC-SP10/NACE 2. Blast clean all surfaces using a sharp, angular abrasive for optimum surface profile (2 mils / 50 microns). Prime any bare steel the same day as it is cleaned or before flash rusting occurs.

Aluminum

Remove all oil, grease, dirt, oxide and other foreign material by Solvent Cleaning per SSPC-SP1. Minimum surface preparation is Brush Off Blast Cleaning per SSPC-SP7.

Surface Preparation Standards

Condition of Surface	ISO 8501-1 BS7079:A1	Swedish Std. SIS055900	SSPC	NACE
White Metal	Sa 3	Sa 3	SP 5	1
Near White Metal	Sa 2.5	Sa 2.5	SP 10	2
Commercial Blast	Sa 2	Sa 2	SP 6	3
Brush-Off Blast	Sa 1	Sa 1	SP 7	4
Hand Tool Cleaning	CCSt 2	CCSt 2	SP 13	-
Pitted & Rusted	CCSt 2	CCSt 2	SP 13	-
Rusted	CCSt 3	CCSt 3	SP 13	-
Power Tool Cleaning	CCSt 3	CCSt 3	SP 13	-
Pitted & Rusted	CCSt 3	CCSt 3	SP 13	-

APPLICATION CONDITIONS

Temperature:
 air and surface: 35°F (1.6°C) minimum, 100°F (38°C) maximum
 material: 60°F (16°C) minimum
 At least 5°F (2.8°C) above dew point

Relative humidity: 85% maximum

APPLICATION EQUIPMENT

The following is a guide. Changes in pressures and tip sizes may be needed for proper spray characteristics. Always purge spray equipment before use with listed reducer. Any reduction must be compliant with existing VOC regulations and compatible with the existing environmental and application conditions.

Reducer/Clean Up Reducer #130, R7K130

Airless Spray

Pump.....30:1 minimum
 Hose.....3/8" ID
 Tip0.015"
 Filter.....30 mesh
 Reduction.....As needed up to 5% by volume

Conventional Spray

GunDeVilbiss MBC
 Air Cap.....64°
 Needle.....D
 Atomization Pressure.....70 psi
 Fluid Pressure.....30 psi
 Reduction.....As needed up to 5% by volume

Brush

Brush.....Natural Bristle
 Reduction.....Not recommended

Roller

Cover3/8" woven with solvent resistant core
 Reduction.....Not recommended

If specific application equipment is not listed above, equivalent equipment may be substituted.



Protective & Marine Coatings

MIL-DTL-24441D, TYPE IV EPOXY POLYAMIDE

N10-450 SERIES

APPLICATION BULLETIN

9.33

APPLICATION PROCEDURES

Surface preparation must be completed as indicated.

Mix contents of each component thoroughly with low speed power agitation. Make certain no pigment remains on the bottom of the can. Then combine one part by volume of Part A with one part by volume of Part B. Thoroughly agitate the mixture with power agitation. Allow the material to sweat-in as indicated below prior to application. Re-stir before using.

If reducer solvent is used, add only after both components have been thoroughly mixed.

Apply paint at the recommended film thickness and spreading rate as indicated below:

Recommended Spreading Rate per coat:

	Minimum	Maximum
Wet mils (microns)	6.0 150	9.0 225
Dry mils (microns)	4.0 100	6.0 150
~Coverage sq ft/gal (m ² /L)	175 4.3	265 6.5
Theoretical coverage sq ft/gal (m ² /L) @ 1 mil / 25 microns dft	1072 26.3	

NOTE: Brush or roll application may require multiple coats to achieve maximum film thickness and uniformity of appearance.

Drying Schedule @ 6.0 mils wet (150 microns):

	35-40°F (1.6-4.5°C)	41-60°F (4.5-16°C)	61-80°F (16-27°C) 50% RH	81-100°F (27-38°C)
Dry to touch:	12 hours	8 hours	6 hours	4 hours
To recoat:				
minimum (epoxy):	24 hours	18 hours	12 hours	8 hours
minimum (non-epoxy)*:	12 hours	8 hours	6 hours	4 hours
maximum:	14 days	12 days	10 days	7 days
Cure to service:	6 days	5 days	4 days	64 hours

*An anti-foulant topcoat must be applied before the previous epoxy topcoat has hardened and while the epoxy is in a slightly tacky condition. This overcoat period is mainly dependent on the existing environmental conditions. If the epoxy is not tacky, an additional coat of epoxy must be applied to provide the required tacky condition.

Pot Life: 5 hours at 77°F/25°C, 50% RH
Sweat-in-Time: None required

Application of coating above maximum or below minimum recommended spreading rate may adversely affect coating performance.

CLEAN UP INSTRUCTIONS

Clean spills and spatters immediately with Reducer #130, R7K130. Clean tools immediately after use with Reducer #130, R7K130. Follow manufacturer's safety recommendations when using any solvent.

DISCLAIMER

The information and recommendations set forth in this Product Data Sheet are based upon tests conducted by or on behalf of The Sherwin-Williams Company. Such information and recommendations set forth herein are subject to change and pertain to the product offered at the time of publication. Consult your Sherwin-Williams representative to obtain the most recent Product Data Information and Application Bulletin.

PERFORMANCE TIPS

Stripe coat all crevices, welds, and sharp angles to prevent early failure in these areas.

When using spray application, use a 50% overlap with each pass of the gun to avoid holidays, bare areas, and pinholes. If necessary, cross spray at a right angle

Spreading rates are calculated on volume solids and do not include an application loss factor due to surface profile, roughness or porosity of the surface, skill and technique of the applicator, method of application, various surface irregularities, material lost during mixing, spillage, overthinning, climatic conditions, and excessive film build.

Excessive reduction of material can affect film build, appearance, and adhesion.

Excessive film build, poor ventilation, and cool temperatures may cause solvent entrapment and premature coating failure.

For Immersion Service: (if required) Holiday test in accordance with ASTM D5162 for steel, or ASTM D4787 for concrete.

Do not apply the material beyond recommended pot life.

Do not mix previously catalyzed material with new.

In order to avoid blockage of spray equipment, clean equipment before use or before periods of extended downtime with Reducer #130, R7K130.

For low temperature, atmospheric application, material should be at least 60°F (16°C).

Refer to Product Information sheet for additional performance characteristics and properties.

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

WARRANTY

The Sherwin-Williams Company warrants our products to be free of manufacturing defects in accord with applicable Sherwin-Williams quality control procedures. Liability for products proven defective, if any, is limited to replacement of the defective product or the refund of the purchase price paid for the defective product as determined by Sherwin-Williams. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY SHERWIN-WILLIAMS, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

MATERIAL SAFETY DATA SHEET

N10A453
22 00

DATE OF PREPARATION
May 28, 2016

SECTION 1 — PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NUMBER

N10A453

PRODUCT NAME

MIL-DTL-24441D/32B Paint, Epoxy-Polyamide, Type IV, Formula 153, Dark Gray Ro1.8

MANUFACTURER'S NAME

THE SHERWIN-WILLIAMS COMPANY
101 W. Prospect Avenue
Cleveland, OH 44115

Telephone Numbers and Websites

Product Information	(800) 524-5979
Regulatory Information	(216) 566-2902 www.paintdocs.com
Medical Emergency	(216) 566-2917
Transportation Emergency*	(800) 424-9300
*for Chemical Emergency ONLY (spill, leak, fire, exposure, or accident)	

SECTION 2 — COMPOSITION/INFORMATION ON INGREDIENTS

% by Weight	CAS Number	Ingredient	Units	Vapor Pressure
22	71-36-3	1-Butanol	ACGIH TLV	20 PPM
			OSHA PEL	50 ppm (Skin) CEILING
8	100-51-6	Phenylmethanol	ACGIH TLV	Not Available
			OSHA PEL	Not Available
3	Proprietary	Amidoamine Polymer	ACGIH TLV	Not Available
			OSHA PEL	Not Available
17	68410-23-1	Polyamide	ACGIH TLV	Not Available
			OSHA PEL	Not Available
36	14807-96-6	Talc	ACGIH TLV	2 mg/m3 as Resp. Dust
			OSHA PEL	2 mg/m3 as Resp. Dust
0.4	13463-67-7	Titanium Dioxide	ACGIH TLV	10 mg/m3 as Dust
			OSHA PEL	10 mg/m3 Total Dust
			OSHA PEL	5 mg/m3 Respirable Fraction

SECTION 3 — HAZARDS IDENTIFICATION

ROUTES OF EXPOSURE

INHALATION of vapor or spray mist.
EYE or SKIN contact with the product, vapor or spray mist.

EFFECTS OF OVEREXPOSURE

EYES: Causes burns.

SKIN: Causes burns.

INHALATION: Irritation of the upper respiratory system.

May cause nervous system depression. Extreme overexposure may result in unconsciousness and possibly death.

Prolonged overexposure to hazardous ingredients in Section 2 may cause adverse chronic effects to the following organs or systems:

- the liver
- the urinary system
- the nervous system

HMIS Codes

Health	3*
Flammability	2
Reactivity	0

SIGNS AND SYMPTOMS OF OVEREXPOSURE

Headache, dizziness, nausea, and loss of coordination are indications of excessive exposure to vapors or spray mists. Redness and itching or burning sensation may indicate eye or excessive skin exposure.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE

May cause allergic skin reaction in susceptible persons or skin sensitization.

CANCER INFORMATION

For complete discussion of toxicology data refer to Section 11.

SECTION 4 — FIRST AID MEASURES

EYES: Flush eyes with large amounts of water for 15 minutes. Get medical attention **IMMEDIATELY**.

SKIN: Wash affected area thoroughly with soap and water.
If irritation persists or occurs later, get medical attention.
Remove contaminated clothing and launder before re-use.

INHALATION: If affected, remove from exposure. Restore breathing. Keep warm and quiet.

INGESTION: Do not induce vomiting. Get medical attention immediately.

SECTION 5 — FIRE FIGHTING MEASURES

FLASH POINT 100 °F PMCC	LEL 1.3	UEL 13.0	FLAMMABILITY CLASSIFICATION Combustible, Flash above 99 and below 200 °F
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EXTINGUISHING MEDIA

Carbon Dioxide, Dry Chemical, Foam

UNUSUAL FIRE AND EXPLOSION HAZARDS

Closed containers may explode when exposed to extreme heat.

Application to hot surfaces requires special precautions.

During emergency conditions overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.

SPECIAL FIRE FIGHTING PROCEDURES

Full protective equipment including self-contained breathing apparatus should be used.

Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible autoignition or explosion when exposed to extreme heat.

SECTION 6 — ACCIDENTAL RELEASE MEASURES**STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED**

Remove all sources of ignition. Ventilate the area.

Remove with inert absorbent.

SECTION 7 — HANDLING AND STORAGE**STORAGE CATEGORY**

DOL Storage Class II

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

Contents are COMBUSTIBLE. Keep away from heat and open flame.

Consult NFPA Code. Use approved Bonding and Grounding procedures.

Keep container closed when not in use. Transfer only to approved containers with complete and appropriate labeling. Do not take internally.

Keep out of the reach of children.

SECTION 8 — EXPOSURE CONTROLS/PERSONAL PROTECTION**PRECAUTIONS TO BE TAKEN IN USE**

Use only with adequate ventilation.

Do not get in eyes or on skin. Avoid breathing vapor and spray mist.

Wash hands after using.

This coating may contain materials classified as nuisance particulates (listed "as Dust" in Section 2) which may be present at hazardous levels only during sanding or abrading of the dried film. If no specific dusts are listed in Section 2, the applicable limits for nuisance dusts are ACGIH TLV 10 mg/m3 (total dust), 3 mg/m3 (respirable fraction), OSHA PEL 15 mg/m3 (total dust), 5 mg/m3 (respirable fraction).

VENTILATION

Local exhaust preferable. General exhaust acceptable if the exposure to materials in Section 2 is maintained below applicable exposure limits. Refer to OSHA Standards 1910.94, 1910.107, 1910.108.

RESPIRATORY PROTECTION

If personal exposure cannot be controlled below applicable limits by ventilation, wear a properly fitted organic vapor/particulate respirator approved by NIOSH/MSHA for protection against materials in Section 2.

When sanding or abrading the dried film, wear a dust/mist respirator approved by NIOSH/MSHA for dust which may be generated from this product, underlying paint, or the abrasive.

PROTECTIVE GLOVES

To prevent skin contact, wear gloves which are recommended by glove supplier for protection against materials in Section 2.

EYE PROTECTION

To prevent eye contact, wear safety spectacles with unperforated sideshields.

OTHER PROTECTIVE EQUIPMENT

Use barrier cream on exposed skin.

OTHER PRECAUTIONS

This product must be mixed with other components before use. Before opening the packages, READ AND FOLLOW WARNING LABELS ON ALL COMPONENTS.

Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal.

SECTION 9 — PHYSICAL AND CHEMICAL PROPERTIES

PRODUCT WEIGHT	11.18 lb/gal	1339 g/l
SPECIFIC GRAVITY	1.35	
BOILING POINT	243 - 405 °F	117 - 207 °C
MELTING POINT	Not Available	
VOLATILE VOLUME	48%	
EVAPORATION RATE	Slower than ether	
VAPOR DENSITY	Heavier than air	
SOLUBILITY IN WATER	Not Available	
VOLATILE ORGANIC COMPOUNDS (VOC Theoretical - As Packaged)		
	3.49 lb/gal 419 g/l	Less Water and Federally Exempt Solvents
	3.49 lb/gal 419 g/l	Emitted VOC
VOLATILE ORGANIC COMPOUNDS (VOC - As Applied)		
	<2.83 lb/gal <340 g/l	Less Water and Federally Exempt Solvents

SECTION 10 — STABILITY AND REACTIVITY**STABILITY — Stable****CONDITIONS TO AVOID**

None known.

INCOMPATIBILITY

None known.

HAZARDOUS DECOMPOSITION PRODUCTS

By fire: Carbon Dioxide, Carbon Monoxide

HAZARDOUS POLYMERIZATION

Will not occur

SECTION 11 — TOXICOLOGICAL INFORMATION**CHRONIC HEALTH HAZARDS**

Reports have associated repeated and prolonged overexposure to solvents with permanent brain and nervous system damage. IARC's Monograph No. 93 reports there is sufficient evidence of carcinogenicity in experimental rats exposed to titanium dioxide but inadequate evidence for carcinogenicity in humans and has assigned a Group 2B rating. In addition, the IARC summary concludes, "No significant exposure to titanium dioxide is thought to occur during the use of products in which titanium is bound to other materials, such as paint."

TOXICOLOGY DATA

CAS No.	Ingredient Name			
71-36-3	1-Butanol	LC50 RAT	4HR	8000 ppm
		LD50 RAT		790 mg/kg
100-51-6	Phenylmethanol	LC50 RAT	4HR	Not Available
		LD50 RAT		Not Available
Proprietary	Amidoamine Polymer	LC50 RAT	4HR	Not Available
		LD50 RAT		3450. mg/kg
68410-23-1	Polyamide	LC50 RAT	4HR	Not Available
		LD50 RAT		Not Available
14807-96-6	Talc	LC50 RAT	4HR	Not Available
		LD50 RAT		Not Available
13463-67-7	Titanium Dioxide	LC50 RAT	4HR	Not Available
		LD50 RAT		Not Available

SECTION 12 — ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION

No data available.

SECTION 13 — DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD

Waste from this product may be hazardous as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261. Waste must be tested for ignitability to determine the applicable EPA hazardous waste numbers. Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State/Provincial, and Local regulations regarding pollution.

SECTION 14 — TRANSPORT INFORMATION

Multi-modal shipping descriptions are provided for informational purposes and do not consider container sizes. The presence of a shipping description for a particular mode of transport (ocean, air, etc.), does not indicate that the product is packaged suitably for that mode of transport. All packaging must be reviewed for suitability prior to shipment, and compliance with the applicable regulations is the sole responsibility of the person offering the product for transport.

US Ground (DOT)

May be Classed as a Combustible Liquid for U.S. Ground.
UN1263, PAINT, 3, PG III, (ERG#128)

DOT (Dept of Transportation) Hazardous Substances & Reportable Quantities

1-Butanol 5000 lb RQ
Xylenes (mixed isomers) 100 lb RQ

Bulk Containers may be Shipped as (check reportable quantities):

UN1263, PAINT, 3, PG III, (ERG#128)

Canada (TDG)

May be Classed as a Combustible Liquid for Canadian Ground.
UN1263, PAINT, 3, PG III, (ERG#128)

IMO

5 Liters (1.3 Gallons) and Less may be Shipped as Limited Quantity.
UN1263, PAINT, 3, PG III, (38 C c.c.), EmS F-E, ~~S-E~~

IMO

5 Liters (1.3 Gallons) and Less may be Shipped as Limited Quantity.
UN1263, PAINT, 3, PG III, (38 C c.c.), EmS F-E, ~~S-E~~

IATA/ICAO

UN1263, PAINT, 3, PG III

SECTION 15 — REGULATORY INFORMATION

SARA 313 (40 CFR 372.65C) SUPPLIER NOTIFICATION

CAS No.	CHEMICAL/COMPOUND	% by WT	% Element
71-36-3	1-Butanol	22	

CALIFORNIA PROPOSITION 65

WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

TSCA CERTIFICATION

All chemicals in this product are listed, or are exempt from listing, on the TSCA Inventory.

SECTION 16 — OTHER INFORMATION

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

The above information pertains to this product as currently formulated, and is based on the information available at this time. Addition of reducers or other additives to this product may substantially alter the composition and hazards of the product. Since conditions of use are outside our control, we make no warranties, express or implied, and assume no liability in connection with any use of this information.

APPENDIX C

WEIR GATES SPECIFICATIONS

SECTION _____
STAINLESS STEEL SLIDE & WEIR GATES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall furnish all labor, materials, equipment and incidentals required to install, ready for operation and field test stainless steel gates and appurtenances as shown on the Contract Drawings and as specified herein.
- B. The gates and appurtenances shall be supplied in accordance with the latest edition of AWWA C561 Standard for Fabricated Stainless Steel Slide Gates as modified herein. The allowable leakage rate for the stainless steel gates in this specification shall be 1/2 the allowable leakage listed in the latest revision of AWWA C561.

1.02 SUBMITTALS

- A. Provide the following information to confirm compliance with the specification in addition to the submittal requirements specified in Section _____.
 - 1. Complete description of all materials including the material thickness of all structural components of the frame and slide.
 - 2. Installation drawings showing all details of construction, details required for installation, dimensions and anchor bolt locations.
 - 3. Maximum bending stress and deflection of the slide under the maximum design head.
 - 4. The location of the company headquarters and the location of the principle manufacturing facility. Provide the name of the company that manufactures the equipment if the supplier utilizes an outside source.

1.03 QUALITY ASSURANCE

- A. Qualifications
 - 1. All of the equipment specified under this Section shall be furnished by a single manufacturer with a minimum of 20 years of experience designing and manufacturing water control gates. The manufacturer shall have manufactured water control gates for a minimum of 100 projects and at least 5 projects of similar design within the last 5 years.
 - 2. The specification is based on the FC-SS Series Stainless Steel Gate as manufactured by Mechanical Associates of 3 Fresno, CA.



PART 2 EQUIPMENT

2.01 GENERAL

- A. Gates shall be as specified herein and have the characteristics and dimensions shown on the Contract Drawings.
- B. Leakage shall not exceed 0.10 gpm/ft of wetted seal perimeter in seating head and unseating head conditions.
- C. The gate shall utilize self-adjusting seals. Due to the difficulty of accessing gates when they are in service, gates that utilize adjustable wedges, wedging devices or pressure pads are not acceptable.
- D. All structural components of the frame and slide shall be fabricated of stainless steel having a minimum thickness of 1/4-inch and shall have adequate strength to prevent distortion during normal handling, during installation and while in service.
- E. All welds shall be performed by welders with AWS certification and when required, weld burn and welds shall be passivated.
- F. Finish: Mill finish on stainless steel. All iron and steel components shall be properly prepared and shop coated with a primer.
- G. Materials:

Components

Materials

Frame Assembly, Yoke, & Retainers	Stainless Steel, Type 304L or 316L, ASTM A240
Slide and Stiffeners	Stainless Steel, Type 304L or 316L, ASTM A240
Stem	Stainless Steel, Type 304 or 316L, ASTM A276
Fasteners, Nuts and Bolts	Stainless Steel, Type 304 or 316L, ASTM A276
Flush Bottom	Neoprene ASTM D-2000 or EPDM
Seat/Seals and Facing	Ultra-High Molecular Weight Polyethylene ASTM D4020
Lift Nuts	Bronze ASTM B584
Pedestals and Wall Brackets	Stainless Steel, Type 304L or 316L, ASTM A276
Operator Housing	Cast aluminum or ductile iron



2.02 FRAME

- A. The frame assembly, including the guide members, invert member and yoke members, shall be constructed of formed stainless steel plate with a minimum thickness of 1/4-inch.
1. Frame design shall allow for embedded mounting, mounting directly to a wall with stainless steel anchor bolts and grout or mounting to a wall thimble with stainless steel mounting studs and a mastic gasket material. Mounting style shall be as shown on the Contract Drawings.
 2. All wall mounted or wall thimble mounted gates shall have a flange frame. Flat frame gates are not acceptable.
 3. The structural portion of the frame that incorporates the seat/seals shall be formed into a one-piece c-channel shape for rigidity.
 4. Gussets shall be provided as necessary to support the guide members in an unseating head condition. The gussets shall extend to support the outer portion of the guide assembly and shall be positioned to ensure that the load is transferred to the anchor bolts or the wall thimble studs.
 5. The frame shall extend to accommodate two thirds the height of the slide when the slide is in the fully opened position on upward opening gates or downward opening weir gates.
 6. On self-contained gates, a yoke shall be provided across the top of the frame. The yoke shall be formed by a single formed structural member or two structural members affixed to the top of the side frame members to provide a one-piece rigid assembly. The yoke shall be designed to allow removal of the slide.
 7. A rigid stainless steel invert member shall be provided across the bottom of the opening. The invert member shall be of the flush bottom type on upward opening gates.
 8. A rigid stainless steel top seal member shall be provided across the top of the opening on gates designed to cover submerged openings.
 9. A rigid stainless steel member shall be provided across the invert of the opening on downward opening weir gates.

2.03 SLIDE

- A. The slide and reinforcing stiffeners shall be constructed of stainless steel plate. All structural components shall have a minimum thickness of 1/4-inch.
1. The slide shall not deflect more than 1/720 of the span or 1/16 inch, whichever is smaller, under the maximum design head.
 2. Stiffeners shall be welded on the outside of the horizontal stiffeners for additional reinforcement.
 3. The stem connector shall be constructed of two angles or formed plates. The stem connector shall be welded to the slide. A minimum of two bolts shall connect the stem to the stem connector.

2.04 SEALS

- A. All gates shall be provided with a self-adjusting UHMW polyethylene seal system to restrict leakage in accordance with the requirements listed in this specification.
1. All gates shall be equipped with UHMW polyethylene seat/seals to restrict leakage and to prevent metal to metal contact between the frame and slide.

2. The seat/seals shall extend to accommodate 2/3 of the slide when gate is fully opened.
3. All upward opening gates shall be provided with a resilient seal to seal the bottom portion of the gate. The seal shall be attached to the invert member or the bottom of the slide.
4. All downward opening weir gates shall be provided with UHMW polyethylene seat/seals across the invert member.
5. The seal system shall be durable and shall be designed to accommodate high velocities and frequent cycling without loosening or suffering damage.
6. All side seals must be bolted or otherwise mechanically fastened to the frame or slide.
7. The seals shall be mounted so as not to obstruct the water way opening.
8. Gates that utilize rubber "J" seals or "P" seals are not acceptable.
9. The seal system shall have been factory tested to confirm negligible wear (less than 0.01") and proper sealing. The factory testing shall consist of an accelerated wear test comprised of a minimum of 30,000 open-close cycles using a well-agitated sand/water mixture to simulate fluidized grit.

2.05 STEM

- A. A threaded operating stem shall be utilized to connect the operating mechanism to the slide. On rising stem gates, the threaded portion shall engage the operating nut in the manual operator or motor actuator. On non-rising stem gates, the threaded portion shall engage the nut on the slide.
 1. The threaded portion of the stem shall have a minimum outside diameter of 1-1/2 inches.
 2. The stem shall be constructed having a tensile strength of not less than 90,000 psi for stems that are 3 inches or less in diameter. Stems that are in excess of 3 inches in diameter shall have a tensile strength of 85,000 psi.
 3. The stem shall be threaded to allow full travel of the slide unless the travel distance is otherwise shown on the Contract Drawings.
 4. Maximum L/R ratio for the unsupported part of the stem shall not exceed 200.
 5. In compression, the stem shall be designed for a critical buckling load caused by a 40 lb effort on the crank or handwheel with a safety factor of 2, using the Euler column formula.
 6. The stem shall be designed to withstand the tension load caused by the application of a 40 lb effort on the crank or handwheel without exceeding 1/5 of the ultimate tensile strength of the stem material.
 7. The threaded portion of the stem shall have machine rolled threads of the Acme type with a 16 micro inch finish or better.
 8. Stems of more than one section shall be joined by stainless steel or bronze couplings. The coupling shall be bolted to the stems.
 9. Stems, on manually operated gates, shall be provided with adjustable stop collars or slide stops to prevent over closing of the slide.

2.06 STEM GUIDES

- A. Stem guide shall be provided when necessary to ensure that the maximum L/R ratio for the unsupported part of the stem is 200 or less.
1. Stem guide brackets shall be fabricated of stainless steel and shall be outfitted with UHMW or bronze bushings.
 2. Adjustable in two directions.

2.07 WALL THIMBLES

- A. Wall thimbles shall be provided when shown on the Contract Drawings.
1. The wall thimble depth shall be equal to the thickness of the concrete wall in which the thimble is to be mounted.
 2. Wall thimbles shall be fabricated stainless steel construction of adequate section to withstand all operational and reasonable installation stresses.
 3. Wall thimbles shall be constructed of 1/4-inch minimum thickness stainless steel and the front face shall have a minimum thickness of 1/4-inch.
 4. The fabrication process shall ensure that the wall thimble is square and plumb and the front face is sufficiently flat to provide a proper mounting surface for the gate frame.
 5. A water stop shall be welded around the periphery of the thimble. Wall thimbles shall be designed to allow thorough and uniform concrete placement during installation.
 6. Studs and nuts shall be stainless steel. Water stop must be continuous welded.
 7. A suitable gasket or mastic shall be provided by contractor to seal between the gate frame and the wall thimble.

2.08 MANUAL OPERATORS

- A. Unless otherwise shown on the Drawings, gates shall be operated by a manual handwheel or a manual crank-operated gearbox. The operator shall be mounted on the yoke of self contained gates or on the pedestal of non-self contained gates.
1. The gate manufacturer shall select the proper gear ratio to ensure that the gate can be operated with no more than a 40 lb effort when the gate is in the closed position and experiencing the maximum operating head.
 2. An arrow with the word "OPEN" shall be permanently attached or cast onto the operator to indicate the direction or rotation to open the gate.
 3. Handwheel operators shall be fully enclosed and shall have a cast ductile iron housing.
 - a. Handwheel operators shall be provided with a threaded cast bronze lift nut to engage the operating stem with UHMW PE bearings for standard lifts.
 - b. Handwheel operators may be equipped with roller bearings above and below the operating nut when required.
 - c. Positive mechanical seals can be provided above and below the operating nut to exclude moisture and dirt and prevent leakage of lubricant out of the hoist when required.
 - d. The handwheel shall be removable and shall have a minimum diameter of 14 inches.

