USG Structural Solutions

USG STRUCTURAL PANELS EVALUATION OF NONCOMBUSTIBILITY FOR CERTAIN STRUCTURAL MAGNESIUM OXIDE PANELS

INTRODUCTION

In recent years Magnesium Oxide (MgO) structural panels manufactured outside of the United States have become available for sale as structural subfloor and structural roof deck panels in the United States. Manufacturers of these products may claim that these panels are noncombustible. They are not.

For the past 120 years, USG has developed products that meet or exceed standard requirements and takes pride in being a leader in the building materials industry. The safety and wellbeing of USG's customers is important, and the public should be aware of the facts behind "noncombustibility" claims being made by the companies that manufacture and sell the following MgO structural panels:

- **NOCOM®**
- **Dragonboard®**
- **extremegreen® (currently known as EXACOR®)**
- **MEGABOARD®**

USG has procured these panels in the marketplace and provided them to an independent, third party laboratory. Industry-standard testing conclusively shows that they do not conform to the noncombustibility requirements of ASTM E136, Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C, as defined in the 2012, 2015 and 2018 IBC model codes.

NONCOMBUSTIBILITY IN THE IBC (2012, 2015 AND 2018) MODEL CODES

This white paper will clarify where noncombustible construction is required per the International Building Code (IBC), how to evaluate for noncombustibility, and the differences between noncombustibility, flame spread and fire-resistance.

From the International Code Council website:

"The International Code Council was established in 1994 with the goal of developing a single set of national model construction codes that came to be known as the International Codes, or I-Codes. The I-Codes are a family of 15 coordinated, modern building safety codes that help ensure the engineering of safe, sustainable, affordable, and resilient structures (ed: The IBC is an I-Code).

The I-Codes are the most widely accepted, comprehensive set of model codes used in the United States. All 50 states, the District of Columbia, and many other countries have adopted the I-Codes at the state or jurisdictional level."

Section 602.2 of the IBC defines Types I and II construction as follows:

> ***Section 602.2 Types I and II.*** *Types I and II construction are those types of construction in which the building elements listed in Table 601 are of noncombustible materials, except as permitted in Section 603 and elsewhere in this code.*

Table 601 includes "floor construction and associated secondary elements," as well as "roof construction and associated secondary members" under the heading "Building Element."

Table 601 - Fire-Resistance Rating Requirements for Building Elements (Hours)

Building Element	Type I		Type II		Type III		Type IV	Type V	
	A	B	A	B	A	B	HT	A	B
Primary structural frame (see Section 202)	3	2	1	0	1	0	HT	1	0
Bearing walls: Exterior	3	2	1	0	2	2	2	1	0
Interior	3	2	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions: Exterior	See Table 602								
Nonbearing walls and partitions: Interior	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1-1/2	1	1	0	1	0	HT	1	0

NONCOMBUSTIBILITY IN THE IBC (2012, 2015 AND 2018) MODEL CODES, CONT.

As defined in Chapter 2 of the IBC, "secondary members" are those structural members of the floor construction and roof construction not having direct connection to the columns. Therefore, structural subfloor and roof deck sheathing are considered "secondary members" which must be noncombustible in Types I and II construction.

The 2012, 2015 and 2018 IBC model codes define noncombustibility in Section 703.5.

> ***Section 703.5.1 Elementary Materials.*** *Materials required to be noncombustible shall be tested in accordance with ASTM E136.*

Section 703.5 further notes that the term "noncombustibility" does not apply to the flame spread characteristics of interior finish or trim materials. Other fire performance-related tests like the test for flame spread (ASTM E84) and the standard for performing fire tests on building construction systems (ASTM E119) should not be confused with the test standard for noncombustibility (ASTM E136).

