Fire Resistance (FR) Testing of Trimer Resin for Infrastructure & Construction Applications

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Abstract

The goal of this project was to evaluate the performance of HARP resin from Trimer Technologies in key fire resistance (FR) tests to demonstrate the suitability of this resin for a wide variety of applications in infrastructure and construction (I&C). Vacuum infusion was the process of choice for all testing, as this process is viewed as most suitable for the large composite structures involved in I&C. Trimer HARP resin-infused laminates easily achieved Class A values in the ASTM E84 testing. Meeting Class A 84 values is important for many applications subject to the International Building Code. Additionally, a HARP resin-infused, web-stiffened, cored wall panel was able to achieve a 60 minute ASTM E119 rating, a significant achievement for a relatively low-cost structural composite panel. The design of the wall structure, such as laminate/overall thicknesses, web spacing, core type, and intumescent coating, was important in achieving the 60 minute rating. These results indicate that Trimer HARP resin-infused panels have significant opportunities in I&C applications.

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Introduction

Trimer Technologies' HARP resin is a new material that has not been used in any infrastructure and construction applications to date. The resin has a low infusion viscosity of 200cP at room temperature, allows rapid wet out, and can be cured in minutes at temperatures of around 140C. Upon curing, the polymer is non-flammable without additives, providing unique commercialization opportunities.

Figure 1 provides a comparison of a Trimer HARP resin (called Trimer RTM polymer in table) with the material properties of two snap cure epoxies and two vinyl esters and demonstrates that the Trimer HARP resin greatly outperforms state-of-the-art materials. Furthermore, the resin has been validated by external testing facilities to greatly exceed FAR 25.853 with a peak OSU Heat Release of 28.4 kW/m2, smoke density of 4.9, and vertical flame spread of 0.0 in. Trimer's resin system is ideally suited for applications in infrastructure structures with a combination of strength, stiffness, toughness and FST performance greatly exceeding all existing technologies. These characteristics make Trimer HARP resins attractive for a wide range of applications in infrastructure and in both interior and exterior applications in the construction market.

Material Property	Trimer Technologies' RTM Resin	Dow Voraforce 5300	Huntsman Araldite LY 3585 / Aradur 3475	AOC VIPEL FO10 BIS-A VE	Reichhold DION IMPACT 9102-75
Polymer Type/Chemistry	-	Epoxy	Epoxy	Vinyl Ester	Vinyl Ester
Glass Transition, Tg Dry °C	375	120	110	130	99
Tensile Strength (MPa)	105	68	77.5	88	79.2
Tensile Modulus (GPa)	4.0	2.8	2.8	3.2	2.9
Tensile Strain to Failure, %	4.0	7	9	6.2	4.5
Compressive Strength (MPa)	149	-	-	121	108.9
Flexural Strength (MPa)	140	-	-	153	144
Fracture Toughness, K_{1C} (MPa/$m^{1/2}$)	1.03	1.22	0.85	0.6	-
Viscosity (cP at 23 °C)	200	500	1,000	3,200	170

Figure 1. Comparison of Trimer resin with current low-cost rapid cure resins

In the infrastructure area, these applications include bridges (including pedestrian sidewalks), tunnel linings, train/subway station platforms, and heli-/vertiports. Building and construction applications include areas such as industrial equipment buildings, data centers, power distribution buildings, prefabricated balconies, and enclosures for battery power backup systems.

Each of these applications represents a significant opportunity for fire-resistant FRP composites. Example applications are depicted below in Figure 2. In order for Trimer HARP resin-infused structures to be considered for many fire-rated applications, they need to achieve, depending on the application, a Class A rating based on ASTM E84 testing, and more importantly, a minimum one hour rating based on ASTM E119 testing.

Figure 2. Vertiport landing pad, mini data center, infused FRP building

Project Objective

The primary objective of this project was to vacuum-infuse composite panels using Trimer HARP resins and to evaluate their performance in the following tests, down-selecting panel construction for each subsequent test, based on previous test results. The ultimate goal was to achieve a minimum one hour rating on ASTM E119 tests of both wall and floor panels.

1. ASTM E1354 - Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter, aka "Cone Calorimeter Test."
2. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
3. E119 "Mini" test
4. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction Materials

Methodology

All laminates were vacuum-infused with Trimer HARP resins and layers of a single type of reinforcement, Vectorply 3610 biaxial fabric. This fabric allowed for consistent high glass content (approx. 70% by wt), high strength laminates. All laminates were cured in an oven at 250F for at least one hour. The E1354 and E84 tests were only necessary to run with single skin laminates as there were no structural requirements. Because the ultimate application is for highly loaded infrastructure, the E119 mini and full-scale E119 testing was done on cored sandwich structure panels. The Ceramic Hybrid Red coating was a post-applied coating. The Tecnofire intumescent was infused at the surface on panels that incorporated it.

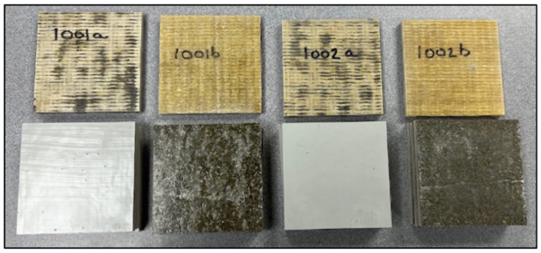
ASTM E1354 Testing

The first test, ASTM E1354, also known as the Cone Calorimeter Test, measures fire characteristics associated with heat and smoke output. Radiant heat is the major cause of fire spread and E1354 measures, among other things, the intensity of the peak heat release rate (PHRR) and the time to reach PHRR, critical factors in predicting the growth rate of fire. The goal of the cone calorimeter testing was to determine which of these systems was likely to perform best in ASTM E119 testing, which is a required rigorous fire protection test which simulates an intense fire inside a compartment. Materials that must achieve a one hour or greater E119 rating must show ability to resist burn-through during this furnace test, as well as resist temperature rise through the material. Orenco Composites infused four sets of 4 inch x 4 inch panels for the E1354 testing, as shown in Figure 3 below.

Test	Serial #	Resin	Coating	Core	Reinforcement
E1354	1001a	HARP RAPID standard w 11 N-fuse catalyst	* Ceramic Hybrid RED	none	Vectorply 3610 Biaxial E-glass fabric (6 plies)
	1001b		** Tecnofire 60152C		
	1002a	HARP F1005 w N-fuse catalyst	Ceramic Hybrid RED		
	1002b		Tecnofire 60152C		

* Mfg by Finnester Coatings Oy

** Mfg by Techical Fibre Products



4" x 4" samples, three samples per serial number, all about 1/4" thick

Figure 3. E1354 test panels and test matrix

Trimer HARP RAPID resin with Tecnofire 60152C (1002b) appear to work rather well with one another, with notable delays in time to ignition, and low fire growth rate. Given how E119 is a "time to burn through" test with an aggressive heat growth curve, delaying ignition while maximizing char and lowering Total HR is a preferred fire performance for a material going into E119 testing. Because of the Ceramic Hybrid Red's ability to prevent thermal damage to the aluminum foil and its lower peak heat release, it was decided to test both Tecnofire and Ceramic Hybrid Red with Trimer HARP RAPID resin in the E119 mini test.

The E1354 testing was completed at the University of Dayton Research Institute (UDRI). The full report is attached as Appendix A. Figure 4 below provides an abbreviated summary of the data from this testing.

Sample	Time to ignition (s)	Peak HRR (kW/m2)	Time to peak HRR (s)	Weight % loss	Total Heat Release (MJ/m2)	Total smoke release (m3/m2)
1001a	40	119	78	18.5	105	867
1001b	109	177	645	21.1	94	1743
1002a	36	110	75	18.3	85	946
1002b	57	165	731	22.3	124	1621

Figure 4. E1354 abbreviated test data summary

ASTM E84 Testing

ASTM E84 tests is used to determine the relative burning behavior of a material by observing the flame spread along the specimen. Test specimens are 2 ft wide x 24 ft long. The test reports the Flame Spread index and Smoke Developed index of the tested product.

While the E84 did not provide insight into material or configuration testing for E119, it is an important test for applications governed by the International Building Code covering interior surfaces of buildings based on building occupancy classification.

Two E84 tests were run on Trimer HARP RAPID based panels, one with Tecnofire infused at the surface and one without any surface treatment. Ceramic Hybrid Red was not used for the E84 testing as material was not available. Figure 5 below shows the E84 test plan.

Test	Serial #	Resin	Coating	Core	Reinforcement
E84	2001a	Trimer HARP Rapid	No coating	none	Vectorply 3610 biaxial E-glass fabric (4 plies)
	2001b		Tecnofire 60152C infused at surface	Airex T90.100, 1" PET, 110 kg/m3	Vectorply 3610, 4 plies on each side of core

Figure 5. E84 test plan

Both samples achieved the highest rating of Class A as determined by the widely adopted National Fire Protection Agency's classification system. ASTM E84 testing was completed at Southwest Research Institute (SWRI). Test photos are shown below in Figure 6 and results in Figure 7. The full E84 test reports are attached as Appendix B.

2001a (no coating), prior to test — 2001a after test — 2001b (PET core, Tecnofire surface), prior to test — 2001b after test

Figure 6. E84 test photos

Sample	FSI	SDI
2001a (Trimer laminate, no coating)	15	250
2001b (PET core, Tecnofire infused at surface)	15	400

Rating	Flame Spread Index (FSI)	Smoke Developed Index (SDI)
Class A	0 - 25	0 - 450
Class B	26 - 75	0 - 450
Class C	76 - 200	0 - 450

Figure 7. E84 test results

E119 Mini Testing

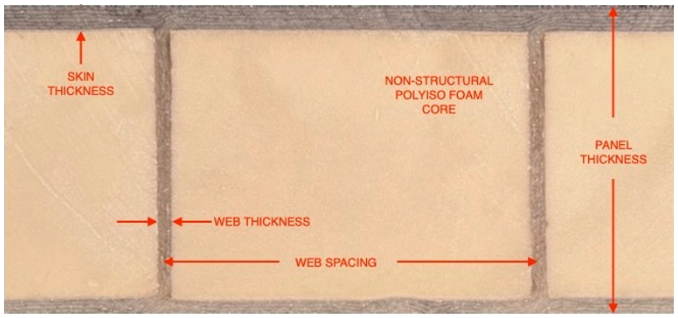
The unofficial ”E119 mini” allows the testing of small scale samples to help determine whether a full-size version will achieve a desired a E119 rating. In this test, the following information is desired:

- Time before average temperature rise exceeds 250F on the backside of test panel
- Verify no passage of flame or gases hot enough to ignite cotton during test duration

Four different test panels were built at 24 inches x 24 inches x 4 inches thick, as described in Figure 8. As determined during the E1354 testing, both surface treatments (Tecnofire and Ceramic Hybrid Red) were used, along with two different 3 inch thick core materials, a 110 kg/m3 thermoplastic FR-rated PET (Airex T90.100) and a 32 kg/m3 thermoset polyiso core. The PET core is considered a structural core and was installed as a solid uninterrupted core. The lightweight polyiso core is considered non-structural and was installed with webs every 4 inches in one direction. Figure 9 describes the structure of the web-stiffened polyiso cored panels. The E119 Mini tests were completed at SwRI. A full test report is attached as Appendix C.

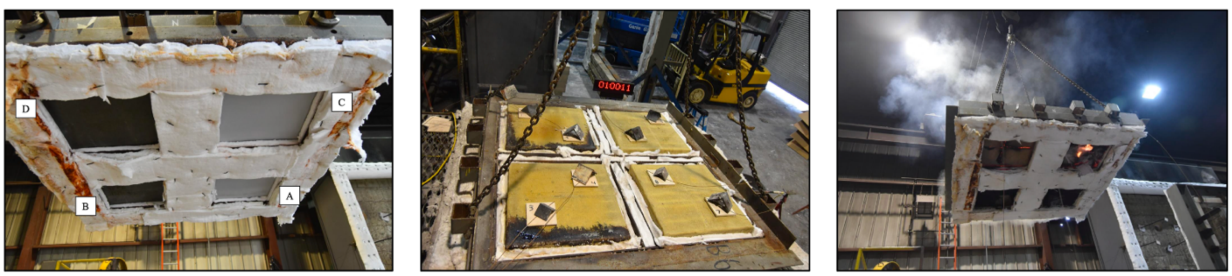
Test	Serial #	Resin	Coating	Core	Reinforcement
E119 Mini	3001a	Trimer HARP Rapid	Ceramic Hybrid RED	Airex T90.100, 3" PET, 110 kg/m3	Vectorply 3610, 6 plies on each side of core, 3 plies on webs
	3001b		Tecnofire infused		
	3001c		Ceramic Hybrid RED	3" thick polyiso, 32 kg/m3, with 4" web spacing	
	3001d		Tecnofire infused		

Figure 8. E119 Mini test plan



- Web spacing = 4 inch
- Web thickness = 3/16 inch
- Skin thickness = 1/4 inch
- Panel thickness = 4 inch

Figure 9. Web-stiffened, cored panel design for E119 Mini test

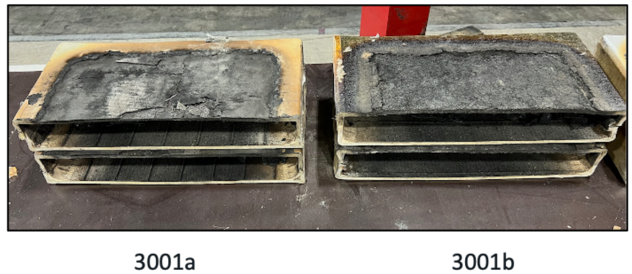


Panels ready to be placed over furnace | Outside top of panels at end of test | Underside of panels at end of test

Figure 10. E119 Mini testing

None of the E119 Mini samples achieved the desired minimum one hour time period before the backside temperature rise exceeded 250F, though sample 3001d missed by less than one minute. One clear result was that the thermoplastic PET core panels failed the test much quicker than the polyiso core. This was likely due to the complete loss of the PET core material during the test as can be seen in Figure 11. Although the thermoset polyiso core was substantially burned, much of it remained intact and likely continued to provide thermal insulation and prevented hot gas from transmitting as much heat to the backside laminate. It was also clear that the webs of the polyiso-cored panel will provide substantial structural strength during and after an E119 test, since a substantial portion of the webs are intact after one hour. In terms of surface treatment, the Tecnofire material clearly performed better than the Ceramic Hybrid Red. Not only did backside temperature remain lower longer with the Tecnofire, the laminate side exposed to the furnace was protected better by the substantial char created by the Tecnofire. This can be seen in the cutaway photographs in Figure 11. It was therefore determined that the full scale E119 testing should be done with panels built with a web-stiffened polyiso core and Tecnofire infused at the surface. It was further decided to increase the core thickness from 3 inches to 4 inches, with the assumption that the extra inch of core insulation would ensure that one hour would be reached before the 250F maximum temperature rise was reached.

Sample	250F temperature exceeded
3001a (Ceramic Red coating, PET core)	48:40 min
3001b (Tecnofire infused, PET core)	51:20 min
3001c (Ceramic Red coating, polyiso webbed core)	58:52 min
3001d (Tecnofire infused, polyiso webbed core)	59:20 min



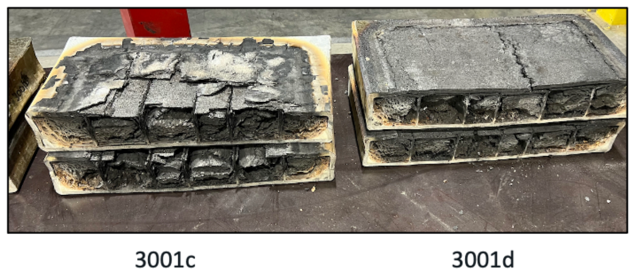


Figure 11. E119 Mini test results

E119 Testing

The E119 test is a severe fire test, with the following requirements to achieve a rating:

- Sustain an applied load during the fire-resistance and hose stream test
- No passage of flame or gases hot enough to ignite cotton for test duration
- No openings shall develop during the application of the hose stream which allows passage of water to the unexposed face
- Average temperature rise on the unexposed surface shall not exceed 250F above the initial temperature for the entire test.

A “furnace temperature vs time” graph for one of the E119 tests is shown in Figure 12. The temperatures approach the meting temperature range of fiberglass (1800F to 2500F).

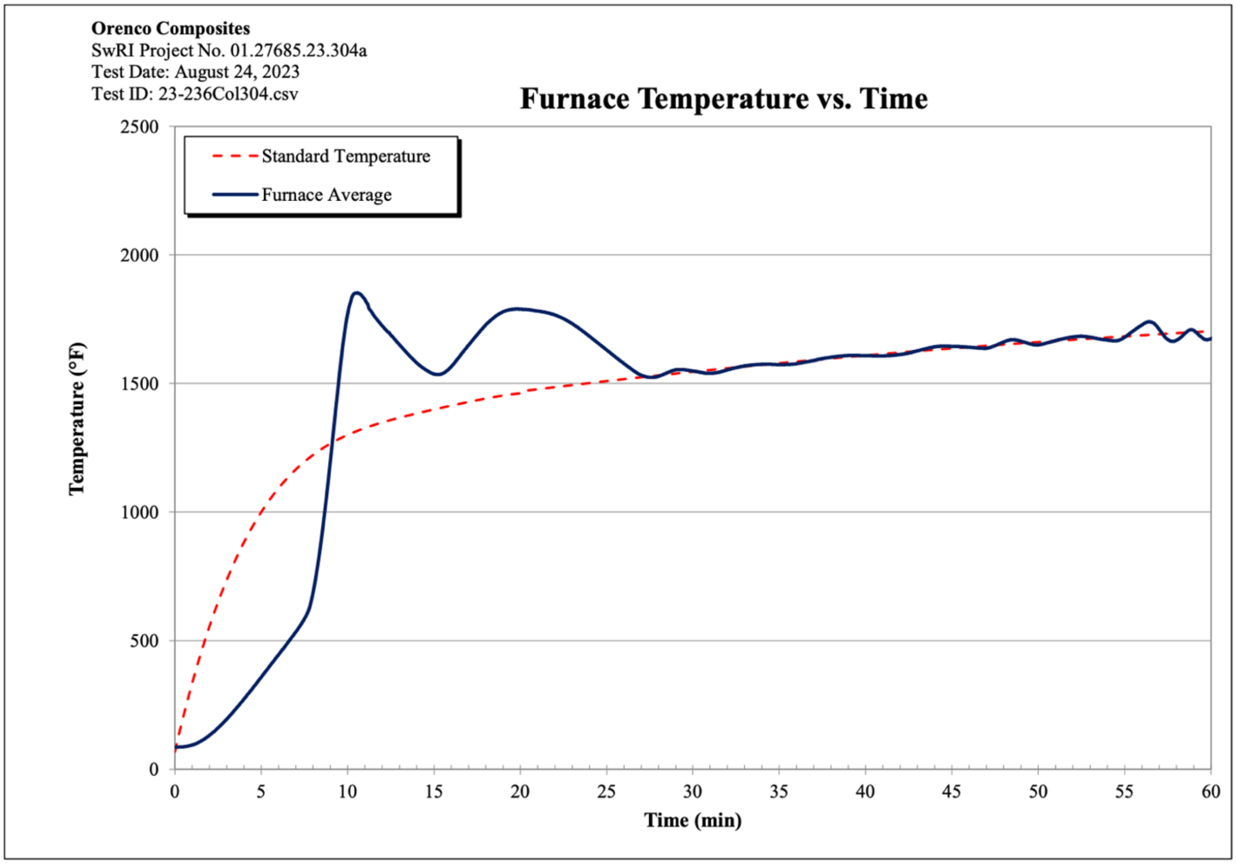
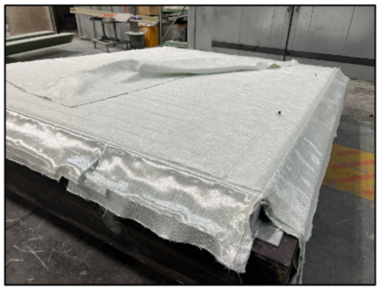


Figure 12. Furnace temperature vs time for E119 test

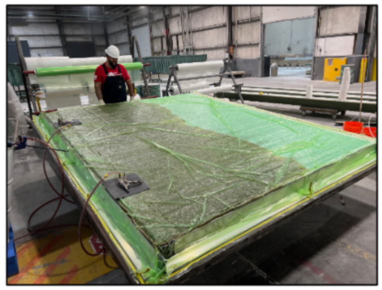
Two large panels were built for E119 testing, one for a wall test and one for floor test. The test plan is shown in Figure 13 and example manufacturing photos are shown in Figure 14. The applied load for the wall panel was chosen at 450 lbs per lineal foot. This load was chosen as it was a maximum design load for typical FRP buildings produced by Orenco Composites. The applied load for the floor panel was chosen at 40 lbs per square foot, a typical design value. The E119 tests were completed at SwRI. Full test reports are attached as Appendix D.

Test	Serial #	Panel Size	Resin	Coating	Core	Reinforcement
E119	4001a	12-8" x 15'-8" floor panel	Trimer HARP Rapid	Tecnofire 60152C infused at surface	4" thick polyiso, 32 kg/m3, with 4" web spacing	Vectorply 3610, 6 plies on each side of core, 3 plies on webs
	4001b	12' W x 9' H wall panel				

Figure 13. E119 test plan



Loading foam & glass prior to infusion



Infusing wall panel

Wall & floor panels shipping to SwRI

Figure 14. E119 panel manufacturing

12 ft wide x 9 ft tall wall panel ready to start test

Test side prior to installation against furnace

Figure 15. E119 wall panel prior to initiating test

Panel frame removed from furnace

60 second fire hose spray

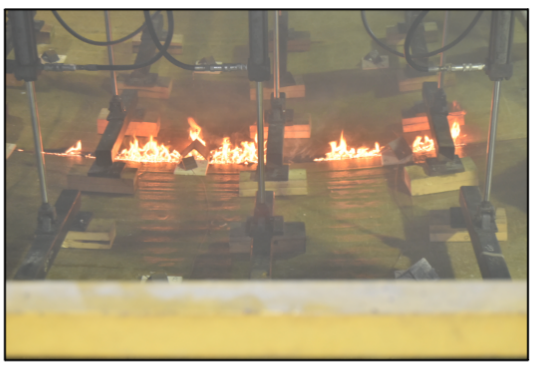
Panel after fire hose spray

Figure 16. E119 wall panel at end of test

12'-8" x 15'-8" floor panel. Note floor panel was molded in two pieces and adhesively-bonded in a tongue/groove joint

Floor panel at 40 minutes into test. Hydraulic cylinders providing continuous 40 lb/ft2 load

Figure 17. E119 floor panel test



Adhesive used to bond center seam caught fire

Underside of panel removed from furnace

Figure 18. E119 floor panel at end of test

The wall panel achieved a one hour E119 rating by meeting the following conditions:

- Sustained the 450 lb/ft applied load during the fire-resistance and hose stream test
- No passage of flame or gases hot enough to ignite cotton for test duration
- No openings developed during the hose stream to allow passage of water to the unexposed face
- Average temperature rise on the unexposed surface did not exceed 250F

The floor panel achieved a 57 minute E119 rating, just missing the desired one hour rating, due to the passage of flame at the center seam. Because the available curing oven was not large enough, the floor panel was molded in two pieces and then assembled as a tongue and groove joint, using a urethane acrylate adhesive. The urethane acrylate adhesive caught fire 57 minutes into the test. If the floor panel had been assembled with Trimer resin as the adhesive, or had been molded in one piece, it very likely would have achieved the desired one hour rating.

Conclusions

- Trimer resin based laminates easily meet Class A E84 values without coatings or additives.

- Based on E84 results, it is likely that Trimer-based laminates would pass an NFPA 286 test, also known as the "room corner test." NFPA 286 has significant benefits in the International Building Code.

- Tecnofire intumescent fabric is not necessary to achieve Class A E84 with Trimer resin based laminates, and probably not desired due to increased smoke over plain Trimer laminate. However, if additional thermal resistance properties are desired, Tecnofire would be beneficial.

- The vacuum-infused, web-stiffened, foam-cored, FRP wall panel based on Trimer HARP Rapid resin achieved an ASTM E119 rating of one hour. This is a very significant accomplishment for a 100% composite wall structure, and opens up many applications that conventional resins are not able to meet.

- The similarly-built floor panel missed the one hour rating by just 3 minutes due to an adhesive-bonded seam issue. It is anticipated that a floor panel would easily meet a one hour rating by eliminating the seam, or using Trimer resin to bond the seam.

- It is predicted that a Trimer resin based laminate would fail to achieve a one hour E119 rating without (a) a web-stiffened, cored design, and (b) the Tecnofire intumescent fabric.

- The ability to achieve a one hour E119 rating opens the door to many applications previously not available to a 100% composite structure with high structural strength requirements.

Technical data sheets for the Trimer resin, glass reinforcement, surface materials, and core materials is attached as Appendix E.

APPENDIX A

ASTM E1354 Cone Calorimeter Test Report

Cone Calorimeter Testing of IACMI Composite materials

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The Quality Management System of the Fire Safety Science Laboratory is certified to ISO 9001:2015 (Eagle Certification Group, Cert No. 5587).

This Project was completed under project number J9EDR1. This report has been approved for release by Dr. Alexander B. Morgan.

DATE OF REPORT: November 11, 2022

Introduction:

The cone calorimeter is a fire testing instrument which quantitatively measures the inherent flammability of material through the use of oxygen consumption calorimetry, and is a standard technique[1] under ASTM E-1354/ISO 5660. This instrument was designed primarily as a fire safety engineering tool, but has found great utility as a scientific tool for understanding fire performance in relation to regulatory pass/fail tests. By looking at various parameters measured by the cone calorimeter, one can correlate those measurements to other tests, or, bring understanding of why a material achieved a particular regulatory rating. Work on comparing cone calorimeter to other tests has included full scale flammability tests,[2] bench scale tests like UL-94 or limiting oxygen index,[3,4,5,6,7] automotive material flame spread tests,[8] wire and cable flame spread tests[9] and other types of fire tests/scenarios.[10,11,12,13,14,15,16] A schematic of the cone calorimeter basic setup is shown below in Figure 1.

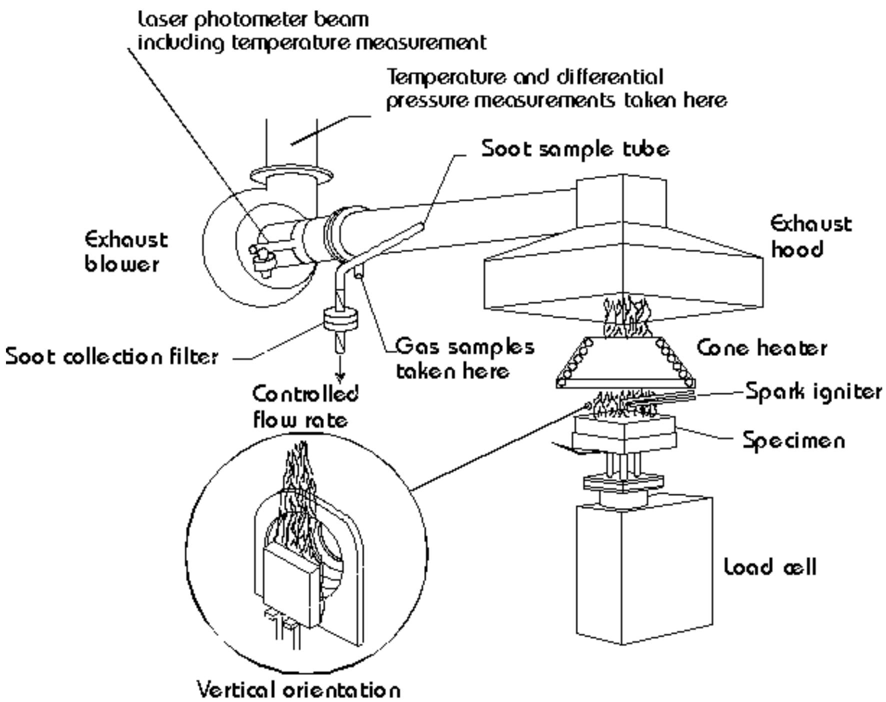


Figure 1. Cone Calorimeter Schematic

There are several measurements obtained from the cone calorimeter. The cone calorimeter at UDRI is equipped with the laser for smoke measurements (laser photometer beam in Figure 1), oxygen sensor for measuring oxygen consumption, and load cell for measuring mass loss as the sample pyrolyses during heat exposure. The instrument at UDRI also has a CO_2/CO detection system, allowing for the measurement of CO_2/CO production as a function of time during sample combustion. From these parts of the instrument various measurements are collected during each test which can reveal scientific information about material flammability performance. For the purposes of understanding the flammability behavior of fiberglass composites containing Trimer resin, and using fire protection coatings that have been-co-cured to the other layer of the composite, only some of the parameters will be discussed in this report, including the following:

- Time to ignition (Tig): Measured in seconds, this is the time to sustained ignition of the sample. Interpretation of this measurement assumes that earlier times to ignition mean that the sample is easier to ignite under a particular heat flux.
- Heat Release Rate (HRR): The rate of heat release, in units of kW/m^2, as measured by oxygen consumption calorimetry.
- Peak Heat Release Rate (Peak HRR): The maximum value of the heat release rate during the combustion of the sample. The higher the peak HRR, the more likely that flame will self-propagate on the sample in the absence of an external flame or ignition source. Also, the higher the peak HRR, the more likely that the burning object can cause nearby objects to ignite.
- Time to Peak HRR: The time to maximum heat release rate. This value roughly correlates the time it takes for a material to reach its peak heat output, which would in turn sustain flame propagation or lead to additional flame spread. Delays in time to peak HRR are inferred to mean that flame spread will be slower in that particular sample, and earlier time to peak HRR is inferred to mean that the flame spread will be rapid across the sample surface once it has ignited.
- Time to Peak HRR – Time to Ignition (Time to Peak HRR – Tig): This is the time in seconds that it takes for the peak HRR to occur after ignition rather than at the start of the test (the previous measurement). This can be meaningful in understanding how fast the sample reaches its maximum energy release after ignition, which can suggest how fast the fire grows if the sample itself catches fire.
- Average Heat Release Rate (Avg HRR): The average value of heat release rate over the entire heat release rate curve for the material during combustion of the sample.
- Starting Mass, Total Mass Lost, Weight % Lost. These measurements are taken from the load cell of the cone calorimeter at the beginning and end of the experiment to see how much total material from the sample was pyrolyzed/burned away during the experiment.
- Total Heat Release (THR). This is measured in units of MJ/m^2 and is basically the area under the heat release rate curve, representing the total heat released from the sample during burning. The higher the THR, the higher the energy content of the tested sample. THR can be correlated roughly to the fuel load of a material in a fire, and is often affected by polymer chemical structure.
- Total Smoke Release: This is the total amount of smoke generated by the sample during burning in the cone calorimeter. The higher the value, the more smoke generated either due to incomplete combustion of the sample, or due to polymer chemical structure.
- Maximum Average Rate of Heat Emission (MARHE): This is a fire safety engineering parameter,[17] and is the maximum value of the average heat rate emission, which is defined as the cumulative heat release (THR) from t=0 to time t divided by time t. The MARHE can best be thought of as an ignition modified rate of heat emission parameter, which can be useful to rank materials in terms of ability to support flame spread to other objects.
- Fire Growth Rate (FIGRA): This is another fire safety engineering parameter, determined by dividing the peak HRR by the time to peak HRR, giving units of kW/m^2 per second. The FIGRA represents the rate of fire growth for a material once exposed to heat, and higher FIGRA suggest faster flame spread and possible ignition of nearby objects.

