# Fire Resistance of Brick Masonry

**Abstract:** This *Technical Note* presents information about the fire resistance of brick masonry assemblies in loadbearing and veneer applications. Fire resistance ratings of several brick masonry wall assemblies tested using ASTM E119 procedures are listed. For untested wall assemblies, procedures are presented for calculating a fire resistance rating.

**Key Words:** balanced design, building codes, equivalent thickness, fire, fire resistance period, fire resistance rating, fire test.

## SUMMARY OF RECOMMENDATIONS:

### Fire Resistance Requirements
- Use the building code to determine the fire resistance rating required for separations, corridors, exterior walls and other building features
- Use fire control systems, compartmentalization of space or other "balanced design" approaches to lower required fire resistance ratings
- Determine whether fire resistance is needed for one side or two sides of fire exposure

### Assembly with Tested Fire Resistance Rating
- Use wall construction prescribed by the building code or testing agency to achieve fire resistance rating
- For wall construction not prescribed by the building code, include reference for test results in design documents

### Assembly with Calculated Fire Resistance Rating
- Determine minimum equivalent thickness required of brick unit from tables in the building code or ACI 216.1/ TMS 0216 [Ref. 5]
- Specify brick standard, brick size and void area to meet the minimum equivalent thickness requirements
- For multi-wythe masonry walls, determine contributions from other wall components such as concrete, concrete masonry, air spaces and plaster

### Construction Details
- Where assemblies with a fire resistance rating are supported by other assemblies, specify that the support assembly have an equal or greater fire resistance rating
- Seal penetrations through assemblies with a fire resistance rating with appropriate sealants or details to maintain fire resistance rating

## INTRODUCTION

Building codes and other local ordinances require critical building components to have a certain level of fire resistance to protect occupants and to allow a means of escape. Several factors contribute to the level of fire resistance required of a wall, floor or roof assembly, including whether combustible (wood) or noncombustible (steel, concrete and masonry) construction is used. Other factors include the building's use, floor area and height, the location of the assembly, and whether a fire suppression system such as stand pipes or sprinklers is installed.

## Definitions

**Fire Resistance.** The property of a building element, component or assembly that prevents or retards the passage of excessive heat, hot gases or flames under conditions of use.

**Fire Resistance Period.** A duration of time determined by a fire test or method based on a fire test that a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function or both.

**Fire Resistance Rating.** A duration of time not exceeding 4 hours (as established by the building code) that a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function or both. A legal term defined in building codes for various types of construction and occupancies. A fire resistance rating is based on a fire resistance period and usually given in half-hour or hourly increments. As an example, a wall with a fire resistance period of 2 hours and 25 minutes may only attain a fire resistance rating of 2 hours. It is also referred to as a fire rating, fire resistance classification or hourly rating.

## Determining a Fire Resistance Rating

Traditionally, a fire resistance rating has been established by testing. The most common test method used is ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials* [Ref. 3]. In this test, a sample of the wall must perform successfully during exposure to a controlled fire for the specified period of time, followed by the impact of a stream of water from a hose.

This standard test, along with other ASTM fire test standards, is used to measure and describe the response of materials, products or assemblies to heat and flame under controlled conditions, but does not by itself replicate actual fire conditions in a building. Rather, the intent of the test is to provide comparative performance to specific fire-test conditions during the period of exposure. Further, the test is valid only for the specific assembly tested.

Fire testing is expensive because each specific assembly must be tested by constructing a large specimen, placing multiple monitoring devices on that specimen and subjecting the specimen to both a fire and a hose stream. As a result, a calculated fire resistance method developed jointly by The Masonry Society and the American Concrete Institute and based on past ASTM E119 tests has largely replaced further fire resistance testing for masonry and concrete materials [Ref. 5].

## FIRE RESISTANCE TESTING

### ASTM E119 Test Method

The test methods described in ASTM E119 are applicable to assemblies of masonry units and to composite assemblies of structural materials for buildings, including bearing and other walls and partitions, columns, girders, beams, slabs and composite slab and beam assemblies for floors and roofs.

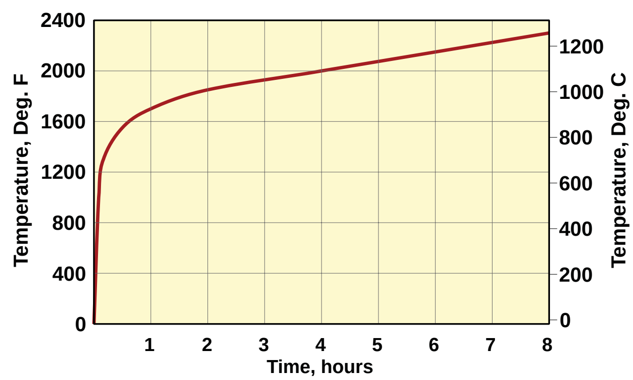


**Figure 1**
**Time-Temperature Curve for ASTM Standard E119**

When fire testing a wall assembly according to ASTM E119, a sample of the wall is built using the materials and details of the assembly to be used in construction. The specimen is then subjected to a controlled fire until a failure occurs (termination point is reached) or a designated extent of time passes. ASTM E119 requires that the air temperature at a distance of 6 in. (152 mm) from the exposed (fire) side of the specimen conform to the standard time-temperature curve, as shown in Figure 1.

**Wall Specimens.** The area exposed to the fire must be at least 100 sq ft (9.3 m$^2$) with no dimension less than 9 ft (2.7 m). Non-bearing walls and partitions are restrained at all four sides, but bearing walls and partitions are not restrained at the vertical edges. Nine thermocouples are placed on the side of the wall unexposed to the fire to measure temperature rise.

**Protected Steel Column Specimens.** If the fire resistant material protecting the column is structural, the column specimen must be at least 9 ft (2.7 m) tall, and acceptance is based on its ability to carry an axial load for the duration of the fire test. If the fire resistant material is not structural, the minimum column height is 8 ft (2.4 m), and acceptance is based on temperature rise on the surface of the column. Temperature rise is measured by placing a minimum of three thermocouples on the column surface (behind the fire resistant material) at each of four levels.

**Hose Stream Test.** For most fire resistance ratings ASTM E119 requires that walls be subjected to both a fire endurance test and a hose stream test. The hose stream test subjects a specimen to impact, erosion and cooling effects over the entire surface area that has been exposed to the fire. The procedure stipulates nozzle size, distance, duration of application and water pressure at the base of the nozzle. Some of these requirements vary with the fire resistance rating. The hose stream test may be performed on a duplicate wall specimen that has been subjected to a fire endurance test for one-half of the period determined by the fire test (but not more than 1 hour); or the hose stream test may be performed on the wall specimen immediately after the full duration of fire exposure. The latter option is typically used to test brick walls because the test termination point is almost always a temperature rise rather than a failure by passage of hot gases or collapse where there is a degradation of the brick wythe from the hose stream test. Some other materials rely on the duplicate specimen to meet certain fire ratings.

**Loading.** Throughout the fire endurance and hose stream tests, a superimposed load is applied to bearing specimens. The applied load is required to be the maximum load condition allowed by nationally recognized structural design criteria or by limited design criteria for a reduced load.

Columns are loaded to simulate the maximum load condition allowed by nationally recognized structural design criteria or by limited design criteria for a reduced load. The column is then subjected to the standard fire on all sides. Where the fire protection is not designed to carry loads, an alternate test method in which the column is not loaded may be used.

## Conditions of Acceptance

The number of criteria considered as termination points for a fire test on an assembly depends on whether the assembly is loadbearing or not.

