



American Railway Engineering and
Maintenance-of-Way Association

CHAPTER 29

WATERPROOFING¹

Current until revision of next edition

Responsibility for this Chapter lies with Committee 8 – Concrete Structures and Foundations

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¹ The material in this and other chapters in the AREMA *Manual for Railway Engineering* is published as recommended practice to railroads and others concerned with the engineering, design and construction of railroad fixed properties (except signals and communications), and allied services and facilities. For the purpose of this Manual, RECOMMENDED PRACTICE is defined as a material, device, design, plan, specification, principle or practice recommended to the railways for use as required, either exactly as presented or with such modifications as may be necessary or desirable to meet the needs of individual railways, but in either event, with a view to promoting efficiency and economy in the location, construction, operation or maintenance of railways. It is not intended to imply that other practices may not be equally acceptable.

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INTRODUCTION

■ The Chapters of the AREMA Manual are divided into numbered Parts, each comprised of related documents (specifications, recommended practices, plans, etc.). Individual Parts are divided into Sections by centered headings set in capital letters and identified by a Section number. These Sections are subdivided into Articles designated by numbered side headings.

Page Numbers – In the page numbering of the Manual (29-2-1, for example) the first numeral designates the Chapter number, the second denotes the Part number in the Chapter, and the third numeral designates the page number in the Part. Thus, 29-2-1 means Chapter 29, Part 2, page 1.

In the Glossary and Bibliography, the Part number is replaced by either a “G” for Glossary or “B” for Bibliography.

Document Dates – The bold type date (Document Date) at the beginning of each document (Part) applies to the document as a whole and designates the year in which revisions were last made somewhere in the document, unless an attached footnote indicates that the document was adopted, reapproved, or rewritten in that year.

Article Dates – Each Article shows the date (in parenthesis) of the last time that Article was modified.

Revision Marks – All current year revisions (changes and additions) which have been incorporated into the document are identified by a vertical line along the outside margin of the page, directly beside the modified information.

Proceedings Footnote – The Proceedings footnote on the first page of each document gives references to all Association action with respect to the document.

■ **Annual Updates** – New manuals will be reprinted and issued yearly, in their entirety.





American Railway Engineering and
Maintenance-of-Way Association



Part 1

Principles Governing the Waterproofing or Dampproofing of Railway Structures¹

— 1999 —

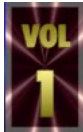
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¹ References, Vol. 36, 1935, pp. 376, 1032; Vol. 37, 1936, pp. 655, 1044; Vol. 48, 1947, pp. 380, 922; Vol. 54, 1953, pp. 827, 1334; Vol. 62, 1961, pp. 420, 902; Vol. 63, 1962, pp. 277, 687; Vol. 84, 1983, p. 93; Vol. 94, 1994, p. 146.

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SECTION 1.1 GENERAL

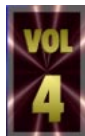
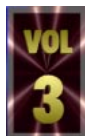
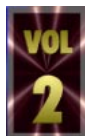
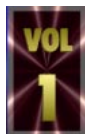
1.1.1 PURPOSE (1994)

These specifications are intended to be used for work carried out by railroad companies or their selected contractors when requested by the Engineer. These specifications apply to all parts of this chapter.

1.1.2 SCOPE (1994)

These specifications describe the selection, sampling and testing of materials to be used, material properties and construction requirements under specific conditions.

SECTION 1.2 WATERPROOFING (1994)



- a. Adequate and effective drainage should be provided to remove free water and lessen the possibilities of the development of a hydrostatic pressure head.
- b. Where the range of temperature varies from above freezing to below freezing, the disintegrating effect of frost action on water-saturated concrete and masonry should be recognized and adequately protected against.
- c. All surfaces of concrete, masonry, or steel structures that are or will be in contact with ballast, fill or water or will be inaccessible for inspection, shall be considered for waterproofing to eliminate the corrosive action of liquids upon the structural members.
- d. All waterproofing materials shall be applied when surface temperature is above 40 degrees F and rain is not likely before completion of the project, unless specifically recommended by the material manufacturer and with written approval of the Engineer.
- e. The materials for waterproofing and the methods of application must ensure that the bond is permanently maintained to the concrete, masonry, or steel interface.
- f. Where the waterproofing membrane is subject to potential injury or violation from abrasion, pressure, puncture, or other job-site abuse, a protection course is required.
- g. Waterproofing shall be applied where required to protect and extend the service life of the structure.
- h. The type of waterproofing should be determined by the use and probable life of the structure as related to the potential future cost of renewal of the waterproofing.
- i. Waterproofing of the most durable and effective type should be used on all concrete, steel and masonry structures:
 - (1) In locations subject to water or other liquids under a hydrostatic head.
 - (2) Where repair or removal is impractical or prohibitive in cost.
 - (3) Where certainty of watertightness must be positive because of heavy damage if water enters.
 - (4) For the protection of structural members from corrosive action caused by liquid infiltration.
- j. Waterproofing specially designed for the purpose should be used where the structure must be protected against liquids containing corrosive or deleterious substances.
- k. A waterproofing membrane on the surface adjacent to the water source is the most effective externally applied waterproofing.