Experimental Section:

The four coated samples were received already cut to 4" x 4" specimens. All samples were tested as received without any further conditioning.

Cone Calorimeter experiments were conducted on a Deatak CC-2 Cone Calorimeter at 1 heat fluxes (50 kW/m^2) with an exhaust flow of 24 L/s using the standardized cone calorimeter procedure (ASTM E-1354-22). Samples were wrapped in aluminum foil on one side as per the ASTM E1354 standard. A metal frame and grid were used to address any potential intumescence that may occur during testing, and to better simulate controlled behavior of

Data collected from all samples is believed to have an error of ±10% and were calculated using a specimen surface area of 88.4 cm^2. All samples were tested in triplicate as per the ASTM E1354 standard.

Results and Discussion:

The formulations provided are shown in Table 1. They compose of two different Trimer resins with two different fire protection coatings. The goal of cone calorimeter testing is to determine which of these systems is likely to perform best in ASTM E119 testing, which is a required rigorous fire protection test which simulates an intense fire inside a compartment. Materials that must pass this test must show ability to resist burn-through during this furnace test, as well as resist temperature rise through the material.

Cone calorimeter testing resulted in the measurements shown in Table 2. Based upon guidance from Orenco, the Ceramic Hybrid Red coatings will not move forward into testing, and so some initial focus of analysis was on the "b" materials containing the Technofire 60152C intumescent mat. Ideally, would have been good to have the two HARP resins side by side, but the standard material with 11 N-fuse catalyst + Technofire 60152C appear to work rather well with one another, with notable delays in time to ignition, and low fire growth rate and MARHE for this particular combination. Given how E119 is a "time to burn through" test with an aggressive heat growth curve, delaying ignition while maximizing char and lowering Total HR is a preferred fire performance for a material going into E119 testing. Therefore, based solely on the data alone, it appears the 1001b sample is the one to consider for future work. However, if Ceramic Hybrid Red as a coating was an allowable option, then the HARP F1005 with N-Fuse catalyst looks to be the better performer due to the notably lower heat release for this material. Further, it should be noted that the ability of the Ceramic Hybrid Red to prevent thermal damage to the aluminum foil suggests that it would do well in E119. It's not so clear that the Technofire would work as well as the analysis of the final chars suggests that the Technofire coating does not provide much thermal insulation. Therefore, there is some concern here that the real need is to come up with an outer protective barrier for the HARP resins that provides both thermal insulation and burn-through performance. The Technofire coating does seem to be providing some benefit, but the results seem to suggest it is not providing the thermal protection benefit needed for this application. ASTM E84 testing may shed some more light on this, especially if the samples can be recovered after testing to look for thermal damage on the back-side of the sample after E84 testing.

Discussions of observed fire behavior, individual sample heat release rate curves, and pictures of the final chars from each sample are shown after Table 2 below.

Table 1. Formulations Tested for Cone Calorimeter and Goals for Future Work

Test	Serial #	Resin	Coating	Core	Reinforcement	Sizing	Panel Size	Specimen Dimensions	Summary	Testing Lab	Lead Times
E1354	1001a	HARP RAPID standard w 11 N-fuse catalyst	Ceramic Hybrid RED	none	Vectorply 3610 (6 plies)	silane	16" x 16"	4.0" x 4.0" (4 specimens per panel)	***4 total tests***	**UDRI**	2 weeks
	1001b		Technofire 60152C								
	1002a	HARP F1005 w N-fuse catalyst	Ceramic Hybrid RED								
	1002b		Technofire 60152C								
E84	2001a	downselect after E1354	No coating	none	Vectorply 3610 (4 plies)	silane	2'x8' (qty.3)		***2 total tests***	**SWRI**	2-3 wks
	2001b		Technofire 60152C	PET 1.00" 100	Wrap core with 3 plies 3610						
E119 Mini	3001a	downselect after E1354/E84	Ceramic Hybrid RED	PET	FG multiaxial	silane			***4 total tests***	**SWRI**	3-4 wks
	3001b		Technofire 60152C								
	3001c		Ceramic Hybrid RED	Other?							
	3001d		Technofire 60152C								
E119 Full Size	4001a	downselect after E119 Mini	downselect after E119 Mini	downselect after E119 Mini	FG multiaxial	silane			***2 total tests (one loaded floor and one unloaded***	**SWRI**	6-8 wks
	4001b										

Table 1. Combined Heat Release Data

Sample Description	Sample Thickness (mm)	Time to ignition (s)	Time to Flameout (min)	Peak HRR (kW/m2)	Time to Peak HRR (s)	Time to Peak HRR - Tig (s)	Average HRR over 60 sec (kW/m2)	Average HRR over 180 sec (kW/m2)	Average HRR over 300 sec (kW/m2)	Starting Mass (g)	Final Mass (g)	Total Mass Loss (g)	Weight % Lost (%)	Total Heat Release (MJ/m2)	Total smoke Release (m2/m2)	Avg. Effective Heat of Comb. (MJ/kg)	MARHE (kW/m2)	FIGRA
1001a	9.6	31	27:00	121	72	41	78	72	63	164.75	136.38	28.4	17.2	121.8	399	37.80	151	1.69
	9.6	52	26:30	121	89	38	78	66	55	162.55	130.63	31.9	19.6	103.7	1186	28.58	137	1.36
	9.6	38	26:30	115	74	36	83	63	48	161.81	131.49	30.3	18.7	89.8	1016	26.06	122	1.55
Average Data	9.6	40		119	78	38	80	67	55	163.04	132.83	30.2	18.5	105.1	867	30.81	137	1.53
1001b	10.0	100	18:00	171	656	556	70	71	77	163.53	128.72	34.8	21.3	93.9	1774	23.73	195	0.26
	10.0	101	18:30	179	628	527	72	73	80	163.98	129.46	34.5	21.1	97.3	1619	24.82	200	0.28
	10.0	127	17:30	182	650	523	74	74	83	163.81	129.55	34.3	20.9	91.8	1837	23.59	197	0.28
Average Data	10.0	109		177	645	536	72	73	80	163.77	129.24	34.5	21.1	94.3	1743	24.05	198	0.27
1002a	10.0	38	26:30	107	74	36	74	61	49	161.52	132.04	29.5	18.3	94.5	994	28.21	125	1.44
	10.0	40	26:30	110	78	38	75	57	46	157.01	127.12	29.9	19.0	75.8	699	22.33	105	1.41
	10.0	30	26:30	112	72	42	68	62	51	159.01	130.92	28.1	17.7	84.7	1146	26.53	119	1.56
Average Data	10.0	36		110	75	39	72	60	48	159.18	130.03	29.2	18.3	85.0	946	25.69	117	1.47
1002b	10.4	54	19:00	173	723	670	76	85	90	166.82	128.99	37.8	22.7	131.4	1965	30.58	239	0.24
	10.4	58	18:45	163	733	675	78	85	87	171.78	134.08	37.7	21.9	124.9	1231	29.15	225	0.22
	10.4	59	19:00	159	737	678	76	85	89	170.29	132.33	38.0	22.3	116.2	1668	26.95	223	0.22
Average Data	10.4	57		165	731	674	77	85	89	169.63	131.80	37.8	22.3	124.2	1621	28.89	229	0.23

Observed Fire Behavior

<u>1001a Samples:</u> Upon exposure to the cone heater, these samples began to crackle (audible noises) at about 13 seconds. They ignited at about 40 seconds and burned for ~ 27 minutes. There was a lot of black sooty smoke during the test and some dripping over the edge and down the holder which was believed to have come from the coating (see Figure 6 at end of report). The Heat Release curve (Figure 2, left) shows a quick initial spike from the coating then a broad second peak from the base material, which is also indicative of a thermally thick charring material, with the peak @ 1000 seconds correlating to char thermal decomposition later in the test. The final char (Figure 2, right) had some crunchy black and white char on the base material. The foil was not damaged in the center, suggesting some good thermal insulation effects generated by the char.

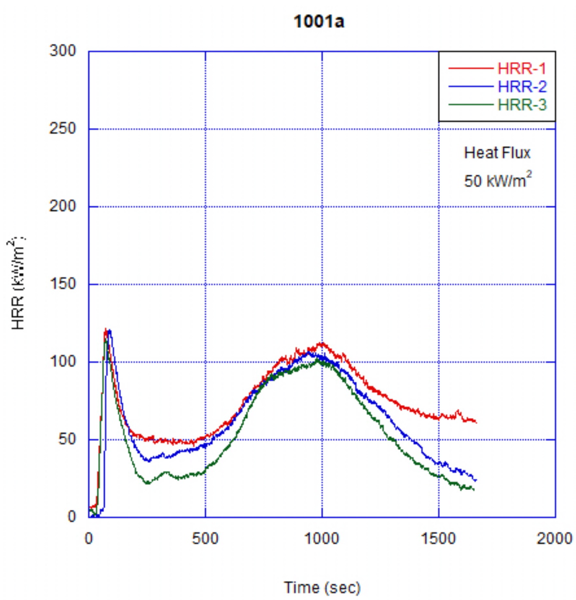
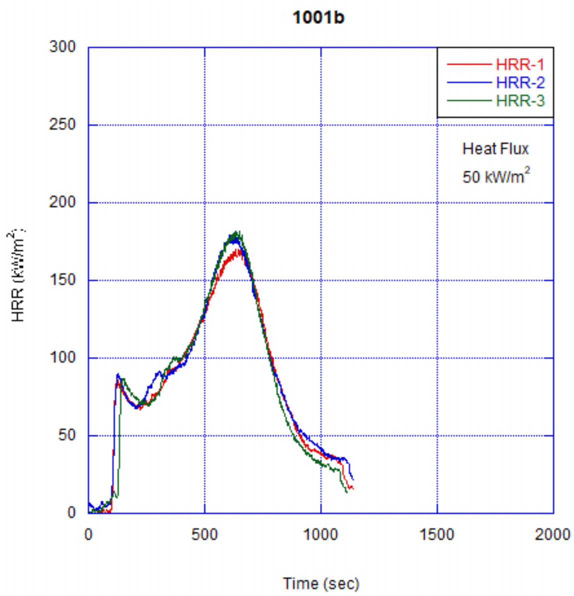


Figure 2. Heat Release Rate curve (left) and char picture (right) for sample 1001a.

<u>1001b Samples:</u> Upon exposure to the cone heater, these samples began to crackle (audible noises) and expel black bits off the surface of the sample at about 13 seconds. They ignited at about 109 seconds and burned for ~ 18 minutes. There was a lot of black sooty smoke during the test but no dripping over the edge. The Heat Release curve (Figure 3, left) shows a quick initial peak followed by a larger secondary peak, which represents char burn through at 750 seconds into the test. The final char (Figure 3, right) had some loose black char on the base material. The foil was damaged in the center which suggests heat from the test penetrated through the sample during testing and resulted in the damage to the aluminum foil.



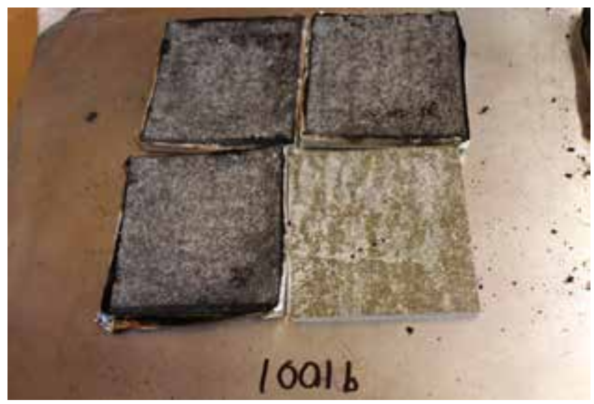


Figure 3. Heat Release Rate curve (left) and char picture (right) for sample 1001b.

1002a Samples: Upon exposure to the cone heater, these samples began to crackle (audible noises) at about 20 seconds . They ignited at about 36 seconds and burned for ~ 27 minutes. There was a lot of black sooty smoke during the test and some dripping over the edge and down the holder which was believed to have come from the coating (see Figure 6 at end of report). The Heat Release curve (Figure 4, left) shows a quick initial spike from the coating then a broad second peak from the base material, similar to what was observed for the 1001a sample. The final char (Figure 4, right) had some crunchy black and white char on the base material. The foil was not damaged in the center, again similar to the 1001a sample, which suggests this coating yields superior thermal insulation performance.

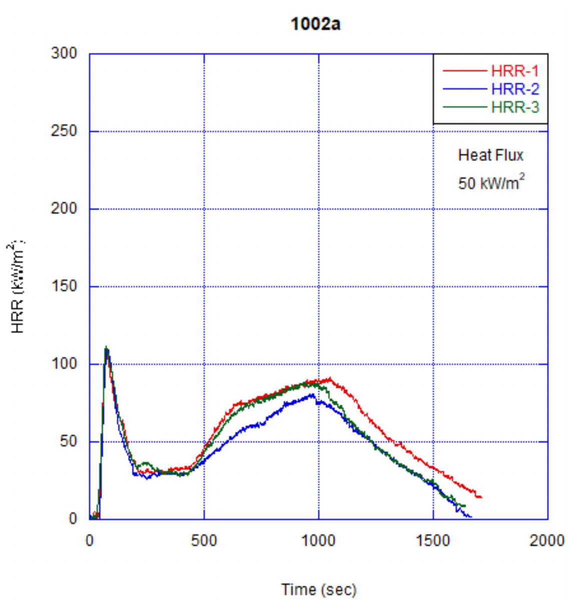
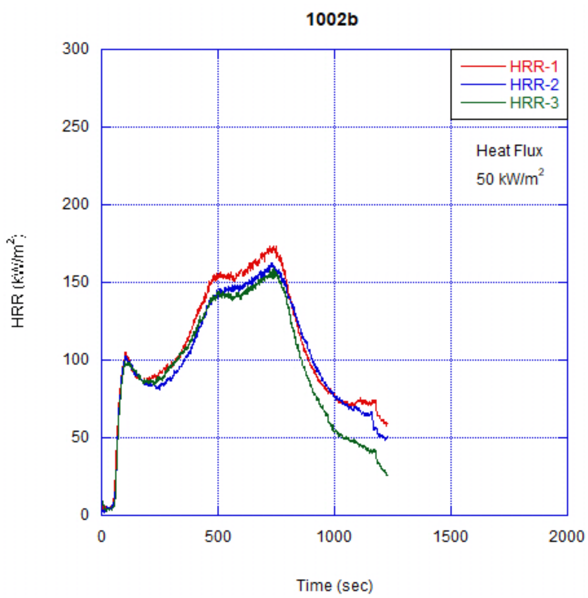


Figure 4. Heat Release Rate curve (left) and char picture (right) for sample 1002a.

1002b Samples: Upon exposure to the cone heater, these samples began to crackle (audible noises) and expelled black bits of the surface of the sample at about 13 seconds, identical to what was seen with sample 1001b. They ignited at about 57 seconds and burned for ~ 19 minutes. There was a lot of black sooty smoke during the test but no dripping over the edge. The Heat Release curve (Figure 5, left) shows a quick initial peak followed by a larger secondary peak. The final char (Figure 5, right) had some loose black char on the base material. The foil was damaged in the center which suggests heat from the test penetrated through the sample during testing and resulted in the damage to the aluminum foil.



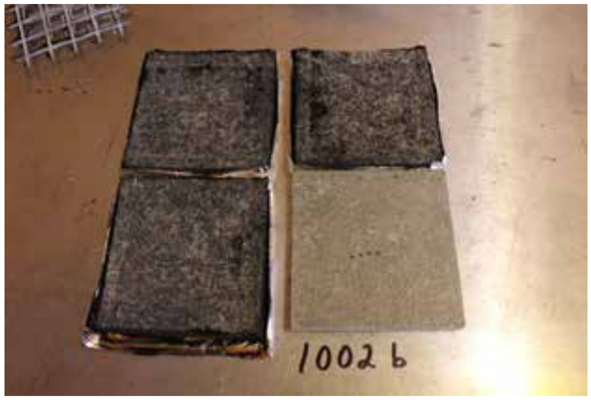


Figure 5. Heat Release Rate curve (left) and char picture (right) for sample 1002b.

Additional photo:

Figure 6. Photo of samples of 1001a dripping and burning under the frame.

References:

(1) Cone Calorimeter: ASTM E1354-22 "Standard Heat Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter"
(2) "Full Scale Flammability Measures for Electronic Equipment" Bundy, M.; Ohlemiller, T. *NIST Technical Note 1461* **August 2004**, US Dept. of Commerce.
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(12) "Heat release rate measurements of thin samples in the OSU apparatus and the cone calorimeter" Filipczak, R.; Crowley, S.; Lyon, R. E. *Fire Safety Journal* **2005**, *40*, 628-645.
(13) "Heat Release Rate: The Single Most Important Variable in Fire Hazard" Babrauskas, V.; Peacock, R. D. *Fire Safety Journal* **1992**, *18*, 255-272.
(14) "Use of Bench-Scale Test Methods To Predict The Fire Growth Of Large-Scale Room Corner Tests For Building Materials" Laymon, R. K.; Borgerson, J. L.; Ghandhi, P. D.; Resing, J. V. *Proceedings of Fire and Materials 2009*, San Francisco, CA. pp 141-153.
(15) "Flammability testing of wool/cellulosic and wool/synthetic fiber blends: Vertical flame spread and heat release results" Alexander B Morgan; Mary L Galaska *J. Fire Sci.* **2020**, *38*, 522-551
(16) "Cone calormimeter and room corner fire testing of balsa wood core/phenolic composite skin sandwich panels" Morgan, A. B.; Toubia, E. *J. Fire Sci.* **2014**, *32*, 328-345.
(17) "New Fire Classifications and Fire Test Methods for the European Railway Industry" Duggan, G. J.; Grayson, S. J.; Kumar, S. Flame Retardants 2004 Proceedings, January 27-28, 2004, London, UK, Interscience Communications

APPENDIX B

ASTM E84 Test Reports

SOUTHWEST RESEARCH INSTITUTE®

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CHEMISTRY AND CHEMICAL ENGINEERING

FIRE TECHNOLOGY DEPARTMENT
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FIRE PERFORMANCE EVALUATION IN ACCORDANCE WITH ASTM E84-23, *STANDARD TEST METHOD FOR SURFACE BURNING CHARACTERISTICS OF BUILDING MATERIALS*

MATERIAL ID: ***Serial No. 2001a (Trimer laminate, no coating)***

FINAL REPORT
Consisting of 9 Pages

SwRI® Project No.: 01.27684.02.017a
Test Date: March 27, 2023
Report Date: May 15, 2023

Prepared for:

Orenco Composites
814 Airway Ave.
Sutherlin, OR 97479

Submitted by:

Marina A. Gonzalez
Digitally signed by Marina A. Gonzalez
Date: 2023.05.15 09:28:56 -05'00'

Marina A. Gonzalez
Technical Specialist
Material Flammability Section

Approved by:

mblais
Digitally signed by mblais
Date: 2023.05.15 10:23:09 -05'00'

Matthew S. Blais, Ph.D.
Director
Fire Technology Department

EXECUTIVE SUMMARY

This report presents the test results for a specimen submitted by Orenco Composites, located in Sutherlin, Oregon, and tested at Southwest Research Institute's (SwRI's) Fire Technology Department, located in San Antonio, Texas. The test was conducted in accordance with the procedure outlined in ASTM E84-23, *Standard Test Method for Surface Burning Characteristics of Building Materials* (UL 723). The results for Flame Spread Index (FSI) and Smoke Developed Index (SDI) are presented below in Table i.

Table i. Classification and Summary of Test Results.

Classification per Section 803.1.2 of International Building Code		
Rating	**FSI**	**SDI**
A	0 – 25	0 – 450
B	26 – 75	0 – 450
C	76 – 200	0 – 450
Test Results		
Material ID	**FSI**	**SDI**
Serial No. 2001a (Trimer laminate, no coating)	15	250

1.0 INTRODUCTION

This report describes a fire performance evaluation conducted for Orenco Composites in accordance with ASTM E84-23, *Standard Test Method for Surface Burning Characteristics of Building Materials* (UL 723). Testing was conducted at the Fire Technology Department of Southwest Research Institute (SwRI), located in San Antonio, Texas.

This standard should be used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions and should not be used to describe or appraise the fire-hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of the test may be used as elements of a fire-hazard assessment or a fire-risk assessment, which takes into account all of the factors that are pertinent to an assessment of the fire hazard or fire risk of a particular end use.

The results apply specifically to the specimens tested, in the manner tested, and not to the entire production of these or similar materials, nor to the performance when used in combination with other materials.

2.0 SAMPLE DESCRIPTION

SwRI received three panels of the material on March 14, 2023, in ready-to-test condition. The samples are described below in Table 1. The panels were conditioned to a constant mass at an ambient temperature of 23 °C ± 3°C and a relative humidity of 50 % ± 5 %. Constant mass was achieved on March 17, 2023.

Table 1. Sample Description.

Material ID	Nominal Tested Dimensions*	Nominal Density	Test Side	Color
Serial No. 2001a (Trimer laminate, no coating)	Each piece measuring: 2,438 × 610 × 0.305 mm	112 lb/ft³	Marked side	Amber

*Assessed by SwRI personnel.

3.0 TEST PROCEDURE AND SETUP

This test procedure exposes a material in a horizontal, rectangular apparatus that is 25 ft × 17-$^{3}/_{4}$ in × 12 in (L × W × H). The apparatus is equipped with two gas burners at one end that direct a flame onto the surface of the material under a controlled airflow. As the test progresses, the possibility of flame spread along the surface of the material may occur. The distance of flame travel and the rate at which the flame front advances during the 10 min exposure determines the calculated flame spread index. The smoke developed measurement is calculated based on a photometer system consisting of a white light source and photocell mounted in the apparatus. The output of the photoelectric cell is proportional to the smoke, soot particulate, and other effluent passing between the light source and photocell. The samples were mounted end-to-end in the furnace, and a cement board was placed on the unexposed side of the specimen to protect the furnace lid assembly.

4.0 TEST RESULTS

Testing was conducted on March 27, 2023, for the material identified as *Serial No. 2001a (Trimer laminate, no coating).* The results for Flame Spread Index (FSI) and Smoke Developed Index (SDI) are presented below in Table 2. Detailed test results can be found in Appendix A and photographic documentation is provided in Appendix B. The ASTM E84 standard does not contain a performance criteria, however; the two model building codes (International Building Code®, Chapter 8 *Interior Finishes*, Section 803 *Wall and Ceiling Finishes*; NFPA 5000, Chapter 10 *Interior Finish*, Section 10.2.3.3, *Interior Wall and Ceiling Finish Materials Tested in Accordance with ASTM E84 or UL 723.*) classify materials based on the Flame Spread and Smoke Developed indices, however, there is not necessarily a relationship between these two measurements.

Table 2. Classification and Summary of Test Results.

Classification per Section 803.1.2 of IBC		
Rating	**FSI**	**SDI**
A	0 – 25	0 – 450
B	26 – 75	0 – 450
C	76 – 200	0 – 450
Test Results		
Material ID	**FSI**	**SDI**
Serial No. 2001a (Trimer laminate, no coating)	15	250

APPENDIX A

TEST RESULTS

(CONSISTING OF 2 PAGES)

TEST RESULTS

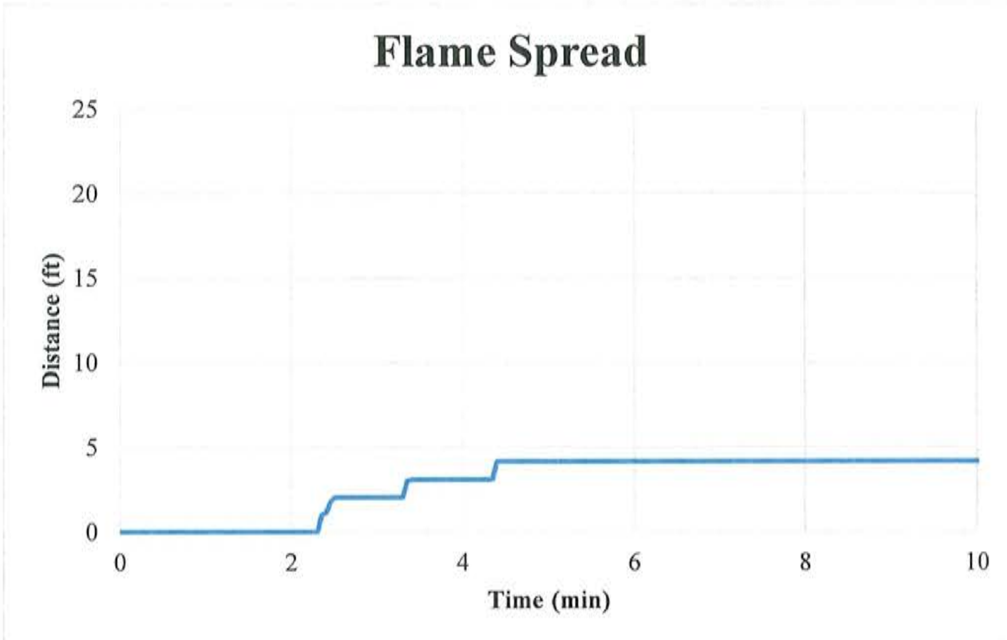
Rounded FSI:	15
Rounded SDI:	250

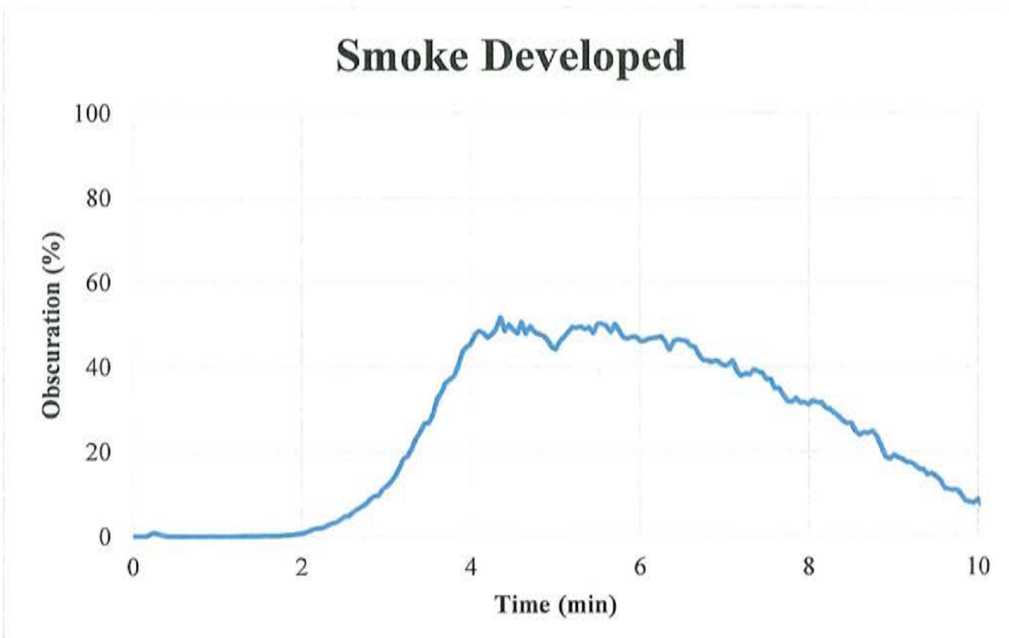
TEST DATA

Unrounded FSI:	15
Unrounded SDI:	243
FS*Time Area (ft*Min):	29.27
Smoke Area (%*Min):	251.97
Fuel Area (°F*Min):	5170.55

OBSERVATIONS DURING TEST

Ignition Time (min: s):	01:24
Maximum Flame Front Advance (ft):	4
Time to Maximum Advance (min: s):	09:45
Maximum Temp. at Exposed TC (°F):	590
Time to Maximum Temp. (min: s):	09:51
Dripping (min: s):	None
Flaming on Floor (min: s):	None
After-flame Top (min: s):	10:00+
After-flame Floor (min: s):	None
Sagging (min: s):	None
Delamination (min: s):	None
Shrinkage (min: s):	None
Fallout (min: s):	None
Charring (min: s):	00:26
Melting (min: s):	None


Flame Spread
Distance (ft)
25
20
15
10
5
0
0
2
4
6
8
10
Time (min)


Smoke Developed
Obscuration (%)
100
80
60
40
20
0
0
2
4
6
8
10
Time (min)

APPENDIX B

PHOTOGRAPHIC DOCUMENTATION

(CONSISTING OF 1 PAGE)

Figure B-1. Exposed side of the material before fire exposure.

