Science.
Applied to Life.™

Adhesives and Tapes Solutions for Flooring in the Transportation Industry

3M Science. Applied to Life.™

Keeping transportation engineering moving.

Every day, transportation design engineers and managers are discovering that 3M™ Industrial Adhesives and Tapes offer outstanding performance. Improved appearance and aesthetics; reduced material and production costs; and improved durability with a continuous bond line are just some of the advantages.

With 3M™, your transportation subfloors are protected against the relentless vibration, twisting and bouncing that typically destroy panels, insulation and floor covers. Plus, our advanced seam-sealing and bonding technologies offer outstanding sheer and peel protection—even after years of hard knocks.

3M™ Industrial Adhesives and Tapes play a vital role in helping you build safe, durable, comfortable, and more attractive modes of transportation. That's why you can count on 3M to keep you moving forward.

Find out how at www.3m.com/bondingandassembly

Trends in Transportation Flooring

- Increased use of composites
- Bonding of dissimilar substrates
- Environmentally friendly materials
- Improved comfort and design

3M™ Industrial Adhesives and Tapes are better than mechanical fasteners

- Excellent chemical resistance
- Lighter weight
- Reduced noise and vibration (NVH)
- Increased corrosion resistance
- Reduced moisture intrusion
- Improved aesthetics

Industrial Adhesives and Tapes

Design & Assembly

Superior bonding solutions for transportation floor assembly.

Whether you're building a train or installing flooring on a bus, 3M™ Industrial Adhesives and Tapes keep your floors secure, and your passengers moving forward. Our bonding, fastening and flooring solutions range from sprayable adhesives, structural adhesives, hot melt adhesives, bonding tapes and adhesive sealants. We help speed up your assembly process, enhance your product's durability, increase your productivity and lighten the load by reducing the number of bolts and rivets needed to hold floors secure.

Wider material selection for flooring assemblies.

Every day, trains and buses around the world move millions of commuters quickly, safely and comfortably. 3M's floor bonding technologies are right there with them—attaching flooring panels and carpets, sealing windows and helping construct next- generation composites. Our solutions include:

- Flooring and panel bonding
- Removable panel attachment
- Window protection
- Insulation attachment
- Fire protection
- Sealing and noise reduction
- Floor system assembly

3M Science. Applied to Life.™

Find what you need—one step at a time.

A + S + P + E + C

Assembly

What type of assembly is required (refer to the common transportation assembly types in the right-hand column)?

What are the overall performance needs of the vehicle (flexibility, high peel strength, strong bond, vibration resistance, etc.)?

Substrate

What are the materials that are being bonded together?

Consider the surface condition and texture of each material, use and impact, comfort of passengers, durability, etc.

Process

What is the current assembly and bonding process?

Does the solution need to fit into the current process/equipment, or can the process/equipment change to accommodate the solution?

What are the various steps involved, and how quickly will the assembly transition through each step?

At any time, might the assembly bond need to be repositioned? If so, why and when?

Are there any environmental, regulatory or transportation safety restrictions that need to be considered?

End Use

What is the end use of the flooring panel, and what is the desired life span?

Will the assembly be exposed to harsh environmental conditions (high foot traffic, vibration, UV, chemicals, high humidity, very high or very low temperatures, etc.)?

Cost

Where can improvements be made in the assembly and bonding process (labor, reduction of process steps, materials, workflow, etc.)?

Assembly solutions are made up of these common applications:

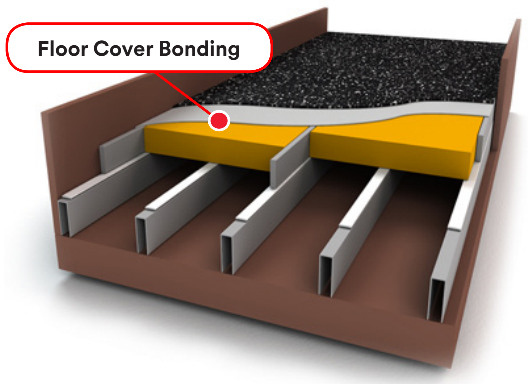
Panel to Frame/ Stiffener to Panel

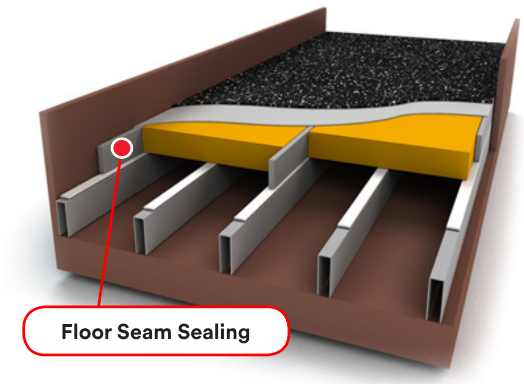
Large Surface Lamination

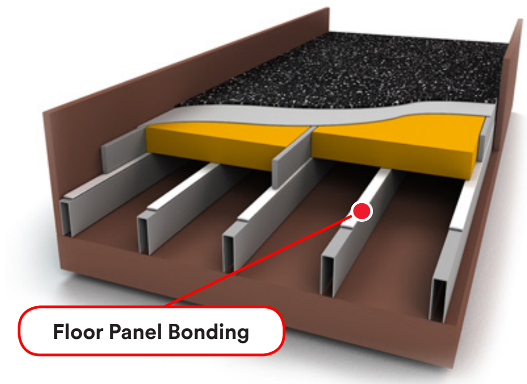
Mounting and Trim Attachment

Sealing

Floor System Assembly







Floor Cover Bonding

Floor Panel Seam Sealing

Floor Panel Bonding

Adhesive solutions for superior performance

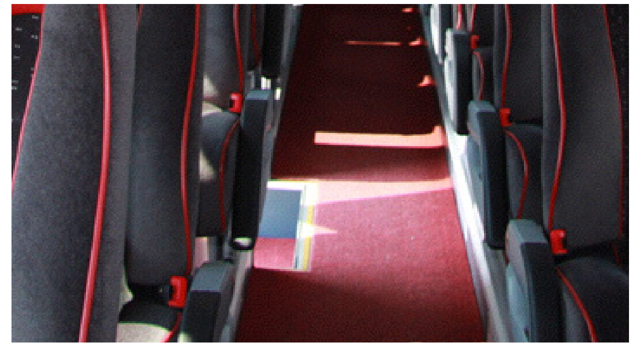
Bonding covers, panels, and sealing seams

Rail-car floors can be stressed by constant vibration, twisting and bouncing. The train sub-floors must be able to "roll with the punches" to maintain their long-term viability. That's why 3M's advanced bonding technologies are designed to maintain their effectiveness and elasticity through years of hard use. Floor panels and covers come in a host of substrates, all of which are held fast by 3M bonding technologies. In fact, our tapes and adhesive solutions provide performance advantages over traditional attachment methods.

Production Method Factors

How long does it take to install a floor?

Ease of Application
(Speed and convenience)



Requires specialized equipment → **Faster and easier to apply**

3M™ Scotch-Weld™ Structural Adhesives

3M™ Adhesive Sealants Polyurethane and Hybrids

3M™ Contact and Spray Adhesives

3M™ VHB™ Tapes & Pressure-Sensitive Adhesives

Assembly | Substrate | Process | End-Use | Cost

Note: Adhesive transfer & VHB tapes can be laminated on a surface in separate step

Production Method Factors

How long does it take to build strength?

Rate of Strength Build



Slowest Strength Build
Time to reposition

Immediate Strength
Walk on Floor right away

3M™ Scotch-Weld™ Structural Adhesives

3M™ Adhesive Sealants Polyurethane and Hybrids

3M™ Contact and Spray Adhesives

3M™ VHB™ Tapes & Pressure-Sensitive Adhesives

Assembly > Substrate > Process > End-Use > Cost

Note: Adhesive transfer & VHB tapes can be laminated on a surface in separate step

Substrate Selector

	SUBSTRATE 2					
SUBSTRATE 1	Metals (Aluminum, Colled Rolled Steel, Galvanized Steel)	Composites (Fiberglass/SMC, Epoxy)	Wood	Plastics/Paints/ Coatings	Plasticized Vinyl	PVC or Rubber
Metals						
Composites						
Wood						
Plastics/Paints/ Coatings						
Plasticized Vinyl						
PVC or Rubber						

Select substrate categories to view recommended 3M product Solutions.

Structural Adhesives

View Structural Adhesive

Learn more »

VHB

View VHBs

Learn more »

Sealants

View Sealants

Learn more »

Select a Product Category

Thin Tapes

View Thin Tapes

Learn more »

Contact Adhesives

View Contact Adhesives

Learn more »

Structural Adhesives

View Structural Adhesive

Learn more »

Sealants

View Sealants

Learn more »

Structural Adhesives

View Structural Adhesive

Learn more »

Contact Adhesives

View Contact Adhesives

Learn more »

Structural Adhesives

View Structural Adhesive

Learn more »

Sealants

View Sealants

Learn more »

Contact Adhesives

View Contact Adhesives

Learn more »

Select a Structural Adhesive

3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60/LSB60NS

- Toughened for high resistance against shock, vibration, impact loads and excellent peel strength
- 90-minute work life with handling strength in 10 hours that provides ample time for repositioning
- Medium viscosity, self-leveling formula easy to spread and coat on surfaces

View Product Details

3M™ Scotch-Weld™ Epoxy Adhesive 7240

- Formulated to create high strength bonds for reliable adhesion
- High shear and peel adhesion for outstanding levels of durability
- Contains glass beads for accurate bond line control
- Tested to FAR25 for the Aerospace market and EN 45545 for the Railway market

View Product Details

3M™ Scotch-Weld™ Epoxy Adhesive DP105

- Extremely flexible adhesive formula provides strong, permanent bond even under vibration and impact
- Maintains high shear and peel strength
- Flexible when cured, making it a good choice for bonding dissimilar surfaces
- 5 minute work life with handling strength in approximately 20 minutes at room temperature

View Product Details

3M™ Scotch-Weld™ Low Odor Acrylic Adhesive DP8825NS/ DP8810NS

- 23 minute work life with 53 minutes to structural strength
- Low odor and non-flammable properties for a safer working environment compared to typical acrylic adhesives
- Bonds difficult surfaces such as powder coats and most plastics

View Product Details

Select a Structural Adhesive

3M™ Scotch-Weld™ Metal Bonder Acrylic Adhesive DP8407NS

- Bonds to a variety of substrates (especially bare metals) while resisting corrosion
- Withstands powder coat and paint bake cycles up to 400°F (204°C) for at least one hour
- Offers high shear, peel and impact strength for a tough and durable bond
- Provides excellent bond strength and impact resistance, even at temperatures down to -40°F (-40°C)

View Product Details

3M™ Scotch-Weld™ Acrylic Adhesive DP8410NS/ DP8425NS

- 23 minute work life with 53 minutes to structural strength
- Durable bond with excellent shear, peel and high impact strength
- Bonds a variety of surfaces, including most metals and plastics
- High strength with minimal surface prep

View Product Details

3M™ Scotch-Weld™ Structural Plastic Adhesive DP8010NS

- Creates strong bond on low surface energy (LSE) plastics such as polyolefin with minimal or no surface prep required
- Delivers non-sag formulation so adhesive stays where when applied
- Resists many chemicals, water, humidity and corrosion
- Formulated to bond multi-material assemblies such as LSE plastics, thermoplastics, composites and metals

View Product Details

3M™ Scotch-Weld™ Multi-Material Composite Urethane Adhesive DP6310NS/ DP6330NS

- Two part urethane paste delivers outstanding strength and performance
- Non-sag formulation resists running and slumping of adhesive
- Primerless to most surfaces
- 10 minute open time

View Product Details

Select a Contact Adhesive

3M™ Fastbond™ Contact Adhesive 30NF

- Bonds most foamed plastics, plastic laminate, wood, plywood and canvas to themselves and to each other
- Creates a very high strength, high temperature resistant bond with up to a four hour bonding range
- Adhesive can be applied by spray, brush or roller
- Non-flammable in its wet state

View Product Details

3M™ Neoprene High Performance Contact Adhesive 1357

- High performance laminating contact adhesive
- Adheres, sheet metals, such as stainless steel, aluminum, cold rolled steel and many plastics to numerous other substrates
- Excellent moisture and heat resistance and will perform up to up to 300°F/148°C

View Product Details

3M™ Nitrile Industrial Adhesive 4491

- Fast-drying adhesive delivers rapid results
- Adhesive provides strong, flexible bonds for a variety of applications
- Low viscosity grade for spray application
- Resistance to weathering, water, fuels, oil and plasticizers provides long-term durability

View Product Details

Select a Sealant

3M™ Polyurethane Window Bonder Adhesive Sealant 590/595

- 3 hour drive-away time and 25 - 40 minute skin time
- Crash tested to FMVSS 212, suitable for structural glass bonding
- Meets several industry FST (fire, smoke and toxicity) requirements

View Product Details

3M™ Polyurethane Adhesive Sealant 560

- High strength bonding to replace mechanical fasteners and rivets
- Permanently elastic to allow joint movement
- 50-60 minute skin time; paintable, once skin forms
- Good UV resistance
- Meets several industry FST (fire, smoke and toxicity) requirements

View Product Details

3M™ Polyurethane Adhesive Sealant 550 Fast Cure

- Fast set and cure time for fast-paced processes and productivity
- Elastic formula creates high-strength bonds
- Multi substrate bonder works on a wide variety of similar and dissimilar substrates
- One component adhesive for easy application with no mixing or guesswork
- Meets several industry FST (fire, smoke and toxicity) requirements

View Product Details

3M™ Adhesive Sealant 760

- High performance bonding
- Excellent UV resistance
- Permanently elastic to allow joint movement
- 10-30 minute skin time, paintable immediately
- Good UV resistance

View Product Details

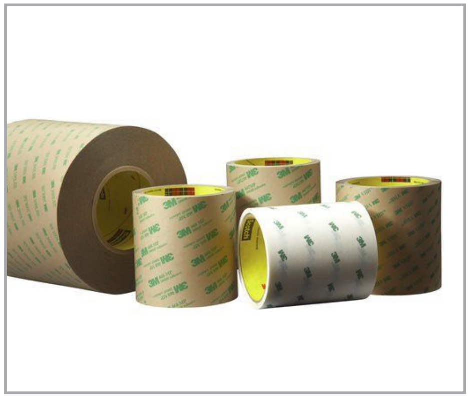
Select a Thin Bonding Tape

3M™ Adhesive Transfer Tape 9775WL (300MP)

- High bond adhesive ideal for use on fabricated foams, plastics, and fabrics
- Exceptional humidity, solvent, chemical and UV resistance helps bond durability
- Performs at temperatures up to 250°F/121°C
- 5.0 mils (.13 mm) thick adhesive on a 7.0 mils (.19 mm), 96 lb. white polycoated kraft liner

View Product Details

3M™ Flame Retardant Adhesive Transfer Tape 9372W



- Meets flammability standards such as F.A.R. 25.853
- Excellent for metals, foams and plastics such as polyethylene
- 2 mil adhesive for a thin bond line
- 83# polycoated kraft paper (PCK) liner adds moisture stability
- Meets several industry FST (fire, smoke and toxicity) requirements

View Product Details

Select a VHB

3M™ VHB™ Tape 4941

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welds, screws) or liquid adhesives
- Gray, 0.045 in (1.1 mm), multi-purpose adhesive and conformable acrylic foam core offers a good balance of strength and conformability

View Product Details

3M™ VHB™ Tape 4956

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welds, screws) or liquid adhesives
- Gray, 0.062 in (1.6 mm) multi-purpose adhesive and conformable acrylic foam core offers a good balance of strength and conformability

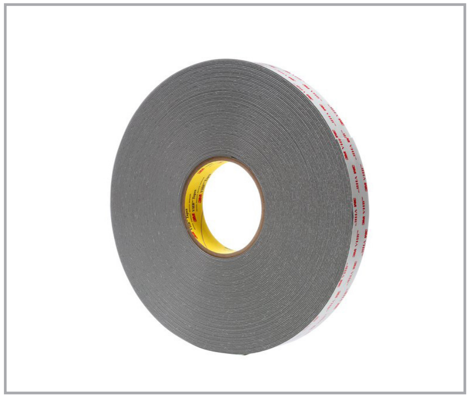
View Product Details

3M™ VHB™ Tape 4991

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welds, screws) or liquid adhesives
- Gray, 0.090 in (2.3 mm), multi-purpose adhesive and conformable acrylic foam core offers a good balance of strength and conformability

View Product Details

3M™ VHB™ Tape RP45

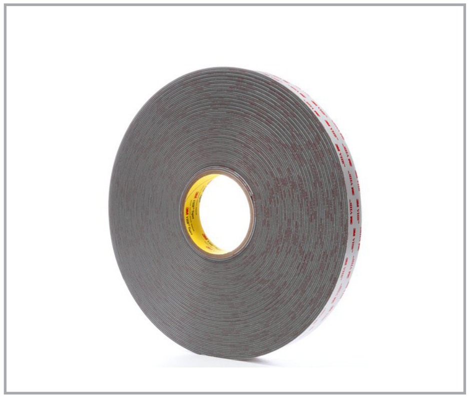


- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welding, screws) or liquid adhesives
- Gray, 0.045 in (1.1 mm), multi-purpose adhesive and conformable acrylic foam core for good performance in a variety of applications

View Product Details

Select a VHB

3M™ VHB™ Tape RP62



- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welding, screws) or liquid adhesives
- Gray, 0.062 in (1.6 mm), multi-purpose adhesive and conformable acrylic foam core for good performance in a variety of applications

View Product Details

3M™ VHB™ Tape 5952

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welding, screws) or liquid adhesives
- Black, 0.045 in (1.1 mm), modified acrylic adhesive and very conformable acrylic foam core bonds to a wide variety of substrates including powder coated paints and irregular surfaces

View Product Details

3M™ VHB™ Tape GPH-160

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Excellent high temperature (short term 450°F) resistance allows for bonding prior to powder coat or liquid painting processes
- Can replace mechanical fasteners (rivets, welding, screws) or liquid adhesives
- Gray, 0.045 in (1.1 mil), acrylic adhesive with a conformable, acrylic foam core

View Product Details

3M™ VHB™ Flame Retardant Tape 5958FR

- Fast and easy-to-use permanent bonding method provides high strength, long-term durability and is flame retardant
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welding, screws) or liquid adhesives
- Black, 0.040 in (1.0 mil), multi-purpose adhesive and very conformable acrylic foam core bonds to a wide variety of substrates including powder coated paints and irregular surfaces

View Product Details

3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60/LSB60NS

Click on the box for detailed FST test information

NFPA 130

For more product information click here.

- Toughened for high resistance against shock, vibration, impact loads and excellent peel strength
- 90 minute work life with handling strength in 10 hours that provides ample time for repositioning
- Medium viscosity, self-leveling formula easy to spread and coat on surfaces
- ASTM E162, ASTM E662, ASTM 1354, Bombardier SMP 800C
- Ideal for bulk application through meter mix dispensing equipment

3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60 is a high performance, two-part toughened epoxy adhesive that offers outstanding shear adhesion and very high durability. With a 90 minute work life and easy 1:1 mix ratio by weight or volume, this epoxy is often used for bulk application through meter mix dispensing equipment and the manufacture of large panel products including honeycomb panels.

When using a Duo-Pak (DP) size adhesive, rely on 3M dispensing equipment 3M for convenient and accurate metering, mixing and dispensing

Works Efficiently for Large Structure Bonding

Unlike using screws or rivets, our 3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60 lets you distribute stress uniformly over the entire bonded area while maintaining surface integrity and the physical properties of the panel. It allows you to use thinner, lighter panel materials without worrying about distortion, splitting, or crazing and will secure even small or thin bonding edges. Offering high resistance against shock and vibration, it features outstanding shear and peel adhesion with very high levels of durability.

Recommended Applications

- Honeycomb panels in rail cars, elevators, and aircraft
- Delivery truck side walls and flooring
- Metal enclosure facing and cabinets
- Panels or screens to frames
- Other large surface bonding applications that require long open times

Designed for Bulk Application

This epoxy dispenses as a medium viscosity adhesive for easy, controlled dispensing. The adhesive reaches handling strength in approximately 5 hours and is fully cured in 7 days at 73°F (23°C).The mix ratio is 1:1 and provides a 90 minute work life, providing ample time to adjust for desired fit prior to curing. Our 3M™ Scotch-Weld Toughened Epoxy Adhesive LSB60 is ideal for bulk application through meter mix dispensing equipment and the manufacture of large panel products.

3M™ Scotch-Weld™ Epoxy Adhesive 7240

Click on the box for detailed FST test information

EN 45545 | NFPA 130

For more product information click here.

3M Scotch Weld 7240 FR B/A epoxy adhesive is a high performance, two-part toughened adhesive.

Formulated to Create Rigid Bonds for Reliable Adhesion

3M™ Scotch-Weld™ Epoxy Adhesive 7240 is a high performance, two-part toughened adhesive that offers high shear and peel adhesion and outstanding levels of durability. This 2:1 mix ratio epoxy has a 45 minute work life, allowing time for adjustments and positioning of substrates and parts. It reaches handling strength in approximately 6 hours. Once cured this adhesive provides a durable bond with high shear strength to deliver better dead load holding. This product can be used in a wide range of industries including: general industrial, metalworking, transportation and aerospace. 3M™ Scotch-Weld™ Epoxy Adhesive 7240 contains glass beads to aid in accurate glue line control.

Recommended Applications

- Rail for stainless steel aluminum and fiberglass

Understanding Epoxy Adhesives

Epoxy adhesives are part of the class of adhesives called “structural adhesives,” which also includes polyurethane, acrylic, cyanoacrylate and others. Epoxies are formulated as liquid reactive polymers that undergo a chemical reaction when mixed and then cure to form a solid plastic material. Once the two parts are mixed in their specified ratio, they begin the curing process and offer a limited working time where the adhesive can be applied and the two surfaces positioned as needed. This work life lasts anywhere from a few minutes to several hours. These structural adhesives provide high shear and peel strengths, depending on the formula, and better heat and chemical resistance than other common adhesives. In general, epoxy adhesives have the highest overall strength and offer the best performance and most resistance to high temperatures, solvents and outdoor weathering.

Epoxy adhesives are widely used in building and home construction; aircraft and automobile manufacturing; bicycle, boat, golf clubs, ski and snowboard assembly as well as a host of home use and other applications. They are used virtually anywhere high-strength bonds are needed along with resistance to environmental conditions. These adhesives are popular for their ease of use, mechanical strength and chemical resistance. Formulations can be created to make epoxies flexible or rigid, transparent or opaque, quick setting or slow setting. The versatility with which epoxy adhesives can be formulated helps meet almost any requirement for bonding wood, metal, glass, stone and various plastics.

- Formulated to create high strength bonds for reliable adhesion
- High shear and peel adhesion for outstanding levels of durability
- Contains glass beads for accurate bond line control
- Tested to FAR25 for the Aerospace market and EN 45545 for the Railway market

3M™ Scotch-Weld™ Epoxy Adhesive DP105

Click on the box for detailed FST test information

EN 45545

For more product information click here.

- Extremely flexible adhesive formula provides strong, permanent bond even under vibration and impact
- Maintains high shear and peel strength
- Flexible when cured, making it a good choice for bonding dissimilar surfaces
- 5 minute work life with handling strength in approximately 20 minutes at room temperature
- Versatile bonder for metals, plastics, glass, ceramics and composites

3M™ Scotch-Weld™ Epoxy Adhesive DP105 is a very flexible, fast-setting, two-part epoxy adhesive that cures clear for invisible bond lines.

When using a Duo-Pak (DP) size adhesive, rely on 3M dispensing equipment for convenient and accurate metering, mixing and dispensing.

Extremely Flexible Adhesive Provides a Strong, Permanent Bond

There's no more versatile structural epoxy than 3M™ Scotch-Weld™ Epoxy Adhesive DP105. It works on a variety of substrates including metals, ceramics, glass, wood and many plastics. The low viscosity makes it easy to dispense and self-level; and an effective tool for filleting and potting. It features high shear strength and good peel and impact performance that, when combined with good flexibility, make it ideal for a variety of applications in the transportation, specialty vehicle, electrical, general industrial, sporting goods, construction, and consumer goods industries.

Recommended Applications

- Glass to metal bonding where it sees significant temperature changes, such as glass oven doors
- Bonding jewelry or other items where appearance is critical
- Bonds many plastics
- General attachment applications in a variety of industries
- Replace 5 minute epoxy for improved performance

Provides Handling Strength in About 20 Minutes

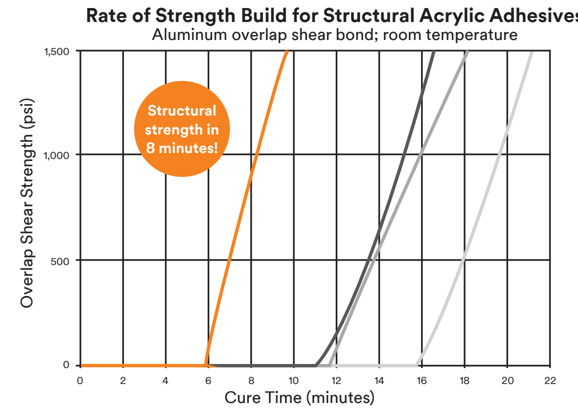
The mix ratio for 3M™ Scotch-Weld™ Epoxy Adhesive DP105 is 1:1 for quick, precise dispensing, and with a 5 minute working time there's some room for repositioning to keep projects on track. The adhesive reaches handling strength in approximately 20 minutes and is fully cured in 48 hours (at 72°F/22°C).

3M™ Scotch-Weld™ Low Odor Acrylic Adhesive DP8825NS/DP8810NS

Click on the box for detailed FST test information

For more product information on DP8810NS click here.	EN 45545
For more product information on DP8825NS click here.	EN 45545

- 23 minute work life with 53 minutes to structural strength
- Low odor and non-flammable properties for a safer working environment compared to typical acrylic adhesives
- Durable finished bond with excellent shear and high impact strength
- Bonds difficult surfaces such as powder coats and most plastics
- 18-month room temperature shelf life simplifies inventory management
- Features spacer beads to control bond line thickness



3M™ Scotch-Weld™ Low Odor Acrylic Adhesive DP8825NS is our low-odor, non-sag, toughened, two-part acrylic adhesive. This adhesive is an ideal choice for a wide variety of industrial and commercial applications.

When using a Duo-Pak (DP) size adhesive, rely on 3M dispensing equipment for convenient and accurate metering, mixing and dispensing.

Non-Sag with Excellent Impact Strength

Making work safer, faster, and more efficient, that's just a few of the benefits of 3M™ Scotch-Weld™ Low Odor Acrylic Adhesive DP8825NS. With a 10:1 mix ratio and a 23 minute work life there's time to position substrates prior to adhesion. Once fully cured it will reach 1,000 psi (7 MPa) of overlap shear strength in about 53 minutes, increasing throughput and productivity while featuring high peel and impact performance.

With lower odor and non-flammable properties, 3M™ Scotch-Weld™ Low Odor Acrylic Adhesive DP8825NS contributes to a safer work environment compared to typical acrylic adhesives. Added non-sag properties assure the adhesive is applied exactly where you want it and won't migrate during the application or bonding processes. And the 18-month room temperature shelf life of the product simplifies inventory management.

Recommended Applications

- Metalworking such as HVAC, appliance, sporting goods, and specialty vehicles
- Sign manufacturing such as panel to frame bonding, trim attachment, letter bonding, and frame assembly
- Bonding plastics, composites and powder coats to metal
- Typically used for larger parts where a longer open time is needed for assembly

3M™ Scotch-Weld™ Metal Bonder Acrylic Adhesive DP8407NS

For more product information click here.

- Bonds to a variety of substrates (especially bare metals) while resisting corrosion
- Withstands powder coat and paint bake cycles up to 400°F (204°C) for at least one hour
- Offers high shear, peel and impact strength for a tough and durable bond
- Provides excellent bond strength and impact resistance, even at temperatures down to -40°F (-40°C)
- 6 minute work life and fast strength build-up at room temperature
- Ideal for industrial applications with minimal surface preparation, such as slightly oily metal bonding
- Moderate non-sag formula won't slump or spread excessively
- Long shelf life, no refrigeration
- Meets several industry FST (fire, smoke and toxicity) requirements

3M™ Scotch-Weld™ Metal Bonder Acrylic Adhesive DP8407NS is a gray structural adhesive with high overlap shear and peel strength with good impact resistance and durability. This adhesive was designed to bond permanently to bare metals with minimal surface preparation, but also bonds well to wide variety of other materials, including most plastics.

When using a Duo-Pak (DP) size adhesive, rely on 3M dispensing equipment for convenient and accurate metering, mixing and dispensing..

Bonds to a Variety of Substrates and Resists Corrosion

Our 3M™ Scotch-Weld™ Metal Bonder Acrylic Adhesive DP8407NS bonds to a variety of materials (especially bare metals such as aluminum, cold rolled steel, copper, brass and bronze) while resisting corrosion. This gray structural adhesive can even bond slightly oily metal with minimal to no surface preparation. It provides excellent bond strength and impact resistance, even at temperatures down to -40°F (-40°C). 3M™ Scotch-Weld™ Metal Bonder Acrylic Adhesive DP8407NS is ideal for industrial applications where permanent, high-strength bonds are required. Using our adhesive helps eliminate the grinding process and surface finishing time associated with welding, spot welding and mechanical fasteners.

Recommended Applications

- Metal office furniture
- HVAC equipment
- Specialty vehicles (ambulance, trailer, fire truck)
- Recreational vehicles (snowmobiles and ATV's)
- Signage
- Appliances
- Metal fabrication

3M™ Scotch-Weld™ Acrylic Adhesive DP8410NS/DP8425NS

Click on the box for detailed FST test information

DP8425NS: EN 45545 DP8410NS: NFPA 130

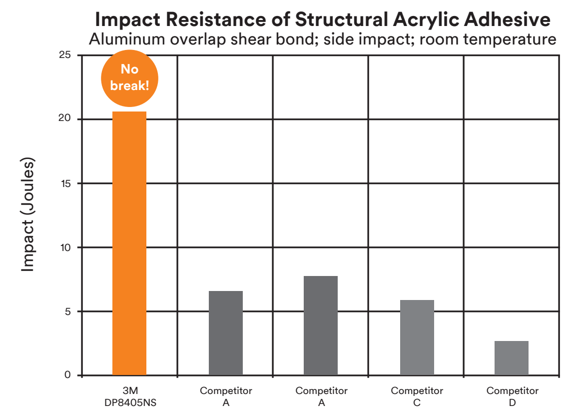
For more product information on DP8410NS click here.

For more product information on DP8425NS click here.

- 23 minute work life with 53 minutes to structural strength
- Durable bond with excellent shear, peel and high impact strength
- Bonds a variety of surfaces, including most metals and plastics
- High strength with minimal surface prep
- Features spacer beads to control bond line thickness
- Meets several industry FST (fire, smoke and toxicity) requirements

3M™ Scotch-Weld™ Acrylic Adhesive DP8425NS is a non-sag, toughed, two-part acrylic adhesive. This toughened product provides improved adhesion to many plastics and metals, including those with slightly oily surfaces. It is a durable product that features a fast rate of strength build to provide structural strength in just minutes.

When using a Duo-Pak (DP) size adhesive, rely on 3M dispensing equipment for convenient and accurate metering, mixing and dispensing.



Non-Sag with Excellent Shear, Peel and Impact Strength

3M™ Scotch-Weld™ Acrylic Adhesive DP8425NS is a non-sag acrylic adhesive with a 10:1 mix ratio. It features a 23 minute work life to allow time to position substrates prior to adhesion. This working life, open time and cure time can be accelerated with heat. Once fully cured, this adhesive will reach 1,000 psi (7 MPa) of overlap shear strength in approximately 53 minutes, increasing throughput and productivity while featuring a high peel and impact performance. Full cure will be reached within 24 hours.

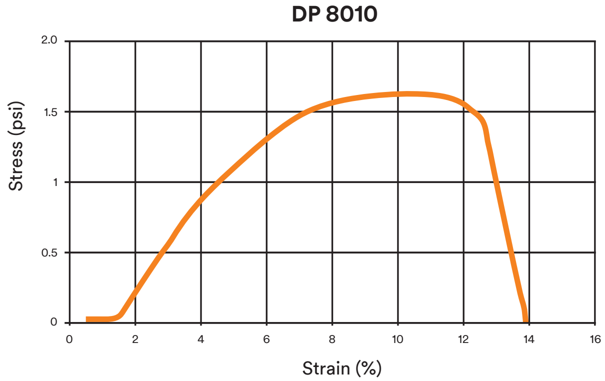
Recommended Applications

- Metalworking such as HVAC, appliance, sporting goods, and specialty vehicles
- Sign manufacturing such as panel to frame bonding, trim attachment, letter bonding, and frame assembly
- Bonding plastics, composites and powder coats to metal
- Typically used for larger parts where a longer open time is needed for assembly

	Mix Ratio (Volume) B:A	Approximate Viscosity (cP) 75°F (24°C)	Approximate Mixed Work Life 75°F (24°C)”	Approximate Time to Handling Strength 75°F (24°C)	Floating Roller Peel (pli) 75°F (24°C)	Overlap Shear Aluminum (psi) -67°F (-55°C)	Overlap Shear Aluminum (psi) 75°F (24°C)	Overlap Shear Aluminum (psi) 180°F (82°C)	Overlap Shear Carbon Fiber-Reinforced Epoxy (psi) 75°F (24°C)	Overlap Shear Glass Fiber-Reinforced Epoxy (psi) 75°F (24°C)	Overlap Shear Sheet Molding Compound (SMC) (psi) 75°F (24°C)	Available Sizes
DP8410NS	10:1	70,000	10 minutes	20 minutes	54	N/A	3,600	900	4570 CF	2310 AF	1170 SF	45ml, 490ml, 5 gale, 55gal

3M™ Scotch-Weld™ Structural Plastic Adhesive DP8010NS

For more product information click here.



- Creates strong bond on low surface energy (LSE) plastics such as polyolefin with minimal or no surface prep required
- Delivers non-sag formulation so adhesive stays where when applied
- Resists many chemicals, water, humidity and corrosion
- Formulated to bond multi-material assemblies such as LSE plastics, thermoplastics, composites and metals
- Medium viscosity allows controlled dispensing
- 10 minute work life with 60 minute handling strength
- Strong adhesive can replace screws, rivets and welding

3M™ Scotch-Weld™ Structural Plastic Adhesive DP8010NS is a non-sag, two-part acrylic adhesive specially formulated to bond many low surface energy plastics, including many grades of polypropylene, polyethylene, and thermoplastic elastomers (TPEs) without special surface preparation.

When using a Duo-Pak (DP) size adhesive, rely on 3M dispensing equipment for convenient and accurate metering, mixing and dispensing.

Creates a Strong Bond on Low Surface Energy Plastics

Structural bonds can be achieved without special surface treatments such as chemical etching, plasma, flame, or corona treatment or priming. Simply wipe the surfaces with isopropanol to remove mold release agents, dust dirt, etc. 3M™ Scotch-Weld™ Structural Plastic Adhesive DP8010NS bonds metals, ceramics, and wood and most other plastics. The non-sag formula creates rigid adhesion. We also formulate this adhesive with 8mil spacer beads for bond line spacing.

Recommended Applications

- Joining plastics to metals, such as in the manufacture or repair of appliances
- Bonding low surface energy plastics without priming
- Impact resistance composite bonding
- Manufacture or repair of various sporting goods equipment

	Mix Ratio (Volume) B:A	Approximate Viscosity (cP) 75°F (24°C)	Approximate Mixed Work Life 75°F (24°C)”	Approximate Time to Handling Strength 75°F (24°C)	Floating Roller Peel (pli) 75°F (24°C)	Overlap Shear Aluminum (psi) -67°F (-55°C)	Overlap Shear Aluminum (psi) 75°F (24°C)	Overlap Shear Aluminum (psi) 180°F (82°C)	Overlap Shear Carbon Fiber-Reinforced Epoxy (psi) 75°F (24°C)	Overlap Shear Glass Fiber-Reinforced Epoxy (psi) 75°F (24°C)	Overlap Shear Sheet Molding Compound (SMC) (psi) 75°F (24°C)	Available Sizes
DP8410NS	10:1	20,000	10 minutes	1 hour	14	2,700	2,700	500	2400 CF	2050 AF	1010 SF	45ml, 490ml, 1 gal, 5 gal, 55gal

3M™ Scotch-Weld™ Multi-Material Composite Urethane Adhesive DP6310NS/DP6330NS

Click on the box for detailed FST test information

EN 45545

For more product information on DP6310NS click here.

For more product information on DP6330NS click here.

- Two part urethane paste delivers outstanding strength and performance
- Non-sag formulation resists running and slumping of adhesive
- Primerless to most surfaces
- 10 minute open time
- Ability to bond most composites and dissimilar substrates
- Excellent water and humidity resistance, very good chemical resistance
- Cures at room temperature but can be accelerated with heat

3M™ Scotch-Weld™ Multi-Material Composite Urethane Adhesive DP6310NS is a green, non-sag, two-component urethane for bonding a variety of composites, plastics, metals and wood. This flexible adhesive has excellent elongation and stress strain properties for durable bonding of composite parts and multi-material assemblies.

When using a Duo-Pak (DP) size adhesive, rely on 3M dispensing equipment for convenient and accurate metering, mixing and dispensing.

Bonds to Most Composites and Dissimilar Substrates

Designed specifically for multi-material and composite assemblies, our 3M™ Scotch-Weld™ Multi-Material Composite Urethane Adhesive DP6310NS delivers outstanding strength and performance. This adhesive has excellent energy absorption and fatigue properties for durable bonding of composite parts and multi-material assemblies, including plastics, metals and wood. With a 1:1 mix ratio, this green adhesive has a 10 minute open time and reaches handing strength in 45 minutes.

Recommended Applications

- Composites and plastics to metal; medium sized parts
- Bonding shaped composites and plastics

3M™ Scotch-Weld™ Multi-Material Composite Urethane Adhesives DP6310NS can replace rivets and screws in attaching composites to other substrates, providing a more aesthetically-pleasing, fatigue-resistant bond line. It also bonds well to most metals without requiring priming.

	Mix Ratio (Volume) B:A	Approximate Viscosity (cP) 75°F (24°C)	Approximate Mixed Work Life 75°F (24°C)"	Approximate Time to Handling Strength 75°F (24°C)	Floating Roller Peel (pli) 75°F (24°C)	Overlap Shear Aluminum (psi) -67°F (-55°C)	Overlap Shear Aluminum (psi) 75°F (24°C)	Overlap Shear Aluminum (psi) 180°F (82°C)	Overlap Shear Carbon Fiber-Reinforced Epoxy (psi) 75°F (24°C)	Overlap Shear Glass Fiber-Reinforced Epoxy (psi) 75°F (24°C)	Overlap Shear Sheet Molding Compound (SMC) (psi) 75°F (24°C)	Available Sizes
DP8410NS	1:1	Paste	10 minutes	30 minutes	23	2000 CF	2050 CF	2300 CF	3200 SF	2400 SF	1000 SF	TBD

3M™ Fastbond™ Contact Adhesive 30NF

For more product information click here.

- Bonds most foamed plastics, plastic laminate, wood, plywood and canvas to themselves and to each other
- Creates a very high strength, high temperature resistant bond with up to a four hour bonding range
- Adhesive can be applied by spray, brush or roller
- Non-flammable in its wet state

3M™ Fastbond™ Contact Adhesive 30NF is a low-odor, water-based, adhesive designed to have high strength, high coverage, long bonding range and good heat resistance. This classic adhesive has proven to bond combinations of most foamed plastics, plastic laminate, wood, plywood, wood veneer and canvas.

We designed 3M™ Fastbond™ Contact Adhesive 30NF to create a very strong bond resistant to high heat with a bonding range of up to four hours. It is deal for decorative laminate applications where non-flammability and low VOCs are critical. Post-formable and heat resistant, it is non-flammable in the wet state, which makes in an optimal solution in settings where fire protection is of utmost concern.