4. Crank-operated gearboxes shall be fully enclosed and shall have a cast aluminum or ductile iron housing.
 - a. Gearboxes shall have either single or double gear reduction depending upon the lifting capacity required.
 - b. Gearboxes shall be provided with a threaded cast bronze lift nut to engage the operating stem.
 - c. Bearings shall be provided above and below the flange on the operating nut to support both opening and closing thrusts.
 - d. Gears shall be steel with machined cut teeth designed for smooth operation.
 - e. The pinion shaft shall be supported on ball or tapered roller bearings.
 - f. Positive mechanical seals shall be provided on the operating nut and the pinion shafts to exclude moisture and dirt and prevent leakage of lubricant out of the hoist.
 - g. The crank shall be cast aluminum or cast iron with a revolving nylon grip.
 - h. The crank shall be removable.
5. All gates having widths greater than twice their height shall be provided with two gearboxes connected by an interconnecting shaft for simultaneous operation.
 - a. Interconnecting shafting shall be constructed of aluminum or stainless steel.
 - b. Universal style couplings shall be provided at each end of the interconnecting shaft.
 - c. One crank shall be provided to mount on the pinion shaft of one of the gearboxes.
6. An extended operator system utilizing chain and sprockets shall be furnished by the manufacturer when the centerline of the crank or handwheel, on a non-gear operator, is located over 48-in above the operating floor. Chain wheels are not acceptable.
 - a. A removable stainless steel or aluminum cover shall be provided to enclose chain and sprockets.
 - b. The extended operator system shall lower the centerline of the pinion shaft to 36-in above the operating floor.
 - c. A handwheel may be utilized in conjunction with a gearbox in lieu of the extended operator system if the centerline of the pinion shaft is 60-in or less above the operating floor.
7. Pedestals shall be constructed of stainless steel. Aluminum pedestals are not acceptable.
 - a. The pedestal height shall be such that the handwheel or pinion shaft on the crank-operated gearbox is located approximately 36-in above the operating floor.
 - b. Wall brackets shall be used to support floor stands where shown on the Drawings and shall be constructed of stainless steel.
 - c. Wall brackets shall be reinforced to withstand in compression at least two times the rated output of the operator with a 40 lb effort on the crank or handwheel.
 - d. The design and detail of the brackets and anchor bolts shall be provided by the gate manufacturer and shall be approved by the ENGINEER. The gate manufacturer shall supply the bracket, anchor bolts and accessories as part of the gate assembly.
8. Operators shall be equipped with fracture-resistant clear butyrate plastic stem covers.
 - a. The top of the stem cover shall be closed.
 - b. The bottom end of the stem cover shall be mounted in a housing or adapter for easy field mounting.
 - c. Stem covers shall be complete with indicator markings to indicate gate position.
9. When shown on the Contract Drawings, provide 2 inch square nut, mounted in a floor box, with a non-rising stem.
 - a. The square nut shall be constructed of bronze.
 - b. The floor box shall be constructed of stainless steel and shall be set in the concrete floor above the gate as shown.



- c. Provide one aluminum or stainless steel T-handle wrench for operation.

2.09 ELECTRIC MOTOR ACTUATORS

- A. See Section _____.

2.10 ANCHOR BOLTS

- A. Anchor bolts shall be provided by the gate manufacturer for mounting the gates and appurtenances.
 - 1. Quantity and location shall be determined by the gate manufacturer.
 - 2. If epoxy type anchor bolts are provided, the gate manufacturer shall provide the studs and nuts.
 - 3. Anchor bolts shall have a minimum diameter of 1/2-inch.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Installation of the gates and appurtenances shall be done in a workmanlike manner. It shall be the responsibility of the CONTRACTOR to handle, store and install the equipment specified in this Section in strict accordance with the manufacturer's recommendations.
- B. The CONTRACTOR shall review the installation drawings and installation instruction prior to installing the gates.
- C. The gate assemblies shall be installed in a true vertical plane, square and plumb.
- D. The CONTRACTOR shall fill the void in between the gate frame and the wall with non-shrink epoxy grout as shown on the installation drawing and in accordance with the manufacturer's recommendations.
- E. The CONTRACTOR shall add a mastic or neoprene gasket between the gate frame and wall thimble (when applicable) in accordance with the manufacturer's recommendations.

3.02 FIELD TESTING

- A. After installation, all gates shall be field tested in the presence of the ENGINEER and OWNER to ensure that all items of equipment are in full compliance with this Section. Each gate shall be cycled to confirm that they operate without binding, scraping, or distorting. The effort to open and close manual operators shall be measured, and shall not exceed the maximum operating effort specified above. Electric motor actuators shall function smoothly and without interruption. Each gate shall be water tested by the CONTRACTOR, at the discretion of the ENGINEER and OWNER, to confirm that leakage does not exceed the specified allowable leakage.





END OF SECTION

Mechanical Associates Contact Information
745 Broadway Street, Fresno, CA 93721 • Ph: 559.272.8157



APPENDIX D

CONCRETE REPAIR TECHNICAL GUIDELINES

DIVISION 3 - CONCRETE
Section 03730 - Concrete Rehabilitation

Part 1 – General

1.01 Summary

- A. This specification describes the patching or overlay of interior and/or exterior vertical and overhead surfaces with a pneumatically placed cementitious, silica fume, fiber-reinforced, high strength shrinkage-compensated portland cement mortar.

1.02 Quality Assurance

- A. Manufacturing qualifications: The manufacturer of the specified product shall be ISO 9001 certified and have in existence a recognized ongoing quality assurance program independently audited on a regular basis.
- B. Contractor qualifications: Contractor shall be a qualified in the field of concrete repair and protection with a successful track record of 5 years or more. Contractor shall maintain qualified personnel who have received product training by a manufacturer's representative.
- C. Install materials in accordance with all safety and weather conditions required by manufacturer or as modified by applicable rules and regulations of local, state and federal authorities having jurisdiction. Consult Material Safety Data Sheets for complete handling recommendations.

1.03 Delivery, Storage, and Handling

- A. All materials must be delivered in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers. Damaged material must be removed from the site immediately.
- B. Store all materials off the ground and protect from rain, freezing or excessive heat until ready for use.
- C. Condition the specified product as recommended by the manufacturer.

1.04 Job Conditions

- A. Environmental Conditions: Do not apply material if it is raining or snowing or if such conditions appear to be imminent. Minimum application temperature 45°F (7°C) and rising.
- B. Protection: Precautions should be taken to avoid damage to any surface near the work zone due to mixing and handling of the specified material.

1.05 Submittals

- A. Submit two copies of manufacturer's literature, to include: Product Data Sheets, and appropriate Material Safety Data Sheets (MSDS).

1.06 Warranty

- A. Provide a written warranty from the manufacturer against defects of materials for a period of one (1) year, beginning with date of substantial completion of the project.

Part 2 - Products

2.01 Manufacturer

- A. **SikaRepair 224**, as manufactured by Sika Corporation, is considered to conform to the requirements of this specification.

2.02 Materials

- A. Silica fume enhanced cementitious mortar:
 - 1. The mortar shall be a blend of selected portland cements, microsilica, fibers, and specially graded aggregates. It shall be applicable for horizontal, vertical, and overhead surfaces.
 - 2. The materials shall be non-combustible, both before and after cure.
 - 3. The materials shall be supplied in a factory-proportioned unit.
 - 4. The cementitious, microsilica mortar must be placeable from 3/8in.(9mm) in depth and greater.

2.03 Performance Criteria

- A. Typical Properties of the mixed silica fume enhanced, fiber reinforced cementitious mortar:
 - 1. Working Time: 45 minutes
 - 2. Finishing Time: immediately after spraying to several hours
 - 3. Color: dark gray
- B. Typical Properties of the cured silica fume enhanced, fiber reinforced cementitious mortar:
 - 1. Compressive Strength (ASTM C-109 Modified) – 3 inch cubes
 - a. 1 day: 4500 psi min. (31 MPa)
 - b. 7 day: 8000 psi min. (55 MPa)
 - c. 28 day: 10000 psi min. (69 MPa)
 - 2. Flexural Strength (ASTM C-78)
 - a. 28 days: 1100 psi (7.6 MPa)
 - 3. Splitting Tensile Strength (ASTM C-496)
 - a. 28 days: 735 psi (5.0 MPa)
 - 4. Slant Shear (ASTM C 882 modified):
 - a. 28 days: 3500 psi (24.1 Mpa)
 - 5. Setting Time (ASTM C 266)
 - Initial 2 to 3 hours
 - Final 5 to 6.5 hours
 - 6. Sulfate Resisistance (ASTM C1012)
 - Less than 0.06%
 - 7. Density (wet mix): 125 lbs./ cu. ft. (2.0 kg/l)
 - 8. The silica fume enhanced, cement mortar shall not produce a vapor barrier.

Note: Tests above were performed with the material and curing conditions @ 71°F – 75°F and 45-55% relative humidity.

Part 3 – Execution

3.01 Surface Preparation

- A. Areas to be repaired must be clean, sound, and free of contaminants. All loose and deteriorated concrete shall be removed by mechanical means. Mechanically prepare concrete substrate to obtain a minimum surface profile of CSP 6 or greater as per ICRI Guidelines with a new exposed aggregate surface. Area to be patched shall not be less than 3/8 in.in depth.
- B. Where reinforcing steel with active corrosion is encountered, sandblast the steel to a white metal finish to remove all contaminants and rust. Where corrosion has occurred due to the presence of chlorides, the steel shall be high pressure washed after mechanical cleaning. Prime steel with 2 coats of Sika Armatec 110 EpoCem as per the technical data sheet. (See Spec Component SC-201)

3.02 Mixing and Application

- A. Material is to be applied by conventional wet spray equipment. Consult TDS.
- B. Placement Procedure Wet Process: At time of application, surface should be saturated surface dry but hold no standing water. Apply material by spraying or troweling for repairing vertical or overhead surfaces. Shoot the material perpendicular to the surface. This minimizes rebound, creates the smoothest pattern (reduces bumps) and properly encases the rebars. The velocity of the shotcrete is sufficient if, at a distance of 18 to 24 in., the shotcrete pattern flattens out on contact with the surface and the rebars are encased. After applying the material, allow to stiffen for approx. 10 minutes before removing bumpy areas with a trowel. If a another layer is desired, allow the material to reach initial set. This will take anywhere from 45 minutes to 2-4 hours depending on mix consistency, mix and ambient temperature, wind conditions and humidity. Begin and finish a given patch on the same day.
- C. As per ACI recommendations for portland cement concrete, curing is required. Moist cure with wet burlap and polyethylene, a fine mist of water or a water-based* compatible curing compound. Moist curing should commence immediately after finishing. Protect newly applied material from rain, sun, and wind, and frost until compressive strength is 70% of the 28-day compressive strength. To prevent from freezing cover with insulating material. Setting time is dependent on temperature and humidity.

*Pretesting of curing compound is recommended.
- D. Adhere to all procedures, limitations and cautions for the silica fume, polymer-modified portland cement mortar in the manufacturers current printed technical data sheet and literature.

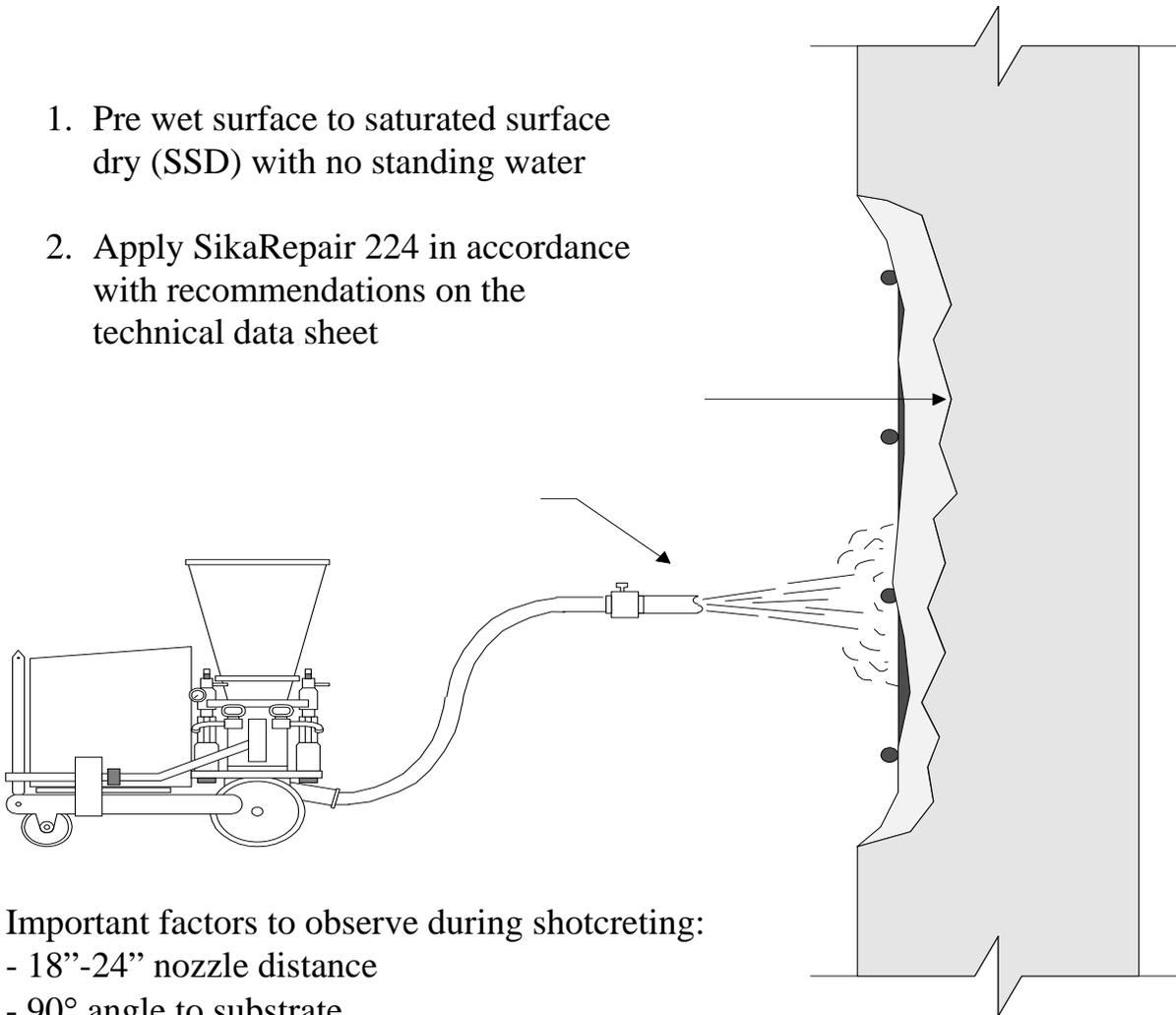
3.03 Cleaning

- A. The uncured silica-fume portland cement mortar can be cleaned from tools with water. The cured silica-fume, portland cement mortar can only be removed mechanically.
- B. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

SC-102 SikaRepair 224

Machine-applied (Wet Spray)

1. Pre wet surface to saturated surface dry (SSD) with no standing water
2. Apply SikaRepair 224 in accordance with recommendations on the technical data sheet



Important factors to observe during shotcreting:

- 18"-24" nozzle distance
- 90° angle to substrate
- consistency of mortar
- allow to stiffen for 10 minutes before removing bumpy areas with a trowel.
- use 6-7 pints of water per 50 lbs.
- use positive displacement pump equipment
- apply at low or high velocity

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SikaRepair® 224

One-component, cementitious, sprayable mortar for structural repairs

Description	SikaRepair® 224 is a one-component, pre-packaged, ready-to-use, cementitious, silica fume, fiber reinforced, high strength shrinkage-compensated mortar. Formulated for application by trowel or low pressure spray. It is designed especially for repair of overhead and vertical surfaces.
Where to Use	A high performance repair mortar for wet spray application. Suitable for new construction, repairs, and maintenance work. Typical applications include: <ul style="list-style-type: none"> ■ Structural repair material for water and wastewater treatment plants, parking structures, industrial plants, bridges, tunnels and dams, etc. ■ Use on vertical and overhead surfaces. ■ Use on grade, above, and below grade on concrete and mortar. ■ Potable water tank. (NSF approved in Marion, OH and Santa Fe Springs, CA)
Advantages	<ul style="list-style-type: none"> ■ Ready-for-use, one-component material. ■ Easy to use; just add water. ■ Sprayable system. ■ Potable water approved. ■ Superior workability. Can be trowelled and screeded after application. ■ Labor-saving system. ■ Superior abrasion resistance over conventional Portland cement mortar. ■ Bond strength ensures superior adhesion. ■ Not a vapor barrier. ■ Compatible with coefficient of thermal expansion of concrete. ■ Increased resistance to de-icing salts. ■ Good freeze/thaw resistance. ■ High early strengths. ■ Very low shrinkage. ■ Silica Fume enhanced. ■ Fiber reinforced.
Coverage	Yield in service will vary. Average yield is approximately 0.40 cu. ft./bag. Estimating should be based on prior experience or actual field evaluation.
Packaging	50-lb. (22.7 kg) multi-wall bags.

Typical Data (Material and curing conditions @ 73°F and 100% R.H.)

RESULTS MAY DIFFER BASED UPON STATISTICAL VARIATIONS DEPENDING UPON MIXING METHODS AND EQUIPMENT, TEMPERATURE, APPLICATION METHODS, TEST METHODS, ACTUAL SITE CONDITIONS AND CURING CONDITIONS.

Shelf Life	1 year in original, unopened bags.	
Storage Conditions	Store dry at 40°-95°F (4°-35°C). Condition material to 65°-75°F before using.	
Color	Dark gray.	
Mixing Ratio	3/4 gallon to 7/8 gallon liquid per 50 lb. bag of material	
Density (wet mix)	125 lbs./cu. ft. (2.0 kg./l.)	
Compressive Strength (ASTM C-109)	73°F	
	1 day	4,500 psi (31 MPa)
	7 day	8,000 psi (55 MPa)
	28 day	10,000 psi (69 MPa)
Flexural Strength (ASTM C-348)	28 day	1,100 psi (7.6 MPa)
Tensile Strength (ASTM C-496)	28 day	735 psi (5.0 MPa)
Direct Tensile Pull off (ACI 503)	28 day	greater than 350 psi (Failure in substrate. Substrate prepared with 20,000 psi hydroblasting)
Slant Shear (ASTM C -882 modified)	28 day	>2,500 psi (24.1 MPa)
Chloride Permeability (ASTM C1202/AASHTO T277)	28 day	less than 500 coulombs
Sulfate Resistance (ASTM C-1012)	1 year	less than 0.06%
Setting Time (ASTM C 266)	Initial: 2 to 3 hours. Final: 5 to 6.5 hours.	



PRIOR TO EACH USE OF ANY SIKA PRODUCT, THE USER MUST ALWAYS READ AND FOLLOW THE WARNINGS AND INSTRUCTIONS ON THE PRODUCT'S MOST CURRENT PRODUCT DATA SHEET, PRODUCT LABEL AND SAFETY DATA SHEET WHICH ARE AVAILABLE ONLINE AT [HTTP://USA.SIKA.COM/](http://usa.sika.com/) OR BY CALLING SIKA'S TECHNICAL SERVICE DEPARTMENT AT 800.933.7452 NOTHING CONTAINED IN ANY SIKA MATERIALS RELIEVES THE USER OF THE OBLIGATION TO READ AND FOLLOW THE WARNINGS AND INSTRUCTIONS FOR EACH SIKA PRODUCT AS SET FORTH IN THE CURRENT PRODUCT DATA SHEET, PRODUCT LABEL AND SAFETY DATA SHEET PRIOR TO PRODUCT USE.

How to Use

Surface Preparation

Substrate must be sound, clean, and free from oil, grease, loose material, surface contaminants and other bond-inhibiting materials. Steel reinforcement must be clean and free from any rust. Be sure repair area is not less than 3/8 in. in depth. Preparation work should be done by high pressure water blast, or other appropriate mechanical means, to obtain an exposed aggregate surface (CSP-6). Saturate surface with clean water. Substrate should be saturated surface dry (SSD) with no standing water during application. Reinforcing Steel: Steel reinforcement should be thoroughly prepared by mechanical cleaning to remove all traces of rust. Where corrosion has occurred due to the presence of chlorides, the steel should be high-pressure washed with clean water after mechanical cleaning. For priming of reinforcing steel, use Sika® Armatec® 110 EpoCem (consult Technical Data Sheet).

Priming

Concrete Substrate: Prime the prepared substrate with a brush or sprayed applied coat of Sika® Armatec® 110 EpoCem (consult Technical Data Sheet). Alternately, a scrub coat of Sika Repair 224 can be applied prior to placement of the mortar. The repair mortar has to be applied into the wet scrub coat before it dries

Mixing

With water: Add the water (approx. 3/4 gal.) directly into mixer. Start the mixer in motion and add the SikaRepair® 224 mortar while continuing to mix. Mix to uniform consistency using a maximum of 7/8 gallons of water per 50 lb. (22.7 kg.) bag (approx. 3 minutes).

With Latex R: Pour 6-7 pints of SikaLatex® R into the mixing container. Slowly add powder and mix as above.

With diluted Latex R: SikaLatex® R may be diluted up to 5:1 (water: SikaLatex® R) for projects requiring minimal polymer-modification. Pour 6-7 pints of the mixture into the mixing container. Slowly add powder and mix as above

SikaRepair 224 Concrete: For horizontal applications greater than 1 inch deep, add 3/8 inch coarse aggregate. Aggregate must be non-reactive (reference ASTM C1260, C227 and C289), clean, well-graded, saturated surface dry (SSD), have low absorption and high density, and comply with ASTM C33 size number 8 per Table 2. Addition rate must not exceed 25 lbs. of aggregate/bag of SikaRepair® 224 (25 lbs. of 3/8 in. aggregate is approximately 2.0 to 2.5 gal. by loose volume of aggregate). If the placement is vertical or overhead, temporary support of the material is required. Contact Sika Technical Service for application details.

Application

Conventional wet-process shotcreting equipment such as a low-pressure or a high-pressure machine should be used. At time of application, surfaces should be saturated surface dry but hold no standing water. Apply SikaRepair® 224 mortar by low pressure spraying or trowelling for repairing vertical or overhead surfaces. Shoot the shotcrete perpendicular to the surface. This minimizes rebound, creates the smoothest pattern (reduces 'bumps') and properly encases the rebars. The velocity of the shotcrete is sufficient if, at a distance of 18 to 24 in., the shotcrete pattern flattens out on contact with the surface and the rebars are encased. After applying the shotcrete, allow it to stiffen for about 10 minutes before removing bumpy areas with a trowel. Before applying the next layer, allow the shotcrete to reach initial set. This will take anywhere from 45 minutes to several hours, depending on mix consistency, mix and ambient temperature, wind conditions and humidity. Begin and finish a given patch on the same day.

Tooling and Finishing

As per ACI recommendations for portland cement mortar, curing is required when jobsite conditions warrant. Moist cure with wet burlap and polyethylene, a fine mist of water or a water based* compatible curing compound. Curing compounds adversely affect the adhesion of following layers of mortar, leveling mortar or protective coatings. Moist curing should commence immediately after finishing. Protect newly applied material from direct sunlight, wind, rain and frost.

*Pretesting of curing compound is recommended.

Limitations

Application thickness:

- Minimum 3/8 inch (9 mm).

Vertical applications:

- SikaRepair® 224 can be spray applied up to 2" thickness in one lift.

Overhead applications:

- The thickness should be no more than 1 to 1.5" per pass. If repair requires several lifts (over 1.5"), each lift should be applied as soon as the previous lift will support it.

General:

- For additional information, consult Technical Service.
- Minimum ambient and surface temperatures 40°F (4°C) and rising at the time of application.
- As with all cement based materials, avoid contact with aluminum to prevent adverse chemical reaction and possible product failure. Insulate potential areas of contact by coating aluminum bars, rails, posts etc. with an appropriate epoxy such as Sikadur® Hi-Mod 32.

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KEEP CONTAINER TIGHTLY CLOSED. KEEP OUT OF REACH OF CHILDREN. NOT FOR INTERNAL CONSUMPTION. FOR INDUSTRIAL USE ONLY. FOR PROFESSIONAL USE ONLY.

For further information and advice regarding transportation, handling, storage and disposal of chemical products, users should refer to the actual Safety Data Sheets containing physical, ecological, toxicological and other safety related data. Read the current actual Safety Data Sheet before using the product. In case of emergency, call CHEMTREC at 1-800-424-9300, International 703-527-3887.

Prior to each use of any Sika product, the user must always read and follow the warnings and instructions on the product's most current Product Data Sheet, product label and Safety Data Sheet which are available online at <http://usa.sika.com/> or by calling Sika's Technical Service Department at 800-933-7452. Nothing contained in any Sika materials relieves the user of the obligation to read and follow the warnings and instruction for each Sika product as set forth in the current Product Data Sheet, product label and Safety Data Sheet prior to product use.

SIKA warrants this product for one year from date of installation to be free from manufacturing defects and to meet the technical properties on the current Product Data Sheet if used as directed within shelf life. User determines suitability of product for intended use and assumes all risks. Buyer's sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor. NO OTHER WARRANTIES EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. SIKA SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSEQUENTIAL DAMAGES. SIKA SHALL NOT BE RESPONSIBLE FOR THE USE OF THIS PRODUCT IN A MANNER TO INFRINGE ON ANY PATENT OR ANY OTHER INTELLECTUAL PROPERTY RIGHTS HELD BY OTHERS. SALE OF SIKA PRODUCTS ARE SUBJECT SIKA'S TERMS AND CONDITIONS OF SALE AVAILABLE AT [HTTP://USA.SIKA.COM/](http://usa.sika.com/) OR BY CALLING 201-933-8800.

Visit our website at usa.sika.com

1-800-933-SIKA NATIONWIDE

Regional Information and Sales Centers. For the location of your nearest Sika sales office, contact your regional center.

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Sika Mexicana S.A. de C.V.
Carretera Libre Celaya Km. 8.5
Fracc. Industrial Balvanera
Corregidora, Queretaro
C.P. 76920
Phone: 52 442 2385800
Fax: 52 442 2250537



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1. Identification

Product name : SikaRepair®-224

Supplier : Sika Corporation

Address : 201 Polito Avenue
Lyndhurst, NJ 07071
USA
www.sikausa.com

Telephone : (201) 933-8800

Telefax : (201) 804-1076

Emergency telephone : CHEMTREC: 800-424-9300
INTERNATIONAL: 703-527-3887
ehs@sika-corp.com

Recommended use of the chemical and restrictions on use : For further information, refer to the product technical data sheet.

2. Hazards identification

GHS Classification

Skin irritation , Category 2 H315: Causes skin irritation.
Serious eye damage , Category 1 H318: Causes serious eye damage.
Carcinogenicity , Category 1A H350: May cause cancer.
Specific target organ systemic toxicity - H335: May cause respiratory irritation.
single exposure , Category 3, Respiratory system

GHS Label element

Hazard pictograms : 

Signal Word : Danger

Hazard Statements : H315 Causes skin irritation.
H318 Causes serious eye damage.
H335 May cause respiratory irritation.
H350 May cause cancer.

Precautionary Statements : **Prevention:**
P201 Obtain special instructions before use.
P202 Do not handle until all safety precautions have been read and understood.
P261 Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray.
P264 Wash skin thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear eye protection/ face protection.



P280 Wear protective gloves.

P281 Use personal protective equipment as required.

Response:

P302 + P352 IF ON SKIN: Wash with plenty of soap and water.

P304 + P340 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.

P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

P308 + P313 IF exposed or concerned: Get medical advice/attention.

P310 Immediately call a POISON CENTER or doctor/physician.

P332 + P313 If skin irritation occurs: Get medical advice/attention.

P362 Take off contaminated clothing and wash before reuse.

Storage:

P403 + P233 Store in a well-ventilated place. Keep container tightly closed.

P405 Store locked up.

Disposal:

P501 Dispose of contents/ container to an approved waste disposal plant.

See Section 11 for more detailed information on health effects and symptoms.