ASTM E84, also known as the Steiner Tunnel Test, evaluates the surface burning of combustible materials and provides a Flame Spread Index (FSI) and Smoke Developed Index (SDI) for an individual material or composite of materials. The scope of the ASTM E84 test standard is limited to providing the characteristics of the material's surface flammability on a 24-ft long sample installed in the test apparatus tunnel.

ASTM E119 is the fire resistance test of an assembly that may be constructed with either noncombustible or combustible materials, depending on the materials allowed for that type of construction. The test specimens are most typically walls, floors and structural steel. The test evaluates the ability of a construction element to prevent passage of fire from the fire side of the assembly to the non-fire side, and to prevent excessive thermal transmission through the elements. The result of an ASTM E119 test is expressed in terms of a period, such as 1-hour, 2-hour, etc., for which the test assembly meets the performance criteria of the test. The results of an ASTM E119 test have no relation to the combustibility of the individual components of the test assembly.

HOW TO PROPERLY TEST ACCORDING TO ASTM E136

The test standard for noncombustibility is titled: *ASTM E136 Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*, published by ASTM International. The furnace consists of a ceramic core and an electric heating coil and the current is set to establish an internal temperature of 750°C (1382°F). The prepared sample is placed inside the furnace and the temperatures are continuously measured at the surface and in the center of the specimen using two independent thermocouples.

Once the sample temperature reaches 750°C (1382°F), any temperature rise above the set furnace temperature is attributed to the burning of material from the sample itself. The sample provides the fuel for the temperature rise. See **Figure 1** for the location of the thermocouple placement.

Section 8.7.2 notes that the test is continued until the temperatures at thermocouples T3 and T4 have reached maxima, or until it is evident that the specimen does not pass this test (as defined below). As per the standard, the test duration is not fixed at 30 minutes, the test must be run for a minimum of 30 minutes.

> ***Section 4.1*** *This test method uses a furnace to expose building materials to a temperature of 750°C (1382°F) until failure occurs or for at least 30 minutes.*

In fact, the test shall continue beyond 30 minutes until such time as 10 minutes elapse since the last time the temperature measured at the center thermocouple T3 rose by at least 1°C in any one minute.

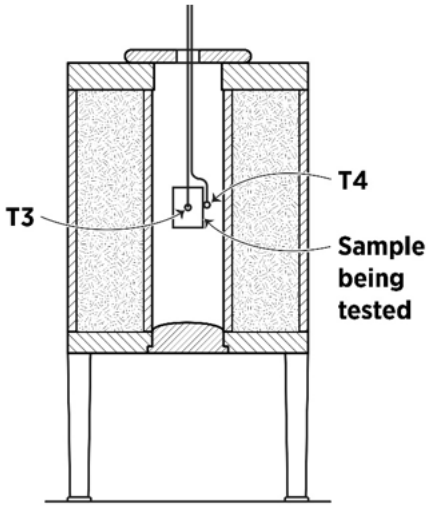

Figure 1 - Vertical Tube Furnace Locating T3 & T4 Sensors

> ***Section 8.7.3*** *After 30 minutes of testing have elapsed, or at any time subsequent to that, testing shall be discontinued if, over the previous 10 minutes, the temperature measured at the center thermocouple T3 has risen by no more than 1°C in any one minute. The final temperature reading shall be recorded as the maximum temperature.*

HOW TO PROPERLY TEST ACCORDING TO ASTM E136, CONT.

The procedure is repeated with four identical test specimens, and the material passes the test if at least three of the four test specimens tested meet both of the two individual test specimen criteria. The weight of the specimen is measured before and after the test, to determine the weight loss during the test. There are different pass criteria if more or less than 50% of the sample material is lost.

All samples tested lost less than 50% of their weight, therefore the test criteria for passing the standard per Section 15 is as follows:

Section 15.2.1 *The recorded temperature of the surface and interior thermocouples do not, at any time during the test, rise more than 30°C (54°F) above the stabilized furnace temperature.*

Section 15.2.2 *There is no flaming from the specimen after 30 seconds.*

RESULTS OF TESTING

Per Section X1.5.1.1 Commentary of ASTM E136, any building material exceeding 3% combustible portion in a noncombustible material is very likely to fail the noncombustibility test.

