OBJECTIVE: CONTAIN FIRE

New Test by USG Verifies Fire-Containment Capabilities of Thermafiber Insulating Materials to Keep Fire to Floor of Origin

A long-standing commitment to protecting people from building fires has led USG Corporation and its subsidiaries to develop many innovative fire protection and containment concepts over the years. One of these, developed about fifteen years ago, addressed the serious problem of preventing the vertical spread of fire from floor to floor in high-rise buildings.

This highly successful firecontainment concept was tested for a series of systems using THERMAFIBER Safing Insulation and THERMAFIBER Curtain Wall Insulation to contain a fire to its floor of origin. Placing these products in the perimeter space between the structural floors and a building’s curtain wall, and on various types of curtain wall framing and spandrel panels, contains fire in two ways. First, they “safe off” the opening between the structural floor and the curtain wall so that fire cannot pass through this opening. Second, they protect the curtain wall framing and spandrel panels so that fire cannot break through and leap to the floor above.

THERMAFIBER Insulations are effective in this fire-protection concept mainly because of their resistance to high temperatures. Testing under actual fire conditions at the USG Corporation Research facility has shown that THERMAFIBER Insulation resists burning and melting when exposed to temperatures above 2,000°F. By comparison, glass fiber insulations that are also sometimes used in curtain wall systems begin to disintegrate at above 1,050 °F. USG Interiors, Inc., markets several systems using these products for curtain wall applications involving aluminum, glass, glass-fiber-reinforced-concrete or granite spandrel panels with firecontainment ratings of up to four hours.

Recently, however, a widely publicized article has raised questions about whether this fire-containment concept is really effective. This article concludes that aluminum and other lightweight curtain-wall panel systems should only be used in sprinklered buildings because neither glass fiber nor rock wool insulations can provide fire containment. Furthermore the article concludes that glass fiber and rock wool insulations are more or less equally ineffective in fire-containment capabilities in these curtain walls.

The article suggests that fire containment cannot be expected in an aluminum curtain wall system, but rather that codes and existing fire-protection practices should be changed to allow the use of any type of thermal insulation, provided that the installation includes an automatic sprinkler system.

Full Scale Test . . .

In order to verify the firecontainment concept being questioned and at the same time to demonstrate the effectiveness of THERMAFIBER Fire-Safety Insulation Systems, USG Corporation conducted a full-scale test at its outdoor fire-test facility in Libertyville, Ill.
The goal of the program was to evaluate the fire-containment characteristics of two aluminum curtain wall systems—one insulated with rock wool and the other with glass fiber, when tested side-by-side under identical conditions at the same time. Furthermore, the program did this evaluation under exposure conditions and scale representative of curtain walls constructed in the field. The live fire test was witnessed by Armand Gustaferro of The Consulting Engineers Group, Inc., Glenview, Ill.

Recognizing that proper design is critical to performance, USG Corporation Research personnel thoroughly considered the factors that result in curtain wall failure in a fire and made sure that the tested fire-containment system accounted for them. For instance, since even fire-protected spandrel panels can fail if the framing supporting them is distorted or melted, the design must provide for protection of the curtain wall framing members as well.

The fire test demonstrated not only that the THERMAFIBER Fire-Protection System contained the fire to the room of origin for the duration of the test, but also that the glass fiber insulation used in a comparable assembly failed within 24 minutes. The test results were so conclusive that they refute the conclusions of the aforementioned article that questions this concept.

Fire containment is defined as the ability of a building system to prevent the passage of fire or excessive heat from one compartment to another, confining the fire to the room of origin.

“Recently, a widely publicized article has raised questions about whether this fire-containment concept (placing insulation in the perimeter space between the structural floors and a building’s curtain wall) is really effective . . . test results refute the conclusions of the article that questions this concept?

The fire-containment performance of building elements, such as floors, ceilings and interior partitions, are evaluated following the test procedures outlined in the ASTM E119 standard, in which an isolated test assembly is exposed to controlled temperatures following the time/temperature curve described in the standard. These procedures, however, apply when only one side of such test assembly is exposed to furnace temperatures of the time/temperature curve. In building fires, exterior walls may be exposed to flames simultaneously impinging on both surfaces (as might happen when vision glass is broken by a fire).

There are no universally recognized fire test standards for performance criteria to specifically evaluate the fire-containment characteristics of building systems or combinations of building elements when simultaneously exposed to fire from both sides. The scope of the USG Corporation test program involved the performance evaluation of such doubly exposed systems.