3. Composition/information on ingredients

Hazardous ingredients

Chemical Name	CAS-No.	Concentration (%)
Quartz (SiO ₂)	14808-60-7	>= 50 - <= 100 %
Portland cement	65997-15-1	>= 25 - < 50 %
Quartz (SiO ₂) <5µm	14808-60-7	>= 0 - < 1 %

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

4. First aid measures

- If inhaled : Move to fresh air.
Consult a physician after significant exposure.
- In case of skin contact : Take off contaminated clothing and shoes immediately.
Wash off with soap and plenty of water.
If symptoms persist, call a physician.
- In case of eye contact : Small amounts splashed into eyes can cause irreversible tissue damage and blindness.
In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice.



	: Continue rinsing eyes during transport to hospital. Remove contact lenses. Keep eye wide open while rinsing.
If swallowed	: Clean mouth with water and drink afterwards plenty of water. Induce vomiting immediately and call a physician. Do NOT induce vomiting. Do not give milk or alcoholic beverages. Never give anything by mouth to an unconscious person.
Most important symptoms and effects, both acute and delayed	: irritant effects carcinogenic effects Cough Respiratory disorder Excessive lachrymation Erythema Dermatitis See Section 11 for more detailed information on health effects and symptoms.
Protection of first-aiders	: Move out of dangerous area. Consult a physician. Show this material safety data sheet to the doctor in attendance.
Notes to physician	: Treat symptomatically.

5. Fire-fighting measures

Suitable extinguishing media	: Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Specific extinguishing methods	: Collect contaminated fire extinguishing water separately. This must not be discharged into drains. Fire residues and contaminated fire extinguishing water must be disposed of in accordance with local regulations.
Special protective equipment for fire-fighters	: In the event of fire, wear self-contained breathing apparatus.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	: Use personal protective equipment. Avoid breathing dust. Deny access to unprotected persons.
Environmental precautions	: Do not flush into surface water or sanitary sewer system. If the product contaminates rivers and lakes or drains inform respective authorities. Local authorities should be advised if significant spillages cannot be contained.
Methods and materials for containment and cleaning up	: Pick up and arrange disposal without creating dust. Keep in suitable, closed containers for disposal.



7. Handling and storage

- Advice on safe handling : Do not breathe vapors/dust.
 Avoid exceeding the given occupational exposure limits (see section 8).
 Do not get in eyes, on skin, or on clothing.
 For personal protection see section 8.
 Smoking, eating and drinking should be prohibited in the application area.
 Follow standard hygiene measures when handling chemical products.
- Conditions for safe storage : Prevent unauthorized access.
 Store in original container.
 Keep in a well-ventilated place.
 Observe label precautions.
 Store in accordance with local regulations.
- Materials to avoid : no data available

8. Exposure controls/personal protection

Component	CAS-No.	Basis **	Value	Exposure limit(s)* / Form of exposure
Quartz (SiO ₂)	14808-60-7	ACGIH	TWA	0.025 mg/m ³ Respirable fraction
		OSHA Z-3	TWA	30 mg/m ³ /SiO ₂ +2 total dust
		OSHA Z-3	TWA	10 mg/m ³ /SiO ₂ +2 respirable
		OSHA Z-3	TWA	250 mppcf/SiO ₂ +5 respirable
		OSHA P0	TWA	0.1 mg/m ³ Respirable fraction
Portland cement	65997-15-1	ACGIH	TWA	1 mg/m ³ Respirable fraction
		OSHA P0	TWA	10 mg/m ³ Total
		OSHA P0	TWA	5 mg/m ³ Respirable fraction
		OSHA Z-1	TWA	15 mg/m ³ total dust



		OSHA Z-1	TWA	5 mg/m3 respirable fraction
		OSHA Z-3	TWA	50 Million particles per cubic foot Dust
fumed silica	69012-64-2	OSHA Z-3	TWA	20 Million particles per cubic foot Dust
		OSHA Z-3	TWA	80 mg/m3 / %SiO2 Dust
calcium sulfate	7778-18-9	OSHA Z-1	TWA	15 mg/m3 total dust
		OSHA Z-1	TWA	5 mg/m3 respirable fraction
		OSHA P0	TWA	15 mg/m3 Total
		OSHA P0	TWA	5 mg/m3 Respirable fraction
		ACGIH	TWA	10 mg/m3 Inhalable fraction
Quartz (SiO2) <5µm	14808-60-7	ACGIH	TWA	0.025 mg/m3 Respirable fraction
		OSHA Z-3	TWA	30 mg/m3/%SiO2+2 total dust
		OSHA Z-3	TWA	10 mg/m3/%SiO2+2 respirable
		OSHA Z-3	TWA	250 mppcf/%SiO2+5 respirable
		OSHA P0	TWA	0.1 mg/m3 Respirable fraction



*The above mentioned values are in accordance with the legislation in effect at the date of the release of this safety data sheet.

****Basis**

ACGIH. Threshold Limit Values (TLV)

OSHA P0. Table Z-1, Limit for Air Contaminat (1989 Vacated Values)

OSHA P1. Permissible Exposure Limits (PEL), Table Z-1, Limit for Air Contaminant

OSHA P2. Permissible Exposure Limits (PEL), Table Z-2

OSHA Z3. Table Z-3, Mineral Dust

Engineering measures : Use of adequate ventilation should be sufficient to control worker exposure to airborne contaminants. If the use of this product generates dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure below any recommended or statutory limits.

Personal protective equipment

Respiratory protection : Use a properly fitted NIOSH approved air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary.

The filter class for the respirator must be suitable for the maximum expected contaminant concentration (gas/vapor/aerosol/particulates) that may arise when handling the product. If this concentration is exceeded, self-contained breathing apparatus must be used.

Hand protection

Remarks : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Eye protection

: Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary.

Skin and body protection

: Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place.

Hygiene measures

: Avoid contact with skin, eyes and clothing.
Wash hands before breaks and immediately after handling the product.
Remove contaminated clothing and protective equipment before entering eating areas.
Wash thoroughly after handling.
Avoid breathing dust.

9. Physical and chemical properties

Appearance : powder



Color	:	gray
Odor	:	odorless
Odor Threshold	:	no data available
Flash point	:	Note: not applicable
Ignition temperature	:	no data available
Decomposition temperature	:	no data available
Lower explosion limit (Vol%)	:	no data available
Upper explosion limit (Vol%)	:	no data available
Flammability (solid, gas)	:	no data available
Oxidizing properties	:	no data available
Autoignition temperature	:	no data available
pH	:	Note: not applicable
Melting point/range / Freezing point	:	no data available
Boiling point/boiling range	:	no data available
Vapor pressure	:	no data available
Density	:	ca.2.60 g/cm ³ at 73 °F (23 °C)
Water solubility	:	Note: insoluble
Partition coefficient: n- octanol/water	:	no data available
Viscosity, dynamic	:	no data available
Viscosity, kinematic	:	no data available
Relative vapor density	:	no data available
Evaporation rate	:	no data available
Burning rate	:	no data available
Volatile organic compounds (VOC) content	:	0 g/l

10. Stability and reactivity

Reactivity	:	No dangerous reaction known under conditions of normal use.
Chemical stability	:	The product is chemically stable.
Possibility of hazardous reactions	:	Stable under recommended storage conditions.



Conditions to avoid : no data available

Incompatible materials : no data available

11. Toxicological information

Acute toxicity

Product

Acute oral toxicity : no data available

Acute inhalation toxicity : no data available

Acute dermal toxicity : no data available

Skin corrosion/irritation

Product

Causes skin irritation.

Serious eye damage/eye irritation

Product

Causes serious eye damage.

Respiratory or skin sensitization

Product

no data available

Germ cell mutagenicity

Product

Mutagenicity : no data available

Carcinogenicity

Product

Carcinogenicity : May cause cancer.

IARC

Group 1: Carcinogenic to humans

Quartz (SiO₂) 14808-60-7

Quartz (SiO₂) <5µm 14808-60-7

NTP

Known to be human carcinogen

Quartz (SiO₂) 14808-60-7

Quartz (SiO₂) <5µm 14808-60-7

Reproductive Toxicity/Fertility

Product

Reproductive toxicity : no data available



Reproductive Toxicity/Development/Teratogenicity

Product

Teratogenicity : no data available

STOT-single exposure

Product

Assessment: May cause respiratory irritation.

STOT-repeated exposure

Prolonged exposure can cause silicosis.

Product

Assessment: no data available

Aspiration toxicity

Product

no data available

12. Ecological information

Other information : Do not empty into drains; dispose of this material and its container in a safe way.

13. Disposal considerations

Disposal methods

Waste from residues : Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements.

Contaminated packaging : Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

Not dangerous goods

IATA

Not dangerous goods

IMDG

Not dangerous goods

Special precautions for user



no data available

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code
not applicable

15. Regulatory information

TSCA list : All chemical substances in this product are either listed on the TSCA Inventory or are in compliance with a TSCA Inventory exemption.

EPCRA - Emergency Planning and Community Right-to-Know

CERCLA Reportable Quantity

This material does not contain any components with a CERCLA RQ.

SARA304 Reportable Quantity

This material does not contain any components with a section 304 EHS RQ.

SARA 311/312 Hazards : Acute Health Hazard
Chronic Health Hazard

SARA 302 : SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 : SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

Clean Air Act

Ozone-Depletion Potential This product neither contains, nor was manufactured with a Class I or Class II ODS as defined by the U.S. Clean Air Act Section 602 (40 CFR 82, Subpt. A, App.A + B).

This product does not contain any hazardous air pollutants (HAP), as defined by the U.S. Clean Air Act Section 12 (40 CFR 61).

This product does not contain any chemicals listed under the U.S. Clean Air Act Section 112(r) for Accidental Release Prevention (40 CFR 68.130, Subpart F).

Clean Water Act

This product does not contain any Hazardous Substances listed under the U.S. CleanWater Act, Section 311, Table 116.4A.

This product does not contain any Hazardous Chemicals listed under the U.S. CleanWater Act, Section 311, Table 117.3.

This product does not contain any toxic pollutants listed under the U.S. Clean Water Act Section 307

California Prop 65 WARNING! This product contains a chemical known in the State of California to cause cancer.
WARNING: This product contains a chemical known in the State of California to cause birth defects or other reproductive harm.

**16. Other information****HMIS Classification**

Health	*	3
Flammability		0
Physical Hazard		0
Personal Protection		X

Caution: HMIS® rating is based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. Although HMIS® rating is not required on SDSs under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® rating is to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). Please note HMIS® attempts to convey full health warning information to all employees.

Notes to Reader

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TECHNICAL **GUIDELINES**

Prepared by the International Concrete Repair Institute

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Guideline for Inorganic Repair Material Data Sheet Protocol

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About ICRI Guidelines

The International Concrete Repair Institute (ICRI) was founded to improve the durability of concrete repair and enhance its value for structure owners. The identification, development, and promotion of the most promising methods and materials are primary vehicles for accelerating advances in repair technology. Working through a variety of forums, ICRI members have the opportunity to address these issues and directly contribute to improving the practice of concrete repair.

A principal component of this effort is to make carefully selected information on important repair subjects readily accessible to decision-makers. During the past several decades, much has been reported in the literature on concrete repair methods and materials as they have been developed and refined. Nevertheless, it has been difficult to find critically reviewed information on the state of the art condensed into easy-to-use formats.

To that end, ICRI guidelines are prepared by sanctioned task groups and approved by the ICRI Technical Activities Committee. Each guideline is designed to address a specific area of practice recognized as essential to the achievement of durable repairs. All ICRI guideline documents are subject to continual review by the membership and may be revised as approved by the Technical Activities Committee.

Synopsis

The purpose of this document is to provide a standardized protocol for testing and reporting of data for inorganic repair materials. It does not address all of the issues associated with material selection. It is the responsibility of the user of this document to determine the suitability of the repair material prior to use. Commentary and supplemental information in this document is italicized. The test methods for the determination of the reported data must be reported from the methods listed in this document and the method used listed adjacent to the reported data. Test data must be reported in the order and sections as listed in this document. Terminology, except as defined within this document, should refer to the current version of the ICRI Concrete Repair Terminology. Further information describing the significance and use of the test methods described herein may be found in ICRI 320.2, ACI 364.3, and ACI 546.3.

Keywords

data sheet protocol; material properties; material specifications; repair material; test methods

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This document is intended as a voluntary guideline for the owner, design professional, and concrete repair contractor. It is not intended to relieve the professional engineer or designer of any responsibility for the specification of concrete repair methods, materials, or practices. While we believe the information contained herein represents the proper means to achieve quality results, the International Concrete Repair Institute must disclaim any liability or responsibility to those who may choose to rely on all or any part of this guideline.

1.0 Introduction

This document, commonly called “The Data Sheet Protocol,” was an outcome of Vision 2020 and is intended to allow the specifier to choose verifiable properties optimized for their selected requirements of a particular repair situation. The repair material applicator can also obtain useful information about yield, working time, surface preparation, application temperature range, curing, and compatibility, as well as verify the material performance. The material producer can optimize products based on market needs and technology improvements.

2.0 Definitions

Cementitious material—That fraction of the inorganic repair material passing a 90 μ (micron) (No. 170 mesh) per ASTM E11, and mortar to be a material consisting of an inorganic binder with the only aggregate being fine aggregate according to ASTM C33/C33M.

Data Sheet Protocol—A list of significant properties, methods for determining those properties, and reporting that information.

Extended mortar—Concrete produced by the addition of coarse aggregate to a mortar product.

Extended mortar and concrete—Those materials that contain both fine and coarse aggregate per ASTM C33/C33M.

Material properties—An intensive, often quantitative property of a material, usually with a unit that may be used as a metric of value to compare the benefits of one material versus another, such as mechanical, physical, or electrochemical characteristics.

Material specifications—An explicit set of requirements to be satisfied by a material.

Polymer-cement materials—A mortar or concrete whose properties benefit from the addition of polymer when cured per ASTM C1439, commonly known as polymer-modified materials.

Repair material—A material applied to hardened concrete intended to restore the concrete to its desired function.

Test methods—A definitive procedure that produces a test result.

3.0 Repair Material Description

3.1 Material Type

Examples: Repair mortar, extended/extendable repair mortar, concrete, etc.

3.2 Recommended Use

Examples: Horizontal, vertical, overhead, traffic-wearing surface repairs, etc.

3.3 Benefits

Examples: Rapid strength development, shrinkage-compensated, polymer-cement, etc.

3.4 Limitations

Examples: Minimum/maximum placement depth with/without aggregate, application temperature range, moisture exposure, etc.

4.0 Composition Properties

4.1 Total Sulfate Trioxide (SO₃) Content, %, ASTM C114

State the percentage of total SO₃ contained within all cementitious materials stated as a percentage by mass. If sulfate levels are above those contributed from portland cement, the material producer shall provide data and methods used to establish suitability for the recommended uses stated in Section 1.0.

4.2 Total Alkali Content, %, ASTM C114

State the total sodium equivalent alkalis contained within all cementitious materials as a percentage by weight.

The typical means by which the alkali content has been controlled with concrete mixtures in the United States has been to establish a maximum limit only on the portland cement. Cement with an alkali content of less than 0.6%, expressed as equivalent Na₂O, is referred to as low-alkali cement. This provision has generally proven to be satisfactory for concrete. The disadvantage of establishing an alkali limit based

on the alkali of the portland cement alone for repair materials is that many proprietary repair materials contain blends of different cements, additives, admixtures, and other constituents that contain alkali. It is the sum of the alkalis from all sources that is pertinent to the potential reaction with a reactive aggregate.

Past research conducted in Germany and Canada led to the conclusion that when the alkali in a mixture is kept below a maximum of 3.0 kg/m³ (5.0 lb/yd³), there will be no alkali-aggregate reaction (Gress 1997).

4.3 Total Chloride Content, %

State the total water-soluble chlorides per ASTM C1218/C1218M and acid-soluble chloride content per ASTM C1152/C1152M as a percentage by weight of the material. The considerations of chloride-ion content discussed in ACI 222R require a cautionary statement on the packaging if an oxidizable metal such as iron, steel, zinc, or aluminum is allowed to be embedded in proximity of a chloride containing concrete repair material.

4.4 pH

Report the pH of the fresh and hardened repair material.

Crush a hardened sample of the inorganic repair material to pass a No. 170 (90 μ) mesh sieve, stir 0.35 oz (10 g) of the crushed material into 3.2 oz (90 g) distilled or deionized water for 1 minute and, after settling, use pH paper or a suitable pH meter per the recommendations of the supplier of the pH equipment. The determination of pH provides an indication whether sufficient hydroxide ion is present to provide passivation of reinforcing steel.

4.5 Characteristics of Aggregate, ASTM C33/C33M

For prepackaged products, use the +170 mesh fraction obtained by wet-sieving according to ASTM C117 for the tests specified in the section titled “Methods of Sampling and Testing” of ASTM C33/C33M. Provide the following information:

4.5.1 Fine Aggregate

- General characteristics
- Grading
- Deleterious substances
- Soundness per ASTM C88
- Reactivity per ASTM C1260

4.5.2 Coarse Aggregate

- General characteristics
- Grading
- Deleterious substances
- Soundness (per ASTM C88)
- Reactivity (per ASTM C1260)

ASTM C1260 provides a means of detecting the potential of an aggregate intended for use in concrete for undergoing alkali-silica reaction, resulting in potentially deleterious internal expansion within 16 days in mortar bars. It is especially useful for aggregates that react slowly or produce expansion late in the reaction. However, the potential reactivity determined by ASTM C1260 does not evaluate all possible factors influencing alkali-aggregate reactions, such as combinations of aggregates with cementitious materials, nor are the test conditions representative of those encountered by concrete in service. Because the specimens are exposed to an NaOH solution, the alkali content of the cement is not a significant factor in affecting expansions. When excessive expansions are observed from the results of ASTM C1260, it is recommended that supplementary information be developed to confirm that the expansion is actually due to alkali-silica reaction. Sources of such supplementary information include: 1) petrographic examination of the aggregate to determine if known reactive constituents are present (ASTM C295/C295M); 2) examination of the specimens after tests (ASTM C856) to identify the products of alkali reaction; and 3) where available, field service records can be used in the assessment of performance. When it has been concluded from the results of tests performed using this test method and supplementary information that a given aggregate should be considered potentially deleteriously reactive, the use of mitigative measures should be evaluated.

5.0 Material Properties

The material property and test methods are to be performed at 1, 7, and 28 days of age, unless otherwise noted.

5.1 Curing Regimen

- Normal-setting nonpolymer-cement materials—
Cure in moist cabinet or room per ASTM C511.

Remove specimens from mold at $23.5 \pm 1/2$ hours from the time of initial contact of liquid and powder during mixing and make initial comparator reading immediately.

- Normal-setting polymer-cement materials—ASTM C1439. Immediately cover molded specimens with polyethylene film (>3.9 mil [0.1 mm] thickness) and store at $73 \pm 3^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and $50 \pm 4\%$ relative humidity (RH). Remove specimens from mold at $23-1/2 \pm 1/2$ hours from the time of initial contact of liquid and powder during mixing and make initial comparator reading immediately.
- Rapid-hardening nonpolymer-cement materials—Cure in moist cabinet or room per ASTM C511. Remove specimens from mold at $2 \pm 1/4$ hours after final set and take initial comparator reading immediately.

Rapid-hardening materials are defined as those materials complying with the compressive strength requirements described in Table 1 of ASTM C928/C928M or materials whose primary binder is compliant with ASTM C1600/C1600M.

- Rapid-hardening polymer-cement materials—ASTM C1439, except remove specimens from mold at $2 \pm 1/4$ hours after final set and take initial comparator reading immediately. Store specimens under the standard conditions for air storage of $73.4 \pm 3^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and $50 \pm 4\%$ RH and water storage $73.4 \pm 1^\circ\text{F}$ ($23.0 \pm 0.5^\circ\text{C}$.)

Rapid-hardening materials are those materials complying with the compressive strength requirements described in Table 1 of ASTM C928/C928M or materials whose primary binder is compliant with ASTM C1600/C1600M.

Comparison of curing regimens using compressive strength testing can be used to determine the benefit of polymer modification for the purposes of this document if such guidance is not provided by the material manufacturer or specifier.

5.2 Unit Weight

- Mortar—ASTM C185 calculated from “mass per 400 mL of mortar” using the calculations for yield from ASTM C138/C138M.
- Extended mortar and concrete—ASTM C138/C138M.

5.3 Air Content

- Mortar—ASTM C231/C231M.
- Extended mortar and concrete—ASTM C231/C231M.

5.4 Yield

- Mortar—ASTM C185.
- Extended mortar and concrete—ASTM C138/C138M.

5.5 Density, Absorption, and Voids—ASTM C642

Use the same air-stored specimens from the length change test as described in the “Property and Test Method” section.

5.6 Setting Time

- At minimum application temperature—ASTM C403/C403M.
- At maximum application temperature—ASTM C403/C403M.

5.7 Compressive Strength

- Mortar—ASTM C109/C109M: 2 in. (51 mm) cubes.
- Extended mortar and concrete—ASTM C39/C39M: 3 x 6 in. (76 x 152 mm) cylinders.

Report the method of capping of the cylinders and the dimensions of the cylinders used, in addition to the other requirements of the report section of ASTM C39/C39M.

- Cure specimens according to the curing regimen section using one of the four regimens, depending on the setting time and polymer modification of the material.

5.8 Flexural Strength

- Mortar—ASTM C348.
- Extended mortar and concrete—ASTM C78/C78M.
- Cure specimens according to the curing regimen section using one of the four regimens, depending on the setting time and polymer modification of the material.

5.9 Splitting Tensile Strength—ASTM C496/C496M

- Mortar—2 x 4 in. (51 x 102 mm) cylindrical specimen.
- Extended mortar and concrete—3 x 6 in. (76 x 152 mm) cylindrical specimen unless otherwise indicated.

If coarse aggregate larger than 3/8 in. (9.5 mm) is used, then refer to ASTM C39/C39M for appropriate specimen size.

- Cure specimens according to the curing regimen section using one of the four regimens, depending on the setting time and polymer modification of the material.

5.10 Direct Tensile Strength—CRD C 164

- Mortar—2 x 4 in. (51 x 102 mm) cylindrical specimen.
- Extended mortar and concrete—3 x 6 in. (76 x 152 mm) cylindrical specimen.
- Cure specimens according to the curing regimen section using one of the four regimens, depending on the setting time and polymer modification of the material.

Unless the repair material is rapid-hardening, there may be erratic results for 1-day tensile adhesion values. For those materials that are not appropriate for 1-day tensile adhesion determination, report 2-day tensile adhesion results.

5.11 Modulus of Elasticity—ASTM C469/C469M

- Mortar, extended mortar and concrete—3 x 6 in. (76 x 152 mm) cylindrical specimen, or as appropriate depending on aggregate size for cylindrical specimens per ASTM C31/C31M.
- Cure specimens according to the curing regimen section using one of the four regimens, depending on the setting time and polymer modification of the material.

5.12 Bond Strength—ICRI 210.3 or ASTM C1583/C1583M

- Use a concrete substrate of 4000 to 5000 psi (27.6 to 34.7 MPa) compressive strength and prepared in accordance with project requirements and equipment manufacturer recommendations for the substrate of the repair material application. Apply the repair material to the manufacturer's recommended thickness (if a range of thicknesses, use the midpoint of the range) using the manufacturer's recommendations for material mixing, surface treatment (such as prewetting, priming, use of a scrub coat, etc.), placement, and curing.

This method is also recommended for evaluation of minimum in-place bond. Comparative data between materials reported should use identical substrates and preparation techniques with the compressive strength of the concrete substrate and the ICRI concrete surface profile (CSP) per ICRI Technical Guideline 310.2 reported.

- Report which test method (ICRI 210.3 or ASTM C1583/C1583M) is used.
- Report the CSP for the prepared surface (ICRI 310.2).
- Cure specimens according to the curing regimen section using one of the four regimens, depending on the setting time and polymer modification of the material. Any additions, requirements, or supplemental materials (such as bonding aids) of the material manufacturer shall be used and reported when performing the testing in this document.
- Report the failure mode for each specimen (that is, cohesive or adhesive through material, at the bond line, or within the substrate). If mixed failure modes are found, report the percent adherence to each interface.
- Report the average bond strength, the age of each specimen since casting, the curing regimen used, the number of specimens tested, and the standard deviation for the specimen set.

Testing at 1-day age may be omitted for normal setting (non-rapid-hardening) materials if so reported.

5.13 Length Change—ASTM C157/C157M (modified as described in the following)

- Standard specimen size is 3 x 3 x 11-1/4 in. (76 x 76 x 275 mm) for mortar, extended mortar, and concrete.

Use of the same specimen size for mortar, extended mortar, and concrete produces the same surface-to-volume ratio, allowing direct comparison of length change values between materials. The specified length change measurement intervals and extrapolation to ultimate length change provides information on drying rates between materials.

- Specimens shall be exposed to both drying at 50% RH and water immersion. Cure specimens according to the curing regimen section using one of the four regimens, depending on the setting time and polymer modification of the material.

- Subsequent comparator readings are to be taken at ages of 3 days, 7 days, 14 days, 1 month, and 2 months; measurements shall continue until 90% of ultimate drying shrinkage is reached. Ultimate drying shrinkage and moisture expansion is to be determined as described in ASTM C596.

5.14 Coefficient of Thermal Expansion— CRD C 39-81 (modified as described in the following)

- Use the same air-stored specimens from the length change test, as described previously.
- 3 x 3 x 11-1/4 in. (76 x 76 x 275 mm) for mortar, concrete, and extended mortar.
- Cycle specimens from 140 to 40°F (60 to 5°C) at 50% RH and greater than 95% RH.

5.15 Resistance to Freezing-and-Thawing Cycles—ASTM C666/ C666M, Procedure A (in addition to the procedure described in the following)

- One set of composite beams comprised of a 3 x 1 x 16 in. (76 x 25 x 406 mm) overlay of repair mortar applied per the manufacturer's recommendations on the top surface of a freezeing-and-thawing-resistant concrete substrate measuring 3 x 3 x 16 in. (76 x 76 x 406 mm) that has been prepared in accordance with the "How to Use the Material" section of this document, or if no profile or surface preparation instructions are provided, is prepared to CSP 3 (ICRI 310.2) for the substrate of the repair material application.
- One set of homogenous beams comprised of the type described in ASTM C666/C666M.
- Cure specimens according to the curing regimen section using the appropriate regimen, depending on the setting time and polymer modification of the material. Continue to cure the specimen in a moist cabinet or room per ASTM C511 until an elapsed time of 28 days from date of casting of the composite specimen has elapsed.
- Start testing after 28 days of curing by determining the initial mass and surface condition of the

specimen. For the forced resonance measurement method, place the vibration device centered on the side surface of the repair mortar layer and the sensor device centered on the top surface of the concrete at the opposite end of the specimen. For the impact resonance method of measurement, strike the specimen in an area centered on the side surface of the repair mortar layer and measure the specimen response by placing the accelerometer centered on the side surface of the concrete at the opposite end of the specimen. This is to measure not only the repair material resistance to freezing and thawing but also any possible deterioration of the bonding between the repair material and substrate concrete.

- Record durability factor for the homogenous repair material specimens and the composite specimens, mass loss, and surface condition of the specimen using the rating's weight loss of ASTM C672/C672M and ICRI 320.2. Record the length change for the homogenous specimen.

5.16 Scaling Resistance— ASTM C672/C672M

- Cure specimens according to the curing regimen section using the appropriate regimen, depending on the setting time and polymer modification of the material. Continue to cure the specimen in a moist cabinet or room per ASTM C511 until an elapsed time of 28 days from date of casting of the composite specimen. Test after 28 days of curing.

5.17 Compressive Creep— ASTM C512/C512M

- Cure specimens according to the curing regimen section using one of the four regimens, depending on the setting time and polymer modification of the material.
- Specimens shall be cured according to the curing regimen section for both sets of specimens. Two sets of specimens shall be used, one with initial loading beginning at 7 days and the other with initial loading beginning at 28 days.
- Report the initial elastic strain, as well as the specific creep, compressive creep strain, compressive creep rate, and compressive creep coefficient values at 1, 7, 28 days, and 1 year of age.