Based on a series of tests on a wide variety of materials, a 30-second flame duration and a 30°C (54°F) rise were proposed as two criteria that could help to distinguish between clearly combustible and clearly noncombustible materials. The results of these tests indicated that the proposed levels would limit the combustible portion of noncombustible materials to a maximum of 3%.

Based on this composition criteria, before they were even tested, it is very likely that none of the MgO structural panels tested and analyzed in this white paper would pass the ASTM E136 test for noncombustibility.

The following graph (Figure 2) reflects the constituent analysis of the Total Organic Carbon (TOC) content of the four (4) MgO structural panels tested.

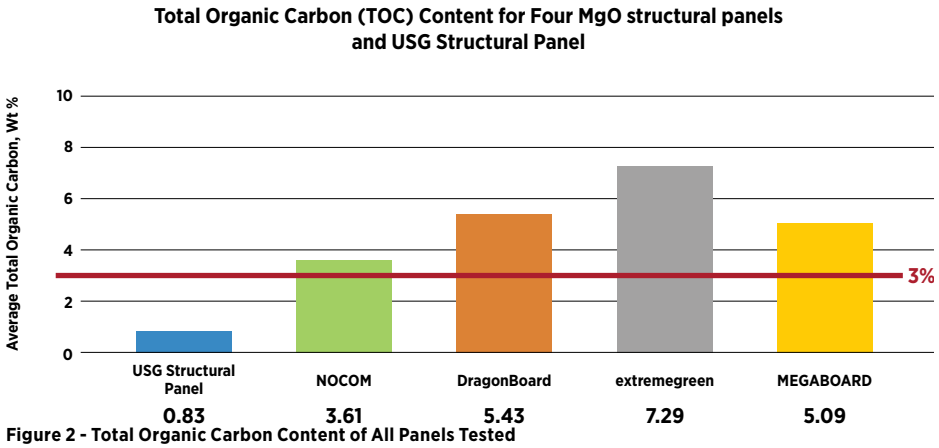

Figure 2 - Total Organic Carbon Content of All Panels Tested

ASTM E136 TESTING

USG obtained results of third-party testing of the four (4) MgO structural panels. The four (4) products were submitted and labeled A,B,C, and D. The laboratory did not know the brand or product names of the four (4) MgO structural panels submitted. The four (4) MgO structural panels were tested between May 4th and May 8th, 2020 and the final report with the test results was presented to USG on the 15th of the same month.

All four (4) samples for each of the MgO structural panels failed ASTM E136, in that every sample tested attained a maxima at a level substantially higher than the 780°C (1436°F) failure threshold of the standard. The results of the four (4) samples for each of the T3 & T4 sensors, for the four (4) panels tested are shown below in the individual product graphs.