Figure B-2. Exposed side of the material after fire exposure.

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FIRE PERFORMANCE EVALUATION IN ACCORDANCE WITH ASTM E84-23, *STANDARD TEST METHOD FOR SURFACE BURNING CHARACTERISTICS OF BUILDING MATERIALS*

MATERIAL ID: ***Serial No. 2001b (Trimer PET-cored panel with Technofire 60152C)***

FINAL REPORT
Consisting of 9 Pages

SwRI® Project No.: 01.27684.02.017b
Test Date: March 27, 2023
Report Date: May 15, 2023

Prepared for:

Orenco Composites
814 Airway Ave.
Sutherlin, OR 97479

Submitted by:

Marina A. Gonzalez — Digitally signed by Marina A. Gonzalez Date: 2023.05.15 09:29:12 -05'00'

Marina A. Gonzalez
Technical Specialist
Material Flammability Section

Approved by:

mblais — Digitally signed by mblais Date: 2023.05.15 10:22:33 -05'00'

Matthew S. Blais, Ph.D.
Director
Fire Technology Department

EXECUTIVE SUMMARY

This report presents the test results for a specimen submitted by Orenco Composites, located in Sutherlin, Oregon , and tested at Southwest Research Institute's (SwRI's) Fire Technology Department, located in San Antonio, Texas. The test was conducted in accordance with the procedure outlined in ASTM E84-23, *Standard Test Method for Surface Burning Characteristics of Building Materials* (UL 723). The results for Flame Spread Index (FSI) and Smoke Developed Index (SDI) are presented below in Table i.

Table i. Classification and Summary of Test Results.

Classification per Section 803.1.2 of International Building Code		
Rating	**FSI**	**SDI**
A	0 – 25	0 – 450
B	26 – 75	0 – 450
C	76 – 200	0 – 450
Test Results		
Material ID	**FSI**	**SDI**
Serial No. 2001b (Trimer PET-cored panel with Technofire 60152C)	15	400

1.0 INTRODUCTION

This report describes a fire performance evaluation conducted for Orenco Composites in accordance with ASTM E84-23, *Standard Test Method for Surface Burning Characteristics of Building Materials* (UL 723). Testing was conducted at the Fire Technology Department of Southwest Research Institute (SwRI), located in San Antonio, Texas.

This standard should be used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions and should not be used to describe or appraise the fire-hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of the test may be used as elements of a fire-hazard assessment or a fire-risk assessment, which takes into account all of the factors that are pertinent to an assessment of the fire hazard or fire risk of a particular end use.

The results apply specifically to the specimens tested, in the manner tested, and not to the entire production of these or similar materials, nor to the performance when used in combination with other materials.

2.0 SAMPLE DESCRIPTION

SwRI received three panels of the material on March 14, 2023, in ready-to-test condition. The samples are described below in Table 1. The panels were conditioned to a constant mass at an ambient temperature of 23 °C ± 3°C and a relative humidity of 50 % ± 5 %. Constant mass was achieved on March 17, 2023.

Table 1. Sample Description.

Material ID	Nominal Tested Dimensions*	Nominal Density	Test Side	Color
Serial No. 2001b (Trimer PET-cored panel with Technofire 60152C)	Each piece measuring: 2,438 × 610 × 31.75 mm	36 lb/ft³	Gray colored side	Gray

*Assessed by SwRI personnel.

3.0 TEST PROCEDURE AND SETUP

This test procedure exposes a material in a horizontal, rectangular apparatus that is 25 ft × 17-3/4 in × 12 in (L × W × H). The apparatus is equipped with two gas burners at one end that direct a flame onto the surface of the material under a controlled airflow. As the test progresses, the possibility of flame spread along the surface of the material may occur. The distance of flame travel and the rate at which the flame front advances during the 10 min exposure determines the calculated flame spread index. The smoke developed measurement is calculated based on a photometer system consisting of a white light source and photocell mounted in the apparatus. The output of the photoelectric cell is proportional to the smoke, soot particulate, and other effluent passing between the light source and photocell. The samples were mounted end-to-end in the furnace, and a cement board was placed on the unexposed side of the specimen to protect the furnace lid assembly.

4.0 TEST RESULTS

Testing was conducted on March 27, 2023, for the material identified as *Serial No. 2001b (Trimer PET-cored panel with Technofire 60152C)*. The results for Flame Spread Index (FSI) and Smoke Developed Index (SDI) are presented below in Table 2. Detailed test results can be found in Appendix A and photographic documentation is provided in Appendix B. The ASTM E84 standard does not contain a performance criteria, however; the two model building codes (International Building Code®, Chapter 8 *Interior Finishes*, Section 803 *Wall and Ceiling Finishes*; NFPA 5000, Chapter 10 *Interior Finish*, Section 10.2.3.3, *Interior Wall and Ceiling Finish Materials Tested in Accordance with ASTM E84 or UL 723.*) classify materials based on the Flame Spread and Smoke Developed indices, however, there is not necessarily a relationship between these two measurements.

Table 2. Classification and Summary of Test Results.

Classification per Section 803.1.2 of IBC		
Rating	**FSI**	**SDI**
A	0 – 25	0 – 450
B	26 – 75	0 – 450
C	76 – 200	0 – 450
Test Results		
Material ID	**FSI**	**SDI**
Serial No. 2001b (Trimer PET-cored panel with Technofire 60152C)	15	400

APPENDIX A

TEST RESULTS

(CONSISTING OF 2 PAGES)

TEST RESULTS

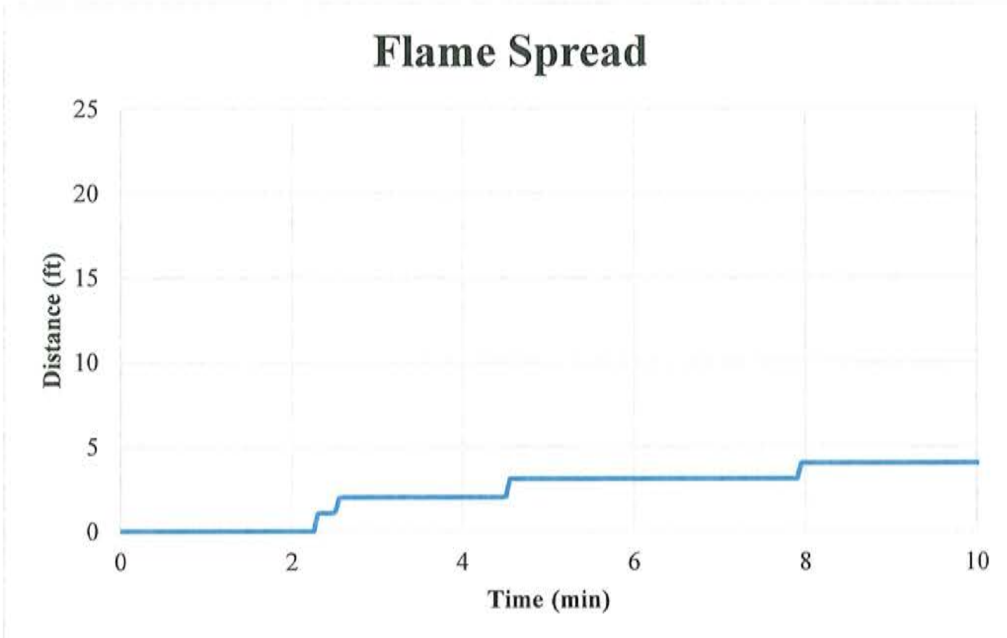
Rounded FSI:	15
Rounded SDI:	400

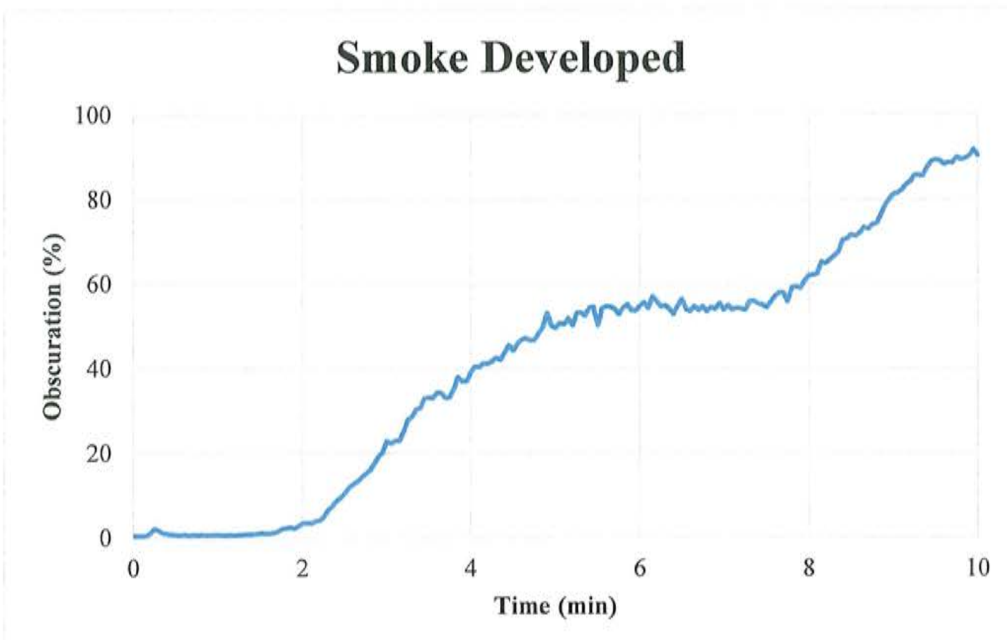
TEST DATA

Unrounded FSI:	13
Unrounded SDI:	417
FS*Time Area (ft*Min):	24.31
Smoke Area (%*Min):	433.06
Fuel Area (°F*Min):	2017.53

OBSERVATIONS DURING TEST

Ignition Time (min: s):	01:40
Maximum Flame Front Advance (ft):	4
Time to Maximum Advance (min: s):	08:33
Maximum Temp. at Exposed TC (°F):	559
Time to Maximum Temp. (min: s):	10:00
Dripping (min: s):	None
Flaming on Floor (min: s):	None
After-flame Top (min: s):	10:00+
After-flame Floor (min: s):	None
Sagging (min: s):	None
Delamination (min: s):	None
Shrinkage (min: s):	None
Fallout (min: s):	None
Charring (min: s):	00:05
Melting (min: s):	None


Flame Spread
25
20
15
10
5
0
Distance (ft)
0
2
4
6
8
10
Time (min)


Smoke Developed
100
80
60
40
20
0
Obscuration (%)
0
2
4
6
8
10
Time (min)

APPENDIX B

PHOTOGRAPHIC DOCUMENTATION

(CONSISTING OF 1 PAGE)

Figure B-1. Exposed side of the material before fire exposure.

Figure B-2. Exposed side of the material after fire exposure.

APPENDIX C

E119 Mini Test Report

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CHEMISTRY AND CHEMICAL ENGINEERING

FIRE TECHNOLOGY DEPARTMENT
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April 27, 2023

Mr. Eric Ball
Orenco Composites
814 Airway Ave.
Sutherlin, OR 97479

Subject: SwRI® Project No. 01.27685.23.304

TEST DATA
(Consisting of 13 Pages)

Dear Mr. Ball:

A fire performance screening evaluation of four *Orenco Systems* panels was conducted on April 18, 2023 for Orenco Composites, located in Sutherlin, Oregon, at Southwest Research Institute's (SwRI) Fire Technology Department, located in San Antonio, Texas. The test was performed in general accordance with ASTM E119-22, *Standard Test Methods for Fire Tests of Building Construction and Materials*. The test was conducted in general accordance due to a reduced sample size and instrumentation.

The test samples were provided in a ready-to-test condition by Orenco Composites and were received by SwRI on March 30, 2023. The four samples, each measuring nominally 2 × 2 ft, were placed into a moveable test frame which exposed the center 20 × 20 in. area of each sample to the furnace conditions. Two thermocouples (TCs), designed in accordance with ASTM E119, were located on the unexposed surface of each sample as shown in Figure 1. Table 1 provides Orenco Composites identification of the four samples, as well as their corresponding TC numbers and sample descriptions.

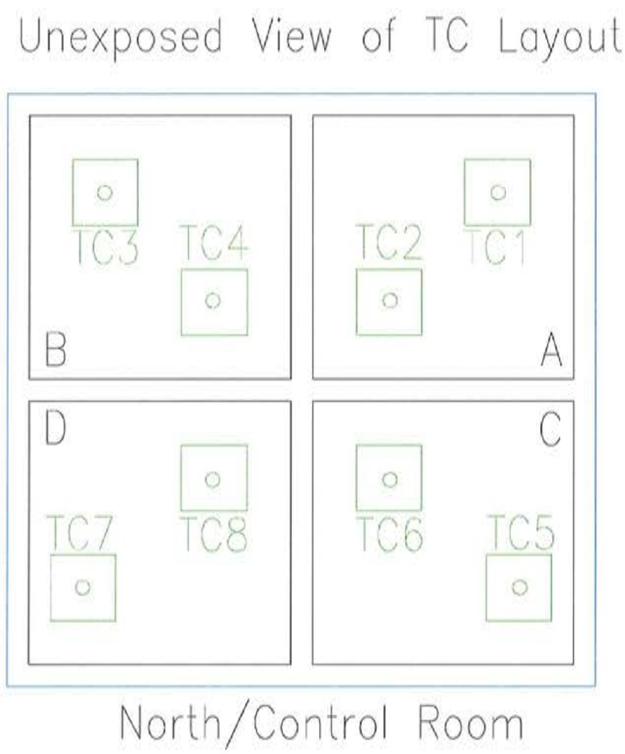


Figure 1. Sample and Thermocouple Locations.

Table 1. Client-Provided Sample Identification.

Sample ID.	TC Nos.	Sample Descriptions
A	1 and 2	Serial No. 3001a-Trimer PET-cored panel with ceramic Hybrid RED coating
B	3 and 4	Serial No. 3001b-Trimer PET-cored panel with ceramic Technofire 60152C
C	5 and 6	Serial No. 3001c-Trimer polyiso-cored panel with ceramic Hybrid RED coating
D	7 and 8	Serial No. 3001d-Trimer polyiso-cored panel with ceramic Technofire 60152C

The test frame was placed on top of SwRI's small-horizontal furnace with the coated side of the samples towards the furnace. The samples were exposed to the time-temperature curve of ASTM E119 for a duration of 60 min. Upon completion of the test, the test frame was removed from the furnace, samples were extinguished with a hose and photographed. The test was witnessed virtually by Mr. Eric Ball, representing Orenco Composites.

The acquired data from the test is provided in Appendix A in graphical format, and selected photographs taken before, during, and after the test are provided in Appendix B. Additional photographs, as well test video, have been provided electronically. Visual observations are provided in Table 2.

Table 2. Test Observations.

Time (min:s)	Observations
00:00	Start of test. 10:14 a.m.
05:00	Samples have ignited within the furnace.
10:00	No visible change on the unexposed side.
18:00	Smoke coming from Sample B.
20:00	Smoke also coming from Sample A.
23:00	Discoloration/darkening along the East edge of Sample B.
27:45	Very light smoke coming from Sample A.
28:00	Discoloration/darkening along the East edge of Sample A.
32:46	Discoloration on Sample A is spreading to the North and South edges.
36:00	No visible changes to Samples C and D.
45:00	TC 2 begins to rapidly increase.
48:40	TC 2 exceeds 250 °F temperature rise.
51:20	TC 4 exceeds 250 °F temperature rise.
53:22	Discoloration has spread to the pad of TC 3.
58:52	TC 6 exceeds 250 °F temperature rise.
59:20	TC 7 exceeds 250 °F temperature rise.
60:00	Test ended.

This report describes the testing of the assemblies described in this report and the results obtained. The results presented in this report apply specifically to the materials tested, in the manner tested, and not to the entire production of these or similar materials, nor to the performance when used in combination with other materials.

If you should have any questions or comments or if I can be of further assistance, please feel free to contact me by phone at (210) 522-3718 or by fax at (210) 522-3377.

Sincerely,

CR Karen C. Carpenter Digitally signed by Karen C. Carpenter Date: 2023.04.28 12:49:57 -05'00'

Karen C. Carpenter, M.S., P.E.
Assistant Director
Fire Resistance Section

Approved:

mblais Digitally signed by mblais Date: 2023.04.28 14:30:54 -05'00'

Matthew S. Blais, Ph.D.
Director
Fire Technology Department

KC/las
W:\Fire\REPORTS\Fire Resistance\R27685.23.304.docx

APPENDIX A

GRAPHICAL DATA

(CONSISTING OF 4 PAGES)

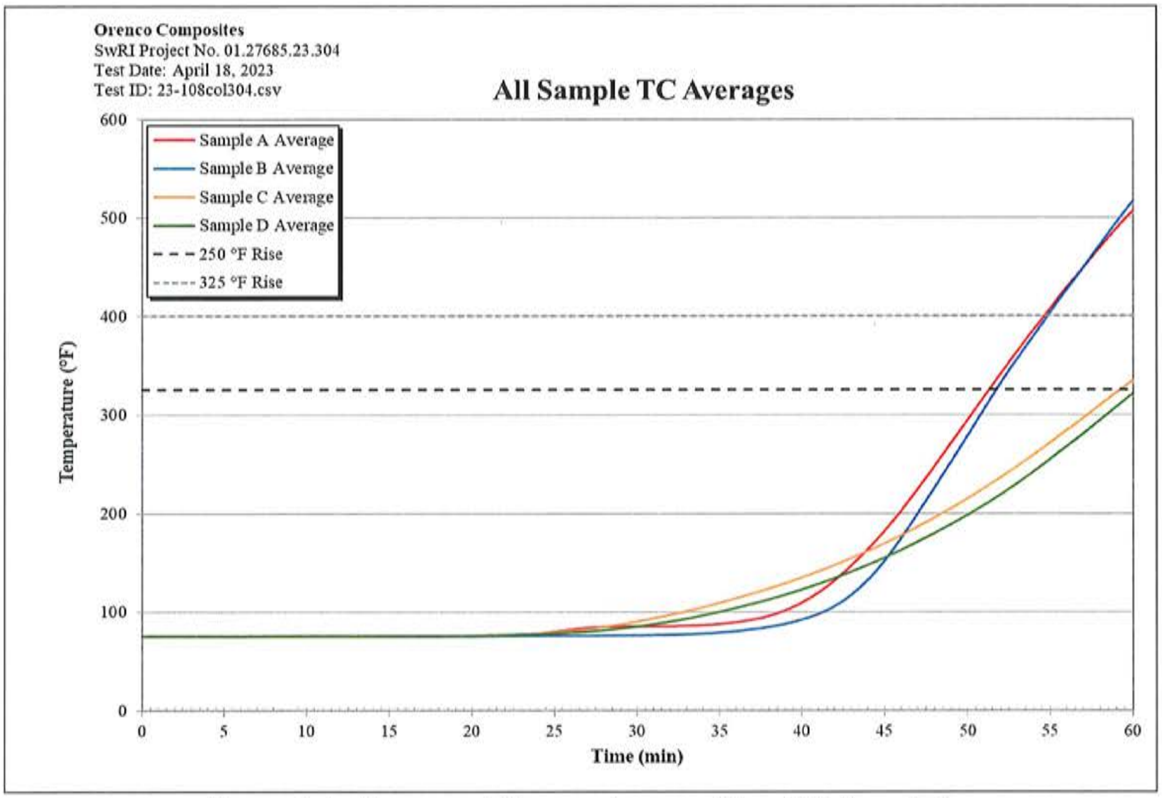


Figure A-1. Unexposed Temperatures vs. Time (All Samples).

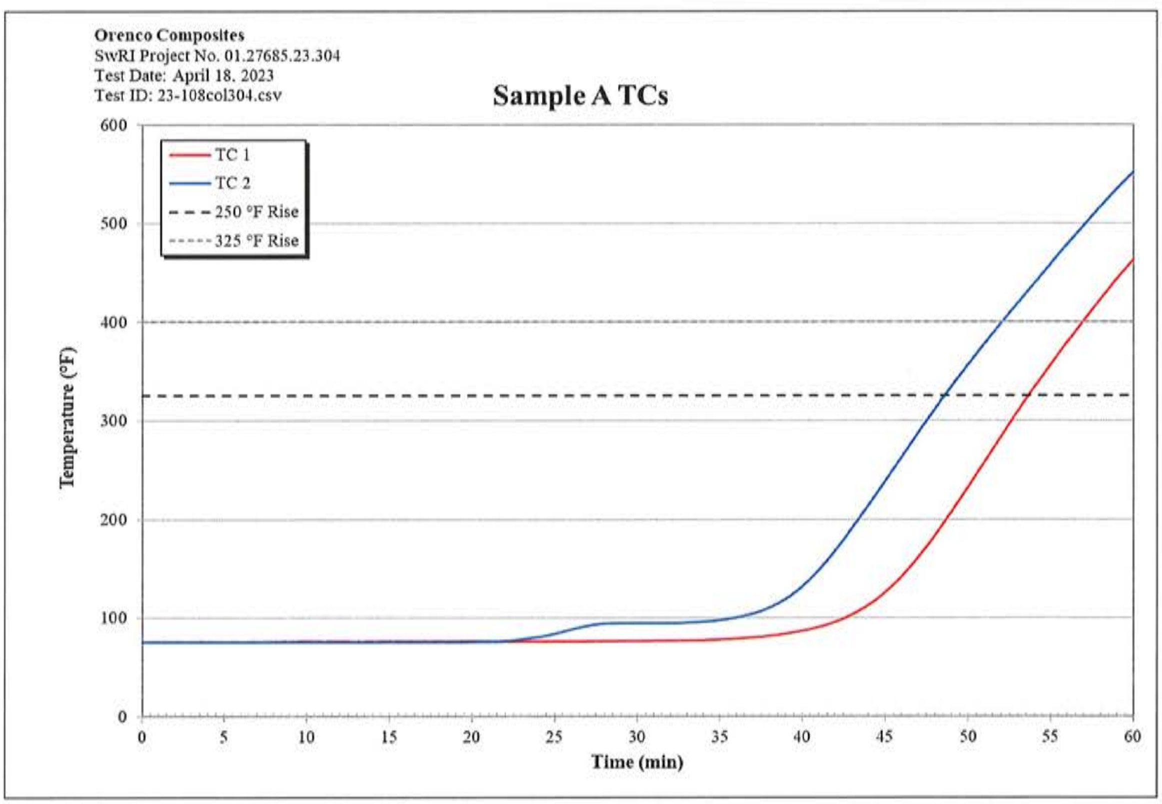


Figure A-2. Unexposed Temperatures vs. Time (Sample A).

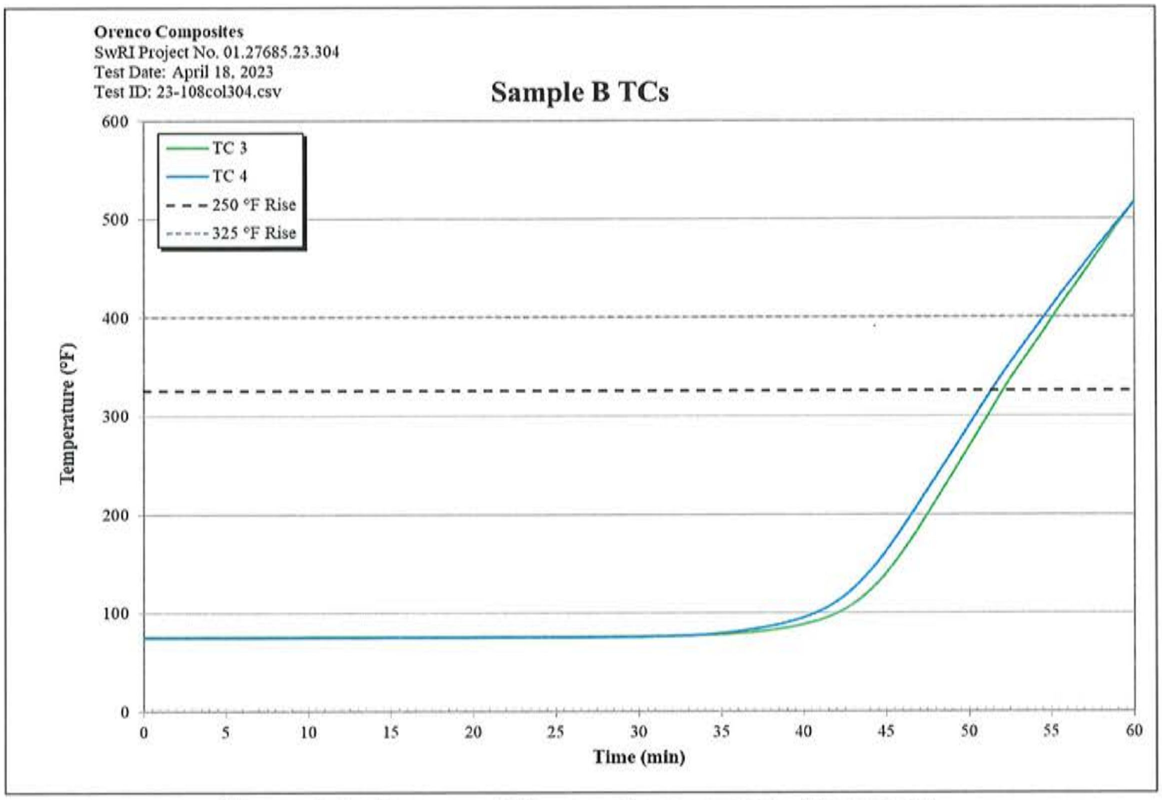


Figure A-3. Unexposed Temperatures vs. Time (Sample B).

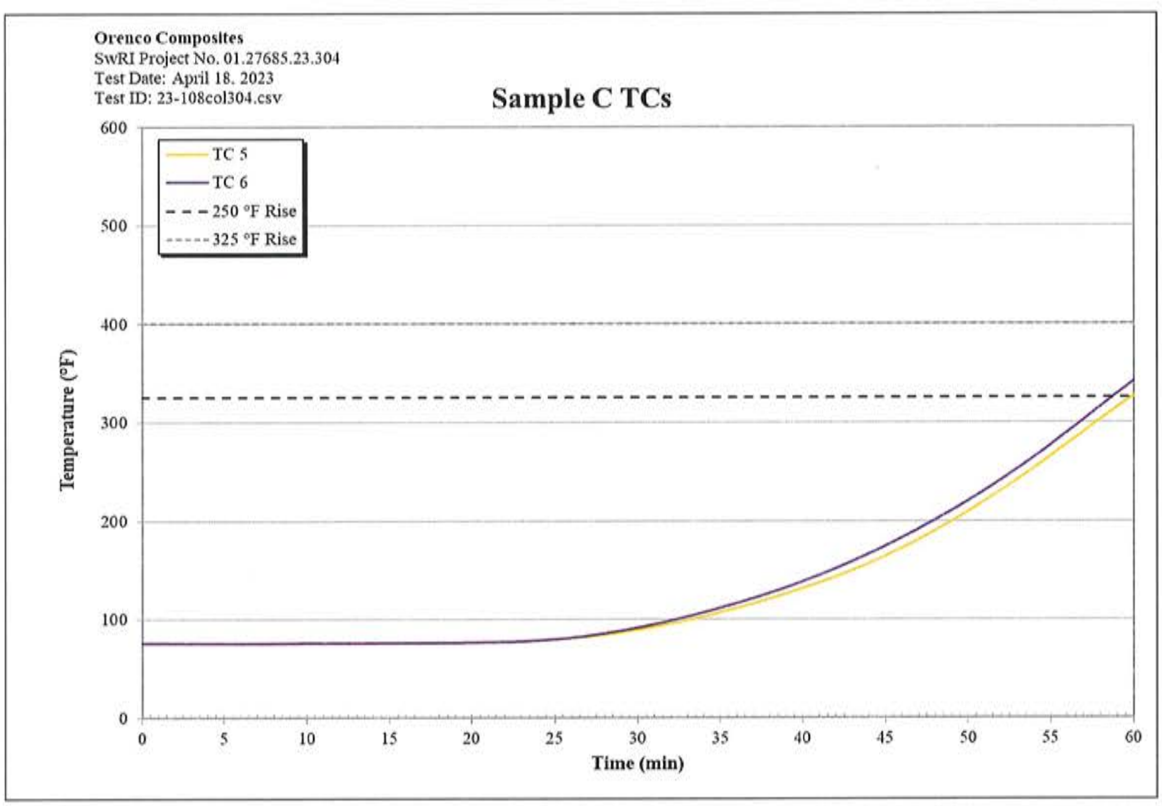


Figure A-4. Unexposed Temperatures vs. Time (Sample C).