**Non-Bearing Walls and Partitions.** The test is successful and a fire resistance rating is assigned to the construction if all of the following criteria are met:

1. The assembly withstands the fire endurance test without passage of flame or gases hot enough to ignite cotton waste for a period equal to that for which classification is desired.
2. The assembly withstands the fire endurance test without passage of flame and the hose stream test without passage of water from the hose stream. If an opening develops in the wall specimen that permits a projection of water beyond the surface of the unexposed side during the hose stream test, the assembly is considered to have failed the test.
3. The average rise in temperature of nine thermocouples on the unexposed surface is not more than 250 ºF (139 ºC) above their average initial temperature, and the temperature rise of a single thermocouple is not more than 325 ºF (181 ºC) above its initial temperature.

**Bearing Walls.** The conditions of acceptance for bearing walls are the same as for non-bearing walls and partitions (above), with the following addition:

4. The specimen must also sustain the applied load during the fire endurance and hose stream tests.

The first three criteria relate to providing a barrier against the spread of fire by penetration of the assembly; the fourth relates to structural integrity. The termination point for fire tests of brick masonry walls is almost invariably due to temperature rise (heat transmission) of the unexposed surface. Brick masonry walls successfully withstand the load during the fire endurance test and the hose stream test conducted immediately after the wall has been subjected to the fire exposure. This structural integrity of brick masonry walls is attested to in many fires where the masonry walls have remained standing when other parts of the building have been destroyed or consumed during the fire.

**Columns.** Columns with integral structural fireproofing are assigned a fire resistance rating when they support the superimposed load during the fire endurance test. For columns with fireproofing not designed to carry loads, a fire resistance rating is assigned when the average temperature rise does not exceed 1000 ºF (556 ºC) or the maximum temperature rise does not exceed 1200 ºF (667 ºC) at any one point.

# FIRE RESISTANCE RATINGS OF WALLS

There are several sources of fire resistance ratings for brick masonry assemblies that will typically satisfy the requirements of the local building official. Model building codes contain results based on testing. Private laboratories report fire test results. Individual associations and companies sponsor fire tests and make the results available.

# Building Codes

Table 1 presents fire resistance ratings for various masonry wall assemblies, as taken from the 2006 International Building Code Table 720.1(2) [Ref. 1]. Note that for item numbers 1.1-1 through 1.1-3, 1-2.1, and 2-1.1 through 2-1.2, the required thickness of clay brick masonry is the equivalent thickness, i.e. the thickness is the volume of clay in a unit divided by the face area. Table 2 presents fire resistance ratings for brick veneer/steel stud wall assemblies as taken from Table 721.4.1(2) of the same code.

**TABLE 1**

**Fire Resistance Ratings (Periods) for Various Walls and Partitions**

| Material | Item Number | Construction | Minimum Finished Thickness, Face-to-Face, in. (mm) | | | |
|---|---|---|---|---|---|---|
| | | | 4 hr | 3 hr | 2 hr | 1 hr |
| 1. Brick of clay or shale[2] | 1-1.1 | Solid brick of clay or shale[1] | 6.0 (152) | 4.9 (124) | 3.8 (97) | 2.7 (69) |
| | 1-1.2 | Hollow brick, not filled | 5.0 (127) | 4.3 (109) | 3.4 (86) | 2.3 (58) |
| | 1-1.3 | Hollow brick unit wall, grouted solid or filled with perlite vermiculite or expanded shale aggregate | 6.6 (168) | 5.5 (140) | 4.4 (112) | 3.0 (76) |
| | 1-2.1 | 4 in. (102 mm) nominal thick units at least 75 percent solid backed with hat-shaped metal furring channel ¾ in. (76 mm) thick formed from 0.021 in. (0.53 mm) sheet metal attached to the brick wall at 24 in. (610 mm) o.c. with approved fasteners, and ½ in. (12.7 mm) Type X gypsum wallboard attached to the metal furring strips with 1 in. (25.4 mm) long Type S screws spaced at 8 in. (203 mm) o.c. | — | — | 5[3] (127) | — |
| 2. Combination of clay brick and loadbearing hollow clay tile[2] | 2-1.1 | 4 in. (102 mm) solid brick and 4 in. (102 mm) tile (at least 40 percent solid) | — | 8 (203) | — | — |
| | 2-1.2 | 4 in. (102 mm) solid brick and 8 in. (203 mm) tile (at least 40 percent solid) | 12 (305) | — | — | — |
| 15. Exterior or interior walls[4,5,6] | 15-1.5[7] | 2¼ × 3¾ in. (57 × 95 mm) clay face brick with cored holes over ½ in. (12.7 mm) gypsum sheathing on exterior surface of 2 × 4 in. (51 × 102 mm) wood studs at 16 in. (406 mm) o.c. and two layers ⅝ in. (15.9 mm) Type X gypsum wallboard on interior surface. Sheathing placed horizontally or vertically with vertical joints over studs nailed 6 in. (152 mm) on center with 1¾ in. (44 mm) by No. 11 gage by 7/16 in. (11.1 mm) head galvanized nails. Inner layer of wallboard placed horizontally or vertically and nailed 8 in. (203 mm) on center with 6d cooler or wallboard nails. Outer layer of wallboard placed horizontally or vertically and nailed 8 in. (203 mm) on center with 8d cooler or wallboard nails. All joints staggered with vertical joints over studs. Outer layer joints taped and finished with compound. Nail heads covered with joint compound. 0.035 in. (0.89 mm) (No. 20 galvanized sheet gage) corrugated galvanized steel wall ties ¾ × 6⅝ in. (19.1 × 168 mm) attached to each stud with two 8d cooler or wallboard nails every sixth course of bricks. | — | — | 10 (254) | — |

1. For units in which the net cross-sectional area of cored brick in any plane parallel to the surface containing the cores is at least 75 percent of the gross cross-sectional area measured in the same plane.
2. Thickness shown for brick and clay tile are nominal thicknesses unless plastered, in which case thicknesses are net. Thickness shown for clay masonry is equivalent thickness defined by Equation 3. Where all cells are solid grouted or filled with silicone-treated perlite loose-fill insulation; vermiculite loose-fill insulation; or expanded clay, shale or slate lightweight aggregate, the equivalent thickness shall be the thickness of the brick using specified dimensions. Equivalent thickness may also include the thickness of applied plaster and lath or gypsum wallboard, where specified.
3. Shall be used for non-bearing purposes only.
4. Staples with equivalent holding power and penetration shall be permitted to be used as alternate fasteners to nails for attachment to wood framing.
5. For all of the construction with gypsum wallboard described in this table, gypsum base for veneer plaster of the same size, thickness and core type shall be permitted to be substituted for gypsum wallboard, provided attachment is identical to that specified for the wallboard, and the joints on the face layer are reinforced and the entire surface is covered with a minimum of 1/16 in. (1.6 mm) gypsum veneer plaster.
6. For properties of cooler or wallboard nails, see ASTM C514, ASTM C547 or ASTM F1667.
7. The design stress of studs shall be reduced to 78 percent of allowable $F'_c$ with the maximum not greater than 78 percent of the calculated stress with studs having a slenderness ratio *l/d* of 33.

