THE BRICK INDUSTRY ASSOCIATION

TECHNICAL NOTES on Brick Construction

12007 Sunrise Valley Drive, Suite 430, Reston, Virginia 20191 | www.gobrick.com | 703-620-0010

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Water Penetration Resistance – Materials

Abstract: This *Technical Note* discusses considerations for the selection of materials used in brickwork and their impact on its resistance to water penetration. Minimum recommended property requirements and performance characteristics of typical materials are described.

Key Words: anchors, brick, coatings, corrosion resistance, flashing, grout, lintels, mortar, sealants, shelf angles, ties, water-resistive barrier, weeps.

SUMMARY OF RECOMMENDATIONS:

Brick and Mortar

- Select brick from the appropriate ASTM standard, designated for exterior exposures
- Use mortar conforming to ASTM C270
- Choose mortar materials and Types that are compatible with the brick selected to achieve optimal bond
- Use mortar Type with lowest compressive strength meeting project requirements

Grout

- Use grout conforming to ASTM C476
- Select appropriate type based on project requirements and dimensions of masonry openings receiving grout

Ties and Anchors

- Use galvanizing, stainless steel or epoxy coatings to provide corrosion resistance
- Do not use ties or anchors with drips
- Detail penetrations at face of backing

Water-Resistive Barriers

- Install when brick veneer is anchored to wood or cold-formed steel framing
- Protect from or avoid prolonged ultraviolet (UV) exposure
- Use No. 15 asphalt felt conforming to ASTM D226 or building paper, polymeric films (sheet membranes [housewraps] or fluid-applied materials), or water-resistive sheathings deemed equivalent or conforming to AC38
- For insulation or sheathings with facings intended to act as a water-resistive barrier or air barrier, tape or seal all joints
- For water-resistive barriers or air barriers, use material with appropriate permeability for wall assembly type and location within wall assembly; if necessary, use hygrothermal analysis to determine proper location and appropriate permeability

Flashing

- Use flashing conforming to applicable ASTM specifications
- Use sheet metal, plastic, rubber or composite materials
- Select flashing that is waterproof and compatible with adjacent materials
- Select materials appropriate for building service life, with higher levels of durability and UV resistance preferred
- Do not use aluminum, sheet lead, polyethylene sheeting, asphalt-saturated felt, building paper or housewraps
- For flashings that degrade when exposed to UV light, use a drip edge
- For flexible flashing anchorage, use a termination bar to anchor flexible flashing where appropriate

Weeps

- Open head joint weeps preferred
- Vents and mesh may be installed within open head joint weeps

Drainage Material or Mortar Collection Devices

- Use of material or devices is recommended
- Select either low-height material placed immediately above flashing or full-height material placed throughout air space
- For low-height material, two-level crenulated shape is recommended
- Use material that fills entire width of air space
- Do not use material that absorbs moisture or transmits moisture to backing

Sealant Joints

- Use sealants conforming to ASTM C920 with compatible movement capability to joint size and type
- Use backer rods where joints are wide enough to accommodate them
- Closed cell or bicellular backer rods recommended
- Size backer rods 25 percent larger than joint width
- Where backer rod cannot be installed, use bond break tape

INTRODUCTION

This *Technical Note* is the second in a series addressing water resistance of brick masonry and provides guidance regarding material selection of brick masonry components. Other *Technical Notes* address brickwork design and details (TN 7), construction techniques and workmanship (TN 7B) and condensation (TN 47).

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The use of quality construction materials in brickwork is of prime importance in attaining a satisfactory degree of water resistance. Requiring that materials meet the minimum criteria of appropriate material specifications helps to ensure that they are of an acceptable quality.

The most recognized and widely used building material specifications for the determination of quality construction materials are those developed by ASTM International (ASTM) [Ref. 2]. The performance of products cannot be predicted by ASTM specifications alone, because design, detailing and workmanship also affect performance. However, the requirements are based on laboratory tests and field experience and, in the case of brick, are the result of experience gained over a time span exceeding 100 years.

BRICK UNITS

Selection of quality brick is very important. Units are normally chosen based on color, texture, size and cost. However, characteristics that can affect water penetration resistance should also be considered. These include durability and those properties that influence brick/mortar compatibility.

Under normal exposures, it is virtually impossible for significant amounts of water to pass directly through brick units. Brick can absorb water, but the density and pore structure of the units does not contribute to bulk water penetration through the brick matrix. Where water penetration through brick masonry occurs, it generally does so through the bond line between the brick and mortar and, depending on the level of workmanship, the mortar joint.

Durability

Because exterior masonry will be exposed to moisture and the elements, durability is a primary concern. Durability of the brickwork is affected not only by the durability of individual materials, but also by the compatibility of materials, how the assembly is designed, how materials are installed and the conditions to which the masonry is exposed.

The ASTM specifications for brick are written to provide guidance in choosing a suitable quality of brick based on specific exposure conditions. The requirements for compressive strength, absorption and saturation coefficient are used to establish the resistance of the brick to damage by freezing and thawing when saturated. Cracking, crazing, spalling and disintegration can occur if an improper choice of brick is made. Many areas of the United States fall within the designation of severe weathering, where the use of Grade SW brick is recommended. Grade SW brick is the default brick grade for brick conforming to ASTM C216 and C652.