Recommended Applications

- Most formed plastics
- Plastic laminate
- Wood
- Plywood
- Wood veneer
- Canvas

High Immediate Strength, Long Bonding Range

Formulated to be a fast-acting solution, 3M™ Low Mist Contact Adhesive 30NF delivers high immediate bonding strength with a long bonding range. Our design offers a great solution for bonding porous substrates to porous or non-porous substrates with time for positioning and adjustments. With 3M™ Low Mist Contact Adhesive 30NF, you can leverage the advantages that come from an adhesive that is ready to meet the demands of many tough applications.

Applying Your Adhesive

Whether it is being sprayed, brushed or rolled on, the application of your 3M™ adhesive is a straightforward process. Start by carefully applying your adhesive to your surface until you've formed a uniform coat. Using an overlapping pattern, the application of one coat should prove sufficient for most surfaces. Effective adhesive coverage is accomplished when 80% or more of the surface is covered. Some substrates, including porous materials, may require an additional coat. In order to apply additional adhesive, simply wait until the existing adhesive becomes dry to the touch, and then proceed with the application of the additional coat.

3M™ Neoprene High Performance Contact Adhesive 1357

Click on the box for detailed FST test information

NFPA 130

For more product information click here.

- High performance laminating contact adhesive
- Adheres, sheet metals, such as stainless steel, aluminum, cold rolled steel and many plastics to numerous other substrates
- Excellent moisture and heat resistance and will perform up to up to 300°F/148°C
- Available in tubes, cans or pails
- Meets several industry FST (fire, smoke and toxicity) requirements

3M™ Neoprene High Performance Contact Adhesive 1357 is a versatile, solvent based adhesive. It offers high immediate handling strength and good heat resistance, and is commonly used for bonding most metals and plastics. It is also suitable for large surface panel or composite lamination.

Adheres Stainless Steel, Aluminum, Cold Rolled Steel and Many Plastics

3M™ Neoprene High Performance Contact Adhesive 1357 has played a significant role in 3M's portfolio of contact adhesives for 50-plus years. Since its inception in 1954 it has become one of our most versatile solvent-based adhesives for heavy duty surface laminations. This adhesive bonds to plastics and metals, including sheet metal, stainless steel. It provides excellent heat and water resistance, performing in temperatures up to 300°F/148°C. 3M™ Neoprene High Performance Contact Adhesive 1357 dries quickly while allowing time for positioning and adjustments without slowing down work processes.

Recommended Applications

- Metal honeycomb composite panels
- Durable stainless steel to wood panels
- Woodworking

Applying Your Adhesive

Whether it is being brushed or rolled on, the application of your 3M™ adhesive is a straightforward process. Start by carefully applying your adhesive to your surface until you've formed a uniform coat. Using an overlapping pattern, the application of one coat should prove sufficient for most surfaces. Effective adhesive coverage is accomplished when 80% or more of the surface is covered. Some substrates, including porous materials, may require an additional coat. In order to apply additional adhesive, simply wait until the existing adhesive becomes dry to the touch, and then proceed with the application of the additional coat.

3M™ Nitrile Industrial Adhesive 4491

For more product information click here.

- Fast-drying adhesive delivers rapid results
- Adhesive provides strong, flexible bonds for a variety of applications
- Low viscosity grade for spray application
- Resistance to weathering, water, fuels, oil and plasticizers provides long-term durability

Can be heat cured to obtain superior physical properties

3M™ Nitrile Industrial Adhesive 4491 is a sprayable, fast-drying adhesive that provides strong, flexible bonds with excellent environmental resistance. We also formulated this spray adhesive to offer good resistance to plasticizer migration. In addition, our 3M™ Nitrile Industrial Adhesive 4491 has the ability to be heat cured to obtain superior physical properties.

Fast-Drying, Versatile and Resilient

A low-viscosity, spray adhesive designed to be fast-drying and resilient, 3M™ Nitrile Industrial Adhesive 4491 offers rapid results and flexible bonds for a variety of applications. The strong bonds created by this nitrile spray adhesive have excellent environmental resistance and they also resist plasticizer migration, offering long-term durability and performance. This versatile plastic adhesive can be heat cured to obtain superior physical properties and bonds vinyl extrusions and sheeting, fabrics, leather, foams and many plastics where high strength and resistance to weathering, water, oil and many other solvents are required.

Recommended Applications

- Cabinet decorative vinyl bonding
- Wall lining and flooring
- Rubber and vinyl floor bonding

Formulated for Minimal Impact

Air quality control is a concern for every industry, including those whose everyday operations rely on performance-grade adhesives. In order to best improve workplace conditions and take care of the environment, 3M has developed a large range of high-strength adhesives with refined formulas — same performance, better for the environment. By continually striving to minimize the environmental impact of an adhesive, while maximizing its benefits, 3M has taken a new approach to redefining our highest performing adhesives.

3M™ Polyurethane Window Bonder Adhesive Sealant 590/595

Click on the box for detailed FST test information

590: NFPA 130 595: EN 45545 NFPA 130

For more product information on 590 click here

For more product information on 595 click here

- 3 hour drive-away time and 25 - 40 minute skin time
- Crash tested to FMVSS 212, suitable for structural glass bonding
- Meets several industry FST (fire, smoke and toxicity) requirements

3M™ Polyurethane Glass Adhesive Sealant 590 and 595 is a one-part, high viscosity polyurethane sealant for bonding windshields and other glass, acrylic, polycarbonate and many other materials. This high strength adhesive stays flexible after cure, resulting in a durable, long-lasting bond that helps joints or bonded areas resist vibration fatigue.

Suitable for Structural Glass Bonding; Crash Tested to FMVSS 212. 3M™ Polyurethane Glass Adhesive Sealant 595 is specifically formulated for the unique characteristics and requirements of structural glass bonding and vehicle window glazing. Strong yet flexible, our crack resistant adhesive sealant offers reliable bonding that expands and contracts with heat and cold.

Recommended Applications

- Structural windshield installations
- PMMA windshield applications
- Hard-to-bond polycarbonates and acrylics
- Flush-mounted glass for both marine and automotive use

Understanding Polyurethane Sealants

Polyurethane sealants provide strong, flexible durable elastomeric bonds that seal against the elements. These sealants excel in challenging industrial, transportation and construction applications. Polyurethane sealants are available in a wide variety of Shore A hardness, open time and colors to meet many application needs. Choose a 3M Manual or Pneumatic Applicator for dispensing 3M adhesives sealant cartridges and 400ml/600ml sausage packs.

Bringing Better Ideas to the Surface through Science and Innovation

In our 3M Industrial Adhesives and Tapes Division, we apply the science of adhesion to deliver innovative solutions that improve the design and manufacturing processes of companies around the world. In the end, our technologies help customers like you deliver competitive products to the market faster and more efficiently.

3M™ Polyurethane Adhesive Sealant 560

Click on the box for detailed FST test information

EN 45545 | NFPA 130

For more product information click here.

- High strength bonding to replace mechanical fasteners and rivets
- Permanently elastic to allow joint movement
- 50-60 minute skin time; paintable, once skin forms
- Good UV resistance
- One component, moisture-curing sealant simplifies production
- Bonds dissimilar materials for increased design flexibility
- Gap filling capability
- Features mid-range Shore A hardness
- Meets several industry FST (fire, smoke and toxicity) requirements

3M™ Polyurethane Adhesive Sealant 560 is a high-strength, single-component, moisture-curing, gap-filling polyurethane adhesive that creates high strength bonds on a wide variety of materials including plastics, metals, fiberglass and wood.

Creates High Strength Elastomeric Bond with Good UV Resistance

Engineered for high performance, 3M™ Polyurethane Adhesive Sealant 560 is a single-component, moisture-curing polyurethane sealant used to bond a wide variety of materials, including plastics, fiberglass reinforced plastic (FRP), sheet molding compound (SMC), aluminum, steel, coated metal and wood. It exhibits high tensile strength, good UV resistance, mid-range Shore A Hardness and high modulus in a wide variety of extreme service environments. Available in cartridge, sausage pack and drum volumes to meet your application needs.

Recommended Applications

- Panel bonding
- Attaching exterior panels and metal framework
- Vehicle flooring attachment
- Transportation manufacturing (bus, rail, truck, trailer)
- Replacement of mechanical fasteners in many situations

Paintable after Skin Forms for Improved Appearance

3M™ Polyurethane Adhesive Sealant 560 offers an alternative to mechanical fasteners and can replace rivets in some applications. It will bond dissimilar substrates and a wide selection of materials. This adhesive will perform in temperatures ranging from -40°F/-40°C to 194°F/90°C. Once skin forms (50-60 minutes), the sealant can be painted to improve the final finish. market faster and more efficiently.

3M™ Polyurethane Adhesive Sealant 550 Fast Cure

Click on the box for detailed FST test information

EN 45545

For more product information click here.

- Fast set and cure time for fast-paced processes and productivity
- Elastic formula creates high-strength bonds
- Multi substrate bonder works on a wide variety of similar and dissimilar substrates
- One component adhesive for easy application with no mixing or guesswork
- Paintable after curing for professional results
- Meets several industry FST (fire, smoke and toxicity) requirements

3M™ Polyurethane Adhesive Sealant 550 Fast Cure is our low viscosity adhesive that has a fast set time and creates a permanently elastic bond. It is ideal for bonding a variety of similar and dissimilar materials. This one-component polyurethane adhesive provides fast cure time. The low viscosity formula is ideal for creating very thin bond lines.

Works on a Wide Variety of Similar and Dissimilar Substrates

3M™ Polyurethane Adhesive Sealant 550 Fast Cure is part of our 500 Series one-component, moisture-curing, urethane adhesives. These adhesives create a permanently elastic bond and bond strongly a variety of substrates such as wood, fiber reinforced plastic (FRP) and many other plastics to themselves, to metal and to glass. Our moisture-curing formula cures by reacting with moisture in the air or the substrate. In addition to spraying, they can also be extruded from hand held or bench mounted applicators and are primarily dispensed with bulk application equipment. Our one-part polyurethane adhesives work well for bonding a wide variety of plastics including polystyrene and polyacrylic. They are also effective on a wide variety of other substrates - from aluminum and glass to plastic and wood.

Recommended Applications

- Marine deck to hull bonding
- Vertical and horizontal expansion joint applications
- Concrete and masonry control joints
- Aluminum curtain wall and storefronts
- Door and window frame perimeters

Paintable after Skin Forms for Improved Appearance

3M™ Polyurethane Adhesive Sealant 550 offers an alternative to mechanical fasteners and can replace rivets in some applications. It will bond dissimilar substrates and a wide selection of materials. This adhesive will perform in temperatures ranging from -40°F/-40°C to 194°F/90°C. Once skin forms (60-90 minutes), the sealant can be painted to improve the final finish.

3M™ Adhesive Sealant 760

For more product information click here.

- High performance bonding
- Excellent UV resistance
- Permanently elastic to allow joint movement
- 10-30 minute skin time, paintable immediately
- Silane Modified Polymer (SMP) adhesive sealant
- Low VOC
- Gap filling capabilities
- Single component, moisture-curing sealant offers a simplified production

3M™ Adhesive Sealant 760-FST is a single-component, moisture-curing, elastomeric, isocyanate-free adhesive sealant that offers exceptional UV resistance and long term durability.

High Performance Sealant for Durable Bonding Applications

3M™ Adhesive Sealant 760-FSTV offers excellent UV resistance and long term durability when exposed to the elements. This sealant is permanently elastic and is capable of bonding dissimilar materials, offering long-lasting bonds and design flexibility. This single-component sealant is paintable when wet and has a 10-30 minute skin time.

Recommended Applications

- Panel to post bonding on trucks, trains, trailers and specialty vehicles
- Architectural panels

Understanding Silane Modified Polymer (SMP) Sealants

Silane Modified Polymer sealants provide strong, flexible durable elastomeric bonds that seal against the elements. These sealants offer excellent UV resistance and excel in challenging industrial, transportation and construction applications. SMP sealants are available in a wide variety of Shore A hardness, open time and colors to meet many application needs. Choose a 3M Manual or Pneumatic Applicator for dispensing 3M adhesives sealant cartridges and 400ml/600ml sausage packs.

3M™ Adhesive Transfer Tape 9775WL (300MP)

Click on the box for detailed FST test information

EN 45545

For more product information click here.

- High bond adhesive ideal for use on fabricated foams, plastics, and fabrics
- Exceptional humidity, solvent, chemical and UV resistance helps bond durability
- Performs at temperatures up to 250°F/121°C
- 5.0 mils (.13 mm) thick adhesive on a 7.0 mils (.19 mm), 96 lb. white polycoated kraft liner

3M™ Adhesive Transfer Tape 9775WL is designed for permanently bonding plastics, foams, wood and textiles. The adhesive easily flows into crevices and voids without the addition of heat. Minimal pressure is required. This transfer tape features 3M™ Adhesive 300MP, a high tack acrylic that delivers good initial bond and full adhesion within 48 - 72 hours.

Ideal for Use on Fabricated Foams, Plastics, and Fabrics

Our 3M™ Adhesive Transfer Tape 9775WL features 5.0 mils (.13 mm) of durable adhesive mounted on a 7.0 mils (.19 mm), 96 lb. white polycoated kraft paper liner. The adhesive is designed to bond to foams, fabrics, wood and most plastic substrates. This adhesive transfer tape resists UV and features good humidity, water, solvent and chemical resistance.

Recommended Applications

- Foam gaskets and general foam bonding
- Bonding of textured and rough surfaces
- Fabric and textile bonding including floorcovering lamination

Easily Flows into Crevices and Voids without Adding Heat

The design of 3M™ Adhesive 300MP creates a consistently strong bond across a broad range of products up to 250°F (121°C). The easy flow properties allow the adhesive to quickly bond to rough and textured substrates, including, foam, wood, textiles and more, without adding heat. The heavy polycoated kraft paper liner makes this adhesive tape ideal for die cutting and converting processes.

Understanding Adhesive Transfer Tapes

3M adhesive transfer tapes are pressure sensitive adhesives coated on a release liner, without a scrim or carrier. These adhesive tapes are more conformable than double coated adhesive tapes for applications with textured or irregular surfaces. For application, the tape is positioned, adhesive side down, to a surface and the liner is removed, exposing the backside of the adhesive to the joining surface.

Click on the box for detailed FST test information

EN 45545

For more product information click here.

3M™ Flame Retardant Adhesive Transfer Tape 9372W

- Meets flammability standards such as F.A.R. 25.853
- Excellent for metals, foams and plastics such as polyethylene
- 2 mil adhesive for a thin bond line
- 83# polycoated kraft paper (PCK) liner adds moisture stability
- Meets several industry FST (fire, smoke and toxicity) requirements

3M™ Flame Retardant Adhesive Transfer Tape 9372W is formulated for use in environments requiring regulatory compliance with flammability standards. The flame-retardant, medium-firm acrylic adhesive delivers excellent adhesion to surfaces including plastics such as polyethylene, as well as metals and foams. A PCK liner adds moisture stability.

Advanced Tape Technology for Flame Retardancy and Strong Bonds

In one adhesive, our 3M™ Flame Retardant Adhesive Transfer Tape 9372W delivers high-performance bonding to environments where flame retardance is important. Featuring 3M™ Flame Retardant Adhesive 300FR, this 2 mil tape meets various flame retardancy standards such as F.A.R. 25.853. A 6.2 mil, 83# polycoated kraft paper (PCK) liner adds plenty of strength and stability for die cutting.

Recommended Applications

- Applications and environments requiring flame retardancy
- Plastic film lamination/bonding
- Splicing
- Foam lamination
- Cell phone lens attachment

About 3M™ Adhesive 300FR

3M™ Flame Retardant Adhesive 300FR is a medium-firm acrylic adhesive featuring high initial adhesion and good high temperature holding power. The high tack adhesive is also tested for adhesion on a range of surfaces including polypropylene, polyester, ABS, polycarbonate and stainless steel. It is formulated to meet flame retardant standards including F.A.R. 25.853.

What Are Adhesive Transfer Tapes?

Adhesive transfer tapes are rolls of pressure sensitive adhesive pre-applied to a special release liner. For application, the tape is simply pressed, adhesive side down, to a surface and the liner is peeled off. A variety of adhesive properties and liners are available to meet requirements for applications such as nameplate attachment to high and low surface energy plastics, appliance graphic overlays that perform in high temperatures, foam gasketing, web splicing, signs, posters, banners, point-of-purchase displays, and more.

3M™ VHB™ Tape 4941

Click on the box for detailed FST test information

EN 45545

For more product information click here.

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welds, screws) or liquid adhesives
- Gray, 0.045 in (1.1 mm), multi-purpose adhesive and conformable acrylic foam core offers a good balance of strength and conformability
- Eliminate drilling, grinding, refinishing, screwing, welding and associated clean-up
- Creates a permanent seal against water, moisture and more
- Pressure sensitive adhesive bonds on contact to provide immediate handling strength
- Allows the use of thinner, lighter weight and dissimilar materials
- UL GREENGUARD and UL GREENGUARD Gold Certified, contributing to LEED Credit
- Meets several industry FST (fire, smoke and toxicity) requirements

Dream, Design, Deliver with our 3M™ VHB™ Tape 4941. It is a gray, 0.045 in (1.1 mm), multi-purpose acrylic adhesive with a conformable, foam core. It can replace rivets, welds and screws. The fast and easy to use permanent bonding method provides high strength and long-term durability. It offers design flexibility with its viscoelasticity and powerful ability to bond to a variety of surfaces.

Convenience Meets Extreme Bonding Power

Our 3M™ VHB™ Tape consists of a durable acrylic adhesive with viscoelastic properties. This provides an extraordinarily strong double sided foam tape that adheres to a broad range of substrates, including aluminum, stainless steel, galvanized steel, composites, plastics, acrylic, polycarbonate, ABS and painted or sealed wood and concrete. Our bonding tapes provide excellent shear strength, conformability, surface adhesion and temperature resistance. They are commonly used in applications across a variety of markets including transportation, appliance, electronics, construction, sign and display and general industrial. Reliably bonds a variety of materials with strength and speed for permanent applications.

Recommended Applications

- Decorative material and trim
- Nameplates and logos
- Electronic displays
- Panel to frame
- Stiffener to panel

3M™ VHB™ Tape 4956

For more product information click here.

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welds, screws) or liquid adhesives
- Gray, 0.062 in (1.6 mm) multi-purpose adhesive and conformable acrylic foam core offers a good balance of strength and conformability
- Eliminate drilling, grinding, refinishing, screwing, welding and associated clean-up
- Creates a permanent seal against water, moisture and more
- Pressure sensitive adhesive bonds on contact to provide immediate handling strength
- Allows the use of thinner, lighter weight and dissimilar materials
- UL GREENGUARD and UL GREENGUARD Gold Certified, contributing to LEED Credit

Dream, Design, Deliver with 3M™ VHB™ Tape 4956. It is a gray, 0.062 in (1.6 mm), multi-purpose acrylic adhesive with a conformable, foam core. It can replace rivets, welds and screws. The fast and easy to use permanent bonding method provides high strength and long-term durability. It offers design flexibility with its viscoelasticity and powerful ability to bond to a variety of surfaces.

Convenience Meets Extreme Bonding Power

Our 3M™ VHB™ Tape consists of a durable acrylic adhesive with viscoelastic properties. This provides an extraordinarily strong double sided foam tape that adheres to a broad range of substrates, including aluminum, stainless steel, galvanized steel, composites, plastics, acrylic, polycarbonate, ABS and painted or sealed wood and concrete. Our bonding tapes provide excellent shear strength, conformability, surface adhesion and temperature resistance. They are commonly used in applications across a variety of markets including transportation, appliance, electronics, construction, sign and display and general industrial. Reliably bonds a variety of materials with strength and speed for permanent applications.

Recommended Applications

- Decorative material and trim
- Nameplates and logos
- Electronic displays
- Panel to frame
- Stiffener to panel

3M™ VHB™ Tape 4991

Click on the box for detailed FST test information

EN 45545

For more product information click here.

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welds, screws) or liquid adhesives
- Gray, 0.090 in (2.3 mm), multi-purpose adhesive and conformable acrylic foam core offers a good balance of strength and conformability
- Eliminate drilling, grinding, refinishing, screwing, welding and associated clean-up
- Creates a permanent seal against water, moisture and more
- Pressure sensitive adhesive bonds on contact to provide immediate handling strength
- Allows the use of thinner, lighter weight and dissimilar materials
- UL GREENGUARD and UL GREENGUARD Gold Certified, contributing to LEED Credit

Dream, Design, Deliver with our 3M™ VHB™ Tape 4991. It is a gray, 0.090 in (2.3 mm), multi-purpose acrylic adhesive with a conformable, foam core. It can replace rivets, welds and screws. The fast and easy to use permanent bonding method provides high strength and long-term durability. It offers design flexibility with its viscoelasticity and powerful ability to bond to a variety of surfaces.

Convenience Meets Extreme Bonding Power

Our 3M™ VHB™ Tape consists of a durable acrylic adhesive with viscoelastic properties. This provides an extraordinarily strong double sided foam tape that adheres to a broad range of substrates, including aluminum, stainless steel, galvanized steel, composites, plastics, acrylic, polycarbonate, ABS and painted or sealed wood and concrete. Our bonding tapes provide excellent shear strength, conformability, surface adhesion and temperature resistance. They are commonly used in applications across a variety of markets including transportation, appliance, electronics, construction, sign and display and general industrial. Reliably bonds a variety of materials with strength and speed for permanent applications.

Recommended Applications

- Decorative material and trim
- Nameplates and logos
- Electronic displays
- Panel to frame
- Stiffener to panel

3M™ VHB™ Tape RP45

For more product information click here.

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welding, screws) or liquid adhesives
- Gray, 0.045 in (1.1 mm), multi-purpose adhesive and conformable acrylic foam core for good performance in a variety of applications
- Eliminate drilling, grinding, refinishing, screwing, welding and clean-up
- Creates a permanent seal against water, moisture and more
- Pressure sensitive adhesive bonds on contact to provide immediate handling strength
- Allows the use of thinner, lighter weight and dissimilar materials

Dream, Design, Deliver with our 3M™ VHB™ Tape RP45. It is a gray, 0.045 in (1.1 mm), multi-purpose acrylic adhesive with a conformable foam core. It can replace rivets, welds and screws. The fast and easy to use permanent bonding method provides good strength and durability. It offers design flexibility with its viscoelasticity and can bond to a variety of surfaces even at lower temperatures.

Convenience Meets Extreme Bonding Power

Our 3M™ VHB™ Tape consists of a durable acrylic adhesive with viscoelastic properties. This provides an extraordinarily strong double sided foam tape that adheres to a broad range of substrates, including aluminum, stainless steel, galvanized steel, composites, plastics, acrylic, polycarbonate, ABS and painted or sealed wood and concrete. Our bonding tapes provide excellent shear strength, conformability, surface adhesion and temperature resistance. They are commonly used in applications across a variety of markets including transportation, appliance, electronics, construction, sign and display and general industrial. Reliably bonds a variety of materials with strength and speed for permanent applications.

Recommended Applications

- Decorative material and trim
- Nameplates and logos
- Electronic displays
- Panel to frame
- Stiffener to panel

3M™ VHB™ Tape RP62

For more product information click here.

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welding, screws) or liquid adhesives
- Gray, 0.062 in (1.6 mm), multi-purpose adhesive and conformable acrylic foam core for good performance in a variety of applications
- Eliminate drilling, grinding, refinishing, screwing, welding and clean-up
- Creates a permanent seal against water, moisture and more
- Pressure sensitive adhesive bonds on contact to provide immediate handling strength
- Allows the use of thinner, lighter weight and dissimilar materials

Dream, Design, Deliver with our 3M™ VHB™ Tape RP62. It is a gray, 0.062 in (1.6 mm), multi-purpose acrylic adhesive with a conformable foam core. It can replace rivets, welds and screws. The fast and easy to use permanent bonding method provides good strength and durability. It offers design flexibility with its viscoelasticity and can bond to a variety of surfaces even at lower temperatures.

Convenience Meets Extreme Bonding Power

Our 3M™ VHB™ Tape consists of a durable acrylic adhesive with viscoelastic properties. This provides an extraordinarily strong double sided foam tape that adheres to a broad range of substrates, including aluminum, stainless steel, galvanized steel, composites, plastics, acrylic, polycarbonate, ABS and painted or sealed wood and concrete. Our bonding tapes provide excellent shear strength, conformability, surface adhesion and temperature resistance. They are commonly used in applications across a variety of markets including transportation, appliance, electronics, construction, sign and display and general industrial. Reliably bonds a variety of materials with strength and speed for permanent applications.

Recommended Applications

- Decorative material and trim
- Nameplates and logos
- Electronic displays
- Panel to frame
- Stiffener to panel

3M™ VHB™ Tape 5952

For more product information click here.

- Fast and easy-to-use permanent bonding method provides high strength and long-term durability
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welding, screws) or liquid adhesives
- Black, 0.045 in (1.1 mm), modified acrylic adhesive and very conformable acrylic foam core bonds to a wide variety of substrates including powder coated paints and irregular surfaces
- Eliminate drilling, grinding, refinishing, screwing, welding and clean-up
- Creates a permanent seal against water, moisture and more by offering better gap filling capabilities
- Pressure sensitive adhesive bonds on contact to provide immediate handling strength
- Allows the use of thinner, lighter weight and dissimilar materials

Dream, Design, Deliver with our 3M™ VHB™ Tape 5952. It is a black, 0.045 in (1.1 mm) modified acrylic adhesive with a very conformable, foam core. It can replace rivets, welds and screws. The fast and easy to use permanent bonding method provides high strength and long-term durability. It offers design flexibility with its viscoelasticity and powerful ability to bond to a variety of surfaces.

Convenience Meets Extreme Bonding Power

Our 3M™ VHB™ Tape consists of a durable acrylic adhesive with viscoelastic properties. This provides an extraordinarily strong double sided foam tape that adheres to a broad range of substrates, including aluminum, stainless steel, galvanized steel, composites, plastics, acrylic, polycarbonate, ABS and painted or sealed wood and concrete. Our bonding tapes provide excellent shear strength, conformability, surface adhesion and temperature resistance. They are commonly used in applications across a variety of markets including transportation, appliance, electronics, construction, sign and display and general industrial. Reliably bonds a variety of materials with strength and speed for permanent applications.

Recommended Applications

- Decorative material and trim
- Nameplates and logos
- Electronic displays
- Panel to frame
- Stiffener to panel

3M™ VHB™ Tape GPH-160

Click on the box for detailed FST test information

EN 45545

For more product information click here.

3M™ VHB™ Tape GPH-160 is a permanent bonding solution that can replace traditional mechanical fasteners and liquid adhesives in challenging, high temperature applications. Its acrylic foam core provides a good balance of strength and conformability. 3M™ VHB™ Tape GPH-160 has excellent temperature resistance, ideal for powder coat or liquid paint processes which undergo a heat bake cycle.

Convenience Meets Extreme Bonding Power

Our 3M™ VHB™ Tape GPH-160 consists of a durable acrylic adhesive with viscoelastic properties. This provides an extraordinarily strong double sided foam tape that adheres to a broad range of substrates, including aluminum, stainless steel, galvanized steel, composites, plastics, acrylic, polycarbonate and painted or sealed wood and concrete. Our bonding tapes provide excellent shear strength, conformability, surface adhesion and temperature resistance. They are commonly used in applications across a variety of markets including transportation, appliance, electronics, construction, sign and display and general industrial. Reliably bonds a variety of materials with strength and speed for permanent applications.

Recommended Applications

- Assembly of components before powder coat or liquid paint processes
- High operating temperature applications
- Stiffener to panel
- Panel to frame
- Decorative material and trim

When The Heat Is On, Stay Strong

Our 3M™ VHB™ Tape GPH family's high temperature resistance (short term 450°F) allows it to be bonded prior to powder coat or liquid painting processes. This reduces the number of "touches," leading to a more streamlined manufacturing process. The GPH family offers the speed and ease assembly found in 3M™ VHB™ Tape, even in applications involving high operating temperatures (long term resistance 300°F).

An Unconventional Foam Tape

We invented 3M™ VHB™ Tapes in 1980 as the first of their kind. These unique tapes combine conformability with a strong, permanent bond. The result is a family of extraordinarily strong tapes that adhere to a broad range of substrates. 3M™ VHB™ Tape is a proven alternative to screws, rivets, welds and other forms of mechanical fasteners. Skyscrapers, cell phones, electronic highway signs, refrigerators, architectural windows and more all rely on this specialty bonding tape for one or more steps in the assembly, mounting, fastening and sealing process. This trusted and reliable tape offers a consistent bond, outstanding durability and excellent solvent and moisture resistance. 3M stands by all of its products and is there to provide you with design guidance and technical support when you need it.

3M™ VHB™ Flame Retardant Tape 5958FR

Click on the box for detailed FST test information

EN 45545

For more product information click here.

- Fast and easy-to-use permanent bonding method provides high strength, long-term durability and is flame retardant
- Virtually invisible fastening keeps surfaces smooth
- Can replace mechanical fasteners (rivets, welding, screws) or liquid adhesives
- Black, 0.040 in (1.0 mil), multi-purpose adhesive and very conformable acrylic foam core bonds to a wide variety of substrates including powder coated paints and irregular surfaces
- Meets flammability test FAR 25.853 (a) 12 second vertical burn, Appendix F, Part I (a)(ii)
- Eliminate drilling, grinding, refinishing, screwing, welding and clean-up
- Creates a permanent seal against water, moisture and more by offering better gap filling capabilities
- Pressure sensitive adhesive bonds on contact to provide immediate handling strength
- Allows the use of thinner, lighter weight and dissimilar materials

Dream, Design, Deliver with our 3M™ VHB™ Flame Retardant Tape 5958FR. It is a black, 0.040 in (1.0 mil) modified acrylic adhesive with a very conformable, foam core. The fast and easy to use permanent bonding method provides high strength, long-term durability and is flame retardant. It offers design flexibility with its viscoelasticity and powerful ability to bond to a variety of surfaces.

Convenience Meets Extreme Bonding Power

Our 3M™ VHB™ Tape consists of a durable acrylic adhesive with viscoelastic properties. This provides an extraordinarily strong double sided foam tape that adheres to a broad range of substrates, including aluminum, stainless steel, galvanized steel, composites, plastics, acrylic, polycarbonate, ABS and painted or sealed wood and concrete. Our bonding tapes provide excellent shear strength, conformability, surface adhesion and temperature resistance. They are commonly used in applications across a variety of markets including transportation, appliance, electronics, construction, sign and display and general industrial. Reliably bonds a variety of materials with strength and speed for permanent applications.

Recommended Applications

- Overhead stow bins
- Signage
- Plastic and metal decorative trim
- Stiffener bonding
- Mirror mounting

ASTM E 1354 Testing of “3M 550 FC”

ACCREDITATION
To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per 3M Purchase Order No.USMMMMP4N4 and Exova Warringtonfire North America Quotation No. 13-002-250,923 RV1 dated September 18, 2013.

IDENTIFICATION
Polyurethane adhesive sealant, identified as “3M 550 FC”. (Exova sample identification number 13-002-S0625-1)

SAMPLE PREPARATION
The polyurethane adhesive sealant was applied by the client onto 6 mm thick fiberglass reinforced cement substrate using a 1/32” x 1/32” square notched trowel. The material was applied on October 25, 2013 and allowed to cure prior to testing on November 4, 2013.

SUMMARY OF TEST PROCEDURE
Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1×10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

ASTM E 1354 Testing of "3M 550 FC"

TEST RESULTS - ASTM E 1354-13

Standard Test Method for Heat and Visible Smoke Release Rates
for Materials and Products Using an Oxygen Consumption Calorimeter

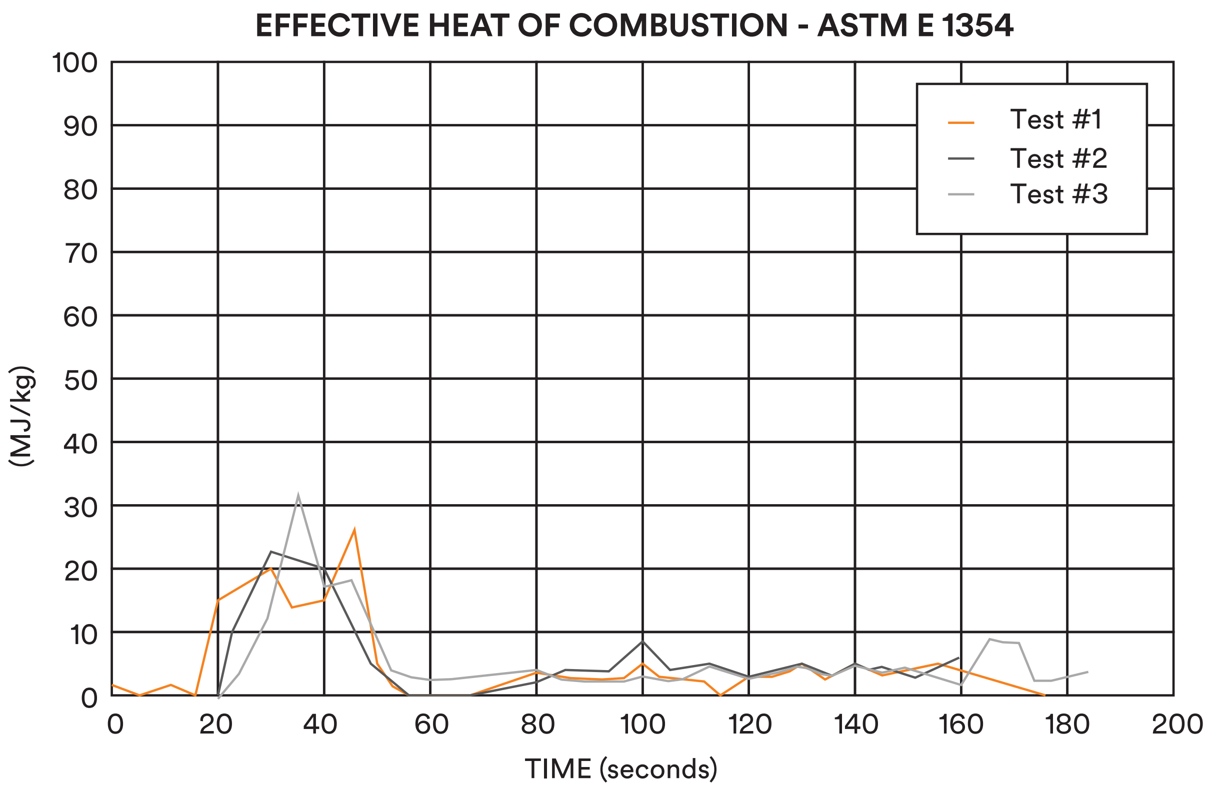
Testing was performed on November 13, 2013 with the sample in the horizontal configuration, utilizing the specimen holder and edge frame and also the specified spark ignition source.

	Test #1	Test #2	Test #3	Average
Heat Flux (kW/m^2)	50	50	50	
Exhaust Flow Rate (l/s)	24	24	24	
Specimen Thickness (mm)	1.0	1.0	1.0	
Initial Mass (g)(including substrate)	92.6	92.4	89.4	
Mass at Sustained Flaming (g)(including substrate)	92.5	92.4	89.4	
Final Mass (g)(including substrate)	84.2	84.4	81.5	
Total Mass Loss (kg/m^2)	0.83	0.80	0.79	0.81
Peak Specific Mass Loss Rate (g/s·m^2)	13.11	14.14	14.97	14.07
Average Mass Loss Rate (g/s·m^2)	9.87	6.58	8.51	8.32
Time to Ignition (s)	13	18	20	17
Time to Flame-out (s)	60	49	66	58
Time of Peak Rate of Heat Release (s)	25	30	35	30
Peak Rate of Heat Release (kW/m^2)	236.0	213.9	183.4	211.1
Average Rate of Heat Release (kW/m^2)	112.3	36.3	77.1	75.2
Total Heat Released (MJ/m^2)	5.08	5.16	3.78	4.67
Average Effective Heat of Combustion (MJ/kg)	12.44	5.74	9.66	**9.28** *
Average Effective Heat of Combustion (BTU/lb)	5359.3	2473.5	4161	**3998** *
Caloric Content (MJ/kg)	0.49	0.49	0.37	**0.45** **
Caloric Content (BTU/lb)	208.96	212.51	161.12	**194** **
Peak Extinction Area (m^2/kg)	515.2	358.9	848.1	574.1
Average Extinction Area (m^2/kg)	303.9	154.3	241.6	233.3

* Total heat produced per unit mass of material consumed
** Total heat produced per unit mass of material tested

ASTM E 1354 Testing of "3M 550 FC"

TEST RESULTS (continued)



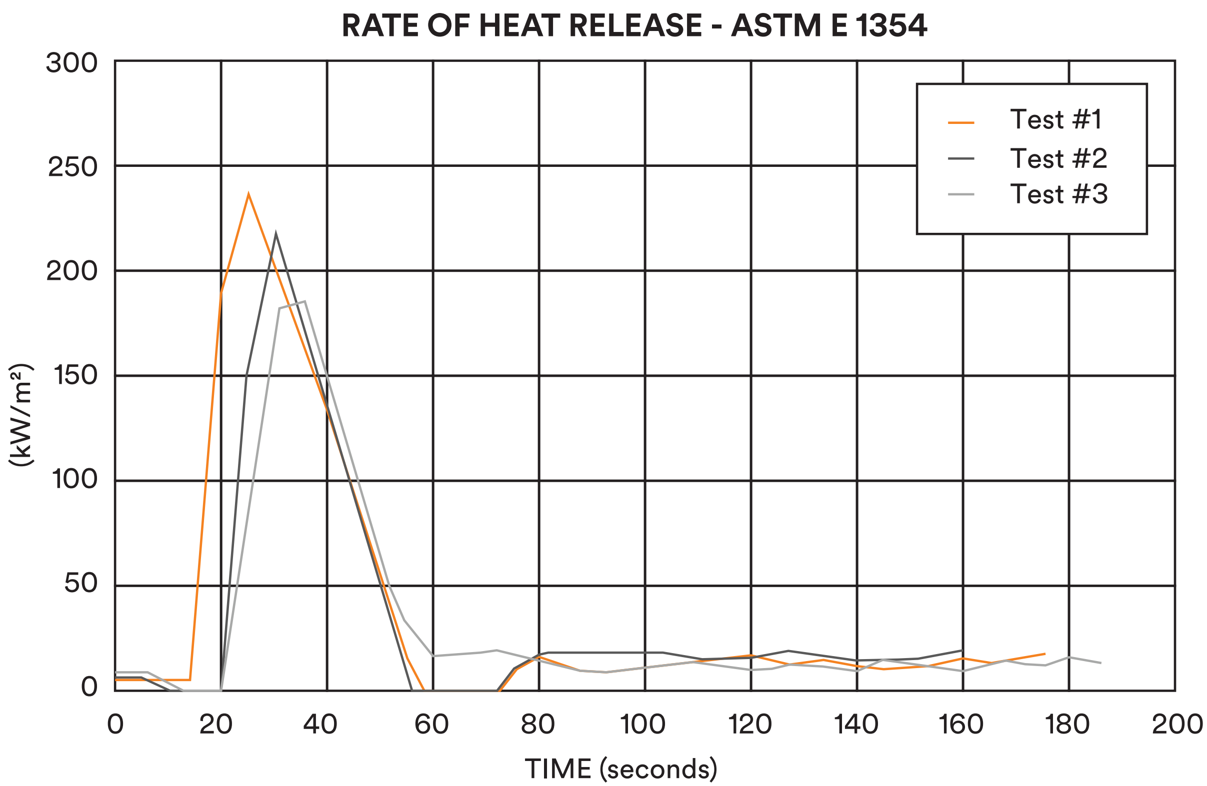
	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	12.44	5.74	9.66	9.28
Heat of Combustion @ 60 s (MJ/kg)**	10.26	8.03	9.00	9.10
Heat of Combustion @ 180 s (MJ/kg)**	0.00	0.00	0.00	0.00
Heat of Combustion @ 300 s (MJ/kg)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.

** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of “3M 550 FC”

TEST RESULTS (continued)



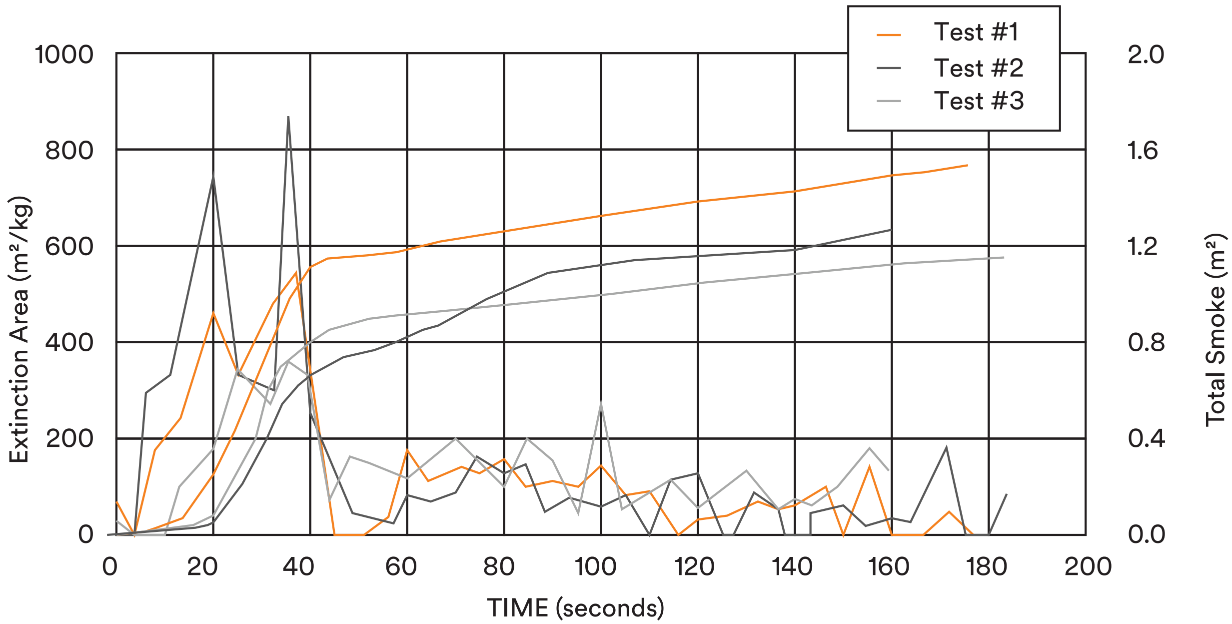
	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m^2)	236.0	213.9	183.4	211.1
Average Heat Release Rate (kW/m^2)*	112.3	36.3	77.1	75.2
Heat Release Rate @ 60 s (kW/m^2)**	83.4	66.5	66.4	72.1
Heat Release Rate @ 180 s (kW/m^2)**	0.00	0.00	0.00	0.00
Heat Release Rate @ 300 s (kW/m^2)**	0.00	0.00	0.00	0.00

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of “3M 550 FC”

TEST RESULTS (continued)

SMOKE GENERATION - ASTM E 1354



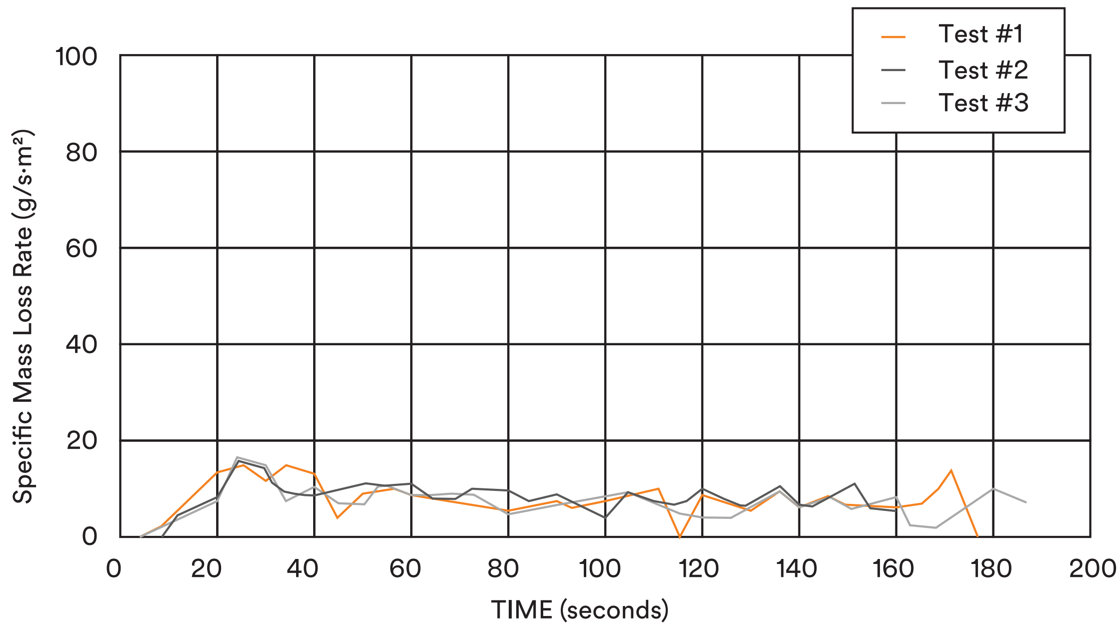
	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m^2/kg)	515.2	358.9	848.1	574.1
Average Extinction Area (m^2/kg)*	303.9	154.3	241.6	233.3
Extinction Area @ 60 s (m^2/kg)**	273.3	214.2	230.5	239.4
Extinction Area @ 180 s (m^2/kg)**	0.00	0.00	0.00	0.00
Extinction Area @ 300 s (m^2/kg)**	0.00	0.00	0.00	0.00
Total Smoke (m^2)	1.14	1.23	0.83	1.07

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "3M 550 FC"

TEST RESULTS (continued)

MASS LOSS RATE - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	13.11	14.14	14.97	14.07
Avg. Specific Mass Loss Rate (g/m²·s)*	9.87	6.58	8.51	8.32
Mass Loss Rate @ 60 s (g/s)**	0.07	0.07	0.06	0.07
Mass Loss Rate @ 180 s (g/s)**	0.00	0.00	0.00	0.00
Mass Loss Rate @ 300 s (g/s)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of “3M 550 FC”

CONCLUSIONS

The polyurethane adhesive sealant material identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, affords an average Effective Heat of Combustion of 9.28 MJ/kg (3998 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m². Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 0.45 MJ/kg (194 BTU/lb).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

ASTM E 1354 Testing of “3M 550 FC”

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion

This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.

Time to Ignition

Also known as ignition delay time, this parameter provides a measure of a material’s propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.

Heat Release Rate (HRR)

HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.

Total Heat Release

This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate “potential heat load” than is the more commonly used “caloric content” based upon the weight of material used.

Mass Loss Rate

This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.

Extinction Area

This refers to the “yield” of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.

Surface Flammability, Smoke and Toxic Gas Generation of "3M 550 FC + AC61"

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, as per 3M Purchase Order No.USMMMMP4N4 and Exova Warringtonfire North America Quotation No. 13-002-250,923 RV1 dated September 18, 2013.

IDENTIFICATION
Polyurethane adhesive sealant with accelerator, identified as "3M 550 FC + AC61".
(Exova sample identification number 13-002-S0625-2)

SAMPLE PREPARATION
The polyurethane adhesive sealant with accelerator was applied by the client onto 6 mm thick fiberglass reinforced cement substrate using a 3M Two-Component Adhesive Sealant Applicator 400A-2K and 1/32 x 1/32" square notched trowel. The material was applied on October 25, 2013 and allowed to cure prior to testing on November 4, 2013.

TEST RESULTS

ASTM E 162-13

Surface Flammability of Materials Using a Radiant Heat Energy Source. (Is = Flame Spread Index).

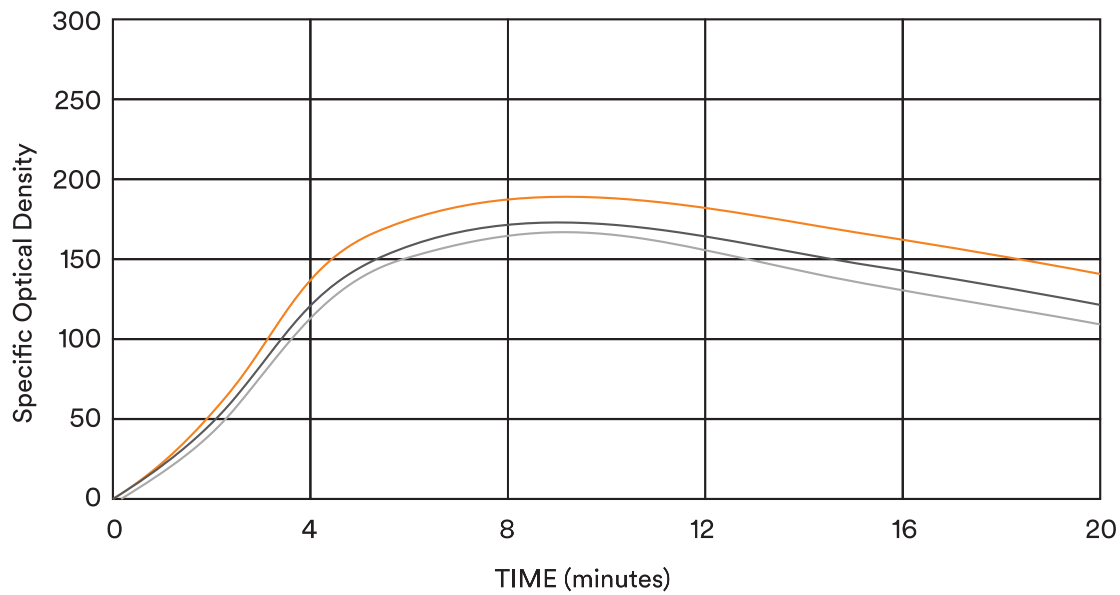
	Fs	Q	Is	Observations
1:	1.3	2.8	4	Flashing flame front propagation to a distance of 8 inches.
2:	1.4	1.6	2	Surface venting observed.
3:	1.6	4.6	7	No Flaming running and flaming dripping observed.
4:	1.6	3.4	5	
Rounded Average:			5	
Specified Maximum:			35	No flaming running or flaming dripping allowed

Surface Flammability, Smoke and Toxic Gas Generation of “3M 550 FC + AC61”

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

FLAMING MODE - ASTM E 662-13d



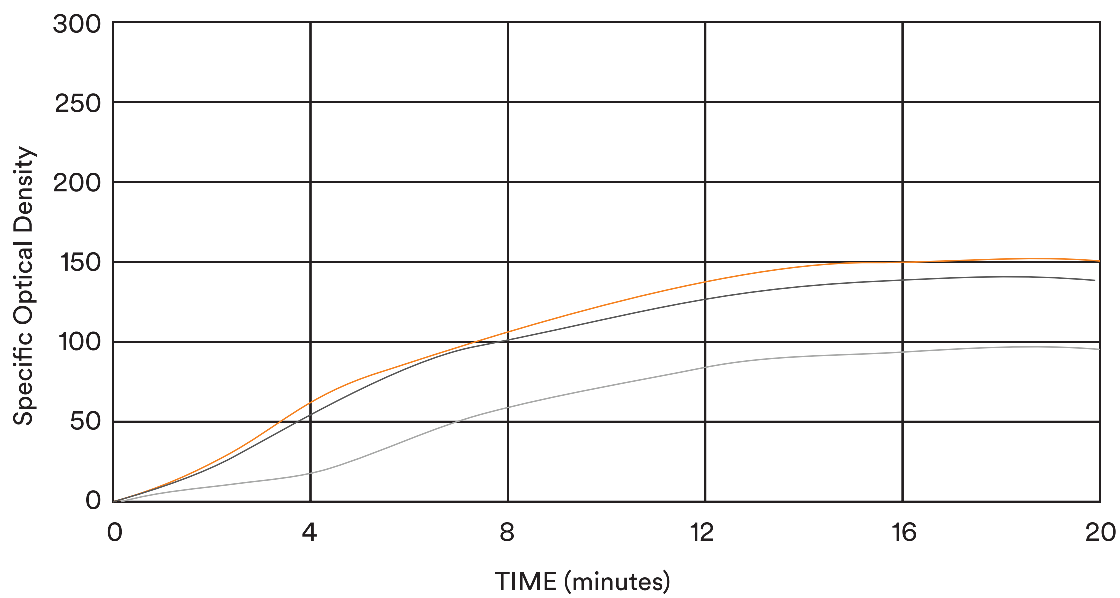
Relative Room Humidity: 28%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	30	29	35	31	100
Specific Optical Density at 4.0 minutes	120	124	134	126	200
Maximum Specific Optical Density	155	159	181	165	-
Maximum Corrected Optical Density	153	157	179	163	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M 550 FC + AC61"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

NON FLAMING MODE - ASTM E 662-13d



Relative Room Humidity: 28%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Non-Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	1	2	1	1	100
Specific Optical Density at 4.0 minutes	14	18	12	14	200
Maximum Specific Optical Density	148	136	92	125	-
Maximum Corrected Optical Density	147	136	91	125	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M 550 FC + AC61"

TEST RESULTS (continued)

ASTM E 662 Observations

In the flaming mode, ignition was initially observed at the point of pilot flame impingement followed by visible smoke and charring. In the non-flaming mode, visible smoke production was observed within 30 seconds followed by charring.

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Generation from Material Combustion

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	<1	<1	-
	at 4.0 minutes	85	<1	-
	at maximum	923	273	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	<1	51	-
	at 4.0 minutes	772	163	-
	at maximum	11508	1011	90000
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<1	5	100
Hydrogen Chloride (HCl ppm)		21	59	500
Hydrogen Fluoride (HF ppm)		<2	<2	100
Hydrogen Bromide (HBr ppm)		3	<1	100
Hydrogen Cyanide (HCN ppm)		3	1	100
Original Weight (g)(including substrate)		49.63	51.31	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		3	Did not ignite	-
Burning Duration (s)		60	-	-

Surface Flammability, Smoke and Toxic Gas Generation of “3M 550 FC + AC61”

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Typical Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	<1	<1	-
	at 4.0 minutes	139	<1	-
	at maximum	998	276	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		11	<3	100
Hydrogen Chloride (HCl ppm)		94	150	500
Hydrogen Fluoride (HF ppm)		<12	<12	200
Hydrogen Cyanide (HCN ppm)		2	<1	150
Original Weight (g)(including substrate)		47.18	46.52	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		3	Did not ignite	-
Burning Duration (s)		60	-	-

CONCLUSIONS AND COMMENTS

There are currently no specific performance criteria cited by the Federal Railroad Administration foradhesive sealant materials. However, the adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, would meet all of the current requirements (for all specified categories) as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The polyurethane adhesive sealant also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and as such, has no specific pass/fail criteria of its own. The reference criteria cited are typical for the transportation industry and are listed for reference purposes only. They may or may not apply to this specific product.

The polyurethane adhesive sealant identified in this report meets the M-7 Technical Specification requirements as they pertain to toxic gas generation (Boeing BSS 7239).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Surface Flammability, Smoke and Toxic Gas Generation of “3M 550 FC + AC61”

APPENDIX - Summaries of Test Procedures

ASTM E 162-13

Surface Flammability of Materials Using a Radiant Energy Source

As specified, four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C. Section 10.1 of ASTM E 162-13 states to then condition the specimens to “equilibrium (constant weight)” but does not specify a definition or procedure with respect to establishing the “constant weight”. Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where: Is is the flame spread index

Fs is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

Surface Flammability, Smoke and Toxic Gas Generation of "3M 550 FC + AC61"

APPENDIX - Summaries of Test Procedures

ASTM E 662-13d

Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

As specified, the test samples are pre-dried for 24 hours at 60°C. Section 9.1 of ASTM E 662-13d states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Three specimens, 3" square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37° C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer's law:

$$D_s = (V/AL) \cdot \log(100/T) = G \cdot \log(100/T) = 132 \cdot \log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

$D_{s\,1.5}$ - specific optical density after 1.5 minutes
$D_{s\,4.0}$ - specific optical density after 4.0 minutes

D_m -maximum specific optical density at any time during the 20 minute test
$D_{m\,(corr)}$ - Dm corrected for incidental deposits on the optical surfaces

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

Surface Flammability, Smoke and Toxic Gas Generation of “3M 550 FC + AC61”

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Surface Flammability, Smoke and Toxic Gas Generation of “3M 550 FC + AC61”

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

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Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
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Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

ASTM E 1354 Caloric Content Determination of "3M 560 Polyurethane Adhesive Sealant"

ASTM E 1354 Testing of "3M 560 Polyurethane Adhesive Sealant"

ACCREDITATION
To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per your Purchase Order No. USMMM8U18T and our Quote No. 11-006-08170 RV1 dated September 21, 2011.

IDENTIFICATION
Polyurethane adhesive sealant identified as "3M 560 Polyurethane Adhesive Sealant".
(Exova sample identification number 11-002-S0639-2)

SAMPLE PREPARATION
The coating material was applied onto 6 mm thick fiberglass reinforced cement substrate using a 1/32 x 1/32" square notched trowel and was allowed to dry 48 hours prior to testing.

SUMMARY OF TEST PROCEDURE
Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1 x 10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

ASTM E 1354 Testing of “3M 560 Polyurethane Adhesive Sealant”

TEST RESULTS - ASTM E 1354-11

Standard Test Method for Heat and Visible Smoke Release Rates
for Materials and Products Using an Oxygen Consumption Calorimeter

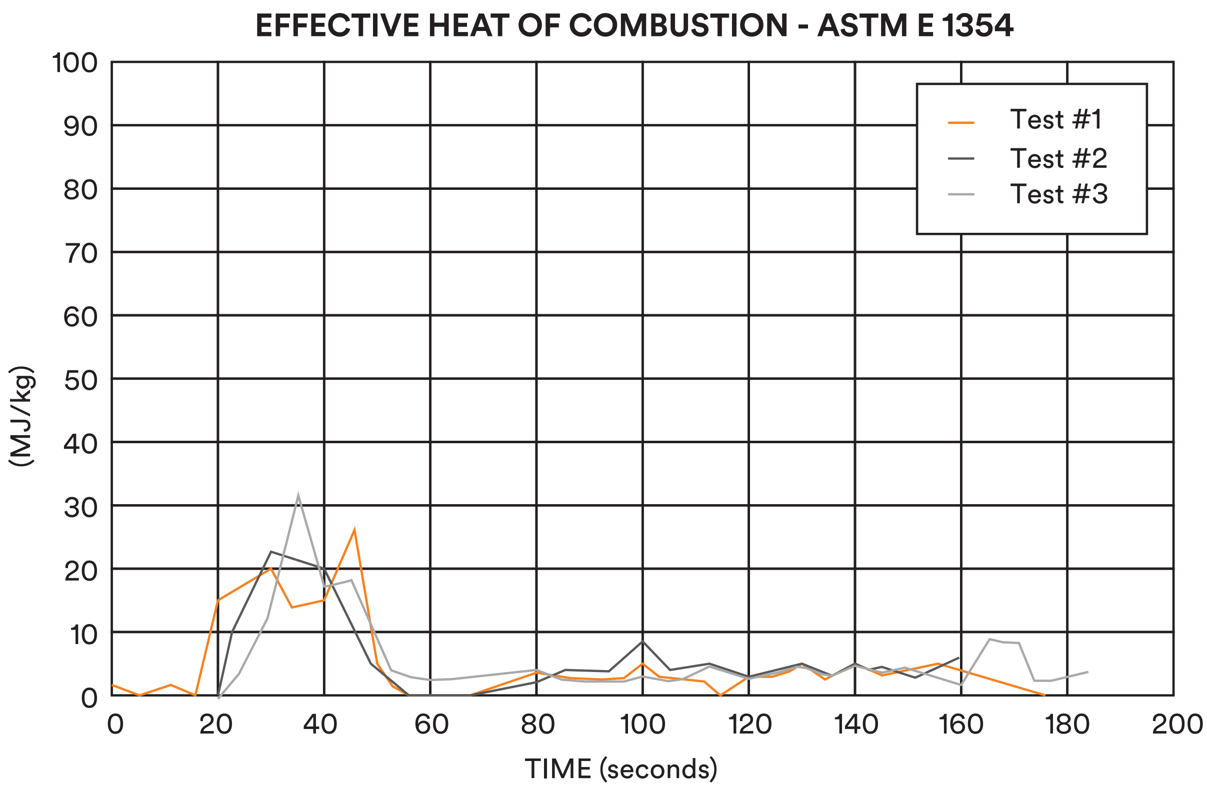
Testing was performed on October 12, 2011 with the sample in the horizontal configuration, utilizing the specimen edge frame and also the specified spark ignition source.

	Test #1	Test #2	Test #3	Average	
Heat Flux (kW/m²)	50	50	50		
Exhaust Flow Rate (l/s)	24	24	24		
Specimen Thickness (mm)	0.1	0.1	0.4		
Initial Mass (g)	88.4	88.7	88.7		
Mass at Sustained Flaming (g)	87.7	88.2	88.6		
Final Mass (g)	78.66	80.32	78.91		
Total Mass Loss (kg/m²)	0.97	0.84	0.97	0.93	
Peak Specific Mass Loss Rate (g/s·m²)	30.42	20.57	21.87	24.28	
Average Mass Loss Rate (g/s·m²)	6.04	6.70	10.09	7.61	
Time to Ignition (s)	28	33	22	28	
Time to Flame-out (s)	83	69	63	72	
Time of Peak Rate of Heat Release (s)	40	45	35	40	
Peak Rate of Heat Release (kW/m²)	210.7	176.5	199.9	195.7	
Average Rate of Heat Release (kW/m²)	40.8	40.0	55.9	45.6	
Total Heat Released (MJ/m²)	6.39	5.29	5.95	5.87	
Average Effective Heat of Combustion (MJ/kg)	6.43	5.87	7.76	**6.69**	*
Average Effective Heat of Combustion (BTU/lb)	2769.4	2528.1	3342.9	**2880**	*
Caloric Content (MJ/kg)	0.64	0.53	0.59	**0.59**	**
Caloric Content (BTU/lb)	274.99	226.91	255.35	**252**	**
Peak Extinction Area (m²/kg)	849.7	452.4	1029.6	777.2	
Average Extinction Area (m²/kg)	116.2	67.6	175.6	119.8	

* Total heat produced per unit mass of material consumed
** Total heat produced per unit mass of material tested

ASTM E 1354 Testing of "3M 560 Polyurethane Adhesive Sealant"

TEST RESULTS (continued)

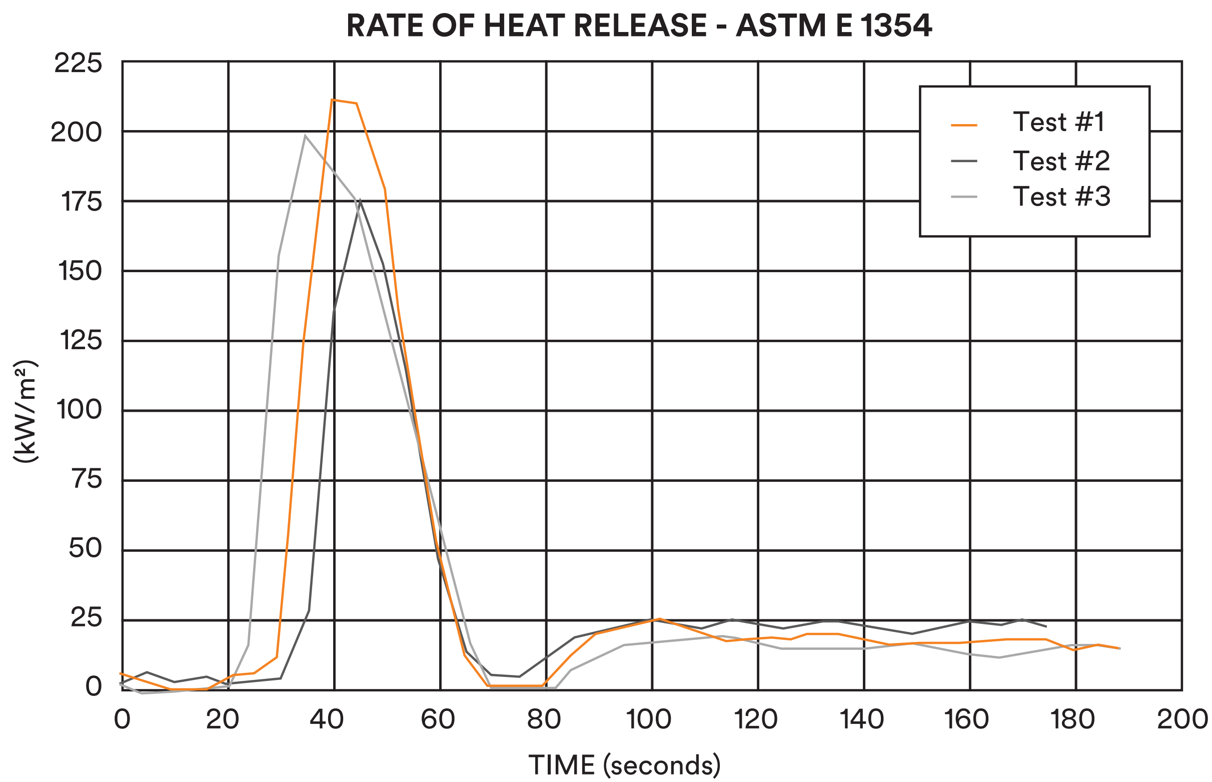


	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	6.43	5.87	7.76	6.69
Heat of Combustion @ 60 s (MJ/kg)**	9.91	6.61	9.95	8.82
Heat of Combustion @ 180 s (MJ/kg)**	0.00	0.00	0.00	0.00
Heat of Combustion @ 300 s (MJ/kg)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of “3M 560 Polyurethane Adhesive Sealant”

TEST RESULTS (continued)



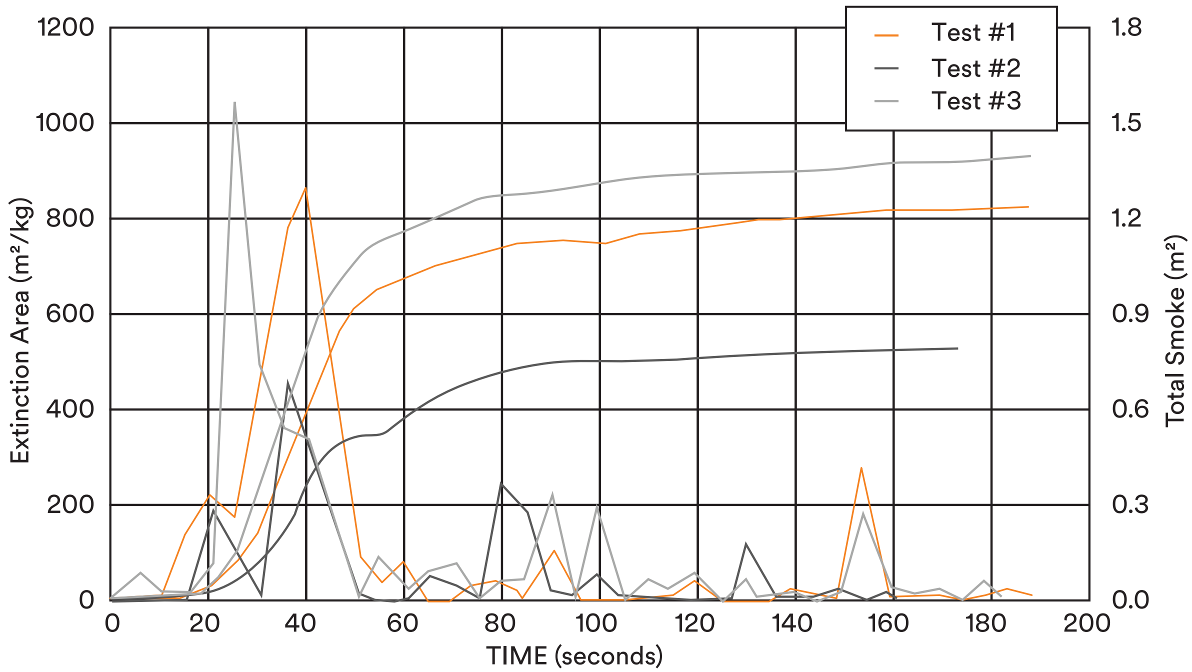
	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m^2)	210.7	176.5	199.9	195.7
Average Heat Release Rate (kW/m^2)*	40.8	40.0	55.9	45.6
Heat Release Rate @ 60 s (kW/m^2)**	76.1	59.2	86.0	73.8
Heat Release Rate @ 180 s (kW/m^2)**	0.00	0.00	0.00	0.00
Heat Release Rate @ 300 s (kW/m^2)**	0.00	0.00	0.00	0.00

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of “3M 560 Polyurethane Adhesive Sealant”

TEST RESULTS (continued)

SMOKE GENERATION - ASTM E 1354



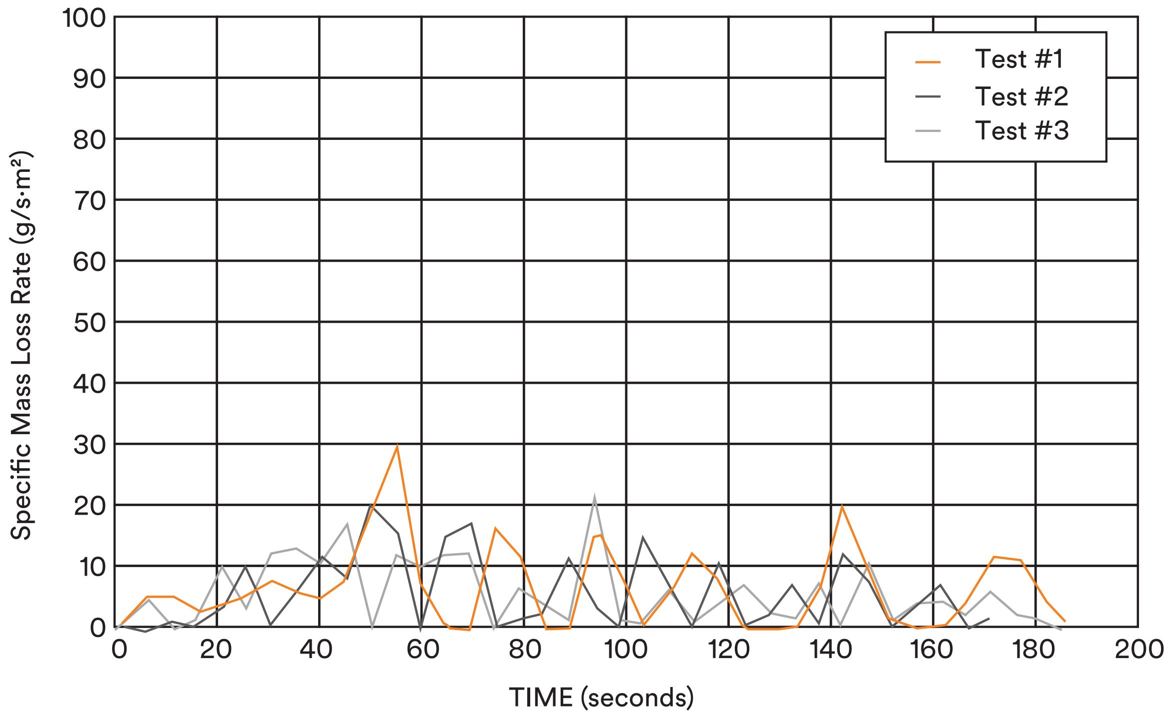
	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m^2/kg)	849.7	452.4	1029.6	777.2
Average Extinction Area (m^2/kg)*	116.2	67.6	175.6	119.8
Extinction Area @ 60 s (m^2/kg)**	222.6	108.0	242.7	191.1
Extinction Area @ 180 s (m^2/kg)**	0.00	0.00	0.00	0.00
Extinction Area @ 300 s (m^2/kg)**	0.00	0.00	0.00	0.00
Total Smoke (m^2)	1.1	0.7	1.3	1.0

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of “3M 560 Polyurethane Adhesive Sealant”

TEST RESULTS (continued)

MASS LOSS RATE - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	30.42	20.57	21.87	24.28
Avg. Specific Mass Loss Rate (g/m²·s)*	6.04	6.70	10.09	7.61
Mass Loss Rate @ 60 s (g/s)**	0.07	0.08	0.08	0.07
Mass Loss Rate @ 180 s (g/s)**	0.00	0.00	0.00	0.00
EMass Loss Rate @ 300 s (g/s)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred

ASTM E 1354 Testing of “3M 560 Polyurethane Adhesive Sealant”

CONCLUSIONS

The polyurethane adhesive sealant identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, affords an average Effective Heat of Combustion of 6.69 MJ/kg (2880 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m². Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 0.59 MJ/kg (252 BTU/lb).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

ASTM E 1354 Testing of “3M 560 Polyurethane Adhesive Sealant”

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion
This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.

Time to Ignition
Also known as ignition delay time, this parameter provides a measure of a material’s propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.

Heat Release Rate (HRR)
HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.

Total Heat Release
This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate “potential heat load” than is the more commonly used “caloric content” based upon the weight of material used.

Mass Loss Rate
This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.

Extinction Area
This refers to the “yield” of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.

FST Testing of “3M 560 Polyurethane Adhesive Sealant”

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, as per your Purchase Order No. USMMM8U18T and our Quote No. 11-006-08170 RV1 dated September 21, 2011.

IDENTIFICATION
Polyurethane adhesive sealant, identified as “3M 560 Polyurethane Adhesive Sealant”.
(Exova sample identification number 11-002-S0639-2)

SAMPLE PREPARATION
The coating material was applied onto 6 mm thick fiberglass reinforced cement substrate using a 1/32 x 1/32” square notched trowel and was allowed to dry 48 hours prior to testing.

TEST RESULTS

ASTM E 162-11a

Surface Flammability of Materials Using a Radiant Heat Energy Source. (Is = Flame Spread Index).

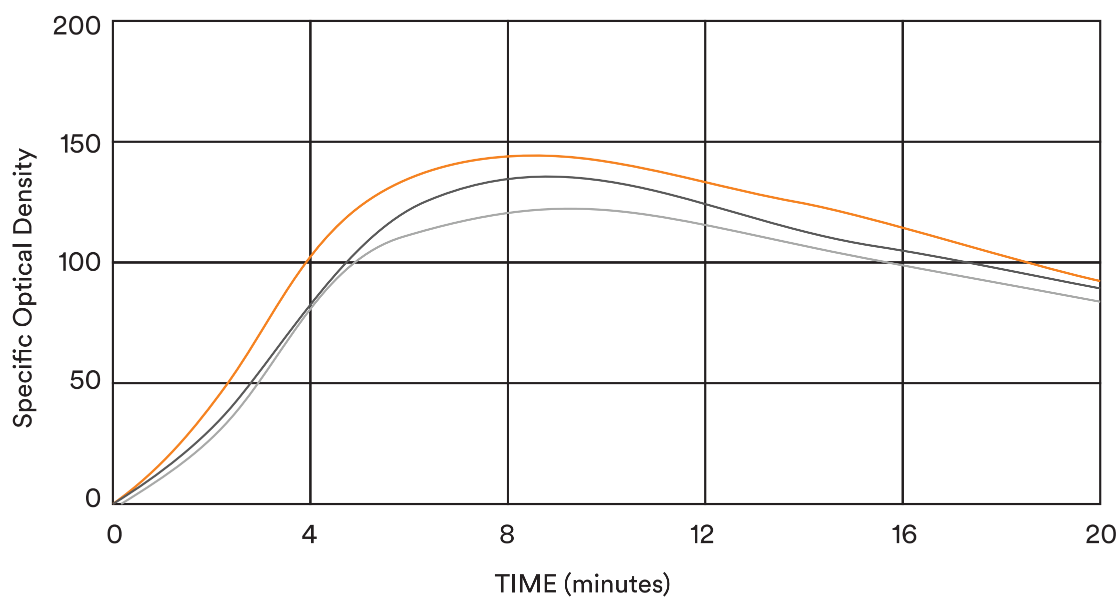
	Fs	Q	Is	Observations
1:	4.1	6.7	27	Maximum flame front propagation to a distance of 17 inches.
2:	4.1	5.7	23	No flaming running or flaming dripping observed.
3:	4.0	5.9	24	
4:	4.1	5.7	24	
Rounded Average:			25	
Specified Maximum:			35	No flaming running or flaming dripping allowed

FST Testing of “3M 560 Polyurethane Adhesive Sealant”

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

FLAMING MODE - ASTM E 662-09



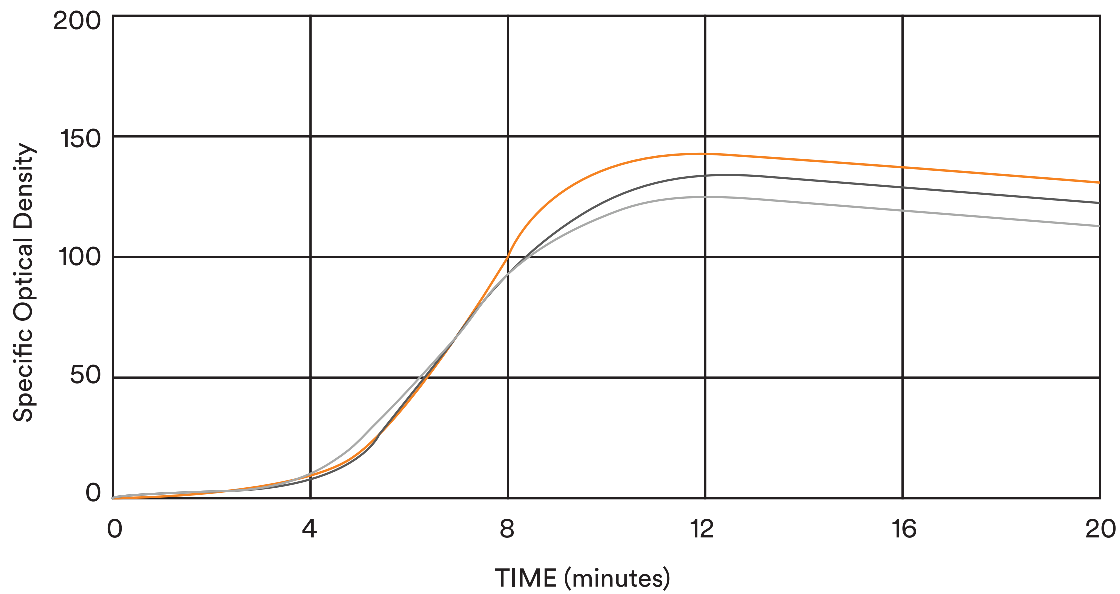
Relative Room Humidity: 28%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	21	31	11	21	100
Specific Optical Density at 4.0 minutes	84	107	93	94	200
Maximum Specific Optical Density	112	142	124	126	-
Maximum Corrected Optical Density	109	139	120	123	-

FST Testing of “3M 560 Polyurethane Adhesive Sealant”

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

NON FLAMING MODE - ASTM E 662-0



Relative Room Humidity: 28%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Non-Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	1	1	1	1	100
Specific Optical Density at 4.0 minutes	16	18	19	18	200
Maximum Specific Optical Density	134	127	113	125	-
Maximum Corrected Optical Density	133	124	112	123	-

FST Testing of “3M 560 Polyurethane Adhesive Sealant”

TEST RESULTS (continued)

ASTM E 662 Observations

In the flaming mode, ignition was initially observed at the point of pilot flame impingement. Surface charring and visible smoke production were also observed. In the non-flaming mode, visible smoke production was observed within 40 seconds followed by surface charring.