**TABLE 2**

**Fire Resistance Ratings for Brick Veneer/Steel Stud Assemblies**

| Wall or Partition Assembly | Plaster Side Exposed (hours) | Brick Faced Side Exposed (hours) |
|---|---|---|
| **Outside facing of steel studs:** ½ in. (12.7 mm) wood fiberboard sheathing next to studs, ¾ in. (19.1 mm) air space formed with ¾ × 1⅝ in. (19.1 × 41 mm) wood strips placed over the fiberboard and secured to the studs; metal or wire lath nailed to such strips, 3¾ in. (95 mm) brick veneer held in place by filling ¾ in. (19.1 mm) air space between the brick and lath with mortar. **Inside facing of studs:** ¾ in. (19.1 mm) unsanded gypsum plaster on metal or wire lath attached to 5⁄16 in. (7.9 mm) wood strips secured to edges of the studs. | 1.5 | 4 |
| **Outside facing of steel studs:** 1 in. (25.4 mm) insulation board sheathing attached to studs, 1 in. (25.4 mm) air space, and 3¾ in. (95 mm) brick veneer attached to steel frame with metal ties every fifth course. **Inside facing of studs:** ⅞ in. (22.2 mm) sanded gypsum plaster (1:2 mix) applied on metal or wire lath attached directly to the studs. | 1.5 | 4 |
| Same as above except use ⅞ in. (22.2 mm) vermiculite — gypsum plaster — or 1 in. (25.4 mm) sanded gypsum plaster (1:2 mix) applied to metal or wire. | 2 | 4 |
| **Outside facing of steel studs:** ½ in. (12.7 mm) gypsum sheathing board, attached to studs, and 3¾ in. (95 mm) brick veneer attached to steel frame with metal ties every fifth course. **Inside facing of studs:** ½ in. (12.7 mm) sanded gypsum plaster (1:2 mix) applied to ½ in. (12.7 mm) perforated gypsum lath securely attached to studs and having strips of metal lath 3 in. (76 mm) wide applied to all horizontal joints of gypsum lath. | 2 | 4 |

# UL Listings

Underwriters Laboratories is a resource recognized throughout the building industry that has thousands of published fire resistance rated designs and product certifications that appear in the *UL Fire Resistance Directory* [Ref. 7] and are typically accepted without modification by building officials. The UL certification is based on an assembly complying with the ASTM E119 test, as described previously. The directory lists several masonry wall assemblies with various potential alternates in materials as shown in Table 3.

**TABLE 3**

**UL Fire Resistance Ratings for Brick Masonry Walls**

| Design Number | Rating[1] | Assembly |
|---|---|---|
| | | **Brick Veneer/Wood Stud, Loadbearing** |
| U302 | 2 hr | • (2) layers ⅝ in. (15.9 mm) thick gypsum wallboard or nominal 3⁄32 in. (2.4 mm) thick gypsum veneer plaster on Classified veneer baseboard<br>• (1) layer ½ in. (12.7 mm) thick exterior gypsum sheathing<br>• 1 (25.4 mm) in. (51 × 102 mm) air space<br>• nominal 2 × 4 in. wood studs spaced at 16 in. (406 mm) o.c.<br>• nominal 4 in. (102 mm) clay facing brick laid in mortar with ¾ in. (19.1 mm) wide × 6⅝ in. 168 mm) long 20 MSG corrugated wall ties spaced at 16 in. (406 mm) o.c. each way |

1. Unless noted otherwise, fire resistance rating applies to both sides of assembly.

## TABLE 3 (continued)
**UL Fire Resistance Ratings for Brick Masonry Walls**

| Design Number | Rating[1] | Assembly |
|---|---|---|
| **Brick Veneer/Wood Stud, Loadbearing (continued)** | | |
| U356 | 1 hr | • (1) layer ⅝ in. (15.9 mm) thick gypsum board<br>• nominal 2 × 4 in. (51 × 102 mm) wood studs spaced at 16 in. (406 mm) o.c., with 3½ in. (89 mm) thick glass fiber batt or spray applied cellulose insulation<br>• 7/16 in. (11.1 mm) min. thick wood structural panels or min. ½ in. (12.7 mm) thick mineral and fiber boards<br>• 1 in. (25.4 mm) air space<br>• nominal 4 in. (102 mm) brick veneer with corrugated metal wall ties spaced not more than each sixth course of brick and max. 32 in. (813 mm) o.c. horizontally |
| U371 | 1 hr | • (2) layer ⅝ in. (15.9 mm) thick gypsum board<br>• nominal 2 × 4 in. (51 × 102 mm) wood studs spaced at 16 in. (406 mm) o.c. with min. 3 in. (76 mm) mineral wool batt insulation<br>• (1) layer ⅝ in. (15.9 mm) thick gypsum board<br>• 1 in. (25.4 mm) air space<br>• nominal 4 in. (102 mm) brick veneer with corrugated metal wall ties attached with screws and spaced not more than each fourth course and a max. 24 in. (610 mm) o.c. horizontally |
| **Brick Veneer/Steel Stud, Loadbearing** | | |
| U418 | 45 min<br>1 hr<br>2 hr | • (45 min): (1) layer ⅝ in. (15.9 mm) thick gypsum wallboard<br>(1 hr): (2) layers ½ in. (12.7 mm) thick gypsum wallboard<br>(2 hr): (3) layers ½ in. (12.7 mm) thick gypsum wallboard<br>• 3½ or 5½ in., (89 or 140 mm) 18 gage, steel studs, spaced at 24 in. (610 mm) o.c., with 3½ in. (89 mm) thick glass fiber batt insulation<br>• (1) layer ½ in. (12.7 mm) thick exterior gypsum sheathing<br>• 1 in. (25.4 mm) air space<br>• 4 in. (102 mm) nominal clay facing brick laid in mortar with metal ties at 24 in. (610 mm) o.c. horizontally and 16 in. (406 mm) o.c. vertically |
| U424 | 45 min<br>1 hr<br>1½ hr<br>2 hr | • (45 min): (1) layer ⅝ in. (15.9 mm) thick gypsum wallboard<br>(1 hr): (2) layers ½ in. (12.7 mm) thick gypsum wallboard<br>(1½ hr): (2) layers ⅝ in. (15.9 mm) thick gypsum wallboard<br>(2 hr): (3) layers ½ in. (12.7 mm) or (2) layers ¾ in. (19.1 mm) thick gypsum wallboard<br>• 3½ in. (89 mm), 20 gage steel studs, spaced up to 24 in. (610 mm) o.c., with 3½ in. (89 mm) thick glass fiber or mineral wool batt or blanket insulation<br>• (1) layer ½ or ⅝ in. (12.7 or 15.9 mm) thick exterior gypsum sheathing<br>• Air space thickness not specified<br>• 3¾ in. (95 mm) min. brick veneer with corrugated metal wall ties attached to each stud with steel screws, not more than each sixth course of brick |
| U425 | 45 min<br>1 hr<br>1½ hr<br>2 hr | • (45 min): (1) layer ⅝ in. (15.9 mm) thick gypsum wallboard<br>(1 hr): (2) layers ½ in. (12.7 mm) thick gypsum wallboard<br>(1½ hr): (2) layers ⅝ in. (15.9 mm) thick gypsum wallboard<br>(2 hr): (3) layers ½ in. (12.7 mm) or (2) layers ¾ in. (19.1 mm) thick gypsum wallboard<br>• 3½ in. (89 mm), 20 gage steel studs, spaced up to 24 in. (610 mm) o.c., with 3½ in. (89 mm) thick glass fiber or mineral wool batt or blanket insulation<br>• (1) layer ½ or ⅝ in. (12.7 or 15.9 mm) thick exterior gypsum sheathing<br>• Air space thickness not specified<br>• 3¾ in. (95 mm) brick veneer with corrugated metal wall ties attached to each stud with steel screws, not more than each sixth course of brick |