SECTION 1.3 DAMPPROOFING (1994)

- a. Dampproofing is effective in preventing the accumulation of surface moisture from condensation only in proportion to its temperature-insulating value.
- b. Dampproofing is not effective where masonry is subject to moisture saturation accompanied by cycles of freezing and thawing.
- c. Dampproofing is not effective where cracks may occur in concrete or masonry walls as they do not have the ability to bridge those cracks.
- d. A frequent fault of one-coat dampproofing is failure to produce a continuous covering free from pin holes. This should be considered in deciding upon the number of coats that should be applied.
- e. The purpose and character of dampproofing should not require special protection or covering. Where protection or covering is necessary, the conditions will usually warrant the use of a waterproofing membrane.
- f. A prime requisite of a dampproof coating is that it must remain in place. Bond with the surface is therefore essential.
- g. The selection of materials for dampproofing should include consideration of the effect of temperature extremes, the effect of ultraviolet exposure, and the physical and chemical effects of the liquid to which they will be subjected.



SECTION 1.4 SPECIFIC APPLICATION

1.4.1 ABUTMENTS AND RETAINING WALLS (1994)

On the assumption that effective drainage has been provided, waterproofing on the back of an abutment or retaining wall is generally not necessary, but dampproofing should be provided above the footings. Where it is desired to prevent the passage of water, expansion joints, contraction joints or construction joints, across a suitable waterstop shall be installed.

1.4.2 SHORT SINGLE-SPAN ARCHES AND BOX CULVERTS (1994)

Short single-span arches and box culverts should be dampproofed on the surfaces in contact with the fill.

1.4.3 PEDESTRIAN SUBWAYS (1994)

Pedestrian subways should be waterproofed on surfaces in contact with the fill.

1.4.4 ARCHES—LONG SINGLE-SPAN AND MULTIPLE-SPAN WITH SPANDREL FILL (1994)

Long single-span arches and arches of multiple span with spandrel fill should be fully waterproofed on all surfaces in contact with the fill, including the parapets. Special attention should be given to the drainage and to the position of the fill in order to prevent the pocketing of water.

1.4.5 PRECAST SLABS FOR BRIDGE DECKS AND FLOORS (1994)

- a. The top surface of reinforced slabs and the backs of parapets should be dampproofed or waterproofed. When construction is over streets or walkways, waterproofing shall be applied.
- b. Prior to the application of hot-pour rubberized asphalt joint sealing material, a heat-resistant backer rod should be inserted to a minimum depth of $\frac{1}{2}$ inch below the slab surface. The remaining reservoir should then be filled with hot-pour rubberized asphalt joint sealing compound, flush with the slab surface (see [Figure 11-1](#)).

1.4.6 CAST IN PLACE CONCRETE BRIDGE DECKS OR FLOORS (1994)

- a. The top surface of slabs and the backs of parapets should be waterproofed or dampproofed and the construction joints closed with suitable waterstops, where the slab is an integral part of the structure, as in rigid frames or girderless flat slabs, or where it is the main load-carrying element, as in simple or continuous slabs.
- b. When the slab is supported on steel beams, all construction joints should be closed with suitable waterstops and membrane waterproofing applied.

1.4.7 PUMP PITS FOR SUBWAYS AND BASEMENTS (1994)

Pump pits should be waterproofed or dampproofed on all exterior surfaces.

1.4.8 PIPE MANHOLES AND PIPE TUNNELS (1994)

Pipe manholes and pipe tunnels should be dampproofed or waterproofed on all exterior surfaces.