The requirements within the ASTM specifications for brick and other component materials are not intended to serve as an indicator of the degree of water resistance of the masonry assembly, which includes brick, mortar, grout, etc. The durability of the masonry is related to the degree of water resistance in that the more water that enters the system, the greater the probability that the masonry will be in a saturated condition during freeze/thaw cycles.

Brick Standards. Each kind of brick currently in use has its own designated ASTM standard, with specific requirements for durability stipulated by physical properties of the brick. The most commonly used brick standards and the classification for the most severe exposures are the following [Ref. 2]:

- ASTM C216, Grade SW - *Facing Brick (Solid Masonry Units Made From Clay or Shale)*
- ASTM C652, Grade SW - *Hollow Brick (Hollow Masonry Units Made From Clay or Shale)*
- ASTM C62, Grade SW - *Building Brick (Solid Masonry Units Made From Clay or Shale)*
- ASTM C1405, Class Exterior - *Glazed Brick (Single Fired, Brick Units)*
- ASTM C126, *Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units* (note that this standard does not include physical requirements for the brick body; therefore, specify Grade SW within ASTM C216 or C652 as applicable)

Please see *Technical Note* 9A for additional information regarding the physical properties of brick units.

MORTAR AND GROUT

Choosing the proper Type of mortar or grout to use in a particular application is very important. To minimize water penetration, the primary concern is to choose a mortar and/or grout that will result in the most complete bond with the masonry units chosen. The *Technical Note* 8 Series provides detailed information on mortar. *Technical Note* 3A provides further information on grout.

Mortar

The standard for specifying mortars for unit masonry is ASTM C270, *Standard Specification for Mortar for Unit Masonry* [Ref. 2]. Four Types of mortar (M, S, N and O) are covered in the standard, although building codes typically require the use of Types M, S or N. Type O mortar is generally used in repair of older brickwork where other mortar Types may be incompatible with the existing brick. ASTM C270 addresses portland cement-lime (PCL) mortars and those made with mortar cements and masonry cements. Detailed information on the provisions of ASTM C270, including mortar Types, proportion formulas and required properties, can be found in *Technical Note* 8.

No single Type of mortar is best for all purposes. As a general rule, when selecting mortar for a project, always select the mortar Type with the lowest compressive strength that meets the performance requirements of the project. Mortar with higher cement content may be more difficult to clean off the face of the wall, may increase the risk of shrinkage cracks and may decrease the workability of the mortar. Decreased workability increases the chances of partially filled joints.

This general rule must be tempered with good judgment. For example, it would be uneconomical and unwise to continuously change mortar Types for various parts of a structure. However, the general intent of the rule should be followed, using good judgment and economic sense. For most brick veneer applications, Type N mortar is appropriate. Refer to the “Brick/Mortar Compatibility” section of this *Technical Note*.

Grout

Grout is used in reinforced brick masonry to fill cells and cavities that contain reinforcing steel. This not only applies to reinforced walls, but also to beams and lintels constructed of brick masonry. In some barrier masonry walls, grout is used to fill the collar joint that bonds the outer and inner masonry wythes together.

For brickwork, use grout conforming to ASTM C476, *Standard Specification for Grout for Masonry* [Ref. 2]. The standard covers two types of grout: fine and coarse. Fine grout consists of cement and sand, while coarse grout also contains coarse aggregates such as pea gravel. Each grout type is further classified as either conventional or self-consolidating. Conventional grout requires consolidation by external means, such as vibration, while self-consolidating grout, as its name implies, does not require external means of consolidation. Within each of these classifications, the grout can be either fine or coarse, depending on the geometric constraints of the application. Grout can be prepared by mixing the components on the jobsite, or it can be obtained as a ready-mix product. The volume of material needed for conventional grout may be specified by proportions or by strength requirements; self-consolidating grout must be specified using the strength requirements. When using conventional grout in brickwork, specification by proportions is recommended. Volumes of materials used in grout (or mortar) specified by proportions should be measured consistently throughout the project via the use of a calibrated container, which is periodically checked by material weights and densities. Where possible, whole bags of components should be used to determine proportions.

Specification for Masonry Structures (TMS 602) [Ref. 12] contains requirements for the maximum height of grout pour, the minimum width of grout space and the minimum dimensions of cells receiving grout for each grout type. Fine grout requires a minimum grout space width of ¾ in. (19.1 mm) and any cells receiving grout to be a minimum dimension of 1½ × 2 in. (38 × 51 mm). Coarse grout requires a minimum grout space width of 1½ in. (38 mm) and any cells receiving grout to be a minimum dimension of 1½ × 3 in. (38 × 76 mm).

BRICK/MORTAR COMPATIBILITY

When water passes through brick masonry walls, it does so through separations that form between the brick and the mortar at the time of laying or through cracks that form after the mortar has cured. The dominant property affecting the amount of water entering brickwork from the standpoint of materials selection is the extent of bond between the brick and the mortar. Extent of bond is a measure of the area of contact at the interface between brick and mortar surfaces.

Not to be confused with extent of bond, bond strength is a measure of the adhesion between brick and mortar. Bond strength is one factor that determines whether cracks will form after the mortar cures. Brick-and-mortar combinations that have high bond strengths do not necessarily provide high resistance to water penetration. Extent of bond is more important to water penetration resistance of brick masonry than bond strength.