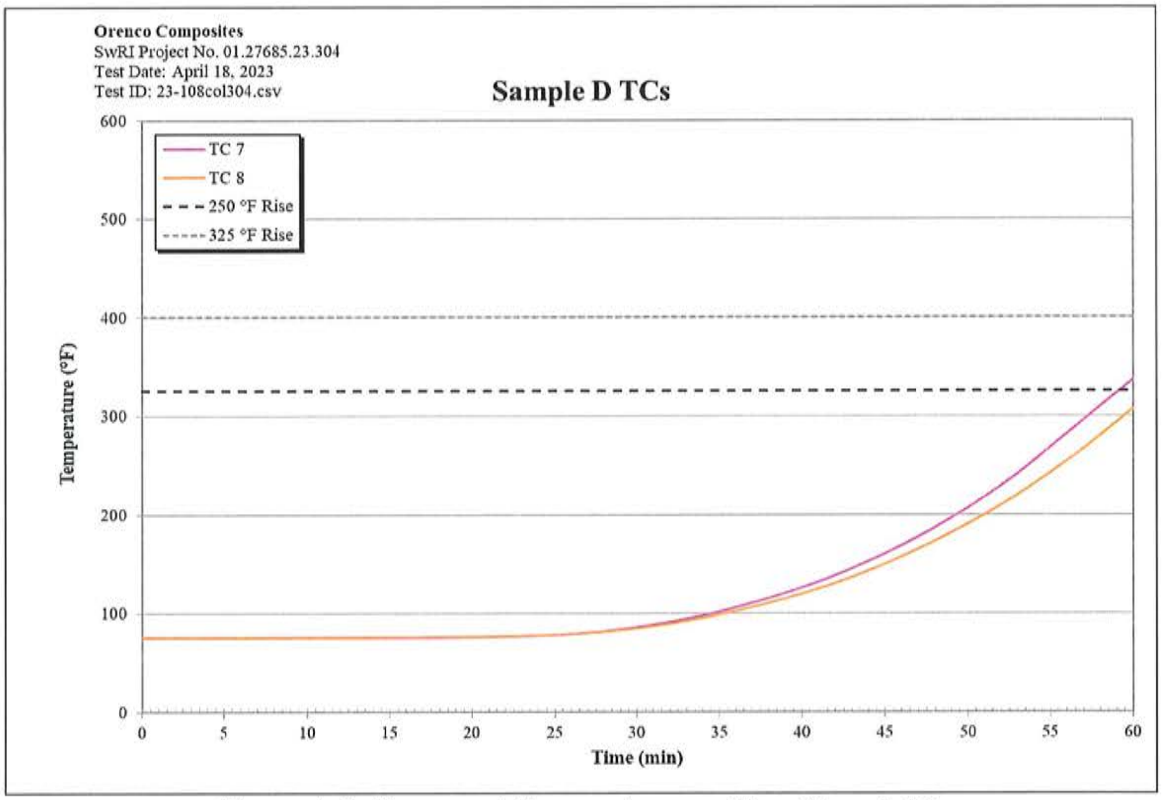


Figure A-5. Unexposed Temperatures vs. Time (Sample D).

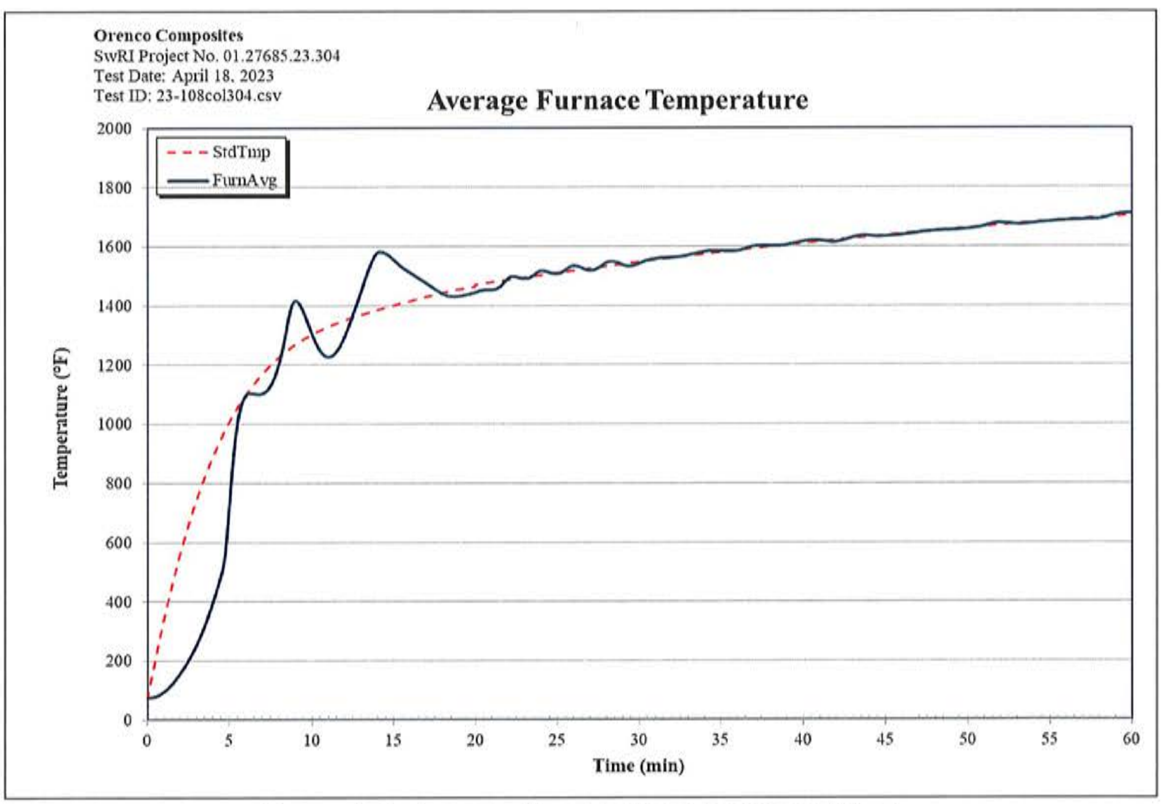


Figure A-6. Average Furnace Temperature vs. Time.

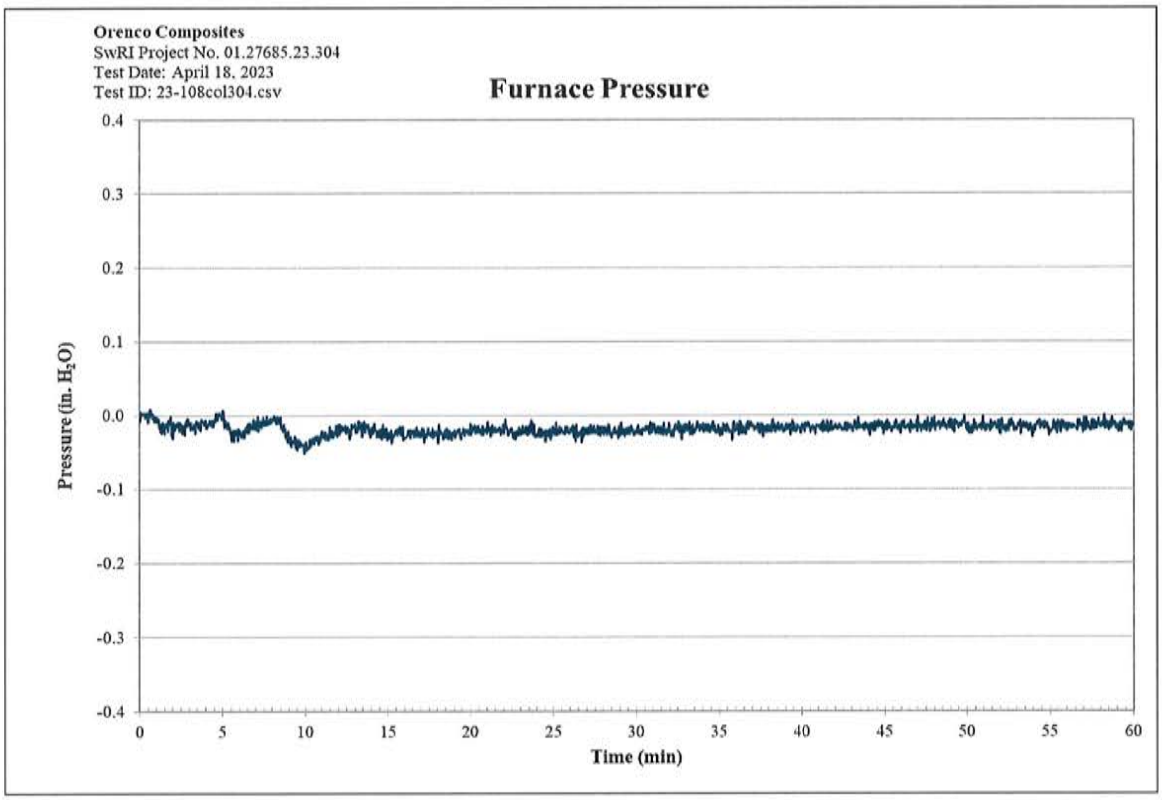


Figure A-7. Furnace Pressure vs. Time.

APPENDIX B

PHOTOGRAPHIC DOCUMENTATION

(CONSISTING OF 4 PAGES)

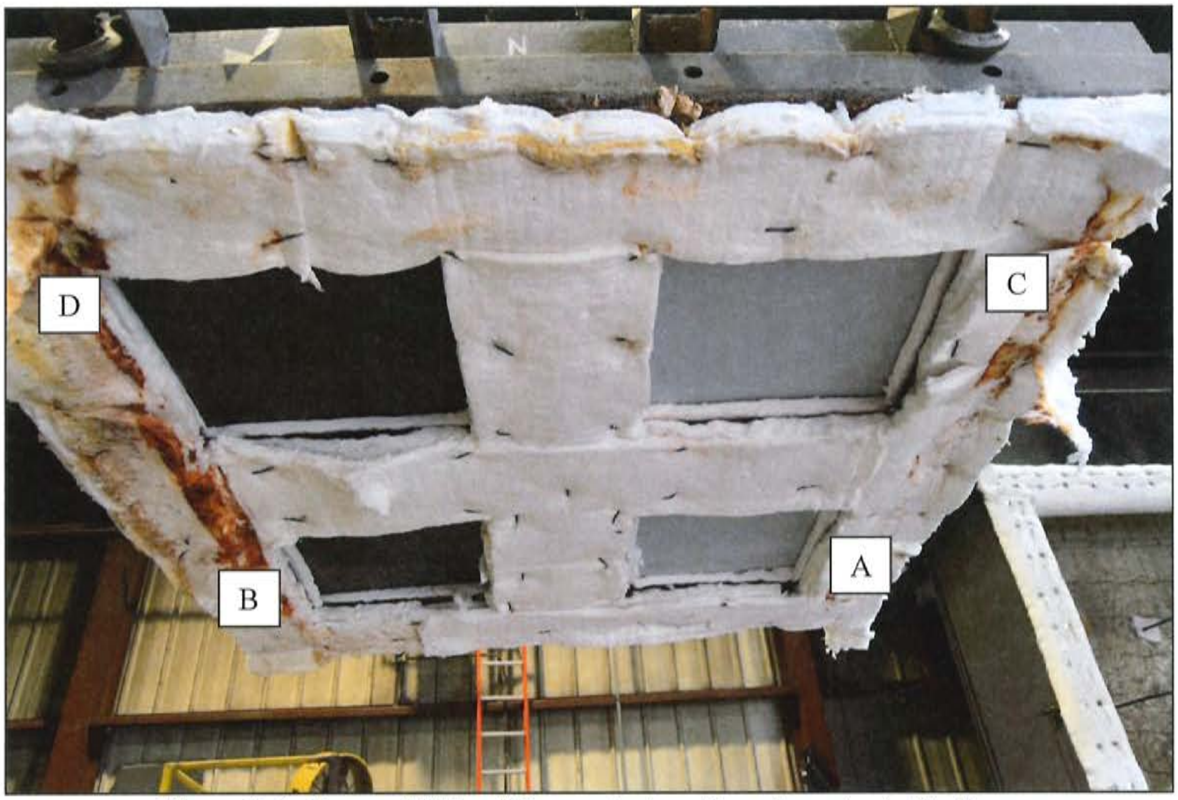


Figure B-1. Exposed Side of *Orenco Systems* Samples prior to Testing.

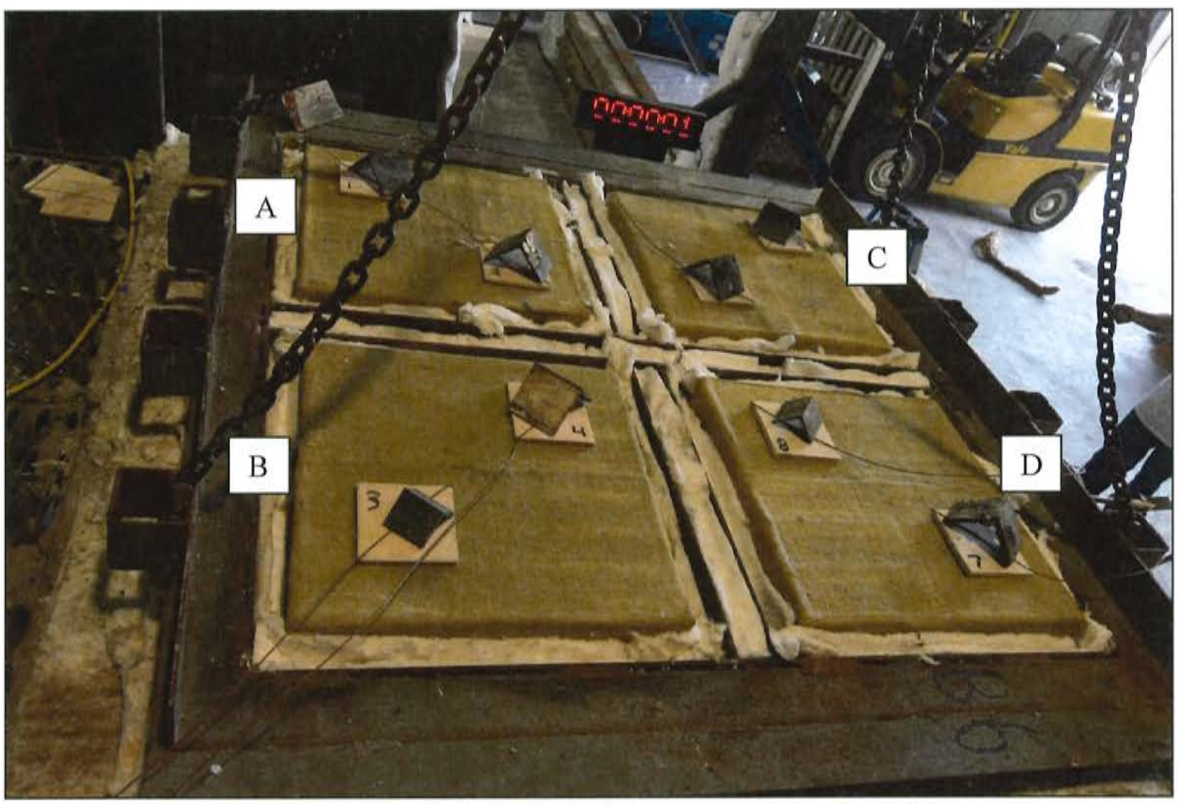


Figure B-2. Unexposed Side of *Orenco Systems* Samples with TCs Installed.

Figure B-3. Unexposed Side of *Orenco Systems* Samples at 20 min into the Test.

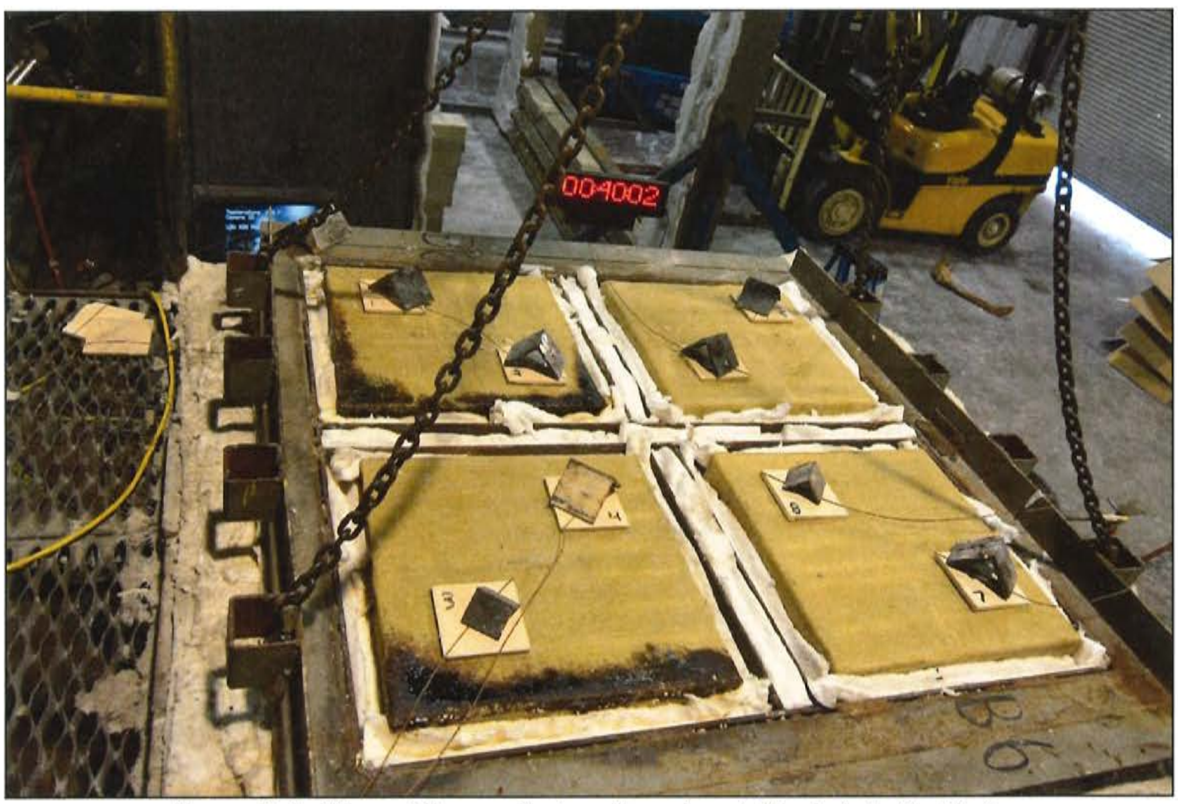


Figure B-4. View of *Orenco Systems* Samples at 40 min into the Test.

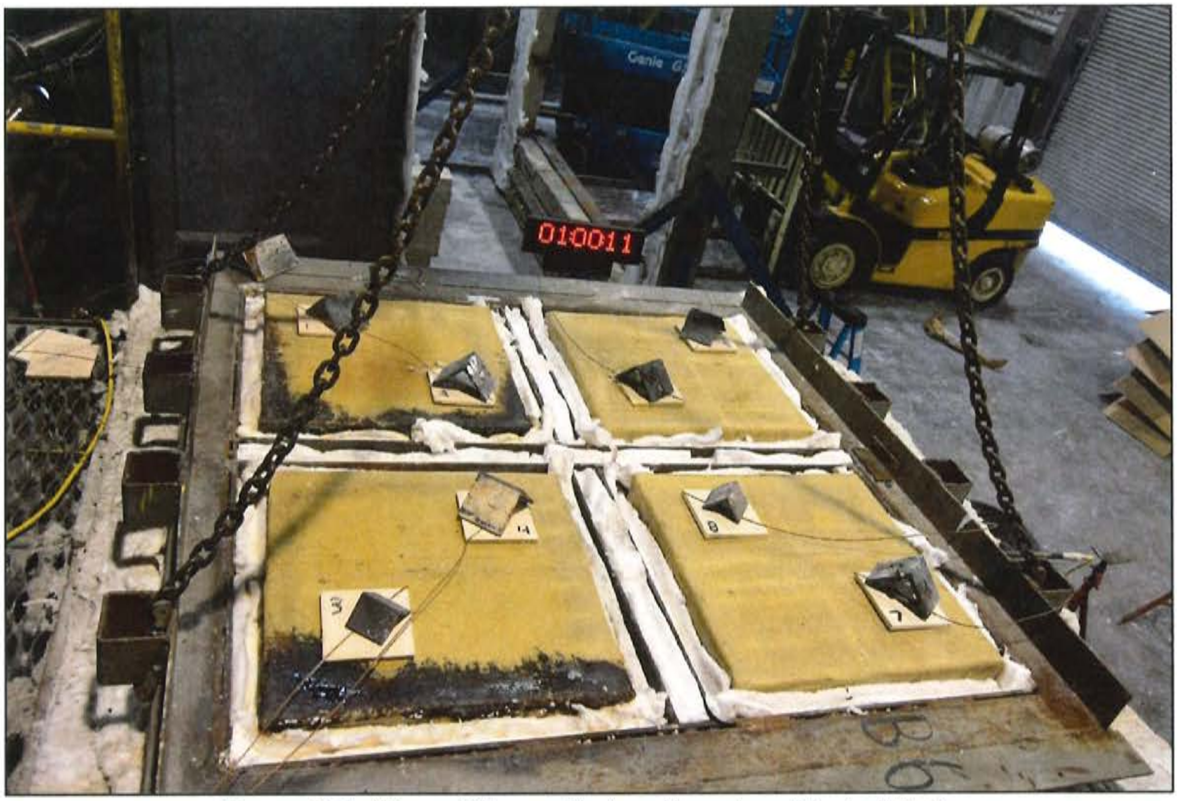
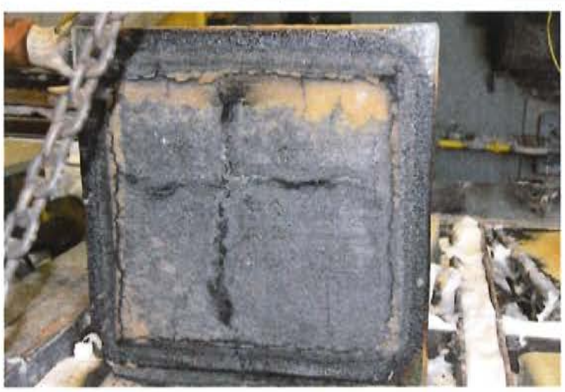


Figure B-5. View of *Orenco Systems* Samples at End of Test.

Figure B-6. View of Exposed Side of Samples during Removal from Furnace

Sample A

Sample B



Sample D

Sample C

Figure B-7. View of Exposed Side of Samples Posttest.

APPENDIX D

ASTM E119 Test Report

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FIRE PERFORMANCE EVALUATION OF A SYMMETRICAL LOADBEARING WALL ASSEMBLY IDENTIFIED AS *SERIAL NO. 4001B* TESTED IN ACCORDANCE WITH ASTM E119-22, *STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS*

FINAL REPORT
Consisting of 23 Pages

SwRI® Project No. 01.27685.23.304a
Test Date: August 24, 2023
Report Date: September 22, 2023

Prepared for:

Orenco Composites
814 Airway Ave.
Sutherlin, OR 97479

Submitted by:

CR

Karen C. Carpenter

Digitally signed by Karen C. Carpenter
Date: 2023.09.22 09:09:24 -05'00'

Karen C. Carpenter, M.S., P.E.
Assistant Director
Fire Resistance Section

Approved by:

mblais

Digitally signed by mblais
Date: 2023.09.22 10:25:39 -05'00'

Matthew S. Blais, Ph.D.
Director
Fire Technology Department

ABSTRACT

Southwest Research Institute's® (SwRI®) Fire Technology Department, located in San Antonio, Texas, conducted testing on a symmetrical loadbearing wall assembly identified as *Serial No. 4001b (Trimer Resin/Polyiso-Core FRP Wall Panel with Technofire 60152C)* for Orenco Composites, located in Sutherlin, Oregon. Testing was performed in accordance with ASTM E119-22, *Standard Test Methods for Fire Tests of Building Construction and Materials*.

Testing was performed on August 24, 2023 in San Antonio, Texas. The performance criteria of loadbearing walls are specified in Section 8.2.4 of ASTM E119 and is summarized as follows:

- Sustained the applied load during the fire-resistance and hose stream test.
- No passage of flame or gases hot enough to ignite cotton for the entire test duration.
- No openings shall develop during the application of the hose stream which allows passage of water to the unexposed face.
- The average temperature rise on the unexposed surface shall not exceed 250 °F above the initial temperature for the entire test duration.
- The temperature rise at any point on the unexposed surface shall not exceed a rise of 325 °F above the initial temperature for the entire test duration.

No flaming on the unexposed side was observed during the 60 min exposure. A summary of the unexposed-face temperature rise measurements is provided in Table i.

Table i. Temperature Rise Summary.

TC	Initial Temperature	Maximum Temperature	Temperature Rise	ASTM E119 Criteria	Meets Criteria
TC 1	84 °F	234 °F	151 °F	< 325 °F	Yes
TC 2	84 °F	235 °F	152 °F	< 325 °F	Yes
TC 3	83 °F	227 °F	144 °F	< 325 °F	Yes
TC 4	83 °F	211 °F	128 °F	< 325 °F	Yes
TC 5	83 °F	314 °F	231 °F	< 325 °F	Yes
TC 6	83 °F	194 °F	110 °F	< 325 °F	Yes
TC 7	84 °F	190 °F	106 °F	< 325 °F	Yes
TC 8	84 °F	196 °F	113 °F	< 325 °F	Yes
TC 9	84 °F	190 °F	106 °F	< 325 °F	Yes
Avg. TCs 1–9	83 °F	221 °F	138 °F	< 250 °F	Yes

Based on the test results, the symmetrical loadbearing wall assembly identified as *Serial No. 4001b (Trimer Resin/Polyiso-Core FRP Wall Panel with Technofire 60152C)*, tested, as described in this report, achieved a rating of 1 h when tested in accordance with ASTM E119.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 OBJECTIVE

The objective of the test described in this report was to determine the fire resistance of symmetrical loadbearing wall assembly in accordance with ASTM E119-22, *Standard Test Methods for Fire Tests of Building Construction and Materials*, for Orenco Composites, located in Sutherlin, Oregon. Testing was conducted by Southwest Research Institute's (SwRI) Fire Technology Department, located in San Antonio, Texas. The assembly was identified by the Client as *Serial No. 4001b (Trimer Resin/Polyiso-Core FRP Wall Panel with Technofire 60152C).*

2.0 TEST METHOD

The ASTM E119 test method is intended to evaluate the duration for which a building element will contain a fire, or retain its structural integrity, or display both properties dependent upon the type of building element involved, during a predetermined fire exposure time. The test exposes a specimen to a standard fire controlled to achieve specified temperatures throughout a specified period. When required, the fire exposure is followed by the application of a specified standard fire hose stream applied in accordance with ASTM E2226-15b (Reapproved 2019), *Standard Practice for Application of Hose Stream*.

This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled laboratory conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.

This report describes the test results obtained for a loadbearing wall assembly. The performance of the assembly is expressed in terms of the transmission of heat and hot gases during the standard fire exposure and penetration of water to the unexposed side of the assembly during the hose stream test. The results presented in this report apply specifically to the materials tested, in the manner tested, and not to the entire production of these or similar materials, nor to the performance when used in combination with other materials.

3.0 TEST ASSEMBLY

The 12 × 9-ft (w × h) 4¾-in. thick wall assembly was provided fully constructed and was received by SwRI on August 18, 2023. The *Serial No. 4001b* wall assembly was described by Orenco Composites as a "vacuum-infused, web-stiffened FRP wall panel." The Client-provided drawing in Appendix A provides additional constructions and material details for the *Serial No. 4001b* wall assembly.

SwRI personnel placed the wall assembly into a vertical test frame with a floating I-beam located at the top of the test wall. The *Serial No. 4001b* wall was oriented such that the mottled gray side was facing the furnace conditions. Four hydraulic cylinders were placed between the floating I-Beam and the test frame to apply the load to the test wall during the test. The frame was then protected around the perimeter with a 6-lb ceramic fiber blanket. For the test, the frame was secured against SwRI's large-vertical furnace. The wall assembly tested was a symmetrical loadbearing wall with overall dimensions of 12 × 9 ft. Photographs are provided in Appendix C.

4.0 INSTRUMENTATION

The unexposed side of the sample was instrumented with nine thermocouples (TCs) designed in accordance with ASTM E119. One approximately at the center of the wall, one at approximately the center of each quarter section and one approximately placed intermediately between each quarter section. The TCs were attached to the wall using fine thread bugle head screws at two of the corners. A drawing of the TC layout is provided in Figure 1.