1.4.9 WATER CONTAINERS (1994)

The walls and floors of water containers, such as reservoirs and tanks, should be made of dense concrete to insure watertightness. Special attention should be given to the waterproofing of all joints and a suitable waterstop shall be installed.

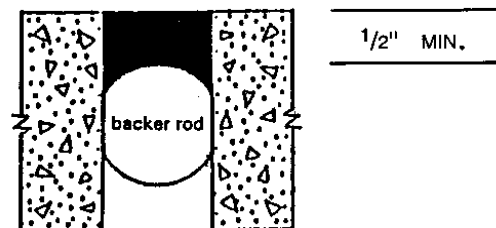


Figure 11-1. Joint Preparation

1.4.10 WALLS AND FLOORS OF BUILDINGS (1994)

- a. The walls and floors of all buildings subject to hydrostatic pressure should be waterproofed on pressure surfaces.
- b. If not subject to hydrostatic pressure, all exterior walls should be dampproofed below ground.
- c. Dampproofing should be applied to the back and top (under coping) of parapet walls and to the back and to the embedded surfaces of architectural masonry trim; also, to the inside of exterior masonry walls if plaster is to be directly applied.
- d. Special attention should be given to all joints and to places where pipes or other facilities pass through walls.



1.4.11 PLATFORMS, WALKWAYS AND ROADWAYS (1994)

Platforms, walkways and roadways over rooms or spaces used as adjuncts to building should be waterproofed.



1.4.12 GRAIN ELEVATOR PITS AND SIMILAR UNDERGROUND STRUCTURES (1994)

Grain elevator pits and similar underground structures should be made watertight by design and construction and waterproofed on the exterior.



1.4.13 SCALE PITS AND OTHER SIMILAR STRUCTURES BELOW GRADE (1994)

Scale pits and other similar structures below grade should be made watertight by design and construction as well as waterproofed or dampproofed, subject to the following conditions:

- The walls and floors of all pits subject to hydrostatic pressure should be waterproofed.
- If not subject to hydrostatic pressure, all exterior walls should be dampproofed below grade.
- Utility openings that pass through these walls shall be given special attention to prevent water infiltration or leakage.



SECTION 1.5 DEFINITIONS (1994)

The following terms are for general use in [Part 1, Principles Governing the Waterproofing or Dampproofing of Railway Structures](#). Specialized terms appear in individual articles. Refer to the Glossary located at the end of the chapter for definitions.

Asphaltic Panels for Waterproofing Protection

Fortified asphaltic panels for the protection of membrane waterproofing from ballast penetration and abrasion. Furnished in sheet form, applied either dry or in asphalt mastic at the Engineer's option.



Butyl Rubber

A sheet, elastomeric membrane formed of multiple plies of rubber factory fabricated into a single ply rubber membrane for waterproofing bridge decks, all foundations and tunnels. Capable of field splicing with appropriate adhesive, cement and butyl gum tape.



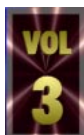
EPDM

A sheet, elastomeric membrane formed of Ethylene-Propylene-Diene-Monomers for waterproofing bridge decks, all foundations and tunnels. Capable of field splicing with appropriate adhesive, cement and butyl gum tape.



Rubberized asphalt with Plastic Film or Preformed Board Membrane

Consists of a layer of highly rubberized asphalt formed on plastic film or preformed board for bridge deck, wall foundation and tunnel waterproofing. In roll or sheet form, fully capable of field splicing with appropriate primer, adhesive and/or gusset gum tape.



SECTION 1.6 APPLICABLE ASTM DESIGNATIONS

1.6.1 GENERAL (1994)

These Specifications are offered as an assist to railway engineers as a capsulized summary of their intended usage; whether it be on grade, above grade or whether they be used in structures horizontally or vertically, to include railway bridges and structures.



1.6.2 ASTM D 41 (1994)

Covers asphaltic primers suitable for use with asphalt in dampproofing and waterproofing below or above ground level, for application to concrete and masonry surfaces.

1.6.3 ASTM D 43 (1994)

Covers creosote primers suitable for use with coal-tar pitch and dampproofing and waterproofing below or above ground level, for application to concrete and masonry surfaces.