Extent of bond is influenced by both brick and mortar properties and is best achieved when both are considered and paired accordingly. Initial rate of absorption is the key property of the brick related to brick/mortar compatibility. Mortar properties include water retention, air content and workability.

The initial rate of absorption (IRA) of a brick is a measure of the amount of water taken into a 30 sq in. (194 cm^2) area on the bedding surface of the brick within one minute. A brick's IRA can be measured in the laboratory under controlled drying conditions or in the field. The field IRA of a brick will vary depending on the moisture condition of the brick at the time of testing.

Tests over the years have shown that the most complete bond is achieved when the IRA of a brick, at the time of laying, is below 30 g/min•30 sq in. (30 g/min•194 cm^2). As a result, TMS 602 requires brick with initial rates of absorption in excess of this value to be wetted prior to laying. Water penetration tests of masonry built with low- and high-IRA brick [Ref. 4 and Ref. 5] indicate that mismatch between brick IRA and the amount of water retentivity in the mortar may result in poor bond, which can increase the risk of water penetration. Thus, low IRA brick (less than 5 g/min•30 sq in.) should be combined with mortars that exhibit low water retention, and high IRA brick should be combined with mortars with high water retention. See *Technical Note* 8B for mortar recommendations with brick of various IRAs.

Mortar air content will also affect extent of bond because the air voids present along the bond line reduce the length of direct contact between mortar and brick. Higher air content mortars such as masonry cement mortars and those made with air-entrained cements or lime are more likely to increase water penetration.

Several studies have shown that workmanship is critical with respect to water penetration. Tooling is the first defense, as the process consolidates and densifies the mortar at the outer surface and forces the mortar against the brick surfaces. Additional information on tooling is presented in *Technical Note* 7B. With respect to mortar, many masons have more experience with certain mortar formulations than others. Allowing masons to use mortars they have experience with will generally result in better workmanship than using unfamiliar mortar formulations.

TIES AND ANCHORS

Ties and anchors in a masonry wall system connect two or more wythes together or attach the brick veneer to structural backing. Ties and anchors do not directly influence water penetration, except when related to cracking of the brickwork and resulting water entry. All ties and anchors must be corrosion-resistant. Applicable ASTM standards for corrosion resistance of masonry ties and anchors are discussed later in this *Technical Note*. More detailed information on ties and anchors can be found in *Technical Note* 44B.

Joint Reinforcement. Truss-type joint reinforcement that engages the brick wythe with fixed diagonal cross wires is permitted only in multi-wythe walls with a filled collar joint. In other walls, it can restrict differential in-plane movement between masonry wythes, which can lead to cracking and subsequent water penetration.

Drips. A drip is a bend or crimp in a tie or anchor that breaks the surface tension of any moisture traveling across the tie, forcing it to form a droplet and fall before reaching the interior masonry wythe or other backing. Ties and anchors of wire with drips are not permitted by the *Building Code Requirements for Masonry Structures* (TMS 402) [Ref. 6] because the drips reduce the compressive and tensile load capacity of the ties when transferring the lateral loads between the wythes. Detailing the penetration of the tie at the plane of the backing is a more effective method of protection against this condition.

Penetrations. Brick ties and anchors will penetrate the water-resistive barrier, air barrier and/or vapor retarder and will require additional detailing to maintain watertightness of the wall assembly. Apply compatible sealant or other approved patching materials around the penetration at the face of the membrane to ensure continuity of the water-resistive barrier, air barrier and/or vapor retarder. With fluid-applied products, care should be exercised to ensure full coverage around penetrations and protrusions. It is recommended to install self-adhered membrane directly behind brick tie base plates for additional protection with polymeric air and water-resistive barriers. Use manufacturer-recommended accessories with fasteners, such as large-diameter plastic caps for nails, staples or screws. Metal washers with ethylene propylene diene monomer (EPDM), neoprene or equivalent gaskets are also recommended for screw fasteners.

Corrosion Resistance. Corrosion resistance is usually provided by using galvanized steel or stainless steel. Epoxy coatings are used in some situations. The level of corrosion protection required for wall ties and anchors varies with their expected exposure conditions, as follows:

- When exposed to earth or weather or to a mean relative humidity exceeding 75 percent, ties and anchors are required to be hot-dip galvanized, stainless steel or epoxy-coated.
- In other exposures, ties and anchors must be mill galvanized, hot-dip galvanized or stainless steel.

In addition, the designer should consider the potential for corrosion due to contact between dissimilar metals.

Galvanized steel items may be hot-dip or mill galvanized; however, hot-dip galvanizing is preferred. With mill galvanizing, the steel is galvanized before the joint reinforcement or wall tie is fabricated. Therefore, welds and ends cut during or after the manufacturing process are not coated. With hot-dip galvanizing, the finished fabricated item is galvanized, providing more complete coverage. Stainless steel items should be AISI Type 304 or Type 316 and conform to the appropriate specification listed below. TMS 402 also allows epoxy coatings to be used as corrosion protection. When epoxy coatings are specified, consider including touch-up material for the coating in order to restore protection when coating is scratched or cut during construction.