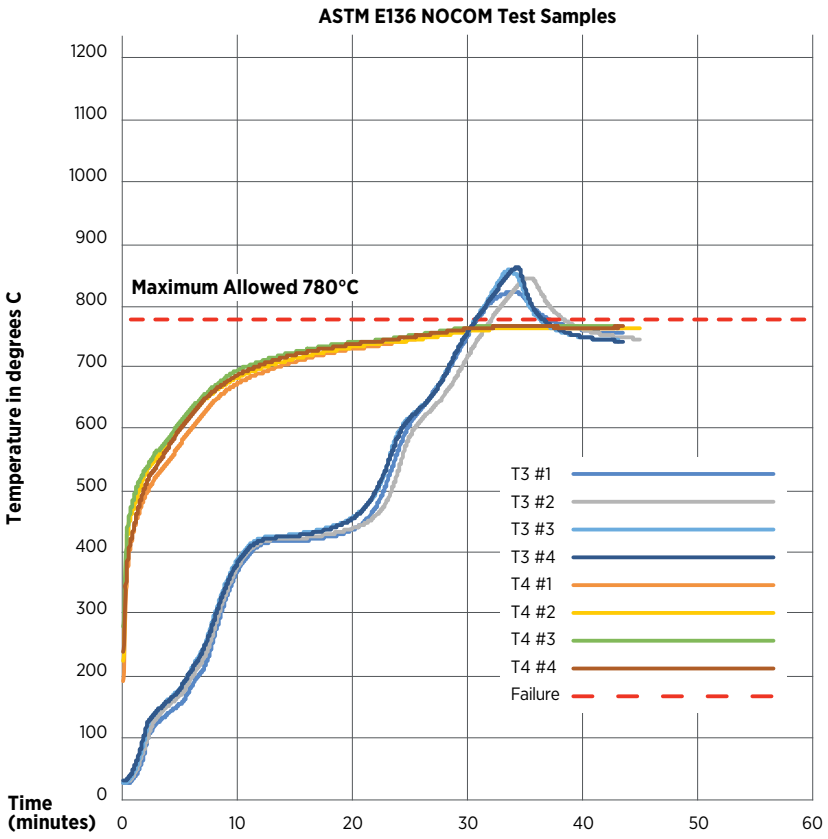

Figure 3 - NOCOM Time/Temperature Curves

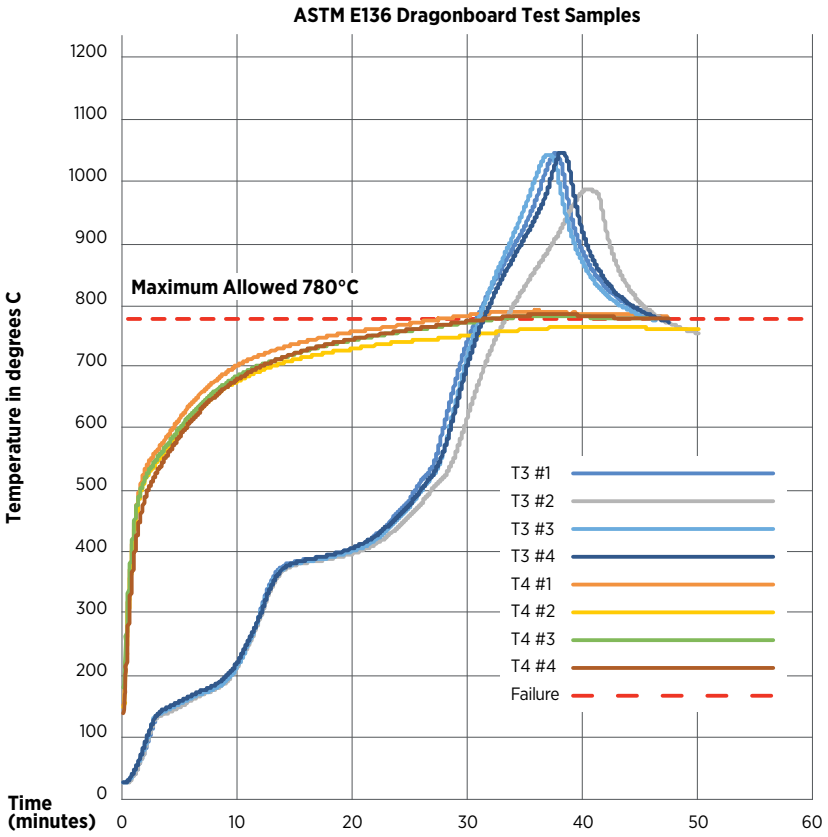

Figure 4 - Dragonboard Time/Temperature Curves

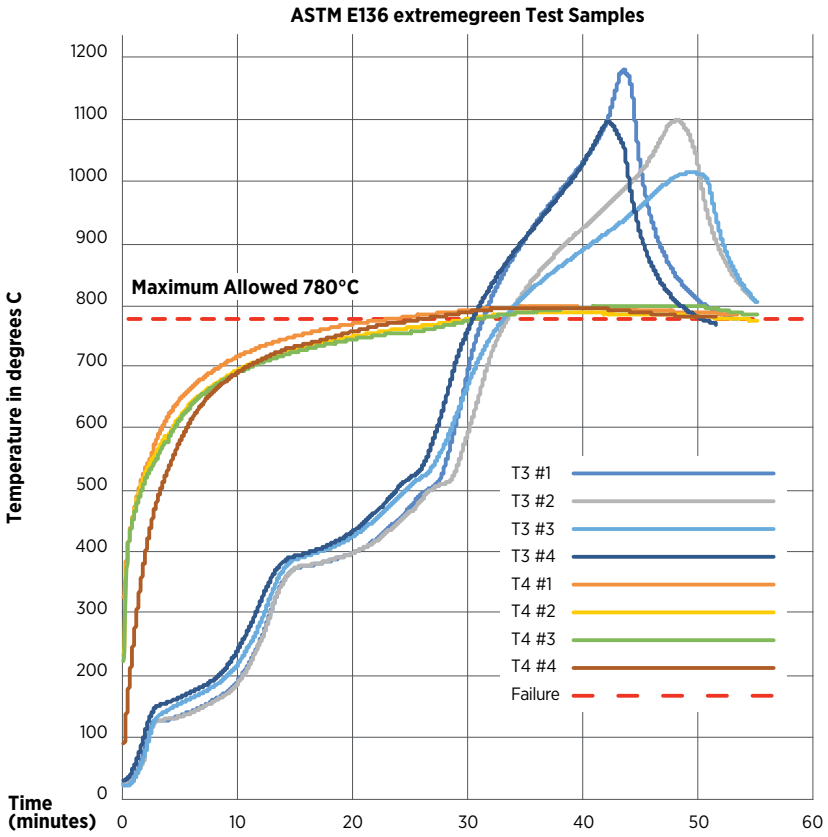

Figure 5 - extremegreen Time/Temperature Curves

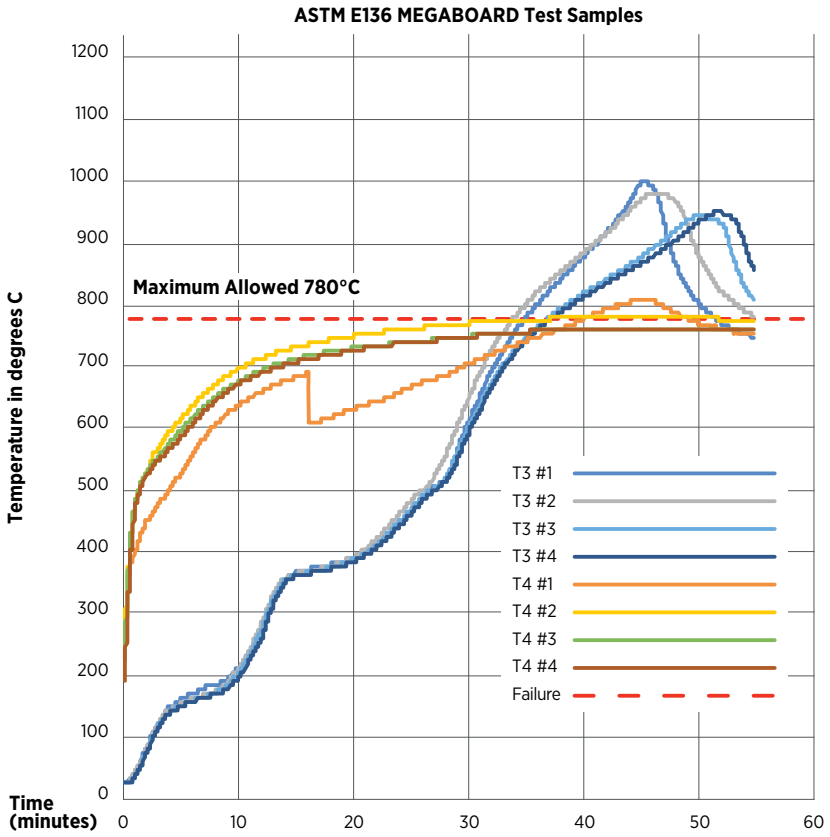

Figure 6 - MEGABOARD Time/Temperature Curves

Please note that the tests were performed for the minimum 30 minutes and continued until the interior thermocouples attained a maxima. The maxima for each MgO structural panel are summarized in **Figure 7**. Again, any temperature maximum over 780°C (1436°F) is a failure.

	NOCOM	DragonBoard	extremegreen	MEGABOARD
Average Maximum Temperature	840°C (1544°F)	1002°C (1836°F)	1042°C (1908°F)	971°C (1780°F)

Figure 7 – Average Maximum Temperatures Attained for Four (4) Samples of Each Tested

After testing, each sample was weighed, and the percentage of material lost is summarized in **Figure 8.**

Weight Loss	NOCOM	Dragonboard	extremegreen	MEGABOARD
Sample 1	31%	42%	41%	43%
Sample 2	31%	42%	42%	43%
Sample 3	33%	42%	42%	43%
Sample 4	32%	43%	42%	42%

Figure 8 – Percentage of Material Lost for Four (4) Samples of Each Tested