- If initial loading begins at ages other than specified, a separate set of replicate specimens shall be used for each initial loading age and reported separately.

The requirement for separate specimens to be used for loading at other ages is to initiate creep measurements at different ages when initial loading occurs—that is, if creep is determined on 3-day-old specimens, then the specimens are cured for 3 days, then initially loaded; if creep is determined on 28-day-old specimens, then another set of specimens is cured for 28 days, then initially loaded.

5.18 Rapid Chloride Ion Permeability— ASTM C1202

- Start test after 28 days of curing.
- Rapid chloride permeability testing shall be correlated with ASTM C1543 chloride ponding, as described in the following.

Rapid chloride permeability testing per ASTM C1202 is actually a measurement of electrical conductivity of the material under standardized conditions that can be correlated to chloride diffusion if chloride ponding has been performed on the same material. Use of certain admixtures, fibers, and other ingredients can affect this correlation. Therefore, correlation of ASTM C1202 with chloride ponding results per ASTM C1543 for a given material provides a more realistic means of estimating chloride ingress using the rapid method.

5.19 Chloride Ponding— ASTM C1543

- Cure specimens according to the curing regimen section using the appropriate regimen, depending on the setting time and polymer modification of the material. Continue to cure the specimen in a moist cabinet or room per ASTM C511 until an elapsed time of 14 days from date of casting, then dried for 14 days as specified in ASTM C1543 and then abraded to a minimum of CSP 3, as defined by ICRI 310.2 before beginning the test.

5.20 Sulfate Resistance— ASTM C1012/C1012M

- Cure specimens according to the curing regimen section using one of the four regimens,

depending on the setting time and polymer modification of the material.

For concrete materials, the aggregate shall be removed by screening of the material prior to mixing using the method described in Compositional Information. The coarse aggregate shall be removed from separate samples and the resulting mortar tested according to ASTM C1012/C1012M, as described in the aggregate characteristics section.

5.21 Chemical Resistance—ASTM D1308 Spot Test, Covered

- Use same-size specimens as used for length change.

Unless otherwise stated, the chemical exposure testing shall be conducted on 28-day-old hardened specimens cured as described in the curing regimen section using exposure times of 15 minutes, 1 hour, and 16 hours.

5.22 Cracking Resistance—Ring Test ASTM C1581/C1581M

- Description of the ring test.

This method allows the determination of materials' sensitivity to cracking caused by restrained volume changes. Material in the mold should be consolidated as recommended by the manufacturer. The material rings are to be kept in their molds and covered with plastic for the first 24 hours after they are cast. After the completion of the recommended curing period, the specimen should then be kept for a minimum of 60 days under the standard laboratory conditions: $73.4 \pm 3^\circ\text{F}$ ($24.0 \pm 2^\circ\text{C}$) and $50 \pm 4\%$ RH. The rings should be monitored using the prescribed strain gauges and visually inspected daily for evidence of cracking. On the day that cracking is observed, the width should be recorded with precision of 0.001 in. (0.04 mm). Each of the cracks that formed should be measured periodically for width at quarter points and in the middle along the crack and the average width recorded. Report per ASTM C1581/C1581M.

If specimens are cured by another procedure other than as described in the preceding

paragraph, such curing procedures should be described in sufficient detail to allow the duplication of results by others wishing to verify the data.

6.0 Packaging and Storage

6.1 Packaging

All packages shall show at least the following information in clearly legible form:

- Brand name;
- Usable working time for high and low temperatures within which the product will meet the stated performance parameters;
- Date of manufacture;
- Recommended use expiration date;
- Storage conditions, including minimum and maximum temperature, humidity, and other conditions;
- Conditioning requirements of the material prior to use;
- Lot identification number;
- Net weight in each container;
 - The contents of any container shall not vary by more than 2% from the weight stated in the markings.
 - The average weight of filled containers in a lot shall be not less than the weight stated in the markings.
- If the product is formulated for use in vertical or overhead applications, it shall be so stated on the package.

6.2 Other Information

Other information shall be marked on either the package and/or on the product data sheet.

7.0 How to Use the Material

7.1 Surface Preparation

- Specify the CSP number or range (ICRI 310.2) and prepare the surface in accordance with ICRI 310.2.
- Report the moisture condition for the surface.

7.2 Mixing

7.2.1 Aggregate Extension

If the product is permitted to be aggregate-extended, report:

- The mass quantity to add per unit of material;
- The grading size number per ASTM C33/C33M;
- The recommended aggregate moisture content; and
- Any other requirements of the aggregate to be used shall be listed.

7.2.2 Mixing Time

Specify the recommended length of mixing time or sequence of mixing and resting times in minutes.

7.2.3 Mixing Equipment

Specify the recommended mixing equipment per ICRI 320.5.

7.2.4 Mixing Liquid

Specify the amount of mixing water or other designated liquid to be used, or maximum recommended consistency or range.

7.2.5 Yield

Report the yield at maximum mixing liquid content, or maximum consistency. The yield claimed shall not be greater than that measured in Section 5.4 and shall be reported in ft³ (L) or yield in ft²/in. (m²/mm) for the designated package size.

7.2.6 Application

Placing instructions: Specify the minimum and maximum application thickness.

7.2.7 Finishing

Specify the finishing instructions.

7.2.8 Curing

Specify the curing instructions:

- List the acceptable methods and materials for curing of the applied material.
- Indicate the return-to-service time guidelines at maximum and minimum curing temperatures.

7.3 Bonding Agents

When a bonding agent is recommended, the type, kind, and allowable interval of the adhesive

recommended to bond fresh repair material to the concrete or mortar being repaired shall be listed.

7.4 Cleanup

Provide recommendations for cleanup and disposal of material in accordance with local regulations and requirements.

7.5 Safety

Refer to the manufacturer's Material Safety Data Sheet (MSDS). This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. Useful guidance can also be found in ICRI 120.1.

8.0 References

8.1 Referenced Standards and Reports

The standards and reports listed as follows were the latest editions at the time this document was prepared. Because these documents are revised frequently, the reader is advised to contact the proper sponsoring group if it is desired to refer to the latest version.

American Concrete Institute

- 222R, "Protection of Metals in Concrete Against Corrosion"
- 364.3, "Guide for Cementitious Repair Material Data Sheet"
- 546.3, "Guide for the Selection of Materials for the Repair of Concrete"

ASTM International

- C31/C31M, "Standard Practice for Making and Curing Concrete Test Specimens in the Field"
- C33/C33M, "Standard Specification for Concrete Aggregates"
- C39/C39M, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens," Vol. 4.02
- C78/C78M, "Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)"

- C88, "Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate"
- C109/C109M, "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)"
- C114, "Standard Test Methods for Chemical Analysis of Hydraulic Cement"
- C117, "Standard Test Method for Materials Finer than 75- μ (No. 200) Sieve in Mineral Aggregates by Washing"
- C138/C138M, "Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"
- C157/C157M, "Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete"
- C185, "Standard Test Method for Air Content of Hydraulic Cement Mortar"
- C231/C231M, "Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method"
- C295/C295M, "Standard Guide for Petrographic Examination of Aggregates for Concrete"
- C348, "Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars"
- C403/C403M, "Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance"
- C469/C469M, "Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression"
- C496/C496M, "Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens"
- C511, "Standard Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes"
- C512/C512M, "Standard Test Method for Creep of Concrete in Compression"
- C596, "Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement"
- C642, "Standard Test Method for Density, Absorption, and Voids in Hardened Concrete"
- C666/C666M, "Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing"
- C672/C672M, "Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals"

- C856, “Standard Practice for Petrographic Examination of Hardened Concrete”
- C928/C928M, “Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs”
- C1012/C1012M, “Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution”
- C1107, “Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)”
- C1152/C1152M, “Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete”
- C1202, “Standard Test Method for Electrical Indication of Concrete’s Ability to Resist Chloride Ion Penetration”
- C1218/C1218M, “Standard Test Method for Water-Soluble Chloride in Mortar and Concrete”
- C1260, “Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)”
- C1439, “Standard Test Methods for Evaluating Polymer Modifiers in Mortar and Concrete”
- C1543, “Standard Test Method for Determining the Penetration of Chloride Ion into Concrete by Ponding”
- C1581/C1581M, “Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage”
- C1583/C1583M, “Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull off Method)”
- C1600/C1600M, “Standard Specification for Rapid Hardening Hydraulic Cement”
- D1308, “Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes”
- E11, “Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves”
- 320.2R, “Guide for Selecting and Specifying Materials for Repair of Concrete Surfaces”
- 320.5, “Pictorial Atlas of Concrete Repair Material Mixing Equipment”

These publications may be obtained from these organizations:

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
www.concrete.org

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428
www.astm.org

International Concrete Repair Institute
10600 West Higgins Road, Suite 607
Rosemont, IL 60018
www.icri.org

8.2 Other Cited References

CRD C 164, “Standard Test Method for Direct Tensile Strength of Cylindrical Concrete or Mortar Specimens,” *Handbook for Concrete and Cement*, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, http://www.wes.army.mil/SL/MTC/handbook/crd_c164.pdf. (last accessed October 6, 2011)

CRD C 39-81, “Test Method for Coefficient of Linear Thermal Expansion of Concrete,” *Handbook for Concrete and Cement*, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, http://www.wes.army.mil/SL/MTC/handbook/crd_c39.pdf. (last accessed October 6, 2011)

Gress, D., 1997, “Early Distress of Concrete Pavements,” *Publication No. FHWA-SA-97-045*, Federal Highway Administration, Washington, DC, http://www.fhwa.dot.gov/pavement/pub_details.cfm?id=158. (last accessed October 6, 2011)

Material Safety Data Sheet (MSDS), 1983, *Federal Register*, V. 48, No. 228, Occupational Safety and Health Administration, U.S. Department of Labor, Washington, DC.

International Concrete Repair Institute

- 120.1, “Guidelines and Recommendations for Safety in the Concrete Repair Industry”
- 210.3, “Guide for Using In-Situ Tensile Pull-Off Tests to Evaluate Bond of Concrete Surface Materials”
- 310.2, “Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays”



TECHNICAL GUIDELINES

Prepared by the International Concrete Repair Institute

October 2013



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**Selecting and Specifying Concrete
Surface Preparation for Sealers,
Coatings, Polymer Overlays, and
Concrete Repair**



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About ICRI Guidelines

The International Concrete Repair Institute (ICRI) was founded to improve the durability of concrete repair and enhance its value for structure owners. The identification, development, and promotion of the most promising methods and materials are primary vehicles for accelerating advances in repair technology. Working through a variety of forums, ICRI members have the opportunity to address these issues and to directly contribute to improving the practice of concrete repair.

A principal component of this effort is to make carefully selected information on important repair subjects readily accessible to decision makers. During the past several decades, much has been reported in the literature on concrete repair methods and materials as they have been developed and refined. Nevertheless, it has been difficult to find critically reviewed information on the state of the art condensed into easy-to-use formats.

To that end, ICRI guidelines are prepared by sanctioned task groups and approved by the ICRI Technical Activities Committee. Each guideline is designed to address a specific area of practice recognized as essential to the achievement of durable repairs. All ICRI guideline documents are subject to continual review by the membership and may be revised as approved by the Technical Activities Committee.

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Synopsis

Proper surface preparation is a key element in determining the success of a concrete restoration project. Improper surface preparation may lead to the failure of the protective system or repair material, resulting in further repairs, added expense, and loss of use, and may ultimately compromise the integrity of the structure.

Surface preparation is the process by which a sound, clean, and suitably roughened surface is produced on a concrete substrate. Surface preparation includes the removal of laitance, dirt, oil, films, paint, coatings, sound and unsound concrete, and other materials that will interfere with the adhesion or penetration of a sealer, coating, polymer overlay, or repair material. Surface preparation will open the pore structure of the concrete substrate and establish profiles suitable for the application of the specified protective system or repair material.

Keywords

Abrasive blasting; acid etching; detergent scrubbing; grinding; handheld concrete breakers; high- and ultra-high-pressure water jetting; low-pressure water cleaning; microcracking; needle scaling; rotomilling; scabbling; scarifying; shotblasting; surface preparation; surface profile; surface retarders.

This document is intended as a voluntary guideline for the owner, design professional, and concrete repair contractor. It is not intended to relieve the professional engineer or designer of any responsibility for the specification of concrete repair methods, materials, or practices. While we believe the information contained herein represents the proper means to achieve quality results, the International Concrete Repair Institute must disclaim any liability or responsibility to those who may choose to rely on all or any part of this guideline.

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1.0 Introduction

1.1 Surface Preparation

This guide provides owners, designers, specifiers, contractors, and manufacturers with the tools needed to select and specify the methods for preparing concrete surfaces prior to the application of a protective system or repair material. Surface preparation is the process by which a sound, clean, and suitably roughened surface is produced on a concrete substrate. Surface preparation includes the removal of laitance, dirt, oil, films, paint, coatings, sound and unsound concrete, and other materials that will interfere with the adhesion or penetration of a sealer, coating, polymer overlay, or repair material. Proper surface preparation will open the pore structure of the concrete substrate and establish profiles suitable for the application of the specified protective system or repair material.

Proper surface preparation is a key element in determining the success of a concrete restoration project. Improper surface preparation may lead to the failure of the protective system or repair material, resulting in further repairs, added expense, and loss of use, and may ultimately compromise the integrity of the structure. The existing conditions of the concrete and the type of protective system or repair material to be applied should be considered in determining the surface preparation method(s). The designer, specifier, contractor, and manufacturer should all participate in the selection of the surface preparation method(s). Detailed attention to proper surface preparation will help ensure the long-term success of the restoration project.

1.2 Guideline Tools

The following tools are contained within the guideline to assist the user in the selection and/or specification of the proper surface preparation method(s):

- Method Selector (Section 7.0): Identifies methods capable of producing the concrete surface profile(s) (CSP[s]) typically recommended for the protective system or repair material.
- Method Summaries (Section 8.0): Discusses the capabilities, limitations, operating requirements, and environmental factors for each method.
- CSP Chips (Section 6.0): Provides replicas of surface preparation profiles produced by methods described in the guide and visual standards for specification, execution, and verification of surface profiles.

- Method Selection Checklists (Appendix A): Provides checklists to help ensure that critical information is identified, organized, and considered in the development of criteria for the selection of a surface preparation method(s).
- Testing (Appendix B): Discusses various test methods that may be used to specify and evaluate the quality of the surface preparation.
- Safety (Appendix C): Provides links to specific safety information.

2.0 Definitions

Definitions for terms used in this guideline may be found in ICRI Concrete Repair Terminology (<http://www.icri.org/GENERAL/repairterminology.aspx>).

3.0 Selecting Surface Preparation Method(s)

3.1 Project Evaluation

Concrete surface conditions, material requirements, and job-site conditions will vary considerably for each project. Most projects will have unique conditions and requirements that must be evaluated to determine which surface preparation method(s) is/are suitable for the project and which will ensure the long-term success of the protective system and/or repair material. More than one method may be capable of producing the desired results. Appendix A provides a more complete list of items to be considered and can be used as a checklist in evaluating a project. The checklist will help ensure that the various conditions affecting the surface preparation have been considered.

3.1.1 Substrate condition

The condition of the substrate, including the presence of unsound concrete, bond-inhibiting materials, substrate deterioration, cracking, and surface contaminants, need to be evaluated to determine the nature and degree of preparation required. The surface preparation method must provide a clean, sound substrate with a surface profile appropriate for the specific material installation.

3.1.2 Material requirements

Surface preparation requirements may vary with the material selected. The manufacturer of the system may have specific requirements for surface preparation, including the surface profile and moisture sensitivity, and should be consulted. Proper surface preparation could impact the



manufacturer's warranty. The properties and application requirements of the selected protective system or repair material must be determined prior to the selection of a surface preparation method.

3.1.3 Job-site requirements

Noise, vibration, dust, and water may be generated by various preparation methods. The need for uninterrupted use of the structure, concerns about the operating environment, or the potential for property damage may limit the choices. Mechanical ventilation, available power sources, the size of door openings, and minimum clearance may also affect surface preparation decisions. The surface preparation may also release hazardous contaminants (for example, asbestos from old flooring mastic). Any condition that may affect the method of surface preparation should be considered.

3.2 Evaluate Surface Preparation Method(s)

Selecting the method(s) that will provide a clean, sound substrate and optimize the success of the material installation requires knowledge of the available options. The surface profile achieved following the surface preparation is often the primary requirement in specifying the preparation method(s). The method selector chart may be used to make a preliminary identification of the methods capable of producing the required CSP.

Each of the methods capable of meeting the CSP requirement can be compared in the method summaries section, which provides data on the capabilities, limitations, operating requirements, and environmental considerations for each surface preparation method.

3.3 Select and Specify Surface Preparation Method(s)

The final selection is based on the relationship between substrate conditions, material requirements, and job-site conditions. The specification may include a CSP range as well as other criteria, such as bond strength. These requirements should be clearly defined in the specification, along with the test method(s) that will be used to evaluate the completed surface preparation. The test procedures described in Appendix B may be used in preparing the specifications to ensure that the desired results are achieved.

3.4 Quality Control

The CSP chips (CSP 1-10) provide benchmark profiles to aid in achieving the desired result. The

prepared surface should be compared to the CSP chips specified for the project. Tests, such as the tensile bond test, may be performed to verify that all deteriorated or damaged concrete has been removed. Other specified tests should be performed prior to installing the protective system or repair material. The cost of providing additional surface preparation will be significantly less than the cost of correcting a failure of the installed system or repair. Appendix B describes various tests that may be used to evaluate the prepared concrete surface. SSPC-SP 13/NACE No. 6, ASTM D5295, ASTM E1857, and ASTM F2471 provide additional considerations for surface preparation and quality control.

4.0 Mechanics of Concrete Removal

4.1 Introduction

In addition to project-specific requirements, the selection of a surface preparation method should ensure that:

- The surface is not damaged;
- The reinforcing steel is not damaged, nor its bond with the concrete compromised; and
- Vibration, impact, or construction loads do not weaken the concrete.

This section describes the mechanics used by the various surface preparation methods to remove deteriorated concrete and contaminants from the surface. This information will help users determine the potential of each preparation method to achieve the desired results and also assess the potential for damage to the substrate that may be caused by the individual methods.

4.2 Cleaning

Cleaning does not noticeably alter the profile of concrete surfaces. Cleaning and detergent scrubbing are accomplished through one or a combination of the following: the surfactant effect of detergents, the solvent effect of water, the shearing force of brushes, and the force of low-velocity water. Applicable methods: low-pressure water cleaning and detergent scrubbing.

4.3 Acid Etching and Surface Retarder

Acid etching chemically dissolves calcium hydroxide and calcium silicate, which make up the hydrated solids in cement paste. The dissolution of these materials at the surface causes a

slight loss of cement paste and produces a very light profile on the exposed surface. Surface retarders slow the hydration of cement, allowing low-pressure water cleaning to remove the retarded layer, creating an exposed aggregate surface. Applicable methods: acid etching and surface retarders.

4.4 Abrasion

Abrasive force applied through grinding with stones, abrasive discs, or blocks with embedded diamonds wears away the cement paste, fines, and coarse aggregate at a uniform rate to produce a nearly flat surface having little or no profile (Fig. 4.1). Applicable methods: grinding.

cutting the coarse aggregate to produce a surface that will become highly profiled as exposure time is increased. Applicable methods: steel shot-blasting and abrasive blasting.

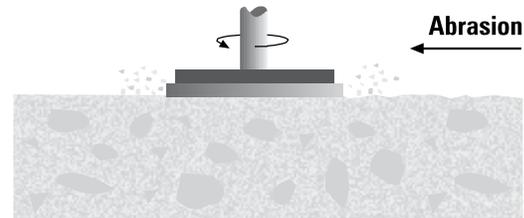


Fig. 4.1: Grinding

4.5 High-Pressure Water Erosion

Erosion causes the flushing away or progressive disintegration of concrete surfaces. A stream of water projected onto the surface under high pressure will result in the gradual erosion of the surface. The impact of the water and the water velocity combine to wear away the cement paste. As exposure to water jetting increases, so will the profile as the softer paste and embedded fines erode, leaving behind “islands” of the harder coarse aggregate. Under prolonged exposure to water jetting, the coarse aggregate will be undercut and washed away (Fig. 4.2). Applicable methods: high- and ultra-high-pressure water jetting.

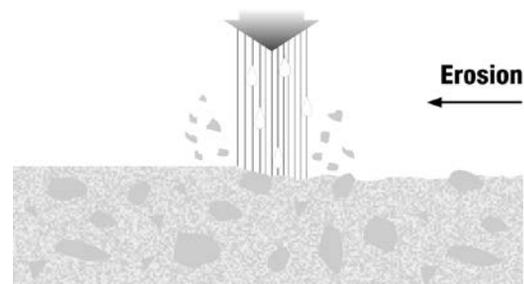


Fig. 4.2: High- and ultra-high-pressure water jetting

4.6 Impact

Several preparation methods strike the surface repeatedly with hardened points to produce momentary mechanical loads that exceed the strength of the concrete, causing it to fracture. The force of the impact pulverizes and fractures the cement paste and aggregate at and adjacent to the point of contact (Fig. 4.3 and 4.4). Some of the cracks and loosened aggregate may remain, leaving a “bruised” layer at the surface. Applicable methods: scarifying, scabbling, rotomilling, needle scaling, and handheld concrete breakers.

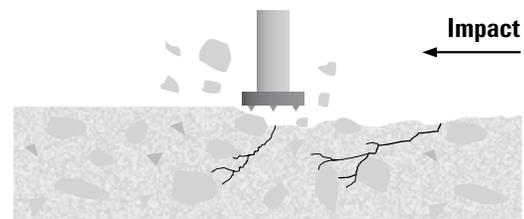


Fig. 4.3: Scarifying, scabbling, rotomilling, needle scaling

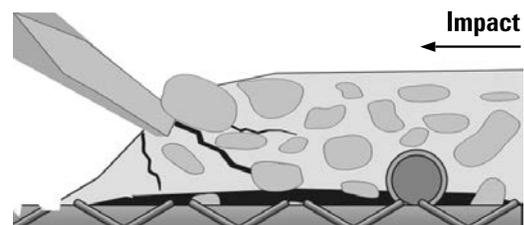


Fig. 4.4: Handheld concrete breaker

4.7 Pulverization

The cutting effect is derived from the collision of small particles traveling at a high velocity against the concrete surface (Fig. 4.5). Because the mass of the particles is comparatively small, their impact is not known to produce bruising. Hard, sharp-edged media and high pressure can produce fast cutting rates. As with water jetting, the cement paste is usually reduced at a faster rate than the coarse aggregate. This difference in removal rate has the effect of exposing and under-

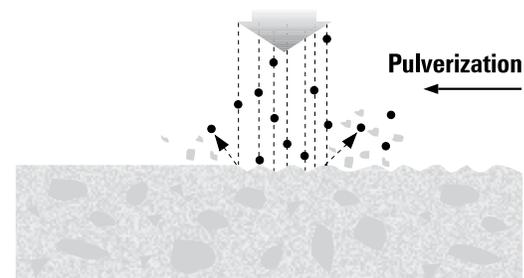


Fig. 4.5: Abrasive blasting, shotblasting

5.0 Microcracking (Bruising)

5.1 Effect on Bond Strength

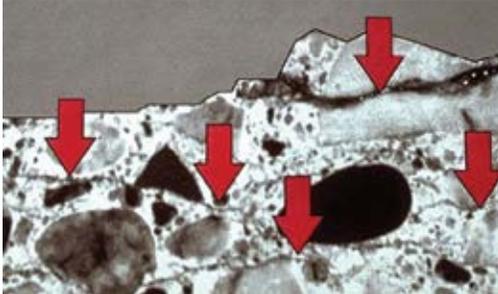


Fig. 5.1.a: Microcracking of the concrete

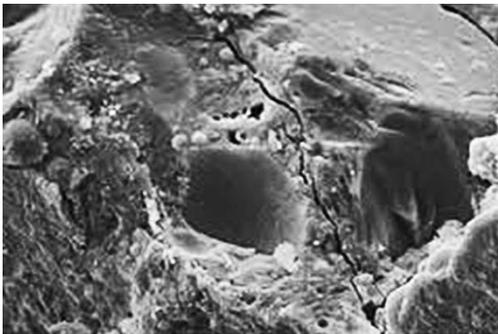


Fig. 5.1.b: Microcracking

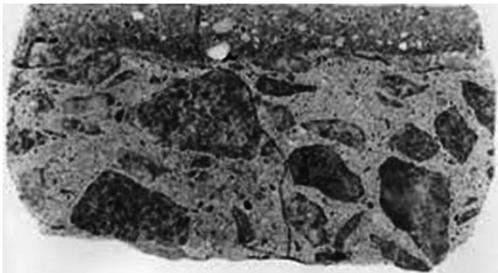


Fig. 5.1.c: Microcracking under LMC overlay

Several of the preparation methods described may locally damage the prepared substrate. Field studies have shown that bond strengths of surfaces prepared using high-impact mechanical methods are frequently lower compared to surfaces prepared using nonimpact methods. This reduction in bond strength is caused by the fracturing of the cement paste and loosening of the aggregate without fully separating from the surface. This creates a weakened or “bruised” surface layer of interconnecting microcracks typically extending to a depth of 1/8 to 3/8 in. (3 to 10 mm). Microscopic examination usually indicates that cracks initiate at the surface at approximately a 45-degree angle and propagate horizontally to produce a

weakened plane (Fig. 5.1a to 5.1c). It is generally accepted that the extent of the damage increases with the weight and power of the equipment used. However, the use of sharp, fine-toothed cutters contacting the surface at a shallow angle may reduce or prevent the development of bruising. The relative risk of introducing bruising or microcracking into the substrate is indicated for each method in Section 5.2. Surfaces prepared using impact methods should be tested using a tensile pulloff test to confirm that the prepared surface does not contain microcracks that may compromise the installation of a repair material or protective system (refer to Appendix B).

5.2 Risk of Introducing Microcracking

Figure 5.2 identifies the potential risk of introducing microcracking when performing surface preparation using the method listed.

Surface preparation using methods resulting in a high probability of microcracking, including handheld concrete breakers, rotomilling, and scabbling, generally require further surface preparation to remove the microcracks. Surface preparation using methods resulting in a moderate probability of microcracks, including needle scaling and scarifiers, may require further surface preparation, and the surface should be evaluated to determine if the preparation created microcracks. All surfaces should be tested, regardless of preparation method, to ensure adequate concrete strength and a properly prepared surface (refer to Appendix B).

Risk of Introducing Microcracking		
Very low	Moderate	High
●	●	●
Abrasive blasting	●	●
Acid etching	●	●
Handheld concrete breakers	●	●
Detergent scrubbing	●	●
Grinding	●	●
High- and ultra-high-pressure water jetting	●	●
Low-pressure water cleaning	●	●
Rotomilling	●	●
Needle scaling	●	●
Scabbling	●	●
Scarifying	●	●
Shotblasting	●	●
Surface retarders	●	●

Fig. 5.2: Potential risk of microcracking during surface preparation

6.0 Concrete Surface Profiles (CSPs)

Several of the methods summarized are capable of producing a range of profiles on concrete surfaces. Communication of project objectives and requirements may be improved by using CSPs to define the desired surface profile (amplitude or roughness).

ICRI has identified 10 distinct profiles produced by the surface preparation methods described in this guideline. As a set, these profiles replicate degrees of roughness considered to be suitable for the application of one or more of the sealer, coating, polymer overlay systems, and/or concrete repair materials. Each profile carries a CSP number ranging from CSP 1 (nearly flat) through CSP 10 (very rough; amplitude greater than 1/4 in. [6 mm]). The profile characteristics for each preparation method are identified by CSP number in the “Profile” section of the method summaries. Molded replicas* of these

profiles provide clear visual standards for purposes of specification, execution, and verification. These benchmark profiles may be referenced in specifications, material data sheets, application guidelines, and contract documents to effectively communicate the required surface profile. It is probable that more than one profile will produce acceptable results, and a range of suitable profiles should be specified.