1. Unless noted otherwise, fire resistance rating applies to both sides of assembly.

**TABLE 3 (continued)**
**UL Fire Resistance Ratings for Brick Masonry Walls**

| Design Number | Rating[1] | Assembly |
|---|---|---|
| **Brick Veneer/Steel Stud, Loadbearing (continued)** | | |
| V434 | 1 hr | • (1) layer ⅝ in. (15.9 mm) thick gypsum wallboard<br>• 3½ in. (89 mm), 20 gage, steel studs with max. spacing at 24 in. (610 mm) o.c., with 3½ in. (89 mm) thick glass fiber batt insulation<br>• 2 in. (51 mm) max. thick foamed plastic<br>• 1 in. (25.4 mm) min. air space<br>• 4 in. (102 mm) nominal brick veneer with wall anchor ties attached to studs at max. 24 in. (610 mm) o.c. |
| V454 | 1 hr | • (1) layer ⅝ in. (15.9 mm) thick gypsum wallboard<br>• 3½ in. (89 mm), 20 gage, steel studs at max. spacing of 24 in. (610 mm) o.c.<br>• (1) layer ⅝ in. (15.9 mm) thick gypsum wallboard<br>• 4 in. (102 mm) max. thick rigid polystyrene insulation<br>• 1 in. (25.4 mm) min. air space<br>• 4 in. (102 mm) nominal brick veneer with wall anchor ties attached to studs at max. 24 in. (610 mm) o.c. |
| V458 | 45 min | • (1) layer ⅝ in. (15.9 mm) thick gypsum wallboard bearing UL Classification Mark<br>• 3⅝ in. (92 mm) 18 gage steel studs at max. spacing of 24 in. (610 mm) o.c. with nominal 3.5 pcf mineral wool batt<br>• (1) layer ⅝ in. (15.9 mm) thick gypsum wallboard<br>• 1 in. (25.4 mm) min. air space<br>• 3¾ in. (95 mm) min. thick brick veneer with corrugated metal wall ties attached to each stud with steel screws, not more than each sixth course of brick |
| **Brick Veneer/Steel Stud, Non-Loadbearing** | | |
| V414 | 3 hr, interior<br><br>1 hr, exterior | • (1) layer ⅝ in. (15.9 mm) thick gypsum wallboard<br>• 3⅝ in. (92 mm) wide, 1⅝ in. (41 mm) legs, 20 gage steel studs, spaced 16 in. (406 mm) o.c., studs cut ¾ in. (19.1 mm) less than assembly height<br>• 2 in. (51 mm) thick foamed plastic (rigid insulation)<br>• 2 in. (51 mm) air space<br>• 4 in. (102 mm) nominal clay facing brick laid in mortar with metal ties at 16 in. (406 mm) o.c. max. each way |
| **Brick/Concrete Masonry, Loadbearing** | | |
| U902 | 4 hr | • 4 in. (102 mm) nominal loadbearing concrete masonry unit laid with full mortar beds and with 9 gage joint reinforcement at 16 in. (406 mm) o.c. vertically<br>• min. 1 in. (25.4 mm) air space with up to 4 in. (102 mm) foamed plastic (rigid insulation) as option<br>• ¾ in. (19.1 mm) wide, 7 in. (178 mm) long, 26 gage corrugated metal ties spaced at 8 in. (203 mm) o.c. horizontally and 16 in. (406 mm) o.c. vertically or truss or ladder type joint reinforcement of 9 gage wire for full width of wall assembly, cross wires at 16 in. (406 mm) o.c., spaced at 16 in. (406 mm) o.c. vertically<br>• 4 in. (102 mm) nominal clay facing brick laid in mortar |

1. Unless noted otherwise, fire resistance rating applies to both sides of assembly.

# Other

In addition to assemblies listed above, there are several other assemblies previously tested with results published in past building codes or other publications. A selection of these appears in Table 4.

**TABLE 4**

**Fire Resistance Ratings for Other Brick Masonry Wall Assemblies[1]**

| Test | Rating[2] | Assembly |
|---|---|---|
| **Brick Veneer/Wood Stud** | | |
| 1 | 1 hr | • (1) layer ½ in. (12.7 mm) thick gypsum wallboard<br>• 2 × 4 in. (51 × 102 mm) wood studs spaced at 16 in. (406 mm) o.c. with 3½ in. (89 mm) glass fiber batt insulation between studs<br>• (1) layer ½ in. (12.7 mm) thick wood fiberboard sheathing<br>• (1) layer No. 15 asphalt felt paper<br>• 1 in. (25.4 mm) air space<br>• 3½ in. (89 mm) actual width hollow clay brick with void area of 34.5% (equivalent thickness of 2.3 in. (58 mm)), laid in mortar with ⅞ in. (22.2 mm) wide, 22 gage corrugated wall ties spaced at 24 in. (610 mm) o.c. horizontally and 16 in. (406 mm) o.c. vertically |
| 2 | 1 hr | • (1) layer ½ in. (12.7 mm) thick gypsum wallboard<br>• 2 × 4 in. (51 × 102 mm) wood studs spaced at 16 in. (406 mm) o.c. with 3½ in. (89 mm) glass fiber batt insulation between studs<br>• (1) layer ½ in. (12.7 mm) thick wood fiberboard sheathing<br>• (1) layer No. 15 asphalt felt paper<br>• 1 in. (25.4 mm) air space<br>• 2⅞ in. (73 mm) actual width hollow clay brick with void area of 36% (equivalent thickness of 1.8 in. (46 mm)), laid in mortar with ⅞ in. (22.2 mm) wide, 22 gage corrugated wall ties spaced at 24 in. (610 mm) o.c. horizontally and 16 in. (406 mm) o.c. vertically |
| 3 | 1 hr | • (1) layer ½ in. (12.7 mm) thick gypsum wallboard<br>• 2 × 4 in. (51 × 102 mm) wood studs spaced at 16 in. (406 mm) o.c. with 3½ in. (89 mm) glass fiber batt insulation between studs<br>• (1) layer ½ in. (12.7 mm) thick wood fiberboard sheathing<br>• (1) layer No. 15 asphalt felt paper<br>• 1 in. (25.4 mm) air space<br>• 1¾ in. (44 mm) actual width[3] hollow clay brick with void area of 26.9% (equivalent thickness of 1.3 in. (32 mm)), laid in mortar with ⅞ in. (22.2 mm) wide, 22 gage corrugated wall ties spaced at 24 in. (610 mm) o.c. horizontally and 16 in. (406 mm) o.c. vertically |

1. As tested by the Southwest Research Institute [Ref. 4].
2. Fire resistance rating applies to brick (exterior) side only. Test stopped at 1 hour.
3. Width not in compliance with 2006 IBC veneer requirements; however, complies with 2006 IRC [Ref. 2] veneer requirements.

# CALCULATED FIRE RESISTANCE

## Theory and Derivation

The extent of fire resistance provided by a clay masonry wall is a function of the wall's mass or thickness. This well-established fact is based on the results of many fire resistance tests conducted on walls of solid and hollow clay units. During the ASTM E119 fire test, the fire resistance period of clay masonry walls is usually established by the temperature rise on the unexposed side of the wall specimen. Few masonry walls have failed due to loading or thermal shock of the hose stream.

The method for calculating a fire resistance period is described in NBS BMS 92, *Fire-Resistance Classifications of Building Construction* [Ref. 6]. The construction must be similar to others for which the fire resistance periods are known or of composite construction for which the fire resistance period of each component is known. The calculated fire resistance formulas are based on the temperature rise on the unexposed side of the wall.

Heat transmission theory states that when a wall made of a given material is exposed to a heat source that maintains a constant temperature at the surface of the exposed side and the unexposed side is protected against heat loss, the unexposed side will attain a given temperature rise inversely proportional to the square of the wall's thickness.

In the standard fire test, the time required to attain a given temperature rise on the unexposed side will be different than when the temperature on the exposed side remains constant. This is because the fire in the standard fire test increases the temperature at the exposed surface of the wall as the test proceeds. Based on fire test data collected from many fire tests, the following formula has been derived to express the fire resistance period of a wall based on its thickness:

$$R = (cV)^n \quad \text{Eq. 1}$$

where:
R = fire resistance period, hr
c = coefficient depending on the material, design of the wall, and the units of measurement of R and V
V = volume of solid material per unit area of wall surface, and
n = exponent depending on the rate of increase of temperature at the exposed face of the wall

For walls of a given material and design, an increase of 50 percent in volume of solid material per unit area of wall surface results in a 100 percent increase in the fire resistance period. This relationship results in a value of 1.7 for n. The lower value for n compared with 2 for the theoretical condition should be anticipated since a rising temperature at the exposed surface will shorten the fire resistance period of a wall.

