



## Technical Features – Fire Construction There Is A Difference In Drywall

### UNIQUE FORMULATIONS GIVE U. S. GYPSUM DRYWALL EXCEPTIONAL FIRE PERFORMANCE

(Editor's Note: This article originally appeared in the 1991, Issue 2 of Form Function. Some pictures, graphics or charts may not appear in this version. To receive printed copies of this article, or information about the products mentioned in it, can be obtained by writing: Editor, FORM FUNCTION, 125 South Franklin Street, Chicago, IL 60606-4678.)

It is a commonly held contention that there are two basic kinds of drywall—regular and type 'X'—and that beyond this difference drywall products from various manufacturers are about the same. However, laboratory fire tests by United States Gypsum Company and tests by independent testing organizations provide strong evidence that there are significant fire-performance differences between SHEETROCK® brand Gypsum Panels and the drywall products from other manufacturers.

It is well-known in the construction industry that the single most unique characteristic of gypsum drywall is in its fire retardancy. This is provided by the principal raw material used in its manufacture,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$  (gypsum). As the chemical formula shows, gypsum contains chemically combined water (about 50% by volume). When gypsum drywall panels are exposed to fire, the heat converts a portion of the combined water to steam. The heat energy that converts the water to steam is thus used up, keeping the opposite side of the gypsum panel cool as long as there is water left in the gypsum, or until the panel is breached.

In the case of regular gypsum panels, as the water is driven off by heat, the reduction of volume within the gypsum causes cracks to form, eventually causing the gypsum panel to fail.

Type 'X' gypsum drywall, such as SHEETROCK® brand Gypsum Panels, FIRECODE Core, has glass fibers mixed with the gypsum to reinforce the core of the panels. These fibers have the effect of bridging and reducing the extent and size of the cracks that form as the water is driven off, thereby extending the length of time that the gypsum can resist heat without failure. This increased fire resistance of FIRECODE Core Panels was demonstrated in a special test (described further in this article), that measures a gypsum panel's integrity when it is exposed to fire. Under these test conditions, 5/8-in. thick regular-core panels failed in about 10 to 15 minutes while 5/8-in. thick FIRECODE Core Panels retained their integrity for 45 to 60 minutes.

While regular-core SHEETROCK® brand Gypsum Panels are considered the industry's consistently highest quality gypsum panels because of their extra smooth paper facing, firm, easy-to-cut cores and true dimensions, their cores' chemically combined water content is similar to the regular-core gypsum panels of other manufacturers. Consequently, regular-core panels from various manufacturers

perform similarly when exposed to fire. Furthermore, 5/8-in. type 'X' gypsum panels are considered to resist fire in about the same way. However, there are gypsum panels with special cores that resist fire to different degrees and may not be substituted for each other. U. S. Gypsum's special cores are described on page 12.

#### Some Drywall Cores Are Proprietary

Several years ago United States Gypsum developed a third-generation gypsum drywall product called SHEETROCK® brand Gypsum Panels, FIRECODE C Core, which provided even better performance in the heat of fire than panels classified type 'X.' As is true with type 'X' panels, the FIRECODE C Core has glass fibers, but the core also contains a shrinkage-compensating additive which expands in the presence of heat at about the same rate as the gypsum in the core shrinks from loss of water. Thus the core becomes highly stable in the presence of fire. In fact, a 5/8-in. FIRECODE C Core Panel retained its integrity for over two hours as compared to 45 to 60 min. for type 'X' and 10 to 15 min. for regular gypsum cores under the same fire conditions. Of course these FIRECODE C Core Panels also qualify for the type "X" rating.

Figs. 1, 2 and 3 show an actual test conducted at U. S. Gypsum's research facility in which regular-core SHEETROCK® brand Gypsum Panels, type 'X'-core SHEETROCK® brand Panels, FIRECODE Core, and SHEETROCK® brand Panels, FIRECODE C Core, were compared. All three samples of drywall were 5/8-in. thick and were exposed to gas-fired burners producing a temperature of 18500F. Each sample was 13x13 in. in size and had a 12-lb. 9-oz. weight on top to dramatize the point at which the sample failed.