The vertical deflection of the wall was measured and recorded using a string potentiometer located at the center of the wall. A pressure transducer was used to measure and record the pressure of the hydraulic jacks. A computer-based data acquisition system was used to record the applied load, displacement, pressure and temperature measurements.

5.0 TEST RESULTS

Test Date: August 24, 2023

Test Witnesses: Mr. Eric Ball, representing Orenco Composites and Mr. Henry Sodano, representing Trimer Technologies, LLC

Ambient Temperature: 79 °F

Relative Humidity: 94%

Load: A load of 450 lb/ft, including a dead load, was applied using four hydraulic jacks which resulted in a total load of 5,400 lb. Based on calibration of the cylinders, a hydraulic pressure of 88 psi was targeted. The jacks were placed at the top of the assembly so that the load would be applied from the top. The load was applied just prior to testing and remained throughout the fire resistance and hose stream tests. Based on the recorded data, the actual applied load was 460 lb/ft.

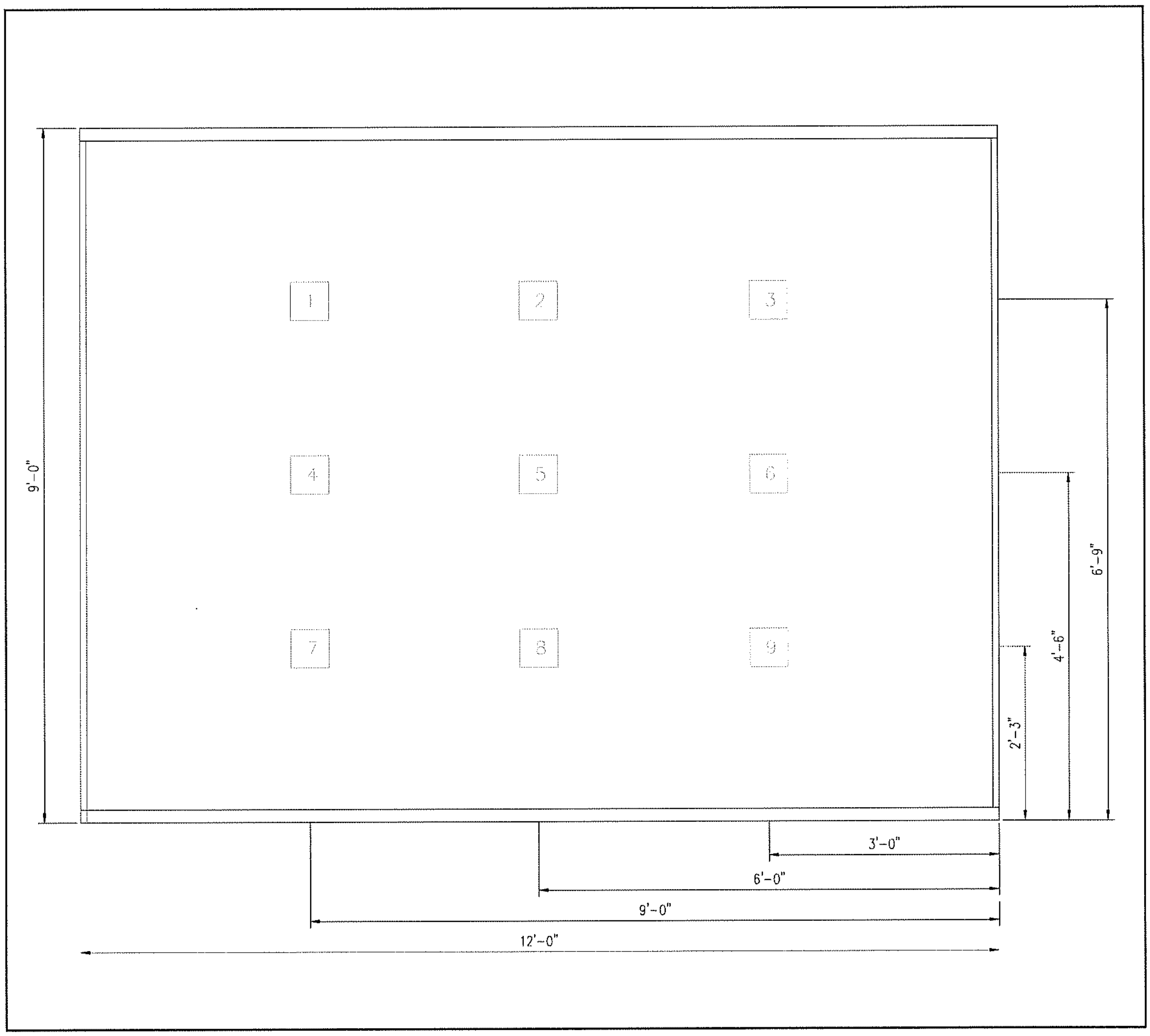


Figure 1. Thermocouple Layout.

Observations: Refer to Table 1. Digital photographs and video the wall assembly have been provided electronically.

Table 1. Fire-Resistance and Hose Stream Test Visual Observations.

Time (min:s)	Observation
00:00	Furnace Ignited. Test Started (9:20 a.m.).
07:48	Puffs of smoke from the top and bottom of the wall.
09:00	Light smoke coming from the upper corners.
11:00	Furnace burners on idle due to combustion of wall.
17:36	Smoke coming from screw hold 6 in. from bottom of wall.
20:00	Visible bowing of the wall away from the furnace.
20:50	Flames visible between gap at bottom of wall and test frame.
21:50	Light smoke from the top of the wall only.
26:00	Gas flow to the burners resumes.
29:15	Glowing along the left edge of the wall.
35:24	Smoke resumes from the hole near the bottom of the wall.
38:24	0.5 in. of deflection.
45:00	Bowing in the center of the bottom edge of the wall.
56:00	0.9 in. of deflection.
57:04	TC 5 is beginning to increase faster than other TCs.
60:00	Tested ended. No flame-through observed. Ending vertical deflection was 0.98 in. Applied load sustained.
63:00	Hose stream test begins. Nozzle water pressure of 30 psi.
64:05	65 s duration hose stream test complete.
Post-Test	No pass through of water to unexposed side is observed. Applied load sustained.

Hose Stream Test: Based on the exposure area of 108 ft^2 (12 × 9 ft), a hose stream test was conducted for a duration of 1 min 5 s with a nozzle pressure of 30 psi. No pass through of water was observed.

Rating Obtained: 60 min (1 h) Loaded

Results: The performance criteria of loadbearing walls are specified in Section 8.2.4 of ASTM E119 and is summarized as follows:

- Sustained the applied load during the fire resistance and hose stream test.
- No passage of flame or gases hot enough to ignite cotton for the entire test duration.

- No openings shall develop during the application of the hose stream which allows passage of water to the unexposed face.
- The average temperature rise on the unexposed surface shall not exceed 250 °F above the initial temperature for the entire test duration.
- The temperature rise at any point on the unexposed surface shall not exceed a rise of 325 °F above the initial temperature for the entire test duration.

No flaming on the unexposed side was observed during the 60 min exposure A summary of the unexposed-face temperature rise measurements is provided in Table 2. The acquired data is located in Appendix B in graphical form.

Table 2. Temperature Rise Summary.

TC	Initial Temperature	Maximum Temperature	Temperature Rise	ASTM E119 Criteria	Meets Criteria
TC 1	84 °F	234 °F	151 °F	< 325 °F	Yes
TC 2	84 °F	235 °F	152 °F	< 325 °F	Yes
TC 3	83 °F	227 °F	144 °F	< 325 °F	Yes
TC 4	83 °F	211 °F	128 °F	< 325 °F	Yes
TC 5	83 °F	314 °F	231 °F	< 325 °F	Yes
TC 6	83 °F	194 °F	110 °F	< 325 °F	Yes
TC 7	84 °F	190 °F	106 °F	< 325 °F	Yes
TC 8	84 °F	196 °F	113 °F	< 325 °F	Yes
TC 9	84 °F	190 °F	106 °F	< 325 °F	Yes
Avg. TCs 1–9	83 °F	221 °F	138 °F	< 250 °F	Yes

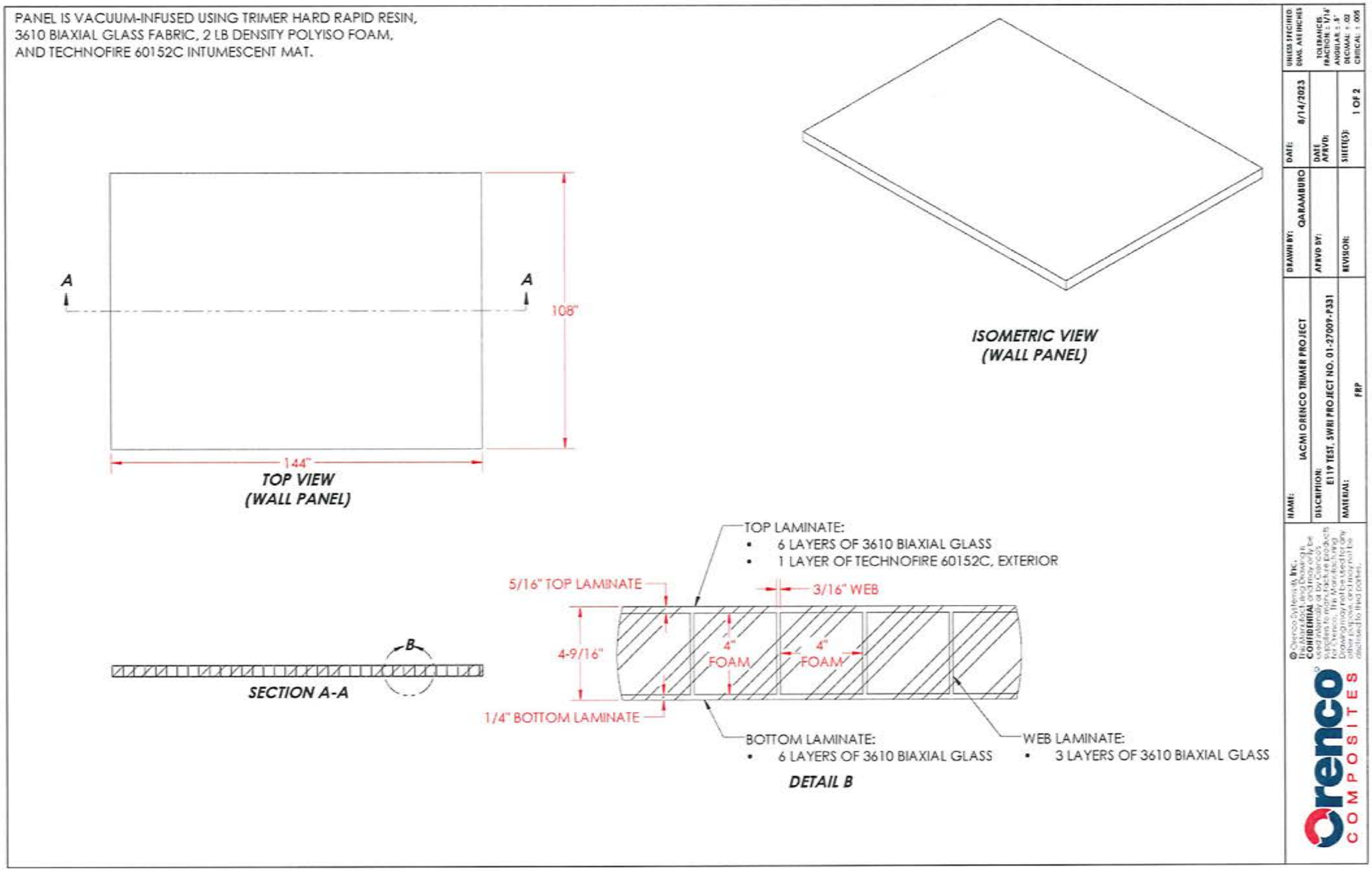
6.0 CONCLUSION

Based on the test results, the symmetrical loadbearing wall assembly identified as *(Trimer Resin/Polyiso-Core FRP Wall Panel with Technofire 60152C)*, tested as described in this report, achieved a rating of 1 h when tested in accordance with ASTM E119.

APPENDIX A

CLIENT-PROVIDED DRAWING

(CONSISTING OF 1 PAGE)


PANEL IS VACUUM-INFUSED USING TRIMER HARD RAPID RESIN,
3610 BIAXIAL GLASS FABRIC, 2 LB DENSITY POLYISO FOAM,
AND TECHNOFIRE 60152C INTUMESCENT MAT.
A
A
108"
144"
TOP VIEW
(WALL PANEL)
ISOMETRIC VIEW
(WALL PANEL)
B
SECTION A-A
TOP LAMINATE:
• 6 LAYERS OF 3610 BIAXIAL GLASS
• 1 LAYER OF TECHNOFIRE 60152C, EXTERIOR
5/16" TOP LAMINATE
3/16" WEB
4-9/16"
4"
FOAM
4"
FOAM
1/4" BOTTOM LAMINATE
BOTTOM LAMINATE:
• 6 LAYERS OF 3610 BIAXIAL GLASS
WEB LAMINATE:
• 3 LAYERS OF 3610 BIAXIAL GLASS
DETAIL B
Orenco COMPOSITES
© Orenco Systems Inc.
NAME: IACMI ORENCO TRIMER PROJECT
DESCRIPTION: E119 TEST, SWRI PROJECT NO. 01-27009-P331
MATERIAL: FRP
DRAWN BY: QARAMBURO
APRVD BY:
REVISION:
DATE: 8/14/2023
DATE APRVD:
SHEET(S): 1 OF 2
UNLESS SPECIFIED: DIMS. ARE INCHES
TOLERANCES: FRACTION: ± 1/16" ANGULAR: ± .5° DECIMAL: ± .02 CRITICAL: ± .005

APPENDIX B

GRAPHICAL TEST DATA

(CONSISTING OF 5 PAGES)

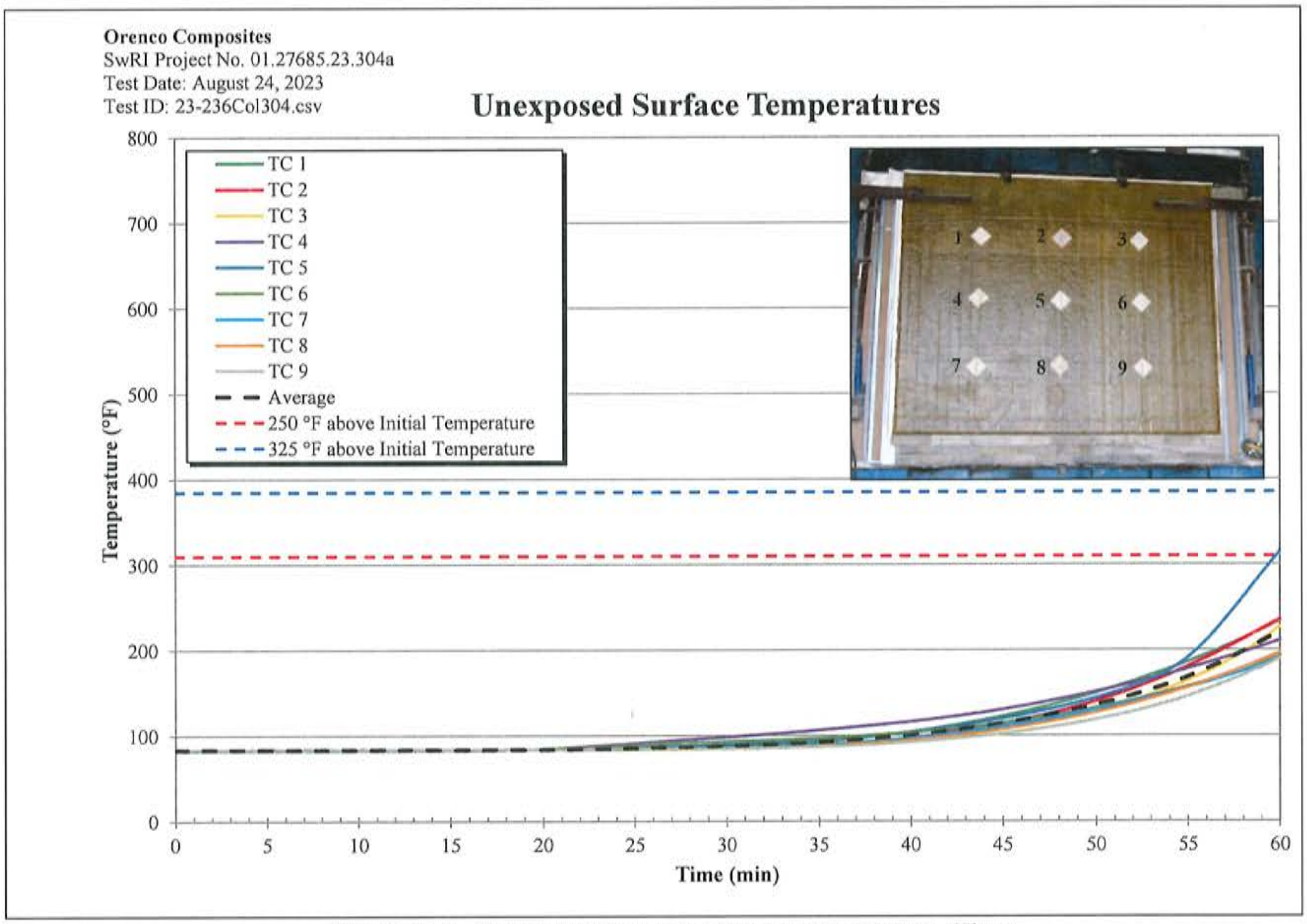


Figure B-1. Unexposed Surface Thermocouples vs. Time.

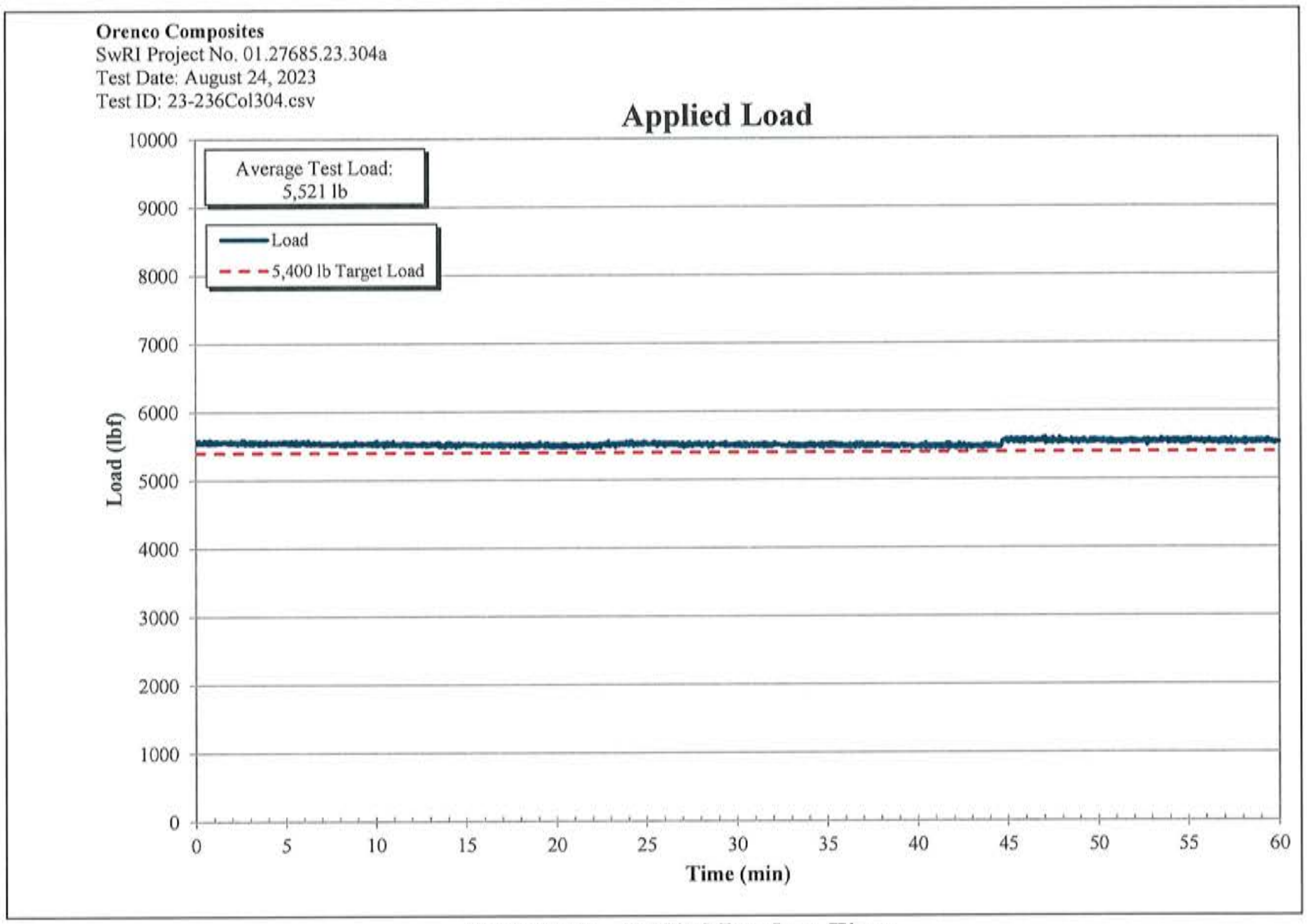


Figure B-2. Applied Load vs. Time.

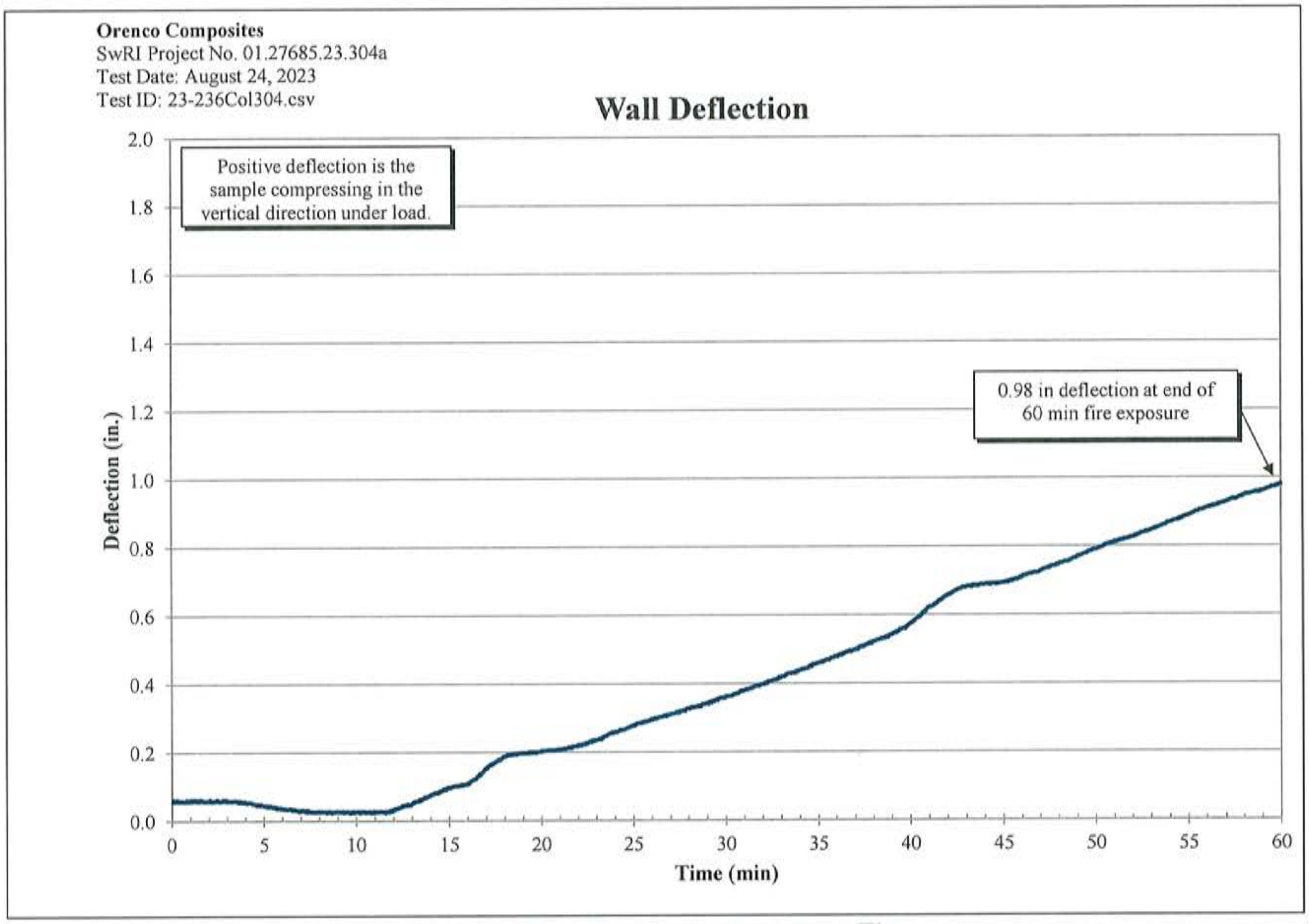


Figure B-3. Sample Deflection vs. Time.

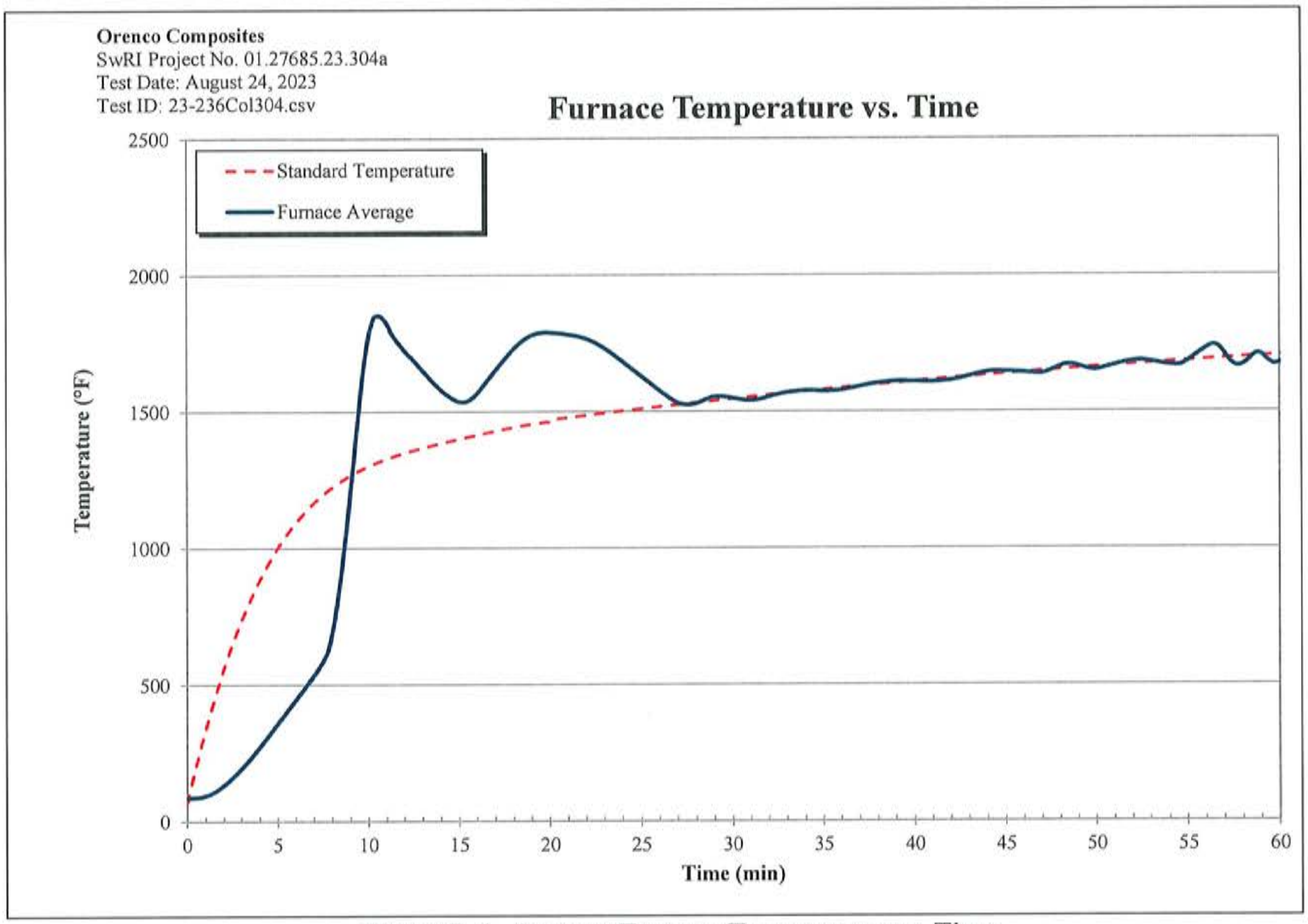


Figure B-4. Average Furnace Temperature vs. Time.