THE "SUPPORT" OFFERED FOR CLAIMS OF NONCOMBUSTIBILITY

Those associated with the manufacture and sale of NOCOM, Dragonboard, extremegreen and MEGABOARD may point to code reports and outdated test reports that they suggest support their claims of noncombustibility. However, those reports either relate to panels of different thicknesses or failed to provide adequate detail supporting their conclusions.

NOCOM
Product Code Report ICC ESR-4268 categorizes the NOCOM panel as falling under Section 09 28 15 of the MasterSpec Format titled "Fibered Gypsum Backing Boards," as opposed to Section 06 12 13 titled "Cementitious Structural Sheathing," which would apply to structural panels.

Under the heading "USES," this report explains that *"NOCOM is used on interior surfaces as defined in the IBC Section 2502, as substrate sheets suitable for decoration with paint, wallpaper, ceramic tile, natural stone or dimension stone on walls in interior dry areas and on walls and ceilings as permitted in IBC Section 2509.2…"* Chapter 25 of the IBC is entitled: "Gypsum Board, Gypsum Panel Products and Plaster." Thus, the report makes clear that NOCOM's intended "use" is not as a structural subfloor or roof deck panel.

The report notes under the "DESCRIPTION" heading that its conclusions are only intended to cover 1/2", 3/8" and 5/8" thick panels, not 3/4" or larger structural panels. Ameriform, the sales agent for NOCOM, notes on its website that: ***"Scope of this report does not include 3/4" thickness or floor applications at this time,"*** although a link to the report is located on Ameriform's **Tech Docs** page for subfloor structural panels.

Lastly, ICC ESR-4268 notes in Sections 5.5 and 5.8 that the *"use of NOCOM™ as floor sheathing or floor underlayment or in horizontal diaphragms is outside of the scope of this report."* Analysis of the floor diaphragm capacities would be a requirement relevant to the use of the panel as a subfloor.

Because the ESR-4268 report does not assess the noncombustibility of 3/4" structural panels, it does not support the conclusion that NOCOM 3/4" structural panels are noncombustible. As shown in Figure 3 of this white paper, testing of commercially available NOCOM 3/4" structural panels, conducted by an independent laboratory in 2020, indicates that they are **not** noncombustible.