In Fig. 1 the test has been in progress for 12 min. and the regular-core SHEETROCK® brand Gypsum Panel has just failed. The heat from the fire has caused enough loss of water to make the gypsum panel crack severely and lose its ability to support the applied load. In Fig. 2 the test has been in progress for 57 min. and the type 'X'-core SHEETROCK® brand Gypsum Panel, FIRECODE Core, has developed a large crack and is beginning to fail. The glass fibers in the type 'X' panel have given it the strength to last nearly five times as long as the regular panel under the applied load. In Fig. 3 the test has just been terminated at 2 hr. 2 min. with still no sign of failure of the type 'C'-core SHEETROCK® brand Gypsum Panel, FIRECODE C Core. The type 'C' panel has resisted failure for twice as long as the type 'X' panel and ten times as long as the regular panel.

This test proved that the stability of volume provided by the core additive and the strength provided by the glass fibers produce a gypsum panel product that is vastly superior to type 'X' fire-rated products. Until recently there were no products on the market comparable to U. S. Gypsum's type 'C' core panels.

Some manufacturers have recently developed similar improved type 'X' gypsum core panels. Some may appear to have products equal to the U. S. Gypsum 'C' core and may even call their product "type C," but have not achieved the same fire ratings in tests. A specifier shouldn't assume universal equivalence; that is, even improved type 'X' core panels can't be safely substituted in assemblies unless verified by test. If a fire test lists SHEETROCK® brand Gypsum Panels with FIRECODE C Cores, it means that only that product has been validated by test for that assembly, and any brand substitution may compromise the assembly's fire rating.

### Understanding The Fire-Protection Puzzle

It is important that the specifier and applicator understand fire test standards, levels of fire resistance in gypsum products and how to determine when a product can be substituted in a fire-rated assembly. A review of a manufacturer's product literature will likely reveal misunderstood references, such as "ASTM C-36," the "Gypsum Association" and the "UL Fire Design Directory." To understand how to evaluate the fire performance claims of the various gypsum panel manufacturers, one must understand how each of these organizations fits into the fire-rating puzzle.

ASTM is the American Society for Testing Materials, a consensus group of the entire building materials industry. ASTM sets standards for products and establishes methods for testing.

Underwriters Laboratories Inc. (UL) is an independent fire testing agency which conducts fire testing based on ASTM methods. UL also does follow-up inspections at manufacturing plants to assure quality conformance to the products tested. UL also publishes the 'Fire-Resistance Directory of Tested Assemblies,' which lists assemblies UL has tested. A list of UL designations for U. S. Gypsum's products is shown in Table 1 on page 11. U. S. Gypsum also lists other laboratories and agencies that have conducted or witnessed fire tests.

The Gypsum Assn. is an association of gypsum manufacturers. It defines performance of its members' products and publishes a list of fire and sound tested assemblies, entitled "Fire Resistance Design Manual." Some aspects of the way these organizations interact can be confusing. For instance, the ASTM and Gypsum Assn. fire resistance standards for gypsum board are not the same. A gypsum panel that just meets ASTM 1/2-in, type 'X' standards may not have sufficient performance features to qualify in rated assemblies listed for 1/2-in, type 'X' panels in the Gypsum Assn. "Fire Resistance Design Manual." The Gypsum Assn. requirement for type 'X' panels is more stringent than that of ASTM.

Neither the Gypsum Assn. "Fire Resistance Design Manual" nor the UL "Fire-Resistance Directory of Tested Assemblies" contain all tested assemblies. The UL Directory contains only UL-tested assemblies and not those tested by other laboratories. On the other hand, the Gypsum Assn. Manual doesn't list all fire-rated assemblies either. It lists only those assemblies that are generic and those proprietary assemblies that various manufacturers have chosen to list.

### Fire-Protection Standards

Some important ASTM standards to understand are ASTM E-119 and C-36. ASTM E-119 is a fire testing method in which an assembly must resist the fire exposure described for the desired classification time without passage of flame or gases hot enough to ignite cotton waste on the non-fire side. The method also entails a specific temperature rise during the test and a second partition specimen that must resist the effects of a hose stream after a fire test of one-half the time duration of the first test.