The concrete surfaces shown in Fig. 6.1 to 6.10 were produced using a variety of preparation methods. Although each numbered CSP replica bears the characteristic pattern and texture of the specific preparation method used, each replica is representative of the profile height (amplitude) obtained with all methods identified with the same CSP number.

**Molded replicas are available with this guideline by contacting ICRI at the number listed on the back cover of this document or on ICRI’s website at <http://www.icri.org/bookstore/bkstr.asp>.*

Caution! The texture and appearance of the profile obtained will vary depending on the concrete strength, the size and type of aggregate, and the finish of the concrete surface. On sound substrates, the range of variation can be sufficiently controlled to resemble the referenced CSP standard. As the depth of removal increases, the profile of the prepared substrate will be increasingly dominated by the type and size of the coarse aggregate.



Fig. 6.1: CSP 1
(acid-etched)

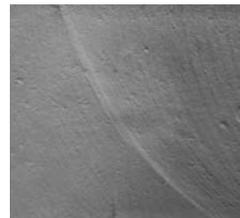


Fig. 6.2: CSP 2
(grinding)

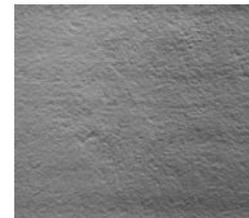


Fig. 6.3: CSP 3
(light shotblast)



Fig. 6.4: CSP 4
(light scarification)



Fig. 6.5: CSP 5
(medium shotblast)



Fig. 6.6: CSP 6
(medium scarification)



Fig. 6.7: CSP 7
(heavy abrasive blast)



Fig. 6.8: CSP 8
(scabbled)



Fig. 6.9: CSP 9
(heavy scarification—
rotomilled)

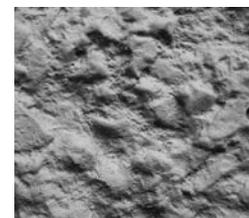


Fig. 6.10: CSP 10
(handheld concrete
breaker followed by
abrasive blasting)

Figures 6.11 and 6.12 provide a guide to the general appearance of a CSP 10. After preparation is complete, the aggregate should appear clean and crisp and protrude above the paste line a minimum of 1/4 in. (6 mm).



Fig. 6.11: CSP 10—Surface prepared using handheld concrete breaker followed by abrasive blasting



Fig. 6.12: CSP 10—Surface prepared using high-pressure water jetting

7.0 Method Selector

7.1 CSP and Protective Systems

The type of protective system or repair material to be applied will impact the type of surface preparation selected. Penetrating sealers will have little or no effect on the appearance of the prepared surface. Any surface defects, contaminants, or profile resulting from the surface preparation will be visible. Thin films may be formulated to achieve high hiding power; however, even relatively minor surface imperfections and profiles produced by surface preparation equipment will be visible. High-build materials will have both high hiding power and some ability to fill irregularities and level the prepared surfaces. A smooth finish over higher profiles may be achieved by increasing the thickness of the applied coating system. Manufacturers of these materials often have minimum thickness requirements, which can be affected by the surface profile. A surface profile greater than specified by the manufacturer may result in an increase in the cost of the system. Overlays and repair materials are generally installed such that the depth of the material covers the amplitude of the surface profile.

Possible surface profiles to be used with various protective systems are given in Table 7.1. Consult the manufacturer to determine the recommended surface profile.

7.2 CSP and Preparation Methods

An approximate range of surface profiles obtained using various preparation methods is shown in Table 7.2.

Table 7.1: Protective Systems

Material to be applied	Concrete Surface Profile									
	CSP 1	CSP 2	CSP 3	CSP 4	CSP 5	CSP 6	CSP 7	CSP 8	CSP 9	CSP 10
Sealers, 0 to 3 mils (0 to 0.075 mm)	■	■	■	■	■	■	■	■	■	■
Thin films, 4 to 10 mils (0.01 to 0.025 mm)	■	■	■	■	■	■	■	■	■	■
High-build coatings, 10 to 40 mils (0.025 to 1.0 mm)	■	■	■	■	■	■	■	■	■	■
Self-leveling toppings, 50 mils to 1/8 in. (1.2 to 3 mm)	■	■	■	■	■	■	■	■	■	■
Polymer overlays, 1/8 to 1/4 in. (3 to 6 mm)	■	■	■	■	■	■	■	■	■	■
Concrete overlays and repair materials, >1/4 in. (>6 mm)	■	■	■	■	■	■	■	■	■	■

Table 7.2: Preparation Methods

Surface preparation method	Concrete Surface Profile									
	CSP 1	CSP 2	CSP 3	CSP 4	CSP 5	CSP 6	CSP 7	CSP 8	CSP 9	CSP 10
Detergent scrubbing	■	■	■	■	■	■	■	■	■	■
Low-pressure water cleaning	■	■	■	■	■	■	■	■	■	■
Grinding	■	■	■	■	■	■	■	■	■	■
Acid etching	■	■	■	■	■	■	■	■	■	■
Needle scaling	■	■	■	■	■	■	■	■	■	■
Abrasive blasting	■	■	■	■	■	■	■	■	■	■
Shotblasting	■	■	■	■	■	■	■	■	■	■
High- and ultra-high-pressure water jetting	■	■	■	■	■	■	■	■	■	■
Scarifying	■	■	■	■	■	■	■	■	■	■
Surface retarder (1)	■	■	■	■	■	■	■	■	■	■
Rotomilling	■	■	■	■	■	■	■	■	■	■
Scabbling	■	■	■	■	■	■	■	■	■	■
Handheld concrete breaker	■	■	■	■	■	■	■	■	■	■

(1) Only suitable for freshly placed cementitious materials

8.0 Method Summaries

8.1 Abrasive Blasting



Fig. 8.1.a: Column



Fig. 8.1.b: Floor

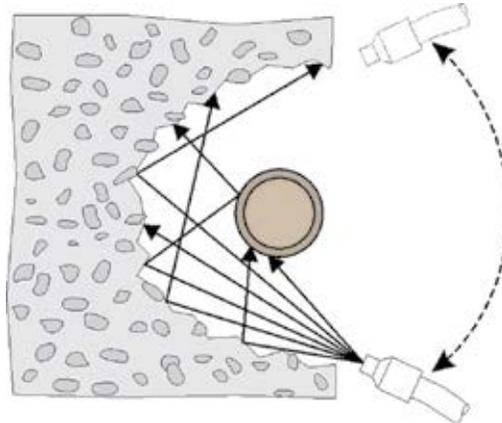


Fig. 8.1.c: Reinforcement cleaning



Fig. 8.1.d: Protective equipment

8.1.1 Summary

Abrasive blasting is used to clean and profile concrete surfaces (Fig. 8.1.a). The process can provide a light, clean profile, often referred to as a “brush blast,” or it can be used to achieve a moderate profile. It may also be used to remove surface contaminants and thin, brittle coatings or adhesive films (Fig. 8.1.b) from surfaces and corrosion products from reinforcing steel (Fig. 8.1.c). This method may be used on horizontal, vertical, and overhead surfaces and is suitable for both interior and exterior applications. Both vacuum recovery and wet abrasive blasting equipment are sometimes used to reduce environmental contamination from the abrasive blasting technique. Abrasive blasting is often used to mitigate microcracking caused by other surface preparation methods.

8.1.2 Removal

This method uses a compressed air stream with an abrasive media to clean concrete and steel surfaces. Removal is accomplished by the eroding effect of the blast media impacting the surface at high velocity.

8.1.3 Profile

CSP 2-7—Abrasive blasting should not introduce any noticeable pattern. The profile achieved is dependent on the duration of exposure to the blast stream and the size and cutting efficiency of blast media.

8.1.4 Accessibility

The small size and portability of the hose and blast nozzle provide virtually unrestricted access to all surfaces, including edges, corners, and recessed spaces.

8.1.5 Limitations

Abrasive blast is not recommended for the following:

- Removal of resilient coatings, uncured coatings or adhesives, and tar-based materials;
- When occupied space, goods, or equipment cannot be adequately protected from dust infiltration; and
- Removal of significant quantities of concrete.

8.1.6 Environmental factors

Dry abrasive blasting will produce airborne dust containing silica and particles of any material being removed.

Any special requirements for containment and disposal will depend on the specific contaminants or materials being removed. Blast media substitutes such as sodium bicarbonate are sometimes used to reduce the dust hazard or volume of debris. Water may be injected into the blast stream to reduce dust. Vacuum recovery systems may also be used with abrasive blast units to reduce dust and cleanup. Noise levels are likely to exceed 85 dB.

8.1.7 Execution

The blast media stream is directed at the surface using a controlled sweeping motion. The required duration of exposure to the blast stream will depend on the strength of the substrate, air pressure, air volume, blast media type, and degree of cleaning or profiling required. Special provisions are often needed to protect people, property, and the environment from dust and airborne debris. Blast curtains and containment areas may be used to isolate the blast process.

8.1.8 Equipment

- Blast nozzle and hose;
- Air compressor of sufficient capacity;
- Blast media hopper (meters the media into the air stream passing through the hose and nozzle);
- Moisture and oil separators to ensure clean, dry air supply; and
- Protective equipment, including an air-supplied hood (Fig. 8.1.d).

8.1.9 Materials

The most common abrasive blast materials are silica sand and slag. There are a wide variety of blast materials available to meet different needs. These materials are consumed in the blast operation and are generally not recycled.

8.1.10 Employee skill level

Medium skill level is required. Special training in safe operation and environmental hazards is required for crew members. A two-person crew per blast unit is required. One crew member will operate the blast nozzle while the other supports the operation by monitoring the blast operation and maintaining the blast media hopper, compressor, and hoses.

8.1.11 Setup and downtime

Time required for mobilization, setup, and maintenance of blast equipment and compressor will take several hours. Significant time may be needed to set up dust protection around the work area.

8.1.12 Cleanup

Dust, fine particles of concrete or other pulverized materials, and blast media are generated by the dry abrasive blast process. The area will require sweeping and/or vacuuming to collect the debris. Dust will accumulate on all unprotected surfaces and will require cleaning. Recuperative or wet abrasive blasting may substantially reduce the volume of dust generated.

8.1.13 Production rates

Productivity is highly variable and is dependent on the strength of the concrete, surface contaminants, accessibility, capacity of blast media hopper, compressor capacity, and type of blast media used. Production rate estimates range from 1000 to 6000 ft² (100 to 600 m²) per 8-hour shift per unit.

8.1.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface. ASTM D4259 provides additional considerations for surface preparation and quality control using this method.

8.1.15 Safety hazard

Abrasive blasting will cause the release of dust containing silica. Minimum recommended personal protective equipment (PPE) is as follows:

- Eye protection—Hood incorporating eye and face protection;
- Respiratory protection—Air-supplied hood;
- Hearing protection—Earplugs and/or earmuffs;
- Protective clothing;
- Automatic shutoff for the blast nozzle; and
- Leather or specialty gloves while operating handheld equipment.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Technical Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.2 Acid Etching



Fig. 8.2.a: Etched and clean surface



Fig. 8.2.c: Spreading acid



Fig. 8.2.b: Acid applied to concrete



Fig. 8.2.d: Rinsing to remove acid

8.2.1 Summary

Acid etching is designed to remove cement paste from the surface and surface pores of concrete (Fig. 8.2.a).

8.2.2 Removal

The acid in the etching solution attacks the calcium hydroxide ($\text{Ca}(\text{OH})_2$) and calcium silicate hydrate (CSH) in the cement paste, causing rapid deterioration at the surface. The concentration and volume of solution applied are controlled to limit the depth of chemical attack. The typical depth of removal is 0.004 to 0.010 in. (0.1 to 0.25 mm). Etching will remove the cement paste and slightly profile the surface by exposing fine silica aggregate.

8.2.3 Profile

CSP 1-3—Etching should not introduce any noticeable pattern effect on sound concrete surfaces. The surface should feel like fine sandpaper with no residue or grit. The surface should have a dull, even appearance. If the surface is still smooth or glossy, repeat procedure.

8.2.4 Accessibility

The equipment used for this method is portable and maneuverable. Access may be restricted by the presence of nonportable machinery or equipment subject to damage from corrosive mist or splash.

8.2.5 Limitations

- Caution must be exercised to avoid excessive absorption of acid by the concrete. Absorption may result in the introduction of contaminants such as chlorides (in the case of muriatic/hydrochloric acid);
- The surface may require neutralization following acid etching. All traces of the acid must be removed. Incomplete removal or neutralization of the acid may leave bond-inhibiting contaminants on the surface;
- Solution is highly corrosive. Electronic equipment, machines, and other metal components should be protected or removed;
- Thorough removal of etching debris requires large quantities of rinse water, mechanical scrubbing, and vacuum removal;
- Hydrochloric acid may not be used on metallic hardened surfaces;
- A significant amount of oils, grease, and other surface deposits must be removed prior to etching;
- Not recommended for use on green concretes;
- The etching process will saturate the substrate. When used in preparation for moisture-sensitive materials, time restrictions may not allow for sufficient drying; and
- Environmental considerations may require full containment and recovery of spent acid and rinse water.

8.2.6 Environmental factors

Applied as an acid wash, the mixture may corrode metals on contact. Debris produced by acid etching will contain particles of the material or contaminants being removed. Any special requirements for containment and disposal will depend on the specific materials or contaminant being removed. Spent acid and rinse water must be disposed of as required by local regulations or project restrictions. The acid solution may release toxic vapors.

8.2.7 Execution

1. Dilute acid mixture according to floor type, strength of concentrate, and manufacturer's recommendations. Dense or chemically hardened floors may require higher concentrations and/or multiple passes;
2. Thoroughly wet concrete surfaces to minimize absorption of the acid solution into the concrete surface. Standing water must be removed prior to application of acid;
3. Apply mixed solution uniformly (Fig. 8.2.b);
4. Agitate acid solution with stiff bristle broom or power brush for 5 to 10 minutes (Fig. 8.2.c). Do not allow surface to dry;
5. Vacuum residue;
6. Thoroughly scrub with an alkaline detergent and then vacuum the residue. Repeat as necessary to completely remove etching debris;
7. Rinse with clean water (Fig. 8.2.d), scrub, and vacuum dry; and
8. Verify that all acid etching material has been removed by checking the pH of the rinse water (refer to Appendix B.4).

8.2.8 Equipment

- Container to mix etching solution;
- Applicator: Low-pressure sprayer, plastic sprinkling can, or mop;
- Floor scrubber or disc machine equipped with an abrasive bristle brush;
- Power washer or hose to apply rinse water; and
- Vacuum system or scrubber for recovery.

The use of automatic scrubbing equipment to apply acid etching solution is not generally recommended. However, this equipment is often used to recover etching solution after it has been diluted with rinse water. Consult the equipment manufacturer to determine suitability.

8.2.9 Materials

- Acid etch solution. Typical solutions include muriatic (hydrochloric), sulfamic, phosphoric, and citric acids. **Always add acid to water—never add water to acid;**
- Alkaline detergent for cleanup scrub;
- Water source; and
- Plastic sheeting to protect materials and equipment.

8.2.10 Labor

Medium to above-medium skill level is required to safely handle and mix hazardous materials and operate equipment.

8.2.11 Setup and downtime

Minimal time is required to mix etching solution. Filling and emptying scrubber and wet-vacuum tanks should take 10 to 20 minutes. Additional time may be required to protect material and equipment in the work area.

8.2.12 Production rates

The rates shown as follows are approximate. Actual rates will vary with the method used, density of surface, dilution ratio, and size of machines.

- Manual application with wet/dry vacuum recovery: 1600 ft²/h (150 m²/h); and
- Medium scrubber: 8000 ft²/h (740 m²/h).

8.2.13 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface. Testing (such as pH testing) should verify that all acid materials have been removed by checking the pH of the rinse water before and after rinsing. ASTM D4260 provides additional considerations for surface preparation and quality control using this method.

8.2.14 Safety hazards

Acid etching involves the use of dangerous chemicals that will cause serious injury if exposed to any part of the body. Always add acid to water, as some acids may react violently if water is added to the acid. The acid may also produce dangerous vapors, which may damage the respiratory system. Operators must be trained in the proper use and handling of the acid materials. Minimum recommended PPE is as follows:

- Eye protection—Anti-fog goggles meeting ANSI requirements for high impact and face shield;
- Acid- and alkaline-resistant gloves, boots, aprons, and clothing;
- Respiratory protection using respirators equipped with acid-gases canister; and
- Hearing protection may be required if powered scrubbers are used.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.3 Handheld Concrete Breakers



Fig. 8.3.a: Jackhammer



Fig. 8.3.b: Chipping hammer with chisel and point tools

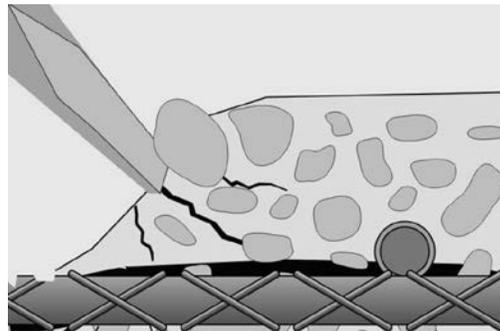


Fig. 8.3.c: Chisel tool

8.3.1 Summary

Handheld concrete breakers are typically classified by their weight. Larger handheld concrete breakers (jackhammers) in the 30 lb (14 kg) class and larger (Fig. 8.3.a) are typically used on horizontal surfaces, while smaller breakers (chipping hammers) weighing 20 lb (9 kg) or less (Fig. 8.3.b) may be used on horizontal, vertical, and overhead surfaces to remove concrete to a predetermined depth (SHRP-S-336). A typical application for a chipping hammer is the removal of deteriorated and/or chloride-contaminated concrete from around reinforcing steel. Handheld concrete breakers may also be used as an initial step in preparation for overlays. This method is suitable for use in interior and exterior applications.

8.3.2 Removal

Removal is accomplished by the impact of the tool (point or chisel) on the surface. The tools may be pneumatic, electric, or hydraulic. The impact of the tool on the surface will fracture and split the concrete. This will also result in microcracks in the remaining substrate, which will affect the bond of the repair material (Fig. 8.3.c). Surfaces prepared using chipping hammers and handheld concrete breakers will require further preparation (sandblasting, waterblasting, or shotblasting) to remove microcracks in the substrate (Fig. 8.3.d and 8.3.e). The use of heavier handheld concrete breakers will result in deeper microcracking.

8.3.3 Profile

CSP 7-10—Handheld concrete breakers will produce a very irregular surface dominated by fractured coarse aggregate. They will cause microcracks in the substrate and the points and chisel will leave marks on the concrete surface.



Fig. 8.3.d: Chipped surface using handheld concrete breaker before additional surface preparation



Fig. 8.3.e: Chipped surface followed by abrasive blasting to remove fractured substrate

8.3.4 Accessibility

Most surfaces are accessible to chipping hammers, while handheld concrete breakers are used on horizontal surfaces.

8.3.5 Limitations

- Handheld concrete breakers will induce microcracking, requiring further surface preparation;

- The use of handheld concrete breakers can damage reinforcing and other embedded items;
- The specification of smaller handheld concrete breakers (chipping hammers) in an attempt to minimize bruising will reduce production and often limits this method to low-volume removal;
- Significant loss in productivity when breaking action is other than downward;
- Localized impacts distributed over a surface inevitably result in significant variability in roughness characteristics compared to other methods. This limits the minimum thickness of repairs and overlays; and
- The use of handheld concrete breakers, followed by abrasive blasting, resulted in weaker bond strengths compared to other methods evaluated (Bissonnette et al. 2006).

8.3.6 Environmental factors

Handheld concrete breakers will produce airborne dust containing silica and particles of any other materials being removed. Special requirements for disposal of dust and debris will depend on the specific materials or contaminants being removed. Noise levels are likely to exceed 85 dB. Vibration levels are moderate to severe and will transmit through a structure. Vibration of the reinforcing steel may dislodge the reinforcing steel from the surrounding concrete, requiring additional removal to fully expose the reinforcing steel. Work area enclosures and special ventilation provisions may be required indoors to prevent dust intrusion into nearby occupied spaces.

8.3.7 Execution

Handheld concrete breakers are operated by placing the tool against the surface and activating the pneumatic, electric, or hydraulic drive system. When activated, the handheld concrete breaker rapidly impacts the tool (point or chisel) driving the working edge into the concrete surface. The operator controls the depth of removal by observation. The area being chipped will require debris removal to allow the operator to see the removal progress. Further preparation will be required to remove microcracking.

8.3.8 Equipment

- Handheld concrete breakers (Fig. 8.3.a) typically range from 30 to 90 lb (14 to 41 kg);
- Chipping hammers (Fig. 8.3.b) typically range from 12 to 20 lb (5.5 to 9.0 kg);
- Tools (chisels or points [Fig. 8.3.b]);
- Compressed air, electricity, or hydraulic power source; and
- Air hose if compressed air is used.

8.3.9 Materials

Chisels and points will require periodic sharpening and/or replacement.

8.3.10 Employee skill level

Operator skill requirements are low.

8.3.11 Setup and downtime

The setup of air hoses and changing tools is required daily. Tool changes for handheld concrete breakers will take 1 minute or less, while chipping hammers will take approximately 5 minutes.

8.3.12 Cleanup

Dust and larger pieces of concrete will be generated from the handheld concrete breaker operation. Sweeping and/or vacuuming will be required to remove the rough debris and fines to allow the operator to see the quality of the removal. Additional cleanup will be required following sandblasting or any other method used as additional surface preparation.

8.3.13 Production rates

Productivity will vary considerably depending on the size of the handheld concrete breaker used, orientation of the surface, strength of substrate, depth of removal, and type of material being removed. The typical removal rate for normal (4000 psi [27.5 MPa]) concrete using a chipping hammer is 1.5 to 4.0 ft³/h (0.04 to 0.11 m³/h) per operator. The removal rate for a handheld concrete breaker is significantly higher depending on the weight of the tool.

8.3.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate an adequate bond between the prepared surface and repair material. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface.

8.3.15 Safety hazards

Handheld concrete breakers will cause dust and produce airborne debris. Minimum recommended PPE is:

- Eye protection—Meeting ANSI requirements for high impact and face shield;
- Respiratory protection—Required in confined areas or where dust is present;
- Hearing protection—Process will likely generate noise levels in excess of 85 dB. Noise levels may require the use of earplugs and/or earmuffs; and
- Leather gloves while operating handheld equipment.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.4 Detergent Scrubbing



Fig. 8.4.a: Floor scrubbing



Fig. 8.4.c: Ride-on scrubber



Fig. 8.4.b: Floor scrubbing machine



Fig. 8.4.d: Walk-behind scrubber

This method removes oil, grease, and other deposits on concrete surfaces by scrubbing with a detergent solution.

8.4.1 Summary

This method may be used on horizontal concrete surfaces to remove dirt, oil, and grease. Corner and edge cleaning can be detailed manually. The scrubbing process should produce clean surfaces devoid of dirt, oil, grease, and loose debris without altering the surface texture. Detergent scrubbing is frequently used to prepare concrete for acid etching.

8.4.2 Removal

Removal is accomplished through the combined action of detergent/chemical cleaners, scrubbing of the surface with brushes (Fig. 8.4.a and 8.4.b), and rinsing or vacuuming of the cleaning solution and debris from the surface (Fig. 8.4.c and 8.4.d). This method is suitable for superficial removal of oil, grease, organic or inorganic residues, wax, rust, and other deposits from concrete surfaces. Absorbed fluids such as oils and grease may require several treatments to achieve acceptable results or may not be adequately removed depending on the nature of the absorbed fluid and depth of penetration.

8.4.3 Profile

CSP 1—Detergent scrubbing will not produce any noticeable pattern effect on sound concrete surfaces.

8.4.4 Accessibility

With the variety of portable and maneuverable equipment available, most surfaces are accessible. Access to corners, recesses, and between penetrations is restricted by the reach and arc of the brushes. These areas may be addressed manually.

8.4.5 Limitations

This method is limited to the removal of water-soluble or detergent-emulsifiable contaminants and debris, which can be readily loosened by light mechanical action of the scrubbers. Note that in heavily contaminated substrates, additional contaminants may diffuse to the cleaned surface within hours/days of cleaning.

8.4.6 Environmental factors

Moderate-to-heavy contamination may produce significant amounts of sludge or other debris. Some debris may be considered hazardous or otherwise unqualified for discharge into sewer systems. Debris produced by

detergent scrubbing will contain particles of the material or contaminants being removed. Any special requirements for containment and disposal will depend on the specific materials or contaminant being removed. Suitable measures for the containment, collection, and proper disposal of debris and rinse water should be considered. Detergents and cleaning chemicals may produce odors.

8.4.7 Execution

1. Apply chemical detergent solution;
2. Scrub in chemical solution with stiff-bristled broom or scrubbing machine;
3. Collect and dispose of solution;
4. Rinse or vacuum surface to remove all residues; and
5. Repeat process as needed to achieve acceptable results.

8.4.8 Equipment

Manual methods:

- Mop;
- Floor scrubber (Fig. 8.4.a and 8.4.b);
- Pump-up sprayer;
- Stiff broom;
- Pressure washer; and
- Squeegee or wet/dry vacuum.

Mechanical methods:

- Automatic scrubbing machine (walk-behind or self-propelled—Fig. 8.4.c and 8.4.d) available in gas-, electric-, propane-, or diesel-powered models. Brush rotation speeds of up to 300 rpm;
- Brushes: Nylon bristle brushes are relatively soft. Polyethylene bristles are stiffer and more aggressive. Polyethylene/abrasive composite bristles will provide the most aggressive mechanical cleaning;
- Sizes range from an 18 to 60 in. (0.5 to 1.5 m) brush path; and
- Solution tanks range from 3 to 365 gal. (11 to 1380 L) with recovery tanks to hold scrubbing residue.

8.4.9 Materials

- Industrial detergent rated to remove heavy oil and grease; and
- Water source.

8.4.10 Labor

Low skill is required for manual scrubbing method. Medium skill is required to operate automatic scrubber and mix chemical solutions.

8.4.11 Setup and downtime

- Manual methods: Very little time is required to set up equipment and mix detergents; and
- Mechanical methods: Mixing chemicals, filling tanks, and removing debris from recovery tanks will involve some downtime. Changing brushes is quick and infrequent. Replacement frequency for pickup squeegees will depend on wear factors.

8.4.12 Cleanup

Scrubbing manually with brooms or mechanically with electric single-disc machines will generate a liquid residue that must be removed by a squeegee, vacuum, or low-pressure water cleaning method to obtain a clean surface. Automatic scrubbers have an internal squeegee/vacuum system to collect the liquid residue immediately behind the scrub brushes.

8.4.13 Production rates

The following rates are approximate. Actual rates will vary considerably with the severity of soil, size of machine, and effectiveness of chemical solution being used.

- Manual with wet/dry vacuum recovery: 500 ft²/h (50 m²/h);
- Manual with electric brush machine with wet/dry vacuum recovery: 1000 ft²/h (100 m²/h);
- Small walk-behind scrubber: 5000 ft²/h (500 m²/h); and
- Medium or large riding scrubber: 50,000 ft²/h (5000 m²/h).

8.4.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface. ASTM D4258 provides additional considerations for surface preparation and quality control using this method.

8.4.15 Safety hazards

Operators must be trained in the proper use of this equipment and the proper handling of the cleaning solutions. Minimum recommended PPE is as follows:

- Eye protection—Anti-fog goggles meeting ANSI requirements for high impact;
- Hearing protection—Required while operating machinery; and
- Chemical-resistant gloves while handling cleaning solutions.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.5 Grinding



Fig. 8.5.a: Floor grinding



Fig. 8.5.c: Floor grinding with vacuum



Fig. 8.5.b: Grinding disc



Fig. 8.5.d: Hand grinder for detail work

8.5.1 Summary

This method may be used on horizontal, vertical, and overhead surfaces to smooth slight surface irregularities and remove thin coatings and rigid high-build coatings such as epoxy, polyurethane, and methacrylate coatings. Grinding may also be used to remove mineral deposits, efflorescence, rust, and other deposits. Grinding may be used on almost any substrate and is suitable for interior and exterior applications.