Dragonboard
Dragonboard is a magnesium oxide panel manufactured in China. Unverified specimens of Dragonboard were tested 13 years ago in December of 2007 at Southwest Research (report number: 01.13544.01.313) in accordance with ASTM E136-04. The test report Southwest generated ("the report") specifically notes that *"(t)he results presented in this report apply specifically to the specimens tested, in the manner tested,* ***and not to the entire production of these or similar materials, …"*** The report further explains that "Dragonboard provided four pieces of the material, identified as Dragonboard Sheathing."

The report identifies no quality control or follow-up service procedure allowing for verification that the specimens tested were, in fact, commercially available Dragonboard. The testing facility does not refer to any witnessed production of the samples or any chain of custody from the manufacturing facility in China to the testing laboratory in the United States. The report simply indicates that "Dragonboard" presented some samples of a product. As shown in Figure 4 of this white paper, testing of commercially available 3/4" structural Dragonboard panels, conducted by an independent laboratory in 2020, indicates that they are **not** noncombustible.

Of related interest is the fact that, according to the report, one of the four tested samples ignited at 25:30 (after 25 minutes and 30 seconds exposure to the test furnace) and continued to burn until the end of the test. While the report indicates that the other three specimens purported to be Dragonboard passed the test, the outlier specimen's maximum temperature reached 958°C, well over the ASTM E136 780°C failure criteria.

extremegreen
ICC NTA Evaluation Report NER-1031 ("the report") evaluates the extremegreen magnesium oxide panel, which is produced in Nantong, China. Again, the report evaluates only 1/2" panels. In fact, **Section 7.1.1** of the report specifically notes that *"(t)his report applies only to the board thickness specifically listed herein."*

Although the report deems the 1/2" extremegreen panel to be a noncombustible building element, Section 8 ("EVIDENCE SUBMITTED") does not identify ASTM E136 as one of the standards against which the panel was tested. Without testing to the ASTM E136 standard, it is unclear as to how a determination of noncombustibility could have been reached (even with respect to a 1/2" panel).

THE "SUPPORT" OFFERED FOR CLAIMS OF NONCOMBUSTIBILITY, CONT.

Structural designers will note that Section 5.2 of the report (titled "Permanent Loads") reduces the panel capacities listed in Table 1 to 50% of their listed values when loads of long duration such as permanent loads are applied. No other panel has this restriction.

The report provides no information with respect to the noncombustibility of the 3/4" or thicker extremegreen structural panels, such as would be used as structural panels in Types I and II construction. Because the NER-1031 report does not assess the noncombustibility of 3/4" structural panels, it does not support the conclusion that extremegreen 3/4" structural panels are noncombustible. As shown in Figure 5 of this white paper, testing of commercially available extremegreen 3/4" structural panels, conducted by an independent laboratory in 2020, indicates that they are **not** noncombustible.

MEGABOARD

Report ESL-1151 ("the report") covers MEGABOARD which is manufactured in Jianzhou, Qingdao, Shangdong, China. MEGABOARD is categorized in the report under MasterFormat Section 09 00 00 FINISHES; specifically, 09 28 15 titled "Fibered Gypsum Backing Boards," as opposed to Section 06 12 13 titled "Cementitious Structural Sheathing" which would apply to structural panels.

The report specifically notes in the "Condition of Listing" (note #3) that "the listing report applies only to the materials tested and as submitted for review by ICC-ES." As was the case with the other test reports referenced above, the ESL-1151 report contains no reference to chain of custody with respect to the specimens submitted for review.

As shown in Figure 6 of this white paper, testing by an independent laboratory in 2020 indicates that MEGABOARD panels purchased in the marketplace were clearly **not** noncombustible per ASTM E136.

CONCLUSION

USG procured NOCOM, Dragonboard, extremegreen and MEGABOARD panels in the open marketplace and subjected them to ASTM E136 noncombustibility testing by an independent, third-party laboratory. See results summarized in **Figure 9**.