To ensure adequate resistance to corrosion, coatings or materials should conform to the following [Ref. 2]:

Zinc Coatings	ASTM A123 (for steel plates and bars) or A153 Class B (for sheet metal ties and sheet metal anchors) or minimum 1.50 oz/sq ft (458 g/m^2) (for joint reinforcement, wire ties and wire anchors)
	ASTM A641, minimum 0.1 oz/sq ft (0.031 kg/m^2) (joint reinforcement)
Stainless Steel	ASTM A240 (for sheet metal anchors and sheet metal ties)
	ASTM A480 (for sheet metal anchors and sheet metal ties and for plate and bent-bar anchors)
	ASTM A580 (for joint reinforcement, wire anchors and wire ties)
	ASTM A666 (for plate and bent-bar anchors)
Epoxy Coatings	ASTM A884 Class A, Type 1, minimum 7 mils (175 μm) (for joint reinforcement)
	ASTM A899, Class C, minimum 20 mils (508 μm) (for wire ties and wire anchors)

Masonry Headers. A header is a masonry unit laid perpendicular to the wythe that is used to connect two wythes of masonry. Although TMS 402 allows wythes of masonry designed for composite action to be bonded structurally by masonry headers, they are not commonly used in contemporary construction. Structural header units are no longer recommended because they provide a direct path for water penetration from the outside of the wall to the interior along the head and bed joints. Many bond patterns such as Flemish, Old English, Old English Cross, etc. use header units that can be replicated in a veneer with clipped or false headers without the risk of water penetration.

WATER-RESISTIVE BARRIERS

As discussed in *Technical Note 7*, the *International Building Code* (*IBC*) [Ref. 8] and the *International Residential Code* (*IRC*) [Ref.9], water-resistive barriers are used to prevent the passage of liquid (bulk) water to underlying materials, and some may also serve as an air barrier. The permeability of the water-resistive barrier must also be considered in order to ensure that water vapor does not remain in the wall.

Permeability. With respect to water vapor management, the unit "perm" is used to identify the permeability of a water-resistive barrier, with a higher number indicating greater permeability. This property is measured using one of the test procedures in ASTM E96, *Standard Test Methods for Water Vapor Transmission of Materials* [Ref. 2]. The manufacturer's literature of the water-resistive barrier should include the test method when citing the perm rating to allow for an accurate comparison among different materials. These materials are identified in the *IBC* and *IRC* as different classes of vapor retarders based on the perm rating. See Table 1.

Table 1
Vapor Retarder Classification

Vapor Retarder Class	Rating (perms)
Class I	Less than 0.1
Class II	Above 0.1 and less than or equal to 1.0
Class III	Above 1.0 and less than or equal to 10

Class I vapor retarders are sometimes referred to as vapor barriers. The *IBC* and *IRC* categorize Class III vapor retarders as vapor permeable when they have a perm rating of 5 or higher per ASTM E96, desiccant method.

Wall Assemblies. As discussed in *Technical Note* 7, wall assemblies with brick masonry at the exterior are categorized in two main groups: those with continuous insulation within the drainage cavity or air space and those with insulation in the stud cavity only.

When continuous insulation is present in the air space behind the brick veneer, the face of the sheathing or backing generally serves as the plane where bulk water, air and water vapor are controlled. In many climate zones, the vapor retarder does not need to be permeable at this location (e.g., Class I is permitted), and a single product can serve all functions. But in colder climate zones, enough continuous insulation must be placed on the exterior side of the water-resistive barrier to ensure that condensation will occur within the air space and not within the backing. The insulation thickness can be determined by hygrothermal analysis, which models the movement of heat and moisture through a building.

When insulation is only within the stud cavity, the water-resistive barrier must be vapor permeable (5 perms or higher) and serve to protect against bulk water. If feasible, the water-resistive barrier can be detailed to function as the air barrier also. Alternatively, the exterior sheathing can be detailed to serve as the air barrier by treating the seams and penetrations with sealant or tape. For more information on vapor barriers and their placement, refer to "Understanding Vapor Barriers" [Ref. 7].

Examples of water-resistive membranes include No. 15 asphalt felt, building paper, certain high-density polyethylene or polypropylene plastics (housewraps), and certain water-resistive sheathings. The various material options are discussed in detail below.

Sheet Membranes

Felt-Based Barrier. One layer of No. 15 asphalt felt is prescribed by most building codes as the baseline material for water-resistive barriers. The felt should conform to Type I of ASTM D226, *Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing* [Ref. 2]. It may be attached directly to the studs or sheathing in such a manner as to provide a continuous water-resistive, vapor-permeable barrier and should have a performance of at least two layers of water-resistive barriers complying with Type I of ASTM E2556, *Standard Specification for Vapor Permeable Flexible Sheet Water-Resistive Barriers Intended for Mechanical Attachment* [Ref. 2]. The durability of asphalt-saturated felt is adequate; however, it may be easily torn during or after installation. Asphalt-saturated felt typically has a high water vapor permeability, which increases when wet, categorizing it as a Class II vapor retarder per *IBC* (Class III when wet). Felt cannot be detailed to act as an air barrier; therefore, other methods should be used to limit air flow through the assembly.

Paper-Based Barrier. Asphalt-saturated kraft paper (generally referred to as building paper) has a long history as an approved and common substitute for No. 15 asphalt felt. Building paper for use as a water-resistive barrier should conform to the requirements of Federal Specification UU-B-790a, Type I, Grade D. This specification requires that Grade D paper have a minimum water-resistance rating of 10 minutes as determined by ASTM D779, *Standard Test Method for Water Resistance of Paper, Paperboard, and Other Sheet Materials by the Dry Indicator Method* [Ref. 2]. Characteristics of building paper are similar to those of asphalt-saturated felt. Building paper typically has less asphalt and lower permeance than felt and can offer better resistance to bending damage. One of the disadvantages of the product is that it will deteriorate if subjected to sustained moisture without sufficient drying.