8.5.2 Removal

Removal is accomplished by the rotation of one or more abrading stones or discs applied under pressure at right angles to the concrete surface. The grinding stone or disc is moved across the surface until the desired effect is achieved.

8.5.3 Profile

CSP 1-2—Grinding produces a smooth surface. Other methods may be used in conjunction with grinding to provide the required profile. Small handheld grinders are likely to produce gouging and a circular, grooved pattern. Walk-behind units will eliminate gouging but are likely to show a circular pattern. Larger units using fine stones

should not produce any detectable pattern and are frequently used for producing polished concrete and terrazzo.

8.5.4 Accessibility

Most surfaces, including edges, are accessible. Equipment ranges from small handheld grinders to walk-behind units with multiple discs. Access to corners and tight configurations is restricted by the arc of the grinding disc.

8.5.5 Limitations

Grinding is not recommended for the following applications:

- Preparation for coating or sealing unless followed by acid etching, shotblasting, or high-pressure water-blasting;
- Removal of chlorinated rubber, acrylic, or other soft coatings or finishes;
- Removal of tile or carpet adhesives; and
- Removal of materials that may smoke or burn when heated.

8.5.6 Environmental factors

Dry grinding will produce a dust containing silica and other contaminants being removed from the surface. Dust

may be minimized with vacuum systems attached to the grinder (Fig. 8.5.a, 8.5.c, and 8.5.d). Debris generated by this method will contain fine particles of any material or contaminant being removed. Wet grinding, which may be used to minimize airborne dust, will produce a slurry residue and rinse water that will require proper disposal. Grinding soft, easily charred materials will generate smoke, which may be hazardous. Noise and vibration levels are considered to be low.

8.5.7 Execution

Grinders are moved over the surface in a linear or sweeping motion until the desired removal or effect is achieved.

8.5.8 Equipment

Grinders are available in electric-, pneumatic-, or gas-driven models. Sizes range from walk-behind machines (Fig. 8.5.a to 8.5.c) to handheld grinders (Fig. 8.5.d). Rotation speeds vary from 1000 to 9000 rpm. Grinders are typically connected to a vacuum dust recovery system.

8.5.9 Materials

The grinding medium (stone or disc) is consumed during the process. Some discs have inserts that may be changed as they wear out. Grinding discs range in diameter from 4 to 18 in. (100 to 450 mm). Their composition varies from very fine polishing media to aggressive cutting media with wet or dry diamonds. The disc shape may be flat, cone-shaped, or cup-shaped.

8.5.10 Employee skill level

Low to medium skill is required.

8.5.11 Setup and downtime

Setup requires very little time unless dust protection includes draping and taping. Changing stones or discs is quick. Frequency of replacement will depend on the composition of the stone or disc, substrate, and material being removed.

8.5.12 Cleanup

Grinding will produce a fine powder and small chips. The debris can be swept, rinsed with water, or vacuumed.

8.5.13 Production rates

Productivity will vary depending on the grinding media selected and the type of material being removed. Estimated rates are:

- Handheld units: 20 ft²/h (2 m²/h); and
- Walk-behind units: 800 ft²/h (75 m²/h).

8.5.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface. ASTM D4259 provides additional considerations for surface preparation and quality control using this method.

8.5.15 Safety hazards

Grinding will cause the release of dust. Minimum recommended PPE is as follows:

- Eye protection—Meeting ANSI requirements;
- Respiratory protection—May be required in confined areas where dust is present; and
- Hearing protection—Process may generate noise levels in excess of 85 dB. Noise levels may require the use of earplugs and/or earmuffs.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.6 High- and Ultra-High-Pressure Water Jetting

(5000 to 45,000 psi [35 to 275 MPa] at 2 to 50 gal./min [8 to 190 L/min])



Fig. 8.6.a: Surface preparation—handheld lance



Fig. 8.6.c: Coating removal



Fig. 8.6.b: Coating removal—robotic equipment



Fig. 8.6.d: Membrane removal—mower

8.6.1 Summary

High- and ultra-high-pressure water jetting may be used to remove laitance, efflorescence, scale, dirt, or other contaminants. With suitable pressure and a nozzle, epoxy, urethane, and methacrylate coatings and thin overlay systems may be removed (Fig. 8.6.b, 8.6.c, and 8.6.d). It may also be used to remove carbonated, freezing-and-thawing-damaged, weakened, delaminated, or otherwise undesirable concrete from the substrate. The method is suitable for horizontal, vertical, and overhead applications. Pressures in the higher ranges may be needed to remove certain coating materials. This method will clean the reinforcing steel; however, flash rust may occur. High-pressure water jetting may be used for hydro-demolition (refer to ICRI Guideline No. 310.3; SHRP-S-336).

8.6.2 Removal

Removal is accomplished when the water jet strikes the surface. The degree of removal is controlled by the force of the water jet (pressure and volume) and the length of time the water jet is in contact with the surface. Multi-jet systems rotating at a high speed (1000 to 3000 rpm) spread the force of the water over a larger area and result in minimal contact time with the surface. The multi-jet

systems are effective in removing surface contaminants, including coatings and weakened concrete. A single water jet rotating at slower speeds (300 to 900 rpm) or oscillating concentrates the force of the water and produces a longer contact time with the surface, resulting in more aggressive removal. The single-jet systems are effective in removing sound and unsound concrete.

8.6.3 Profile

CSP 3-10—When using multi-jet tools, the surface profile of sound concrete may remain largely unaffected by this process. The use of multi-jet heads and a short contact time will clean the surface while creating a minimal profile (CSP 3). Pressure and nozzle tips may be adjusted to produce the desired profile. The use of high- and ultra-high-pressure water jetting on low-strength or deteriorated surfaces will produce a much more aggressive profile as surface defects are removed. The use of a single nozzle will result in a surface profile of CSP 10. The amplitude of $\pm 1/2$ the diameter of the coarse aggregate can be expected (ICRI 310.3).

8.6.4 Accessibility

With the wide variety of portable and maneuverable equip-

ment available, most surfaces are easily accessible. Tight spaces can be accessed with a handheld lance.

8.6.5 Limitations

This method should not be used where goods or equipment may be damaged by impact from water jets or where they cannot be protected from heavy mist or flooding. Proper precautions for live electrical wiring or conduit need to be considered when using high-/ultra-high-pressure water.

8.6.6 Environmental factors

This process produces loud noise. Mist and a significant volume of water will be introduced into the work area. The volume of water introduced will range from 2 to 50 gal./min (8 to 150 L/min) and is determined by the type of removal to be performed and the requirements of the equipment selected. Environmental regulations may require containment and regulated disposal of the liquid waste generated. Frequently, the pH of the spent hydrodemolition water and suspended solids are adjusted prior to disposal.

8.6.7 Execution

The concrete surface is prepared by uniformly moving the water jet back and forth over the surface until the desired results are achieved. Automated equipment typically moves the nozzle(s) left and right as the unit advances. Standing water may need to be pumped or squeegeed off the surface. Units that clean and recycle jetting water are available. Solid debris, slurry, and water residue are disposed of as required by local regulations or project restrictions.

8.6.8 Equipment

- Water pump capable of producing the desired pressure and volume;
- Compressed air source producing a minimum of 85 ft³/min at 120 psi (2.4 m³/min at 0.8 MPa) (for power spin or rotation function);
- High-pressure hoses;
- Self-propelled equipment (Fig. 8.6.b and 8.6.d) for horizontal surfaces and handheld lance (Fig. 8.6.a) for vertical and overhead applications, corners, or other difficult-to-reach locations. Robots may be used on horizontal, vertical, and overhead surfaces;
- Suitable nozzle; and
- Runoff protection to contain water and debris.

8.6.9 Materials

Potable water is recommended and may be provided from a fire hydrant connection, tanker, or similar source capable of meeting the requirements of the equipment.

8.6.10 Employee skill level

Medium to above-medium skill level with appropriate training is required. Must be able to maintain high-pressure pumps and components and safely operate equipment. Skilled supervision may be needed if complex equipment

is used. Everyone operating high- or ultra-high-pressure waterblasting equipment must be trained in the hazards of this type of equipment.

8.6.11 Setup and downtime

Setup time is variable depending on the size of the work area and specific protective measures required. Downtime may be required to maintain equipment and replace consumable parts, such as nozzles and seals.

8.6.12 Cleanup

Collect water for proper disposal. Debris can be rinsed, swept, or vacuumed from the surface. Jetting of deteriorated surfaces may produce additional debris.

8.6.13 Production rates

The rates shown as follows are approximate and assume sound, 4000 psi (28 MPa) concrete. Actual production rates will vary considerably and will depend on the strength of the concrete, hardness and bond strength of material to be removed, preparation objectives, operator skill, and efficiency of equipment employed.

- Handheld lances—Horizontal surfaces: 125 to 300 ft²/h (12 to 28 m²/h);
- Handheld lances—Vertical and overhead surfaces: 50 to 250 ft²/h (5 to 23 m²/h); and
- Automated equipment—Horizontal, vertical, and overhead surfaces: 300 to 2000 ft²/h (30 to 200 m²/h).

8.6.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface.

8.6.15 Safety hazards

Water jetting will create a dangerous water stream, loud noise, flying debris, and water spray. A water jet cut or puncture can force bacteria into the body, resulting in a serious infection. Operators must be trained in the proper use of this equipment. Minimum recommended PPE is:

- Eye protection—Anti-fog goggles meeting ANSI requirements for high impact and face shield;
- Hearing protection—Process will generate noise levels in excess of 85 dB. Earmuff-type protectors are strongly recommended. Noise levels may require the use of earplugs and earmuffs;
- Steel-toed waterproof boots, helmet, and waterproof gloves and clothing; and

- Handheld lance operator—Metatarsal guards and protective clothing capable of deflecting the high- or ultra-high-pressure water. Consult the material and equipment manufacturer’s current recommended safety procedure. Consult ICRI Guideline No. 120.1

(Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation. Consult ASTM E1575, ICRI 310.3, and WJTA for safety practices for pressure water cleaning.

8.7 Low-Pressure Water Cleaning

1000 to 5000 psi (7 to 35 MPa) at 2 to 10 gal./min (8 to 40 L/min)



Fig. 8.7.a: Wall and floor cleaning



Fig. 8.7.c: Floor cleaning



Fig. 8.7.b: Curb cleaning

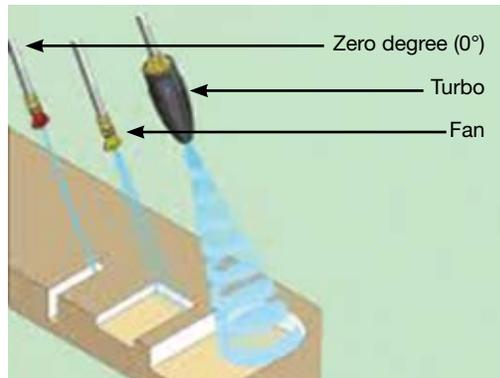


Fig. 8.7.d: Various nozzle types

8.7.1 Summary

This method may be used outdoors to remove dust, friable materials, debris, or water-soluble contaminants from concrete surfaces and surface cavities (Fig. 8.7.a to 8.7.c). It may be used in interior spaces where mist, noise, and standing water can be tolerated. The method is suitable for horizontal, vertical, and overhead applications. For surface preparation applications, low-pressure water cleaning is often used to perform a final rinse following other surface preparation techniques.

8.7.2 Removal

Water is sprayed at pressures less than 5000 psi (35 MPa) to remove dirt and loose, friable material. This method does not remove any significant amount of concrete.

8.7.3 Profile

CSP 1—This method does not produce any significant texture, profile, or pattern on sound concrete.

8.7.4 Accessibility

Most low-pressure water cleaning is performed with a handheld lance and is readily accessible to all surfaces.

8.7.5 Limitations

The presence of materials or equipment that cannot be adequately protected from mist or spray may restrict use of this method. This method is not suitable for the removal of sealers, coatings, curing membranes, or any concrete other than what is already loose.

8.7.6 Environmental factors

Mist and a large volume of water will be introduced into the work area. Debris produced by low-pressure water cleaning will contain particles of material or contaminants being removed. Any special requirements for containment and disposal will depend on the specific materials or contaminant being removed. Environmental regulations may require containment and regulated disposal of the liquid waste generated.

8.7.7 Execution

- A water spray is methodically moved back and forth over the surface until the desired results are achieved. If automated equipment is used, the operator typically makes parallel passes. If handheld lances are used, the process will be slower but similar;
- Standing water may need to be pumped, vacuumed, or squeegeed off the surface; and
- Solid debris and water residue are disposed of as required by local regulations or project restrictions.

8.7.8 Equipment

- Booster pump (to increase pressure);
- Heater for hot water applications;
- Pressure-rated hoses;
- Wheeled equipment for horizontal surfaces; handheld lance for vertical and overhead applications, corners, or other difficult-to-reach locations;
- Suitable nozzles (Fig. 8.7.d); and
- Runoff protection to catch debris flowing off site or toward drains.

8.7.9 Materials

Water source may be provided by tanker, hydrant connection, industrial spigot, or pump.

8.7.10 Labor

Work may be performed with unskilled labor. Skilled supervision may be needed if complex equipment is used.

8.7.11 Setup and downtime

Equipment setup time is very short but additional time may be necessary to protect surfaces and install runoff protection to catch loosened materials.

8.7.12 Cleanup

Low-pressure water cleaning is often used to clean up following other surface preparation techniques or repair

procedures. Water and debris produced during the cleaning will have to be contained, collected, and disposed of.

8.7.13 Production rates

The rates that follow are approximate. Actual rates will vary with the pressure, volume of water, type of spray nozzle, number of passes, speed of travel, and efficiency of equipment employed and preparation objectives.

- 1000 to 2000 ft²/h (100 to 200 m²/h) for flat surface; and
- 250 to 1000 ft²/h (25 to 100 m²/h) for handheld equipment on vertical and overhead surfaces.

8.7.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface. ASTM D4259 provides additional considerations for surface preparation and quality control using this method.

8.7.15 Safety hazards

Low-pressure water cleaning will create a dangerous water stream, loud noise, flying debris, and water spray. A water spray may cut or puncture the skin and can force bacteria into the body, resulting in a serious infection. Operators must be trained in the proper use of this equipment. Minimum recommended PPE is as follows:

- Eye protection—Anti-fog goggles meeting ANSI requirements for high impact and face shield;
- Handheld lance operator—Steel-toed waterproof boots, metatarsal guards, helmet, protective clothing capable of deflecting the water jet, and waterproof gloves and outer layers; and
- Hearing protection—Process will generate noise levels in excess of 85 dB. Earmuff-type protectors are strongly recommended. Noise levels may require the use of earplugs and earmuffs.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation. Consult ASTM E1575, ICRI 310.3, and WJTA for safety practices for pressure water cleaning.

8.8 Rotomilling



Fig. 8.8.a: Skid-steer-mounted rotomilling unit



Fig. 8.8.c: Rotomilled concrete surface



Fig. 8.8.b: Rotomilling drum with teeth



Fig. 8.8.d: Rotomilling used to remove membrane

8.8.1 Summary

Rotomilling is used on horizontal surfaces to remove unsound concrete, mastics or other high-build coatings, and asphaltic materials (Fig. 8.8.d). It may also be used to profile concrete substrates (Fig. 8.8.c). This method is suitable for use in interior and exterior applications, primarily on horizontal surfaces. Milling attachments mounted to excavators are used for milling vertical surfaces and corners.

8.8.2 Removal

The rotomilling equipment contains a rotating drum with teeth (Fig. 8.8.b). As the machine moves forward, the cutting teeth strike the surface with great force, fracturing material into chips and dust. The depth of concrete removal ranges from 1/4 to 4 in. (6 to 100 mm). The machine's maximum removal depth is determined by the number and size of teeth, and the size and weight of the machine. A greater number of small teeth will produce a smoother surface CSP 6 to 7, while fewer, larger teeth will produce a CSP 9 and greater. The weight of the machine provides the downward force on the cutting drum. Most machines are equipped with depth gauges,

which allow the operator to adjust and monitor the depth of removal.

8.8.3 Profile

CSP 6 to 9—Rotomilling will produce a rough surface with fractured coarse aggregate. The teeth of the rotating drum will produce a pattern with linear striations (grooving). The profile obtained is determined by the number and size of teeth. The prepared surface may be very rough and can exceed CSP 9. This method will cause microcracking in the prepared surface.

8.8.4 Accessibility

Most rotomilling equipment will reach within 6 in. (150 mm) of vertical surfaces such as walls, curbs, and columns.

8.8.5 Limitations

Supported slabs must be structurally capable of supporting large, heavy equipment. This method will produce high levels of noise, dust, and vibration. Rotomilling operations will cause microcracking. The deleterious effects of microcracking may be reduced or eliminated by following initial removal with steel shotblasting, abrasive blasting, or high- and ultra-high-pressure water jetting. The depth

of microcracking may be deeper than can be readily addressed by abrasive blasting or shotblasting.

8.8.6 Environmental factors

Rotomilling will produce airborne dust containing concrete and particles of any other materials or contaminants being removed. Requirements for containment and disposal of dust and debris will depend on the specific materials or contaminants being removed. Special ventilation provisions may be required when operating gasoline- or diesel-powered units indoors. Water that is used to control dust or clean the substrate may need to be collected and treated prior to disposal. Noise levels will exceed 85 dB. Rotomilling equipment operation results in significant vibration to the structure.

8.8.7 Execution

The surface is prepared by driving the rotomilling equipment in a straight path across the surface. The depth is controlled by adjusting the depth of the drum.

8.8.8 Equipment

Large rotomilling machines are self-propelled ride-on units that collect the debris on a conveyor and transport it to a container, usually a dump truck working with the rotomill. Smaller units consist of a special rotomilling head mounted on a skid-steer loader (Fig. 8.8.a). A rotomilling head mounted on an excavator may be used for vertical or overhead removal.

8.8.9 Materials

Teeth mounted on the rotomilling drum.

8.8.10 Employee skill level

Experienced, trained machine operators are needed to operate equipment and perform periodic maintenance or replacement of cutting heads and teeth. Additional workers with appropriate skills are needed to operate the support equipment, such as conveyors, dump trucks, microcrack mitigation equipment, and for general cleanup.

8.8.11 Setup and downtime

Machines arrive at the site ready to work. Downtime may be experienced as a result of periodic maintenance and replacement of teeth.

8.8.12 Cleanup

Debris removal equipment may include dump trucks, loaders, a conveyor system, shovels, and brooms. Large machines will convey the debris directly into a dump truck. Smaller units leave the debris on the surface, which is removed using skid-steer loaders, brooms, and shovels.

8.8.13 Production rates

The removal rate will depend on the depth and hardness of the substrate concrete. Estimated removal rates are:

- Small skid-steer-mounted machines—1000 ft²/h (90 m²/h);
- Mid-range machines—3000 to 4000 ft²/h (280 to 370 m²/h); and
- Large roadway machines—15,000 ft²/h (1400 m²/h).

8.8.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials and microcracking. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface.

8.8.15 Safety hazards

Rotomilling creates dust, flying debris, and loud noise. Operators must be trained in the proper use of this equipment. Minimum recommended PPE is as follows:

- Eye protection—meeting ANSI requirements;
- Respiratory protection to protect against silica containing dust. If materials being removed contain toxic substances, additional protection may be required; and
- Hearing protection—Process will generate noise levels in excess of 85 dB. Earplugs and/or earmuffs are required.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.9 Needle Scaling



Fig. 8.9.a: Needle gun



Fig. 8.9.b: Steel rods (needles)



Fig. 8.9.c: Masonry surface preparation



Fig. 8.9.d: Metal surface preparation

8.9.1 Summary

Needle scaling tools are primarily used for metal cleaning (Fig. 8.9.d); however, they are also used in concrete and masonry surface preparation (Fig. 8.9.c). This method can be used on surfaces indoor, outdoor, or underwater and on surfaces of any orientation to remove efflorescence, brittle encrustations, and coating systems. It is frequently used for work on edges and other tight spaces that cannot be accessed by larger, more automated equipment. It may be used underwater to remove barnacles and other marine shellfish attached to submerged surfaces.

8.9.2 Removal

Removal is accomplished by the superficial fracturing and pulverization of the concrete surface. The surface is impacted by the pointed tips of a bundle of steel rods that are pulsed by compressed air or hydraulics.

8.9.3 Profile

CSP 2 to 4—Needle scaling will produce random, evenly distributed impact craters around larger aggregate, imparting a textured surface.

8.9.4 Accessibility

Handheld needle scaling tools are available in several sizes, providing virtually unrestricted accessibility.

8.9.5 Limitations

Needle scaling is not recommended for removal of coatings that are thick or resilient, preparation of large surface areas, or the removal of sound concrete. Needle scaling may produce microcracking of the surface.

8.9.6 Environmental factors

Needle scaling will produce dust containing silica and particles of any material or contaminants being removed. Any special requirements for containment and disposal will depend on the specific contaminants being removed. Noise levels are loud and vibration levels are low to medium.

8.9.7 Execution

The needle scaling tool is held against the surface with light-to-medium pressure. The pneumatically driven rods are activated by a trigger located in the unit's handle.

8.9.8 Equipment

- Needle guns ranging in weight from 2.5 to 15 lb (1 to 7 kg) (Fig. 8.9.a);
- The size of the steel rod will vary and the number of rods in a bundle range from 12 to more than 30 (Fig. 8.9.b);
- Air compressor and air hose producing 3 to 15 ft³/min at 80 to 120 psi (0.08 to 0.42 m³/min at 0.6 to 0.8 MPa); and
- Vacuum or other cleanup equipment.

8.9.9 Materials

The hardened steel rods are consumed during surface preparation.

8.9.10 Employee skill level

Low skill is required.

8.9.11 Setup and downtime

Minimal. Approximately 5 minutes per hour to change needle bundles. Rebuilding needle bundles is usually an off-site activity.

8.9.12 Cleanup

Needle scaling will generate dust and small airborne particles. The tools are not equipped to collect debris, which may be vacuumed or swept up for proper disposal.

8.9.13 Production rates

Productivity will range from 10 to 50 ft²/h (1 to 5 m²/h). Rate is dependent on size of needle gun, number of needles per bundle, available air pressure and volume, strength of substrate, and hardness of material being removed.

8.9.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface. ASTM D4259 provides additional considerations for surface preparation and quality control using this method.

8.9.15 Safety hazards

Needle scaling tools will cause the release of dust. Minimum recommended PPE is as follows:

- Eye protection—Meeting ANSI requirements for high impact, and face shield;
- Respiratory protection—May be required in confined areas where dust is present;
- Hearing protection—Process may generate noise levels in excess of 85 dB. Noise levels may require the use of earplugs and/or earmuffs; and
- Leather gloves while operating handheld equipment.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.10 Scabbling



Fig. 8.10.a: Coating removal



Fig. 8.10.c: Multi-head scabbler



Fig. 8.10.b: Typical scabbler head



Fig. 8.10.d: Multi-head scabbler

8.10.1 Summary

Scabbling is used primarily on horizontal surfaces to remove concrete or brittle coatings such as epoxy, polyurethane, or methyl methacrylate systems up to 1/4 in. (6 mm) thick (Fig. 8.10.a) in preparation for overlays. It may also be used to deeply profile concrete surfaces. Handheld units (bush hammers) are available for vertical and overhead surfaces. This method is suitable for use in interior and exterior applications.

8.10.2 Removal

Removal is accomplished by the impact of the scabbling head (Fig. 8.10.b) on the surface. The piston-driven cutting heads are pneumatically activated. Repeated blows to the surface result in chipping and crushing of the concrete surface and material being removed.

8.10.3 Profile

CSP 7 to 9—Scabbling will produce a very irregular surface dominated by fractured coarse aggregate. Scabbling will cause microfractures in the substrate. There should be no discernible tool pattern.

8.10.4 Accessibility

Most surfaces are accessible using equipment ranging from small handheld to large walk-behind units. Corners, recesses, and tight configurations are accessible with handheld tools (bush hammers).

8.10.5 Limitations

Scabbling is not recommended for the removal of elastomeric membranes or gummy materials such as tile or carpet adhesives.

8.10.6 Environmental factors

Scabbling will produce airborne dust containing silica and particles of any other materials being removed. Any special requirements for containment and disposal of dust and debris will depend on the specific materials or contaminants being removed. Noise levels are likely to exceed 85 dB. Vibration levels are moderate to severe and will transmit through a structure. Work area enclosures and special ventilation provisions may be required indoors to prevent dust intrusion into nearby occupied work space.

8.10.7 Execution

Scabblers are operated by manually pushing the units across the surface in a back-and-forth motion at slow speed. The area being scabbled will require continuous debris removal to allow the operator to see the removal progress.

8.10.8 Equipment

- Scabblers—Manually operated walk-behind machines having up to 12 heads (Fig. 8.10.c and 8.10.d);
- Handheld tools for detail work;
- Air compressor or other air source producing a minimum of 180 ft³/min at 120 psi (5.1 m³/min at 0.8 MPa). Air volume requirements are likely to increase with larger equipment and multiple heads; and
- Air hose—1/2 to 2 in. (13 to 50 mm) in diameter.

8.10.9 Materials

Impact bits are the consumed material (Fig. 8.10.b). These are available in varying configurations with tungsten carbide inserts.

8.10.10 Employee skill level

Operator skill requirements are low.

8.10.11 Setup and downtime

Setup of air hoses and changing bits is required once per day. Bit changes will take anywhere from 10 minutes for single-head units to as much as 35 minutes for large, multi-head units.

8.10.12 Cleanup

Dust and larger particles up to 1/2 in. (13 mm) in diameter will be generated from the impact of the bits. Sweeping

and/or vacuuming will be required to continuously remove the rough debris and fines to allow the operator to see the quality of the removal.

8.10.13 Production rates

Productivity will vary considerably depending on the size of the machine, strength of substrate, depth of removal, and type of material being removed. For heavy removal, estimated rates range from 20 to 100 ft²/h (1.9 to 9.3 m²/h).

8.10.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved and microcracking has been mitigated. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface. ASTM D4259 provides additional considerations for surface preparation and quality control using this method.

8.10.15 Safety hazards

Scabblers will cause the release of dust and will produce airborne debris. Minimum recommended PPE is:

- Eye protection—Meeting ANSI requirements for high impact and face shield;
- Respiratory protection—May be required in confined areas where dust is present;
- Hearing protection—Process may generate noise levels in excess of 85 dB. Noise levels may require the use of earplugs and/or earmuffs; and
- Leather gloves while operating handheld equipment.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.11 Scarifying

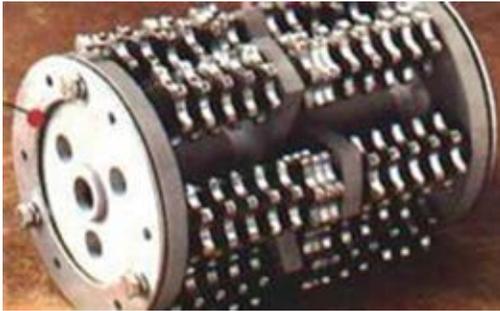


Fig. 8.11.a: Cutting drum with teeth



Fig. 8.11.b: Cutter teeth



Fig. 8.11.c: Scarified surface showing teeth marks



Fig. 8.11.d: Typical scarifying machine

8.11.1 Summary

Scarification is used primarily on horizontal surfaces for the removal of concrete and brittle coatings up to 1/8 in. (3 mm) thick. Multiple passes may be made for deeper removal. It may also be used to profile concrete surfaces (Fig. 8.11.c). Adhesives may be removed by the adjustment of spacers and the selection of appropriate cutters. Handheld units are available for vertical and overhead applications. Scarifying may be used on almost any concrete substrate and is suitable for both interior and exterior applications. This method is also known as concrete planing.