ASTM C-36 defines the standards for gypsum board (the product rather than a system containing gypsum board). The C-36 standard entails a variety of product standards that the product must be tested to meet, including composition of various types of gypsum board, flexural strength, humidified deflection, hardness, nail-pull

resistance and dimensions. Although the only fire-related characteristics regular core gypsum board must have in ASTM C-36 are a noncombustible core and a maximum flame spread classification of 25, type "X" board, referred to as "special fire-resistant," must meet specific fire-resistance standards.

To meet the ASTM C-36 standard for 1/2-in. type 'X' board, an assembly using the 1/2-in. type 'X' board on both sides of a load-bearing wood-stud wall must withstand an ASTM E-119 method fire test for 45 minutes. To meet the standard for 5/8-in. type "X" board, a similar assembly with 5/8-in. type "X" board must withstand a similar fire test for 1 hour.

The Gypsum Assn. defines 1/2-in. and 5/8-in. regular and 5/8-in. type "X" board the same way ASTM does. However, the Gypsum Assn. definition for 1/2-in. type "X" board is more restrictive because it adds the requirement that an assembly must achieve a 1-hr. fire rating when the board is applied to a basic floor-ceiling assembly. Floor-ceiling assemblies require an improved core, such as the U. S. Gypsum Type "C," because they are suspended in a horizontal plane. Furthermore, while ASTM uses the term "special fire-resistant" to define type "X," the Gypsum Association uses the term "improved core" to mean superior to type "X."

U. S. Gypsum's "improved core" is FIRECODE C Core. Other companies also have improved cores with various names. However, while all these improved core products meet the Gypsum Assn. definition for type "X," they all may not perform as well as the FIRECODE C Core. To find a full list of systems utilizing the FIRECODE C Core (as well as FIRECODE type "X" core), one must look in the USG Corporation Construction Selector, SA-1 00. This folder contains more than 300 tested assemblies, including fire and sound test results for plaster and drywall partitions and ceilings, fire and sound test results for acoustical ceilings, fire test results for exterior walls, beams and columns; and loading data for access floor systems.

#### Fire Tests Prove Performance

Over the years U. S. Gypsum has been the recognized leader in the development of high-performance drywall products and fire-rated systems. Again and again, its drywall assemblies were the first to be tested and often the only ones to achieve specific fire ratings from independent laboratories such as Underwriters Laboratories Inc. (UL), Ohio State University (OSU), University of California (U of C) and Warnock Hersey International (WHI). In addition, many U. S. Gypsum in-house laboratory tests have been witnessed by Consulting Engineers Group (CEG). As a result of all this testing, U. S. Gypsum has more fire-rated assemblies than any of the other gypsum manufacturers, including many associated performance tests that no gypsum manufacturer has. A few examples of U. S. Gypsum's fire-rated assemblies are shown in Figs. 4 to 9 on page 12.

Fig. 4 shows the basic USG Cavity Shaft Wall System, which achieves a 2-hr. fire rating with double-layer 1/2-in., drywall, when the drywall is SHEETROCK® brand Panels, FIRECODE C Core. The same assembly with type "X" drywall would need to use 5/8-in. board to achieve the same rating. This important proprietary assembly is listed by Underwriters Laboratories as UL Des. U438. Note that the 1-in, thick SHEETROCK® brand Gypsum Liner Panels and USG Steel C-H Studs used in this assembly are proprietary in their fire resistance

Fig. 5 is a 3-hr. fire-rated partition with 1 5/8-in. steel studs and triple-layer 1/2-in. SHEETROCK® brand Panels, FIRECODE C Core, on each side (UL Des. U435). This high-performance assembly also achieves a 59 STC sound rating when THERMAFIBER Sound Attenuation Fire Blankets (SAFB) are added to the metal stud cavity.

Figs. 6 & 7 compare two assemblies with the same fire endurance, but with two different thicknesses of drywall. In Fig. 6, 1/2-in. SHEETROCK® brand Panels, FIRECODE C Core, enable the assembly to achieve a 2-hr. rating because of the high-performance FIRECODE C Core (CEG 5-9-84). Fig. 7 is a similar construction, but because the gypsum panels are only type "X," they have to be 5/8-in. thick to achieve the same endurance (CEG 8-11-83).