1.6.4 ASTM D 173 (1994)

Covers woven cotton fabrics saturated with either asphalt or coal-tar bitumen and suitable for use respectively with asphalts conforming to D 449 or coal-tar bitumens conforming to D 450 in the membrane system of waterproofing.

1.6.5 ASTM D 226 (1994)

Covers asphalt-saturated felts, either with or without perforations 36 inches in width, suitable for use with mopping asphalts conforming to D 449 in the membrane system of waterproofing, and with mopping asphalts conforming to D 312 in the construction of built-up roofs.

1.6.6 ASTM D 227 (1994)

Covers coal-tar-saturated organic felt for use with coal-tar pitches conforming to the appropriate requirements of D 450 in the construction of built-up roofs and in the membrane system of waterproofing.

1.6.7 ASTM D 312 (1994)

Covers four types of asphalt intended for use in built-up roofing construction. This specification is intended for general classification purposes only and does not imply restrictions on the slope in which an asphalt must be used.

- Type 1. Includes asphalts that are relatively susceptible to flow at roof temperatures, with good adhesive and “Self-Healing Properties.” They are generally used in slag or gravel surface roofs on inclines up to 4.17% ($\frac{1}{2}$ inch/1 foot) slope.
- Type 2. Includes asphalts that are moderately susceptible to flow at roof temperatures. They are generally for use with built-up roof construction on inclines from approximately 4.17% ($\frac{1}{2}$ inch/1 foot) slope to 12.5% ($1\frac{1}{2}$ inches/1 foot) slope.
- Type 3. Includes asphalts that are relatively non-susceptible to flow at roof temperatures for use in the construction of built-up roof construction on inclines from approximately 8.3% (1 inches/1 foot) slope to 25% (3 inches/1 foot) slope.
- Type 4. Includes asphalts that are generally non-susceptible to flow at roof temperature, for use in the construction of built-up roofing on inclines from approximately 16.7% (2 inches/1 foot) slope to 50% (6 inches/1 foot) slope. These asphalts may be useful in areas where relatively high year-round temperatures are experienced.

1.6.8 ASTM D 449 (1994)

Covers three types of asphalts suitable for use as a mopping coat in dampproofing; or as a plying or mopping cement in the construction of membrane waterproofing systems with felts conforming to D 226 or D 250; fabrics conforming to D 173 or D 1668 (asphalt types); asphalt-impregnated glass mat conforming to 2178 and with primer conforming to D 41.

- Type 1. A soft, adhesive, “self-healing” asphalt that flows easily and is suitable for use below grade under uniformly moderate temperature conditions both during the process of installation and during the service.

NOTE: Type 1 asphalt is suitable for foundations, tunnels, subways, etc.

- Type 2. An asphalt less susceptible to flow with good adhesive and “self-healing” properties, suitable for use above grade where it will not be exposed to temperatures exceeding 122 degrees F.

NOTE: Type 2 asphalt is suitable for railroad bridges, culverts, retaining walls, tanks, dams, conduits, spray decks, etc.

- Type 3. An asphalt less susceptible to temperature than Type 2, with good adhesive properties, and suitable for use above grade on vertical surfaces exposed to direct sunlight or temperatures above 122 degrees F.



1.6.9 ASTM D 450 (1994)

Covers three types of coal-tar bitumens suitable for use in the construction of pitch built-up roofing, dampproofing and membrane waterproofing systems.

- Type 1. Suitable for use in built-up roofing systems with felts conforming to the requirements of D 227 or as specified by the manufacturer.
- Type 2. Suitable for use in dampproofing and in membrane waterproofing systems with primers conforming to the requirements of D 43, felts conforming to the requirements of D 227, and fabrics with coal-tar saturant conforming to the requirements of D 173, D 1327, or D 1668 or in systems using any combination of components specified by the manufacturer.
- Type 3. Suitable for use in built-up roofing systems, but having less volatile components than Type 1.

1.6.10 ASTM D 517 (1994)

Covers asphalt plank of two types as used for bridge floors:

- Type 1. Plan asphalt plank.
- Type 2. Mineral-surfaced asphalt plank.

1.6.11 ASTM D 692 (1994)

Covers crushed stone, crushed hydraulic cement concrete, crushed blast furnace slag, and crushed gravel suitable for use in bituminous paving mixtures, as described in D 3515 or D 4215.