**Fire Test Description . . .**

The test facility is a two-story, steel-framed, permanent, outdoor structure approximately 16x32 ft. in size and 24 ft. high. For the purposes of this test, the facility was divided vertically so that it would have two totally isolated two-story units (see Fig. 1). Identical aluminum curtain wall assemblies with different insulation products were installed on the faces of the units.

Both units utilized a PPG Wall 70 Framing System, with aluminum spandrel panels and vision glass. On one unit craftsmen applied CW-90 THERMAFIBER Safing Insulation in the 4-in. wide space between the edge of the second-floor slab and the spandrel insulation. The safing insulation was friction-fitted into the opening and secured with Z-shaped clips mechanically attached to the structure. Fig. 2 shows a detail of this construction. The “Glass Fiber Unit” was constructed with the same components except that 2¼ lb./cu. ft. density glass fiber curtain wall insulation was substituted for the THERMAFIBER Curtain Wall Insulation used in the “THERMAFIBER Insulation Unit.” All installations were done by experienced craftsmen skilled in curtain wall construction.

The evaluation of performance during the test was done by the following means: visual observations of combustible targets located on the second floor were made to detect the passage of flame from the room of fire origin through the safing or curtain-wall insulation. Visual observations of the outside surface of the curtain wall were...
Fig. 1. Face of full-scale, permanent, fire-test facility at USG Corporation Research Center is set up for curtain wall fire test. Metal frame supports thermocouples for measuring flame plume temperature. Left side is “THERMAFIBER Curtain Wall Insulation Unit”; right side is “Glass Fiber Unit.”

Fig. 2. Isometric drawing shows typical aluminum curtain wall system construction at the juncture of the curtain wall and floor slab between the fire floor and second floor level. Same construction was used in both THERMAFIBER Insulation and Glass Fiber Insulation Units.
made to note the effects of flame-impingement on that surface (which could result in breaching the spandrel wall). Vi observations were made to note the spread of flame on the outside skin of the wall. Continuous monitoring of the temperature rise at vulnerable and critical areas of the wall were made by means of thermocouples. Thermocouples were also used to monitor temperatures in the second floor rooms above the rooms of fire origin.

Fuel for the fire test consisted of wood cribs in each fire compartment (lower floor of each unit). The fuel load for each room was 7.5 lbs./sq. ft. of Class A combustibles, which approximates the time/temperature conditions of ASTM E119 for a period of 45 minutes (Fig. 3).

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**Fire Test Results . . .**

To begin the test, the wood cribs were simultaneously ignited. They burned slowly until vented by the breaking of the vision glass panels. At 8 min. 50 sec., the first of the six vision glass panels on the fire rooms shattered. The vision glass on the lower floor of both units continued to break until 14 min. into the test when all the glass panels on the lower floor had shattered. A dramatic increase in flame intensity inside both fire rooms occurred with the breaking of the vision glass panels, and was followed by flames leaping out of the broken windows.

- At 15 min., partial melting of one of the aluminum window heads on the Glass Fiber Unit became visible.
- At 20 min., the aluminum spandrel panels began melting on the Glass Fiber unit.
- At 21 min., one of the window heads on the Glass Fiber Unit fell, causing the spandrel panel above it to be dislodged (see Fig. 4).
- At 24 min. into the test, the middle spandrel panel fell to the ground, revealing that the insulation had partially disintegrated above the second floor of the Glass Fiber Unit. No sign of panel deterioration had occurred in the THERMAFIBER Insulation Unit.
- At 25 min. 20 sec., a second aluminum spandrel panel in the Glass Fiber Unit became dislodged, exposing the insulation behind it.
- By 31 min., the third aluminum spandrel panel on the Glass Fiber Unit had partially melted and the bottom corner had fallen off (see Fig. 5).
- At 46 min., the test was terminated.

Close-up inspection of the curtain wall assemblies following the test indicated that when the first spandrel panel on the Glass Fiber Unit failed, the glass fiber insulation had already disintegrated and the wall had been breached at the floor/wall intersection and along the vertical joints of the glass fiber curtain wall insulation (Fig. 6). It appears that the spandrel panels failed at 15 min. because of disintegration of the glass fiber insulation, which then exposed the framing to the fire. A second failure was also noted. As a result of the disintegration of the glass fiber insulation, the safing detail was also compromised. This created openings be-
Fig. 4. View shows that middle spandrel panel has been dislodged on Glass Fiber Unit at 21 min. into test. Note that no damage (other than scorching) is visible on THERMAFIBER Insulation Unit.

Fig. 5. Obvious failure of glass fiber curtain wall insulation in Glass Fiber Unit is apparent in photo taken at 31 min. into the test. Middle spandrel panel has fallen to the ground, exposing glass fiber insulation above the second floor of the Glass Fiber Unit. This photo illustrates disadvantage of glass fiber insulations (which begin to disintegrate at 1,050 °F.) compared to high-melt-point of THERMAFIBER Insulations (over 2,000 °F.)