For a wall composed of layers of multiple materials, the fire resistance period may be expressed as follows:

$$R = (c_1V_1 + c_2V_2 + c_3V_3)^n$$
$$= (R_1^{1/n} + R_2^{1/n} + R_3^{1/n})^n$$

Substituting 1.7 for n and 0.59 for 1/n, the general formula for calculating a fire resistance period becomes:

$$R = (R_1^{0.59} + R_2^{0.59} + R_3^{0.59} \ldots + R_i^{0.59})^{1.7} \quad \text{Eq. 2}$$

where:
$R_1, R_2, R_3, \ldots R_i$ = known fire resistance period of each component layer, hr

Where available, the fire resistance period (the full duration of the fire test before a termination point is reached) should be used. Where this period is not available (many brick wall tests are stopped after the desired rating time period elapses), the fire resistance rating (typically truncated to be the highest full hour of fire test duration) can be used. However, using the fire resistance rating for a component layer will generally result in a lower calculated fire resistance period for the overall assembly than using the fire resistance period for each component layer.

The calculated fire resistance, calculated using either the fire resistance period or fire resistance rating of each layer, can then be used to verify that the wall assembly equals or exceeds the fire resistance rating required by the building code. The theory proposed and derived in NBS BMS 92 has been incorporated into *Code Requirements for Determining Fire Resistance of Concrete and Masonry Assemblies* (ACI 216.1/TMS-0216) [Ref. 5].

# Calculations

The 2006 International Building Code (IBC) [Ref. 1] permits the fire resistance of masonry assemblies to be calculated in accordance with TMS-0216. In addition, the IBC also includes methods for calculating the fire resistance of a masonry assembly that are based on and very similar to those in TMS-0216. The methods discussed below are taken from TMS-0216 unless noted otherwise.

**Equivalent Thickness of a Single Wythe.** The average thickness of the solid material (i.e., minus cores or cells) in a masonry unit as placed in the wall is the equivalent thickness of the masonry unit. This is determined by measuring the total volume of the masonry unit, subtracting the volume of the core or cell spaces and dividing by the area of the exposed face of the masonry unit, which is expressed as follows:

$$T_e = V_n / LH \quad \text{Eq. 3}$$

where:
$T_e$ = equivalent thickness of the masonry unit, in.
$V_n$ = net volume of the masonry unit, in.$^3$
L = specified length of the masonry unit, in.
H = specified height of the masonry unit, in.

Equation 3 can be simplified as follows:

$$T_e = [WLH \times (1 - P_v)] / LH$$
$$= (1 - P_v) \times W \quad \text{Eq. 4}$$
$$= P_s \times W \quad \text{Eq. 5}$$

where:
W = specified width of the masonry unit, in.
$P_v$ = percent void of the masonry unit
$P_s$ = percent solid of the masonry unit

For ungrouted and partially grouted construction, the equivalent thickness should be determined according to Equation 3. The equivalent thickness should be taken as the actual thickness of the masonry unit for solid grouted construction or brickwork constructed of hollow brick units complying with ASTM C652 and filled with one of the following:

- Sand, pea gravel, crushed stone or slag complying with ASTM C33
- Pumice, scoria, expanded shale, clay, slate, slag or fly ash; or cinders complying with ASTM C331
- Perlite complying with ASTM C549
- Vermiculite complying with ASTM C516

**Fire Resistance of a Single Wythe.** The minimum equivalent thickness required to achieve a given fire resistance rating with a clay masonry wythe is listed in Table 5. The table is organized by material type and hourly fire resistance ratings. For fire resistance periods that are between the hourly increments listed in the table, the minimum equivalent thickness may be determined by linear interpolation. Where combustible members such as wood floor joists are framed into the wall, the thickness of solid material between the end of each member and the opposite face of the wall, or between members set in from opposite sides is allowed to be no less than 93 percent of the thickness shown in Table 5.

**TABLE 5**

**Fire Resistance Ratings of Clay Masonry Walls**

| Material Type | Minimum Equivalent Thickness for Fire Resistance, in. (mm)[1,2,3] | | | |
|---|---|---|---|---|
| | 1 hr | 2 hr | 3 hr | 4 hr |
| Solid brick of clay or shale[4] | 2.7 (69) | 3.8 (97) | 4.9 (124) | 6.0 (152) |
| Hollow brick or tile of clay or shale, unfilled | 2.3 (58) | 3.4 (86) | 4.3 (109) | 5.0 (127) |
| Hollow brick or tile of clay or shale, grouted or filled with materials specified | 3.0 (76) | 4.4 (112) | 5.5 (140) | 6.6 (168) |

1. Equivalent thickness as determined from Equations 3, 4 or 5.
2. Calculated fire resistance between the hourly increments listed shall be determined by linear interpolation.
3. Where combustible members are framed into the wall, the thickness of solid material between the end of each member and the opposite face of the wall, or between members set in from opposite sides, shall not be less than 93% percent of the thickness shown.
4. Units in which the net cross-sectional area of cored or deep frogged brick in any plane parallel to the surface containing the cores or deep frogs is at least 75 percent of the gross cross-sectional area measured in the same plane.

**Multiple Wythe Walls.** For walls with multiple wythes of brick, concrete masonry or concrete, the calculated fire resistance formula is:

$$R = (R_1^{0.59} + R_2^{0.59} + \ldots R_n^{0.59} + A_1 + A_2 + \ldots A_n)^{1.7} \qquad \text{Eq. 6}$$

where:

R = calculated fire resistance period of the assembly, hr

$R_1, R_2 \ldots R_n$ = fire resistance periods of the individual wythes, hr

$A_1, A_2 \ldots A_n$ = 0.30; the air factor for each continuous air space having a distance of ½ to 3½ in. (12.7 to 89 mm) between wythes

The fire resistance period used in Equation 6 for each individual wythe or layer is determined from Table 5 for a wythe made of clay units, from Table 6 for a wythe made of concrete masonry units and from Table 7 and Figure 2 for a concrete layer.

**TABLE 6**

**Fire Resistance Periods of Concrete Masonry Walls**

| Aggregate Type | Minimum Equivalent Thickness for Fire Resistance Rating in. (mm)[1,2] | | | | | | |
|---|---|---|---|---|---|---|---|
| | ½ hr | ¾ hr | 1 hr | 1½ hr | 2 hr | 3 hr | 4 hr |
| Calcareous or siliceous gravel (other than limestone) | 2.0 (51) | 2.4 (61) | 2.8 (71) | 3.6 (91) | 4.2 (107) | 5.3 (135) | 6.2 (157) |
| Limestone, cinders, or air-cooled slag | 1.9 (48) | 2.3 (58) | 2.7 (69) | 3.4 (86) | 4.0 (102) | 5.0 (127) | 5.9 (150) |
| Expanded clay, expanded shale or expanded slate | 1.8 (46) | 2.2 (56) | 2.6 (66) | 3.3 (84) | 3.6 (91) | 4.4 (112) | 5.1 (130) |
| Expanded slag or pumice | 1.5 (38) | 1.9 (48) | 2.1 (53) | 2.7 (69) | 3.2 (81) | 4.0 (102) | 4.7 (119) |

1. Fire resistance periods between the hourly fire resistance rating listed shall be determined by linear interpolation based on the equivalent thickness value of the concrete masonry assembly.
2. Minimum required equivalent thickness corresponding to the fire resistance rating for units made with a combination of aggregates shall be determined by linear interpolation based on the percent by dry-rodded volume of each aggregate used in manufacturing the units.