8.11.2 Removal

Removal is accomplished by the rotary action of cutters (toothed washers) on the surface to fracture or pulverize the concrete. The cutters are assembled on steel rods mounted at the perimeter of a drum that rotates at high

speeds. Removal depth may range from light surface profiling to 1/4 in. (6 mm) for smaller equipment and 1/2 to 3/4 in. (13 to 19 mm) for larger equipment. Removal depths greater than 1/8 in. (3 mm) are accomplished in multiple passes.

8.11.3 Profile

CSP 4 to 7—Scarifying will produce a parallel, striated pattern. The deepest removal pattern will be produced at surface high points.

8.11.4 Accessibility

With portable equipment ranging in size from small handheld devices to large, self-propelled units, most surfaces are accessible to within 1/4 in. (6 mm) of the edge. Access to corners and tight configurations such as around and between pipes is restricted by the dimensions of the drum housing.

8.11.5 Limitations

Scarification is not recommended for surface preparation for sealers or coatings less than 15 mils (0.38 mm) thick or the removal of heavy elastomeric membranes. This method may cause microcracking in the substrate.

8.11.6 Environmental factors

Scarifying will produce airborne dust containing concrete and particles of the material being removed. Any special requirements for containment and disposal of dust and debris will depend on the specific contaminants being removed. Noise levels are likely to exceed 85 dB. Vibration levels are moderate. Ventilation may be required when operating gasoline- or diesel-powered units indoors.

8.11.7 Execution

With the exception of handheld units, most scarifiers are operated by pushing the machine forward over the surface, advancing at a slow walk. The depth and rate of removal are adjusted by raising or lowering the drum to increase or decrease the impact of the cutters. Several passes may be required to achieve the desired profile. Debris must be removed after each pass.

8.11.8 Equipment

- Mechanical scarifiers are available in electric-, pneumatic-, or gasoline-powered models in sizes ranging from walk-behind (Fig. 8.11.d) to self-propelled ride-on units. Path widths range from 4 to 36 in. (100 to 900 mm);
- Replacement drums (Fig. 8.11.a);
- Air compressor or other air supply (pneumatic models only); and
- Industrial vacuum cleaner to be used with vacuum adapter attachments to limit airborne dust.

8.11.9 Materials

The cutters are consumed during the removal (Fig. 8.11.b). The rate of consumption depends on the following:

- Cutter configuration;
- Cutter composition (hardened steel, tungsten carbide);
- Substrate hardness;
- Composition of materials to be removed; and
- Force of equipment on concrete surface (weight, pressure).

8.11.10 Labor

Low to medium skill is required.

8.11.11 Setup and downtime

Minimal. Setup requires very little time. Drum changes will take approximately 5 to 10 minutes. Rebuilding drums is usually done off-site.

8.11.12 Cleanup

Sweeping and removal of the dust and debris will be required.

8.11.13 Production rates

The rates shown as follows are estimates. Productivity will vary considerably depending on equipment size, depth of removal, and type of material being removed.

- Handheld units: 20 ft²/h (2 m²/h); and
- Walk-behind units: 800 ft²/h (75 m²/h).

8.11.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved and that the concrete has no bruising (microcracking). Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface. ASTM D4259 provides additional considerations for surface preparation and quality control using this method.

8.11.15 Safety hazards

Mechanical scarifiers will produce dust. If gas- or diesel-powered equipment is used, the area should be well-ventilated. Minimum recommended PPE is as follows:

- Eye protection—Meeting ANSI requirements for high impact and face shield;
- Respiratory protection—May be required in confined areas where dust is present; and
- Hearing protection—Process may generate noise levels in excess of 85 dB. Noise levels may require the use of earplugs and/or earmuffs.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.12 Shotblasting



Fig. 8.12.a: Shotblasting warehouse floor



Fig. 8.12.c: CSP 3 surface using shotblasting



Fig. 8.12.b: Shotblast equipment



Fig. 8.12.d: 8 in. (203 mm) unit for trim work

8.12.1 Summary

Shotblasting is principally used to clean and profile horizontal surfaces in preparation for the application of sealers, coatings, or polymer overlays. This method is also used to remove dirt, laitance, curing compounds, sealers, or other superficial contaminants and some existing coatings and adhesives (Fig. 8.12.c). Handheld machines are available for use on vertical surfaces. Shotblasting is suitable for use in both interior and exterior applications.

8.12.2 Removal

Removal is accomplished by the pulverizing effect of a steel shot impacting the surface at high velocity. The steel shot is propelled against the surface (Fig. 8.12.b—red arrows) by a rotating wheel. The steel shot and removed material (Fig. 8.12.b—yellow arrows) are collected with the aid of a dust collection system. The removed material is separated as waste and the steel shot is reused. The depth of removal is controlled by shot size, number of repeated passes, and rate of linear travel.

8.12.3 Profile

CSP 2 to 9—As the depth of removal increases, the profile will be increasingly dominated by the size and shape of the coarse aggregate.

8.12.4 Accessibility

Shotblasting equipment is available in a range of sizes to provide ready access to most surfaces. Removal widths range from 5 to 48 in. (130 mm to 1.2 m). Edges and corners may be detailed to within 1/4 in. (6 mm) of the vertical surfaces with specialty edging machines or handheld units.

8.12.5 Limitations

This method is generally not suitable for removing uncured resin systems and resilient or tar-based materials. Overlapping passes may lead to a stripping pattern with deeper removal in the overlap area.

8.12.6 Environmental factors

Shotblast systems produce very little airborne dust or contamination. Most models can be fitted with a filter to further lower the level of airborne dust produced. Debris

produced by shotblasting will contain particles of material or contaminants being removed. Any special requirements for containment and disposal will depend on the specific materials or contaminant being removed. Special ventilation provisions may be required when operating gasoline-, diesel-, or propane-powered units indoors. The noise factor may exceed 85 dB. Vibration is not considered to be a factor.

8.12.7 Execution

Shotblasting provides a uniform cleaning pattern across the width of the machine. The machine is steered in a straight line across the surface. At the end of each pass, the machine is turned around and steered parallel to the previous path with minimum overlap. Some overlap is required to prevent the development of unprepared strips between passes.

8.12.8 Equipment

- Shotblasting machine including vacuum system available in gasoline-, diesel-, propane-, or electric-powered units (Fig. 8.12.a and 8.12.d);
- Power source: Requirements for electric-powered units will vary from 110/120 V at 18 A to 460 V at 80 A;
- Brooms and shovels;
- Spare parts for blaster maintenance; and
- Magnets or magnetic broom to retrieve fugitive steel shot.

8.12.9 Materials

Steel shot is the consumed material. Consumption ranges from 10 to 20 lb/h (5 to 9 kg/h). The typical size of the steel shot is shown as follows:

Type	Diameter	Profile [†]
S-170 [†]	0.017 in. (0.43 mm)	CSP 3
S-230	0.023 in. (0.58 mm)	CSP 3
S-280	0.028 in. (0.71 mm)	CSP 3
S-330	0.033 in. (0.84 mm)	CSP 5
S-390	0.039 in. (1.0 mm)	CSP 5
S-460	0.046 in. (1.17 mm)	CSP 7
S-550 [†]	0.055 in. (1.40 mm)	CSP 9

[†]Each type of shot will produce a CSP range. The profile obtained is also influenced by machine setup and rate of travel.

[†]Use of this size is not recommended by some manufacturers.

8.12.10 Labor

Individuals operating the equipment should be experienced and well-trained. An individual with intermediate mechanical skills can operate and maintain most shotblast systems. Large, electrically powered machines require connection to a three-phase, high-voltage power source that may require a licensed electrician.

8.12.11 Setup and downtime

Surfaces must be dry and broom-cleaned prior to shotblasting. Electrical equipment must be connected to an

adequate power source. A test area is required to ensure that media size and machine adjustment will achieve desired performance. Replacement of worn blasting wheels and liners is required every 20 to 40 hours and will take 20 to 45 minutes. Equipment is shut down every 30 to 60 minutes to remove debris from the collection system.

8.12.12 Cleanup

Steel shot may remain on the surface, in edges or corners, or trapped in cracks. It may be recovered by using magnets, a magnetic broom, air blasting, a vacuum, or a stiff-bristle broom.

8.12.13 Production rates

The following rates are approximate and assume a sound horizontal concrete surface. Actual production rates may vary considerably and depend on the strength of the concrete, the type of material being removed, preparation objectives, operator skill, and efficiency of equipment employed.

- Small units (5 to 8 in. [130 to 200 mm]): 150 to 250 ft²/h [15 to 25 m²/h];
- Medium units (8 to 13 in. [200 to 330 mm]): 350 to 1800 ft²/h [30 to 170 m²/h]; and
- Large units (15 to 30 in. [380 to 760 mm]): 2000 to 7500 ft²/h [200 to 700 m²/h].

8.12.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength. Beads of water may indicate a surface contaminant that could require further surface preparation to achieve a clean surface.

8.12.15 Safety hazards

Shotblasting may cause the release of high-velocity steel shot. If gas- or diesel-powered equipment is used, the area should be well-ventilated. Minimum recommended PPE is:

- Eye protection—Meeting ANSI requirements for high impact and face shield;
- Respiratory protection—May be required in confined areas where dust is present; and
- Hearing protection—Process may generate noise levels in excess of 85 dB. Noise levels may require the use of earplugs and/or earmuffs.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

8.13 Surface Retarder

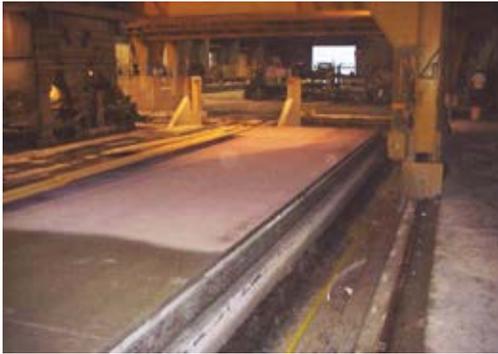


Fig. 8.13.a: Application of surface retarder



Fig. 8.13.c: Rinsing of exposed surface



Fig. 8.13.b: Removal of retarder using broom and rinse water



Fig. 8.13.d: Exposed surface

8.13.1 Summary

Concrete surface hydration retarders may be used to remove the surface of unhydrated cement following concrete placement. The process exposes the aggregate and provides a deep profiled textured finish for bonding materials such as epoxies and cementitious grouts, toppings, and overlays (Fig. 8.13.c and 8.13.d). Surface retarders may be used to provide a light profile for rapid-hardening concrete, spray-applied mortars, or shotcrete. They are suitable for freshly placed, sloped, and horizontal surfaces. Some specialty types of surface retarders are designed to apply to formwork prior to concrete placement to achieve an architectural finish or a profiled surface for construction joints.

8.13.2 Removal

This method involves the application of a material that temporarily inhibits the surface hydration of freshly placed concrete or mortar. The retarder is washed off within several days following application to provide a high-profile, textured surface. This method does not cause microcracking.

8.13.3 Profile

CSP 5 to 10—Surface hydration retarders produce a range of profiles depending on the following factors:

- The chemical composition of the surface hydration retarder;

- The speed of hydration of the freshly placed concrete or mortar, the temperature of the material, the ambient conditions, and other factors;
- The time between application of the retarder and removal; and
- The pressure of the wash water and aggressiveness of the removal of the retarder.

Retarders may be used to produce a CSP 10 for the application of monolithic toppings, additional layers of shotcrete or spray-applied mortar, and epoxy or cementitious grouts. The surface hydration retarder should not produce any noticeable pattern.

8.13.4 Accessibility

The surface retarder may be used on any surface that can be accessed prior to hardening of the freshly placed concrete or mortar. The surface retarder may have to be covered, which could affect accessibility. Formwork retarders should typically be allowed to dry prior to concrete or mortar placement.

8.13.5 Limitations

Surface hydration retarders are suitable for application to freshly placed cementitious concrete or mortar. They should not be used on:

- Hardened substrates;

- When control of the hydration is not possible or when timing of the removal of the retarded material cannot be accurately assessed; and
- When close tolerance of the surface profile (less than CSP 5) is required.

8.13.6 Environmental factors

Surface hydration retarders will produce wash water that will have a pH similar to that of the freshly placed concrete or mortar (pH 12 to 13.5). The chemical composition of the retarder may require additional precautions (consult the manufacturer's material safety data sheet [MSDS]).

8.13.7 Execution

Follow the manufacturer's recommendation for mixing and application of the retarder. Apply the surface hydration retarder immediately following placement of fresh concrete or mortar by evenly spraying the liquid material onto the surface in accordance with the manufacturer's instructions (Fig. 8.13.a).

For spray-on surface types, prevent the surface from drying by covering the surface with polyethylene, burlap/polyethylene laminate, or other impervious sheet covering. For formwork retarders, allow to dry or harden in accordance with the manufacturer's instructions.

Allow the concrete to cure sufficiently to resist the effects of the washing of the unhydrated surface material (typically overnight). Retarders slow the hydration process but do not stop it and need to be removed before the surface can harden and prevent removal (typically remove within 4 days following application). Periodic inspections are needed to determine the amount of hardening that has occurred to determine the timing of the removal of the unhydrated material.

The retarder and unhydrated cement may be removed using potable water with a garden-hose nozzle or a pressure washer with sufficient power to expose the aggregate (Fig. 8.13.b and 8.13.c). Rinse until the washing water runs clear. Dispose of the debris and wash water in accordance with state and local requirements. Overspray of the surface hydration retarder can usually be removed by rinsing with water.

8.13.8 Equipment

A sprayer is recommended to evenly apply the retarder material. A garden hose or pressure washer should be used to remove the retarder and unhydrated material following curing.

8.13.9 Materials

Surface hydration retarder and polyethylene, burlap, or other impervious sheet film for curing of the system.

8.13.10 Employee skill level

Low skill is required for application and removal. Moderate skill is required to assess proper timing of removal.

8.13.11 Setup and downtime

Minimum setup is required for preparing the retarder for application. Time must be allowed for the concrete or mortar to cure sufficiently to allow the removal of the unhydrated material to the desired depth.

8.13.12 Cleanup

Cleanup and disposal of rinse water and unhydrated material will be required. Incidental overspray during the washing operation may require precautions for flying debris caused by pressure washing.

8.13.13 Production rates

Productivity is very high. Limiting factors are typically determined by the accessibility of the application area to the surface hydration retarder spray, the amount of area that can be covered with the film after surface hydration retarder application, and the labor involved in washing off and disposal of the unhydrated material and wash water. The production rate is estimated at 300 to 1000 ft²/h (28 to 93 m²/h) depending on placement configuration.

8.13.14 Quality control

Various test techniques are described in Appendix B. The practitioner is encouraged to specify the appropriate test to verify that the desired surface preparation results have been achieved. At a minimum, verify that the CSP required by the specifications has been achieved. Visual inspection should show no dirt, laitance, or debris on the surface. The prepared surface should be free of bond-inhibiting materials. A bond test may be required to demonstrate adequate bond strength.

8.13.15 Safety hazards

Surface retarders are chemicals that may cause injury if exposed to any part of the body. In addition, water will be used to rinse the unhydrated material from the surface. This rinse water will be highly alkaline (pH 12 to 13.5). Employees must be trained in the proper use and handling of the retarder materials. Minimum recommended PPE is:

- Eye protection—Anti-fog goggles meeting ANSI requirements for chemical resistance, high impact, and face shield;
- Alkaline-resistant gloves, aprons, and clothing;
- Respiratory protection using respirators equipped with acid-gases canister;
- Hearing protection may be required if powered scrubbers are used; and
- Boots, gloves, and water-resistant clothing are required during the washing operation.

Consult the material and equipment manufacturer's current recommended safety procedure. Consult ICRI Guideline No. 120.1 (Sections 2.0 through 7.0) for guidelines and recommendations for safety in the concrete repair industry. Refer to Appendix C for additional information on safety issues related to concrete surface preparation.

9.0 References

9.1 Referenced Standards and Reports

The standards and reports listed as follows were the latest editions at the time this document was prepared. Because these documents are revised frequently, the reader is advised to contact the proper sponsoring group if it is desired to refer to the latest version.

ASTM International

ASTM D4258, "Standard Practice for Surface Cleaning Concrete for Coating"

ASTM D4259, "Standard Practice for Abrading Concrete"

ASTM D4260, "Standard Practice for Liquid and Gelled Acid Etching of Concrete"

ASTM D5295, "Standard Guide for Preparation of Concrete Surfaces for Adhered (Bonded) Membrane Waterproofing Systems"

ASTM E1575, "Standard Practice for Pressure Water Cleaning and Cutting"

ASTM E1857, "Standard Guide for Selection of Cleaning Techniques for Masonry, Concrete, and Stucco Surfaces"

ASTM F2471, "Standard Practice for Installation of Thick Poured Lightweight Cellular Concrete Underlayments and Preparation of the Surface to Receive Resilient Flooring"

International Concrete Repair Institute

ICRI Technical Guideline No. 120.1, "Guideline and Recommendations for Safety in the Concrete Repair Industry"

ICRI Technical Guideline No. 310.3, "Guide for the Preparation of Concrete Surfaces for Repair Using Hydrodemolition Methods"

The Society for Protective Coatings

SSPC-SP 13/NACE No. 6, "Surface Preparation of Concrete"

Transportation Research Board

SHRP-S-336, "Techniques for Concrete Removal and Bar Cleaning on Bridge Rehabilitation Projects," Chapter 4; Hand-held Pneumatic Breakers; Chapter 6, Hydrodemolition

WaterJet Technology Association

WJTA, "Recommended Practices for the Use of High Pressure Water jetting Equipment"

These publications may be obtained from these organizations:

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428
www.astm.org

International Concrete Repair Institute (ICRI)
10600 West Higgins Road, Suite 607
Rosemont, IL 60018
www.icri.org

The Society for Protective Coatings (SSPC)
40 24th Street, 6th Floor
Pittsburgh, PA 15222
www.sspc.org

Transportation Research Board Office (SHRP)
500 Fifth Street, NW
Washington, DC 20001
www.trb.org

WaterJet Technology Association (WJTA)
906 Olive Street; Suite 1200
St. Louis, MO 63101
www.wjta.org

9.2 Cited References

Bissonnette, B.; Courard, L.; Vaysburd, A. M.; and Belair, N., 2006, "Concrete Removal Techniques," *Concrete International*, V. 28, No. 12, Dec., pp. 49-55.

Appendix A

Surface Preparation Selection

The Method Selection Process

Surface preparation decisions require a thorough understanding of the substrate conditions, protective system or repair material requirements, and the job-site conditions. The type of material selected for installation will generally determine the type of surface preparation required and the resulting concrete surface profile (CSP) to be achieved. However, substrate conditions can vary, ranging from concrete in good condition to deteriorated concrete. Careful examination and testing of the substrate will ensure that the proper surface preparation method(s) is/are selected.

The checklists that follow will help ensure that critical information is identified and considered. The information collected during the initial evaluation phase is used to develop criteria for the selection of a surface preparation method(s). Once the criteria have been determined, the Method Selector (Section 7.0) and Method Summaries (Section 8.0) may be used to identify the method, or combination of methods, most likely to produce the desired results for the project.

A.1 Substrate Condition

The condition of the substrate, including strength, cause and extent of deterioration, existing coatings and sealers, and many other factors, will define the nature and degree of preparation required. Although a discussion of the various techniques to perform a complete survey of existing conditions is beyond the scope of this guideline, the following checklist provides examples of the types of information that should be considered. Methods to test and verify the surface preparation are provided in Appendix B.

The following is a checklist of the items found in the Substrate Condition Evaluation Tree (Fig. A.1):

A.1.1 Surface Conditions

- Efflorescence, Encrustations, Soil
 - a) Type
 - b) Thickness
 - c) Bond strength
- Surface Imperfections
 - a) Laitance
 - b) Bugholes

- c) Dusting
- d) Ridges
- e) Exposed aggregate
- f) Abrasion
- Previous Patches
- Bond Breaking Contaminants
 - a) Form Release
 - b) Curing Compound
 - c) Existing Membrane/Coatings
 - d) Oil
 - e) Latex modifiers

A.1.2 Soundness

- Delaminated Concrete Depth
 - a) Spalled
 - b) Strength
 - c) Porosity
 - d) Freeze/Thaw
 - e) Alkali Reactivity
 - f) Sulfate Attack
- Pull-off tests
- Chloride Content and Penetration Depth
- Carbonation Depth and pH

A.1.3 Hazardous Materials

- PCB
- Frangible Asbestos
- Chemicals
- Lead
- Heavy Metals

A.1.4 Finish

- Formed
- Wood Float
- Metal Trowel
- Power Trowel
- Broom Finish
- Sacking
- Stoning
- Block
- Shotcrete

A.1.5 Moisture

- Concrete Maturity (Fresh/Green Concrete)
- Hydrostatic Pressure
 - a) Positive Hydrostatic
 - b) Negative Hydrostatic
- Substrate Moisture
 - a) Internal Relative Humidity (Probes)
 - b) Moisture Vapor Emission
- Vapor Barrier Present
 - a) Over Granular Fill
 - b) Under Granular Fill
- No Vapor Barrier
- Drainage

A.1.6 Joints and Cracking

- Cold Joints
- Construction Joints
- Expansion
- Dynamic
- Static
- Cracking
- Leaking

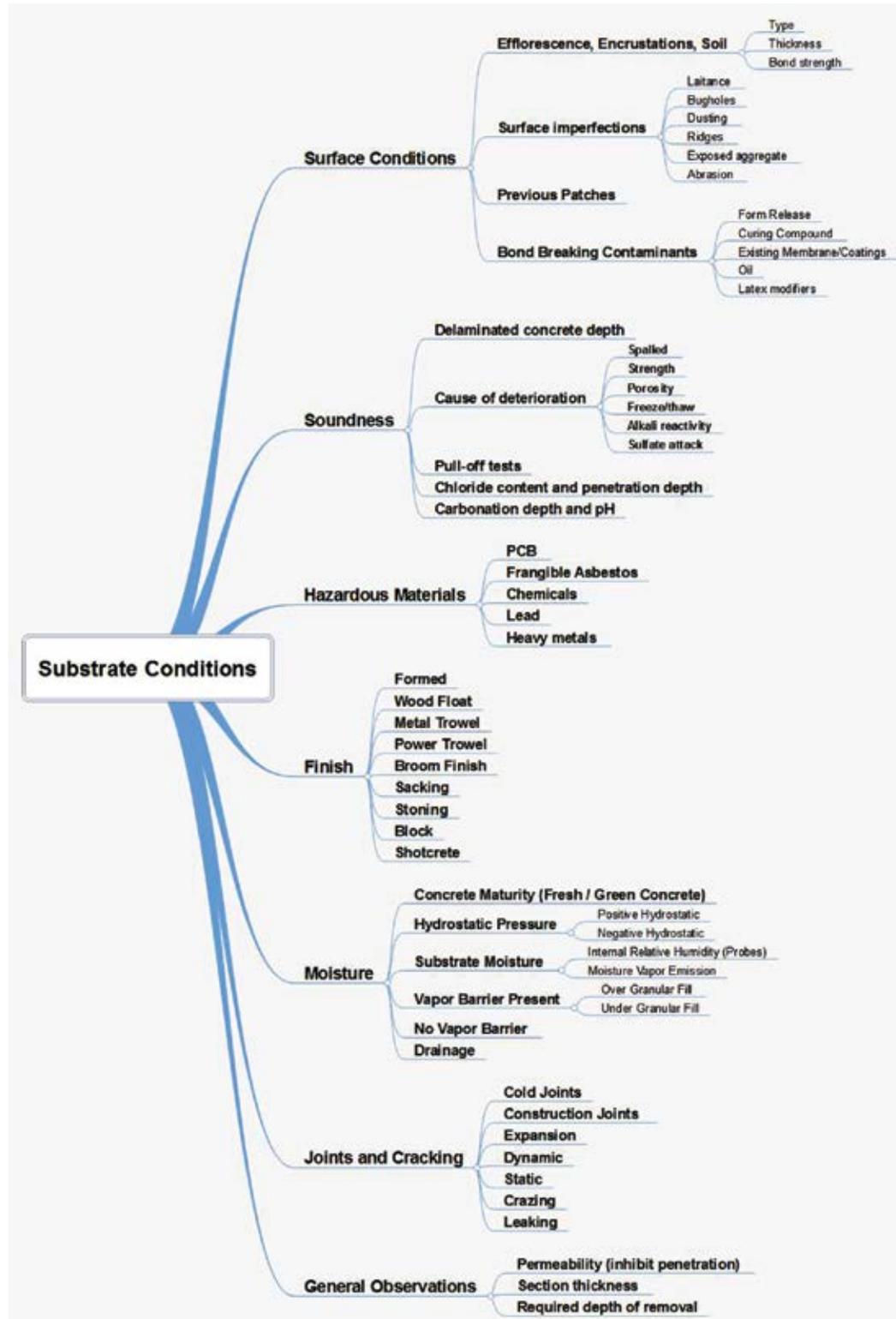


Fig. A.1: Substrate Condition Evaluation Tree

A.1.7 General Observations

- Permeability (inhibit penetration)
- Section Thickness
- Required Depth of Removal

- c) Moisture vapor emission
- d) Cleaning method
- Alkali tolerance
- Cleanliness (dust)

A.2 Protective system and repair material requirements

Decisions concerning surface preparation cannot be made without knowing the properties and application requirements of the material to be applied. Surface preparation and profile requirements in particular will vary with the repair material and/or protective system.

The following is a checklist of the items found in the Material Requirement Evaluation Tree (Fig. A.2):

A.2.1 Substrate Strength

- Tensile bond strength

A.2.2 Profile

- Sealers—0 to 3 mils (0 to 0.075 mm): CSP 1-2
- Thin film coatings—4 to 10 mils (0.01 to 0.025 mm): CSP 1-3
- High build coatings—10 to 40 mils (0.025 to 1.0 mm): CSP 3-5
- Self-leveling—50 mils to 1/8 in. (1.2 to 3.0 mm): CSP 4-6
- Polymer overlays (1/8 to 1/4 in. ([3 to 6 mm]): CSP 5-9
- Concrete overlays, toppings, and repairs—>1/4 in. (>6 mm): CSP 5-10

A.2.3 Other

- Application thickness
- Moisture tolerance
 - a) Wet substrate OK
 - b) Dry substrate needed

A.3 Job-site Conditions

Noise, vibration, dust, and water may be generated by various preparation methods. These can disrupt use of the structure or damage its contents. The owner's need for uninterrupted use of the structure, concerns about the operating environment, or property damage potential may limit the choice of surface preparation method. The generation of dust, slurries, or large volumes of water may introduce requirements for their containment and safe disposal. The type and capacity of mechanical ventilation and available power sources, the size of door openings, and minimum vertical clearance are all examples of application conditions that will affect decisions regarding surface preparation method selection.