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Generation from Material Combustion

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	33	<10	-
	at 4.0 minutes	195	<10	-
	at maximum	990	603	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	300	100	-
	at 4.0 minutes	1650	150	-
	at maximum	12750	1650	90000
Nitrogen Oxides (as NO2 ppm)		2	2	100
Sulfur Dioxide (SO2 ppm)		12	6	100
Hydrogen Chloride (HCl ppm)		17	54	500
Hydrogen Fluoride (HF ppm)		5	4	100
Hydrogen Bromide (HBr ppm)		1	1	100
Hydrogen Cyanide (HCN ppm)		5	5	100
Original Weight (g)(including substrate)		43.4	43.6	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		5	Did not ignite	-
Burning Duration (s)		60	-	-

FST Testing of "3M 560 Polyurethane Adhesive Sealant"

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Typical Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	53	<10	-
	at 4.0 minutes	230	13	-
	at maximum	1053	638	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		17	<6	100
Hydrogen Chloride (HCl ppm)		53	110	500
Hydrogen Fluoride (HF ppm)		21	19	200
Hydrogen Bromide (HBr ppm)		<3	<3	0
Hydrogen Cyanide (HCN ppm)		4	<1	150
Original Weight (g)(including substrate)		43.7	49.8	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		5	Did not ignite	-
Burning Duration (s)		60	-	-

CONCLUSIONS AND COMMENTS

The polyurethane adhesive sealant identified in this report, when tested at applied onto 6 mm thick fiberglass reinforced cement substrate, meets The Federal Railroad Administration requirements as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The polyurethane adhesive sealant also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and, as such, has no specific pass/fail criteria of its own. The M-7 Technical Specification criteria are cited for reference purposes only, and may or may not apply to this specific product. The polyurethane adhesive sealant identified in this report meets the M-7 Technical Specification requirements as they pertain to toxic gas generation (Boeing BSS 7239).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

FST Testing of “3M 560 Polyurethane Adhesive Sealant”

APPENDIX - Summaries of Test Procedures

ASTM E 162-11a

Surface Flammability of Materials Using a Radiant Energy Source

Four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C and conditioned to equilibrium at 50 ± 5% relative humidity and 23 ± 3°C before testing.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where: Is is the flame spread index

Fs is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

FST Testing of “3M 560 Polyurethane Adhesive Sealant”

APPENDIX - Summaries of Test Procedures

ASTM E 662-09

Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

Specimens are dried for 24 hours at 60°C and conditioned to equilibrium at 50% RH and 23°C.

Three specimens, 3” square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37° C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer’s law:

$$Ds = (V/AL)\cdot\log(100/T) = G\cdot\log(100/T) = 132\cdot\log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

$Ds_{1.5}$ - specific optical density after 1.5 minutes
$Ds_{4.0}$ - specific optical density after 4.0 minutes

Dm -maximum specific optical density at any time during the 20 minute test

$Dm_{(corr)}$ - Dm corrected for incidental deposits on the optical surfaces

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

FST Testing of "3M 560 Polyurethane Adhesive Sealant"

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-\,2}$ and $SO4^{-\,2}$). Hydrogen peroxide is added to convert $SO3^{-\,2}$ to $SO4^{-\,2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

FST Testing of “3M 560 Polyurethane Adhesive Sealant”

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation

Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)

CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling

HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)

Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.

Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)

Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.

Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)

Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)

Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)

SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-\,2}$ and $SO4^{-\,2}$). Hydrogen peroxide is added to convert $SO3^{-\,2}$ to $SO4^{-\,2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402

Summary VHB GPH-160 J385524-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

26th October 2017
Our ref: 385408/19/29/39/524

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 3.5mm composite comprising you adhesive (product reference "VHB GPH-160") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 385429
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 116
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.01

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m³)	ND	ND	ND	ND	ND	ND	ND	ND
8 minutes (mg/m³)	1	1	1	1	1	1	1	1

WF Number: 385524
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 1
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 0
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.03

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m³)	4	2992	ND	ND	ND	ND	ND	5
8 minutes (mg/m³)	6	6412	ND	ND	ND	ND	ND	8

Summary VHB GPH-160 J385524-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 385439
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	0.00

WF Number: 385419
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	31.1
Time to MARHE	seconds	600

WF Number: 385408
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 26th June 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation

Summary VHB GPH-060 J385523-BD170831zBS EN 45545-2 2013+A1 2015 Annex

26th October 2017
Our ref: 385408/18/28/38/523

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 2.6mm composite comprising you adhesive (product reference "VHB GPH-060") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 385428
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 3
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 23
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.00

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	ND	ND	ND	ND	ND	ND	ND	ND
8 minutes (mg/m^3)	1	1	1	1	1	1	1	1

WF Number: 385523
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 1
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 1
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.02

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	ND	3264	ND	ND	ND	ND	ND	5
8 minutes (mg/m^3)	ND	5510	ND	ND	ND	ND	ND	7

Summary VHB GPH-060 J385523-BD170831zBS EN 45545-2 2013+A1 2015 Annex

WF Number: 385438
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	0.00

WF Number: 385418
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	8.5
Time to MARHE	seconds	804

WF Number: 385407
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 26th June 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

Summary VHB 5958FR J385527-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

26th October 2017
Our ref: 385412/23/33/42/527

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 2.9mm composite comprising you adhesive (product reference "VHB 5958FR") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 385433
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 45
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.01

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	ND	59	ND	ND	ND	ND	ND	2
8 minutes (mg/m^3)	3	72	ND	ND	ND	ND	ND	3

WF Number: 385527
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flam

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 1
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 0
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.02

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	3	2618	ND	ND	ND	ND	ND	4
8 minutes (mg/m^3)	5	5496	ND	ND	ND	ND	ND	6

Summary VHB 5958FR J385527-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 385442
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	6.75

WF Number: 385423
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	2.9
Time to MARHE	seconds	886

WF Number: 385412
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 26th June 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation

Summary VHB 4991 J385530-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

26th October 2017
Our ref: 385415/26/36/45/530

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 4.3mm composite comprising you adhesive (product reference "VBH 4991") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 385436
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 140
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.00

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	1	57	ND	ND	ND	ND	ND	2
8 minutes (mg/m^3)	3	60	ND	ND	ND	ND	ND	2

WF Number: 385530
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 1
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 0
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.02

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	3	2091	ND	ND	ND	ND	ND	2
8 minutes (mg/m^3)	5	4608	ND	ND	ND	ND	ND	5

Summary VHB 4991 J385530-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 385445
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	0.00

WF Number: 385426
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	43.7
Time to MARHE	seconds	760

WF Number: 385415
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 26th June 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

Summary VHB 4941 J385529-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

26th October 2017
Our ref: 385415/26/36/45/530

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 3.1mm composite comprising you adhesive (product reference "VBH 4941") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 385435
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 62
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.00

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m³)	1	29	ND	ND	ND	ND	ND	2
8 minutes (mg/m³)	5	41	ND	ND	ND	ND	ND	2

WF Number: 385529
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 2
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 1
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.02

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m³)	3	2107	ND	ND	ND	ND	ND	5
8 minutes (mg/m³)	5	4679	ND	ND	ND	ND	ND	6

Summary VHB 4941 J385529-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 385444
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	43.80

WF Number: 385425
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	15.3
Time to MARHE	seconds	914

WF Number: 385414
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 26th June 2017. Exova Warringtonfire was no involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

Summary ATT 9372W J385528-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

26th October 2017
Our ref: 385413/24/34/43/528

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 2.0mm composite comprising you adhesive (product reference "ATT 9372W") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 385434
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 16
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.00

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	ND	49	ND	ND	ND	ND	ND	2
8 minutes (mg/m^3)	2	61	ND	ND	ND	ND	ND	2

WF Number: 385528
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 1
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 0
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.02

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	3	2273	ND	ND	ND	ND	ND	4
8 minutes (mg/m^3)	5	4978	ND	ND	ND	ND	ND	8

Summary ATT 9372W J385528-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 385443
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	0.00

WF Number: 385424
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	2.7
Time to MARHE	seconds	12

WF Number: 385413
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 26th June 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

Summary ATT 9372W J385528-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

26th October 2017
Our ref: 385406/16/27/37/522

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 2.1mm composite comprising you adhesive (product reference "ATT 9775WL") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 385427
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 20
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.00

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	ND	26	ND	ND	ND	ND	ND	2
8 minutes (mg/m^3)	2	37	ND	ND	ND	ND	ND	2

WF Number: 385522
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 3
Smoke accumulation, VOF4 = 5
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 6
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 6
Critical Index of Toxicity, CIT value (4 minutes) = 0.04
Critical Index of Toxicity, CIT value (8 minutes) = 0.05

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	72	5781	10	8	ND	ND	ND	7
8 minutes (mg/m^3)	103	8119	17	12	ND	ND	ND	7

Summary ATT 9372W J385528-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 385437
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	0.00

WF Number: 385416
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	6.1
Time to MARHE	seconds	2

WF Number: 385406
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 26th June 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

ASTM E 1354 Testing of "3M Scotch-Weld™ 1357"

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per 3M Purchase Order No. USMMM6NM4 and Exova Warringtonfire North America Quotation No. 14-002-327,516 accepted November 24, 2014.

IDENTIFICATION
Neoprene contact adhesive, identified as "3M Scotch-Weld™ 1357".
(Exova sample identification number 14-002-S0743-2)

SAMPLE PREPARATION
As per client's instructions, the adhesive material was applied onto 6 mm thick fiberglass reinforced cement substrate using a medium nap paint roller. Due to the porous nature of the substrate, a second coat was applied in order to achieve the required 2.5 - 3.5 gms/ft^2 dry coat weight. The adhesive was applied and allowed to cure at room temperature for at least 20 minutes prior to testing.

SUMMARY OF TEST PROCEDURE
Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1 x 10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

ASTM E 1354 Testing of "3M Scotch-Weld™ 1357"

TEST RESULTS - ASTM E 1354-13

Standard Test Method for Heat and Visible Smoke Release Rates
for Materials and Products Using an Oxygen Consumption Calorimeter

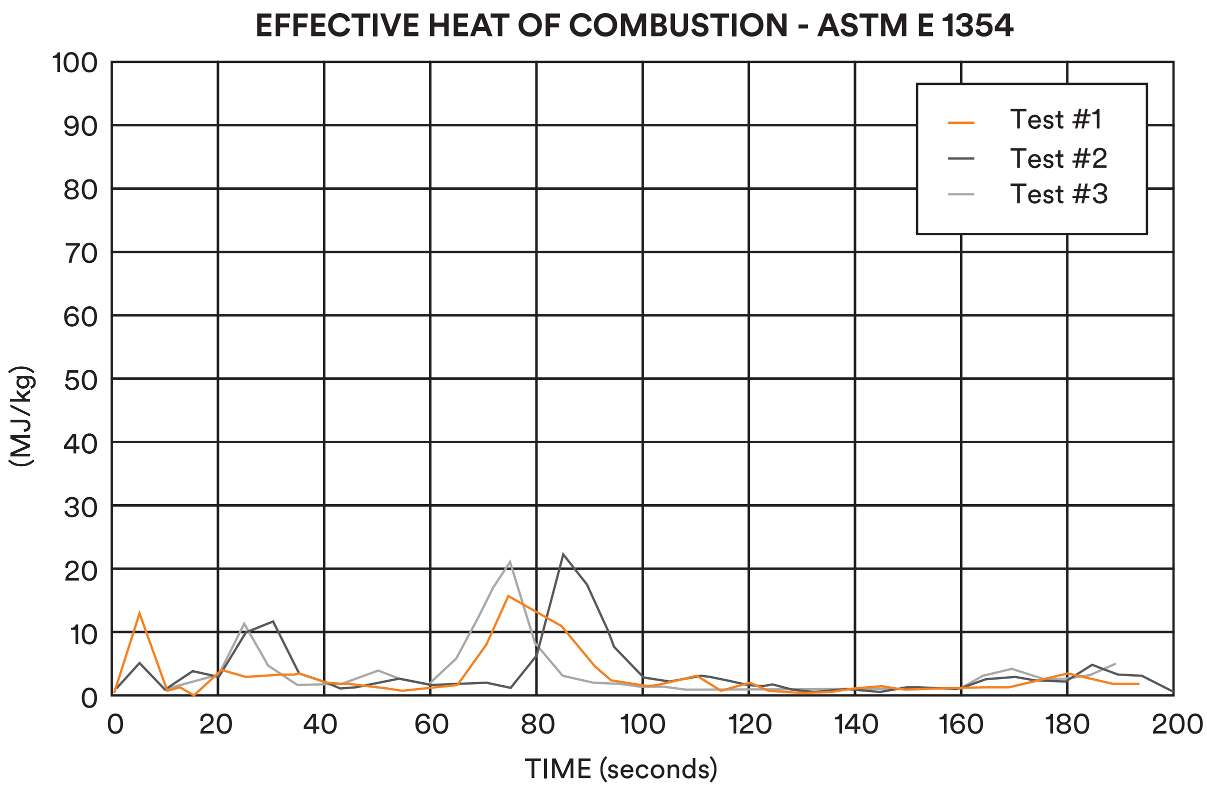
Testing was performed on December 11, 2014 with the sample in the horizontal configuration, utilizing the specimen holder and edge frame and also the specified spark ignition source.

	Test #1	Test #2	Test #3	Average	
Heat Flux (kW/m^2)	50	50	50		
Exhaust Flow Rate (l/s)	24	24	24		
Specimen Thickness (mm)	0.1	0.1	0.1		
Initial Mass (g)(including substrate)	88.8	92.9	95.7		
Mass at Sustained Flaming (g)(including substrate)	87.2	91.0	94.3		
Final Mass (g)(including substrate)	85.2	89.6	92.5		
Sample Mass Loss (kg/m^2)	0.19	0.14	0.18	0.17	
Peak Specific Mass Loss Rate (g/s·m^2)	10.78	10.34	11.50	10.87	
Average Mass Loss Rate (g/s·m^2)	7.63	7.36	7.14	7.38	
Time to Ignition (s)	62	74	55	64	
Time to Flame-out (s)	85	90	80	85	
Time of Peak Rate of Heat Release (s)	75	85	70	77	
Peak Rate of Heat Release (kW/m^2)	104.3	90.1	80.4	91.6	
Average Rate of Heat Release (kW/m^2)	73.5	56.1	47.3	59.0	
Total Heat Released (MJ/m^2)	1.50	0.87	1.18	1.19	
Average Effective Heat of Combustion (MJ/kg)	8.57	7.86	6.62	**7.69**	*
Average Effective Heat of Combustion (BTU/lb)	3691.9	3387	2850.1	**3310**	*
Caloric Content (MJ/kg)	0.15	0.08	0.11	**0.11**	**
Caloric Content (BTU/lb)	64.318	35.793	47.012	**49**	**
Peak Extinction Area (m^2/kg)	681.1	265.6	412.9	453.2	
Average Extinction Area (m^2/kg)	220.4	134.9	197.3	184.2	

* Total heat produced per unit mass of material consumed
** Total heat produced per unit mass of material tested

ASTM E 1354 Testing of "3M Scotch-Weld™ 1357"

TEST RESULTS (continued)

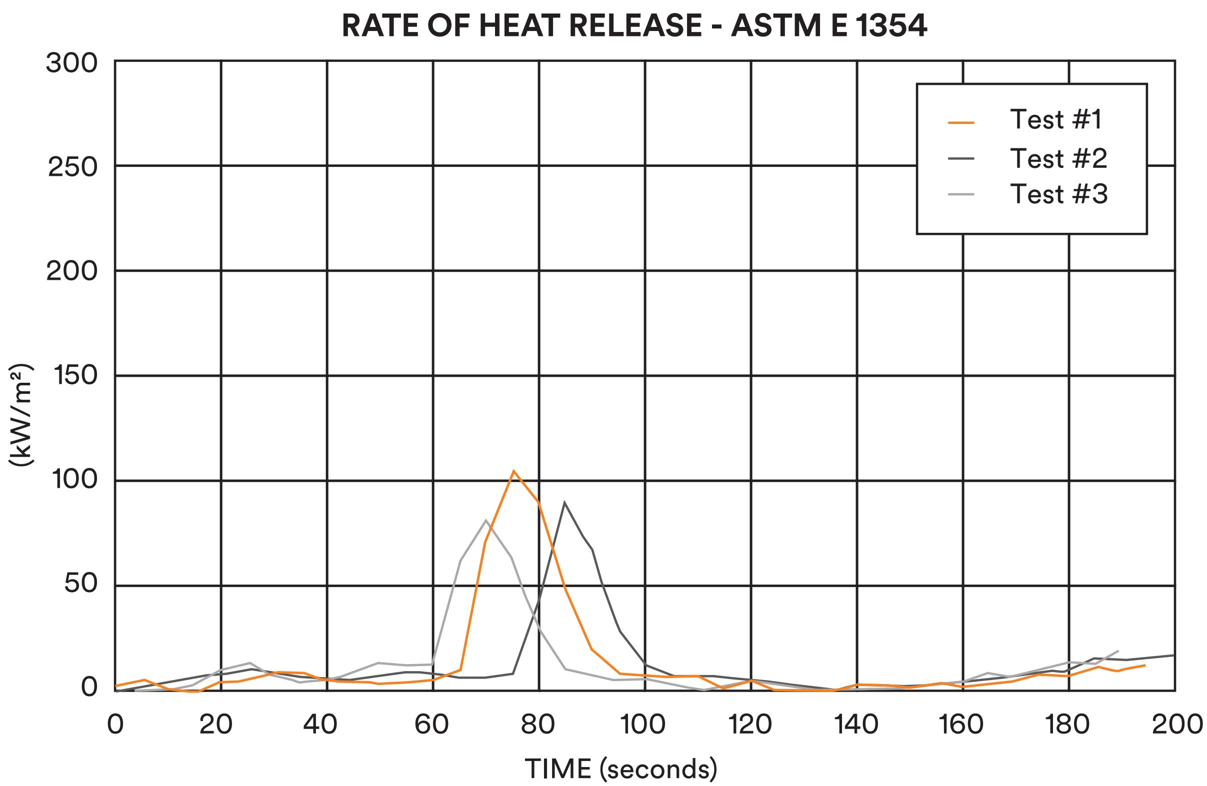


	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	8.57	7.86	6.62	7.69
Heat of Combustion @ 60 s (MJ/kg)**	5.74	4.98	4.41	5.04
Heat of Combustion @ 180 s (MJ/kg)**	0.00	0.00	0.00	0.00
Heat of Combustion @ 300 s (MJ/kg)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of "3M Scotch-Weld™ 1357"

TEST RESULTS (continued)



	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m^2)	104.3	90.1	80.4	91.6
Average Heat Release Rate (kW/m^2)*	73.5	56.1	47.3	59.0
Heat Release Rate @ 60 s (kW/m^2)**	30.7	22.3	23.5	25.5
Heat Release Rate @ 180 s (kW/m^2)**	0.00	0.00	0.00	0.00
Heat Release Rate @ 300 s (kW/m^2)**	0.00	0.00	0.00	0.00

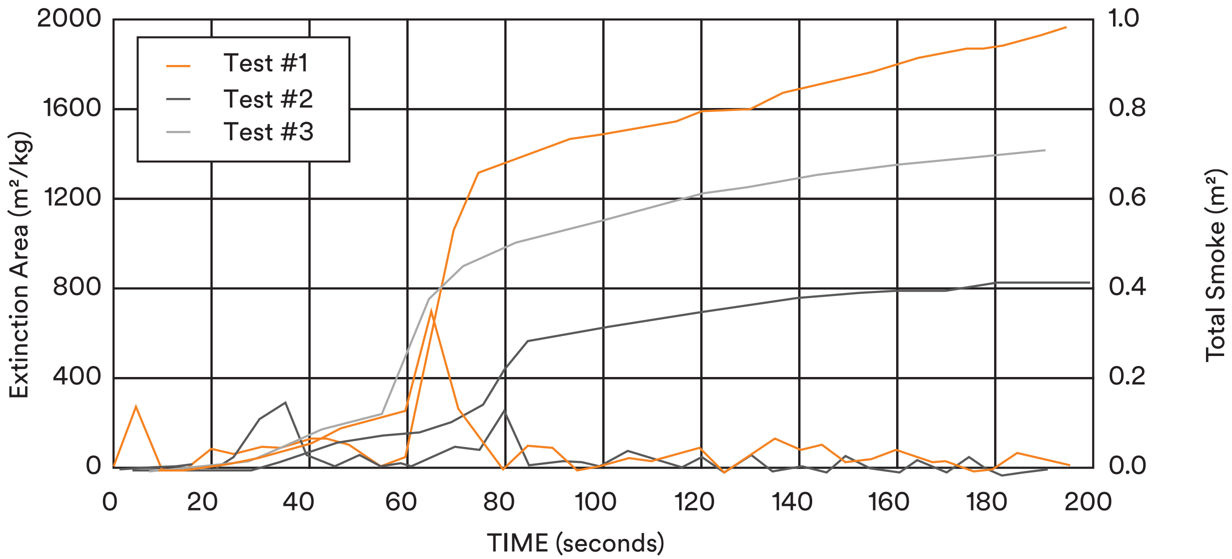
* Averaged over the test period (from ignition to flameout).

** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "3M Scotch-Weld™ 1357"

TEST RESULTS (continued)

SMOKE GENERATION - ASTM E 1354



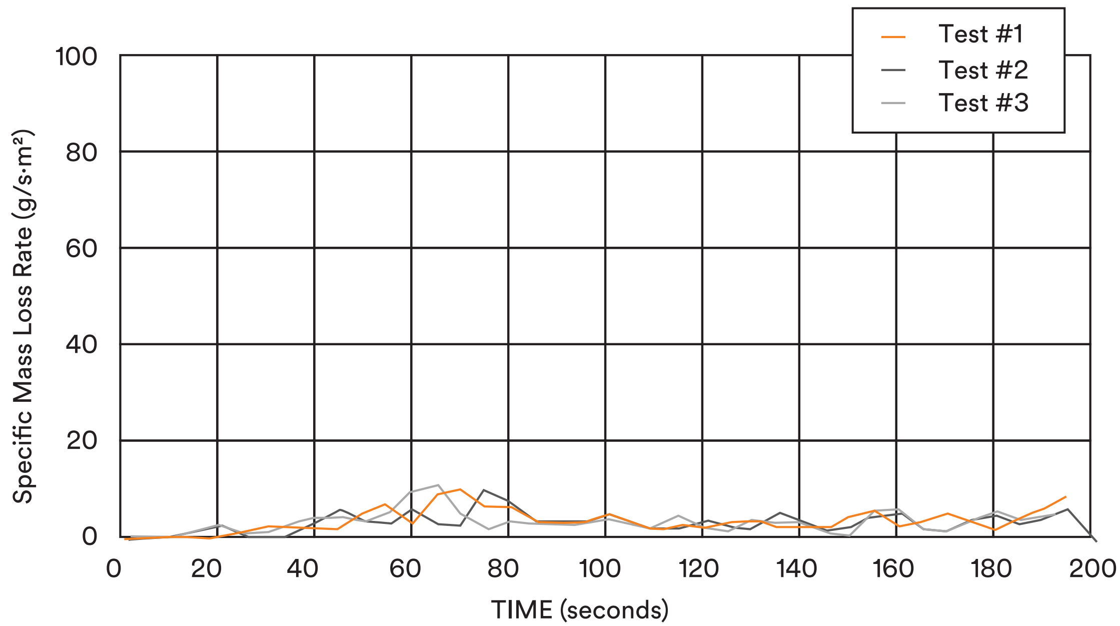
	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m^2/kg)	681.1	265.6	412.9	453.2
Average Extinction Area (m^2/kg)*	220.4	134.9	197.3	184.2
Extinction Area @ 60 s (m^2/kg)**	145.1	80.3	144.6	123.4
Extinction Area @ 180 s (m^2/kg)**	0.0	0.0	0.0	0.0
Extinction Area @ 300 s (m^2/kg)**	0.0	0.0	0.0	0.0
Total Smoke (m^2)	0.94	0.40	0.68	0.67

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "3M Scotch-Weld™ 1357"

TEST RESULTS (continued)

MASS LOSS RATE - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	10.78	10.34	11.50	10.87
Avg. Specific Mass Loss Rate (g/m²·s)*	7.63	7.36	7.14	7.38
Mass Loss Rate @ 60 s (g/s)**	0.05	0.04	0.05	0.05
Mass Loss Rate @ 180 s (g/s)**	0.00	0.00	0.00	0.00
Mass Loss Rate @ 300 s (g/s)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of "3M Scotch-Weld™ 1357"

<u>CONCLUSIONS</u>
The neoprene contact adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, affords an average Effective Heat of Combustion of 7.69 MJ/kg (3310 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m². Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 0.11 MJ/kg (49 BTU/lb).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

ASTM E 1354 Testing of "3M Scotch-Weld™ 1357"

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion
This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.

Time to Ignition
Also known as ignition delay time, this parameter provides a measure of a material's propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.

Heat Release Rate (HRR)
HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.

Total Heat Release
This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate "potential heat load" than is the more commonly used "caloric content" based upon the weight of material used.

Mass Loss Rate
This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.

Extinction Area
This refers to the "yield" of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 1357"

ACCREDITATION
To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, as per 3M Purchase Order No. USMMM6NM4 and Exova Warringtonfire North America Quotation No. 14-002-327,516 accepted November 24, 2014.

IDENTIFICATION
Neoprene contact adhesive, identified as "3M Scotch-Weld™ 1357". (Exova sample identification number 14-002-S0743-2)

SAMPLE PREPARATION
As per client's instructions, the adhesive material was applied onto 6 mm thick fiberglass reinforced cement substrate using a medium nap paint roller. Due to the porous nature of the substrate, a second coat was applied in order to achieve the required 2.5 - 3.5 gms/ft² dry coat weight. The adhesive was applied and allowed to cure at room temperature for at least 20 minutes prior to testing.

TEST RESULTS

ASTM E 162-13

Surface Flammability of Materials Using a Radiant Heat Energy Source. (Is = Flame Spread Index).

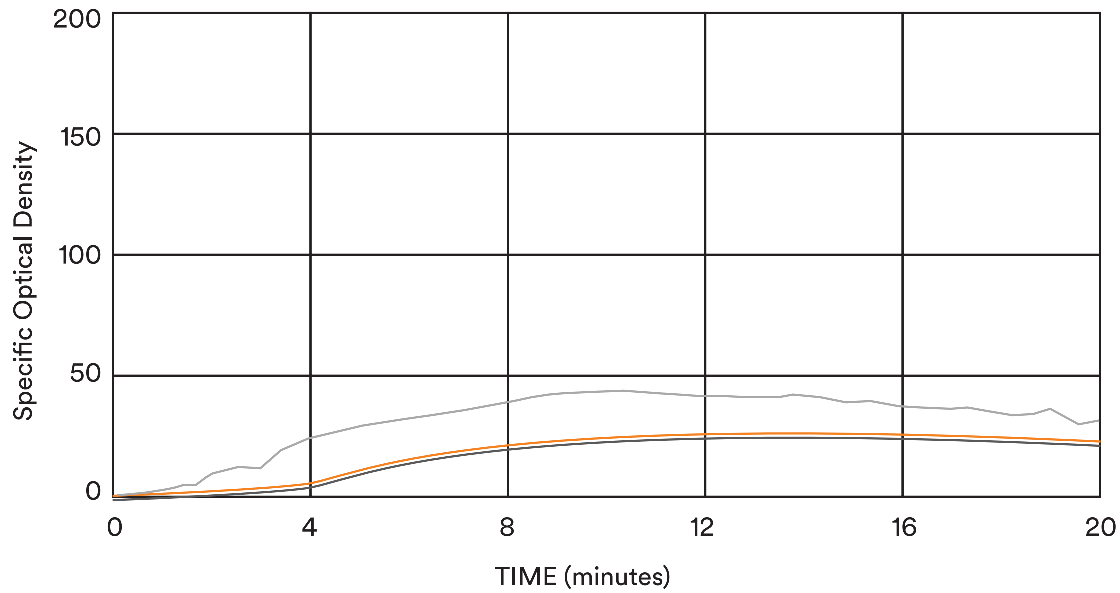
	Fs	Q	Is	Observations
1:	1.0	1.1	1	Maximum flame front propagation to a distance
2:	1.0	1.4	1	of 2 inches. Surface flashing was observed.
3:	1.0	1.0	1	No Flaming running and flaming dripping observed.
4:	1.0	1.1	1	Test duration: 15 minutes
Rounded Average:			0	
Specified Maximum:			35	No flaming running or flaming dripping allowed

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 1357"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

FLAMING MODE - ASTM E 662-14



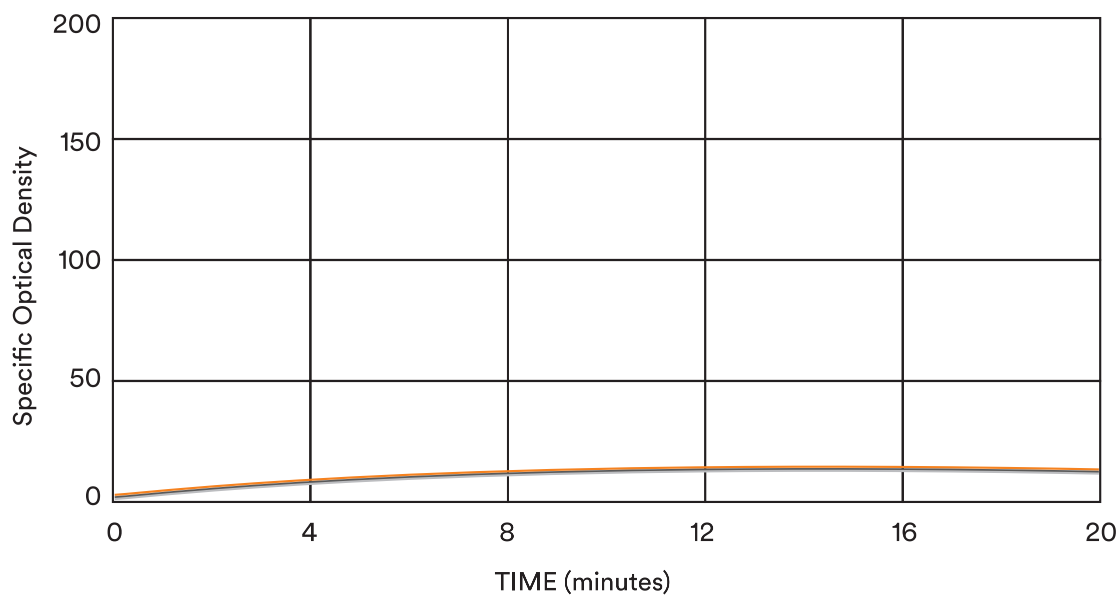
Relative Room Humidity: 21%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	1	1	2	2	100
Specific Optical Density at 4.0 minutes	5	6	15	9	200
Maximum Specific Optical Density	24	25	39	29	-
Maximum Corrected Optical Density	24	23	37	28	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 1357"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

NON-FLAMING MODE - ASTM E 662-14



Relative Room Humidity: 21%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	1	1	2	1	100
Specific Optical Density at 4.0 minutes	4	5	4	4	200
Maximum Specific Optical Density	11	8	11	10	-
Maximum Corrected Optical Density	11	7	11	10	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 1357"

TEST RESULTS (continued)

ASTM E 662 Observations

In the flaming mode, ignition was initially observed at the point of pilot flame impingement followed by visible smoke and charring. In the non-flaming mode, visible smoke production was observed followed by charring.

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Generation from Material Combustion

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	16	<1	-
	at 4.0 minutes	67	<1	-
	at maximum	746	110	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	514	132	-
	at 4.0 minutes	1778	179	-
	at maximum	11871	505	90000
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<1	5	100
Hydrogen Chloride (HCl ppm)		16	16	500
Hydrogen Fluoride (HF ppm)		<2	<2	100
Hydrogen Bromide (HBr ppm)		<1	<1	100
Hydrogen Cyanide (HCN ppm)		<1	<1	100
Original Weight (g)(including substrate)		47.36	47.07	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		5	Did not ignite	-
Burning Duration (s)		Not determinable	-	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 1357"

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	15	<1	-
	at 4.0 minutes	99	3	-
	at maximum	730	134	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<6	<6	100
Hydrogen Chloride (HCl ppm)		39	43	500
Hydrogen Fluoride (HF ppm)		<12	<12	200
Hydrogen Cyanide (HCN ppm)		<1	<1	150
Original Weight (g)(including substrate)		46.38	46.53	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		5.0	Did not ignite	-
Burning Duration (s)		Not determinable	-	-

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

CONCLUSIONS AND COMMENTS

T=There are currently no specific performance criteria cited by the Federal Railroad Administration for adhesive materials. However, the neoprene contact adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, would meet all of the current requirements (for all specified categories) as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The neoprene contact adhesive also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and as such, has no specific pass/fail criteria of its own. The reference criteria cited are typical for the transportation industry and are listed for reference purposes only. They may or may not apply to this specific product.

The neoprene contact adhesive would meet the typically-specified industry requirements as they pertain to toxic gas generation (Boeing BSS 7239).

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 1357"

APPENDIX - Summaries of Test Procedures

ASTM E 162-13

Surface Flammability of Materials Using a Radiant Energy Source

As specified, four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C. Section 10.1 of ASTM E 162-13 states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where: Is is the flame spread index

Fs is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 1357"

APPENDIX - Summaries of Test Procedures

ASTM E 662-14

Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

As specified, the test samples are pre-dried for 24 hours at 60°C. Section 9.1 of ASTM E 662-14 states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Three specimens, 3" square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37° C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer's law:

$$D_s = (V/AL)\cdot\log(100/T) = G\cdot\log(100/T) = 132\cdot\log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

$D_{s\,1.5}$ - specific optical density after 1.5 minutes

$D_{s\,4.0}$ - specific optical density after 4.0 minutes

Dm -maximum specific optical density at any time during the 20 minute test

$D_{m\,(corr)}$ - Dm corrected for incidental deposits on the optical surfaces

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 1357"

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 1357"

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

ASTM E 1354 Testing of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

ACCREDITATION
To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per your Purchase Order No. USMMM81UD5 and our Quote No. 11-006-08983 dated September 21, 2011.

IDENTIFICATION
Polyurethane adhesive sealant identified as "3M 590 OEM Polyurethane Glass Adhesive Sealant".
(Exova sample identification number 11-002-S0710)

SAMPLE PREPARATION
The coating material was applied onto 6 mm thick fiberglass reinforced cement substrate using a 1/32 x 1/32" square notched trowel and was allowed to dry 48 hours prior to testing.

SUMMARY OF TEST PROCEDURE
Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1 x 10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

ASTM E 1354 Testing of “3M 590 OEM Polyurethane Glass Adhesive Sealant”

TEST RESULTS - ASTM E 1354-11

Standard Test Method for Heat and Visible Smoke Release Rates
for Materials and Products Using an Oxygen Consumption Calorimeter

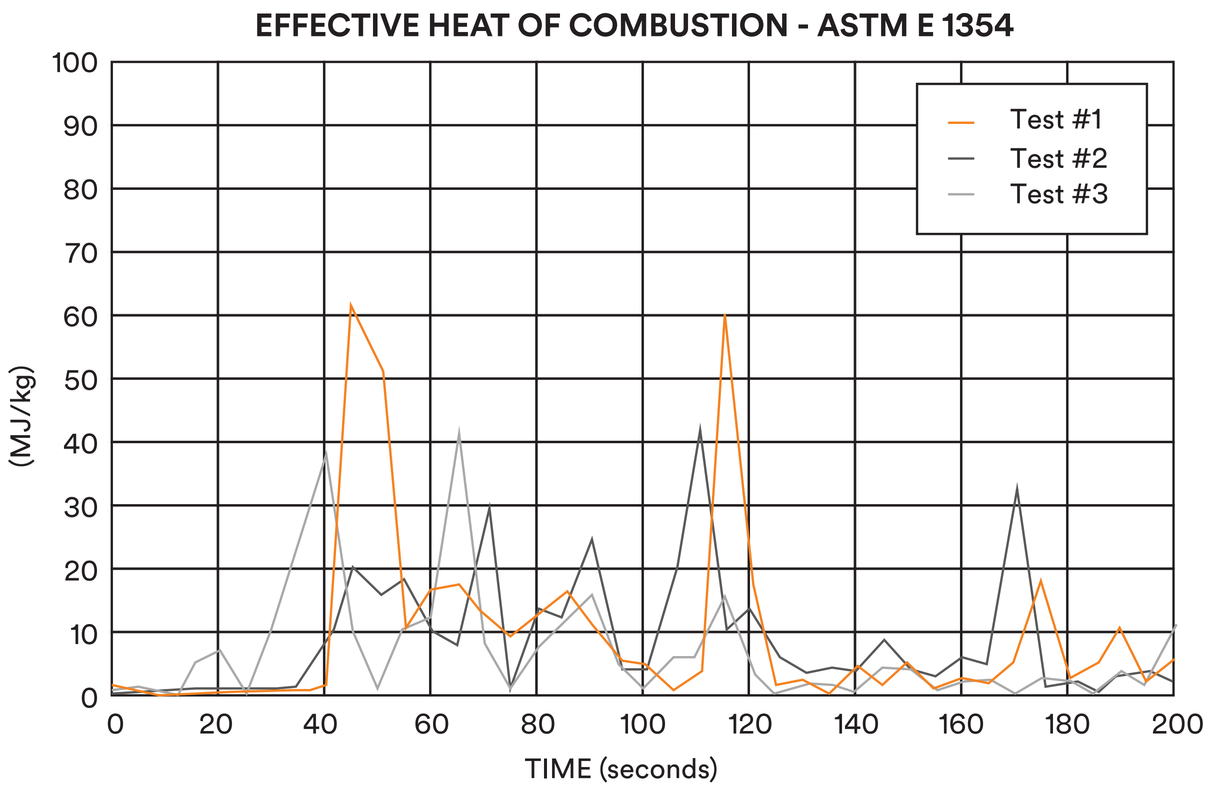
Testing was performed on October 31, 2011 with the sample in the horizontal configuration, utilizing the specimen edge frame and also the specified spark ignition source.