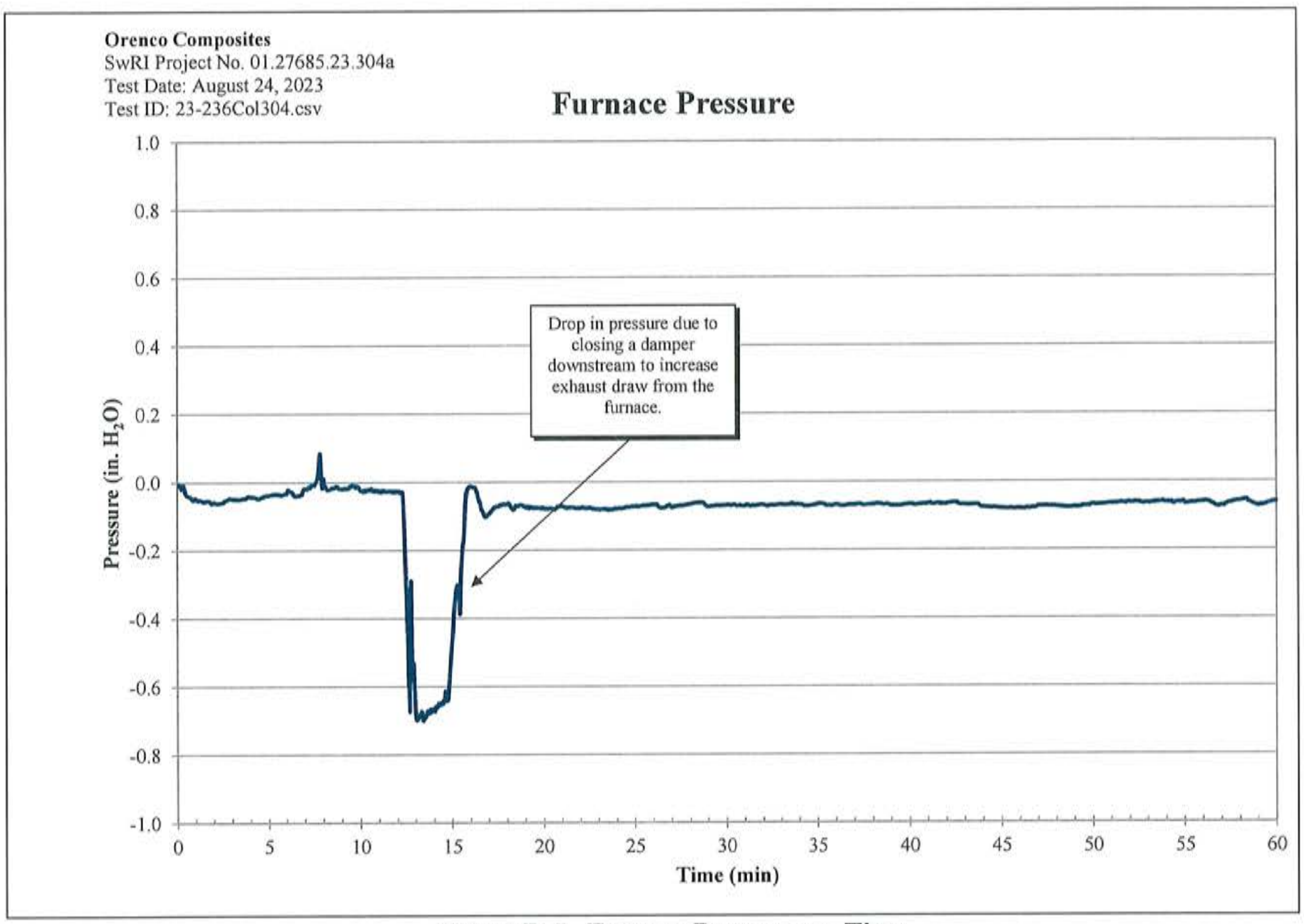


Figure B-5. Furnace Pressure vs. Time.

APPENDIX C

TEST PHOTOGRAPHS

(CONSISTING OF 6 PAGES)

Figure C-1. View of the *Serial No. 4001b* Wall Assembly as Received.

Figure C-2. Exposed Side of *Serial No. 4001b* Wall Assembly prior to Testing.

Figure C-3. Unexposed Side of *Serial No. 4001b* Wall Assembly prior to Testing.

Figure C-4. Unexposed Side of *Serial No. 4001b* Wall Assembly 10 min into Test.

Figure C-5. Lower Edge of *Serial No. 4001b* Wall Assembly 29 min into Test.

Figure C-6. Unexposed Side of *Serial No. 4001b* Wall Assembly 31 min into Test.

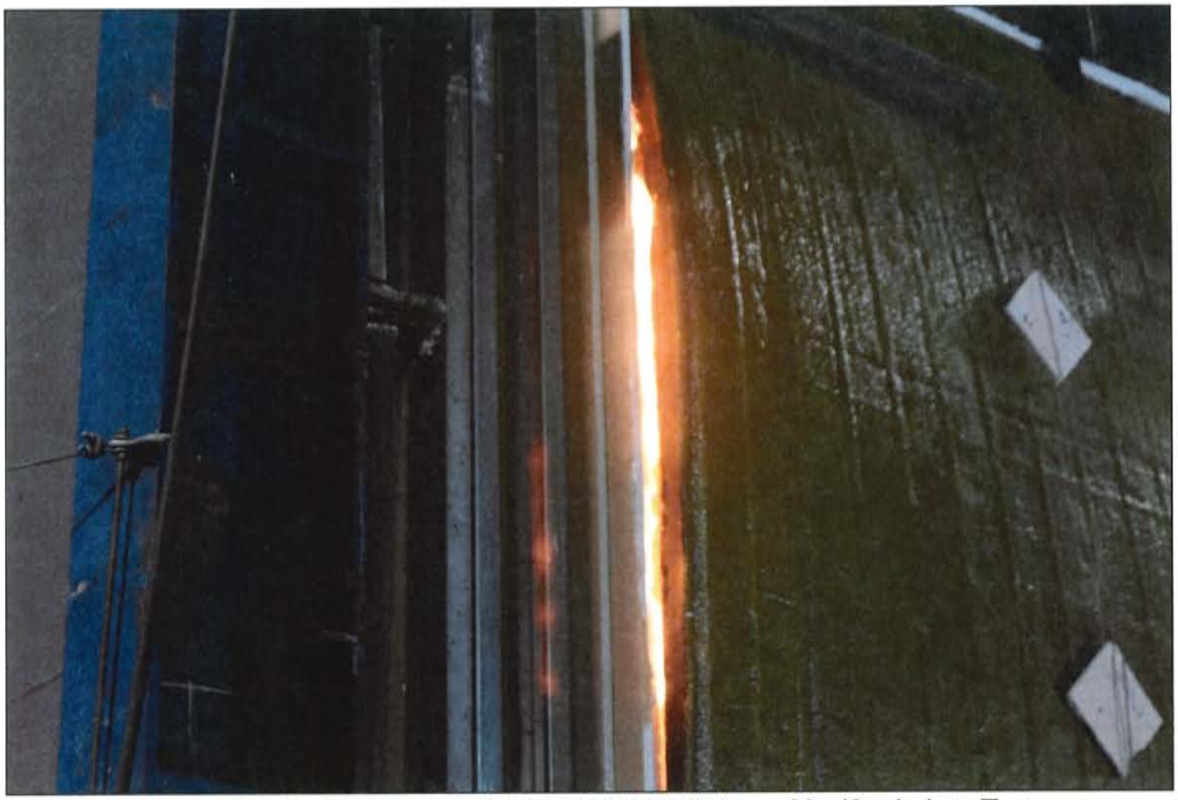


Figure C-7. Left Edge of *Serial No. 4001b* Wall Assembly 43 min into Test.

Figure C-8. Unexposed Side of *Serial No. 4001b* Wall Assembly 1 h into Test.

Figure C-9. Exposed Side of *Serial No. 4001b* Wall Assembly prior to Hose Stream Test.

Figure C-10. Hose Stream Test in Progress.

Figure C-11. Unexposed Side of *Serial No. 4001b* Wall Assembly after Hose Stream Test.

Figure C-12. Exposed Side of *Serial No. 4001b* Wall Assembly after Hose Stream Test.

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FIRE PERFORMANCE EVALUATION OF A LOADBEARING FLOOR ASSEMBLY IDENTIFIED AS *SERIAL NO. 4001A* TESTED IN ACCORDANCE WITH ASTM E119-22, *STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS*

FINAL REPORT
Consisting of 23 Pages

SwRI® Project No. 01.27685.23.304b
Test Date: August 24, 2023
Report Date: September 22, 2023

Prepared for:

Orenco Composites
814 Airway Ave.
Sutherlin, OR 97479

Submitted by:

CR Karen C. Carpenter
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Date: 2023.09.22 09:09:08 -05'00'

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Matthew S. Blais, Ph.D.
Director
Fire Technology Department

ABSTRACT

Southwest Research Institute's (SwRI) Fire Technology Department, located in San Antonio, Texas, conducted testing on an unrestrained loadbearing floor assembly identified as *Serial No. 4001a (Trimer Resin/Polyiso-Core FRP Floor Panel with Technofire 60152C)* for Orenco Composites, located in Sutherlin, Oregon. Testing was performed in accordance with ASTM E119-22, *Standard Test Methods for Fire Tests of Building Construction and Materials*.

Testing was performed on August 24, 2023 in San Antonio, Texas. The performance criteria of unrestrained loadbearing floors are specified in Section 8.6.6 of ASTM E119. The criteria applicable to this assembly is summarized as follows:

- Sustained the applied load during the fire-resistance test.
- No passage of flame or gases hot enough to ignite cotton for the entire test duration.
- The average temperature rise on the unexposed surface shall not exceed 250 °F above the initial temperature for the entire test duration.
- The temperature rise at any point on the unexposed surface shall not exceed a rise of 325 °F above the initial temperature for the entire test duration.

At 56 min and 56 s, flames were observed on the unexposed side. A summary of the unexposed-face temperature rise measurements is provided in Table i.

Table i. Temperature Rise Summary.

TC	Initial Temperature	Maximum Temperature	Temperature Rise	ASTM E119 Criteria	Meets Criteria
TC 1	98 °F	222 °F	124 °F	< 325 °F	Yes
TC 2	97 °F	234 °F	138 °F	< 325 °F	Yes
TC 3	97 °F	257 °F	160 °F	< 325 °F	Yes
TC 4	85 °F	96 °F	11 °F	< 325 °F	Yes
TC 5	94 °F	123 °F	29 °F	< 325 °F	Yes
TC 6	94 °F	150 °F	56 °F	< 325 °F	Yes
TC 7	94 °F	145 °F	51 °F	< 325 °F	Yes
TC 8	96 °F	173 °F	77 °F	< 325 °F	Yes
TC 9	96 °F	189 °F	93 °F	< 325 °F	Yes
Avg. TCs 1–9	94 °F	177 °F	82 °F	< 250 °F	Yes

Based on the test results, the unrestrained loadbearing floor assembly identified as *Serial No. 4001a (Trimer Resin/Polyiso-Core FRP Floor Panel with Technofire 60152C)*, tested, as described in this report, achieved a rating of 57 min when tested in accordance with ASTM E119.

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1.0 OBJECTIVE

The objective of the test described in this report was to determine the fire resistance of unrestrained loadbearing floor assembly in accordance with ASTM E119-22, *Standard Test Methods for Fire Tests of Building Construction and Materials*, for Orenco Composites, located in Sutherlin, Oregon. Testing was conducted by Southwest Research Institute's (SwRI) Fire Technology Department, located in San Antonio, Texas. The assembly was identified by the Client as *Serial No. 4001a (Trimer Resin/Polyiso-Core FRP Floor Panel with Technofire 60152C).*

2.0 TEST METHOD

The ASTM E119 test method is intended to evaluate the duration for which a building element will contain a fire, or retain its structural integrity, or display both properties dependent upon the type of building element involved, during a predetermined fire exposure time. The test exposes a specimen to a standard fire controlled to achieve specified temperatures throughout a specified period.

This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled laboratory conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.

This report describes the test results obtained for an unrestrained loadbearing floor assembly. The performance of the assembly is expressed in terms of the transmission of heat and hot gases during the standard fire exposure and penetration of water to the unexposed side of the assembly during the hose stream test. The results presented in this report apply specifically to the materials tested, in the manner tested, and not to the entire production of these or similar materials, nor to the performance when used in combination with other materials.

3.0 TEST ASSEMBLY

The 12¾ × 15¾-ft (w × h), 4¾-in. thick floor assembly was provided fully constructed and was received by SwRI on August 18, 2023. The *Serial No. 4001a Floor Assembly* was described by Orenco Composites as a "vacuum-infused, web-stiffened FRP floor panel." The Client-provided drawing in Appendix A provides additional constructions and material details for the *Serial No. 4001a* floor assembly.

SwRI personnel placed the floor assembly into a reaction frame such that each side was supported by the frame but was left in an unrestrained condition. The *Serial No. 4001a* floor was oriented such that the mottled gray side was facing the furnace conditions. A hydraulic load frame consisting of 12 cylinders with 24 load contact point was used to apply a total load of 40 lb/ft^2. The load was distributed using 6 × 6-in. steel squares placed on 6 × 10 in. sections of dimensional lumber. For the test, the frame was secured against SwRI's large-horizontal furnace. The floor assembly tested was an unrestrained loadbearing floor with overall dimensions of 12¾ × 15¾ ft. Photographs are provided in Appendix C.

4.0 INSTRUMENTATION

The unexposed side of the sample was instrumented with nine thermocouples (TCs) designed in accordance with ASTM E119. One approximately at the center of the floor, one at approximately the center of each quarter section and one approximately placed intermediately between each quarter section. The TCs were held in place on the floor using pieces of steel angle placed on the felted pads. A drawing of the TC layout is provided in Figure 1.

The vertical deflection of the floor was measured and recorded using a string potentiometer located at the center of the floor. A pressure transducer was used to measure and record the pressure of the hydraulic jacks. A computer-based data acquisition system was used to record the applied load, displacement, and pressure and temperature measurements.

5.0 TEST RESULTS

Test Date: August 24, 2023

Test Witnesses: Mr. Eric Ball, representing Orenco Composites and Mr. Henry Sodano, representing Trimer Technologies, LLC

Ambient Temperature: 97 °F

Relative Humidity: 44%

Load: A load of 40 lb/ft^2, including a dead load, was applied using four hydraulic jacks. Based on calibration of the cylinders, a hydraulic pressure of 200 psi was targeted. The jacks were placed at the top of the assembly so that the load would be applied from the top. The load was applied just prior to testing and remained throughout the fire resistance test. Based on the recorded data, the actual applied load was 41 lb/ft^2.

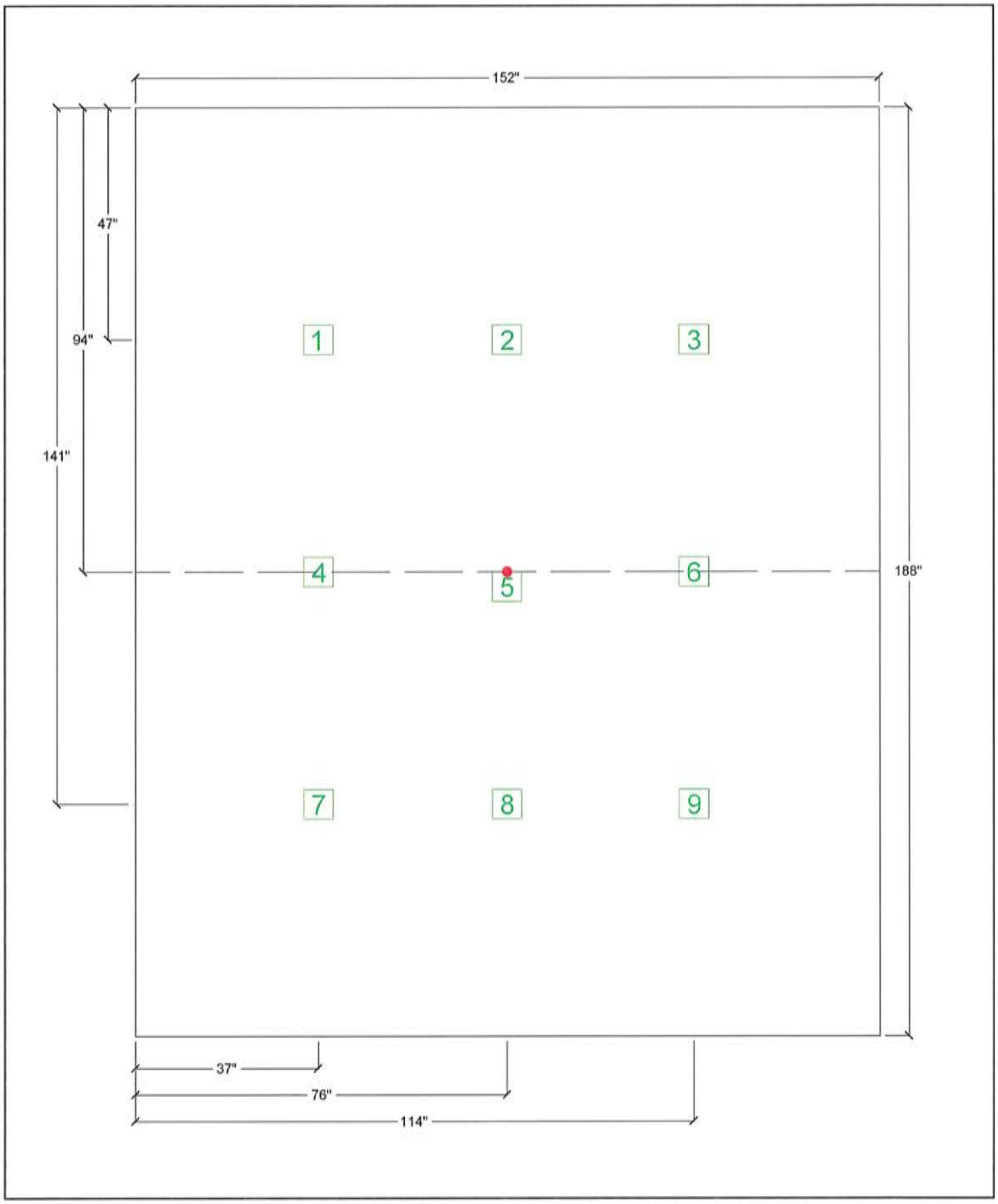

Figure 1. Thermocouple Layout.

Observations: Refer to Table 1. Digital photographs and video of the floor assembly have been provided electronically.

Table 1. Fire-Resistance and Hose Stream Test Visual Observations.

Time (min:s)	Observation
00:00	Furnace Ignited. Test Started (2:20 p.m.).
03:45	Ignition of the sample. Puff of dark, black, smoke.
04:30	Furnace burners on idle due to combustion of floor.
05:56	Four furnace burners turned off to decrease temperature.
10:00	Two additional burners are turned off.
13:00	Two additional burners are turned off. A total of eight are off.
15:00	Smoke begins to come through the floor seam.
21:00	Gas flow to the furnace burners resumes.
28:00	Two burners are turned back on.
32:00	Smoke continues to come from the seam between TCs 5 and 6.
35:30	Two additional burners are turned back on.
40:58	2 in. of deflection.
45:00	2.5 in. of deflection.
46:36	Increasing smoke along the floor seam.
48:00	3 in. of deflection.
51:30	4 in. of deflection.
51:44	Smoke coming through the seam increases.
52:50	4.5 in. of deflection.
54:08	5 in. of deflection.
56:56	Flames on the unexposed side at the seam.
57:00	Test ended.

Rating Obtained: 57 min Unrestrained Loaded Floor

Results: The performance criteria of unrestrained loadbearing floors are specified in Section 8.6.6 of ASTM E119. The applicable criteria for this assembly is summarized as follows:

- Sustained the applied load during the fire resistance test.
- No passage of flame or gases hot enough to ignite cotton for the entire test duration.
- The average temperature rise on the unexposed surface shall not exceed 250 °F above the initial temperature for the entire test duration.

- The temperature rise at any point on the unexposed surface shall not exceed a rise of 325 °F above the initial temperature for the entire test duration.

At 56 min and 56 s, flames were observed on the unexposed side. A summary of the unexposed-face temperature rise measurements is provided in Table 2. The acquired data is located in Appendix B in graphical form.

Table 2. Temperature Rise Summary.

TC	Initial Temperature	Maximum Temperature	Temperature Rise	ASTM E119 Criteria	Meets Criteria
TC 1	98 °F	222 °F	124 °F	< 325 °F	Yes
TC 2	97 °F	234 °F	138 °F	< 325 °F	Yes
TC 3	97 °F	257 °F	160 °F	< 325 °F	Yes
TC 4	85 °F	96 °F	11 °F	< 325 °F	Yes
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TC 8	96 °F	173 °F	77 °F	< 325 °F	Yes
TC 9	96 °F	189 °F	93 °F	< 325 °F	Yes
Avg. TCs 1–9	94 °F	177 °F	82 °F	< 250 °F	Yes

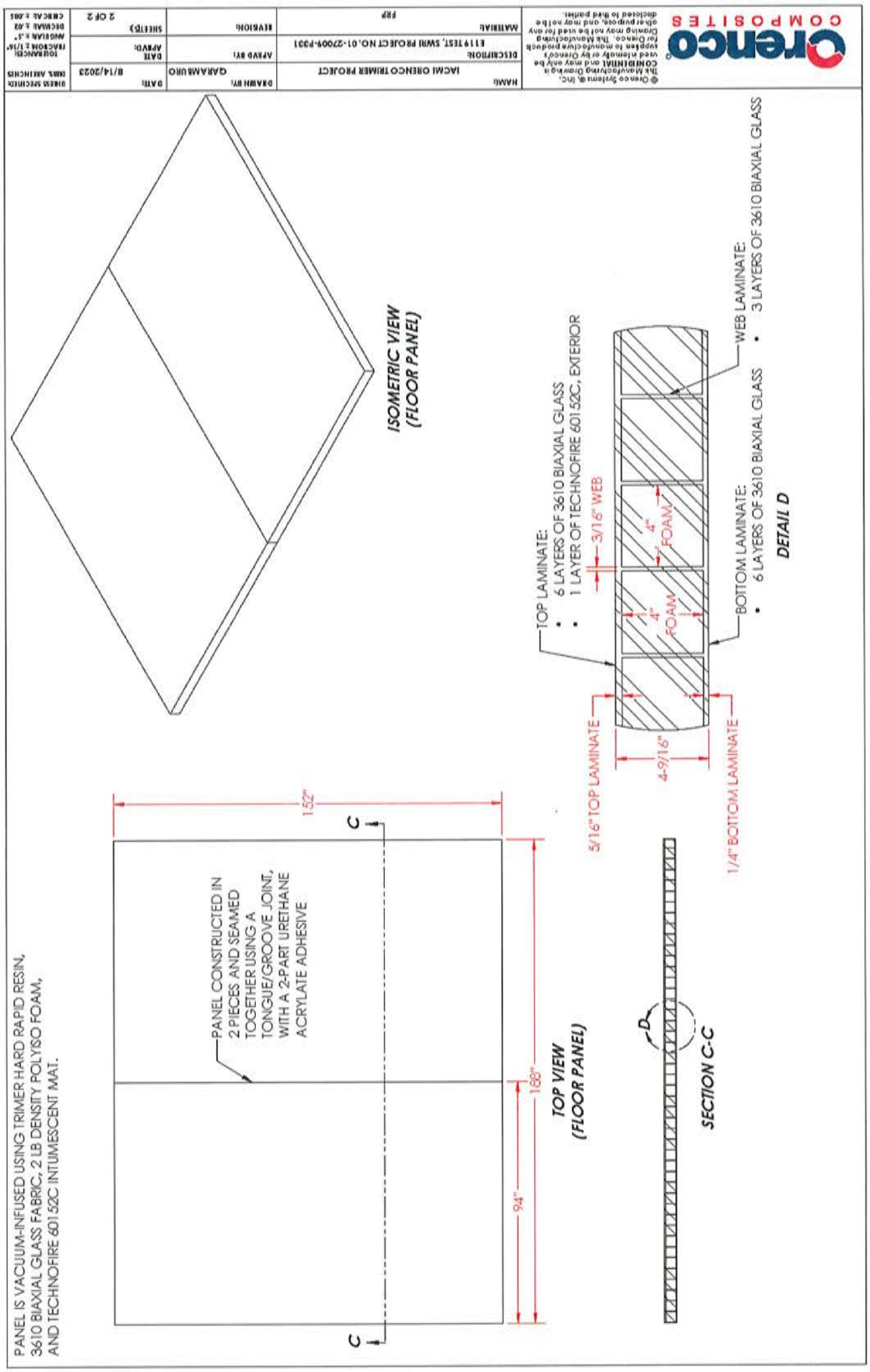
6.0 CONCLUSION

Based on the test results, the unrestrained loadbearing floor assembly identified as *(Trimer Resin/Polyiso-Core FRP Floor Panel with Technofire 60152C)*, tested as described in this report, achieved a rating of 57 min when tested in accordance with ASTM E119.

APPENDIX A

CLIENT-PROVIDED DRAWING

(CONSISTING OF 1 PAGE)


PANEL IS VACUUM-INFUSED USING TRIMER HARD RAPID RESIN, 3610 BIAXIAL GLASS FABRIC, 2 LB DENSITY POLYISO FOAM, AND TECHNOFIRE 60152C INTUMESCENT MAT.
PANEL CONSTRUCTED IN 2 PIECES AND SEAMED TOGETHER USING A TONGUE/GROOVE JOINT, WITH A 2-PART URETHANE ACRYLATE ADHESIVE
152"
188"
94"
C
C
TOP VIEW (FLOOR PANEL)
D
SECTION C-C
ISOMETRIC VIEW (FLOOR PANEL)
5/16" TOP LAMINATE
4-9/16"
1/4" BOTTOM LAMINATE
TOP LAMINATE:
• 6 LAYERS OF 3610 BIAXIAL GLASS
• 1 LAYER OF TECHNOFIRE 60152C, EXTERIOR
3/16" WEB
4" FOAM
4" FOAM
BOTTOM LAMINATE:
• 6 LAYERS OF 3610 BIAXIAL GLASS
WEB LAMINATE:
• 3 LAYERS OF 3610 BIAXIAL GLASS
DETAIL D
IACMI ORENCO TRIMER PROJECT
E119 TEST, SWRI PROJECT NO. 01-27009-P331
FRP
GARAMBURO
8/14/2023
2 OF 2
Orenco COMPOSITES

APPENDIX B

GRAPHICAL TEST DATA

(CONSISTING OF 5 PAGES)

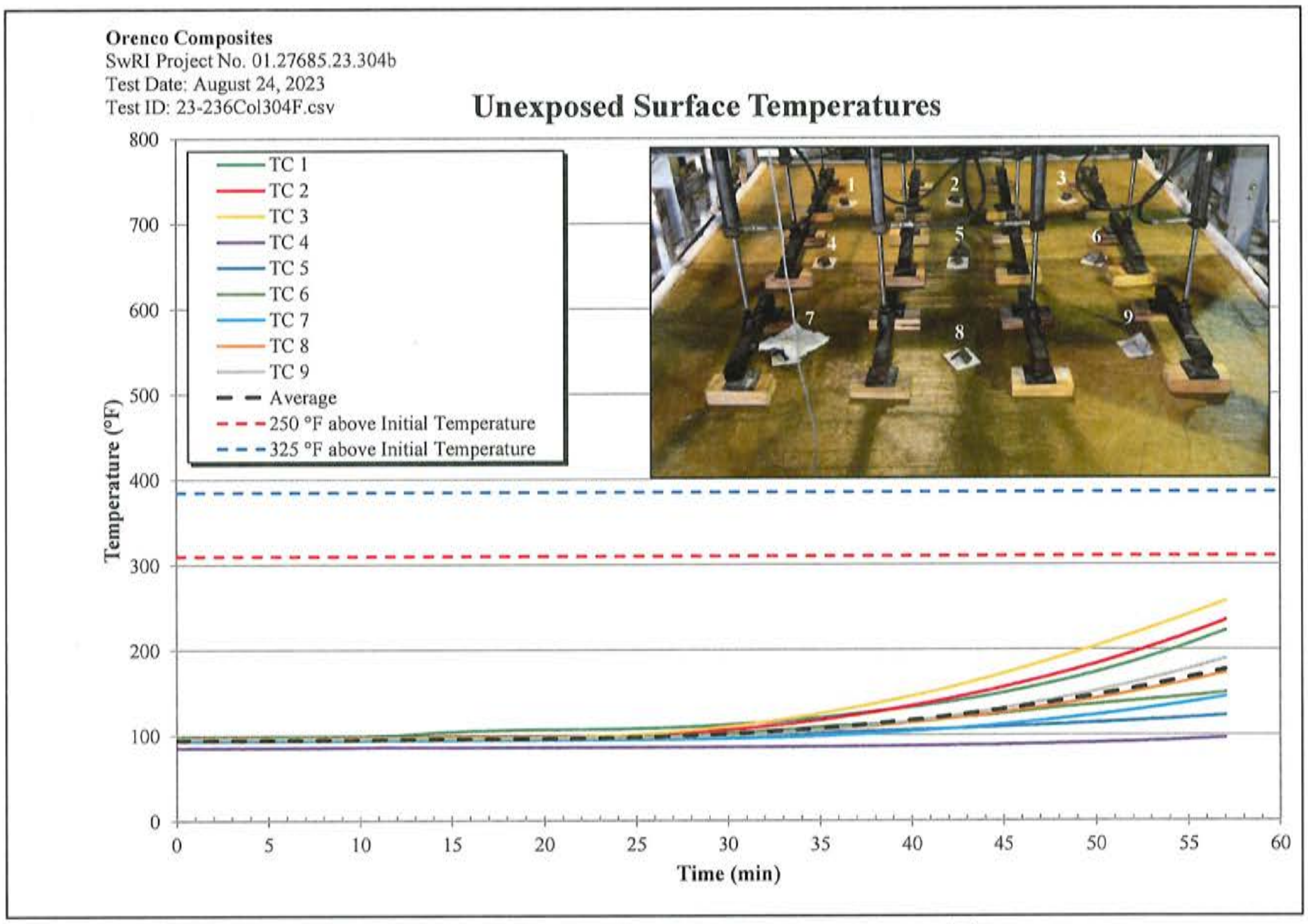


Figure B-1. Unexposed Surface Thermocouples vs. Time.