Polymeric-Based Barrier. Some plastic films (building wraps or housewraps) have been approved for use as water-resistive barriers. These films may have qualities similar to those of other water-resistive barriers, but ascertaining the effectiveness of a particular plastic as a water-resistive barrier can be difficult, as a standard specification is yet to be developed.

Some plastic membranes act as vapor barriers and can potentially trap water vapor inside the stud wall, where it can condense if the temperature in the wall drops below the dew point. Thus, not all plastic membranes should be considered suitable, and caution should be exercised when specifying them as water-resistive barriers. AC38, *Acceptance Criteria for Water-Resistive Barriers* [Ref. 1], developed by the International Code Council Evaluation Service, Inc., is typically used to establish the suitability of a polymeric film as a water-resistive barrier. Under these criteria, polymeric-based barriers are proprietary polymeric sheet materials for use as water-resistive barriers that are either mechanically fastened or coated on one side with an adhesive material.

Polymeric films are generally divided into two categories: perforated and non-perforated. Non-perforated films allow water vapor to pass between the fibers of the plastic fabric, while perforated films are made from vapor-tight plastic films that are punched with small holes to allow vapor to pass through. Non-perforated films are recommended over perforated films because they resist water penetration more consistently in commonly used performance tests than perforated films.

Polymeric films are highly resistant to tearing and can often function concurrently as air barriers when detailed to do so; however, they do not tend to seal themselves when penetrated by fasteners, as felts sometimes do. Some manufacturers recommend that fasteners with large heads or plastic caps be used rather than standard fasteners to enhance water penetration resistance at fastener locations. Polymeric films can often be installed with fewer lap joints than felt and building paper, as they are supplied in larger rolls up to 10 ft (3.1 m) wide.

Self-adhered rubberized asphalt sheet membranes that are used primarily as air barriers may also function as vapor-impermeable water-resistive barriers. These consist of a rubberized asphalt backing with a polymeric facing, the same material that can be used for masonry through-wall flashing. Generally, this type of membrane has some self-healing capabilities and is significantly more resistant to tears than the sheet materials listed previously.

Fluid-Applied Films

Fluid-applied films often have the capability of serving as both vapor and air barriers, and sometimes thermal insulation, in addition to providing water resistance. These coatings are varied in type and may be applied by spray, roller or trowel; however, they generally have the benefit of providing a seamless, monolithic membrane that adheres to most substrates. Although these materials can be applied rapidly, they require skilled applicators to ensure quality and performance.

These membranes have a unique set of service requirements because they are bonded to the substrate. The effects of wet substrates, expansion and contraction at substrate joints, volume changes of building materials, and stresses caused by lateral loads must be considered so that the membrane performs successfully during its life. Membrane transition strips are frequently used in combination with fluid-applied films to address concerns with changes and variations in the substrate. Consistent installations are more difficult to achieve on substrates with rough surfaces and may require increased thicknesses, which can adversely affect the permeability of the film.

Board Products

Sheathings and other board products that are inherently water resistive or have water-resistive facings are permitted to serve as water-resistive barriers when the edges and joints of boards are completely taped or sealed. To perform successfully, the materials providing this seal must maintain their integrity and performance when subjected to moisture and other environmental conditions for the entire service life of the wall. Board products that act as water-resistive barriers should be vapor permeable except when they are also intended to serve as a vapor barrier.

SHELF ANGLES AND LINTELS

Although similar, shelf angles and lintels differ in the way each is incorporated into brickwork. A shelf angle supports brick veneer and is anchored to the structure. Shelf angles typically occur at floor lines and above ribbon windows. A lintel, on the other hand, is a structural beam placed over an opening to carry superimposed loads. As such, it is supported by the masonry on each side of the opening and is not attached to the structure.

Lintels may be loose steel angles, stone, precast concrete or reinforced masonry. The proper specification of material for lintels is important for both structural and serviceability requirements.

Non-galvanized and non–stainless steel shelf angles and lintels should be primed and painted at a minimum to inhibit corrosion. A commercial or industrial coating instead of exterior-grade paint is an upgrade to consider for mild steel without galvanizing and is also recommended to provide additional protection for existing steel that has experienced minor corrosion. For severe climates and exposures, such as in coastal areas, consider using galvanized or stainless steel shelf angles and lintels, as well as anchors and joint reinforcing. Stainless steel components used in construction are typically Type 304. Type 316 stainless steel has an increased resistance to chlorides and is recommended for coastal areas and the most extreme exposures. Even where galvanized or stainless steel shelf angles and lintels are used, continuous flashing should be installed to protect the angle. To ensure adequate resistance to corrosion, galvanized zinc coatings should conform to ASTM A123, *Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products* [Ref. 2]. Additional discussion and details of shelf angles and lintels may be found in *Technical Notes* 21, 21A, 28, 28B, 31 and 31B.