	Test #1	Test #2	Test #3	Average	
Heat Flux (kW/m²)	50	50	50		
Exhaust Flow Rate (l/s)	24	24	24		
Specimen Thickness (mm)	0.1	0.1	0.1		
Initial Mass (g)(including substrate)	90.3	89.5	91.8		
Mass at Sustained Flaming (g)(including substrate)	90.2	89.4	92.3		
Final Mass (g)(including substrate)	79.75	77.92	78.89		
Total Mass Loss (kg/m²)	1.05	1.19	1.29	1.18	
Peak Specific Mass Loss Rate (g/s·m²)	21.55	20.42	24.20	22.05	
Average Mass Loss Rate (g/s·m²)	7.23	5.73	5.69	6.22	
Time to Ignition (s)	38	34	19	30	
Time to Flame-out (s)	135	172	204	170	
Time of Peak Rate of Heat Release (s)	50	50	40	47	
Peak Rate of Heat Release (kW/m²)	234.4	217.9	217.3	223.2	
Average Rate of Heat Release (kW/m²)	85.0	46.8	56.0	62.6	
Total Heat Released (MJ/m²)	8.09	10.54	12.79	10.48	
Average Effective Heat of Combustion (MJ/kg)	11.98	8.06	10.73	**10.26**	*
Average Effective Heat of Combustion (BTU/lb)	5160.8	3469.5	4622.1	**4417**	*
Caloric Content (MJ/kg)	0.79	1.04	1.23	**1.02**	**
Caloric Content (BTU/lb)	341.4	448.34	530.17	**440**	**
Peak Extinction Area (m²/kg)	920.2	620.1	567.7	702.7	
Average Extinction Area (m²/kg)	41.0	65.4	65.7	57.4	

* Total heat produced per unit mass of material consumed
** Total heat produced per unit mass of material tested

ASTM E 1354 Testing of “3M 590 OEM Polyurethane Glass Adhesive Sealant”

TEST RESULTS (continued)

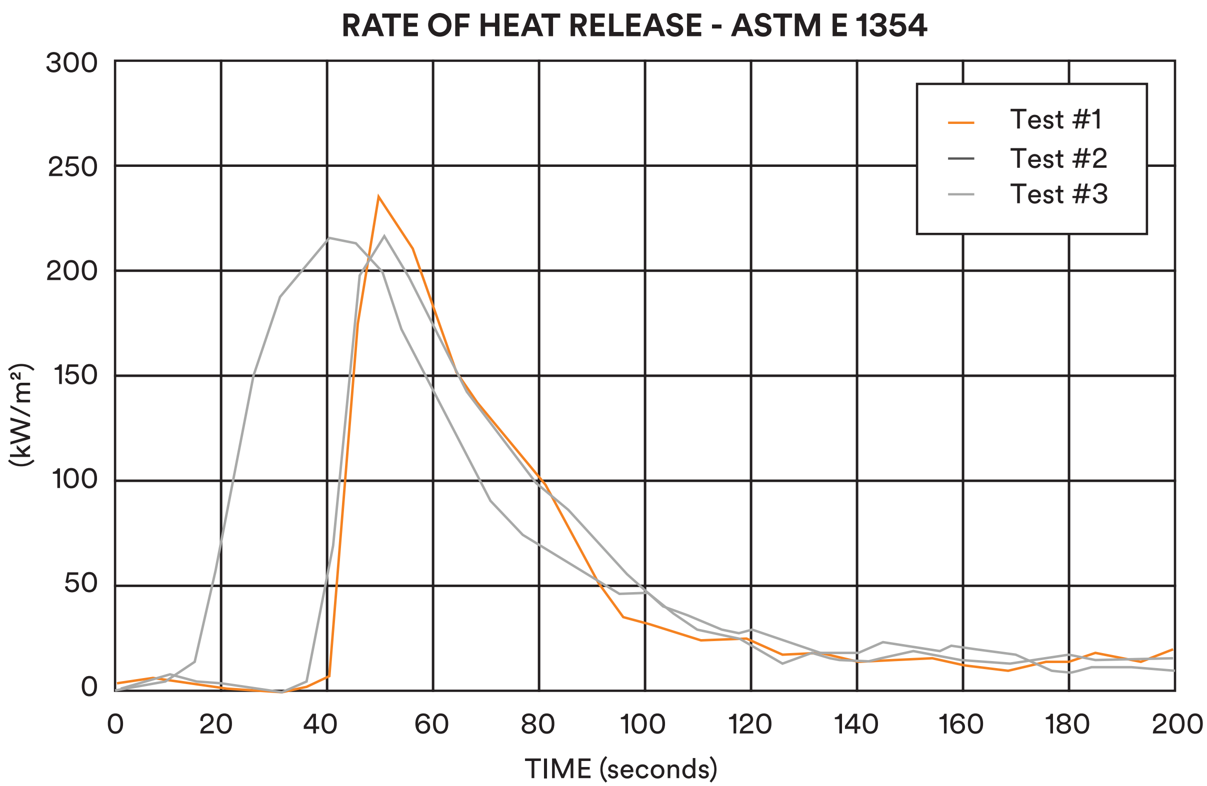


	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	11.98	8.06	10.73	10.26
Heat of Combustion @ 60 s (MJ/kg)**	13.20	13.71	18.26	15.06
Heat of Combustion @ 180 s (MJ/kg)**	9.03	8.89	11.65	9.86
Heat of Combustion @ 300 s (MJ/kg)**	0.00	0.00	9.63	3.21

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of “3M 590 OEM Polyurethane Glass Adhesive Sealant”

TEST RESULTS (continued)



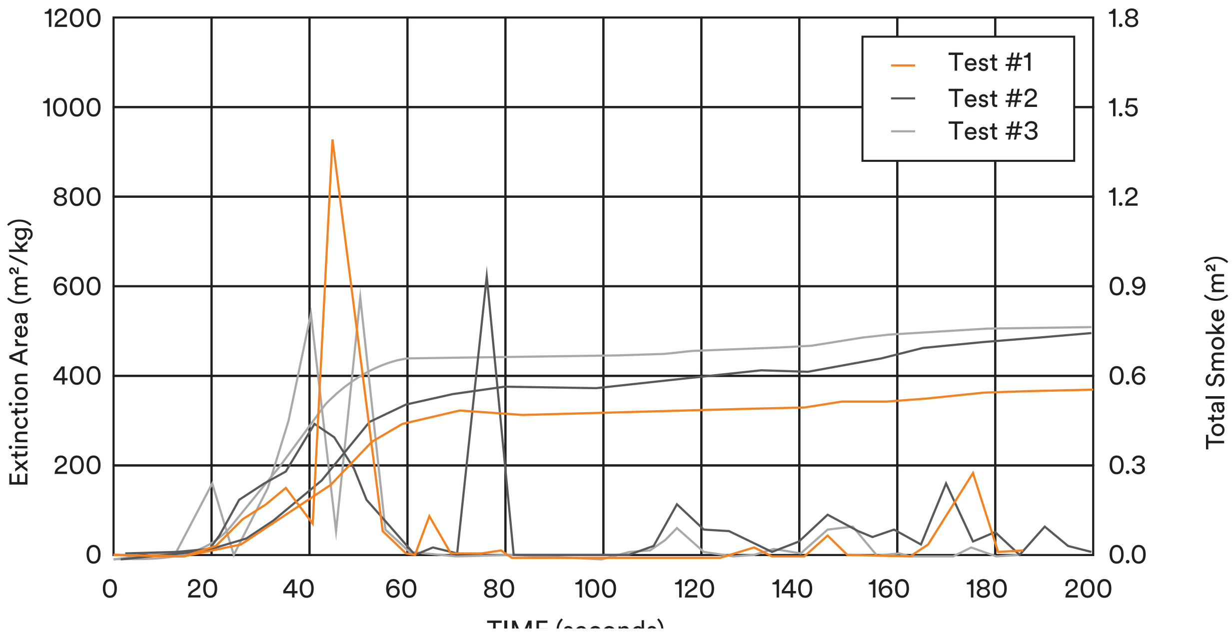
	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m^2)	236.0	213.9	183.4	211.1
Average Heat Release Rate (kW/m^2)*	112.3	36.3	77.1	75.2
Heat Release Rate @ 60 s (kW/m^2)**	83.4	66.5	66.4	72.1
Heat Release Rate @ 180 s (kW/m^2)**	0.00	0.00	0.00	0.00
Heat Release Rate @ 300 s (kW/m^2)**	0.00	0.00	0.00	0.00

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

TEST RESULTS (continued)

SMOKE GENERATION - ASTM E 1354

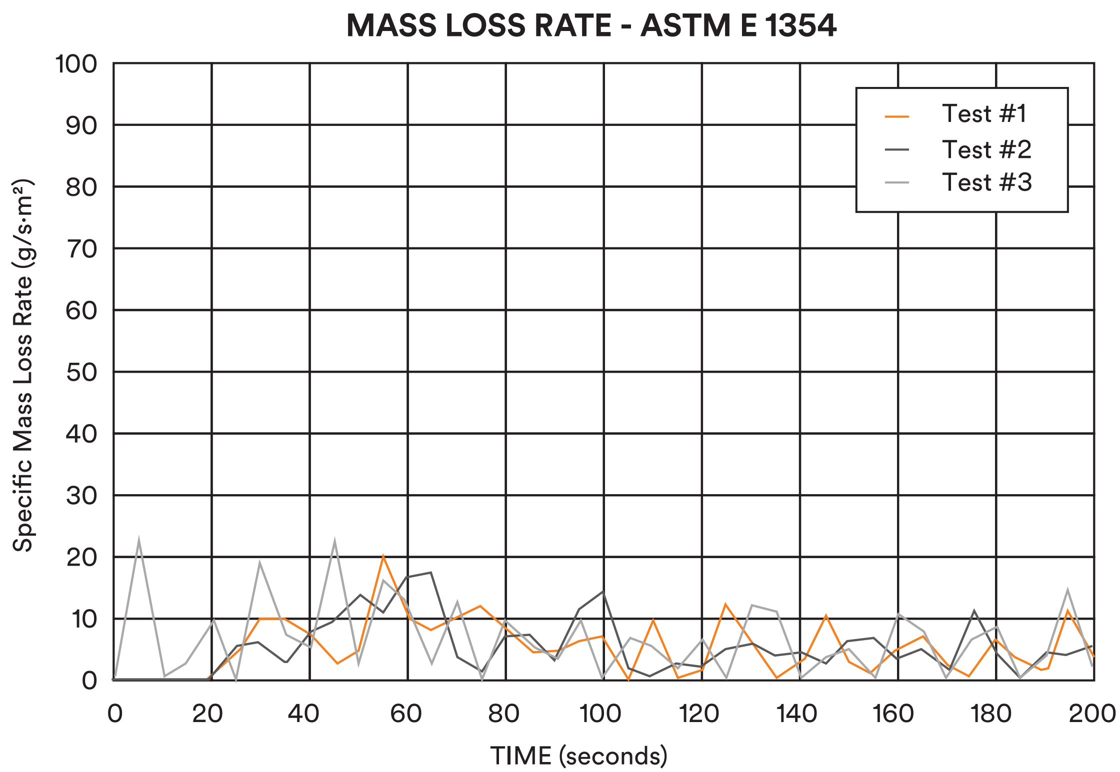


	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m^2/kg)	920.2	620.1	567.7	702.7
Average Extinction Area (m^2/kg)*	41.0	65.4	65.7	57.4
Extinction Area @ 60 s (m^2/kg)**	52.1	86.9	139.3	92.8
Extinction Area @ 180 s (m^2/kg)**	28.2	63.0	71.7	54.3
Extinction Area @ 300 s (m^2/kg)**	0.00	0.00	58.3	19.4
Total Smoke (m^2)	0.3	0.8	0.8	0.6

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of “3M 590 OEM Polyurethane Glass Adhesive Sealant”

TEST RESULTS (continued)



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	21.55	20.42	24.20	22.05
Avg. Specific Mass Loss Rate (g/m²·s)*	7.23	5.73	5.69	6.22
Mass Loss Rate @ 60 s (g/s)**	0.08	0.08	0.08	0.08
Mass Loss Rate @ 180 s (g/s)**	0.05	0.05	0.05	0.05
Mass Loss Rate @ 300 s (g/s)**	0.00	0.00	0.04	0.01

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.

** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

CONCLUSIONS

The polyurethane adhesive sealant identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, affords an average Effective Heat of Combustion of 10.26 MJ/kg (4417 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m². Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 1.02 MJ/kg (440 BTU/lb).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

ASTM E 1354 Testing of “3M 590 OEM Polyurethane Glass Adhesive Sealant”

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion

This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.

Time to Ignition

Also known as ignition delay time, this parameter provides a measure of a material’s propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.

Heat Release Rate (HRR)

HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.

Total Heat Release

This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate “potential heat load” than is the more commonly used “caloric content” based upon the weight of material used.

Mass Loss Rate

This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.

Extinction Area

This refers to the “yield” of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.

Surface Flammability, Smoke and Toxic Gas Generation of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, as per your Purchase Order No. USMMM81UD5 and our Quote No. 11-006-08983 dated September 21, 2011.

IDENTIFICATION
Polyurethane adhesive sealant identified as "3M 590 OEM Polyurethane Glass Adhesive Sealant". (Exova sample identification number 11-002-S0710)

SAMPLE PREPARATION
The coating material was applied onto 6 mm thick fiberglass reinforced cement substrate using a 1/32 x 1/32" square notched trowel and was allowed to dry 48 hours prior to testing.

TEST RESULTS

ASTM E 162-11a

Surface Flammability of Materials Using a Radiant Heat Energy Source. (Is = Flame Spread Index).

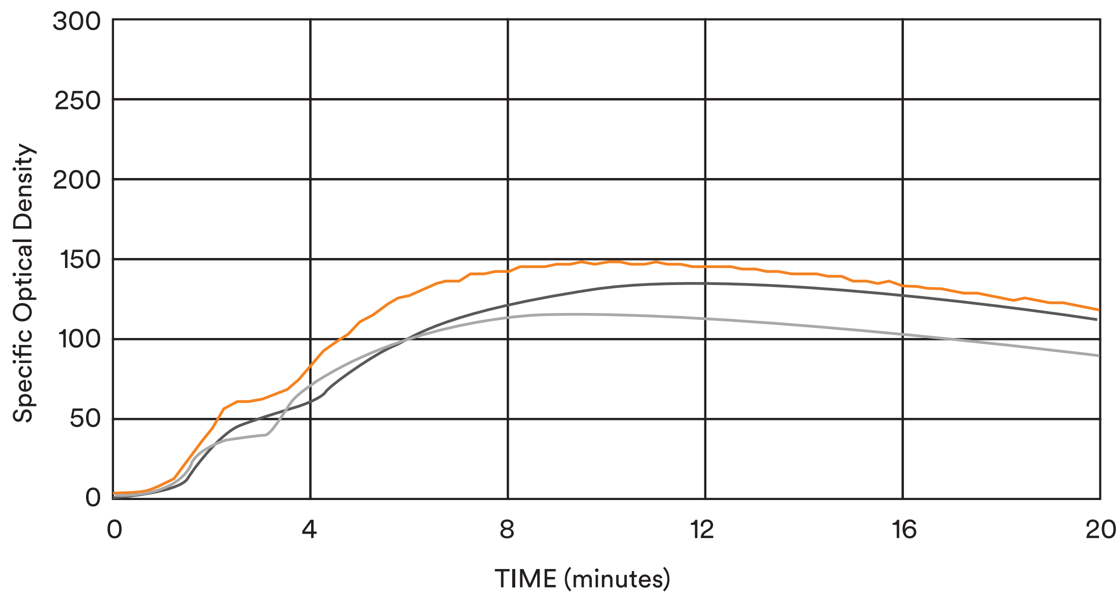
	Fs	Q	Is	Observations
1:	3.5	5.5	19	Flashing flame front propagation to a distance of 17 inches.
2:	4.2	9.4	40	No Flaming running and flaming dripping observed.
3:	4.5	13.1	60	
4:	3.5	5.9	21	
Rounded Average:			35	
Specified Maximum:			35	No flaming running or flaming dripping allowed

Surface Flammability, Smoke and Toxic Gas Generation of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

FLAMING MODE - ASTM E 662-09



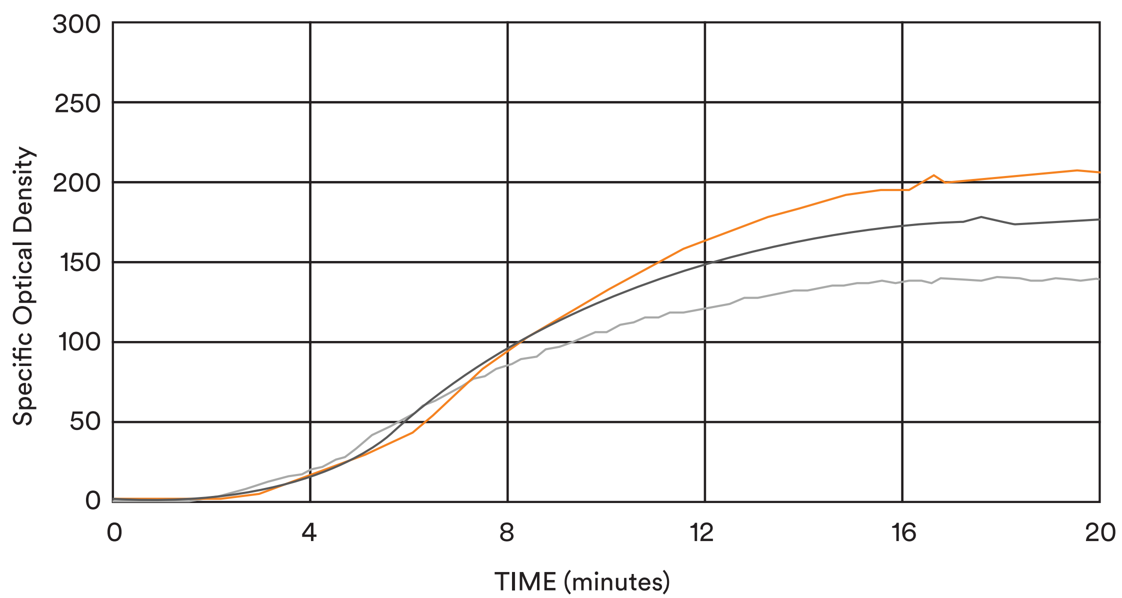
Relative Room Humidity: 30%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	11	16	13	15	100
Specific Optical Density at 4.0 minutes	60	70	80	70	200
Maximum Specific Optical Density	134	115	147	132	-
Maximum Corrected Optical Density	131	113	143	129	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

NON FLAMING MODE - ASTM E 662-09



Relative Room Humidity: 30%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Non-Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	1	1	1	1	100
Specific Optical Density at 4.0 minutes	14	17	19	17	200
Maximum Specific Optical Density	211	182	140	178	-
Maximum Corrected Optical Density	200	173	134	169	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

TEST RESULTS (continued)

ASTM E 662 Observations

In the flaming mode, ignition was initially observed at the point of pilot flame impingement followed by visible smoke and charring. In the non-flaming mode, visible smoke production was observed within 30 seconds followed by charring.

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Generation from Material Combustion

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	28	<10	-
	at 4.0 minutes	169	<10	-
	at maximum	832	357	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	962	144	-
	at 4.0 minutes	4473	192	-
	at maximum	14430	1299	90000
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		23	2	100
Hydrogen Chloride (HCl ppm)		<2	<2	500
Hydrogen Fluoride (HF ppm)		<2	<2	100
Hydrogen Bromide (HBr ppm)		<1	<1	100
Hydrogen Cyanide (HCN ppm)		2	<1	100
Original Weight (g)(including substrate)		44.9	45.4	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10	Did not ignite	-
Burning Duration (s)		250	-	-

Surface Flammability, Smoke and Toxic Gas Generation of “3M 590 OEM Polyurethane Glass Adhesive Sealant”

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Typical Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	45	<10	-
	at 4.0 minutes	193	<10	-
	at maximum	905	383	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		46	<6	100
Hydrogen Chloride (HCl ppm)		<12	<12	500
Hydrogen Fluoride (HF ppm)		<12	<12	200
Hydrogen Cyanide (HCN ppm)		1	<1	150
Original Weight (g)(including substrate)		51.4	52.1	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10	Did not ignite	-
Burning Duration (s)		300	-	-

CONCLUSIONS AND COMMENTS

The polyurethane glass adhesive sealant identified in this report, when tested at applied onto 6 mm thick fiberglass reinforced cement substrate, meets The Federal Railroad Administration requirements as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The polyurethane glass adhesive sealant also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and, as such, has no specific pass/fail criteria of its own.
The M-7 Technical Specification criteria are cited for reference purposes only, and may or may not apply to this specific product. The polyurethane glass adhesive sealant identified in this report meets the M-7 Technical Specification requirements as they pertain to toxic gas generation (Boeing BSS 7239).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

Surface Flammability, Smoke and Toxic Gas Generation of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

APPENDIX - Summaries of Test Procedures

ASTM E 162-11a

Surface Flammability of Materials Using a Radiant Energy Source

Four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C and conditioned to equilibrium at 50 ± 5% relative humidity and 23 ± 3°C before testing.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where: Is is the flame spread index

Fs is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

Exova

Surface Flammability, Smoke and Toxic Gas Generation of “3M 590 OEM Polyurethane Glass Adhesive Sealant”

APPENDIX - Summaries of Test Procedures

ASTM E 662-09

Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

Specimens are dried for 24 hours at 60°C and conditioned to equilibrium at 50% RH and 23°C.

Three specimens, 3” square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37° C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer’s law:

$$Ds = (V/AL)\cdot\log(100/T) = G\cdot\log(100/T) = 132\cdot\log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

Ds 1.5 - specific optical density after 1.5 minutes

Ds 4.0 - specific optical density after 4.0 minutes

Dm -maximum specific optical density at any time during the 20 minute test

Dm (corr) - Dm corrected for incidental deposits on the optical surfaces

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

Surface Flammability, Smoke and Toxic Gas Generation of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation

Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)

CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling

HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)

Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^{-} . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.

Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)

Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.

Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)

Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)

Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)

SO2 is trapped in the NaOH impinger as sulfite and sulfate (SO3^{-2} and SO4^{-2}). Hydrogen peroxide is added to convert SO3^{-2} to SO4^{-2}. Resulting sulfate is determined using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402

Surface Flammability, Smoke and Toxic Gas Generation of "3M 590 OEM Polyurethane Glass Adhesive Sealant"

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

ASTM E 1354 Testing of "DP8410NS Green"

ACCREDITATION
To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per Exova Warringtonfire North America Quotation No. 14-002-272,152 RV1 accepted January 13, 2014.

IDENTIFICATION
Two component structural acrylic adhesive, identified as "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green". (Exova sample identification number 14-002-S0031-1)

SAMPLE PREPARATION
As per client's instructions, the two component structural acyrlic adhesive was applied onto 6 mm thick fiberglass reinforced cement substrate using a flat trowel at a typical thickness range of 0.125 to 0.5 mm. The material was applied and allowed to cure at room temperature for a minimum of 3 days prior to testing.

SUMMARY OF TEST PROCEDURE
Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1 x 10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

ASTM E 1354 Testing of "DP8410NS Green"

TEST RESULTS - ASTM E 1354-13

Standard Test Method for Heat and Visible Smoke Release Rates
for Materials and Products Using an Oxygen Consumption Calorimeter

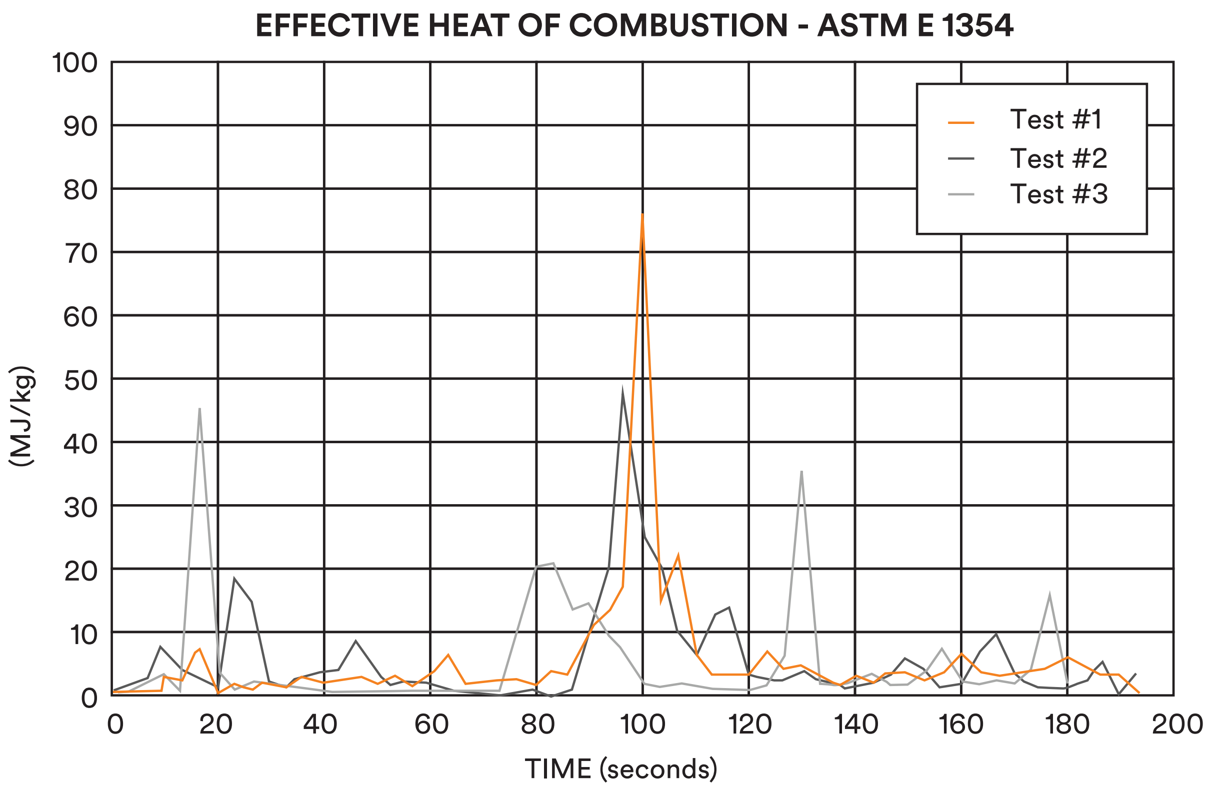
Testing was performed on February 12, 2014 with the sample in the horizontal configuration, utilizing the specimen holder and edge frame and also the specified spark ignition source.

	Test #1	Test #2	Test #3	Average	
Heat Flux (kW/m²)	50	50	50		
Exhaust Flow Rate (l/s)	24	24	24		
Specimen Thickness (mm)	0.3	0.3	0.3		
Initial Mass (g)(including substrate)	91.1	87.5	81.9		
Mass at Sustained Flaming (g)(including substrate)	87.1	84.3	78.6		
Final Mass (g)(including substrate)	79.1	77.6	71.0		
Total Mass Loss (kg/m²)	1.20	0.98	1.10	1.09	
Peak Specific Mass Loss Rate (g/s·m²)	21.18	17.19	13.90	17.42	
Average Mass Loss Rate (g/s·m²)	5.34	4.83	5.40	5.19	
Time to Ignition (s)	131	128	108	122	
Time to Flame-out (s)	180	184	160	175	
Time of Peak Rate of Heat Release (s)	140	140	120	133	
Peak Rate of Heat Release (kW/m²)	262.7	250.5	233.1	248.7	
Average Rate of Heat Release (kW/m²)	40.6	37.1	33.5	37.1	
Total Heat Released (MJ/m²)	6.55	5.39	5.21	5.72	
Average Effective Heat of Combustion (MJ/kg)	7.32	7.70	6.26	**7.09**	*
Average Effective Heat of Combustion (BTU/lb)	3151.6	3317.2	2695.2	**3055**	*
Caloric Content (MJ/kg)	0.64	0.55	0.56	**0.58**	**
Caloric Content (BTU/lb)	273.81	234.79	241.99	**250**	**
Peak Extinction Area (m²/kg)	1438.6	1355.1	1473.5	1422.4	
Average Extinction Area (m²/kg)	124.8	196.3	182.0	167.7	

* Total heat produced per unit mass of material consumed
** Total heat produced per unit mass of material tested

ASTM E 1354 Testing of "DP8410NS Green"

TEST RESULTS (continued)

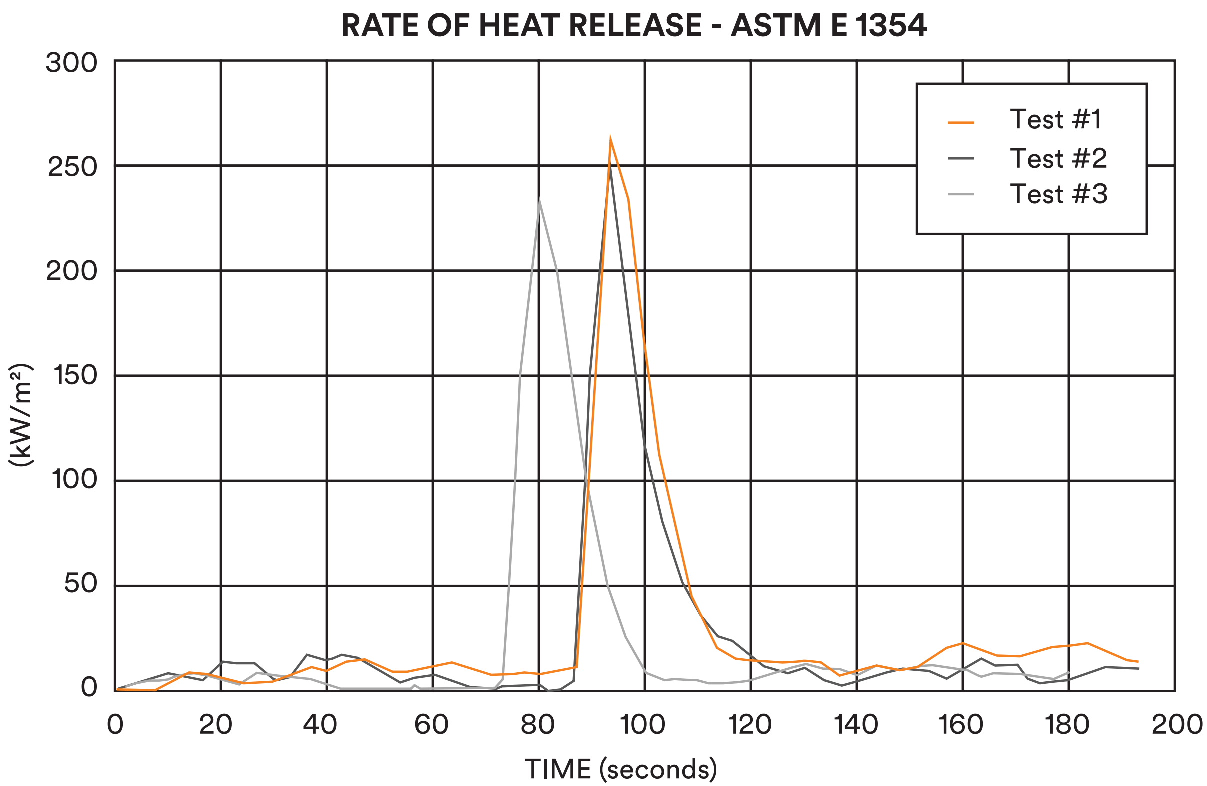


	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	7.32	7.70	6.26	7.09
Heat of Combustion @ 60 s (MJ/kg)**	12.04	12.57	10.89	11.83
Heat of Combustion @ 180 s (MJ/kg)**	0.00	0.00	0.00	0.00
Heat of Combustion @ 300 s (MJ/kg)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of "DP8410NS Green"

TEST RESULTS (continued)



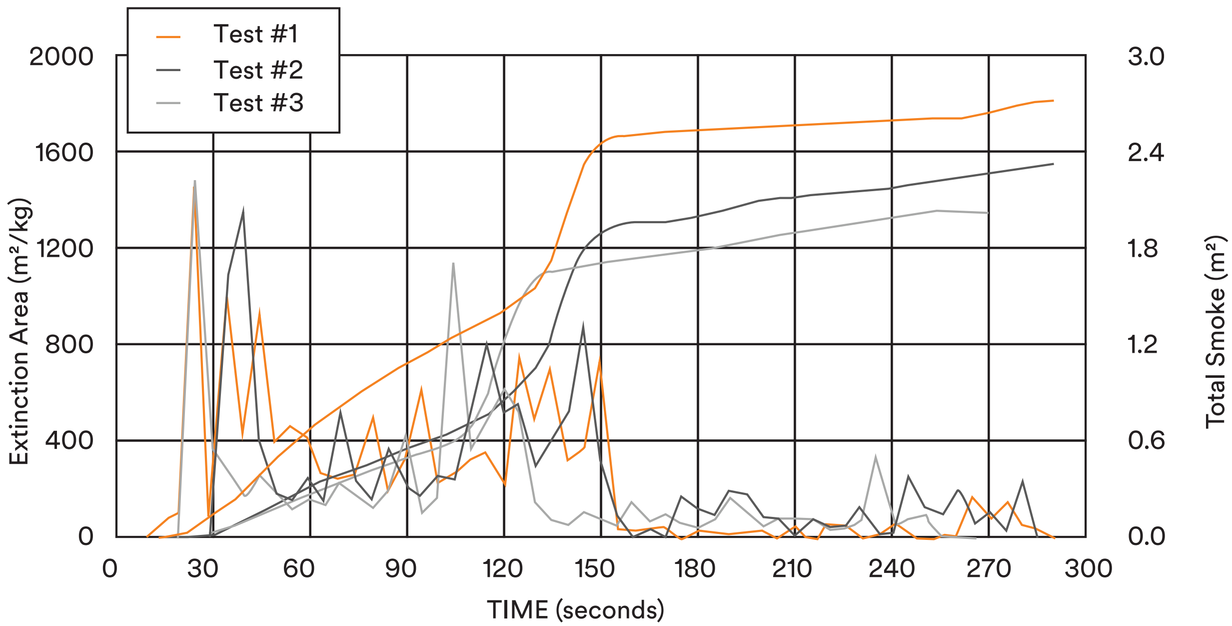
	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m^2)	262.7	250.5	233.1	248.7
Average Heat Release Rate (kW/m^2)*	40.6	37.1	33.5	37.1
Heat Release Rate @ 60 s (kW/m^2)**	81.6	80.3	74.9	78.9
Heat Release Rate @ 180 s (kW/m^2)**	0.00	0.00	0.00	0.00
Heat Release Rate @ 300 s (kW/m^2)**	0.00	0.00	0.00	0.00

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "DP8410NS Green"

TEST RESULTS (continued)

SMOKE GENERATION - ASTM E 1354



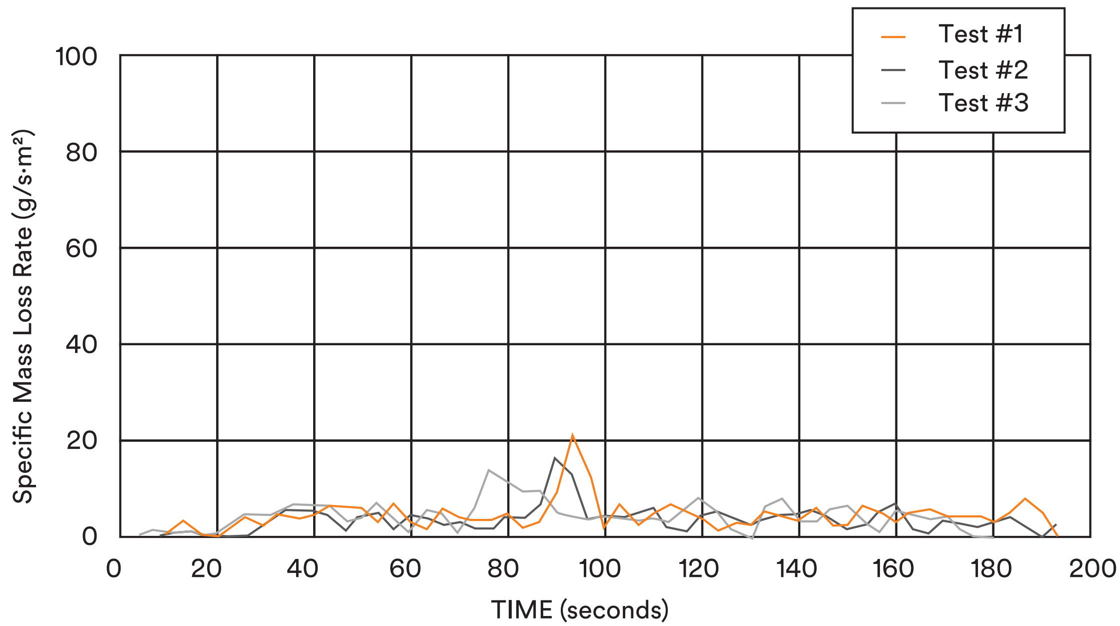
	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m^2/kg)	1438.6	1355.1	1473.5	1422.4
Average Extinction Area (m^2/kg)*	124.8	196.3	182.0	167.7
Extinction Area @ 60 s (m^2/kg)**	219.3	288.7	295.3	267.8
Extinction Area @ 180 s (m^2/kg)**	0.00	0.00	0.00	0.00
Extinction Area @ 300 s (m^2/kg)**	0.00	0.00	0.00	0.00
Total Smoke (m^2)	2.70	2.31	2.02	2.34

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "DP8410NS Green"

TEST RESULTS (continued)

MASS LOSS RATE - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	21.18	17.19	13.90	17.42
Avg. Specific Mass Loss Rate (g/m²·s)*	5.34	4.83	5.40	5.19
Mass Loss Rate @ 60 s (g/s)**	0.06	0.06	0.06	0.07
Mass Loss Rate @ 180 s (g/s)**	0.00	0.00	0.00	0.00
Mass Loss Rate @ 300 s (g/s)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of "DP8410NS Green"

CONCLUSIONS

The two component acrylic adhesive sealant material identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, affords an average Effective Heat of Combustion of 7.09 MJ/kg (3055 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m². Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 0.58 MJ/kg (250 BTU/lb).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

ASTM E 1354 Testing of "DP8410NS Green"

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion
This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.

Time to Ignition
Also known as ignition delay time, this parameter provides a measure of a material's propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.

Heat Release Rate (HRR)
HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.

Total Heat Release
This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate "potential heat load" than is the more commonly used "caloric content" based upon the weight of material used.

Mass Loss Rate
This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.

Extinction Area
This refers to the "yield" of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER

Determine surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, as per Exova Warringtonfire North America Quotation No. 14-002-272,152 RV1 accepted January 13, 2014.

IDENTIFICATION

Two component structural acrylic adhesive, identified as "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green". (Exova sample identification number 14-002-S0031-1)

SAMPLE PREPARATION

As per client's instructions, the two component structural acyrlic adhesive was applied onto 6 mm thick fiberglass reinforced cement substrate using a flat trowel at a typical thickness range of 0.125 to 0.5 mm. The material was applied and allowed to cure at room temperature for a minimum of 3 days prior to testing.

TEST RESULTS

ASTM E 162-13

Surface Flammability of Materials Using a Radiant
Heat Energy Source. (Is = Flame Spread Index).

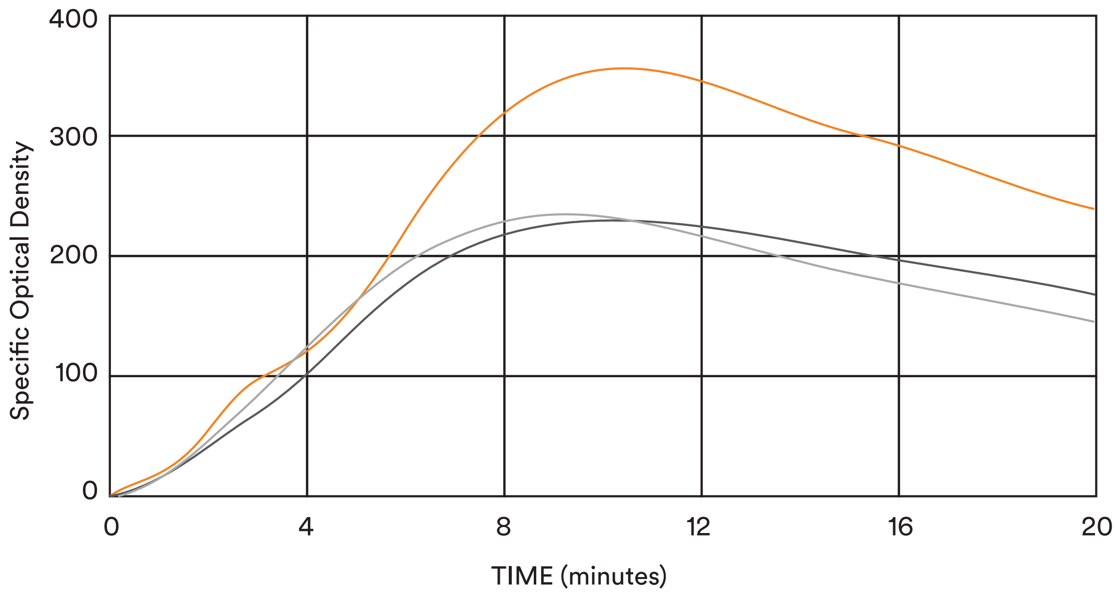
	Fs	Q	Is	Observations
1:	3.6	6.7	24	Maximum flame front propagation to a distance
2:	2.0	4.2	8	of 12 inches.
3:	3.1	4.0	12	Surface venting observed.
4:	3.5	4.2	15	No Flaming running and flaming dripping observed.
Rounded Average:			15	
Specified Maximum:			35	No flaming running or flaming dripping allowed

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

FLAMING MODE - ASTM E 662-13d



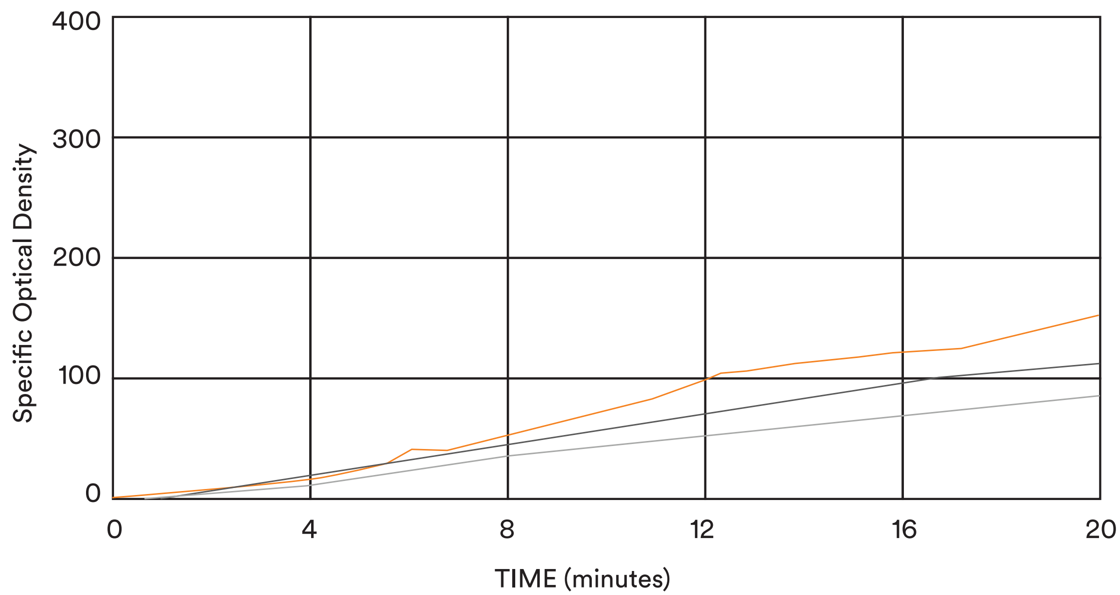
Relative Room Humidity: 28%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	14	21	24	20	100
Specific Optical Density at 4.0 minutes	76	96	85	85	200
Maximum Specific Optical Density	189	295	188	224	-
Maximum Corrected Optical Density	185	289	186	220	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

NON FLAMING MODE - ASTM E 662-13d



Relative Room Humidity: 28%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Non-Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	2	2	3	2	100
Specific Optical Density at 4.0 minutes	15	13	21	16	200
Maximum Specific Optical Density	112	84	151	116	-
Maximum Corrected Optical Density	112	83	151	115	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

TEST RESULTS (continued)

ASTM E 662 Observations

In the flaming mode, ignition was initially observed at the point of pilot flame impingement followed by visible smoke and charring. In the non-flaming mode, visible smoke production was observed within 30 seconds followed by charring.