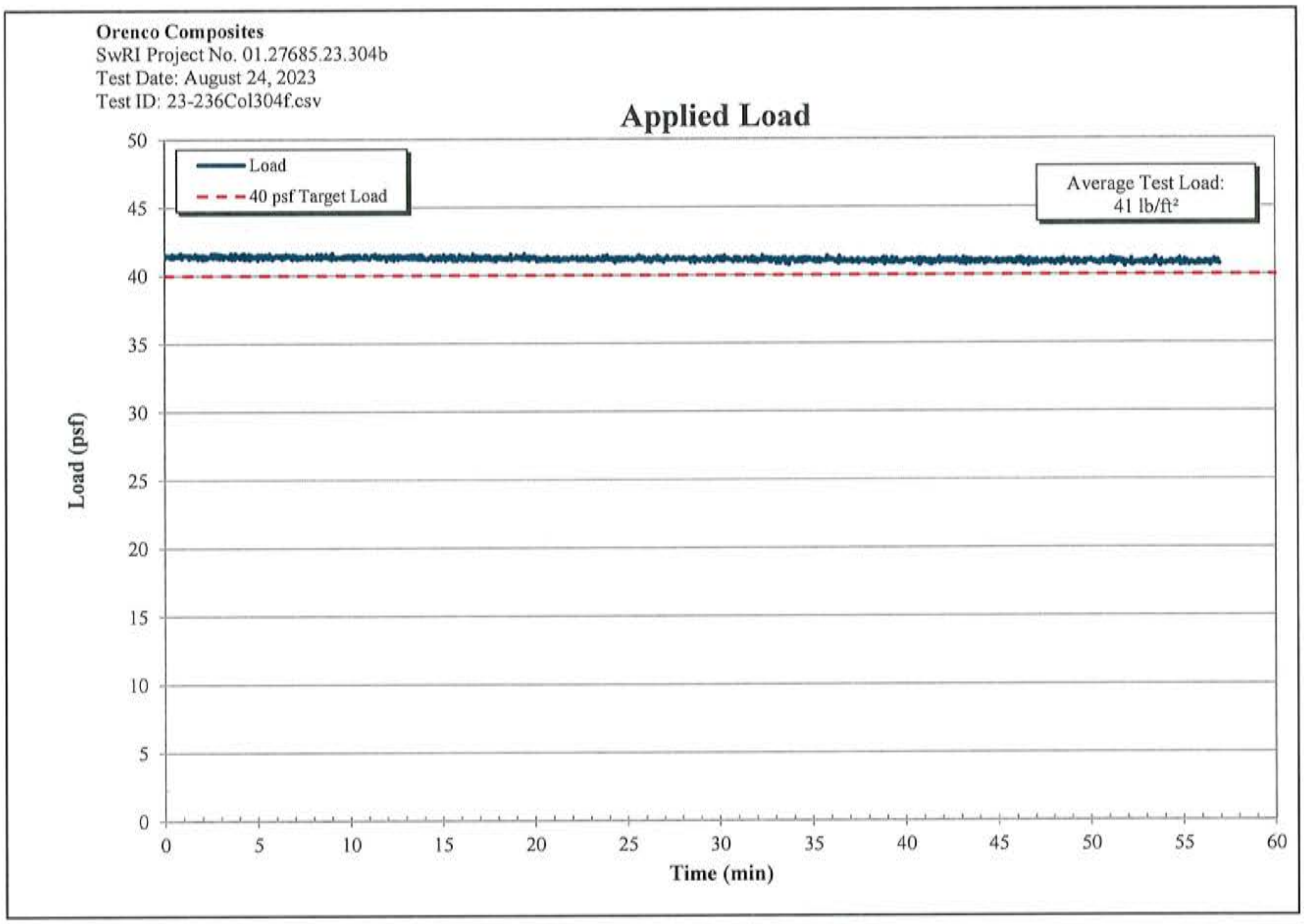


Figure B-2. Applied Load vs. Time.

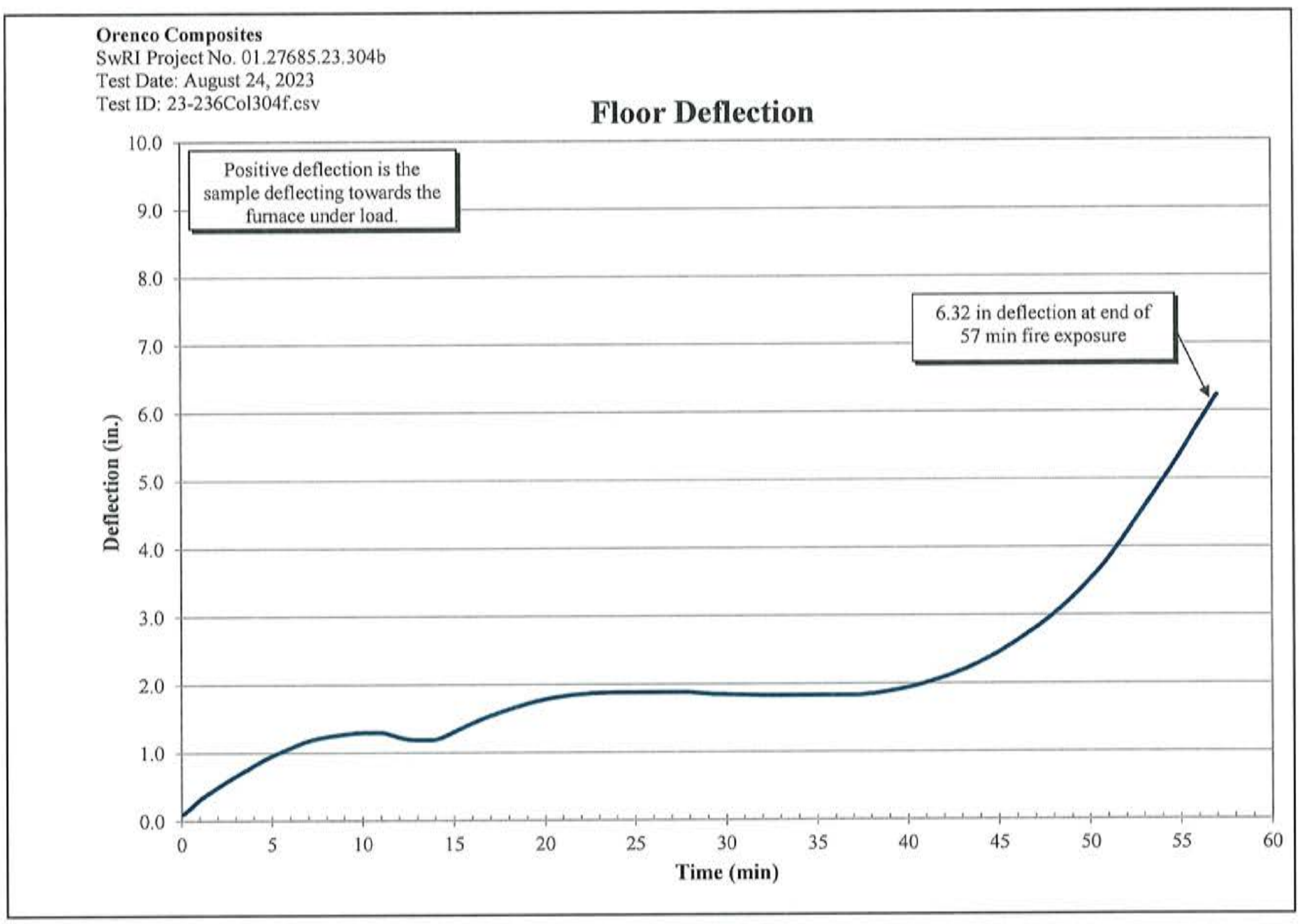


Figure B-3. Sample Deflection vs. Time.

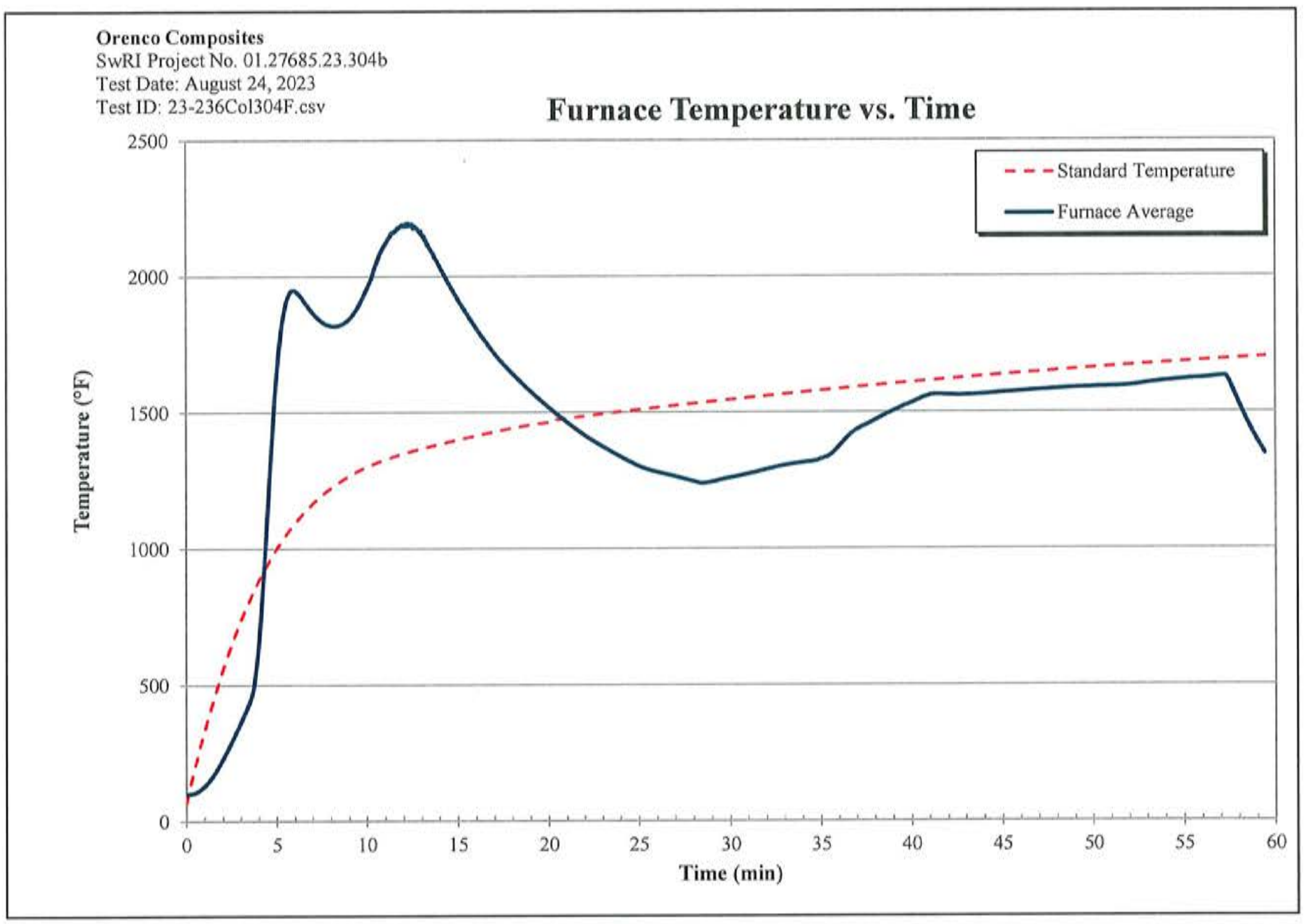


Figure B-4. Average Furnace Temperature vs. Time.

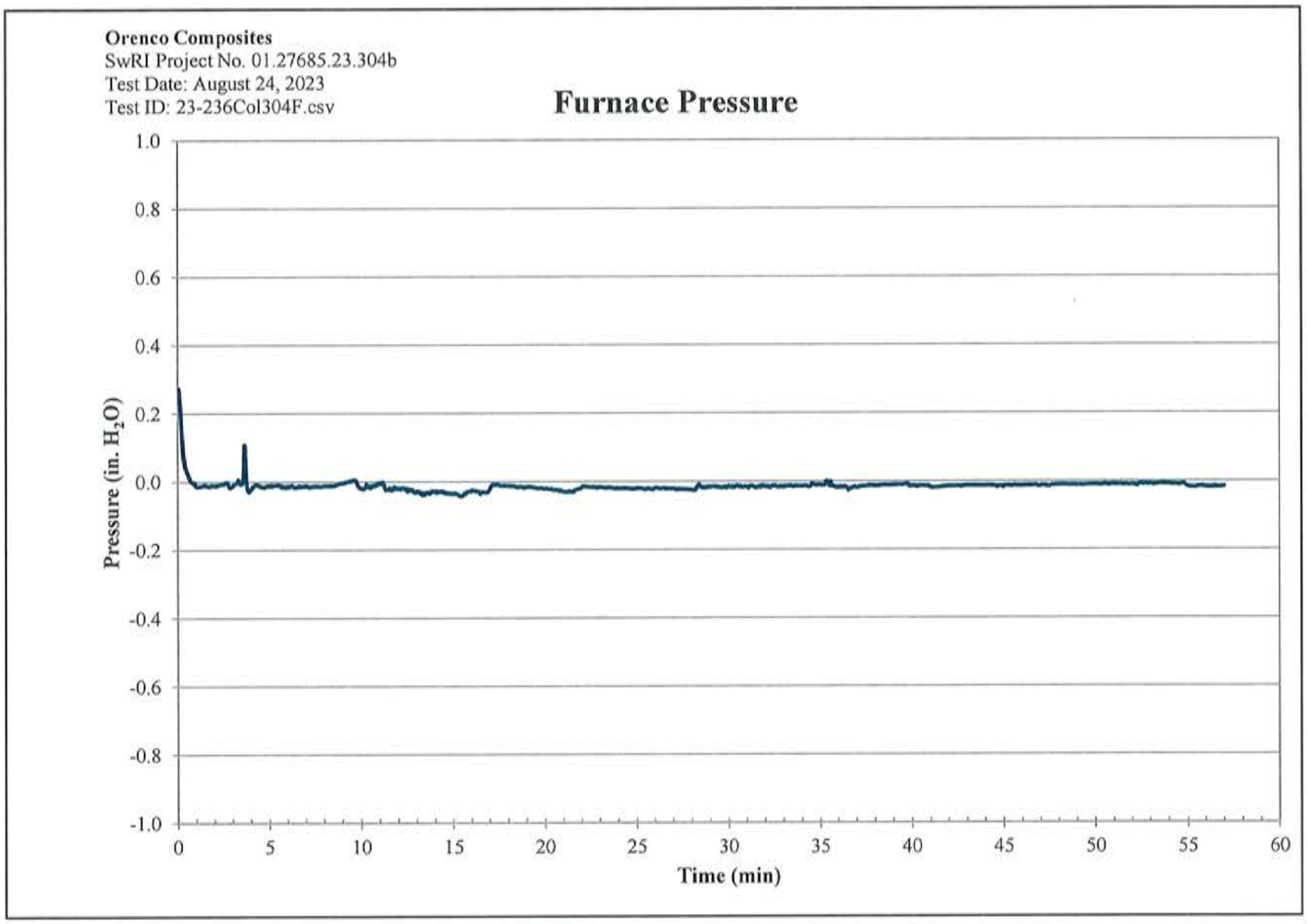


Figure B-5. Furnace Pressure vs. Time.

APPENDIX C

TEST PHOTOGRAPHS

(CONSISTING OF 6 PAGES)

Figure C-1. View of the *Serial No. 4001a Floor Assembly* as Received.

Figure C-2. Exposed Side of *Serial No. 4001a Floor Assembly* prior to Testing.

Figure C-3. Unexposed Side of *Serial No. 4001a Floor Assembly* prior to Testing.

Figure C-4. Unexposed Side of *Serial No. 4001a Floor Assembly* 10 min into Test.

Figure C-5. Smoke from Seam of *Serial No. 4001a Floor Assembly* 18 min into Test.

Figure C-6. Unexposed Side of *Serial No. 4001a Floor Assembly* 30 min into Test.

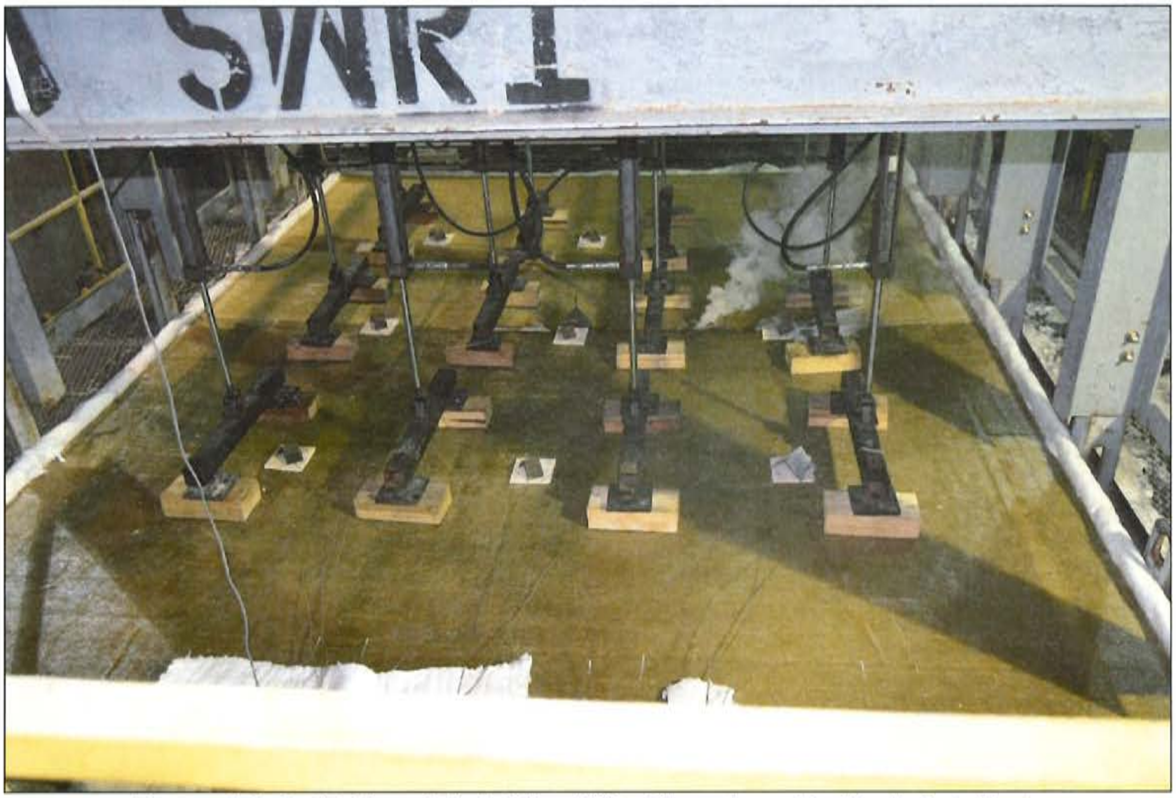


Figure C-7. Left Edge of *Serial No. 4001a Floor Assembly* 40 min into Test.

Figure C-8. Smoke from Seam on the Unexposed Side 47 min into Test.

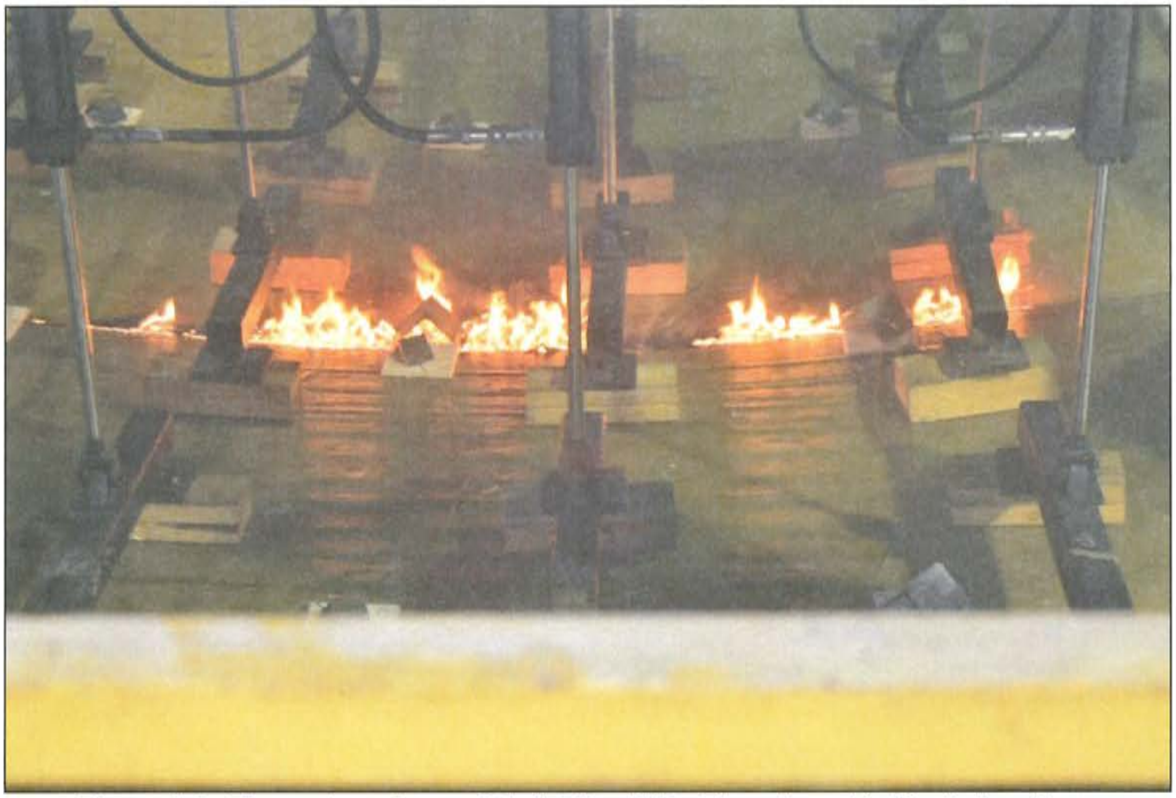


Figure C-9. Flames from Seam of *Serial No. 4001a Floor Assembly* 56 min into Test.

Figure C-10. Exposed Side of *Serial No. 4001a Floor Assembly* during Removal from Furnace.

Figure C-11. Unexposed Side of *Serial No. 4001a Floor Assembly* after Removal of Jacks.

Figure C-12. Exposed Side of *Serial No. 4001a Floor Assembly* after Cooling.

APPENDIX E

Material Technical Data Sheets

HARP Rapid

Non-Flammable Rapid Cure RTM Resin with High Strength, Damage Resistance and Thermal Stability

trimer

Product Data Sheet

Description

HARP Rapid is a patent pending snap curing resin with a low room temperature viscosity which can be demolded in as little as 45 seconds. The resin achieves excellent mechanical properties and a high glass transition temperature without a post cure. Furthermore, the cured polymer is non-flammable without additives. HARP Rapid provides a long pot life and can be cured out of autoclave in a vacuum bag or a press. The low room temperature viscosity makes HARP Rapid ideal for Infusion, RTM, filament winding or pultrusion manufacturing.

Features

- High glass transition temperature (Tg) of 437°F (225° C)
- High wet glass transition temperature
- Low room temperature viscosity (250 cP)
- Very low cure shrinkage
- Parts can be demolded in as little as 45 second at 140° C mold temperature
- Low coefficient of thermal expansion
- High toughness and strength
- Excellent adhesive properties
- Resin is free of styrene and other volatile diluents
- Cured polymer is non-flammable and meets FAR 25.853
- Certified for 14 CFR 25.853 OSU Heat Release, Smoke Density and Vertical Flame Spread

Neat Resin Properties

Glass Transition, Tg Dry*	225 °C (437°F)
Tensile Strength	108 MPa (14.2 ksi)
Tensile Modulus	4.1 GPa (0.551 msi)
Tensile Strain to Failure	3.9%
Flexural Strength	139 MPa
Compressive Strength	149 MPa
Fracture Toughness, K_{1C}	0.8 MPa/m$^{1/2}$
Room Temperature Viscosity	200 cP
Coefficient of Thermal Expansion	29 ppm/°C
Thermal Conductivity	0.3 W/m·K
Water Absorption (24h at 20°C)	0.18%
Water Absorption (21 days at 20°C)	1.4%
Cure Shrinkage	0.75%
Density	1.28 g/cc

* Measured from peak Tanδ in DMA

HARP Rapid

Non-Flammable Rapid Cure RTM Resin with High Strength, Damage Resistance and Thermal Stability

trimer

Composite Properties

Testing performed on VectorPly ELA2412 Unidirectional E-Glass fabric with a veil and Unidirectional non-crimp carbon fiber fabric with 50k Zoltek PX35 Fiber and areal weight of 11.8oz/400gsm
Composites infused using VARTM resulting in an average fiber volume fraction of 48%

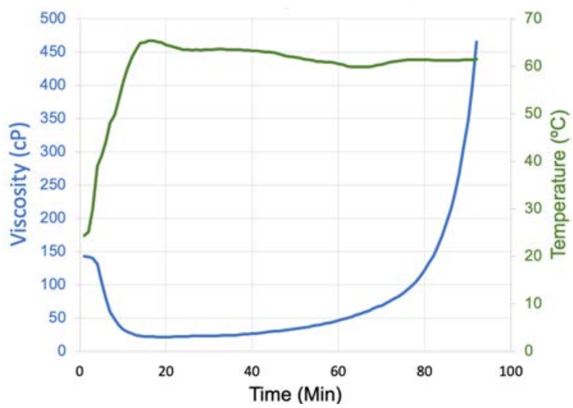
Property	Temp	Condition	ELA2412	PX35 UD
0º Tensile Strength, GPa (ASTM D3039)	RT	Dry	1.04	1.5
0º Tensile Modulus, GPa (ASTM D3039)	RT	Dry	44	117
0º Compression Strength, MPa (ASTM D6641)	RT	Dry	966	856
0º Compression Modulus, GPa (ASTM D6641)	RT	Dry	47	128
90º Tensile Strength, MPa (ASTM D3039)	RT	Dry	36	212
90º Tensile Modulus, GPa (ASTM D3039)	RT	Dry	14	8.85
90º Compression Strength, MPa (ASTM D6641)	RT	Dry	184	186
90º Compression Modulus, GPa (ASTM D6641)	RT	Dry	31	10.1
Short Beam Shear Strength, MPa (ASTM 2344)	RT	Dry	70	--
In-Plane Shear Strength, MPa (ASTM D3518)	RT	Dry	65	107
In-Plane Shear Modulus, GPa (ASTM D3518)	RT	Dry	3.4	5
Mode I Fracture Toughness, J/m^2, (ASTM D5528)*	RT	Dry	437	231
Mode II Fracture Toughness, J/m^2, (ASTM D7905)†	RT	Dry	1,510	--
Translaminar Fracture Toughness, MPa•m$^{1/2}$ (ASTM E1922)	RT	Dry	61	--

* Mode I Fracture toughness measured using the compliance calibration method and using the load and deflection measured at the point of deviation from linearity in the load-displacement curve.

† Mode II Fracture toughness measure from the pre-cracked specimen.

Viscosity

Resin Heated to 60° C



Storage Life

This TDS contain confidential information of Trimer Technologies

Shelf Life: 6 months at 70°F

Handling and Safety Precautions

Trimer recommends that customers observe established precautions for handling resins and fine fibrous materials. Operators working with this product should wear clean, impervious gloves to reduce the possibility of skin contact and to prevent contamination of the material. Material Safety Data Sheets (MSDS) have been prepared for HARP Rapid and are available to company safety officers on request from Timer Technologies.

Tecnofire®

Technical Data Sheet

60152C

Mineral Intumescent Mat

Description: **Flexible, thermally expandable intumescent mat**

Composition: **Graphite based, with mineral & glass fibers**

Activation Temperature: **>190°C / >375°F**

Typical Expansion Ratio: **9:1 (at 450°C / 840°F)**

Thickness (10 kPa)		Typical Density (10 kPa)		Tensile Strength	
mm	Mil	kg/m³	lb/ft³	N/15mm	lb/in
2.0	79	220	14	175	67

TFP manufactures a unique range of intumescent materials, providing the ideal solution for passive fire protection. **Tecnofire**® intumescents are mineral fiber stabilised, graphite-based products which exhibit unidirectional expansion to form a highly effective fire barrier.

The unique combination of graphite and mineral fiber produces both greatly enhanced char stability and excellent insulation properties that protect any underlying structure.