### TABLE 7
### Fire Resistance Periods of Normal-Weight Concrete Panels

| Aggregate Type | Minimum Equivalent Thickness for Fire Resistance Rating, in. (mm) | | | | |
|---|---|---|---|---|---|
| | 1 hr | 1½ hr | 2 hr | 3 hr | 4 hr |
| Siliceous | 3.5 (89) | 4.3 (109) | 5.0 (127) | 6.2 (157) | 7.0 (178) |
| Carbonate | 3.2 (81) | 4.0 (102) | 4.6 (117) | 5.7 (145) | 6.6 (168) |
| Semi-lightweight | 2.7 (69) | 3.3 (84) | 3.8 (97) | 4.6 (117) | 5.4 137) |
| Lightweight | 2.5 (64) | 3.1 (79) | 3.6 (91) | 4.4 (112) | 5.1 (130) |

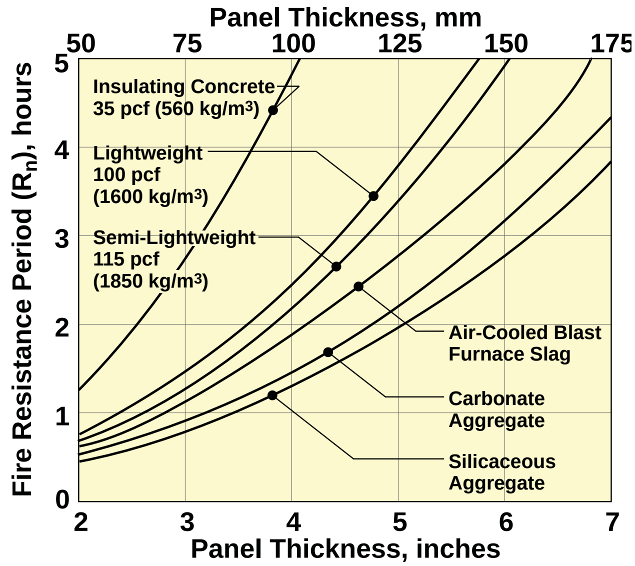


**Figure 2**
**Fire Resistance Periods for Other Concrete Panels**

**Finish Materials.** When drywall, stucco or plaster finishes are applied to a masonry wall, the fire resistance of the wall is increased. Where finish materials are used to attain a required fire resistance rating, the fire resistance provided by the masonry alone must be a minimum of half the required fire resistance rating to ensure the structural integrity of the wall.

For finishes applied to the non-fire exposed side of a wall, the finish is converted to an equivalent thickness of brickwork. This adjusted thickness is then calculated by multiplying the thickness of the finish by the applicable factor from Table 8 established by the durability of the finish and the wall material. The adjusted finish thickness is then added to the base equivalent thickness of the wall used in Table 5.

### TABLE 8
### Multiplying Factor for Finishes on Non-Fire Exposed Side of Masonry and Concrete Walls

| Type of Material Used in Slab or Wall | Type of Finish Applied to Slab or Wall | | | |
|---|---|---|---|---|
| | Portland Cement-Sand Plaster[1] or Terrazzo | Gypsum-Sand Plaster | Gypsum-Vermiculite or Perlite Plaster | Gypsum Wallboard |
| Clay masonry – solid brick of clay or shale | 1.00 | 1.25 | 1.75 | 3.00 |
| Clay masonry – hollow brick or tile of clay or shale | 0.75 | 1.00 | 1.50 | 2.25 |
| Concrete masonry – siliceous, calcareous, limestone, cinders, sir-cooled blast-furnace slag | 1.00 | 1.25 | 1.75 | 3.00 |
| Concrete masonry – made with 80% of more by volume of expanded shale, slate or clay, expanded slag, or pumice | 0.75 | 1.00 | 1.25 | 2.25 |
| Concrete – siliceous, carbonate, air-cooled blast-furnace slag | 1.00 | 1.25 | 1.75 | 3.00 |
| Concrete – semi-lightweight | 0.75 | 1.00 | 1.50 | 2.25 |
| Concrete – lightweight, insulating concrete | 0.75 | 1.00 | 1.25 | 2.25 |

1. For portland cement-sand plaster ⅝ in. (15.9 mm) or less in thickness and applied directly to clay masonry on the non-fire exposed side of the wall, the multiplying factor shall be 1.0.

For finishes on the fire exposed side of the wall, a time is assigned to the finish according to Table 9, which is the length of time the finish will contribute toward the fire resistance rating of the fire exposed side of the wall. This time is added to the fire resistance rating determined for the base wall and non-fire exposed finish.

**TABLE 9**
**Time Assigned to Finish Materials on Fire Exposed Side of Wall**

| Finish | Thickness | Time (minutes) |
|---|---|---|
| Gypsum wallboard | ⅜ in. (9.5 mm) | 10 |
| | ½ in. (12.7 mm) | 15 |
| | ⅝ in. (15.9 mm) | 20 |
| | Two layers of ⅜ in. (9.5 mm) | 25 |
| | One layer of ⅜ in. (9.5 mm) and one layer of ½ in. (12.7 mm) | 35 |
| | Two layers of ½ in. (12.7 mm) | 40 |
| Type X gypsum wallboard | ½ in. (12.7 mm) | 25 |
| | ⅝ in. (15.9 mm) | 40 |
| Direct-applied portland cement-sand plaster | See Note 1 | |
| Portland cement-sand plaster on metal lath | ¾ in. (19.1 mm) | 20 |
| | ⅞ in. (22.2 mm) | 25 |
| | 1 in. (25.4 mm) | 30 |
| Gypsum-sand plaster on ⅜ in. (9.5 mm) gypsum lath | ½ in. (12.7 mm) | 35 |
| | ⅝ in. (15.9 mm) | 40 |
| | ¾ in. (19.1 mm) | 50 |
| Gypsum-sand plaster on metal lath | ¾ in. (19.1 mm) | 50 |
| | ⅞ in. (22.2 mm) | 60 |
| | 1 in. (25.4 mm) | 80 |

1. For purposes of determining the contribution of portland cement-sand plaster to the equivalent thickness of concrete or masonry for use in Tables 5, 6 or 7, it shall be permitted to use the actual thickness of the plaster or ⅝ in. (15.9 mm), whichever is smaller.

# Examples

**Example 1, Cavity Wall with Air Space.** A multi-wythe cavity wall consists of a wythe of 4 in. (102 mm) nominal solid brick units complying with ASTM C216 and cored at 25 percent, a 2 in. (51 mm) air space and a wythe of 8 in. (203 mm) nominal concrete masonry unit made of calcareous gravel. The concrete masonry unit has actual dimensions of 7⅝ × 7⅝ × 15⅞ inches (194 × 194 × 397 mm) and is 53 percent solid. The fire resistance rating is determined by Equation 6 as follows:

a. From Equation 4, the equivalent thickness of the solid brick is:
$T_e$ = (1 – 0.25) × 3.625 in. (92 mm) = 2.71 in. (69 mm)

b. From Table 5, the fire resistance period for the clay unit is:
$R_1$ = 1.0 hr

c. For a 2 in. (51 mm) air space:
A = 0.30

d. From Equation 5, the equivalent thickness of the concrete masonry unit is:
$T_e$ = 0.53 × 7.625 in. (194 mm) = 4.0 in. (102 mm)

e. Interpolating from Table 7, the fire resistance period of the concrete masonry is:
$R_2$ = 1.5 hr + 0.5 hr [(4.0 – 3.6) / (4.2 – 3.6)] = 1.5 hr + 0.5 hr (0.67) = 1.8 hr

f. From Equation 6, the fire resistance rating of the entire wall assembly is:
$R = [(1.0)^{0.59} + (1.8)^{0.59} + 0.3]^{1.7} = 5.5$ hr → Fire Resistance Rating = 4 hr

**Example 2, Composite Wall.** A multi-wythe composite wall consists of 4 in. (102 mm) nominal hollow brick complying with ASTM C652 with a mortared collar joint and 4 in. (102 mm) siliceous aggregate concrete wall. The gross volume of the hollow brick includes 36 percent void. The fire resistance rating is determined as follows:

a. From Equation 4, the equivalent thickness of the hollow brick is:
$T_e$ = (1 – 0.36) × 3.625 in. (92 mm) = 2.3 in. (58 mm)

b. From Table 5, the fire resistance period for the hollow brick is:
$R_1$ = 1.0 hr

c. From Figure 2, the fire resistance period for the concrete wall with siliceous aggregate is:
$R_2$ = 1.3 hr

d. Using Equation 6, the fire resistance rating of the wall assembly is:
$R = [(1.0)^{0.59} + (1.3)^{0.59}]^{1.7}$ = 3.7 hr → Fire Resistance Rating = 3 hr