FLASHING

Selection of a proper flashing material is of utmost importance because the flashing is a critical element to the drainage of water that may penetrate the wall system. Flashing materials must be waterproof, durable, and resist puncture and cracking during and after construction. To promote drainage, flashing should extend beyond the face of the brick to form a drip. Because flashing may be installed in advance of the exterior brick wythe, it should be able to endure some exposure to ultraviolet (UV) light without significant deterioration. When using a flashing that deteriorates with UV exposure, a metal drip edge is recommended to extend the flashing beyond the face of the brickwork. When a drip edge is not used, the flashing should stop, or be cut, flush with the face of the wall. The flashing should also resist damage from contact with metal, mortar or water and be compatible with adjacent adhesives and sealants. Minimum recommended flashing thicknesses are included in this section for each type of flashing. In general, thicker flashings are more durable but may be more difficult to form.

Flashing materials generally fall into three categories: sheet metals, composite materials (combination flashings), and plastic or rubber compounds. The selection is largely determined by cost and suitability. Only superior quality materials should be selected, since replacement in the event of failure may be expensive. Materials such as polyethylene sheeting, asphalt-impregnated building felt, building paper and housewraps should not be used as flashing materials. These materials are not necessarily waterproof, are easily damaged during installation and, in many cases, turn brittle and decay over time.

Sheet Metals

Stainless Steel. Stainless steel is an excellent rigid flashing material that has superior chemical resistance and does not stain masonry. Stainless steel flashing should conform to ASTM A240/A240M, Type 304 [Ref. 2]. The minimum thickness should be at least 0.01 in. (0.25 mm) or 32 gauge. A thickness of at least 0.016 in. (0.41 mm) or 28 gauge is recommended for drip edges and other typical masonry flashings.

Because a sheet metal brake is required to create flashing assemblies, preformed shapes are commonly used, although these are difficult to modify on-site if field adjustments are required. Stainless steel shapes, such as pans, end dams and mitered corner transitions, should have fully soldered seams to achieve watertightness; however, linear sections of flashing can be joined using cover plates and multiple parallel lines of sealant appropriate for sheet metal applications to permit expansion and contraction of the metal. Exposed edges, particularly drips, should be hemmed.

Copper. Copper is another excellent rigid flashing material that is durable, easy to form and solder, and is available in preformed shapes. The recommendations regarding fully soldered seams and hemmed edges in stainless steel apply to copper as well. Exposed copper may stain adjacent masonry, but it is not damaged by the caustic alkalis present in masonry mortars. It can be safely embedded in fresh mortar and will not deteriorate in continuously saturated, hardened mortar, unless excessive chloride ions are present. When using copper flashing, prohibit the use of mortar admixtures containing even small amounts of chlorides.

Copper flashing should conform to ASTM B370, *Standard Specification for Copper Sheet and Strip for Building Construction*, or B882, *Specification for Pre-Patinated Copper for Architectural Applications* [Ref. 2]. The Copper Development Association recommends minimum weights of 12 oz/sq ft and 16 oz/sq ft for high-yield and standard cold rolled copper, respectively, used as through-wall flashing. If copper flashing is used adjacent to other metals, then proper care should be taken to account for separation of the materials. Laminated copper flashing and combinations of copper sheet and other materials are discussed in the "Composites" section of this *Technical Note*.

Mill-Galvanized Steel. Galvanized flashing is available, but the coating is not hot-dipped, resulting in a thinner protective layer. Bending galvanized sheets to create flashing shapes will crack the coating and compromise the corrosion protection. In addition, the coating is sacrificial compared with the inert finishes of other metal flashings, which results in reduced service life and durability. Therefore, use of galvanized steel as through-wall flashing is not recommended.

Aluminum. Aluminum should not be used as a flashing material in brick masonry. The caustic alkalis in fresh, unhardened mortar will attack aluminum. Although dry, seasoned mortar will not affect aluminum, corrosion can occur if the adjacent mortar becomes wet. Anodized or organic coatings can provide some protection against this condition but are still not recommended for flashing, as they will not provide the same performance as an inert material for embedded elements. These coatings should provide adequate protection of exposed aluminum elements within the wall system, such as window frames, from precipitation runoff.

Lead. Historically, lead sheets were widely used to flash masonry walls. Because lead, like aluminum, is susceptible to corrosion in fresh mortar, a coating was applied to the lead for protection. Galvanic action can also occur where lead is only partially embedded in cured mortar with moisture present. In the United States and elsewhere, the use of lead as a building material has fallen out of favor due to environmental and worker safety concerns. Consequently, thin lead sheet is no longer recommended as a flashing material in brick masonry. Contemporary materials are available to replicate a lead flashing appearance where new flashing is required to match existing lead flashing.

Plastics and Rubbers

Plastic and rubber flashings are resilient, corrosion resistant materials that are easy to form and join. However, because the chemical compositions of these products vary widely, their durability is also variable. Thus, it is necessary to rely on performance records of the material, the reputation of the manufacturer and, where possible, test data to ensure satisfactory performance. Some of the critical areas are (1) resistance to degradation in UV light; (2) compatibility with alkaline masonry mortars; (3) compatibility with joint sealants, and (4) resistance to tear and puncture during construction. A minimum thickness of 40 mils (1 mm) is recommended for plastic and rubber flashing.