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Generation from Material Combustion

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	<1	<1	-
	at 4.0 minutes	76	<1	-
	at maximum	847	85	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	<10	<10	-
	at 4.0 minutes	<10	<10	-
	at maximum	7076	180	90000
Nitrogen Oxides (as NO2 ppm)		5	<1	100
Sulfur Dioxide (SO2 ppm)		<1	<1	100
Hydrogen Chloride (HCl ppm)		6	<2	500
Hydrogen Fluoride (HF ppm)		4	<2	100
Hydrogen Bromide (HBr ppm)		3	<1	100
Hydrogen Cyanide (HCN ppm)		8	2	100
Original Weight (g)(including substrate)		46.70	48.52	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10	Did not ignite	-
Burning Duration (s)		240	-	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Typical Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	2	<1	-
	at 4.0 minutes	94	<1	-
	at maximum	724	117	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<3	<3	100
Hydrogen Chloride (HCl ppm)		<12	<12	500
Hydrogen Fluoride (HF ppm)		<12	<12	200
Hydrogen Cyanide (HCN ppm)		6	<1	150
Original Weight (g)(including substrate)		49.37	45.53	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10.0	Did not ignite	-
Burning Duration (s)		240.0	-	-

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

CONCLUSIONS AND COMMENTS

There are currently no specific performance criteria cited by the Federal Railroad Administration for adhesive materials. However, the adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, would meet all of the current requirements (for all specified categories) as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The two component acrylic adhesive also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and as such, has no specific pass/fail criteria of its own. The reference criteria cited are typical for the transportation industry and are listed for reference purposes only. They may or may not apply to this specific product.

The two component acrylic adhesive would meet the typically-specified industry requirements as they pertain to toxic gas generation (Boeing BSS 7239).

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

APPENDIX - Summaries of Test Procedures

ASTM E 162-13

Surface Flammability of Materials Using a Radiant Energy Source

As specified, four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C. Section 10.1 of ASTM E 162-13 states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where: Is is the flame spread index

Fs is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

APPENDIX - Summaries of Test Procedures

ASTM E 662-13d

Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

As specified, the test samples are pre-dried for 24 hours at 60°C. Section 9.1 of ASTM E 662-13d states to then condition the specimens to “equilibrium (constant weight)” but does not specify a definition or procedure with respect to establishing the “constant weight”. Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Three specimens, 3” square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37° C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer’s law:

$$D_s = (V/AL)\cdot\log(100/T) = G\cdot\log(100/T) = 132\cdot\log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

$D_{s\,1.5}$ - specific optical density after 1.5 minutes

$D_{s\,4.0}$ - specific optical density after 4.0 minutes

Dm -maximum specific optical density at any time during the 20 minute test

$D_{m\,(corr)}$ - Dm corrected for incidental deposits on the optical surfaces

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-\,2}$ and $SO4^{-\,2}$). Hydrogen peroxide is added to convert $SO3^{-\,2}$ to $SO4^{-\,2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO$^-$. After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate (SO3^{-2} and SO4^{-2}). Hydrogen peroxide is added to convert SO3^{-2} to SO4^{-2}. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

ASTM E 1354 Testing of "DP8810NS Green"

ACCREDITATION
To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per Exova Warringtonfire North America Quotation No. 14-002-272,152 RV1 accepted January 13, 2014.

IDENTIFICATION
Two component structural acrylic adhesive, identified as "3M Scotch-Weld™ Acrylic Low Odor Adhesive DP8810NS Green". (Exova sample identification number 14-002-S0031-2)

SAMPLE PREPARATION
As per client's instructions, the two component structural acyrlic adhesive was applied onto 6 mm thick fiberglass reinforced cement substrate using a flat trowel at a typical thickness range of 0.125 to 0.5 mm. The material was applied and allowed to cure at room temperature for a minimum of 3 days prior to testing.

SUMMARY OF TEST PROCEDURE
Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1 x 10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

ASTM E 1354 Testing of "DP8810NS Green"

TEST RESULTS - ASTM E 1354-13

Standard Test Method for Heat and Visible Smoke Release Rates
for Materials and Products Using an Oxygen Consumption Calorimeter

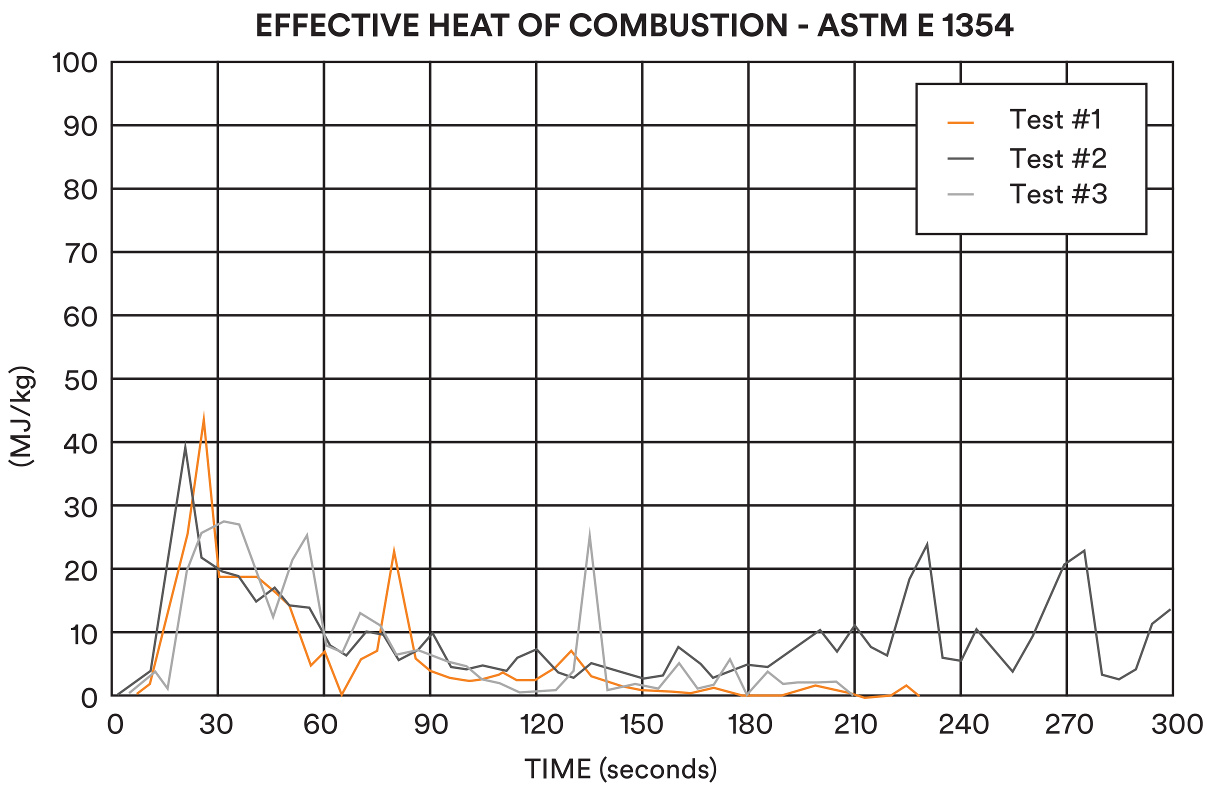
Testing was performed on February 12, 2014 with the sample in the horizontal configuration, utilizing the specimen holder and edge frame and also the specified spark ignition source.

	Test #1	Test #2	Test #3	Average	
Heat Flux (kW/m²)	50	50	50		
Exhaust Flow Rate (l/s)	24	24	24		
Specimen Thickness (mm)	0.3	0.3	0.3		
Initial Mass (g)(including substrate)	90.8	90.8	88.8		
Mass at Sustained Flaming (g)(including substrate)	90.8	90.8	88.8		
Final Mass (g)(including substrate)	78.8	74.0	78.4		
Total Mass Loss (kg/m²)	1.20	1.67	1.04	1.31	
Peak Specific Mass Loss Rate (g/s·m²)	15.90	11.36	13.59	13.61	
Average Mass Loss Rate (g/s·m²)	6.61	5.30	8.63	6.84	
Time to Ignition (s)	8	6	12	9	
Time to Flame-out (s)	150	400	104	218	
Time of Peak Rate of Heat Release (s)	20	20	25	22	
Peak Rate of Heat Release (kW/m²)	241.7	238.1	325.3	268.4	
Average Rate of Heat Release (kW/m²)	68.4	40.6	112.4	73.8	
Total Heat Released (MJ/m²)	9.61	16.13	10.07	11.94	
Average Effective Heat of Combustion (MJ/kg)	10.74	8.90	14.34	**11.33**	*
Average Effective Heat of Combustion (BTU/lb)	4624.8	3834.8	6174.3	**4878**	*
Caloric Content (MJ/kg)	0.94	1.57	1.00	**1.17**	**
Caloric Content (BTU/lb)	402.84	676.57	431.7	**504**	**
Peak Extinction Area (m²/kg)	617.2	500.5	419.6	512.4	
Average Extinction Area (m²/kg)	117.4	97.3	192.7	135.8	

* Total heat produced per unit mass of material consumed
** Total heat produced per unit mass of material tested

ASTM E 1354 Testing of "DP8810NS Green"

TEST RESULTS (continued)

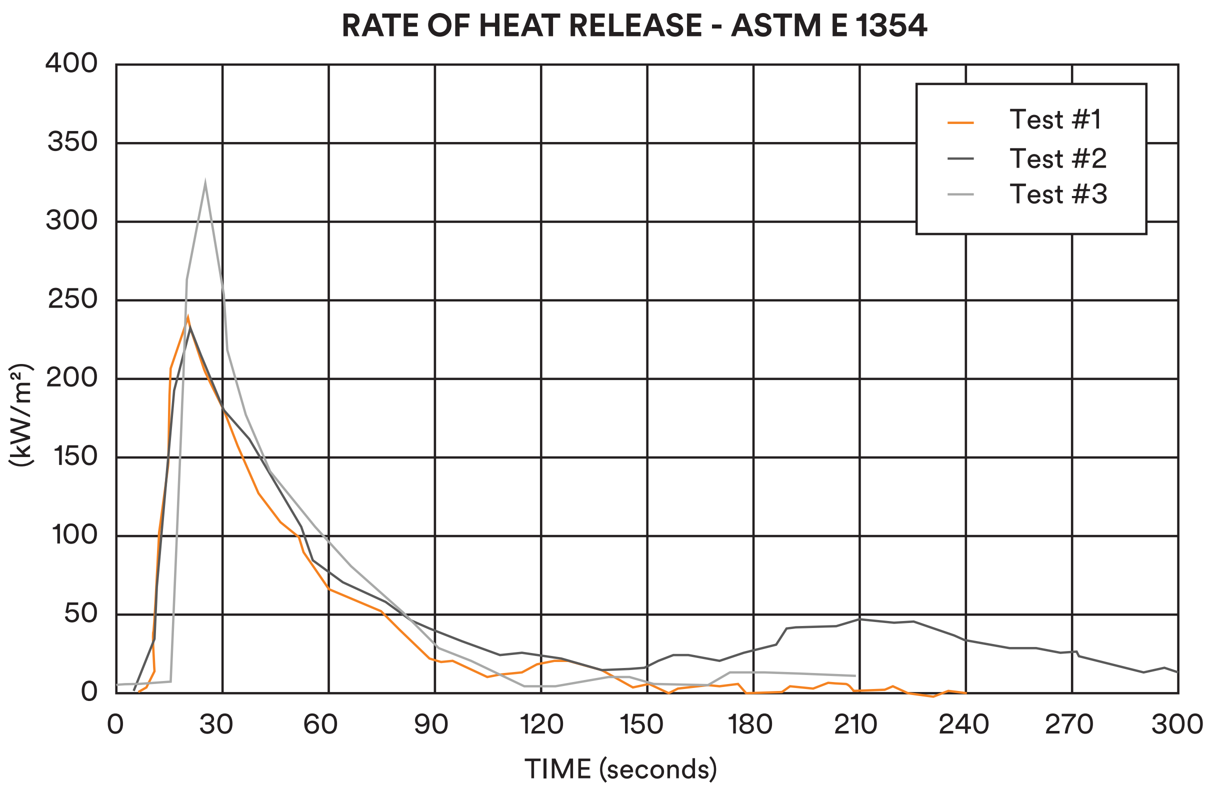


	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	10.74	8.90	14.34	11.33
Heat of Combustion @ 60 s (MJ/kg)**	16.06	15.83	16.78	16.22
Heat of Combustion @ 180 s (MJ/kg)**	9.05	10.07	10.06	9.73
Heat of Combustion @ 300 s (MJ/kg)**	0.00	9.48	0.00	3.16

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of "DP8810NS Green"

TEST RESULTS (continued)



	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m^2)	241.7	238.1	325.3	268.4
Average Heat Release Rate (kW/m^2)*	68.4	40.6	112.4	73.8
Heat Release Rate @ 60 s (kW/m^2)**	131.4	138.6	151.3	140.4
Heat Release Rate @ 180 s (kW/m^2)**	53.8	65.2	60.9	60.0
Heat Release Rate @ 300 s (kW/m^2)**	0.00	51.6	0.00	17.2

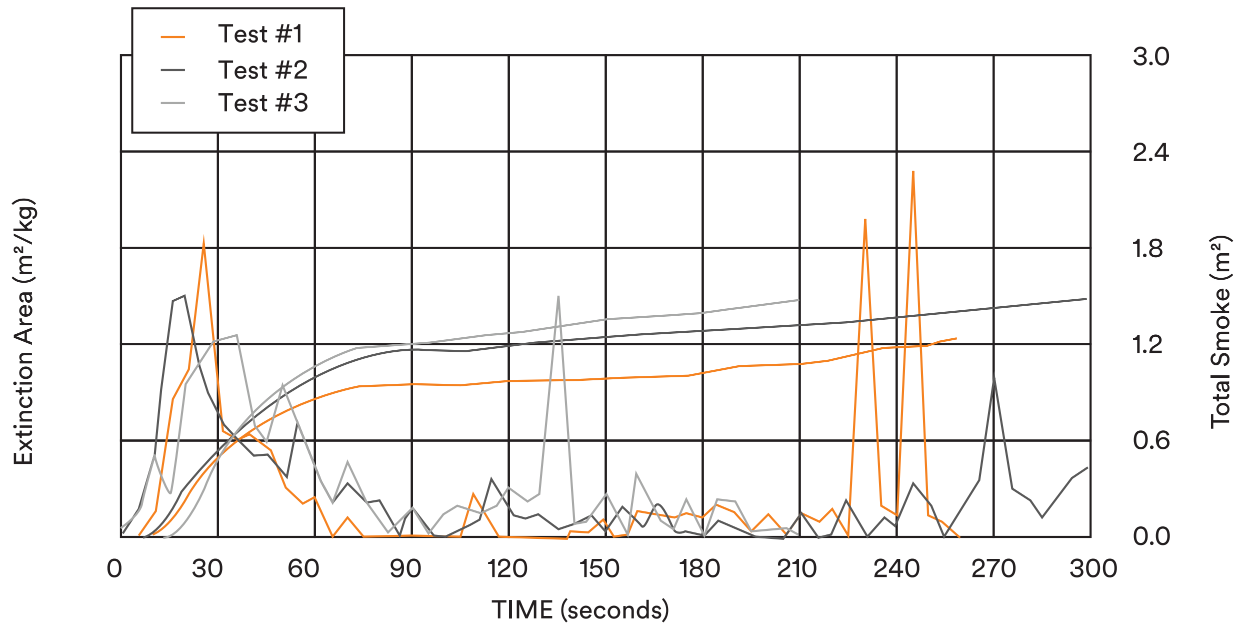
* Averaged over the test period (from ignition to flameout).

** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "DP8410NS Green"

TEST RESULTS (continued)

SMOKE GENERATION - ASTM E 1354



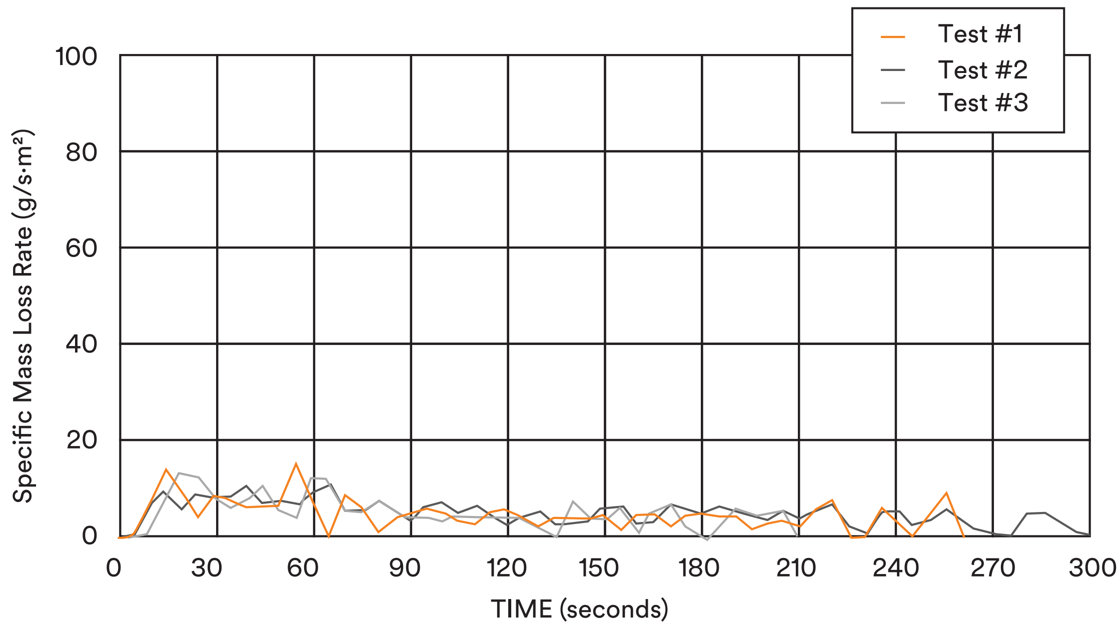
	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m^2/kg)	617.2	500.5	419.6	512.4
Average Extinction Area (m^2/kg)*	117.4	97.3	192.7	135.8
Extinction Area @ 60 s (m^2/kg)**	213.5	227.2	244.0	228.2
Extinction Area @ 180 s (m^2/kg)**	105.8	122.8	146.6	125.1
Extinction Area @ 300 s (m^2/kg)**	0.00	100.4	0.00	33.5
Total Smoke (m^2)	0.98	1.61	1.22	1.27

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "DP8810NS Green"

TEST RESULTS (continued)

MASS LOSS RATE - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	15.90	11.36	13.59	13.61
Avg. Specific Mass Loss Rate (g/m²·s)*	6.61	5.30	8.63	6.84
Mass Loss Rate @ 60 s (g/s)**	0.07	0.08	0.08	0.08
Mass Loss Rate @ 180 s (g/s)**	0.05	0.06	0.05	0.05
Mass Loss Rate @ 300 s (g/s)**	0.00	0.05	0.00	0.02

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of "DP8810NS Green"

CONCLUSIONS

The two component acrylic adhesive sealant material identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, affords an average Effective Heat of Combustion of 11.33 MJ/kg (4878 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m². Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 1.17 MJ/kg (504 BTU/lb).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

ASTM E 1354 Testing of "DP8810NS Green"

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion
This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.

Time to Ignition
Also known as ignition delay time, this parameter provides a measure of a material's propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.

Heat Release Rate (HRR)
HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.

Total Heat Release
This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate "potential heat load" than is the more commonly used "caloric content" based upon the weight of material used.

Mass Loss Rate
This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.

Extinction Area
This refers to the "yield" of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Low Odor Acrylic Adhesive DP8810NS Green"

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, as per Exova Warringtonfire North America Quotation No. 14-002-272,152 RV1 accepted January 13, 2014.

IDENTIFICATION
Two component structural acrylic adhesive, identified as "3M Scotch-Weld™ Acrylic Low Odor Adhesive DP8810NS Green". (Exova sample identification number 14-002-S0031-2)

SAMPLE PREPARATION
As per client's instructions, the two component structural acyrlic adhesive was applied onto 6 mm thick fiberglass reinforced cement substrate using a flat trowel at a typical thickness range of 0.125 to 0.5 mm. The material was applied and allowed to cure at room temperature for a minimum of 3 days prior to testing.

TEST RESULTS

ASTM E 162-13

Surface Flammability of Materials Using a Radiant
Heat Energy Source. (Is = Flame Spread Index).

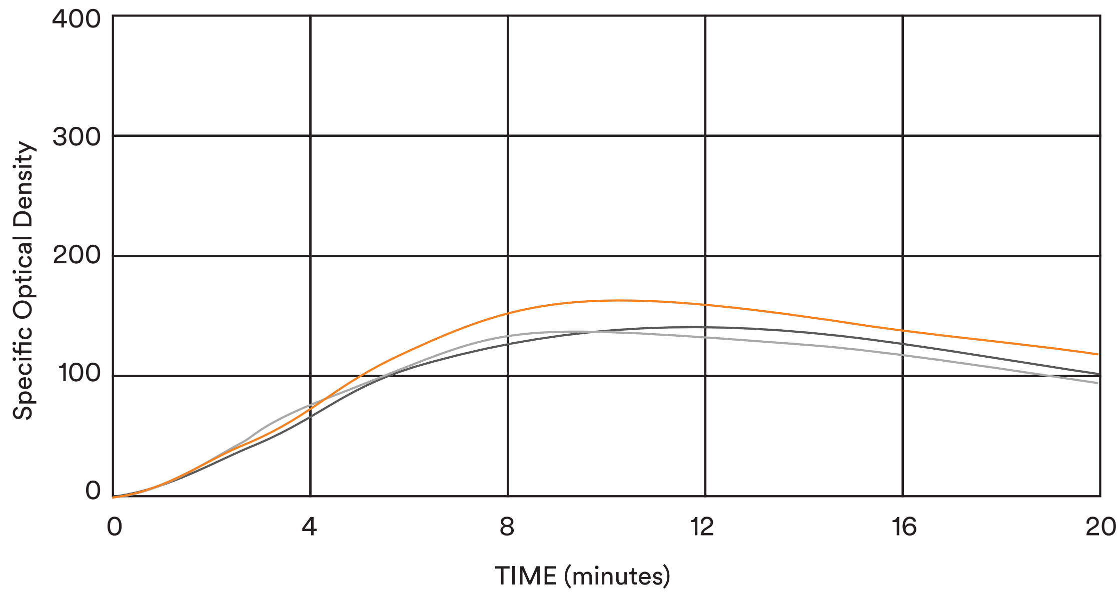
	Fs	Q	Is	Observations
1:	2.8	6.4	18	Maximum flame front propagation to a distance
2:	3.7	6.3	23	of 14 inches.
3:	3.5	5.2	18	Surface venting observed.
4:	2.1	3.1	7	No Flaming running and flaming dripping observed.
Rounded Average:			15	
Specified Maximum:			35	No flaming running or flaming dripping allowed

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Low Odor Acrylic Adhesive DP8810NS Green"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

FLAMING MODE - ASTM E 662-13d



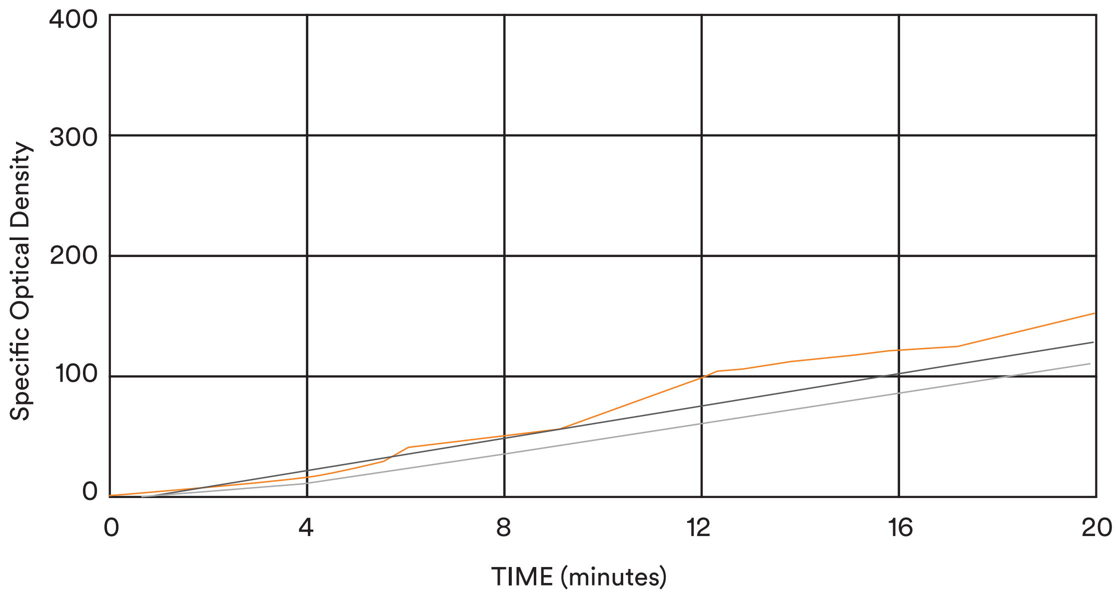
Relative Room Humidity: 28%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	12	29	35	25	100
Specific Optical Density at 4.0 minutes	66	60	89	72	200
Maximum Specific Optical Density	161	134	123	139	-
Maximum Corrected Optical Density	156	129	119	135	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Low Odor Acrylic Adhesive DP8810NS Green"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

NON FLAMING MODE - ASTM E 662-13d



Relative Room Humidity: 20%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Non-Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	13	10	12	12	100
Specific Optical Density at 4.0 minutes	37	23	26	29	200
Maximum Specific Optical Density	121	118	145	128	-
Maximum Corrected Optical Density	119	117	144	127	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Low Odor Acrylic Adhesive DP8810NS Green"

TEST RESULTS (continued)

ASTM E 662 Observations

In the flaming mode, ignition was initially observed at the point of pilot flame impingement increasing to full ignition within 15 seconds. Visible smoke and charring were also observed. In the non-flaming mode, visible smoke production was observed followed by charring.

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Generation from Material Combustion

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	5	<1	-
	at 4.0 minutes	114	3	-
	at maximum	779	98	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	<10	<10	-
	at 4.0 minutes	31	<10	-
	at maximum	10254	106	90000
Nitrogen Oxides (as NO2 ppm)		4	<1	100
Sulfur Dioxide (SO2 ppm)		<1	<1	100
Hydrogen Chloride (HCl ppm)		<2	<2	500
Hydrogen Fluoride (HF ppm)		3	<2	100
Hydrogen Bromide (HBr ppm)		3	4	100
Hydrogen Cyanide (HCN ppm)		3	3	100
Original Weight (g)(including substrate)		50.28	49.97	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		5	Did not ignite	-
Burning Duration (s)		180	-	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Low Odor Acrylic Adhesive DP8810NS Green"

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Typical Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	2	<1	-
	at 4.0 minutes	94	<1	-
	at maximum	724	117	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<3	<3	100
Hydrogen Chloride (HCl ppm)		<12	<12	500
Hydrogen Fluoride (HF ppm)		<12	<12	200
Hydrogen Cyanide (HCN ppm)		6	<1	150
Original Weight (g)(including substrate)		49.37	45.53	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10.0	Did not ignite	-
Burning Duration (s)		240.0	-	-

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

CONCLUSIONS AND COMMENTS

There are currently no specific performance criteria cited by the Federal Railroad Administration for adhesive materials. However, the adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, would meet all of the current requirements (for all specified categories) as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The two component acrylic adhesive also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and as such, has no specific pass/fail criteria of its own. The reference criteria cited are typical for the transportation industry and are listed for reference purposes only. They may or may not apply to this specific product.

The two component acrylic adhesive would meet the typically-specified industry requirements as they pertain to toxic gas generation (Boeing BSS 7239).

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Low Odor Acrylic Adhesive DP8810NS Green"

APPENDIX - Summaries of Test Procedures

ASTM E 162-13

Surface Flammability of Materials Using a Radiant Energy Source

As specified, four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C. Section 10.1 of ASTM E 162-13 states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where: I_s is the flame spread index

F_s is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Acrylic Adhesive DP8410NS Green"

APPENDIX - Summaries of Test Procedures

ASTM E 662-13d

Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

As specified, the test samples are pre-dried for 24 hours at 60°C. Section 9.1 of ASTM E 662-13d states to then condition the specimens to “equilibrium (constant weight)” but does not specify a definition or procedure with respect to establishing the “constant weight”. Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Three specimens, 3” square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37° C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer’s law:

$$Ds = (V/AL)\cdot\log(100/T) = G\cdot\log(100/T) = 132\cdot\log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

$Ds_{1.5}$ - specific optical density after 1.5 minutes
$Ds_{4.0}$ - specific optical density after 4.0 minutes

Dm -maximum specific optical density at any time during the 20 minute test

$Dm_{(corr)}$ - Dm corrected for incidental deposits on the optical surfaces

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Low Odor Acrylic Adhesive DP8810NS Green"

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation

Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)

CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling

HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)

Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.

Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)

Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.

Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)

Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)

Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)

SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ Low Odor Acrylic Adhesive DP8810NS Green"

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

ASTM E 1354 Testing of "3M Scotch-Weld™ 7240 B/A FR"

ACCREDITATION
To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per 3M Purchase Order No. USMMMGT34Y and Exova Warringtonfire North America Quotation No. 14-002-278,515 accepted January 20, 2014.

IDENTIFICATION
Two component structural acrylic adhesive, identified as "3M Scotch-Weld™ 7240 B/A FR". (Exova sample identification number 14-002-S0050)

SAMPLE PREPARATION
As per client's instructions, the two component structural acyrlic adhesive was applied onto 6 mm thick fiberglass reinforced cement substrate using a flat trowel at a typical thickness range of 0.125 to 0.5 mm. The material was applied and allowed to cure at room temperature for a minimum of 3 days prior to testing.

SUMMARY OF TEST PROCEDURE
Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1 x 10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

ASTM E 1354 Testing of "3M Scotch-Weld™ 7240 B/A FR"

TEST RESULTS - ASTM E 1354-13

Standard Test Method for Heat and Visible Smoke Release Rates
for Materials and Products Using an Oxygen Consumption Calorimeter

Testing was performed on March 19, 2014 with the sample in the horizontal configuration, utilizing the specimen holder and edge frame and also the specified spark ignition source.

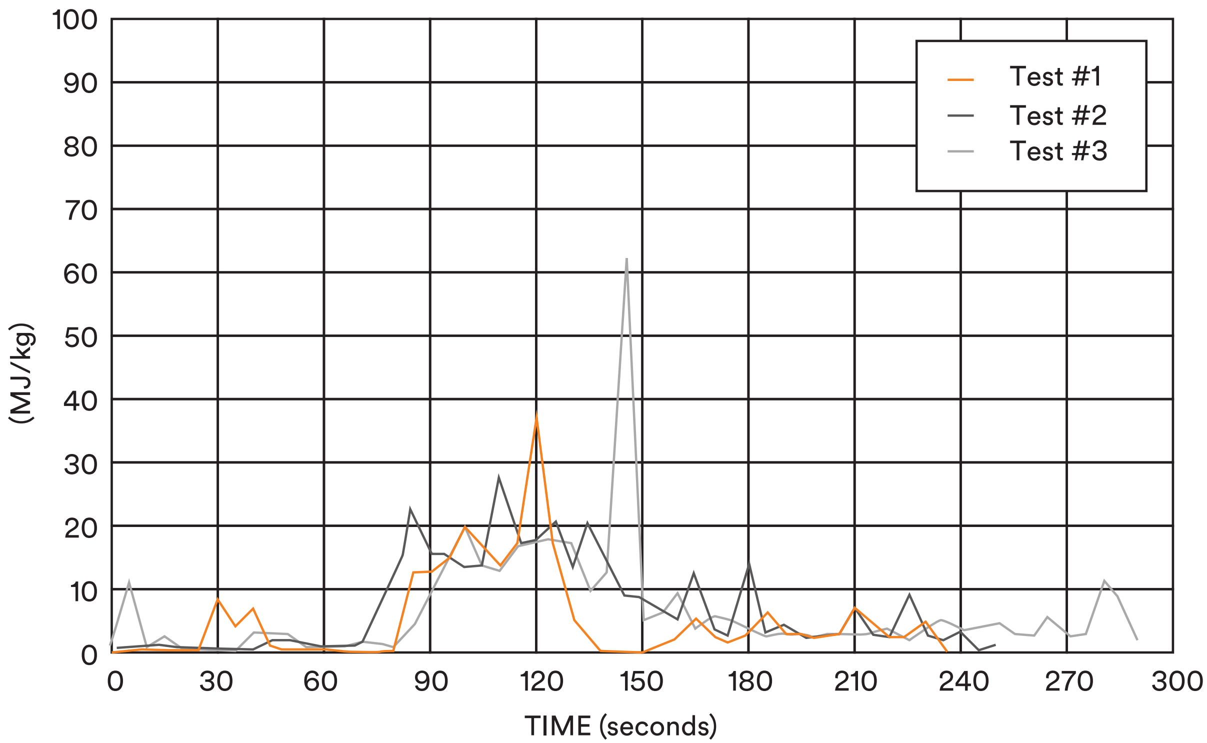
	Test #1	Test #2	Test #3	Average	
Heat Flux (kW/m²)	50	50	50		
Exhaust Flow Rate (l/s)	24	24	24		
Specimen Thickness (mm)	0.3	0.3	0.3		
Initial Mass (g)(including substrate)	97.9	99.7	92.7		
Mass at Sustained Flaming (g)(including substrate)	96.7	98.8	91.1		
Final Mass (g)(including substrate)	89.1	89.2	80.9		
Total Mass Loss (kg/m²)	0.88	1.04	1.17	1.03	
Peak Specific Mass Loss Rate (g/s·m²)	11.81	12.73	13.08	12.54	
Average Mass Loss Rate (g/s·m²)	5.54	9.39	5.63	6.85	
Time to Ignition (s)	74	64	76	71	
Time to Flame-out (s)	126	140	170	145	
Time of Peak Rate of Heat Release (s)	100	90	100	97	
Peak Rate of Heat Release (kW/m²)	166.5	167.1	159.7	164.4	
Average Rate of Heat Release (kW/m²)	42.3	115.6	44.2	67.4	
Total Heat Released (MJ/m²)	6.64	8.68	9.09	8.14	
Average Effective Heat of Combustion (MJ/kg)	7.75	13.69	8.38	**9.94**	*
Average Effective Heat of Combustion (BTU/lb)	3337.3	5897.4	3610.7	**4282**	*
Caloric Content (MJ/kg)	0.60	0.77	0.87	**0.75**	**
Caloric Content (BTU/lb)	258.3	331.69	373.62	**321**	**
Peak Extinction Area (m²/kg)	1081.2	1142.3	897.9	1040.4	
Average Extinction Area (m²/kg)	342.5	594.1	352.9	429.8	

* Total heat produced per unit mass of material consumed
** Total heat produced per unit mass of material tested

ASTM E 1354 Testing of "3M Scotch-Weld™ 7240 B/A FR"

TEST RESULTS (continued)

EFFECTIVE HEAT OF COMBUSTION - ASTM E 1354

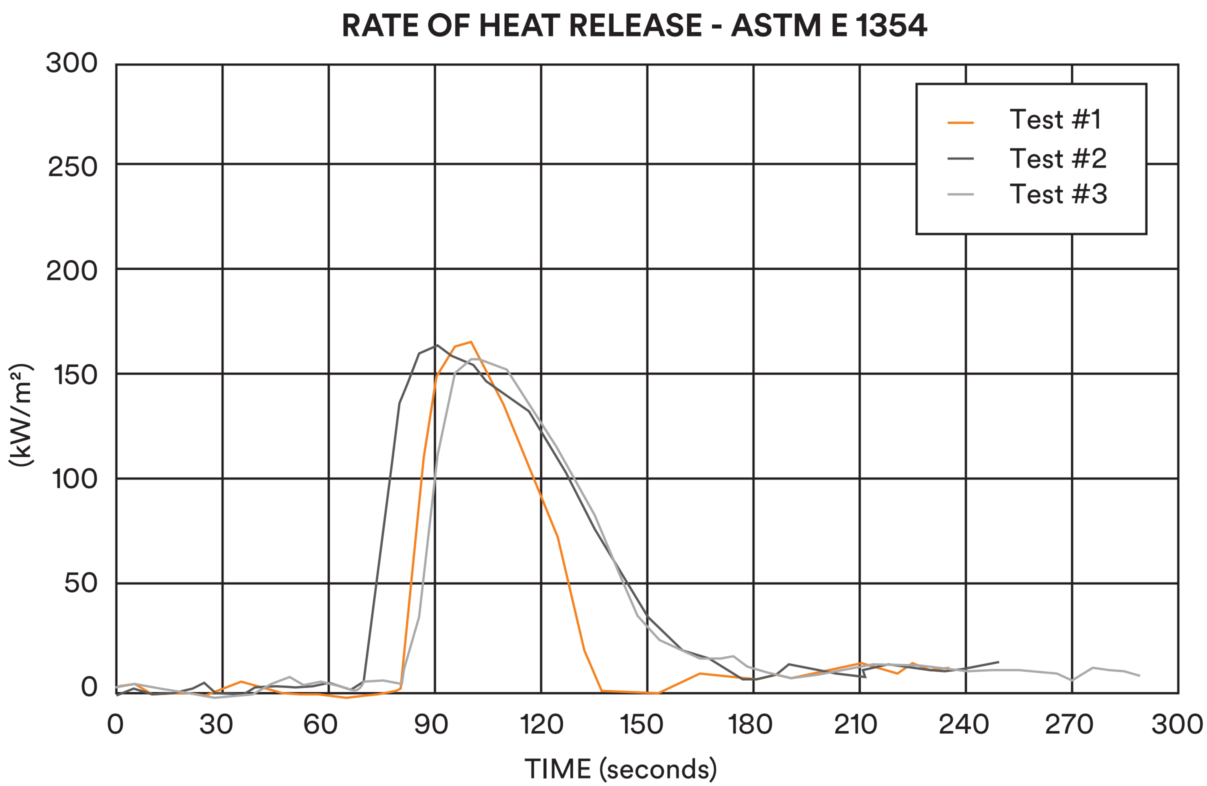


	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	7.75	13.69	8.38	9.94
Heat of Combustion @ 60 s (MJ/kg)**	12.11	13.27	12.29	12.56
Heat of Combustion @ 180 s (MJ/kg)**	0.00	9.94	8.59	6.18
Heat of Combustion @ 300 s (MJ/kg)**	0.00	0.00	0.00	3.16