**Example 3, Composite Wall with Gypsum Wallboard.** Determine the fire resistance rating for the composite wall of Example 2 when ½ in. (12.7 mm) thick gypsum wallboard is applied to the interior side of the wall. The fire resistance rating will apply to only the exterior side of the wall.

a. Using Table 8, the multiplying factor for a siliceous concrete wall and gypsum wallboard is 3.00. The equivalent thickness of concrete for the gypsum wallboard on the unexposed side is:
$T_e$ (finish) = 3.00 × 0.5 (12.7 mm) in. = 1.5 in. (38 mm)

b. The equivalent thickness of concrete for the gypsum wallboard finish and concrete is:
$T_e$ (finish) + $T_e$ (concrete) = 1.5 in. (38 mm) + 4 in. (102 mm) = 5.5 in. (140 mm)

c. From Figure 2, the fire resistance period for a 5.5 in. (140 mm) thick concrete wall of siliceous aggregate is:
$R_2$ = 2.4 hr

d. Using Equation 6, the fire resistance rating of the wall assembly is:
$R = [(1.00)^{0.59} + (2.4)^{0.59}]^{1.7}$ = 5.3 hr → Fire Resistance Rating = 4 hr

**Example 4, Composite Wall with Gypsum Wallboard.** Determine the fire resistance rating for the composite wall of Example 3 when the fire resistance rating will apply to both sides of the wall. Since the fire resistance rating will be applied to both sides, a calculation for fire exposure on each side of the wall must be performed.

*Gypsum Board Side (Interior) Exposed to Fire*

a. Using Table 9, the contribution of the ½ in. (12.7 mm) thick gypsum wallboard to the fire resistance is:
$R_f$ = 15 min / 60 min/hr = 0.25 hr

b. Using the fire resistance period determined in Example 2, the fire resistance period for the interior side of the wall assembly is:
R (interior) = 3.7 hr + 0.25 hr = 3.9 hr

*Brick Side (Exterior) Exposed to Fire*

c. The fire resistance period determined in Example 3 for exposing the exterior side of the wall assembly to fire is:
R (exterior) = 5.3 hr

*Wall Assembly*

d. The fire resistance rating for the wall assembly is the lower of the fire resistance periods calculated from the interior and the exterior:
3.9 hr < 5.3 hr → Fire Resistance Rating = 3 hr

# DESIGN AND DETAILING

## Support of Brick Masonry Rated for Fire Resistance

Walls with a fire resistance rating should be supported by assemblies with a similar or better fire resistance rating. This prevents collapse of a rated assembly by an unrated support that burns through long before the required fire resistance period. Thus for a second-story wall with a 2-hour fire resistance rating, the floor-ceiling assembly providing support for the wall must also have a 2-hour fire resistance rating.

Where steel columns provide the support, clay masonry can be used as fireproofing of those columns. Table 10, taken from TMS 0216, gives the equivalent thickness required to provide various levels of column protection, based on the steel shape used for the column.

**TABLE 10**

**Fire Resistance of Clay-Masonry-Protected Steel Columns[1]**

| W Shapes | | | | | |
|---|---|---|---|---|---|
| Column Size | Clay Masonry Density, lb/ft$^3$ (kg/m$^3$) | Minimum equivalent thickness for fire-resistance rating of clay masonry protection assembly, in. (mm) | | | |
| | | 1 hour | 2 hours | 3 hours | 4 hours |
| W14 × 82 | 120 (1926) | 1.23 (31) | 2.42 (61) | 3.41 (87) | 4.29 (109) |
| | 130 (2087) | 1.40 (36) | 2.70 (69) | 3.78 (96) | 4.74 (120) |
| W14 × 68 | 120 (1926) | 1.34 (34) | 2.54 (65) | 3.54 (90) | 4.43 (113) |
| | 130 (2087) | 1.51 (38) | 2.82 (72) | 3.91 (99) | 4.87 (124) |
| W14 × 53 | 120 (1926) | 1.43 (36) | 2.65 (67) | 3.65 (93) | 4.54 (115) |
| | 130 (2087) | 1.61 (41) | 2.93 (74) | 4.02 (102) | 4.98 (126) |
| W14 × 43 | 120 (1926) | 1.54 (39) | 2.76 (70) | 3.77 (96) | 4.66 (118) |
| | 130 (2087) | 1.72 (44) | 3.04 (77) | 4.13 (105) | 5.09 (129) |
| W12 × 72 | 120 (1926) | 1.32 (34) | 2.52 (64) | 3.51 (89) | 4.40 (112) |
| | 130 (2087) | 1.50 (38) | 2.80 (71) | 3.88 (99) | 4.84 (123) |
| W12 × 58 | 120 (1926) | 1.40 (36) | 2.61 (66) | 3.61 (92) | 4.50 (114) |
| | 130 (2087) | 1.57 (40) | 2.89 (73) | 3.98 (101) | 4.94 (125) |
| W12 × 50 | 120 (1926) | 1.43 (36) | 2.65 (67) | 3.66 (93) | 4.55 (116) |
| | 130 (2087) | 1.61 (41) | 2.93 (74) | 4.02 (102) | 4.99 (127) |
| W12 × 40 | 120 (1926) | 1.54 (39) | 2.77 (70) | 3.78 (96) | 4.67 (119) |
| | 130 (2087) | 1.72 (44) | 3.05 (77) | 4.14 (105) | 5.10 (130) |
| W10 × 68 | 120 (1926) | 1.27 (32) | 2.46 (62) | 3.46 (88) | 4.35 (110) |
| | 130 (2087) | 1.44 (37) | 2.75 (70) | 3.83 (97) | 4.80 (122) |
| W10 × 54 | 120 (1926) | 1.40 (36) | 2.61 (66) | 3.62 (92) | 4.51 (115) |
| | 130 (2087) | 1.58 (40) | 2.89 (73) | 3.98 (101) | 4.95 (126) |
| W10 × 45 | 120 (1926) | 1.44 (37) | 2.66 (68) | 3.67 (93) | 4.57 (116) |
| | 130 (2087) | 1.62 (41) | 2.95 (75) | 4.04 (103) | 5.01 (127) |
| W10 × 33 | 120 (1926) | 1.59 (40) | 2.82 (72) | 3.84 (98) | 4.73 (120) |
| | 130 (2087) | 1.77 (45) | 3.10 (79) | 4.20 (107) | 5.13 (130) |
| W8 × 40 | 120 (1926) | 1.47 (37) | 2.70 (69) | 3.71 (94) | 4.61 (117) |
| | 130 (2087) | 1.65 (42) | 2.98 (76) | 4.08 (104) | 5.04 (128) |
| W8 × 31 | 120 (1926) | 1.59 (40) | 2.82 (72) | 3.84 (98) | 4.73 (120) |
| | 130 (2087) | 1.77 (45) | 3.10 (79) | 4.20 (107) | 5.17 (131) |
| W8 × 24 | 120 (1926) | 1.66 (42) | 2.90 (74) | 3.92 (100) | 4.82 (122) |
| | 130 (2087) | 1.84 (47) | 3.18 (81) | 4.82 (122) | 5.25 (133) |
| W8 × 18 | 120 (1926) | 1.75 (44) | 3.00 (76) | 4.01 (102) | 4.91 (125) |
| | 130 (2087) | 1.93 (49) | 3.27 (83) | 4.37 (111) | 5.34 (136) |

