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Standard Guide for Waterproofing Repair of Concrete by Chemical Grout Crack Injection[1]

This standard is issued under the fixed designation D8109; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide describes the selection of materials, installation methods, and inspection required for sealing leaks at cracks in concrete building walls and slabs using chemical grout. The process discussed in this guide is a waterproofing repair in which voids in a concrete element are sealed with a reactive solution, installed by pressurized injection through drilled or surface-mounted ports.

1.2 This guide does not address the use of chemical grout for waterproofing by curtain grouting or injection into preplaced permeable waterstop tubes. Injection of masonry elements presents additional factors beyond the scope of this guide. This guide does not address the use of injectable materials for structural repairs, or for geotechnical applications such as soil stabilization.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard 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 standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2304 Practice for Sealing of Sewers Using Chemical Grouting

F2414 Practice for Sealing Sewer Manholes Using Chemical Grouting

F2454 Practice for Sealing Lateral Connections and lines from the mainline Sewer Systems by the Lateral Packer Method, Using Chemical Grouting

2.2 *International Concrete Repair Institute (ICRI)*[3]

Guideline No. 340.1 Guide for the Selection of Grouts to Control Leakage in Concrete Structures

2.3 *U.S. Army Corps of Engineers:*[4]

Manual No. 1110-1-3500 Chemical Grouting

2.4 *U.S. Department of the Interior, Bureau of Reclamation:*[5]

Leaking Crack Repair Using Chemical Grouts

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *acrylamide, n*—organic solid of white, odorless, acrylic resinous material available in flake-like crystals and in liquid form.

3.1.2 *acrylate, n*—a general term applied to various water-soluble acrylic resinous materials.

3.1.3 *acrylic resin, n*—a type of resin polymerized from acrylic acid, methacrylic acid, esters of these acids, or acrylonitrile.

3.1.4 *chemical grout, n*—injection repair media other than particulate or cementitious grout that may be multi-component, with or without additives, and based on either polyurethane resin or acrylic resin.

[1] This guide is under the jurisdiction of ASTM Committee D08 on Roofing and Waterproofing and is the direct responsibility of Subcommittee D08.22 on Waterproofing and Dampproofing Systems.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from the International Concrete Repair Institute (ICRI), 10600 West Higgins Road, Suite 607, Rosemont, IL, 60018, www.icri.org.

[4] Available from the U.S. Army Corps of Engineers, www.publications.usace.army.mil.

[5] Available from U.S. Department of the Interior, Bureau of Reclamation, www.usbr.gov/research/projects.

3.1.5 *cohesion, n*—the state in which the constituents of a mass of material are held together by chemical and physical forces.

3.1.6 *control agent, n*—substance added which controls the viscosity or flow properties of the material it is added to.

3.1.7 *curtain grouting, n*—injection of grout into a subsurface formation in such a way as to create a barrier of grouted material transverse to the direction of the anticipated water flow. A grout curtain on the positive side of the leaking sub-grade element can be injected from the interior side of the element or from the exterior surface.

3.1.8 *epoxy, n*—a type of resin polymerized from epoxide groups.

3.1.9 *gel time, n*—time from the initial mixing of the resin with catalyst to gelation, also referred to as "set time."

3.1.10 *hydrophilic, adj*—having a strong affinity for water. Hydrophilic grout will absorb water.

3.1.11 *hydrophobic, adj*—lacking affinity for water. Hydrophobic grout will repel water.

3.1.12 *injection port, n*—port through which materials are injected under pressure into the interior of a concrete element via attached mechanical pumping equipment. Injection ports may consist of a drilled hole fitted with a packer at the opening; or an attachment device mounted flush to the surface of, or directly into, a crack or other void.

3.1.13 *oakum, n*—loose hemp or jute fiber, sometimes treated with resin or grout.

3.1.14 *packer, n*—a tapered or expandable annular plug inserted into a drilled hole or crack in which grout or water is to be injected, which serves as an attachment for pumping equipment and includes a one-way valve fitting to prevent the return of the grout or water when material is not being injected.

3.1.15 *polyurethane resin, n*—any of various polymer resins containing the urethane radical.