1.6.12 ASTM D 946 (1994)

Covers asphalt cement for use in the construction of pavements and covers the following penetration grades:

- 40 - 50.
- 60 - 70.
- 85 - 100.
- 120 - 150.
- 200 - 300.

1.6.13 ASTM D 1187 (1994)

Covers emulsified asphalt suitable for application in a relatively thick film as a protective coating for metal surfaces.

- Type 1. Quick-setting emulsified asphalt suitable for continuous exposure to water within a few days after application and drying.
- Type 2. Emulsified asphalt suitable for continuous exposure to the weather, after application and drying.

1.6.14 ASTM D 1190 (1994)

Covers concrete joints sealer of the hot-pour elastic type, intended for use in sealing joints in concrete pavements, bridges and other structures.

1.6.15 ASTM D 1227 (1994)

Covers emulsified asphalts suitable for use as a protective coating for built-up roofs and other exposed surfaces with inclines of not less than 4%,

- Type 4. Emulsified asphalt prepared with mineral colloid emulsifying agents and containing inorganic fibrous materials.

1.6.16 ASTM D 1327 (1994)

- Covers woven burlap fabrics, saturated with either asphalt or refined coal-tar, as specified by the engineer, for use in the membrane system of waterproofing.
- Asphalt-saturated burlap fabric shall be used with asphalt-based plying cement; typical is a mopping asphalt conforming to D 449.
- Coal-tar-saturated burlap fabric shall be used with coal-tar-based plying cement; typical is a coal-tar pitch conforming to ASTM D 450.

1.6.17 D 1668 (1994)

Covers treated glass fabrics, composed of a woven glass cloth treated with either asphalt coal-tar pitch, or an organic resin compatible with the waterproofing system, as specified by the Engineer.

- Type 1, Asphalt Treated. Is suitable for use with asphalt conforming to D 449, asphalt emulsions conforming to D 1227 and asphalt coatings conforming to D 2823.
- Type 2, Coal Tar Pitch Treated. Is suitable for use with coal-tar pitch conforming to D 450, coal-tar pitch emulsions and solvent solutions.
- Type 3, Organic Resin Treated. The Engineer and supplier shall agree on an organic resin which is compatible or suitable for the plying cement specified. The organic resins shall not be water soluble.

1.6.18 D 2178 (1994)

- Covers glass felt impregnated to varying degrees with asphalt, that may be used with asphalts conforming to the requirements of D 312 in the construction of build-up roofs, and with asphalts conforming to the requirements of D 449 in the membrane system of waterproofing.
- Asphalt-impregnated glass felts covered by this specification:
 - Type 3 - Standard Ply Sheet.
 - Type 4 - Heavy Duty Ply Sheet.

1.6.19 D 2823 (1994)

Covers asphalt roof coatings of brushing or spraying consistency.





- Type 1. Is made from asphalts characterized as self-healing, adhesive and ductile, conforming to the requirements of D 312, Type 1; D 449, Types I or II; or D 946.
- Type 2. Is made from asphalts characterized by a high softening point and relatively low ductility, conforming to the requirements of D 312, Type II or III; or D 449, Type III.

1.6.20 D 3253 (1994)



- a. Covers non-fabric reinforced sheetings made from Butyl (IIR), Ethylene-Propylene-Diene Monomers (EPDM) or Chloroprene (CR) Elastomers, suitable for general waterproofing and lining of fluid containment areas.
- b. Classification of sheeting is based upon the major elastomer present:



- Type I Butyl-Based (IIR).
- Type II Ethylene-Propylene-Diene-Monomer Based (EPDM).
- Type III Chloroprene-Based (CR) (Check Availability).



1.6.21 ASTM D 4479 (1994)

Covers asbestos-free asphalt roof coatings of brushing or spraying consistency.



- Type 1. Made from asphalts characterized as self-healing, adhesive, and ductile, and conforming to the requirements of D 312, Type 1; D 449, Types 1 or 2; or D 946.
- Type 2. Is made from asphalts characterized by high softening point and relatively low ductility, conforming to the requirements of D 312, Types 2 or 3; or D 449, Type 3.

1.6.22 ASTM D 4586 (1994)

Covers asbestos-free asphalt roof coating suitable for trowel application to roofings and flashings.

- Type 1. Made from asphalt characterized as self-healing, adhesive, and ductile, conforming to the requirements of D 312, Type 1; D 449, Types 1 or 2; or D 946.