1. Tabulated values assume a 1 in. (25.4 mm) air gap between masonry and steel section.

## TABLE 10 (continued)

### Fire Resistance of Clay-Masonry-Protected Steel Columns[1]

| Square structural tubing | | | | | |
|---|---|---|---|---|---|
| Nominal tube size, in. (mm) | Clay masonry density, lb/ft³ (kg/m³) | Minimum equivalent thickness for fire-resistance rating of clay masonry protection assembly, in. (mm) | | | |
| | | 1 hour | 2 hours | 3 hours | 4 hours |
| 4 × 4 × ½ (102 × 102 × 12.7) | 120 (1926) | 1.44 (37) | 2.72 (69) | 3.76 (96) | 4.68 (119) |
| | 130 (2087) | 1.62 (41) | 3.00 (76) | 4.12 (105) | 5.11 (130) |
| 4 × 4 × ⅜ (102 × 102 × 9.5) | 120 (1926) | 1.56 (40) | 2.84 (72) | 3.88 (99) | 4.78 (121) |
| | 130 (2087) | 1.74 (44) | 3.12 (79) | 4.23 (107) | 5.21 (132) |
| 4 × 4 × ¼ (102 × 102 × 6.4) | 120 (1926) | 1.72 (44) | 2.99 (76) | 4.02 (102) | 4.92 (125) |
| | 130 (2087) | 1.89 (48) | 3.26 (83) | 4.37 (111) | 5.34 (136) |
| 6 × 6 × ½ (152 × 152 × 12.7) | 120 (1926) | 1.33 (34) | 2.58 (66) | 3.62 (92) | 4.52 (115) |
| | 130 (2087) | 1.50 (38) | 2.86 (73) | 3.98 (101) | 4.96 (126) |
| 6 × 6 × ⅜ (152 × 152 × 9.5) | 120 (1926) | 1.48 (38) | 2.74 (70) | 3.76 (96) | 4.67 (119) |
| | 130 (2087) | 1.65 (42) | 3.01 (76) | 4.13 (105) | 5.10 (130) |
| 6 × 6 × ¼ (152 × 152 × 6.4) | 120 (1926) | 1.66 (42) | 2.91 (74) | 3.94 (100) | 4.84 (123) |
| | 130 (2087) | 1.83 (46) | 3.19 (81) | 4.30 (109) | 5.27 (134) |
| 8 × 8 × ½ (203 × 203 × 12.7) | 120 (1926) | 1.27 (32) | 2.50 (64) | 3.52 (89) | 4.42 (112) |
| | 130 (2087) | 1.44 (37) | 2.78 (71) | 3.89 (99) | 4.86 (123) |
| 8 × 8 × ⅜ (203 × 203 × 9.5) | 120 (1926) | 1.43 (36) | 2.67 (68) | 3.69 (94) | 4.59 (117) |
| | 130 (2087) | 1.60 (41) | 2.95 (75) | 4.05 (103) | 5.02 (128) |
| 8 × 8 × ¼ (203 × 203 × 6.4) | 120 (1926) | 1.62 (41) | 2.87 (73) | 3.89 (99) | 4.78 (121) |
| | 130 (2087) | 1.79 (45) | 3.14 (80) | 4.24 (108) | 5.21 (132) |
| Steel pipe | | | | | |
| Column size, diameter × thickness, in. (mm) | Clay masonry density, lb/ft³ (kg/m³) | Minimum equivalent thickness for fire-resistance rating of clay masonry protection assembly, in. (mm) | | | |
| | | 1 hour | 2 hours | 3 hours | 4 hours |
| 4 × 0.674 (102 × 17.1) | 120 (1926) | 1.26 (32) | 2.55 (65) | 3.60 (91) | 4.52 (115) |
| | 130 (2087) | 1.42 (36) | 2.82 (72) | 3.96 (101) | 4.95 (126) |
| 4 × 0.337 (102 × 8.6) | 120 (1926) | 1.60 (41) | 2.89 (73) | 3.92 (100) | 4.83 (123) |
| | 130 (2087) | 1.77 (45) | 3.16 (80) | 4.28 (109) | 5.25 (133) |
| 4 × 0.237 (102 × 6.0) | 120 (1926) | 1.74 (44) | 3.02 (77) | 4.05 (103) | 4.95 (126) |
| | 130 (2087) | 1.92 (49) | 3.29 (84) | 4.40 (112) | 5.37 (136) |
| 5 × 0.750 (127 × 19.1) | 120 (1926) | 1.17 (30) | 2.44 (62) | 3.48 (88) | 4.40 (112) |
| | 130 (2087) | 1.33 (34) | 2.72 (69) | 3.84 (98) | 4.83 (123) |
| 5 × 0.375 (127 × 9.5) | 120 (1926) | 1.55 (39) | 2.82 (72) | 3.85 (98) | 4.76 (121) |
| | 130 (2087) | 1.72 (44) | 3.09 (78) | 4.21 (107) | 5.18 (132) |
| 5 × 0.258 (127 × 6.6) | 120 (1926) | 1.71 (43) | 2.97 (75) | 4.00 (102) | 4.90 (124) |
| | 130 (2087) | 1.88 (48) | 3.24 (82) | 4.35 (110) | 5.32 (135) |
| 6 × 0.864 (152 × 21.9) | 120 (1926) | 1.04 (26) | 2.28 (58) | 3.32 (84) | 4.23 (107) |
| | 130 (2087) | 1.19 (30) | 2.60 (66) | 3.68 (93) | 4.67 (119) |
| 6 × 0.432 (152 × 11.0) | 120 (1926) | 1.45 (37) | 2.71 (69) | 3.75 (95) | 4.67 (119) |
| | 130 (2087) | 1.62 (41) | 2.99 (76) | 4.10 (104) | 5.08 (129) |
| 6 × 0.280 (152 × 7.1) | 120 (1926) | 1.65 (42) | 2.91 (74) | 3.94 (100) | 4.84 (123) |
| | 130 (2087) | 1.82 (46) | 3.19 (81) | 4.30 (109) | 5.27 (134) |

1. Tabulated values assume a 1 in. (25.4 mm) air gap between masonry and steel section.

## Penetrations

All penetrations through an assembly with a fire resistance rating must conform to building code requirements for those penetrations. Codes typically require doors and windows to have a fire resistance rating, though depending on application, the fire resistance ratings of the doors and windows may be less than that of the surrounding wall construction. For mechanical ducts, fire dampers are typically required. For smaller penetrations, such as for drainage pipes and conduits, the space around the pipes is typically required to be filled with a fire resistant material and sealed to the surrounding masonry with a sealant rated for a specific fire resistance. In all cases, products used to seal penetrations should be carefully researched, selected and installed to ensure that the fire resistance rating of a wall is not compromised.

## Other Details

In fire resistant construction, the intent is to provide fire resistance that surrounds a three-dimensional, occupied space. Where a wall with a fire resistance rating meets an interior wall or floor/ceiling assembly, the integrity of the wall's fire resistance rating should be maintained. In closely spaced buildings, a brick veneer wall assembly with a 1-hour fire resistance rating on the exterior side is typically unaffected by the intersection of interior partition walls. However, in a brick veneer wall assembly with a 2-hour fire resistance rating, the interior wallboard is a required component and may have to be installed prior to framing the interior partitions. Each project and circumstance may require specific details to maintain the fire resistance rating of the masonry assemblies described above.

# SUMMARY

Brick masonry has traditionally been used to provide superior fire resistance and safety for occupants. The fire resistance rating required by the building code for a wall will depend on many factors including the type of construction, the use of building, and the location of the wall within the building. Brick wall assemblies of varying styles have been tested to provide designers with standard wall sections and details that comply with the various fire resistance ratings. Alternatively, for non-standard assemblies, calculation methods presented herein can provide the fire resistance rating of the proposed wall sections based on the results of previously tested assemblies.

> *The information and suggestions contained in this* Technical Note *are based on the available data and the experience of the 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 discussed in this* Technical Note *are not within the purview of the Brick Industry Association and must rest with the project architect, engineer and owner.*

# REFERENCES

1. 2006 *International Building Code*, International Code Council, Inc., Country Club Hills, IL, 2006.

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