Tecnofire® is available in a wide range of thicknesses with various expansion volume and pressure characteristics and these properties can be specifically optimized to produce tailor-made solutions.

Available in both rigid and flexible products, **Tecnofire**® can be supplied in rolls, sheets or narrow coils.

tfp

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Issue 3 :01/2015

AIREX® T90

GM--TDS-122

Economic and Fire Retardant

DATA SHEET 08.2022 - Replaces 03.2022

DESCRIPTION

AIREX® T90 is a closed-cell, thermoplastic and recyclable polymer foam with excellent fire, smoke & toxicity (FST) properties.

It has very good mechanical properties and an extraordinary resistance to fatigue, is chemically stable and has negligible water absorption. It is thermally stable during high temperature processing and post curing. T90 is designed for easy use with all resin systems and processing technologies.

AIREX® T90 is the ideal core material for structural sandwich applications requiring high fire resistance.

CHARACTERISTICS

- Superior fire retardancy (FAR 25.853; EN 45545, EN 13501)
- Outstanding fatigue strength
- Excellent long term thermal stability up to 100 °C (212 °F)
- Best thermal stability in process up to 150 °C (302 °F)
- Good thermal insulation
- Highly consistent material properties
- Easy to process with all types of resin and lamination processes
- Good adhesion (skin-to-core bond)
- Very high chemical stability
- No water absorption, no after-expansion, no outgassing

APPLICATIONS

- **Aerospace:** Interiors, galleys, meal trolleys, radomes
- **Automotive:** Floors, sidewalls, front ends, interiors, roofs, engine covers
- **Marine:** Decks, interiors, superstructures
- **Industrial:** Covers, containers, x-ray tables, sporting goods
- **Building and Construction:** Roofs, claddings, domes, portable building

PROCESSING

- Contact molding (hand/spray)
- Vacuum infusion
- Resin infusion / injection (VARTM / RTM)
- Adhesive bonding
- Pre-preg processing
- Compression molding (GMT, SMC)
- Thermoforming

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T +86 21 585 86 006
corematerials.asia@3AComposites.com

MECHANICAL PROPERTIES

Typical properties for AIREX® T90		Unit (metric)	Value[1]	T90.60	T90.100	T90.150	T90.210
Density	ISO 845	kg/m³	Average *Typ. range*	65 *60 - 70*	110 *105 - 115*	145 *140 - 150*	210 *200 - 220*
Compressive strength perpendicular to the plane	ISO 844 ASTM C365[3]	N/mm²	Average *Minimum*	0.80 *0.7*	1.4 *1.2*	2.2 *2.0*	3.8 *3.2*
Compressive modulus perpendicular to the plane	ASTM C365[3]	N/mm²	Average *Minimum*	50 *35*	80 *70*	105 *95*	170 *145*
Tensile strength perpendicular to the plane	ASTM C297	N/mm²	Average *Minimum*	1.5 *1.2*	2.2 *1.6*	2.7 *2.2*	3.0 *2.4*
Tensile modulus perpendicular to the plane	ASTM C297	N/mm²	Average *Minimum*	85 *70*	120 *90*	170 *140*	225 *180*
Shear strength	ISO 1922	N/mm²	Average *Minimum*	0.46 *0.4*	0.8 *0.7*	1.2 *1.1*	1.85 *1.5*
Shear modulus	ISO 1922	N/mm²	Average *Minimum*	12 *10.5*	20 *18*	30 *26*	50 *44*
Shear elongation at break	ISO 1922	%	Average *Minimum*	25 *15*	10 *5*	8 *4*	5 *3*
Thermal conductivity at 10°C	EN 12667	W/m.K	Average	0.037	0.035	0.038	0.045
Standard sheet	Width[2]	mm ± 5		1220	1220	1220	1220
	Length[2]	mm ± 5		2440	2440	2440	2440
	Thickness	mm ±		5 to 100	5 to 100	5 to 100	5 to 100

Finishing Options, other dimensions and closer tolerances upon request
[1] Statistical minimum values; test sample thickness 20 mm except thermal conductivity (50 mm)
[2] Alternative width 610 mm, alternative length 1220 mm
[3] With surface stabilization

Fire performance	Standard		T90.60	T90.100	T90.150	T90.210
Aircraft	FAR/CS 25.853/ABD0031	Flammability (60s)	passed	passed	passed	passed
	FAR/CS 25.853/ABD0031	Smoke density	passed	passed	passed	passed
	FAR/CS 25.853/ABD0031	Toxicity	passed	passed	passed	passed
Rail	EN 45545-2	Sandwich	HL3 achievable, depending on sandwich design[6]			
		Core alone	HL3 achievable[4]			
Building & Construction	DIN 4102-1	Material Class	tbd	B1[5]	tbd	B1[5]
Building & Construction	EN 13501-1	Fire reaction behaviour Smoke production Flaming droplets	B[5] s1 d0	C[5] s1 d0	tbd	C[5] s2 d0

[4] Depending on density, thickness and application; test results on request
[5] May depend on thickness
[6] Certificates available for specific sandwich designs

The data provided gives approximate values for the nominal density and DNV-GL minimum values according to DNV-GL type approval certificate.

The information contained herein is believed to be correct and to correspond to the latest state of scientific and technical knowledge. However, no warranty is made, either expressed or implied, regarding its accuracy or the results to be obtained from the use of such information. No statement is intended or should be construed as a recommendation to infringe any existing patent.

AIREX

3A CORE MATERIALS COMPOSITES

MECHANICAL PROPERTIES

Typical properties for AIREX® T90		Unit (imperial)	Value[1]	T90.60	T90.100	T90.150	T90.210
Density	ISO 845	lb/ft³	Average *Typ. range*	4.1 *3.7 - 4.4*	6.8 *6.6 - 7.2*	9.1 *8.7 - 9.4*	13 *12.5 - 13.7*
Compressive strength perpendicular to the plane	ISO 844 ASTM C365[3]	psi	Average *Minimum*	116 *102*	203 *174*	319 *290*	551 *464*
Compressive modulus perpendicular to the plane	ASTM C365[3]	psi	Average *Minimum*	7’250 *5’075*	11’600 *10’150*	15’230 *13’780*	24’650 *21’025*
Tensile strength perpendicular to the plane	ASTM C297	psi	Average *Minimum*	218 *174*	319 *232*	392 *319*	435 *350*
Tensile modulus perpendicular to the plane	ASTM C297	psi	Average *Minimum*	12’325 *10’150*	17’400 *13’050*	24’650 *20’300*	32’630 *26’100*
Shear strength	ISO 1922	psi	Average *Minimum*	67 *58*	116 *102*	174 160	268 *215*
Shear modulus	ISO 1922	psi	Average *Minimum*	1’740 *1’520*	2’900 *2’610*	4’350 *3’770*	7’250 *6’380*
Shear elongation at break	ISO 1922	%	Average *Minimum*	25 *15*	10 *5*	8 *4*	5 *3*
Thermal conductivity at 50°F	EN 12667	Btu.in/ hr.ft².F	Average	0.257	0.243	0.263	0.312
Standard sheet	Width[2]	in ± 0.2		48	48	48	48
	Length[2]	in ± 0.2		96	96	96	96
	Thickness	in ± 0.02		⅛ to 4	⅛ to 4	⅛ to 4	⅛ to 4

Finishing Options, other dimensions and closer tolerances upon request
[1] Statistical minimum values; test sample thickness 20 mm (3/4”) except thermal conductivity 50 mm (2”)
[2] Alternative width 24”, alternative length 48”
[3] With surface stabilization

Fire performance	Standard		T90.60	T90.100	T90.150	T90.210
Aircraft	FAR/CS 25.853/ABD0031	Flammability (60s)	passed	passed	passed	passed
	FAR/CS 25.853/ABD0031	Smoke density	passed	passed	passed	passed
	FAR/CS 25.853/ABD0031	Toxicity	passed	passed	passed	passed
Rail	EN 45545-2	Sandwich	HL3 achievable, depending on sandwich design[6]			
		Core alone	HL3 achievable[4]			
Building & Construction	DIN 4102-1	Material Class	tbd	B1[5]	tbd	B1[5]
Building & Construction	EN 13501-1	Fire reaction behaviour Smoke production Flaming droplets	B[5] s1 d0	C[5] s1 d0	tbd	C[5] s2 d0

[4] Depending on density, thickness and application; test results on request
[5] May depend on thickness
[6] Certificates available for specific sandwich designs

The data provided gives approximate values for the nominal density and DNV-GL minimum values according to DNV-GL type approval certificate.

The information contained herein is believed to be correct and to correspond to the latest state of scientific and technical knowledge. However, no warranty is made, either expressed or implied, regarding its accuracy or the results to be obtained from the use of such information. No statement is intended or should be construed as a recommendation to infringe any existing patent.

hybrid | RED

Information on the Hybrid technology

The Hybrid product-family from Finnester coatings Oy is a hybrid inorganic-organic coating technology for indoor and outdoor decorative and protective applications. It cures to form a hard, decorative and mar resistant coating with easy-to-clean properties, exceptional weathering fastness, UV-light degradation resistance, water resistance, and good color and gloss retention. The family includes the HybridRED product range with outstanding fire protection properties.

General characteristics

- solvent-based, high-solids system
- protection for thermoset and thermoplastic composites, also may be applied to steel & aluminium
- range of gloss levels available, may also be textured finish
- RAL colour standards, translucent versions also available
- fast tack-free time
- no need for stoved post-curing
- wide application window

Specific information on the HybridRED products

Due to ceramification, HybridRED has outstanding fire protection properties, i.e. very low smoke generation, prolonged ignition times and low heat release rates when compared with standard organic coatings. There are several members of the HybridRED product range:

HybridRED 100 =	standard version, good overall fire performance and protection
HybridRED 200 =	maximized inorganic content, giving higher fire resistance and minimal heat of combustion. Designed for more demanding applications such as cladding.
HybridRED 500 =	high gloss finish appearance, with excellent scratch resistance and clarity.
HybridRED 900 =	clear topcoat, for maximum gloss (automotive finish)

Applications

- fire proofing of composites in various applications in energy, railway, marine and transport sectors
- decorative and industrial applications
- resurfacing damaged Fire Retardant gelcoats
- indoor and outdoor environments

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Key properties

- EN 45545-2 HL3 R7 compliant
- smooth finish
- anti-graffiti properties
- weather and UV-light resistant
- does not contain halogens or antimony trioxide
- little or no change in fire retardant properties over time in outdoor conditions

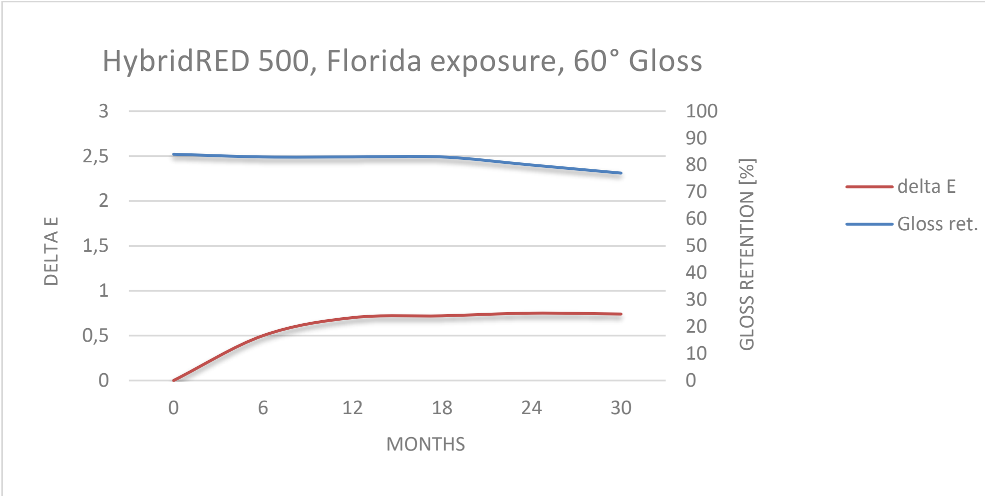
No change in fire retardant properties after accelerated outdoor exposure (tested according to ISO 4892-2 / 5500 hours in 40°C, RH50%, 0.5 W/m2 (340 nm) weather cabinet: Atlas Ci3000+).
See separate information regarding HybridRED fire protection performance by industry sector.

Other information

Impact-Test (ISO 6272)	
Front [cm]	15,0
Back [cm]	< 2,5
Pendulum-Hardness (König) (ISO 1522) [seconds]	146
Buchholz-Hardness (ISO 2815)	
Mark Length [mm]	11,7
Depth of Impression [µm]	11
Indentation Resistance of Buchholz	87

Taber abraser test procedure was implemented according to ASTM D 1044. One cycle equals 1000 revolutions with a weight of 250g.

	HybridRED 100		*2-component, solvent borne polyurethane coating*	
mass lost	mg	%	mg	%
cycle 1	0,25	0,04	6,9	0,76
cycle 2	2,9	0,47	12,1	1,3
cycle 3	9,2	1,55	51,4	5,6



Following chemicals were tested and the appearance was checked visually.

	24h @ RT	*1h @ 80°C*
petrol	no change	blisters
Diesel gasoline	no change	no change
hydraulic oil	no change	no change
NaOH (10%)	slightly matt	haze
HCl (10%)	slightly yellow	slightly matt
H2SO4 (10%)	slightly matt	slightly matt

Further chemical resistance tests were implemented according to DIN 68861. Evaluation after 24 hours and 7 days except for boiling water.

	after 24 h	*after 7 days*	*evaluation marks*
Acetic acid (10%)	2	4	0 = no change
Citric acid (10%)	0	1	1 = minimal change in color and gloss
Lactic acid (85% w/w)	2 – 3	3	2 = slight changes in color and gloss
xylene	1	2	3 = coating largely undamaged
MEK	2	2 – 3	4 = coating damaged
ammonia (25%)	0	1	5 = coating destroyed
Crude oil	0	0	
boiling water (30 min)	0		

Salt Fog/Spray EN ISO 9227, substrate: zinc phosphate steel, coated direct to metal. Exposure time: 1500 hours. No visual change in gloss or color.

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Usage

The working temperature should be 15 – 25°C. Curing agent is supplied with resin part. Add the curing agent accordingly. The mixing ratio is given in the label. The product is ready to use but it can be diluted with Solvent 22 if required. Working time is 8 to 10 hours depending on the ambient temperature and moisture.

Application with conventional spray gun:

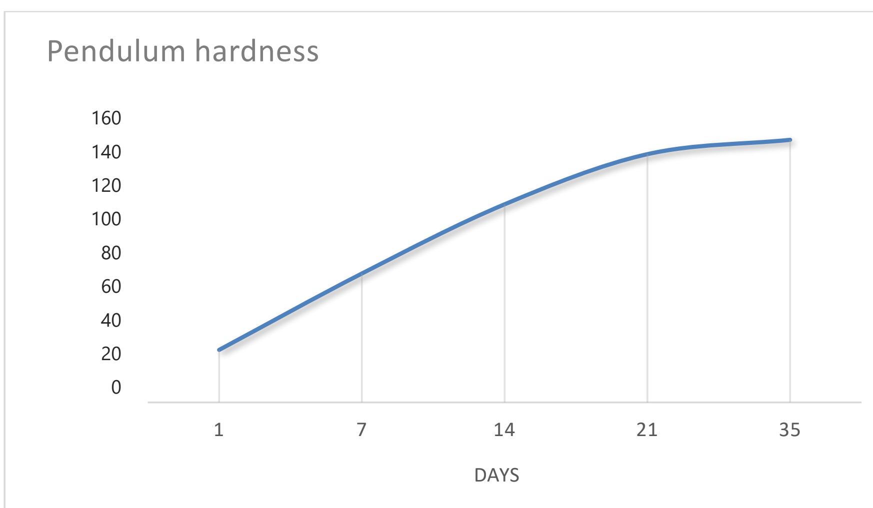
- nozzle size: 1,2 – 1,4 mm
- pressure: 2,5 bar

Application with high pressure spray gun (no FR versions):

- nozzle size: 13 – 15
- pressure: 120 – 150 bar

Spray the first layer as thin tack layer and let it flash-off 15 – 20 minutes. Spray 3 – 4 layers wet-on-wet to reach total wet film thickness maximum of 300 μm. The product can be applied also with brush or roller. Clean tools with acetone or equivalent.

HybridRED is double curing system where initial tack-free cure occurs with ambient moisture. This is a rather fast reaction and a fully tack-free surface can be achieved within a few hours depending on the conditions. The second reaction is cross-linking, which is relatively slow process and highly dependable on temperature. At room temperature achieving the high cross-linking density can take two to three weeks. This needs to be taken account when testing product. The surface will go harder and harder within following weeks as shown in a below chart.



However, initial cross-linking can be accelerated with increasing ambient moisture content – while avoiding direct water contact. After tack-free surface, elevated temperature can be applied. This can range from 50ºC to 140ºC and from 8 hours to 1 hour and any variation between.

When using ventilation and under pressure, extra care must be taken not to exclude all the humidity from the “drying room”. If no water is present, the surface will stay tacky for days and only cross-linking happens which can lead to gloss reduction. Same happens if heat is applied too early.

If the ambient humidity is very low i.e. in the winter, a bucket of water on the floor will be enough.

Safety and Handling

The content of an opened package is influenced by air moisture. Keep tightly capped when not in use. Handle in a well-ventilated area. Store indoors at room temperature in the original containers kept tightly closed. Protect form direct sun light. Detailed safety information is contained in a material data safety sheet.

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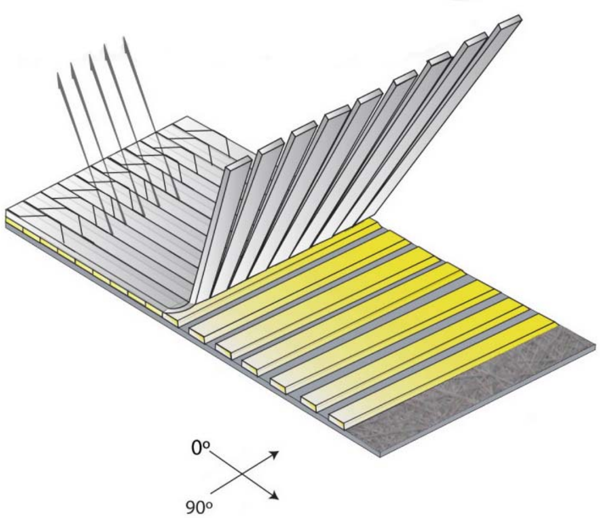
VECTORPLY
Performance Composite Reinforcements



E-LTM 3610

Fiber Type: E-Glass
Architecture: 0/90 Biaxial
Dry Thickness: 0.055 in. / 1.40 mm
Total Weight: 44.84 oz/sq.yd / 1520 g/sq.m

Roll Specifications			Fiber Architecture Data	
Roll Width:	Roll Weight:	Roll Length:	0 ° :	17.92 oz/sq.yd / 608 g/sq.m
50 in / 1270 mm	198 lb / 90 kg	50 yd / 46 m	45 ° :	n/a
			90 ° :	17.92 oz/sq.yd / 608 g/sq.m
			-45 ° :	n/a
			Chopped Mat :	9.00 oz/sq.yd / 305 g/sq.m

1: Packaging: box or bag.
2: Weights do not include polyester stitching.

Laminated Properties

	0 °		0 °	
Laminate Weight				
	E-LTM 3610 Resin Infused		E-LTM 3610 Open Mold	
Fiber	0.31 lb/sq.ft	1.52 kg/sq.m	0.31 lb/sq.ft	1.52 kg/sq.m
Resin	0.15 lb/sq.ft	0.72 kg/sq.m	0.33 lb/sq.ft	1.59 kg/sq.m
Total	0.46 lb/sq.ft	2.24 kg/sq.m	0.64 lb/sq.ft	3.11 kg/sq.m

Physical Properties				
	E-LTM 3610 Resin Infused		E-LTM 3610 Open Mold	
Density	1.08 oz/cu.in	1.87 g/cc	0.93 oz/cu.in	1.62 g/cc
Fiber Content	68% by Wt.	50% by Vol.	49% by Wt.	31% by Vol.
Thickness	0.047 in	1.2 mm	0.076 in	1.9 mm

Laminate Modulii				
	E-LTM 3610 Resin Infused		E-LTM 3610 Open Mold	
Ex	3.38 MSI	23.30 GPa	2.27 MSI	15.66 GPa
Ey	3.38 MSI	23.30 GPa	2.27 MSI	15.66 GPa
Gxy	0.66 MSI	4.52 GPa	0.45 MSI	3.12 GPa
Ex,flex.	3.21 MSI	22.14 GPa	2.16 MSI	14.88 GPa
Ey,flex.	3.21 MSI	22.14 GPa	2.16 MSI	14.88 GPa

Ultimate Stress				
	E-LTM 3610 Resin Infused		E-LTM 3610 Open Mold	
Long. Ten.	52.5 KSI	362.0 MPa	35.3 KSI	243.3 MPa
Long. Comp.	52.5 KSI	362.0 MPa	35.3 KSI	243.3 MPa
Trans. Ten.	55.4 KSI	382.2 MPa	37.2 KSI	256.8 MPa
Trans. Comp.	57.4 KSI	396.0 MPa	38.6 KSI	266.1 MPa
In-Plane Shear	14.9 KSI	103.0 MPa	10.3 KSI	71.1 MPa
Long. Flex.	68.6 KSI	472.9 MPa	46.1 KSI	317.8 MPa
Trans. Flex.	68.6 KSI	472.9 MPa	46.1 KSI	317.8 MPa

In-Plane Stiffness, "EA"				
	E-LTM 3610 Resin Infused		E-LTM 3610 Open Mold	
(EA)x	159,989 lb/in	28,017 N/mm	171,786 lb/in	30,083 N/mm
(EA)y	159,989 lb/in	28,017 N/mm	171,786 lb/in	30,083 N/mm
(GA)xy	31,013 lb/in	5,431 N/mm	34,196 lb/in	5,988 N/mm

Ultimate In-Plane Load				
	E-LTM 3610 Resin Infused		E-LTM 3610 Open Mold	
Long. Ten.	2,485 lb/in	435 N/mm	2,669 lb/in	467 N/mm
Long. Comp.	2,485 lb/in	435 N/mm	2,669 lb/in	467 N/mm
Trans. Ten.	2,624 lb/in	459 N/mm	2,817 lb/in	493 N/mm
Trans. Comp.	2,718 lb/in	476 N/mm	2,919 lb/in	511 N/mm
In-Plane Shear	707 lb/in	124 N/mm	780 lb/in	137 N/mm

Notes:

1: Resin infused laminate made with a poly / vinyl ester resin blend.

2: Open mold laminate made with poly / vinyl ester resin blend.

3: All standard reinforcements should be infused with a flow aid or Vectorfusion® reinforcements.

4: All properties are given assuming a symmetric or quasisymmetric laminate schedule.

VECTORPLY CORPORATION

3500 Lakewood Dr. Phenix City, AL 36867 tel. 334 291 7704 fax. 334 291 7743

REV: 6/16/2015

ACFoam®-III

CGF Roof Insulation

DESCRIPTION: Closed-cell polyisocyanurate (polyiso) foam core integrally bonded to inorganic coated glass facers. ACFoam®-III is offered in a variety of thicknesses, providing long-term thermal resistance (LTTR) values from 5.7 to 26.8. Available in 4ft x 8ft (1220mm x 2440mm) and 4ft x 4ft (1220mm x 1220mm) panels. Manufactured in accordance with **ASTM C1289, Type II, Class 2, Grade 2 (20 psi) or Grade 3 (25 psi) and CAN/ULC-S704 Type 2, Class 3 or Type 3, Class 3.**

ADVANTAGES: When using ACFoam®-III in adhered systems, field testing has confirmed significantly more efficient use of solvent-based adhesives than with organic faced insulation. Adhesive application rates vary by manufacturer. Check adhesive manufacturer's recommendation for application rates. Manufactured using CFC-, HCFC- and HFC-free foam blowing technology with zero ozone depletion potential (ODP) and virtually no (negligible) global warming potential (GWP). This product has been validated by UL Environment as resistant to mold growth based on independent testing to UL 2824. ACFoam®-III contains between 11.2% and 6.2% recycled materials by weight *(Atlas Technical Bulletin: TB-2)*. Class A ratings can be achieved with ACFoam®-III when the total insulation thickness is a minimum of 3.0" and placed directly on a combustible deck (1/2:12 maximum deck slope).

APPLICATION: Manufactured and tested for use in new and re-roofing applications. ACFoam®-III shall be installed over the roof deck. ACFoam®-III is used in built-up (BUR), modified bitumen, metal, ballasted single-ply, mechanically attached single-ply and adhered single-ply roofing systems. These roofing systems depend on proper installation for successful performance. Refer to FM Approvals® RoofNav and UL Online Certifications Directory for additional application details.

INSTALLATION: ACFoam®-III shall be kept dry before, during and after installation. This product will burn if exposed to an ignition source of sufficient heat and intensity. Do not apply flame directly to ACFoam®-III insulation. Refer to product packaging and *PIMA Technical Bulletin #109* for storage and handling recommendations. **An offset or staggered multi-layer application of ACFoam® is strongly recommended when the total insulation thickness exceeds 2.7"** *(Atlas Technical Bulletin: TB-5)*. Typical field fastening requirements can be obtained from membrane system manufacturer or FM Global Property Loss Prevention Data Sheets 1-29.

Prior to installation, Atlas Roofing Corporation recommends that you consult your local building codes, contract documents, professional engineer, FM Global, Miami-Dade County and membrane manufacturer for additional installation guidelines as well as design enhancements.

ACFOAM-III MEETS OR EXCEEDS THE FOLLOWING PHYSICAL PROPORTIES

PROPERTY	TEST METHOD	ASTM C1289 OR CAN/ULC S704 MINIMUM REQUIREMENTS
DIMENSIONAL STABILITY	ASTM D2126	< 2%
COMPRESSIVE STRENGTH	ASTM D1621	20 psi (140 kPa) or 25 psi (172 kPa)
WATER ABSORPTION	ASTM C209 & D2842	< 1.5%, < 3.5%
WATER VAPOR TRANSMISSION	ASTM E96	< 4.0 perm (228.8ng/ (Pa•s•m²))
PRODUCT DENSITY	ASTM D1622	Nominal 2.0 pcf (32.04 kg/m³)
FLAME SPREAD	ASTM E84 (10 min.)	[1]40-60
SMOKE DEVELOPMENT	ASTM E84 (10 min.)	[1]50-170
TENSILE STRENGTH	ASTM D1623	> 730 psf (35 kPa)
SERVICE TEMPERATURE	-	-100° to +250°F

[1]Numerical ratings are not intended to reflect performance under actual fire conditions. Flame spread index of ≤75 and smoke development ≤450 meet code requirements for foam plastic roof insulation. Codes exempt foam plastic insulation when used in FM 4450 or UL 1256. Physical properties listed above are presented as typical average values as determined by accepted ASTM test methods and are subject to normal manufacturing variation.

THERMAL DATA

[2]LTTR VALUE	THICKNESS		[3]RSI	FLUTE SPANABILITY	
	in	mm		in	mm
5.7	1.0	25.4	1.00	2.625	66.68
8.6	1.5	38.1	1.50	4.375	111.13
11.4	2.0	50.8	2.01	4.375	111.13
14.4	2.5	63.5	2.53	4.375	111.13
17.4	*3.0	76.2	3.06	4.375	111.13
20.5	*3.5	88.9	3.60	4.375	111.13
23.6	*4.0	101.6	4.15	4.375	111.13

[2]LTTR (long term thermal resistance) values were determined in accordance with CAN/ULC-S770-09. Test samples were third-party selected and tested by an accredited material testing laboratory. The LTTR results were reviewed by FM Global and certified by the PIMA Quality Mark Program. [3]RSI is the metric expression of R-value (m^2 • K/W).
* *To minimize the effects of thermal bridging, Atlas strongly recommends the use of multiple layers when the total desired or specified R-value requires an insulation thickness greater than 2.7" thick.*

- **ASTM C1289, Type II, Class 2, Grade 2 (20 psi) or Grade 3 (25 psi)**
- **CAN/ULC-S704, Type 2, Class 3 or Type 3, Class 3**
- **CCMC No. 12423-L**
- **UL Certified for Canada –** Insulated Roof Deck Assemblies Construction No. C38 and 52. Meet CAN/ULC-S126, CAN/ULC-S101 and CAN/ULC-S107
- **UL Standard 1256 Classification** Construction No. 120, 123 & 292
- **UL Standard 790 (ASTM E108)** Roofing Systems Classification
- **UL Standard 263 (ASTM E119)** Fire Resistance Classification
- **UL 2824** resistant to mold growth as validated by UL Environment
- **UL Standard 1897** Uplift Resistance
- **FM Standard 4450/4470 Approved** Refer to FM Approvals® RoofNav for Specific System Details
- **IBC Chapter 26 & NBC** Sections on Foam Insulation
- **California State** Insulation Quality Standards and Title 25 Foam Flammability Criteria (License #T 1231)
- **Miami-Dade County Approved**
- **State of Florida Product Approval** (FL17989)
- **Has acheived GREENGUARD GOLD Certification**

GREENGUARD GOLD

PRODUCT CERTIFIED FOR LOW CHEMICAL EMISSIONS: UL.COM/GG UL 2818