4. Significance and Use

4.1 This guide is intended to be used in the selection and installation of chemical grout to seal leaks in concrete walls, floors, and ceilings. The procedure described in this guide focuses on the injection of through-wall cracks, but may be adapted to cold joints, control joints, voids associated with penetrations, and other voids contributing to water intrusion through concrete elements. This guide is intended to assist the building owner, owner's representative, architect, engineer, contractor, or authorized inspector, or combinations thereof, during the selection, specification, or installation, or combinations thereof, of chemical grout for waterproofing repair.

4.2 Prior to attempting any repair, it is important for all parties to have a clear and mutual understanding of the limitations of the repair and the iterative nature of the process. Injection of chemical grout does not affect the source of a leak. The repair obstructs the infiltration of water at a specific location only. The flow of water will be diverted elsewhere, and it is common for water to subsequently appear at a different location that was previously dry. A successful campaign at a given location can significantly reduce the amount of water infiltration, but may not fully prevent leakage. Given the nature of the materials and application technique, and depending on the conditions, the repairs should be periodically monitored and additional repair installations may be required.

4.3 This guide is applicable to installations at below-grade walls and slabs. At above-grade elements, temperature variation on a daily or seasonal basis may lead to significant or more frequent changes, or both, in the width of a crack or joint. The use of injected chemical grout may be appropriate for many above-grade applications, but this guide does not specifically address installation of grout in dynamic cracks or joints.

4.4 Cracks in below-grade walls may be a sign of structural distress. Prior to the injection of chemical grout, the overall conditions and context of the damage should be assessed to determine if a non-structural repair is appropriate.

4.5 This guide does not address repairs intended to provide a seal against air leakage or air infiltration.

4.6 Project-specific or environmental conditions such as existing construction, prior waterproofing installations, access, water volume or flow rate, water chemistry, temperature, humidity, and other factors may warrant the evaluation of curtain grouting as an alternative to crack injection.

4.7 Practices F2304, F2414, and F2454 describe materials and procedures related to the use of chemical grout to seal components of sewer systems. While the specific procedures differ from those described in this guide, the standards contain general information on chemical grouting materials and methods that may be of interest to those involved with waterproofing repair of building elements.

4.8 This guide does not address the use of particulate grouts or epoxy as an injection material.

5. Materials

5.1 *General:*

5.1.1 The intent of this section is to define the properties that a chemical grout should have to perform effectively in the intended application and under expected field conditions.

5.1.2 It is recognized that new and improved chemical grout materials will become available in the future. Sources, manufacturers, formulations, and product names of materials will change from time to time, and therefore specific manufacturers and product names are not provided.

5.2 *Chemical Grout Characteristics:*

5.2.1 The following are general characteristics that should be exhibited by the chemical grout.

5.2.2 The chemical grout should have documented satisfactory performance in similar usage as the intended conditions.

5.2.3 The chemical grout should have controllable reaction times.

5.2.4 The chemical grout should have resistance to the concentrations of chemicals found in the type(s) of water the cured grout is expected to be exposed to (groundwater, stormwater, waste water, etc.).

5.2.5 The chemical grout should be non-toxic in cured form.

5.2.6 The chemical grout should be non-corrosive.

5.2.7 The cured chemical grout formation should not be biodegradable.

5.2.8 The cured material should withstand submergence in water in the environment in which it is installed without degradation.

5.3 *Material Selection:*

5.3.1 ICRI Guideline 340.1 provides additional information on grout properties; guidelines on the selection of an appropriate material; and the limitations, advantages, and disadvantages of the commonly used materials listed in 5.4.

5.3.2 The selection of an appropriate sealing material or combination of materials for a specific repair application depends on a number of interrelated factors, including but not limited to those discussed below. The chemical grout should be able to adequately penetrate and fill a sufficient extent of the crack or void prior to setting, and should remain in place while curing. The resultant chemical grout formation should prevent the passage of water (infiltration) through the crack or void.

5.3.3 Following the examination and discussion of the existing conditions by all involved parties, specific characteristics that pertain to the application requirements and desired performance of the repair should be defined and approved by the owner's representative or project architect or engineer of record.