The following is a checklist of the items found in the Jobsite Conditions Evaluation Tree (Fig. A.3):

A.3.1 Accessibility

- Physical Constraints
 - a) Height
 - b) Load Bearing Capacity
 - c) Doors
 - d) Access
 - e) Width/Turning Radius
 - f) Area
- Surface Orientation
 - a) Horizontal
 - b) Vertical
 - c) Overhead
 - d) Slab on Grade
 - e) Supported



Fig. A.2: Material Requirement Evaluation Tree

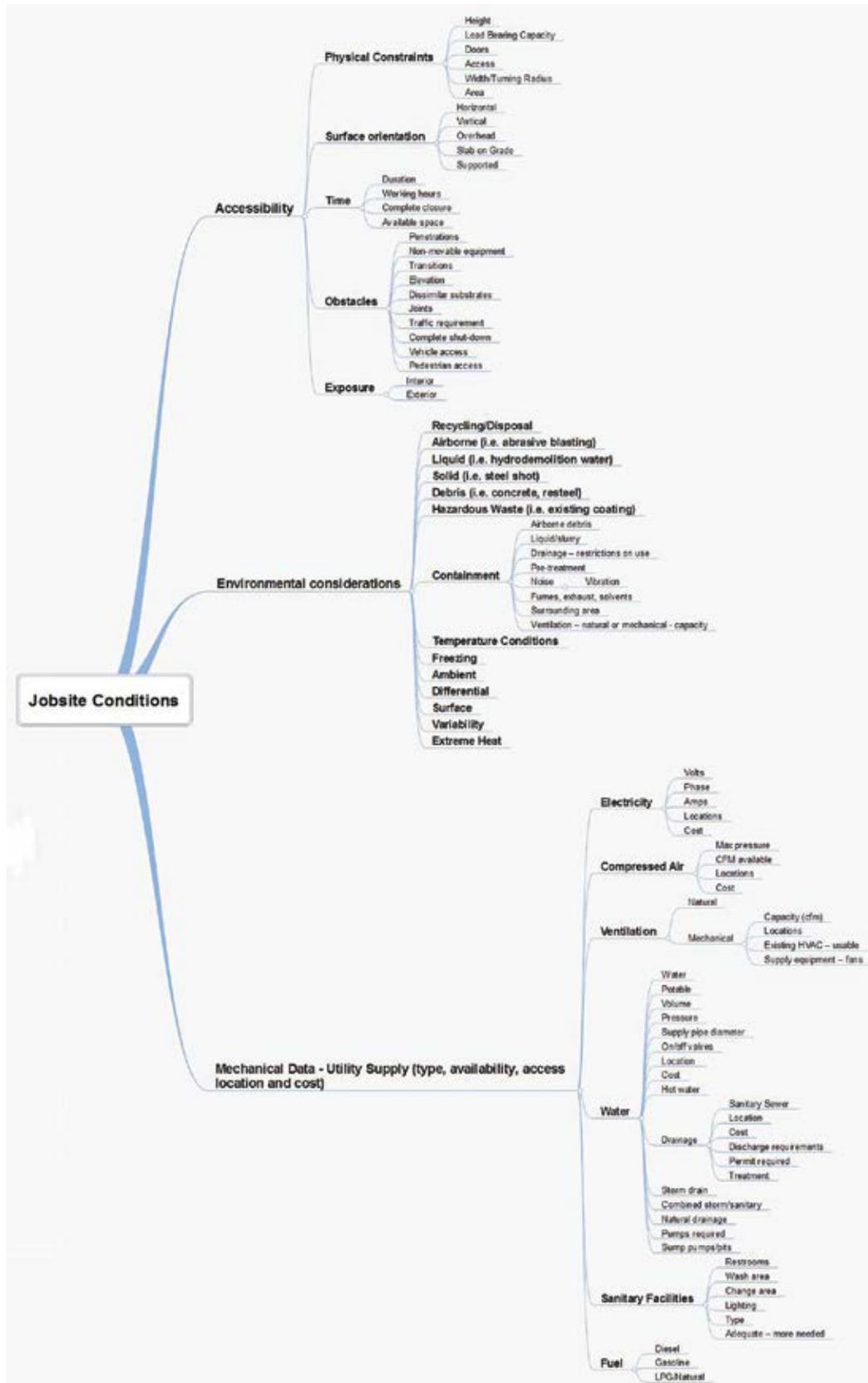


Fig. A.3: Jobsite Conditions Evaluation Tree

- Time
 - a) Duration
 - b) Working Hours
 - c) Complete Closure
 - d) Available Space
- Obstacles
 - a) Penetrations
 - b) Non-Movable Equipment
 - c) Transitions
 - d) Elevation
 - e) Dissimilar Substrates
 - f) Joints
 - g) Traffic Requirement
 - h) Complete Shut-Down
 - i) Vehicle Access
 - j) Pedestrian Access
- Exposure
 - a) Interior
 - b) Exterior

A.3.2 Environmental Considerations

- Recycling/Disposal
- Airborne (i.e. abrasive blasting)
- Liquid (i.e. hydrodemolition water)
- Solid (i.e. steel shot)
- Debris (i.e. concrete, resteel)
- Hazardous Waste (i.e. existing coating)
- Containment
 - a) Airborne Debris
 - b) Liquid/Slurry
 - c) Drainage—restrictions on use
 - d) Pre-treatment
 - e) Noise
 - f) Vibration
 - g) Fumes, Exhaust, Solvents
 - h) Surrounding Area
 - i) Ventilation—natural or mechanical—capacity
- Temperature Conditions
- Freezing
- Ambient
- Differential
- Surface
- Variability
- Extreme Heat

A.3.3 Mechanical Data— Utility Supply (type, availability, access location and cost)

- Electricity
 - a) Volts
 - b) Phase
 - c) Amps
 - d) Locations
 - e) Cost
- Compressed Air
 - a) Maximum Pressure
 - b) CFM Available
 - c) Locations
 - d) Cost
- Ventilation
 - a) Natural
 - b) Mechanical
 - 1. Capacity (cfm/cmm)
 - 2. Locations
 - 3. Existing HVAC—usable
 - 4. Supply equipment—fans
- Water
 - a) Portable
 - b) Volume
 - c) Pressure
 - d) Supply pipe diameter
 - e) On/off valves
 - f) Location
 - g) Cost
 - h) Hot Water
 - i) Drainage
 - 1. Sanitary Sewer
 - 2. Location
 - 3. Cost
 - 4. Discharge Requirements
 - 5. Permit required
 - 6. Treatment
 - j) Storm Drain
 - k) Combined Storm/Sanitary
 - l) Natural Drainage
 - m) Pumps Required
 - n) Sump Pumps/Pits
- Sanitary facilities
 - a) Restrooms
 - b) Wash Area
 - c) Change Area
 - d) Lighting
 - e) Type
 - f) Adequate—more needed
- Fuel
 - a) Diesel
 - b) Gasoline
 - c) LPG Natural

Appendix B Testing

Test methods to determine the quality and suitability of the concrete surface following surface preparation.

Index

- B.1 Tensile Bond Strength Test—
ICRI 210.3 and ASTM C1583/C1583M
- B.2 Adhesion Test—ASTM D7234
- B.3 Knife Adhesion Test—ASTM D6677
- B.4 Measuring the Surface pH following
Chemical Cleaning—ASTM D4262
- B.5 Surface Profile—ICRI 310.2R
- B.6 Replica Putty—ASTM D7682
- B.7 Replica Tape—ASTM D4417
- B.8 Laser Profilometry
- B.9 Sand Method—ASTM E965
- B.10 Visual Inspection—ASTM D4258
- B.11 Petrographic Analysis—ASTM C856
- B.12 Surface Cleanliness Using Tape—
ASTM E1216
- B.13 Sounding the Surface—
ASTM D4580/D4580M
- B.14 Water Absorption—ASTM F21
- B.15 Moisture in Concrete—ASTM D4263,
ASTM F1869, ASTM F2170, and
ASTM F2420
- B.16 ICRI Concrete Slab Moisture Testing
Certification Program

B.1 Tensile Bond Strength Test

ICRI Technical Guideline No. 210.3, “Guide for Using In-Situ Tensile Pull-Off Tests to Evaluate Bond of Concrete Surface Materials,” and ASTM C1583/C1583M, “Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).”

The tensile bond test is used to assess the adequacy of the prepared substrate prior to the installation of material (test the substrate only) or following the application (test the repair composite system). The advantage of evaluating the prepared substrate is that additional surface preparation may be performed if necessary without the cost of removing the applied material afterward. The test is used to determine the potential for bond failure between the applied material and the prepared substrate.

This test is conducted by coring the substrate or repair composite, attaching a metal disc within

the cored area, and applying a load perpendicular to the surface and measuring the force required to cause failure at the substrate or within the repair composite. Load at failure is recorded in pounds per square inch (psi). The location of the failure will identify the weakest link in the repair application and may be an indicator of inadequate surface preparation. Tensile bond test devices are shown in Fig. B.1.a and B.1.b.



Fig. B.1.a: Tensile bond test device

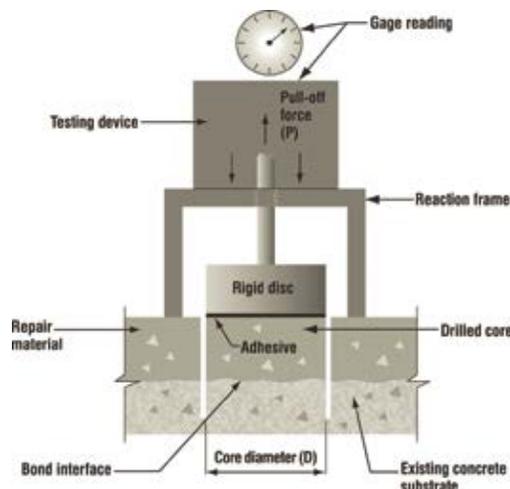


Fig. B.1.b: Tensile bond test device (repair composite system)

B.2 Adhesion Test

ASTM D7234, “Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers” (Fig. B.2).

This test method covers procedures for evaluating the pull-off adhesion strength of a coating on concrete. The test determines the greatest perpendicular force (in tension) that a surface area can bear before a plug of material is detached.

Failure will occur along the weakest plane within the system, which includes:

- Adhesive to test fixture;
- Adhesive to the coating surface;
- Adhesion of each coating layer within a system;
- Adhesion of the coating to the substrate; and
- Tensile strength within the substrate.

The general pulloff adhesion test is performed by scoring through the coating down to the surface of the concrete substrate at a diameter equal to the diameter of the loading fixture (dolly, stud), and securing the loading fixture normal (perpendicular) to the surface of the coating with an adhesive. After the adhesive is cured, a testing apparatus is attached to the loading fixture and aligned to apply tension normal to the test surface. The force applied to the loading fixture is then increased and monitored until a plug of material is detached. When a plug of material is detached, the exposed surface represents the plane of limiting strength within the system. The nature of the failure is qualified in accordance with the percent of adhesive and cohesive failures, and the actual interfaces and layers involved. The pulloff adhesion strength is computed based on the maximum indicated load and the fracture surface area.



Fig. B.2: Portable adhesion tester

B.3 Knife Adhesion Test

ASTM D6677, “Standard Test Method for Evaluating Adhesion by Knife”

This test method covers the procedure for assessing the adhesion of coating films to substrate by using a knife. This test method is used to establish whether the adhesion of a coating to a substrate or to another coating (in multi-coat systems) is at a generally adequate level. This test requires uses a utility knife to remove the coating. It helps determine if the adhesion of a coating to a substrate or to another coating (in multi-coat systems) is acceptable.

Using a knife and straightedge, two cuts are

made into the coating with a 30- to 45-degree angle between them and down to the substrate, which intersects to form an “X.” At the intersection of the two cuts, the point of the knife is used to attempt to peel the coating from the substrate or from the coating below. This is a highly subjective test and its value depends on the inspector’s experience.

B.4 Measuring the Surface pH following Chemical Cleaning

ASTM D4262, “Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces”

Chemical cleaning and etching is sometimes used to prepare concrete for coating. Residual chemicals not removed by water rinsing may adversely affect the performance and adhesion of coatings applied over prepared concrete surfaces. This test method is used to determine if residual chemicals have been removed by measuring the acidity or alkalinity of the final rinsed surface.

B.5 Surface Profile

ICRI 310.2R Concrete Surface Profile (CSP) profiles.

The surface preparation specification may include a CSP required profile, which can be compared with the CSP molded replicas available from ICRI. These replicas provide a visual comparison with the actual profile created during the surface preparation.

Place CSP replicas (Fig. B.3) on the prepared surface and visually compare the profile with the replicas. The profile of the surface should be in the range specified.



Fig. B.3: CSP replicas

B.5.1 Measuring the Surface Profile

Visual observation of the surface profile may not provide a satisfactory determination of the surface profile. More qualitative/quantitative

methods, including the Replica Putty and Sand Method, are available to further define the surface profile. The measurement of roughness can lead to optimization of bonding strength.

B.6 Replica Putty

ASTM D7682, “Standard Test Method for Replication and Measurement of Concrete Surface Profiles Using Replica Putty”



Fig. B.4.a: Method A Visual

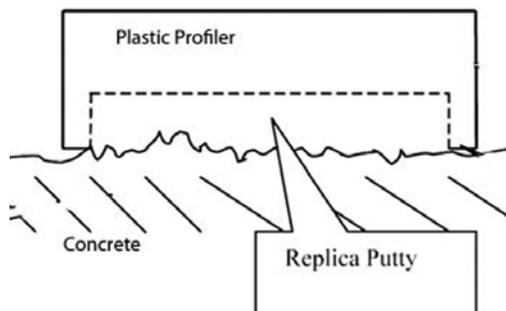


Fig. B.4.b: Replica putty applied to the surface



Fig. B.4.c: Method B Quantitative

Ensuring that the correct surface profile has been achieved can best be done with the use of replica putty. A permanent replication of the surface may be viewed (Method A—Fig. B.4.a) and/or measured (Method B—Fig. B.4.c) to form a permanent record of the surface preparation.

Replica putty is applied to the surface (Fig. B.4.b) and allowed to cure. Once removed from the surface, the putty represents a reverse image of the surface. The peaks and valleys of the surface can be measured using a specially modified thickness gauge (Fig. B.4.c). The data can be analyzed to determine the surface profile range (highest measured peak to lowest measured valley).

B.7 Replica Tape

ASTM D4417, “Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel”



Fig. B.5.a: Surface replica tape kit



Fig. B.5.b: Measuring the surface profile

Method C uses a special tape containing compressible foam attached to a noncompressible uniform plastic film (Fig. B.5.a and B.5.b). A burnishing tool is used to impress the foam face of the tape into the surface to create a reverse replica of the profile that is measured using a spring-loaded micrometer. This method is designed for relatively smooth surfaces (CSP 1 to 3) prepared using sand, grit abrasive blasting,

or steel shotblasting and may not be applicable to rougher profiles.

B.8 Laser Profilometry

The digital surface roughness meter (DSRM) measures the surface roughness of a prepared surface using a line laser.

The DSRM (Fig. B.6) is placed flush with the surface to be measured. An image of the profile is transmitted to a computer, where the image is digitized; the profiles are automatically isolated and measured for roughness. This method will provide a permanent record of the surface roughness. (Maerz, N. H.; Chepur, P.; Myers, J.; and Linz, J., 2001, "Concrete Roughness Measurement Using Laser Profilometry for Fiber Reinforced Polymer Sheet Application," Presented at the Transportation Research Board 80th Annual Meeting, 12 pp.)



Fig. B.6: Digital surface roughness meter

B.9 Sand Method

ASTM E965, "Standard Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique"

The average surface texture (macro-texture) may be measured using a known volume of sand or other fine grain material and spreading it uniformly over the surface and measuring the area covered. Using the standard formula for volume ($L \times W \times D$), the approximate amplitude of the surface may be determined. This method will assist in determining the amount of material that may be necessary to fill the macro-texture before applying a uniform layer of material over the surface.

Apply a known volume of sand to the surface. Carefully spread the sand in a circular motion using a large flat spreading tool, slowly increasing the diameter of the circular motion until all the sand has been spread. Measure the diameter of

the circle and calculate the average depth. $AD = (V \text{ sand}/A \text{ area of the circle})$. Figures B.7.a and B.7.b depict this method.

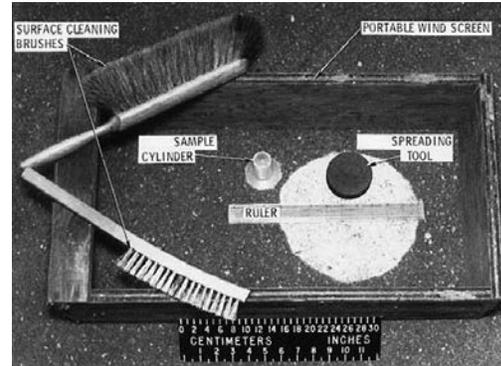


Fig. B.7.a: Sand test (ASTM E965)



Fig. B.7.b: Measuring sand spread

B.10 Visual Inspection

ASTM D4258, "Standard Practice for Surface Cleaning Concrete for Coating"

This describes a method of surface cleaning that is intended to provide a clean, contamination-free surface without removing concrete from an intact, sound surface. Following the cleaning, visually examine the prepared surface to verify that it is free of debris, dust, dirt, oil, grease, loosely adherent concrete, and other contaminants. Test surfaces cleaned with detergent or non-solvent emulsifying agents for pH following ASTM Test Method D4262. Moisture content may be determined following ASTM Test Method D4263.

B.11 Petrographic Analysis

ASTM C856, "Standard Practice for Petrographic Examination of Hardened Concrete"

While petrography can be used to detect a variety of flaws within concrete, it can also be used following surface preparation to determine if the method used to prepare the surface caused microcracking in the substrate.

The test is made by extracting a sample of the concrete and observing it under a microscope (Fig. B.8.a). Microcracks (Fig. B.8.b) weaken the substrate and should be removed by further surface preparation prior to installation of any materials.



Fig. B.8.a: Microscopic examination

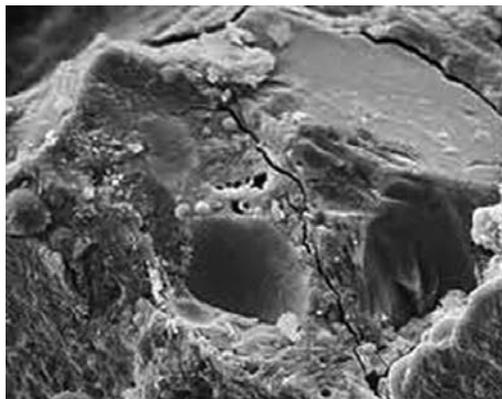


Fig. B.8.b: Microcracks

B.12 Surface Cleanliness Using Tape

ASTM E1216, “Standard Practice for Sampling for Particulate Contamination by Tape Lift”



Fig. B.9: Transparent tape, magnifying light, and background for measuring surface contamination

This practice covers procedures for sampling surfaces to determine the presence of particulate contamination 5 mm and larger. The practice consists of the application of a pressure-sensitive tape to the surface followed by the removal of particulate contamination with the removal of the tape (Fig. B.9).

B.13 Sounding the Surface

ASTM D4580/D4580M, “Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding”

The surface may be sounded either before or after surface preparation to determine if there is any delaminated concrete. Delaminated concrete will produce a hollow sound when a chain is dragged over the area or the surface is struck with a hammer. Areas that are delaminated should be marked for further preparation.

- Electromechanical sounding device (Fig. B.10.a)—Uses an electric-powered tapping device, sonic receiver, and recorder mounted on a cart. The cart is pushed across the concrete surface and delaminations are recorded.



Fig. B.10.a: Electromechanical sounding device

- Chain drag—Consists of dragging a chain over the concrete surface (Fig. B.10.b). The detection of delaminations is accomplished by the operator hearing a dull or hollow sound. Tapping the surface with a steel rod or hammer may be substituted for the chain drag (Fig. B.10.c).
- Rotary percussion—Uses a dual-wheel, multi-toothed apparatus attached to an extension pole, which is pushed over the concrete surface (Fig. B.10.d). The percussive force caused by the tapping wheels will create either a dull or hollow sound, indicating a delamination.



Fig. B.10.b: Chain dragging the surface



Fig. B.10.c: Sounding using a hammer



Fig. B.10.d. Rotary percussion tool

B.14 Water Absorption

ASTM F21, “Standard Test Method for Hydrophobic Surface Films by the Atomizer Test”

The presence of water-repelling materials may interfere with the bond or penetration of applied material. Surface preparation should remove any water-repellent material that may interfere with the performance of the applied material. The atomizer test is performed by

applying a fine water spray to the dry concrete surface and observing the wetting pattern. In the absence of hydrophobic films, the water droplets will wet the surface and spread immediately and darken the surface as the water is absorbed. In areas where hydrophobic materials are present on the surface, the water will not wet the surface but will tend to remain as fine droplets or beads of water on the surface (Fig. B.11). This test is less effective on extremely low-permeability concrete or surfaces with dense finishes upon which water may bead, even in the absence of hydrophobic materials.

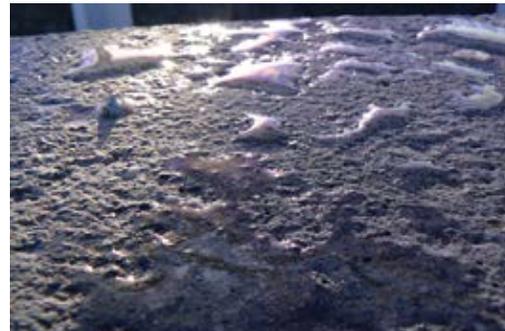


Fig. B.11: Water beading on a water-repellent surface

B.15 Moisture in Concrete

High levels of moisture in a concrete substrate can have a detrimental effect on many types of applied materials. Most manufacturers of coatings and overlay materials have specific levels of moisture that must be reached before their products can safely be installed. ASTM offers several methods to measure moisture in concrete slabs, as follows:

- Plastic Sheet Method—ASTM D4263, “Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.”



Fig. B.12.a: Moisture in concrete test using the plastic sheet method

For this method, an 18 in. (460 mm) square transparent polyethylene sheet, at least 4 mils

(0.10 mm) thick, is taped to the concrete surface (Fig. B.12.a). The plastic sheet remains in place for a minimum of 16 hours, after which the plastic is removed; the underside of the sheet and the concrete surface are then visually inspected for the presence of moisture.

- Calcium Chloride (CaCl) Method—ASTM F1869, “Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.”

This test method (Fig. B.12.b) quantifies the amount of water vapor emitting from the surface region of a concrete subfloor and is performed as follows:

1. Prepare a 20 x 20 in. (500 x 500 mm) area of the concrete surface by dry vacuum grinding to a CSP 1 to 2 to remove any existing coatings, adhesive, or surface contamination.

Note: If an existing coating, sealer, or adhesive is removed, the prepared surface must be left open for 24 hours before installing the test kit. If the surface was bare concrete, then after the surface is ground, the kit can be installed immediately.

2. The dish of calcium chloride crystals with lid and tape is weighed to the nearest 0.004 oz (0.1 g) on a calibrated gram scale.
3. The starting weight, date, time, location, and ambient conditions are recorded along with the name of the person performing the test.
4. The tape is removed and taped to the underside of the plastic dome, the dish is opened, and the lid is inverted and placed beneath the dish and placed in the center of the prepared area.
5. Immediately after setting the dish, the plastic dome is placed over the dish with the dish as close to center beneath the dome as possible, and the dome sealed to the concrete surface.
6. After a minimum of 60 hours, but no more than 72 hours, the dish is removed and resealed with the original lid and tape.
7. The sealed dish is reweighed on a calibrated scale.
8. The moisture vapor emission rate (MVER) is calculated by multiplying the increase in weight by the exposure area and dividing by the time period. The MVER value is expressed in pounds of water / 1000 ft² (100 m²) / 24 hours.



Fig. B.12.b: Moisture vapor emission test using the calcium chloride method

- Moisture Probe Method—ASTM F2170, “Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes”



Fig. B.12.c: Moisture probe method equipment

This test method measures the moisture within the concrete and is a predictor of what the moisture level will be in the slab, top-to-bottom, once the slab is covered. The method uses a humidity probe (Fig. B.12.c) to measure the relative humidity in a concrete subfloor at a specific target depth. For slabs on ground or on a metal deck, the measurement is taken at a depth equaling 40% of the slab thickness. If the slab is elevated such that it can dry from the top and bottom, the measurement is taken at 20% of the slab thickness. A rotary hammer drill with a carbide bit is used to drill into the concrete to the target depth. After the proper depth has been confirmed, the hole is brushed and vacuumed thoroughly clean. A full-depth ribbed hole liner is then inserted to the bottom of the drilled hole such that a relative humidity (RH) measurement can be taken at the specific target depth after the liner has been in place for a minimum period of 72 hours. The RH probe (Fig. B.12.d) can be installed immediately and left in place for the entire test period or inserted after the 72-hour equilibration

period. A measurement is recorded on the reader unit when the RH % does not drift more than 1% in 5 minutes which, in most cases, will take at least 1 hour after a probe is inserted into the liner.



Fig. B.12.d: Installing a moisture probe

- Hood Test—ASTM F2420, “Standard Test Method for Determining Relative Humidity on the Surface of Concrete Floor Slabs Using Relative Humidity Probe Measurement and Insulated Hood”



Fig. B.12.e: ASTM F2420 Test being conducted

The hood method (Fig. B.12.e) is similar to the ASTM F1869 calcium chloride method. However, the units are different and therefore not directly comparable as the hood method is measuring the RH above the slab, while the calcium chloride test is measuring pounds of moisture vapor emission per 1000 ft² (100 m²) per 24-hour period. Both of these tests measure moisture in approximately the top 1/4 to 1/2 in. (6 to 13 mm) of the slab while ASTM F2170 measures moisture within the slab thickness. The hood test is performed by:

1. Cleaning the surface;

2. Sealing an insulated hood firmly to the concrete substrate;
3. Placing a stopper in the probe hole;
4. Allowing a minimum period of 72 hours to elapse before taking readings with a probe;
5. Removing the stopper;
6. Inserting a humidity probe and allowing the probe to equilibrate (probe has reached equilibrium when RH readings do not drift more than 1% over a period of 20 minutes); and
7. Taking readings using the humidity probe (Fig. B.12.e).

B.16 ICRI Concrete Slab Moisture Testing Certification Program

ICRI has a Concrete Slab Moisture Testing Certification program. The purpose of this program is to help improve the performance of concrete slab moisture testing in the United States to result in more consistent, accurate results that will help flooring manufacturers, architects, and contractors to make better decisions as to when a concrete floor is ready for a floor-covering installation. This certification program has two tiers and the certification is valid for 5 years. Tier 1 applicants are those who are not regularly engaged in moisture testing, yet have an active interest in learning more about the tests, what the tests mean, and how the tests should be performed. Tier 2 applicants are those who have applied for full certification as an ICRI Concrete Slab Moisture Testing Technician—Grade 1. The ICRI certification program is based on the following four (4) ASTM Standards, including all Annexes and Appendixes:

- F710, “Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring; Section 5.3 pH Testing”
- F1869, “Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride”
- F2170, “Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes”
- F2420, “Standard Test Method for Determining Relative Humidity on the Surface of Concrete Floor Slabs Using Relative Humidity Probe Measurement and Insulated Hood”

For further information on the ICRI certification program, visit: <http://www.icri.org/Certification/certificationinfo.asp>.

Appendix C

Safety

Safety recommendations for each method are included in the Safety section of the method summaries. This information is intended only to alert users to the nature of the safety issues associated with the method described. Consult the equipment manufacturer's safety requirements for each type of equipment described.

ICRI publications related to safety:

- ICRI Technical Guideline No. 120.1, "Guideline and Recommendations for Safety in the Concrete Repair Industry," Sections 2.0 through 7.0, <http://www.icri.org/publications/bookstore.asp>.
- ICRI White Papers covering hearing and respiratory protection, http://www.icri.org/PUBLICATIONS/2009/PDFs/septoct09/CRBSeptOct09_Silica.pdf; http://www.icri.org/PUBLICATIONS/2012/PDFs/janfeb12/CRBJanFeb12_SafetySolutions.pdf.

OSHA Regulations:

Refer to the OSHA regulations that pertain to each of the surface preparation methods described. These regulations include but are not limited to:

- Eye Protection: 29 CFR - 1926.102, http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10665.
- Personal Protective Equipment - Construction: 29 CFR - 1926.28, http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10614.
- Respiratory Protection: 29 CFR - 1926.103, http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10666&p_table=STANDARDS.
- Hearing Protection: 29 CFR - 1926.101, http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10664&p_table=STANDARDS.
- Hazard Communication: 29 CFR - 1926.59, http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10633&p_table=STANDARDS.