Polyvinyl Chloride (PVC). Historically, PVC flashing became brittle with age and was sensitive to UV exposure. Newer PVC flashing is formulated with different polymers, similar to those used in roofing applications, and is designed not to deteriorate or harden with time or UV exposure. Adding higher percentages of such polymers to PVC flashing can contribute to greater flexibility and durability. Therefore, these newer flashings do not require a separate drip edge, and some manufacturers make a version with an integral drip edge. PVC flashing may be self-adhered or require the use of a separate adhesive to bond to itself and the substrate.

Ethylene Propylene Diene Monomer (EPDM). EPDM is a synthetic rubber that is used as a single-ply roofing membrane as well as flashing; therefore, exposure to UV light is not a concern. It has better low-temperature performance than PVC and better weathering resistance than butyl rubber. Flashing of this type generally requires a separate adhesive to bond to itself and the substrate.

Self-Adhered Rubberized Asphalt. Self-adhered rubberized asphalt flashing adheres to other building materials and itself, speeding flashing installation and making it easier to seal flashing laps and terminations. These flashings are also self-healing, making them less susceptible to small punctures. However, dimensional stability may be a concern. Substrates should be dry and clean for proper adhesion. When self-adhered flashings are used, confirm compatibility between the flashing adhesive and sealants used in the wall. Primers may be required to ensure adequate adhesion of self-adhering flashing to some substrates.

This membrane is not intended for UV exposure, and the rubberized asphalt will bleed onto the brick face when exposed to elevated temperatures or direct sunlight. As a result, this membrane is regularly paired with a sheet metal drip edge, which allows the membrane to be recessed 1 to 1½ in. (25 to 38 mm) and still direct moisture to the exterior. Some manufacturers offer a through-wall flashing version of their typical self-adhered membrane that features a leading edge of facing material without the rubberized asphalt to serve as a drip edge.

Composites

The most common type of composite or combination flashing is a thin layer of metal sandwiched between one or two layers of another material, such as bitumen, kraft paper or various fabrics. The metal layer is usually copper, lead or aluminum. Composite flashings have the advantages of the better properties of each of their component materials. In the case of lead and aluminum composite flashings, the paper and fabric laminates reduce the potential for corrosion resulting from the metal foil contacting the mortar or adjacent dissimilar metals. These flashings also allow the use of thinner metal sheets, making them less expensive and easier to form, but also more prone to tearing and punctures. If the laminate is not durable and stable under UV exposure, then these flashings should be used with stainless steel drip edges. Adhesives are required to bond these materials to themselves and to the substrate. For surface-mounted applications where the flashing is not terminated into a masonry bed joint, termination bars are recommended. It is beyond the scope of this *Technical Note* to describe the various types of composite flashing and their properties. The manufacturers' literature should be consulted for the various types of composite flashing available.

ACCESSORIES

Insulation

Many wall assemblies include continuous insulation in the drainage cavity to improve their thermal resistance. Although thermal resistance is the most important characteristic for insulation, other properties for consideration include water absorption, combustibility, density, insect resistance and ease of installation. Insulation will generally be installed concurrently with the other components in the drainage wall. Materials for this application should conform to the following requirements:

1. Must be durable and resist rot due to moisture or dryness. Must be intended for use in the "wet zone" of the wall assembly with no degradation or loss of insulating value.
2. Must meet the building code requirements for flame propagation within the assembly.
3. Must not serve as a food source to vermin or biological growth.
4. Must permit the air space to perform its function by allowing moisture to drain without wicking to the interior.

Typical insulation types used in brick masonry walls include extruded polystyrene (XPS), polyisocyanurate, mineral wool and spray polyurethane foam (SPF). Each of these types, if properly used, will result in a more thermally efficient wall system but require individual detailing. SPF will be adhered to the backing. Mineral wool batts will be held in place with mechanical fasteners. Rigid boards can be adhered to or mechanically fastened to the backing. Special clips can be added to veneer anchors to secure the insulation. Refer to the *Technical Note* 4 Series as well as *Technical Note* 47 for further information regarding insulation and energy performance of brick wall assemblies.

Drainage Materials and Mortar-Collection Devices

When a high probability of mortar falling into the air space exists, such as for tall brick veneer without shelf angles, drainage materials and mortar diverters may be useful to help prevent mortar from bridging the air space or from blocking weeps. It is beyond the scope of this *Technical Note* to characterize the widely varying types of materials used for these purposes. However, a few basic principles should apply for any material selected for this purpose: Fill the entire width of the air space, do not absorb water and do not transmit moisture to the backing. These materials are available in two basic configurations: full height of air space and low height immediately above flashing. Manufacturers' literature should be used to compare and determine the suitability of drainage materials and mortar-collection devices. If not full height, a two-level mortar-collection device is preferred to a single-level mortar-collection device, as it better maintains a path for moisture to reach the flashing. The use of drainage materials should not preclude good workmanship and an effort to keep the air space clean of excess mortar droppings.

Weeps

Open head joint weeps are the preferred type of weep. Other weep types include wicks and tubes. While not preferred, if used, wicks should be at least 16 in. (406 mm) long and extend through the brick wythe through the air space and along the back of the brick wythe. Weep tubes are not recommended due to an increased risk of clogging. Weeps are permitted by most building codes to have a minimum diameter of $\frac{3}{16}$ in. (4.8 mm). Rope wicks should be at least 16 in. (406 mm) long and consist of cotton sash cord or other materials that wick. Items used to form weeps should not easily deteriorate or stain the brickwork. Open head joint weeps may have noncorrosive plastic, mesh or metal screens or vents installed if desired. Such weeps can serve a dual function of allowing water to drain while also allowing air to enter the cavity, resulting in more drying action and helping to keep insects out.