Fig. 6. Post-test inspection inside second floor shows extent of failure of glass fiber curtain wall insulation. Close-up view shows horizontal breach in insulation at second floor line in Glass Fiber Unit. Also note that a second failure occurred when the insulation disintegrated and separated at the vertical joints.

Fig. 7. Comparable view in THERMAFIBER Insulation Unit following test shows no sign of deterioration or separation of THERMAFIBER Insulation System. Note that insulation reveals no separation at either floor level or vertical joints.

tween the structural floor and the curtain wall and provided another path for the spread of fire. No visible deterioration or separation took place in the THERMAFIBER Curtain Wall or Safing Insulation on the THERMAFIBER Insulation Unit (Fig. 7).

A comparison of the results showed that all three aluminum spandrel panels on the Glass Fiber Unit melted while all of the spandrel panels on the THERMAFIBER Insulation Unit remained intact and stayed in place. All three of the window heads of the Glass
Fiber Unit melted while none of the THERMAFIBER Insulation Unit window heads showed any evidence of melting. Glass fiber insulation below the second floor disintegrated and fell away while the THERMAFIBER Insulation remained intact below and above the second floor level.

Analysis of the temperatures monitored by the thermocouples provided an insight into the performance of the two insulation systems. For instance, the temperature in the room above the fire in the THERMAFIBER Insulation Unit reached a maximum of only 150°F, while the maximum temperature in the Glass Fiber Unit climbed to 410°F. (Fig. 8). The average temperature inside the curtain wall cavity at the second floor level reached only 370°F in the THERMAFIBER Insulation Unit, compared to 1,340°F. at comparable locations in the Glass Fiber Unit (Fig. 9). A graph of temperatures inside the curtain wall insulation at the second floor level also shows a dramatic difference in performance (see Fig. 10).

Of particular interest are the graphs comparing the temperatures in the fire room, upper room, safing insulation and curtain wall insulation in the two units (Figs. 11 and 12). Note that the THERMAFIBER Curtain Wall and Safing Insulations performed as a system in attenuating the heat from the fire room in the THERMAFIBER Insulation Unit (Fig. 11). On the other hand, the glass fiber insulation performed independently in the Glass Fiber Unit with little effectiveness in attenuating the heat from the fire (Fig. 12).

**Conclusions Demonstrated . . .**

Contrary to the conclusions in the article that questions the effectiveness of THERMAFIBER Insulation, the data generated during the full-scale USG Corporation test demonstrated that: curtain wall systems, if properly designed and constructed, can effectively contain the spread of fire with or without the use of sprinklers. However, this containment cannot be realized using thermal insulations having low melt points, such as glass fiber. Specifically, this test program demonstrated that fire containment can be achieved using THERMAFIBER Curtain Wall Insulation for protection of spandrel panels and supporting structural members and THERMAFIBER Safing Insulation for perimeter fire-stopping.

The dramatic results are highlighted by the observations of Ar-
Fig. 9. Comparison of temperatures include curtain wall cavity at second floor level shows difference of 970°F. between maximum temperature in THERMAFIBER Insulation Unit and Glass Fiber Unit.

Fig. 10. Graph shows temperature comparison of thermocouples placed initially at mid-thickness of curtain wall insulation at second floor level of both units.

Fig. 11. Comparison of THERMAFIBER Insulation Unit temperatures in fire room, upper room, safinning insulation and curtain wall insulation shows how THERMAFIBER Curtain Wall Insulation and Safing Insulations performed as system in attenuating heat from fire room.

mand Gustaferro of The Consulting Engineers Group, Inc., Glenview, Ill., who witnessed the test.

“The burnout test results were very dramatic, both visually and from analysis of the data, and the test realistically simulated severe fires occurring adjacent to curtain walls,” said Gustaferro. “The test showed the effectiveness of the THERMAFIBER Curtain Wall and Safing Insulations in preventing the passage of flame from the lower compartment to the upper one.

“Watching the spandrel panels fail on the glass fiber side while those on the THERMAFIBER side remained intact was a clear indication that the glass fiber was not effective in preventing the passage of flame. Equally dramatic were the graphs of thermocouple data illustrating the significant difference in the temperature rise in the rooms above the fires, in the curtain wall cavities and in the insulation itself. For instance, the temperature in the room above the fire increased nearly 338°F. on the glass fiber side, as compared to only 78°F. on the THERMAFIBER side,” Gustaferro said.