5.3.4 The ability of the grout to penetrate into a crack is affected by the width of the crack, and material properties including: viscosity, cohesion, gel time, and expansion rate during reaction, among others. Generally, injected material will travel more quickly through wider cracks, and will require a shorter gel time. Material injected into narrow cracks may require a longer gel time to facilitate travel along the full extent of the cracks. When selecting a chemical grout, a minimum required set time should be established that will achieve adequate grout travel under the project conditions.

5.3.5 For any given product or formulation, material properties vary due to environmental conditions. The material properties will likely change over the course of the injection process, and can vary between laboratory- and field-prepared materials. Reaction times are influenced by the component and mix water temperature, the mix water chemistry, and the temperature of the concrete when injected and during curing of the grout. Thus, when comparing various products, it is important to understand the stated properties, as well as how sensitive those properties may be to the conditions and physical structure of the cracks to be injected. Some products allow for control over gel times through the preparation of the material, while others may be modified with additives (see 5.5).

5.3.6 The strength and durability of the cured grout should be compatible with the anticipated demands. Water type (groundwater, stormwater, waste water, etc.), current or potential wet-dry cycles, ground pressures, hydrostatic pressures, loading of the element, and thermal conditions should be thoroughly reviewed when choosing or approving the appropriate grout. Consideration of wet-dry cycles and crack movement is especially important when selecting a polyurethane grout, which are typically classified as either hydrophilic or hydrophobic. Hydrophilic grouts absorb water and form a flexible foam or gel, but many formulations require constant moisture to maintain an effective seal. Hydrophobic grouts repel water during and after the reaction, and are better suited to cyclical exposure to water. However, some hydrophobic materials form a rigid formation, and expansion and contraction of the crack will compromise the seal.

5.4 *Chemical Grout Materials:*

5.4.1 Acrylics, acrylates, and acrylamides.

5.4.2 Hydrophilic polyurethane foam or gel.

5.4.3 Hydrophobic polyurethane foam or gel.

5.5 *Additives:*

5.5.1 Gel control agents are commonly used to modify the gel time of a chemical grout. In some instances, it may be necessary to modify the gel time multiple times before a crack is completely sealed. For example, if a crack varies in width, different gel times may be required to achieve a consistent repair. When injecting very wide cracks, or cracks with a large volume of flowing water, a common practice consists of an initial injection of material with a short gel time, followed by an injection with a longer gel time. The rapidly setting material serves to seal the majority of the opening, while the subsequent injections are given time to travel into the remaining narrow spaces.

5.5.2 Grout additives may also be used for catalyzing the reaction, inhibiting the reaction, buffering the solution, lowering the freezing temperate of the solution, acting as filler, increasing strength, or inhibiting root growth.

5.5.3 The effect of additives should be limited to the material properties and characteristics targeted for modification.

6. Procedure

6.1 *Assessment of Existing Conditions:*

6.1.1 A thorough assessment of the existing leaks is a necessary step towards an effective repair. In addition to direct examination of active leaks, attention should be paid to past observations by building occupants, and patterns of water staining visible on the surface of the concrete. A timeline of the water infiltration combined with an understanding of the surrounding conditions (natural bodies of water, infrastructure, adjacent construction, existing waterproofing systems and drainage, expansion joints, etc.) is important when determining the performance criteria of the repair, especially if the leak is cyclical or seasonal, or perhaps temporary.

6.1.2 All reasonable effort should be made to understand the assembly into which grout is being injected. Existing drawings, inspection openings, and non-destructive testing (such as ultrasonic or radar scanning) should be utilized as necessary to establish the thickness and composition of the element, the presence of existing waterproofing systems, and to confirm that the injection process will not damage materials contained within or located adjacent to the area of repair. For example, embedded conduit, concealed drainage media, expansion joints, or adjacent finishes can be damaged during drilling or injection procedures. If the grouting operation compromises existing waterproofing systems, the process could result in new or exacerbated leaks. The repair of a leaking wall or slab may simply divert the flow of water to a more problematic location.