Termination Bars

A termination bar is a flat metal or plastic bar, approximately 1 in. (25 mm) wide with predrilled holes used to clamp and mechanically fasten flexible flashing to backing. Sealant is applied along the top edge of the termination bar to protect and encapsulate the leading edge of the flashing. The top edge of the termination bar is sometimes canted for easier sealant installation. Some manufacturers of self-adhered flashing permit termination with a compatible sealant bead encapsulating the leading edge; however, mechanical attachment is recommended for redundancy.

Sealants

Sealants are an important element in preventing water penetration around openings in masonry walls. Too frequently, sealants are relied on as a means of correcting or hiding poor workmanship rather than as an integral part of construction.

A discussion of the characteristics of joint sealants is beyond the scope of this *Technical Note*, but a few comments are in order. Sealants should be selected for their durability, extensibility, compressibility and compatibility with other materials. Other important considerations in sealant selection may include curing time, UV resistance, color stability, resistance to staining and the ability to handle a broad range of joint sizes. A sealant should be able to maintain these qualities under the temperature extremes of the climate in which the building is located. Trial applications and field adhesion testing of sealants under consideration are always helpful in determining suitability for a particular application. Additional discussion of sealants may be found in *Technical Notes* 18 and 18A.

Oil-based caulks and acetoxic silicone sealants that attack cement in mortar should not be applied to masonry. Solvent-based acrylic sealant or butyl caulk should be used only where little or no movement is expected. For joints subject to large movements, such as veneer expansion joints, an elastomeric joint sealant conforming to the requirements of ASTM C920, *Standard Specification for Elastomeric Joint Sealants* [Ref. 2], should be used. This includes neutral-cure silicones, urethanes and polysulfides. Application of a sealant primer may be required to prevent staining of some sealants on certain brick. Multiple sealants may be required in the wall system due to the variety of components and substrates present.

Backer rods are recommended behind sealants in joints large enough to accommodate them. Backer rods should be closed cell or bicellular plastic foam in most cases. Backer rods should be capable of resisting permanent deformation before and during sealant application, which is usually accomplished by sizing the backer rod approximately 25 percent larger than the joint width. Combining, twisting or braiding of the backer rod to fill larger joints is strongly discouraged. They should also be nonabsorbent to liquid water and gas, and should not emit gas, which may cause bubbling of the sealant. A bond breaking tape may be used when there is not sufficient space for a backer rod. For further information on sealants, refer to ASTM C1193, *Guide for Use of Joint Sealants* [Ref. 2].

Coatings

The use of external coatings, such as paint or clear coatings, on brick masonry should be considered only after a detailed evaluation of the possible consequences. Although coatings are not required on properly designed, specified and constructed brick masonry, they may be used successfully to alter the appearance of a wall or to diminish the effects of certain deficiencies.

Coatings intended to reduce water penetration (water repellents) are most effective when their intended use corresponds with the nature of the water penetration problem. Use of coatings for reasons outside their intended application rarely reduces water penetration and often leads to more serious problems. Considerations in the choice of coating include compatibility with brick masonry, water and air permeability, ability to span cracks, applicability to exterior exposure, potential lifespan, and aesthetic considerations. Consult *Technical Notes* 6 and 6A when considering a coating for brick masonry.

SUMMARY

This *Technical Note* is the second in a series on water resistance of brick masonry and covers the proper selection of quality materials for water-resistant masonry work. This *Technical Note* cannot cover all available materials or all conditions. Lack of specific reference to a material should not preclude its use, providing that it results in water-resistive brick masonry.

> *The information and suggestions contained in this* Technical Note *are based on the available data and the combined experience of engineering staff and members of the Brick Industry Association. The information contained herein must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. Final decisions on the use of the information contained in this* Technical Note *are not within the purview of the Brick Industry Association and must rest with the project architect, engineer and owner.*

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A240/A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
A480/A480M	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
A580/A580M	Standard Specification for Stainless Steel Wire
A666	Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
A899	Standard Specification for Steel Wire, Epoxy-Coated

Volume 1.04

A884/A884M	Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement

Volume 1.06

A123/A123M	Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A641/A641M	Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
A653/A653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc- Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

Volume 2.01

B370	Standard Specification for Copper Sheet and Strip for Building Construction
B882	Specification for Pre-Patinated Copper for Architectural Applications

Volume 4.04

D226	Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing

Volume 4.05

C62	Standard Specification for Building Brick (Solid Masonry Units Made From Clay or Shale
C126	Standard Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
C216	Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)
C270	Standard Specification for Mortar for Unit Masonry
C476	Standard Specification for Grout for Masonry
C652	Standard Specification for Hollow Brick (Hollow Masonry Units Made From Clay or Shale)
C1405	Standard Specification for Glazed Brick (Single Fired, Brick Units) Volume 4.07 - C920, Standard Specification for Elastomeric Joint Sealants C1193, Standard Guide for Use of Joint Sealants

Volume 4.06

E96	Standard Test Methods for Water Vapor Transmission of Materials

Volume 4.07

C920	Standard Specification for Elastomeric Joint Sealants
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