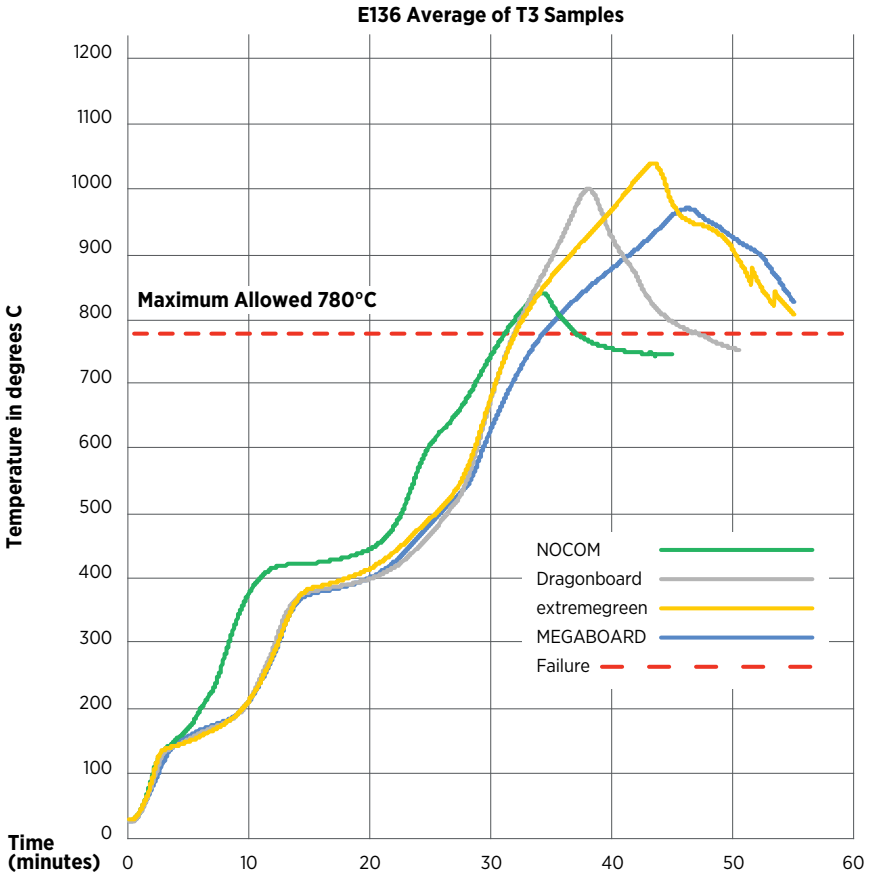

Figure 9 - ASTM E136 T3 Sensors Average Time/Temperature Curve

CONCLUSION, CONT.

The 2012, 2015 and 2018 IBC model codes indicate that MgO subfloor and roof deck "building elements" in Types I and II construction must be noncombustible in accordance with ASTM E136. USG's 3/4" Structural Panels consistently pass the ASTM E136 test.

The results of the testing conducted in 2020 by an independent, third-party laboratory have shown that NOCOM, Dragonboard, extremegreen and MEGABOARD 3/4" structural panels do not meet the requirements of ASTM E136 to qualify as noncombustible structural building elements. Designers, contractors, distributors and owners should be aware that any claims of noncombustibility made by manufacturers of these four (4) 3/4" MgO structural panels, as sold in the market today, (i.e., claims that these panels are capable of passing an unmodified ASTM E136 test) are simply not accurate.

REFERENCES

1. Per 2012, 2015 and 2018 *International Building Code®*
2. Per Jensen Hughes Letter dated November 16, 2018 commissioned by USG
3. Per ASTM E136 – 19 *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*
4. Per ASTM D4129 – 05 (2020) *Standard Test Method for Total and Organic Carbon in Water by High Temperature Oxidation and by Coulometric Detection*

PRODUCT INFORMATION
See usg.com/structural for the most up-to-date product information.

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