Figs. 8 & 9 show a similar situation with floor-ceiling assemblies. Fig. 8 shows a generic assembly for a 2-hr. floor-ceiling, using 5/8-in. "special fire-resistant core" drywall (UL Des. G503). The same assembly suddenly achieves a 3-hr. fire rating when 5/8-in. SHEETROCK® brand Panels, FIRECODE C Core, are selected (Fig. 9, UL Des. G512). These examples show two advantages that the superior fire protection of FIRECODE C Core provides. When the same thickness of FIRECODE C Core panels are used instead of type "X" or "special fire-resistant core," you can frequently achieve a higher fire rating. When you take advantage of substituting 1/2-in. FIRECODE C Core panels for 5/8-in. type "X" panels, you may be able to achieve the same rating with a thinner, lighter-weight assembly that's easier to erect.

One mark of fire protection to look for is the UL Label on the back of SHEETROCK® brand Panels, FIRECODE and FIRECODE C Core. This label means that the product has been manufactured in strict conformance to the specifications used in the tested product and that UL has assured that conformance by conducting third party inspections at the manufacturing plant.

The extra protection afforded by FIRECODE C Panels is an important and valuable plus in designing fire-rated assemblies. When they are specified, you know you'll be on solid ground. And FIRECODE C Core Panels are made only by United States Gypsum Company, the acknowledged leader in fire-rated gypsum products and systems, and the company with the most comprehensive range of fire rated systems. For a copy of SA-100, Construction Selector, with more than 300 fire, sound and loading tests, and a copy of WB-1866, SHEETROCK® brand Gypsum Panel and Joint Treatment Products, which describes the variety of drywall products U. S. Gypsum offers, write to Editor, FORM & FUNCTION, 101 S. Wacker Dr., Chicago, IL 60606-4385.

#### Special-Purpose Drywall Products Have Tailored Cores

Besides the type 'X' core of SHEETROCK® brand Gypsum Panels, FIRECODE Core, and the type 'C' core of SHEETROCK® brand Gypsum Panels, FIRECODE C Core, other U. S. Gypsum gypsum drywall products also have special core formulations for specific performance needs. IMPERIAL Gypsum Base (gypsum base for veneer plaster assemblies) also has the same choice of regular core, FIRECODE Core and FIRECODE C Core that SHEETROCK brand Gypsum Panels have and can be substituted for SHEETROCK® brand Gypsum Panels in fire-rated assemblies.

SHEETROCK® brand Exterior Gypsum Ceiling Board has a special core which includes additives to provide greater sag resistance than other gypsum-panel products have. This product also has a beige, water-repellent face paper.

SHEETROCK® brand Gypsum Panels, Water-Resistant, which are specially designed for use in bathrooms, have a special asphalt-composition core. They also have distinctive green, moisture-resistant face paper and can be obtained with FIRECODE or FIRECODE C Cores that are also moisture-resistant.

SHEETROCK® brand Gypsum Sheathing, an exterior building sheathing, has a water-resistant core, encased in brown, moisture-resistant face paper that breathes. GYP-LAP Gypsum Sheathing is also an exterior building sheathing; it has a regular core, but has a brown, moisture-resistant face paper that breathes. Both of these sheathing products have an optional FIRECODE Core available.

Other U. S. Gypsum drywall products with special gypsum cores or face papers are as follows: SHEETROCK® brand Interior Gypsum Ceiling Board is a 1/2-in. board that has special core additives to increase sag-resistance in residential and light commercial ceiling applications; it can frequently be used in place of 5/8-in. panels. SHEETROCK® brand Gypsum Liner Panels are designed for use in elevator, stair and mechanical shafts in the USG Shaft Wall System and in fire walls in USG Area Separation Walls. These panels have a fire-resistant core and green-colored, moisture-resistant face paper; note that these 1-in. thick liner panels are proprietary in their fire resistance. SHEETROCK® brand Gypsum Coreboard, a 1-in. multi-purpose panel, has a regular core and gray paper on its face and back.