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of "3M Scotch-Weld™ 7240 B/A FR"

TEST RESULTS (continued)



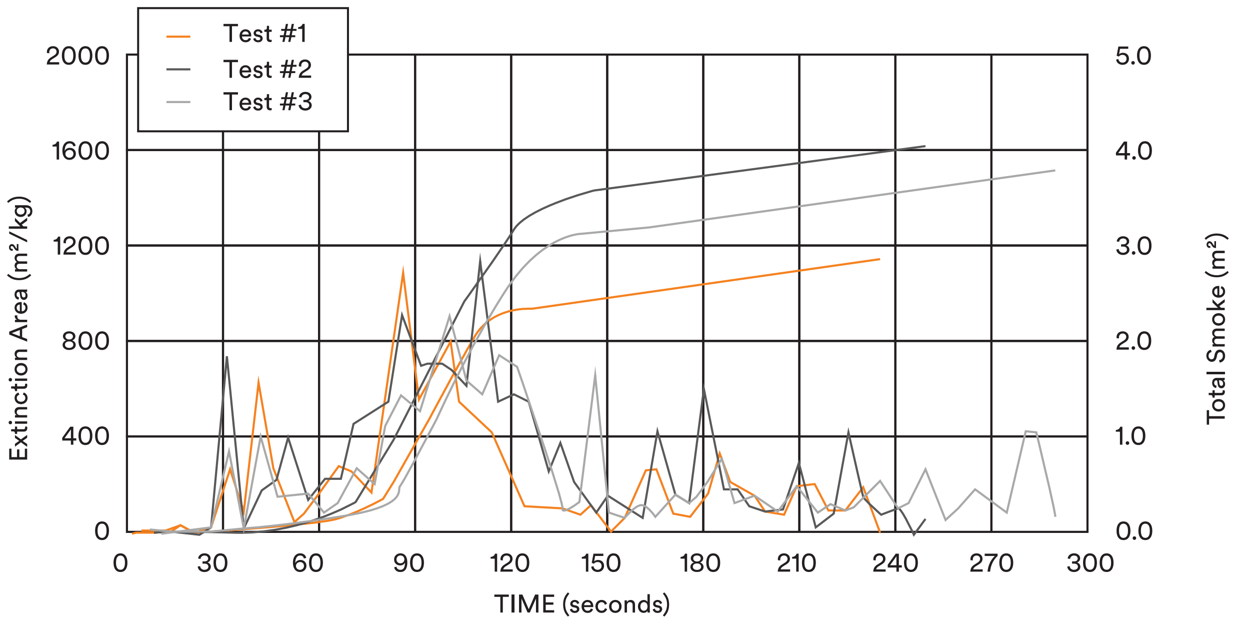
	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m^2)	166.5	167.1	159.7	164.4
Average Heat Release Rate (kW/m^2)*	42.3	115.6	44.2	67.4
Heat Release Rate @ 60 s (kW/m^2)**	97.6	122.9	114.4	111.6
Heat Release Rate @ 180 s (kW/m^2)**	0.0	57.8	48.9	35.6
Heat Release Rate @ 300 s (kW/m^2)**	0.0	0.0	0.0	0.0

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "3M Scotch-Weld™ 7240 B/A FR"

TEST RESULTS (continued)

SMOKE GENERATION - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m²/kg)	1081.2	1142.3	891.9	1040.4
Average Extinction Area (m²/kg)*	342.5	594.1	352.9	429.8
Extinction Area @ 60 s (m²/kg)**	501.9	629.9	558.8	563.5
Extinction Area @ 180 s (m²/kg)**	0.0	408.6	361.6	256.7
Extinction Area @ 300 s (m²/kg)**	0.0	0.0	0.0	0.0
Total Smoke (m²)	2.61	3.37	3.47	3.15

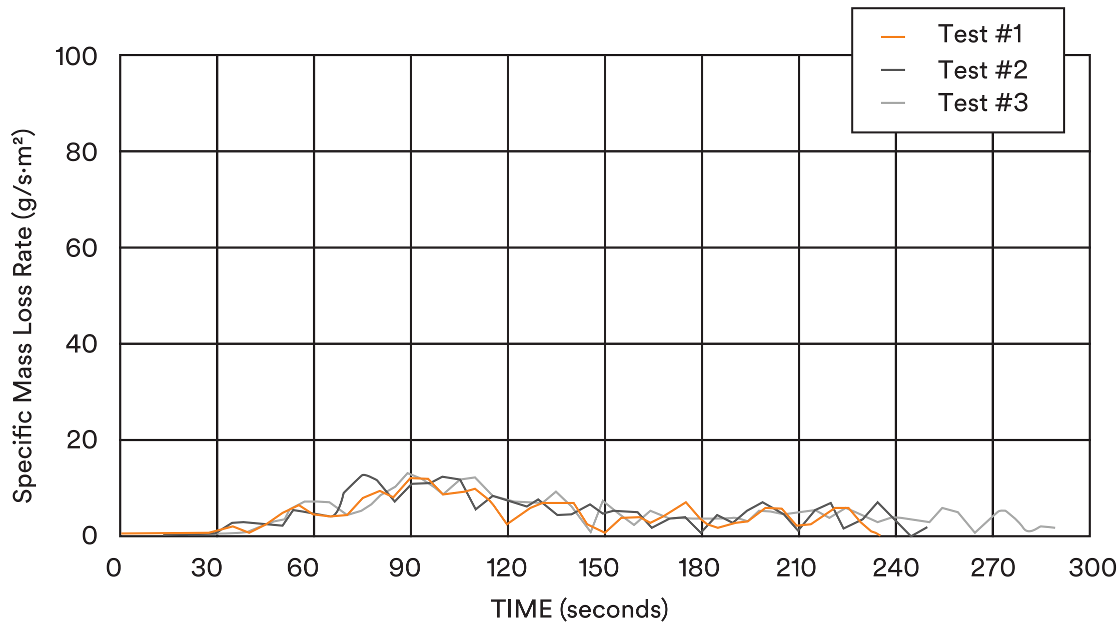
* Averaged over the test period (from ignition to flameout).

** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing of "3M Scotch-Weld™ 7240 B/A FR"

TEST RESULTS (continued)

MASS LOSS RATE - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	11.81	12.73	13.08	12.54
Avg. Specific Mass Loss Rate (g/m²·s)*	5.54	9.39	5.63	6.85
Mass Loss Rate @ 60 s (g/s)**	0.07	0.08	0.08	0.08
Mass Loss Rate @ 180 s (g/s)**	0.00	0.05	0.05	0.03
Mass Loss Rate @ 300 s (g/s)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing of "3M Scotch-Weld™ 7240 B/A FR"

CONCLUSIONS

The two component acrylic adhesive material identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, affords an average Effective Heat of Combustion of 9.94 MJ/kg (4282 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m². Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 0.75 MJ/kg (321 BTU/lb).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

ASTM E 1354 Testing of "3M Scotch-Weld™ 7240 B/A FR"

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion
This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.

Time to Ignition
Also known as ignition delay time, this parameter provides a measure of a material's propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.

Heat Release Rate (HRR)
HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.

Total Heat Release
This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate "potential heat load" than is the more commonly used "caloric content" based upon the weight of material used.

Mass Loss Rate
This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.

Extinction Area
This refers to the "yield" of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 7240 B/A FR"

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, as per 3M Purchase Order No. USMMMGT34Y and Exova Warringtonfire North America Quotation No. 14-002-278,515 accepted January 20, 2014.

IDENTIFICATION
Two component structural acrylic adhesive, identified as "3M Scotch-Weld™ 7240 B/A FR". (Exova sample identification number 14-002-S0050)

SAMPLE PREPARATION
As per client's instructions, the two component structural acyrlic adhesive was applied onto 6 mm thick fiberglass reinforced cement substrate using a flat trowel at a typical thickness range of 0.125 to 0.5 mm. The material was applied and allowed to cure at room temperature for a minimum of 3 days prior to testing.

TEST RESULTS

ASTM E 162-13

Surface Flammability of Materials Using a Radiant
Heat Energy Source. (Is = Flame Spread Index).

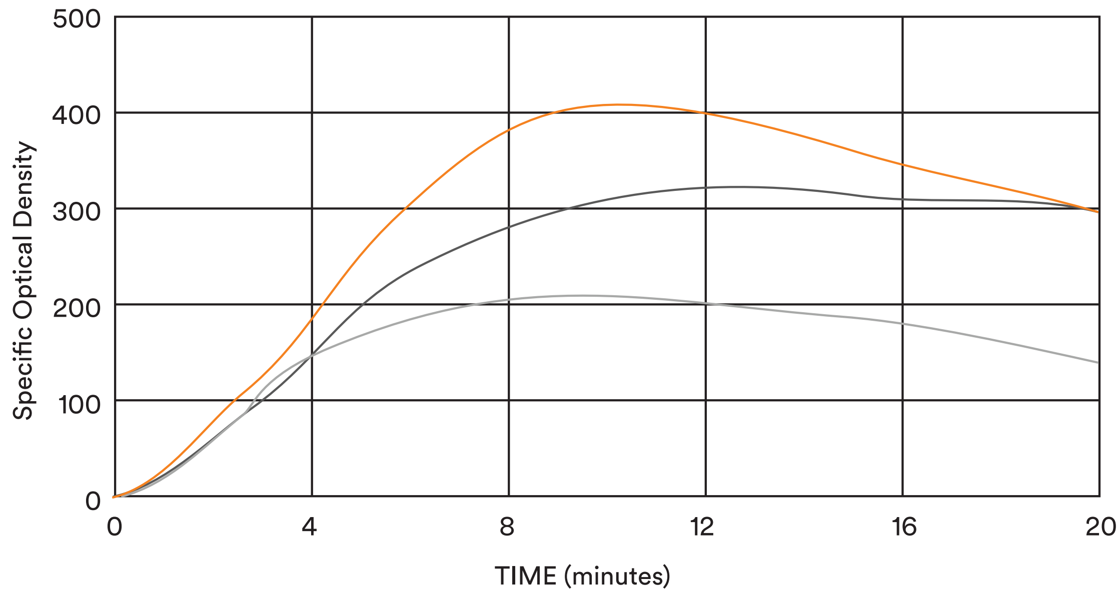
	Fs	Q	Is	Observations
1:	2.0	3.8	7	Maximum flame front propagation to a distance
2:	1.9	3.2	6	of 14 inches.
3:	1.7	3.4	6	Surface venting observed.
4:	2.1	3.2	7	No Flaming running and flaming dripping observed.
Rounded Average:			5	
Specified Maximum:			35	No flaming running or flaming dripping allowed

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 7240 B/A FR"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

FLAMING MODE - ASTM E 662-13d



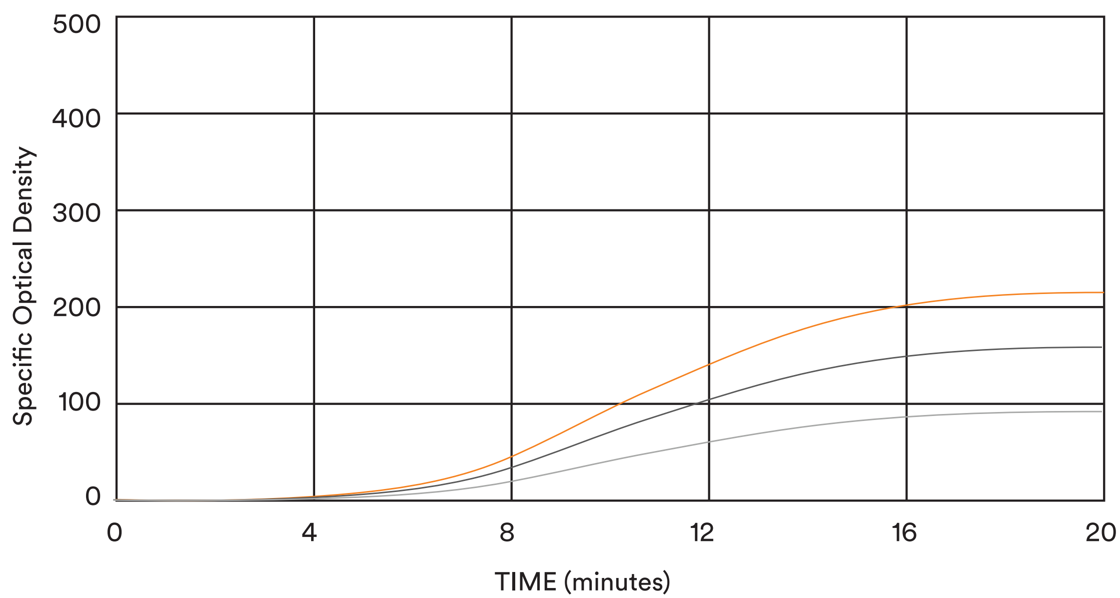
Relative Room Humidity: 21%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	3	5	3	3	100
Specific Optical Density at 4.0 minutes	49	107	57	71	200
Maximum Specific Optical Density	333	421	224	326	-
Maximum Corrected Optical Density	329	415	221	322	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 7240 B/A FR"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

NON FLAMING MODE - ASTM E 662-13d



Relative Room Humidity: 21%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Non-Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	1	1	0	1	100
Specific Optical Density at 4.0 minutes	6	6	6	6	200
Maximum Specific Optical Density	211	158	93	154	-
Maximum Corrected Optical Density	210	156	92	153	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 7240 B/A FR"

TEST RESULTS (continued)

ASTM E 662 Observations

In the flaming mode, ignition was initially observed at the point of pilot flame impingement increasing to full ignition within 15 seconds. Visible smoke and charring were also observed. In the non-flaming mode, visible smoke production was observed followed by charring.

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Generation from Material Combustion

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	1	<1	-
	at 4.0 minutes	96	<1	-
	at maximum	960	107	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	67	<10	-
	at 4.0 minutes	1135	58	-
	at maximum	8999	356	90000
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<1	<1	100
Hydrogen Chloride (HCl ppm)		7	<2	500
Hydrogen Fluoride (HF ppm)		3	<2	100
Hydrogen Bromide (HBr ppm)		<1	<1	100
Hydrogen Cyanide (HCN ppm)		10	1	100
Original Weight (g)(including substrate)		49.12	47.18	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10	Did not ignite	-
Burning Duration (s)		120	-	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 7240 B/A FR"

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Typical Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	<1	<1	-
	at 4.0 minutes	70	1	-
	at maximum	864	124	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<6	<6	100
Hydrogen Chloride (HCl ppm)		28	<12	500
Hydrogen Fluoride (HF ppm)		<12	<12	200
Hydrogen Cyanide (HCN ppm)		7	<1	150
Original Weight (g)(including substrate)		48.00	48.21	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10.0	Did not ignite	-
Burning Duration (s)		120.0	-	-

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

CONCLUSIONS AND COMMENTS

There are currently no specific performance criteria cited by the Federal Railroad Administration for adhesive materials. However, the adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, would meet all of the current requirements (for all specified categories) as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The two component acrylic adhesive also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and as such, has no specific pass/fail criteria of its own. The reference criteria cited are typical for the transportation industry and are listed for reference purposes only. They may or may not apply to this specific product.

The two component acrylic adhesive would meet the typically-specified industry requirements as they pertain to toxic gas generation (Boeing BSS 7239).

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 7240 B/A FR"

APPENDIX - Summaries of Test Procedures

ASTM E 162-13

Surface Flammability of Materials Using a Radiant Energy Source

As specified, four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C. Section 10.1 of ASTM E 162-13 states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where: I_s is the flame spread index

F_s is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 7240 B/A FR"

APPENDIX - Summaries of Test Procedures

ASTM E 662-13d

Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

As specified, the test samples are pre-dried for 24 hours at 60°C. Section 9.1 of ASTM E 662-13d states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Three specimens, 3" square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37° C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer's law:

$$Ds = (V/AL)\cdot\log(100/T) = G\cdot\log(100/T) = 132\cdot\log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

Ds 1.5 - specific optical density after 1.5 minutes
Ds 4.0 - specific optical density after 4.0 minutes

Dm -maximum specific optical density at any time during the 20 minute test
Dm (corr) - Dm corrected for incidental deposits on the optical surfaces

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 7240 B/A FR"

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ 7240 B/A FR"

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

EN 45545-2: 2013

Summary Test Report – Requirement Table 5 (R1)

Test Method References “T02” (ISO 5658-2:2006+A1:2011. Spread of Flame - Lateral Spread of flame test on Building and Transport Products in Vertical Configuration), “T03.01” (ISO 5660-1: Part 1; Heat Release Rate (Cone Calorimeter Method), “T10.01” / “T10.02” (ISO 5659- 2: 2012; Plastics – Smoke Generation. Part 2 Determination of Optical Density by a Single Chamber Method) and “T11.01” (Gas Analysis in the Smoke Box EN ISO 5659-2, using FTIR Technique)

Date: 10th September 2014

Issue No.: 1

Page 1

A Report To: 3M UK PLC

Document Reference: 342059 (Issue 2), 342060 & 342062 (Issue 2)

EN 45545-2: 2013

Objective

To assess the results of tests performed in accordance with methods T02, T03.01, T10.01 / T10.02 and T11.01 as defined in EN 45545-2: 2013 at an irradiance level of 50kW/m² with a pilot flame, on specimens of a product and to provide an opinion of compliance with the requirements for wall composites, as defined in EN 45545-2: 2013.

Generic Description	Product reference	Thickness	Weight per unit area or density
Aluminium facings with and adhesive core	"3M™ Scotchweld™ Structural Epoxy Adhesive 7240 B/A"	1.21mm*	4606.79kg/m³*
Individual components used to manufacture composite:			
Aluminium facings	Non stated	1mm	2725kg/m³
Adhesive	"3M™ Scotchweld™ Structural Epoxy Adhesive 7240 B/A"	0.20 inches	Not stated
***Determined by Exova Warringtonfire**			
Please see page 5 of this test report for the full description of the product tested			

Test Sponsor

3M UK PLC – 3M Centre, Cain Road, Bracknell, RG12 8HT

Opinion

We consider the results of the tests detailed above demonstrate that the product, as tested, complies with the wall composite requirements, R1 (detailed in Table 5 of EN 45545-2: 2013) for a HL1, HL2 and HL3 Hazard Level Classification.

Responsible Officer	Authorised
T. Mort *	S Deeming *
Senior Technical Officer	Operations Manager

* For and on behalf of Exova Warringtonfire.

EN 45545-2: 2013

Summary Test Report – Requirement Table 5 (R1)

Test Method References “T02” (ISO 5658-2:2006+A1:2011. Spread of Flame - Lateral Spread of flame test on Building and Transport Products in Vertical Configuration), “T03.01” (ISO 5660-1: Part 1; Heat Release Rate (Cone Calorimeter Method), “T10.01” / “T10.02” (ISO 5659- 2: 2012; Plastics – Smoke Generation. Part 2 Determination of Optical Density by a Single Chamber Method) and “T11.01” (Gas Analysis in the Smoke Box EN ISO 5659-2, using FTIR Technique)

Date: 10th September 2014

Issue No.: 1

Page 1

A Report To: 3M UK PLC

Document Reference: 342059 (Issue 2), 342060 & 342062 (Issue 2)

EN 45545-2: 2013

Test Details

Terms Of Reference
To assess the results of tests performed in accordance with methods T02, T03.01, T10.01 / T10.02 and T11.01 as defined in EN 45545-2: 2013 at an irradiance level of 50kW/m2 with a pilot flame, on specimens of a product and to provide an opinion of compliance with the requirements for wall composites, as defined in EN 45545-2: 2013.

Introduction
Specimens of a product have been tested in accordance with the test methods "T02" (ISO 5658-2:2006+A1:2011. Spread of Flame - Lateral Spread of flame test on Building and Transport Products in Vertical Configuration), "T03.01" (ISO 5660-1: Part 1; Heat Release Rate (Cone Calorimeter Method), "T10.01" / "T10.02" (ISO 5659-2: 2012; Plastics – Smoke Generation. Part 2 Determination of Optical Density by a Single Chamber Method) and "T11.01" (Gas Analysis in the Smoke Box EN ISO 5659-2, using FTIR Technique) as specified in EN 45545-2:2013 "Requirements for Fire Behaviour of Materials and Components". The results of the tests are fully reported in the Exova Warringtonfire test reports No's. 342059 (Issue 2), 342060 & 342062 (Issue 2).

This summary report has been prepared at the request of the sponsor and relates the results of the tests to the requirements for a wall composite R1, as defined in Table 5 of EN 45545-2: 2013.

This summary should be read in conjunction with, and not accepted as a substitute for the Exova Warringtonfire test reports No's. 342059 (Issue 2), 342060 & 342062 (Issue 2). Those test reports may include additional information which may be relevant to the assessment of the potential fire hazard of the product.

Face subjected to tests
The specimens were mounted in the test positions such that one of two identical faces was exposed to the heating conditions of the tests.

Results of test
The following results were obtained for the specimens, which were tested.

"T02" ISO 5658-2:2006+A1:2011
Critical flux at extinguishment (CFE) = >50.0kW/m²

Heat for sustained burning (Qsb) = Could not be calculated due to lack of ignition

"T03.01" ISO 5660-1
MARHE = 3.84 kW/m2

"T10.01" / "T10.02" ISO 5659-2: 2012
Ds (4) = 1
VOF4 = 2

"T11.01" Gas Analysis in the Smoke Box ISO, Using FTIR Technique
CIT_{4mins} = 0.01
CIT_{8mins} = 0.01

The test results relate only to the behaviour of the test specimens of the product under the particular conditions of the test, they are not intended to be the sole criterion for assessing the potential hazard of the product in use.

EN 45545-2: 2013

Description of Test Specimens

The description of the specimens given below has been prepared from information provided by the sponsor of the test. All values quoted are nominal, unless tolerances are given. The specimens were supplied by the sponsor of the test. Exova Warringtonfire was not involved in any selection or sampling procedure.

General description		Aluminium facings with an adhesive core
Product reference		"3M™ Scotchweld™ Structural Epoxy Adhesive 7240 B/A"
Overall thickness		1.21mm (determined by Exova Warringtonfire)
Product configuration		• Facing • Adhesive • Facing
Facings	Generic type	Aluminium
	Name of manufacturer	Alcoa Aluminum
	Density	2725kg/m³
	Thickness	1mm
	Colour	"Metallic Gray"
	Flame retardant details	**See Note 1 Below**
Core	Product reference	"3M™ Scotchweld™ Structural Epoxy Adhesive 7240 B/A"
	Generic type	Two-part toughened epoxy adhesive
	Name of manufacturer	3M Company
	Thickness	0.020 ± 0.08in (0.5mm)
	Colour	"Dark Grey"
	Flame retardant details	**See Note 2 Below**
Brief description of manufacturing process		**See Note 2 Below**

Note 1: The sponsor of the test has confirmed that no flame retardants were used in the production of this component.

Note 2: The sponsor of the test was unwilling to provide.

ASTM E 1354 Testing "3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60, Gray"

ACCREDITATION
To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per 3M Purchase Order No. USMMMN2Y7J and Exova Warringtonfire North America Quotation No. 15-002-365,513 dated May 29, 2015.

IDENTIFICATION
Two part epoxy adhesive, approximate coat thickness of 5 to 10 mils and identified as "3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60, Gray". (Exova sample identification number 15-002-S0428)

SAMPLE PREPARATION
The two part epoxy adhesive was mixed using the supplied mix nozzle and applicator. The adhesive was then spread onto 6 mm thick fiberglass reinforced cement substrate using a trowel at a coating thickness range of 5 to 10 mils. The epoxy adhesive was allowed to dry and cure prior to testing.

SUMMARY OF TEST PROCEDURE
Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1 x 10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

ASTM E 1354 Caloric Content Determination of "3M Scotch-Weld™ LSB60NS Gray"

ACCREDITATION
To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per 3M Purchase Order No. USMMM6NM4 and Exova Warringtonfire North America Quotation No. 14-002-327,516 accepted November 24, 2014.

IDENTIFICATION
Two component epoxy structural adhesive, identified as "3M Scotch-Weld™ LSB60NS Gray". (Exova sample identification number 14-002-S0743-1)

SAMPLE PREPARATION
As per client's instructions, the two component structural acyrlic adhesive was mixed using the supplied mix nozzle and applicator. The adhesive was then applied onto 6 mm thick fiberglass reinforced cement substrate using a flat trowel at a coating thickness range of 5 - 10 mils. The material was applied and allowed to cure at room temperature for a minimum of 7 days prior to testing.

SUMMARY OF TEST PROCEDURE
Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1×10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

ASTM E 1354 Caloric Content Determination of "3M Scotch-Weld™ LSB60NS Gray"

ASTM E 1354-13

Standard Test Method for Heat and Visible Smoke Release Rates
for Materials and Products Using an Oxygen Consumption Calorimeter

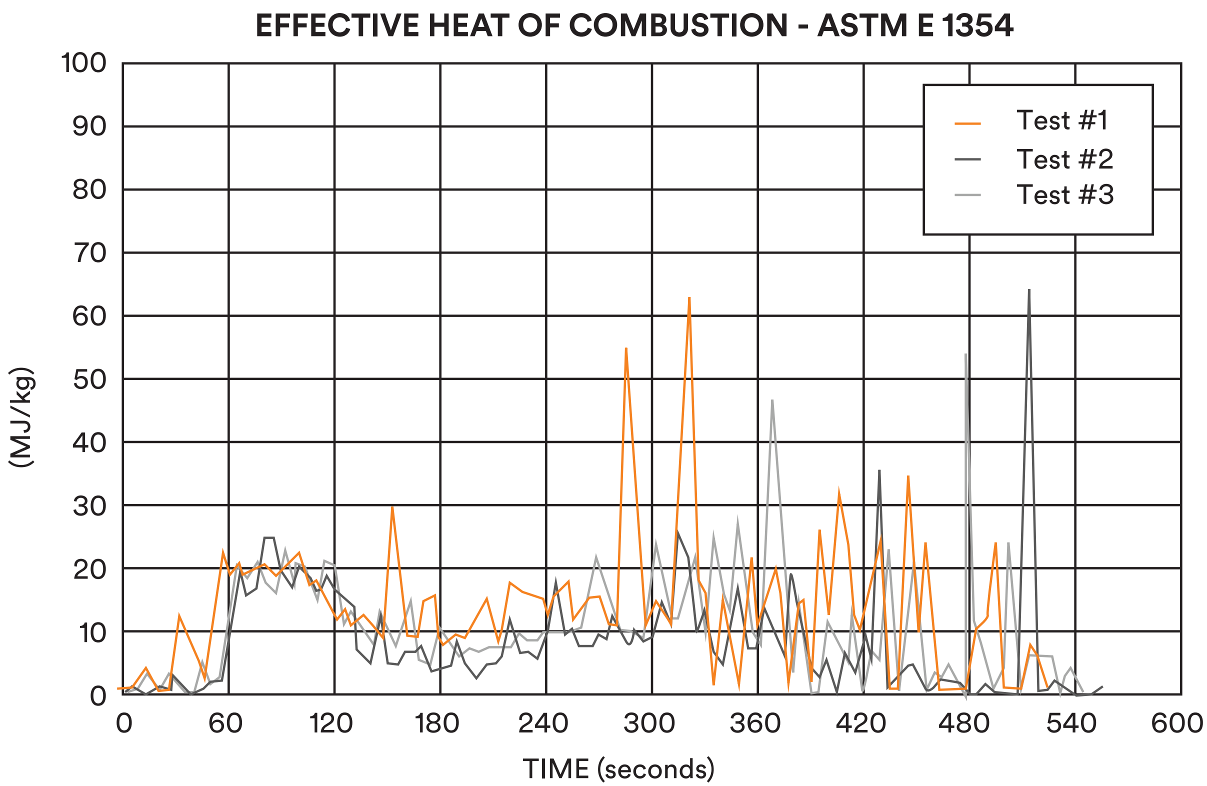
Testing was performed on December 11, 2014 with the sample in the horizontal configuration, utilizing the specimen holder and edge frame and also the specified spark ignition source.

	Test #1	Test #2	Test #3	Average	
Heat Flux (kW/m²)	50	50	50		
Exhaust Flow Rate (l/s)	24	24	24		
Specimen Thickness (mm)	0.3	0.3	0.3		
Initial Mass (g)(including substrate)	96.6	102.0	103.6		
Mass at Sustained Flaming (g)(including substrate)	96.5	101.7	103.2		
Final Mass (g)(including substrate)	80.3	85.0	85.6		
Sample Mass Loss (kg/m²)	1.83	1.88	1.99	1.90	
Peak Specific Mass Loss Rate (g/s·m²)	14.18	16.55	17.73	16.15	
Average Mass Loss Rate (g/s·m²)	5.99	5.68	6.01	5.90	
Time to Ignition (s)	44	48	47	46	
Time to Flame-out (s)	400	450	437	429	
Time of Peak Rate of Heat Release (s)	70	80	65	72	
Peak Rate of Heat Release (kW/m²)	263.4	272.1	291.3	275.6	
Average Rate of Heat Release (kW/m²)	77.8	54.3	66.7	66.3	
Total Heat Released (MJ/m²)	28.06	22.02	26.05	25.38	
Average Effective Heat of Combustion (MJ/kg)	15.34	11.78	13.14	**13.42**	*
Average Effective Heat of Combustion (BTU/lb)	6606.9	5072.2	5657.2	**5779**	*
Caloric Content (MJ/kg)	2.57	1.91	2.22	**2.23**	**
Caloric Content (BTU/lb)	1106.1	822.34	957.63	**962**	**
Peak Extinction Area (m²/kg)	789.8	834.7	676.1	766.8	
Average Extinction Area (m²/kg)	266.6	253.7	249.6	256.6	

* Total heat produced per unit mass of material consumed
** Total heat produced per unit mass of material tested

ASTM E 1354 Caloric Content Determination of "3M Scotch-Weld™ LSB60NS Gray"

TEST RESULTS (continued)

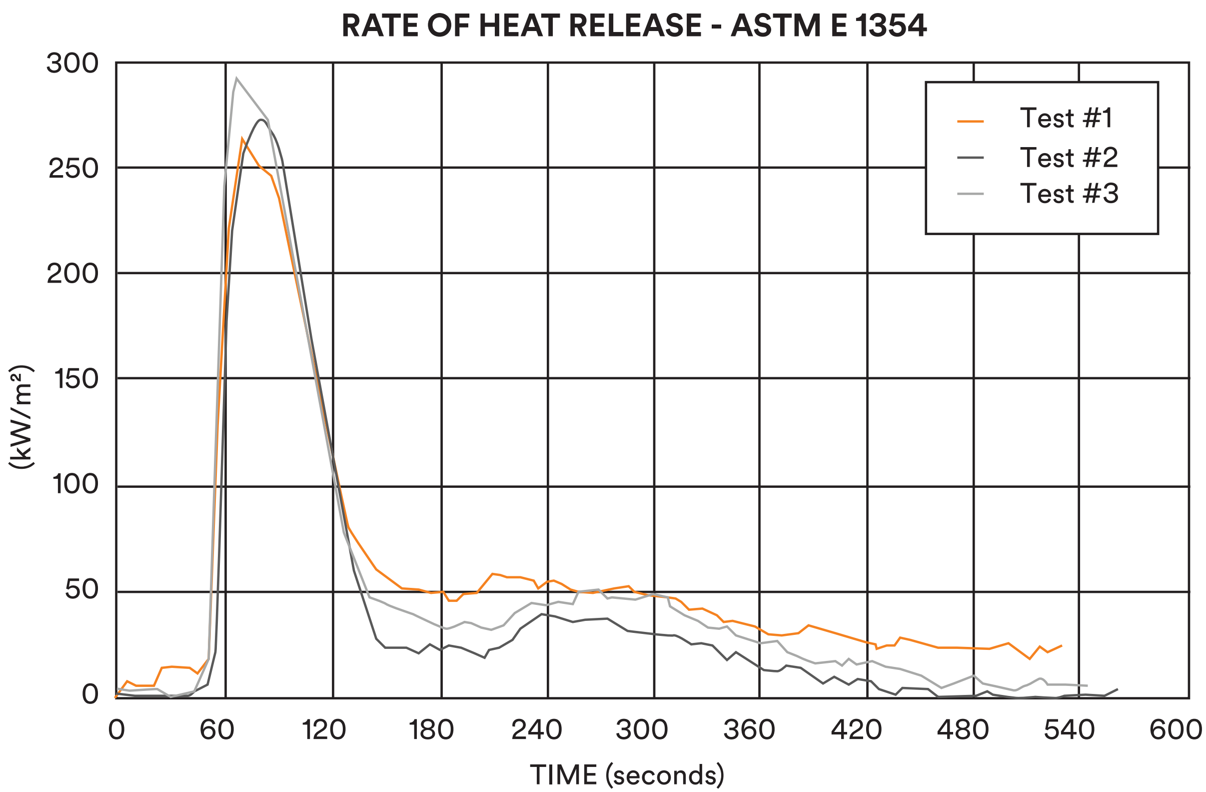


	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	15.34	11.78	13.14	13.42
Heat of Combustion @ 60 s (MJ/kg)**	17.80	16.72	16.67	17.06
Heat of Combustion @ 180 s (MJ/kg)**	14.98	12.96	13.62	13.85
Heat of Combustion @ 300 s (MJ/kg)**	15.23	12.12	13.27	13.54

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Caloric Content Determination of "3M Scotch-Weld™ LSB60NS Gray"

TEST RESULTS (continued)



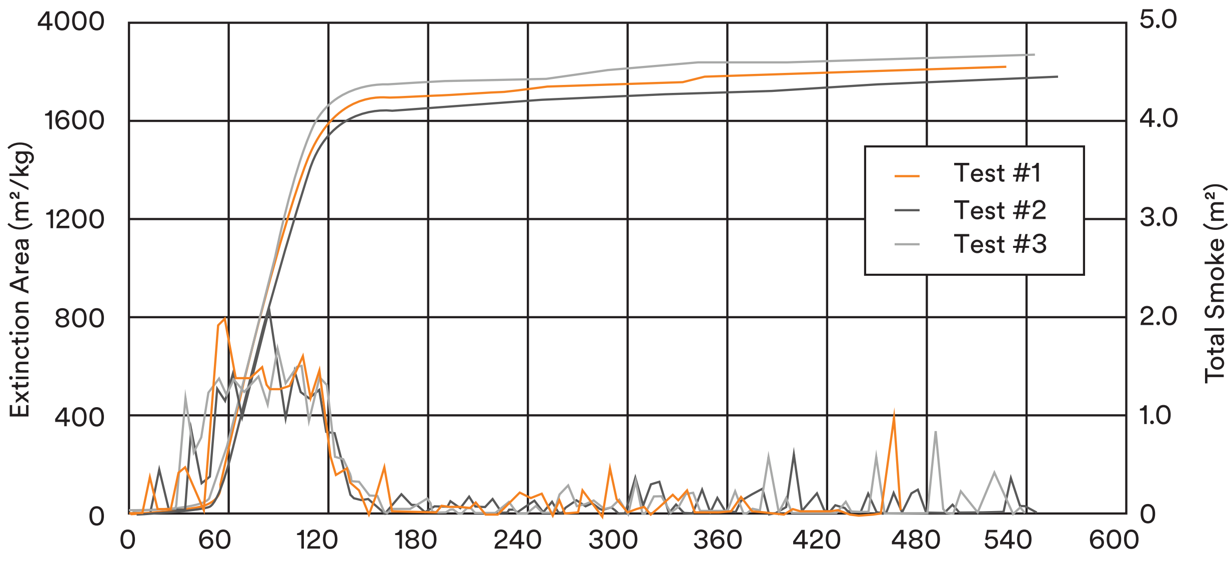
	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m^2)	263.4	272.1	291.3	275.6
Average Heat Release Rate (kW/m^2)*	77.8	54.3	66.7	66.3
Heat Release Rate @ 60 s (kW/m^2)**	198.2	205.0	217.6	206.9
Heat Release Rate @ 180 s (kW/m^2)**	112.9	96.1	106.4	105.1
Heat Release Rate @ 300 s (kW/m^2)**	86.9	70.1	81.2	79.4

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Caloric Content Determination of "3M Scotch-Weld™ LSB60NS Gray"

TEST RESULTS (continued)

SMOKE GENERATION - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m²/kg)	789.8	834.7	676.1	766.8
Average Extinction Area (m²/kg)*	266.6	253.7	249.6	256.6
Extinction Area @ 60 s (m²/kg)**	562.2	526.6	526.6	538.4
Extinction Area @ 180 s (m²/kg)**	348.8	345.1	344.1	346.0
Extinction Area @ 300 s (m²/kg)**	285.0	270.6	270.3	275.3
Total Smoke (m²)	4.39	4.28	4.55	4.40

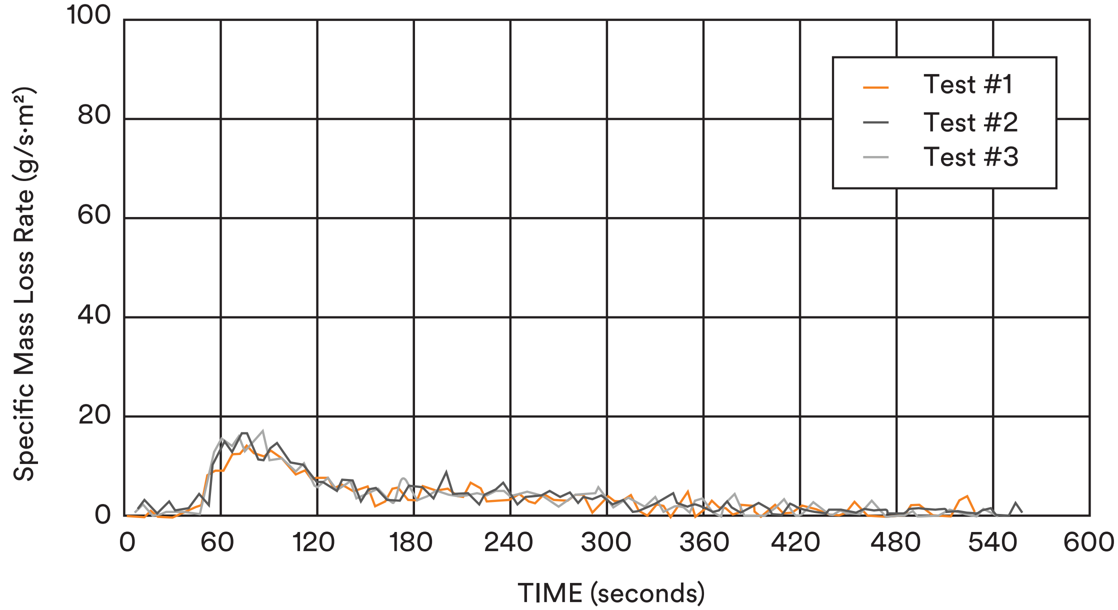
* Averaged over the test period (from ignition to flameout).

** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Caloric Content Determination of "3M Scotch-Weld™ LSB60NS Gray"

TEST RESULTS (continued)

MASS LOSS RATE - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	14.18	16.55	17.73	16.15
Avg. Specific Mass Loss Rate (g/m²·s)*	5.99	5.68	6.01	5.90
Mass Loss Rate @ 60 s (g/s)**	0.10	0.11	0.11	0.11
Mass Loss Rate @ 180 s (g/s)**	0.07	0.07	0.07	0.07
Mass Loss Rate @ 300 s (g/s)**	0.05	0.05	0.05	0.05

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Caloric Content Determination of "3M Scotch-Weld™ LSB60NS Gray"

<u>CONCLUSIONS</u>

The two component epoxy structural adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, affords an average Effective Heat of Combustion of 13.42 MJ/kg (5779 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m². Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 2.23 MJ/kg (962 BTU/lb).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces, Senior Technologist.	Ian Smith, Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

ASTM E 1354 Caloric Content Determination of "3M Scotch-Weld™ LSB60NS Gray"

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion
This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.

Time to Ignition
Also known as ignition delay time, this parameter provides a measure of a material's propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.

Heat Release Rate (HRR)
HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.

Total Heat Release
This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate "potential heat load" than is the more commonly used "caloric content" based upon the weight of material used.

Mass Loss Rate
This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.

Extinction Area
This refers to the "yield" of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ LSB60NS Gray"

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, as per 3M Purchase Order No. USMMM6NM4 and Exova Warringtonfire North America Quotation No. 14-002-327,516 accepted November 24, 2014.

IDENTIFICATION
Two component epoxy structural adhesive, identified as "3M Scotch-Weld™ LSB60NS Gray". (Exova sample identification number 14-002-S0743-1))

SAMPLE PREPARATION
As per client's instructions, the two component structural acrylic adhesive was mixed using the supplied mix nozzle and applicator. The adhesive was then applied onto 6 mm thick fiberglass reinforced cement substrate using a flat trowel at a coating thickness range of 5 - 10 mils. The material was applied and allowed to cure at room temperature for a minimum of 7 days prior to testing.

TEST RESULTS

ASTM E 162-13

Surface Flammability of Materials Using a Radiant
Heat Energy Source. (Is = Flame Spread Index).

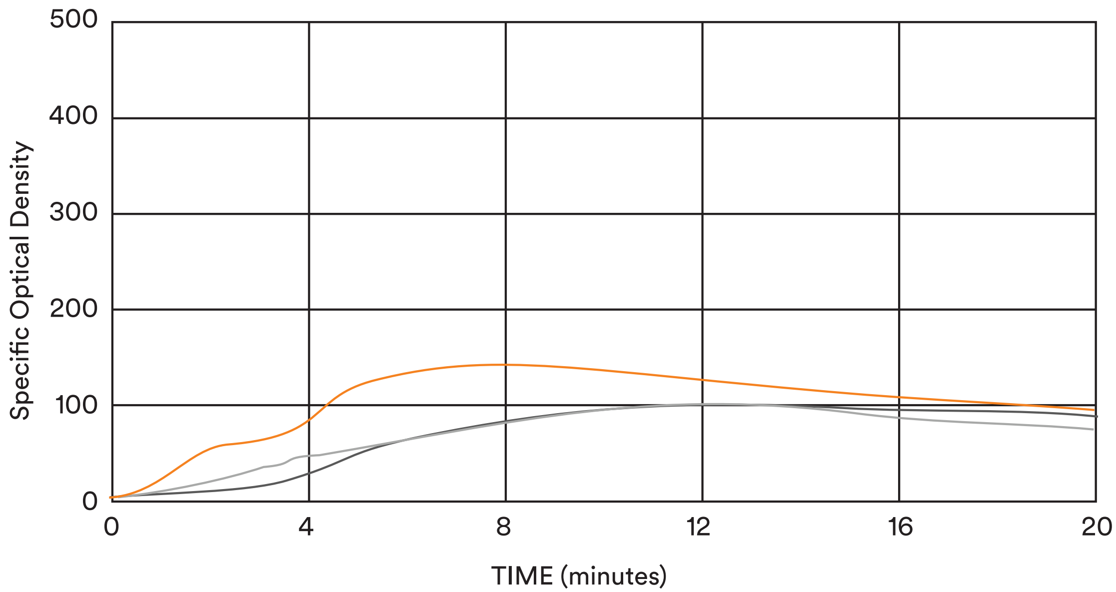
	Fs	Q	Is	Observations
1:	3.0	9.3	28	Maximum flame front propagation to a distance
2:	4.0	9.8	39	of 17 inches.
3:	3.8	7.7	29	No Flaming running and flaming dripping observed.
4:	3.4	7.7	26	Test duration: 15 minutes
Rounded Average:			30	
Specified Maximum:			35	No flaming running or flaming dripping allowed

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ LSB60NS Gray"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

FLAMING MODE - ASTM E 662-14



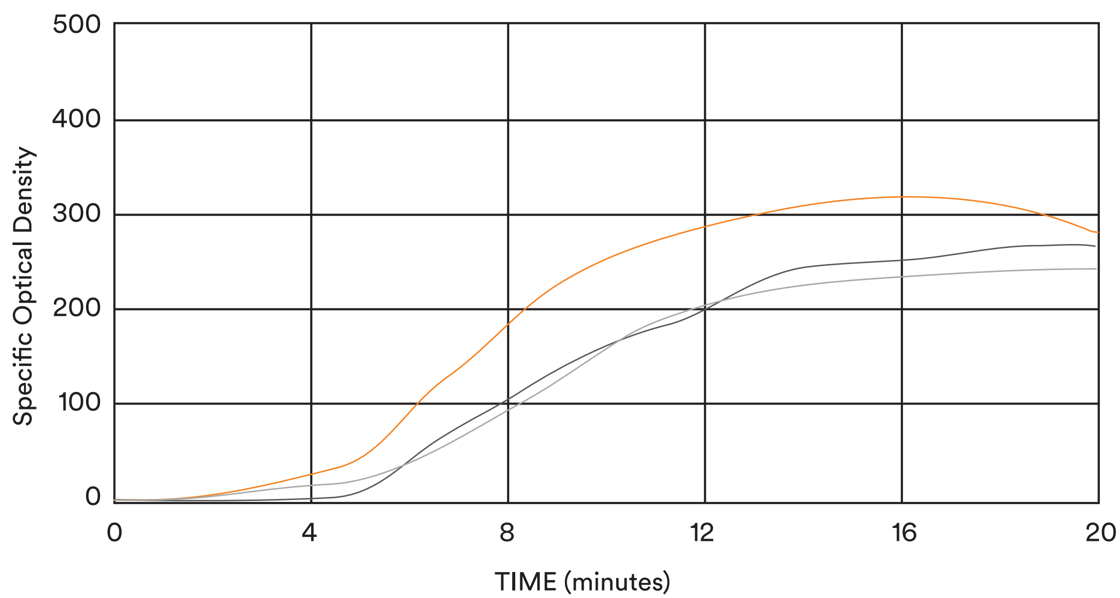
Relative Room Humidity: 21%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	4	4	8	6	100
Specific Optical Density at 4.0 minutes	39	34	81	51	200
Maximum Specific Optical Density	94	86	130	103	-
Maximum Corrected Optical Density	86	80	120	95	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ LSB60NS Gray"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

NON FLAMING MODE - ASTM E 662-14



Relative Room Humidity: 21%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Non-Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	1	1	0	1	100
Specific Optical Density at 4.0 minutes	11	10	21	14	200
Maximum Specific Optical Density	241	261	319	274	-
Maximum Corrected Optical Density	239	255	305	267	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ LSB60NS Gray"

TEST RESULTS (continued)

ASTM E 662 Observations

In the flaming mode, ignition was initially observed at the point of pilot flame impingement increasing to full ignition within 30 seconds. visible smoke and charring were also observed. In the non-flaming mode, visible smoke production was observed followed by charring.

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Generation from Material Combustion

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	<1	1	-
	at 4.0 minutes	84	5	-
	at maximum	935	172	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	<10	76	-
	at 4.0 minutes	5857	114	-
	at maximum	20866	540	90000
Nitrogen Oxides (as NO2 ppm)		6	<1	100
Sulfur Dioxide (SO2 ppm)		<1	<1	100
Hydrogen Chloride (HCl ppm)		15	7	500
Hydrogen Fluoride (HF ppm)		<2	2	100
Hydrogen Bromide (HBr ppm)		<1	<1	100
Hydrogen Cyanide (HCN ppm)		5	1	100
Original Weight (g)(including substrate)		50.12	52.31	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10	Did not ignite	-
Burning Duration (s)		240	-	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ LSB60NS Gray"

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Typical Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	22	<1	-
	at 4.0 minutes	99	<1	-
	at maximum	898	194	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<6	<6	100
Hydrogen Chloride (HCl ppm)		50	44	500
Hydrogen Fluoride (HF ppm)		<12	<12	200
Hydrogen Cyanide (HCN ppm)		5	<1	150
Original Weight (g)(including substrate)		49.60	50.84	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10.0	Did not ignite	-
Burning Duration (s)		300.0	-	-

CONCLUSIONS AND COMMENTS

There are currently no specific performance criteria cited by the Federal Railroad Administration for adhesive materials. However, the two component epoxy structural adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, would meet all of the current requirements (for all specified categories) as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The two component epoxy structural adhesive also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and as such, has no specific pass/fail criteria of its own. The reference criteria cited are typical for the transportation industry and are listed for reference purposes only. They may or may not apply to this specific product.

The two component epoxy structural adhesive would meet the typically-specified industry requirements as they pertain to toxic gas generation (Boeing BSS 7239).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ LSB60NS Gray"

APPENDIX - Summaries of Test Procedures

ASTM E 162-13

Surface Flammability of Materials Using a Radiant Energy Source

As specified, four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C. Section 10.1 of ASTM E 162-13 states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where: I_s is the flame spread index

F_s is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ LSB60NS Gray"

APPENDIX - Summaries of Test Procedures

ASTM E 662-14

Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

As specified, the test samples are pre-dried for 24 hours at 60°C. Section 9.1 of ASTM E 662-13d states to then condition the specimens to “equilibrium (constant weight)” but does not specify a definition or procedure with respect to establishing the “constant weight”. Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Three specimens, 3” square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37° C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer’s law:

$$Ds = (V/AL)\cdot\log(100/T) = G\cdot\log(100/T) = 132\cdot\log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

Ds 1.5 - specific optical density after 1.5 minutes
Ds 4.0 - specific optical density after 4.0 minutes

Dm -maximum specific optical density at any time during the 20 minute test
Dm (corr) - Dm corrected for incidental deposits on the optical surfaces

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ LSB60NS Gray"

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Surface Flammability, Smoke and Toxic Gas Generation of "3M Scotch-Weld™ LSB60NS Gray"

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

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ASTM E 1354 Testing "3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60, Gray"

ASTM E 1354-15

Standard Test Method for Heat and Visible Smoke Release Rates
for Materials and Products Using an Oxygen Consumption Calorimeter

Testing was performed on August 24, 2015 with the sample in the horizontal configuration, utilizing the specimen edge frame and also the specified spark ignition source.

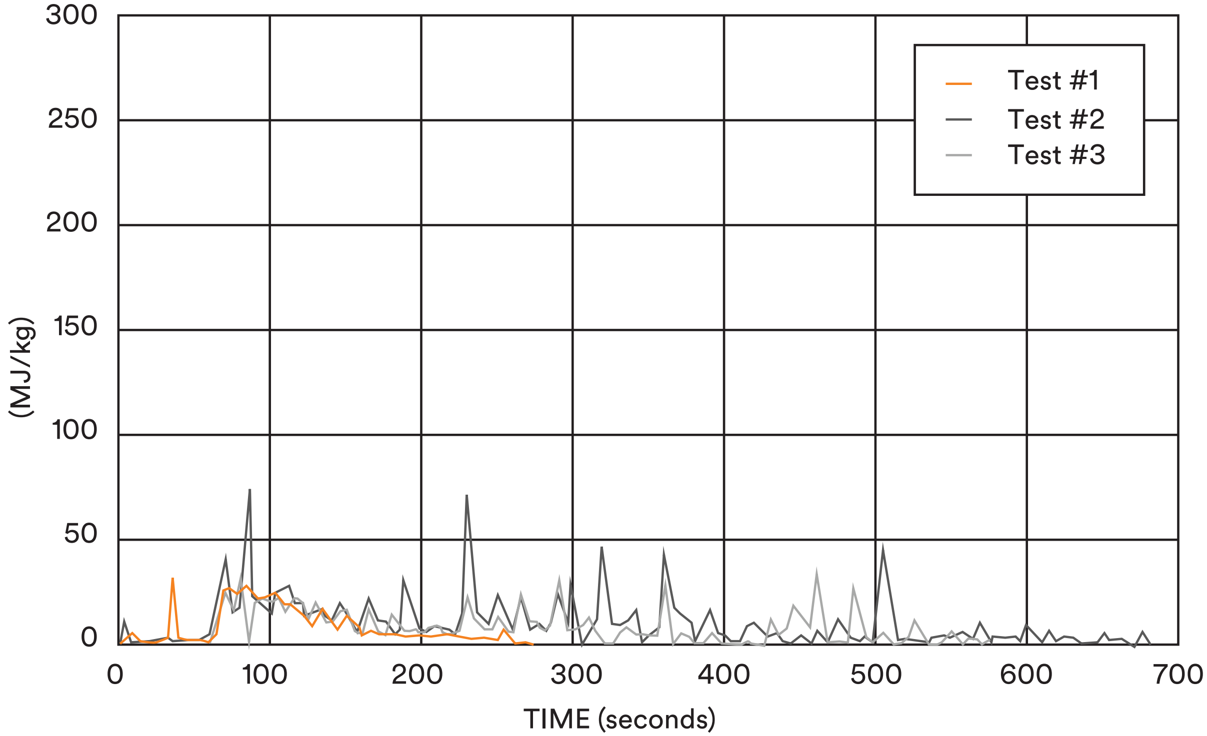
	Test #1	Test #2	Test #3	Average	
Heat Flux (kW/m²)	50	50	50		
Exhaust Flow Rate (l/s)	24	24	24		
Specimen Thickness (mm)	0.3	0.3	0.3		
Initial Mass (g)(including substrate)	95.5	97.9	101.9		
Mass at Sustained Flaming (g)(including substrate)	95.1	97.4	101.0		
Final Mass (g)(including substrate)	83.8	81.0	86.0		
Sample Mass Loss (kg/m²)	1.27	1.86	1.70	1.61	
Peak Specific Mass Loss Rate (g/s·m²)	16.54	23.66	27.79	22.66	
Average Mass Loss Rate (g/s·m²)	6.37	5.83	5.12	5.77	
Time to Ignition (s)	58	51	55	55	
Time to Flame-out (s)	170	450	435	352	
Time of Peak Rate of Heat Release (s)	75	75	75	75	
Peak Rate of Heat Release (kW/m²)	395.5	348.2	436.0	393.2	
Average Rate of Heat Release (kW/m²)	83.7	68.5	64.0	72.1	
Total Heat Released (MJ/m²)	18.02	27.42	24.64	23.36	
Average Effective Heat of Combustion (MJ/kg)	14.38	14.74	14.51	**14.55**	*
Average Effective Heat of Combustion (BTU/lb)	6194.8	6348	6250	**6264**	*
Caloric Content (MJ/kg)	1.67	2.48	2.14	**2.09**	**
Caloric Content (BTU/lb)	718.5	1066.5	920.51	**902**	**
Peak Extinction Area (m²/kg)	739.7	1644.5	705.1	1029.8	
Average Extinction Area (m²/kg)	318.5	263.2	238.7	273.5	

* Total heat produced per unit mass of material consumed
** Total heat produced per unit mass of material tested

ASTM E 1354 Testing "3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60, Gray"

TEST RESULTS (continued)

EFFECTIVE HEAT OF COMBUSTION - ASTM E 1354

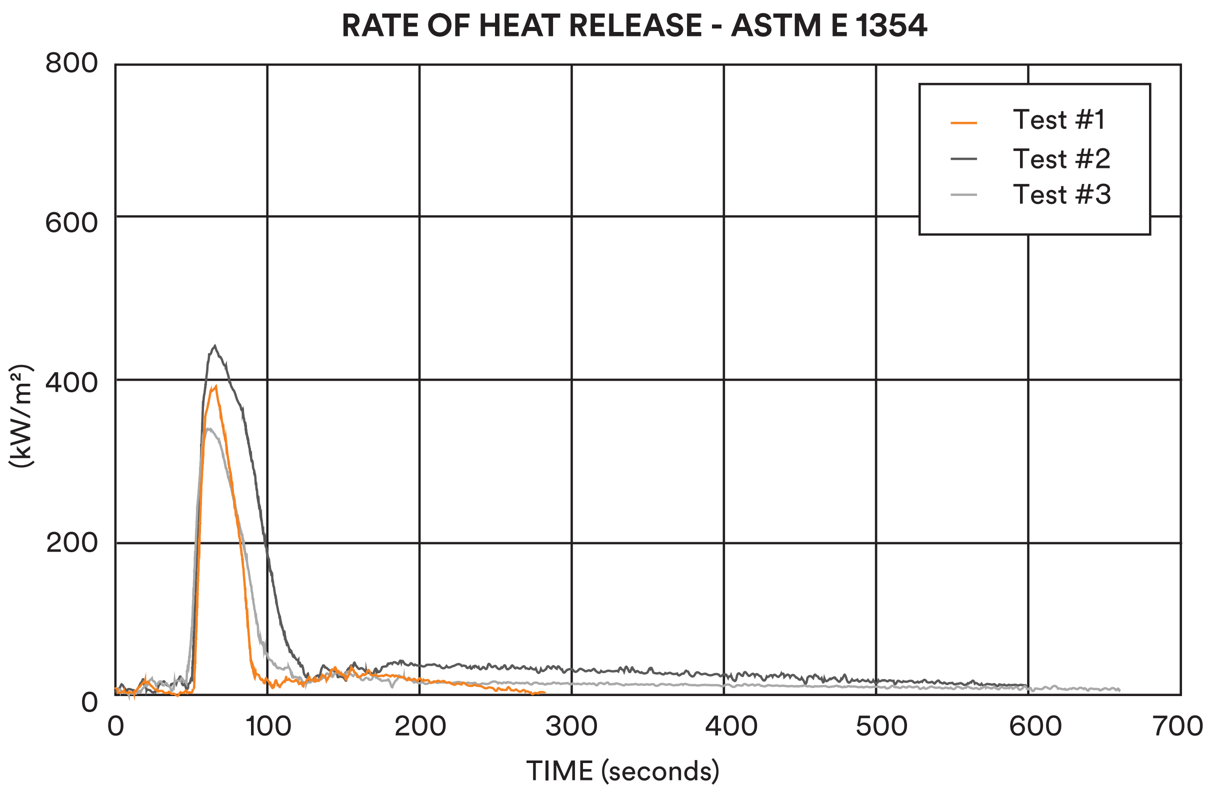


	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	14.38	14.74	14.51	14.55
Heat of Combustion @ 60 s (MJ/kg)**	21.62	18.71	20.68	20.34
Heat of Combustion @ 180 s (MJ/kg)**	15.08	15.64	16.44	15.72
Heat of Combustion @ 300 s (MJ/kg)**	0.00	14.88	14.71	9.86

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing "3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60, Gray"

TEST RESULTS (continued)



	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m^2)	395.5	348.2	436.0	393.2
Average Heat Release Rate (kW/m^2)*	83.7	68.5	64.0	72.1
Heat Release Rate @ 60 s (kW/m^2)**	240.7	250.2	253.0	247.9
Heat Release Rate @ 180 s (kW/m^2)**	98.7	124.3	111.9	111.7
Heat Release Rate @ 300 s (kW/m^2)**	0.0	86.8	78.4	55.1

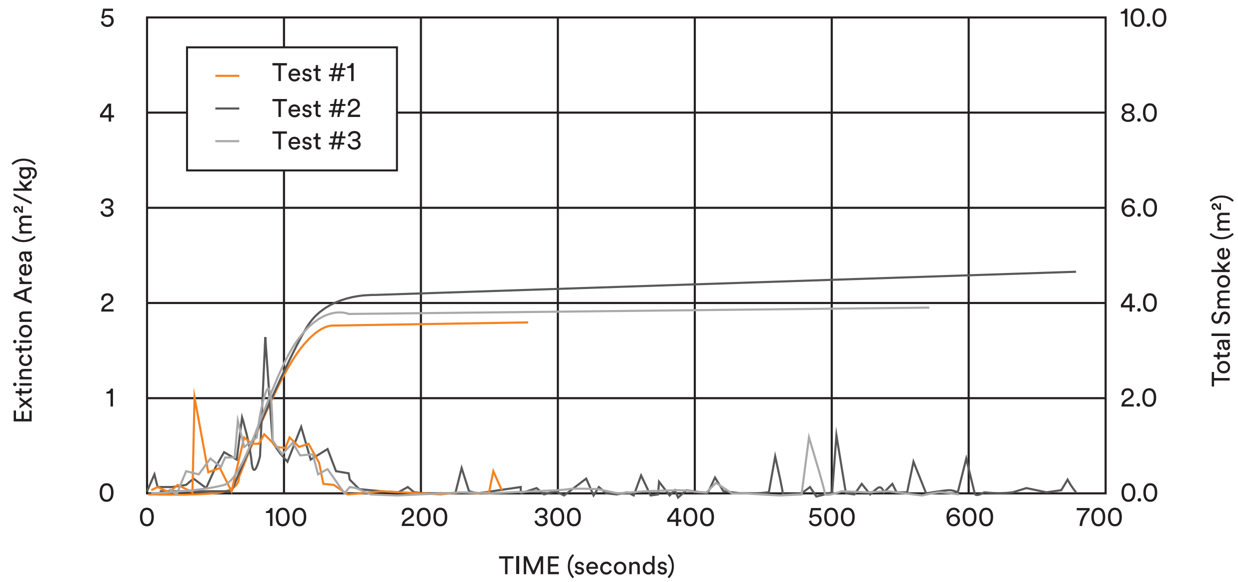
* Averaged over the test period (from ignition to flameout).

** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing "3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60, Gray"

TEST RESULTS (continued)

SMOKE GENERATION - ASTM E 1354



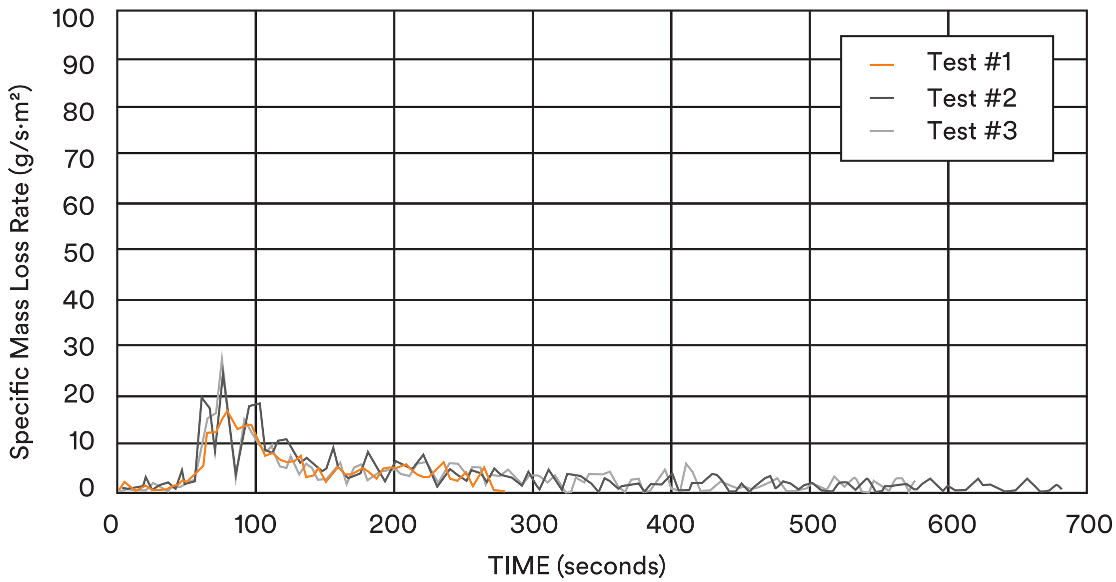
	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m²/kg)	739.7	1644.5	705.1	1029.8
Average Extinction Area (m²/kg)*	318.5	263.2	238.7	273.5
Extinction Area @ 60 s (m²/kg)**	553.5	464.8	519.7	512.7
Extinction Area @ 180 s (m²/kg)**	337.3	327.3	339.1	334.6
Extinction Area @ 300 s (m²/kg)**	0.0	274.0	257.5	177.2
Total Smoke (m²)	3.6	4.4	3.8	3.9

* Averaged over the test period (from ignition to flameout).
** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

ASTM E 1354 Testing "3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60, Gray"

TEST RESULTS (continued)

MASS LOSS RATE - ASTM E 1354



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	16.54	23.66	27.79	22.66
Avg. Specific Mass Loss Rate (g/m²·s)*	6.37	5.83	5.12	5.77
Mass Loss Rate @ 60 s (g/s)**	0.10	0.12	0.11	0.11
Mass Loss Rate @ 180 s (g/s)**	0.06	0.07	0.06	0.06
Mass Loss Rate @ 300 s (g/s)**	0.00	0.05	0.05	0.03

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.
** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

ASTM E 1354 Testing "3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60, Gray"

CONCLUSIONS

The two part epoxy adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate at a coating thickness range of 5 to 10 mils, affords an average Effective Heat of Combustion of 14.55 MJ/kg (6264 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m². Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 2.09 MJ/kg (902 BTU/lb).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

ASTM E 1354 Testing "3M™ Scotch-Weld™ Toughened Epoxy Adhesive LSB60, Gray"

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion
This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.

Time to Ignition
Also known as ignition delay time, this parameter provides a measure of a material's propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.

Heat Release Rate (HRR)
HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.

Total Heat Release
This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate "potential heat load" than is the more commonly used "caloric content" based upon the weight of material used.

Mass Loss Rate
This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.

Extinction Area
This refers to the "yield" of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.

Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray"

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER
Determine surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, as per our Quote No. 11-006-06700-S accepted July 15, 2011.

IDENTIFICATION
Two part epoxy adhesive, approximate coat thickness of 5 to 10 mils and identified as "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray". (Exova sample identification number 11-002-S0503)

SAMPLE PREPARATION
The two part epoxy adhesive was mixed using the supplied mix nozzle and applicator. The adhesive was then spread onto 6 mm thick fiberglass reinforced cement substrate using a trowel at a coating thickness range of 5 to 10 mils. The epoxy adhesive was allowed to dry and cure prior to testing.

TEST RESULTS

ASTM E 162-11

Surface Flammability of Materials Using a Radiant
Heat Energy Source. (Is = Flame Spread Index).

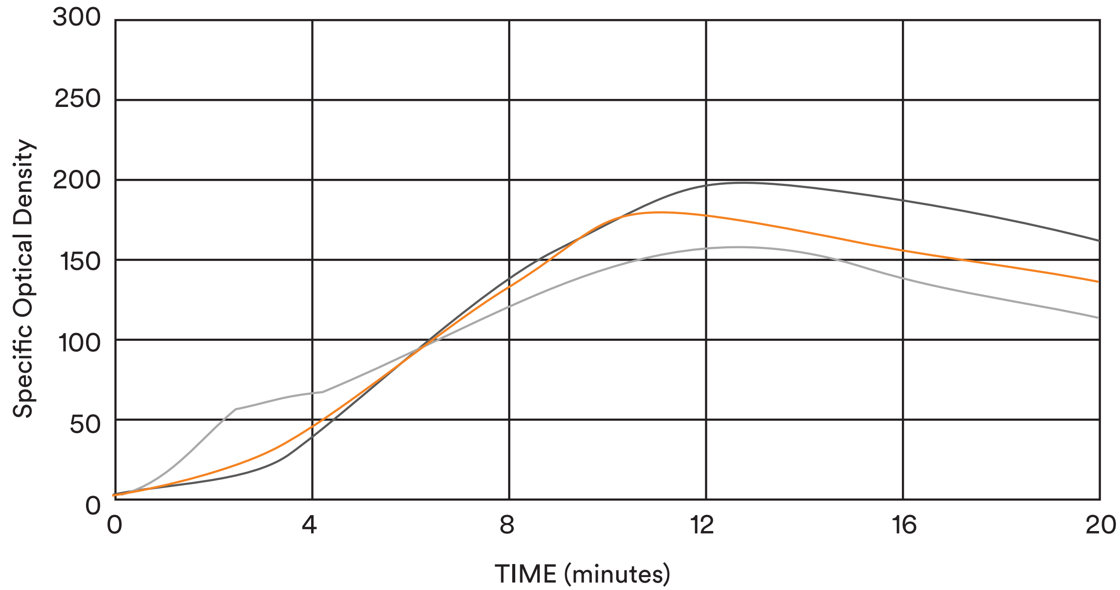
	Fs	Q	Is	Observations
1:	1.5	2.6	4	Flame front propagation to a maximum distance of 6 inches.
2:	1.5	2.9	4	Surface venting observed. No flaming running or flaming
3:	1.5	3.6	6	dripping observed. Note: Specimens were supported in the
4:	1.6	3.4	5	sample holders with 1" hexagonal wire mesh.
Rounded Average:			5	
Specified Maximum:			35	No flaming running or flaming dripping allowed

Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

FLAMING MODE - ASTM E 662-13d



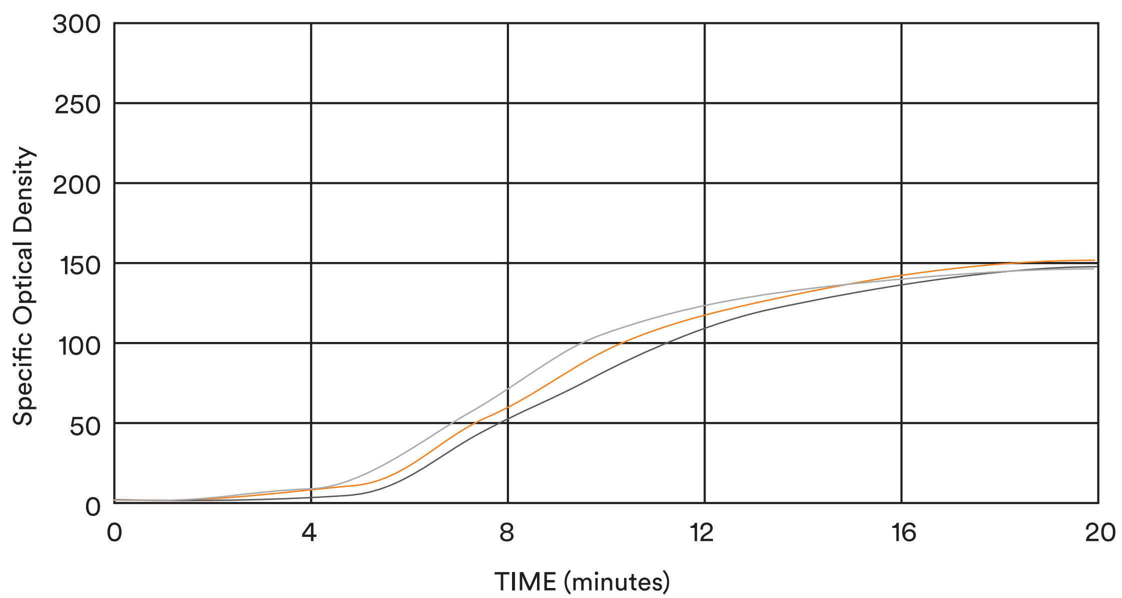
Relative Room Humidity: 44%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	0	0	1	0	100
Specific Optical Density at 4.0 minutes	12	5	11	9	200
Maximum Specific Optical Density	155	161	156	157	-
Maximum Corrected Optical Density	154	160	154	156	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray"

TEST RESULTS (continued)

Specific Optical Density of Smoke Generated by Solid Materials

NON FLAMING MODE - ASTM E 662-13d



Relative Room Humidity: 44%	Test Duration: 20 min.		Chamber Wall Temp: 35°C		
Non-Flaming Mode	Test #1	Test #2	Test #3	Average	
Specific Optical Density at 1.5 minutes	0	0	1	0	100
Specific Optical Density at 4.0 minutes	12	5	11	9	200
Maximum Specific Optical Density	155	161	156	157	-
Maximum Corrected Optical Density	154	160	154	156	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray"

TEST RESULTS (continued)

ASTM E 662 Observations

In the flaming mode, ignition was initially observed at the point of pilot flame impingement, increasing to full surface ignition within 60 seconds. Surface charring, visible smoke and particulates were also observed. In the non-flaming mode, visible smoke production was observed within 30 seconds followed by intumescing and venting.

Bombardier SMP 800-C (Rev. 6 2009-08-31)

Toxic Gas Generation from Material Combustion

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	<10	<10	-
	at 4.0 minutes	153	13	-
	at maximum	1005	165	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	<50	<50	-
	at 4.0 minutes	4050	<50	-
	at maximum	16500	400	90000
Nitrogen Oxides (as NO2 ppm)		4	<1	100
Sulfur Dioxide (SO2 ppm)		<1	<1	100
Hydrogen Chloride (HCl ppm)		5	<2	500
Hydrogen Fluoride (HF ppm)		3	4	100
Hydrogen Bromide (HBr ppm)		<1	<1	100
Hydrogen Cyanide (HCN ppm)		7	1	100
Original Weight (g)(including substrate)		53.2	51.5	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10	Did not ignite	-
Burning Duration (s)		360	-	-

Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray"

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Typical Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	20	<10	-
	at 4.0 minutes	145	<10	-
	at maximum	948	178	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<6	<6	100
Hydrogen Chloride (HCl ppm)		<12	3	500
Hydrogen Fluoride (HF ppm)		<3	<3	200
Hydrogen Cyanide (HCN ppm)		5	<1	150
Original Weight (g)(including substrate)		52.7	49.1	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		10.0	Did not ignite	-
Burning Duration (s)		400.0	-	-

CONCLUSIONS AND COMMENTS

The two part epoxy adhesive identified in this report, when tested adhered onto 6 mm thick fiberglass reinforced cement substrate at a coating thickness range of 5 to 10 mils, meets The Federal Railroad Administration requirements as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The two part epoxy adhesive also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and, as such, has no specific pass/fail criteria of its own. The M-7 Technical Specification criteria are cited for reference purposes only, and may or may not apply to this specific product. The two part epoxy adhesive meets the M-7 Technical Specification requirements as they pertain to toxic gas generation (Boeing BSS 7239).

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

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Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray"

APPENDIX - Summaries of Test Procedures

ASTM E 162-11

Surface Flammability of Materials Using a Radiant Energy Source

As specified, four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C. Section 10.1 of ASTM E 162-13 states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where: Is is the flame spread index

Fs is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray"

APPENDIX - Summaries of Test Procedures

ASTM E 662-09

Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

As specified, the test samples are pre-dried for 24 hours at 60°C. Section 9.1 of ASTM E 662-13d states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Three specimens, 3" square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37° C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer's law:

$$Ds = (V/AL)\cdot\log(100/T) = G\cdot\log(100/T) = 132\cdot\log(100/T)$$

Where: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
L = Length of Light Path in Chamber (3.0 ft)
G = Geometric Factor

Among the parameters normally reported are:

$Ds_{1.5}$ - specific optical density after 1.5 minutes
$Ds_{4.0}$ - specific optical density after 4.0 minutes

Dm -maximum specific optical density at any time during the 20 minute test

$Dm_{(corr)}$ - Dm corrected for incidental deposits on the optical surfaces

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 4.0 of 200 in either flaming or non-flaming test mode.

Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray"

Bombardier SMP 800-C (Rev. 6 2009-08-31)

<u>Toxic Gas Sampling and Analytical Procedures</u>

<u>Toxic Gas Generation</u>
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

<u>Carbon Monoxide (CO) and Carbon Dioxide (CO2)</u>
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

<u>Acid Gas Sampling</u>
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

<u>Analysis of Impingers for Hydrogen Cyanide (HCN)</u>
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO$^-$. After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

<u>Analysis of Impingers for Hydrogen Fluoride (HF)</u>
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

<u>Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)</u>
Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

<u>Analysis of Impingers for Nitrogen Oxides (NOX)</u>
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

<u>Analysis of Impingers for Sulfur Dioxide (SO2)</u>
SO2 is trapped in the NaOH impinger as sulfite and sulfate (SO3^{-2} and SO4^{-2}). Hydrogen peroxide is added to convert SO3^{-2} to SO4^{-2}. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Scotch-Weld™ Epoxy Adhesive LSB60 Toughened Gray"

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation
Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO2)
CO and CO2 are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR)analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling
HCN, HF, HCl, HBr, NOx and SO2 are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)
Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO^- . After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.
Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)
Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.
Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)
Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NOX)
Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite results are combined and the total expressed as nitrogen dioxide (NO2).
Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO2)
SO2 is trapped in the NaOH impinger as sulfite and sulfate ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection.
Reference: In-house SOP 02-13-SP-1402

Summary DP 6310NS J387343-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

17th October 2017
Our ref: 387340/1/2/3/4

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 2.6mm composite comprising you adhesive (product reference "Carbon Bonder DP6310") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 387343 ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m² in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 1
Smoke accumulation, VOF4 = 2
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 153
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.01

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m³)	ND	19	ND	ND	ND	ND	ND	2
8 minutes (mg/m³)	1	29	ND	5	ND	ND	ND	2

WF Number: 387344
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m² in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 0
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.01

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m³)	1	2066	ND	1	ND	ND	ND	3
8 minutes (mg/m³)	3	4476	ND	ND	ND	ND	ND	7

Summary DP 6310NS J387343-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 387340
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	3.65

WF Number: 387341
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	17.0
Time to MARHE	seconds	624

WF Number: 387342
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 7th August 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

Summary DP 6330NS J387353-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

17th October 2017
Our ref: 387350/1/2/3/4

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 3mm composite comprising you adhesive (product reference "Carbon Bonder DP6330NS") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

<u>WF Number: 387353</u>
<u>ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame</u>

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 1
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 204
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.00
Gas CO CO2 SO2 HCl

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m³)	1	172	ND	ND	ND	ND	ND	2
8 minutes (mg/m³)	1	226	ND	ND	ND	ND	ND	2

<u>WF Number: 387354</u>
<u>ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame</u>

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 0
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.02

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m³)	2	2813	ND	ND	ND	ND	ND	5
8 minutes (mg/m³)	4	5850	ND	ND	ND	ND	ND	8

Summary DP 6330NS J387353-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WWF Number: 387350
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	3.65

WF Number: 387352
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	31.5
Time to MARHE	seconds	502

WF Number: 387351
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 7th August 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

Summary ATT 9775WL J385522-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

26th October 2017 Our ref: 385406/16/27/37/522

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 2.1mm composite comprising you adhesive (product reference "ATT 9775WL") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 385427
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 20
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.00

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	ND	26	ND	ND	ND	ND	ND	2
8 minutes (mg/m^3)	2	37	ND	ND	ND	ND	ND	2

WF Number: 385522
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 3
Smoke accumulation, VOF4 = 5
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 6
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 6
Critical Index of Toxicity, CIT value (4 minutes) = 0.04
Critical Index of Toxicity, CIT value (8 minutes) = 0.05

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	72	5781	10	8	ND	ND	ND	7
8 minutes (mg/m^3)	103	8119	17	12	ND	ND	ND	7

Summary ATT 9775WL J385522-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 385437
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	3.65

WF Number: 385416
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	6.1
Time to MARHE	seconds	2

WF Number: 385406
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 26th June 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

NFPA - 130 Testing

Technical Bulletin **May 2018**

Technical Bulletin for NFPA - 130 testing with 3M Polyurethane Window Bonder Adhesive Sealant 595

Description
Testing of 3M™ Polyurethane Window Bonder Adhesive Sealant 595 were completed to NFPA - 130 were completed to see our conformance to this specification.

ASTM E162
Standard test method for surface flammability of materials using a radiant heat energy source

Our average flame spread index was **35**

Looking at the test requirements specified by Federal Guidelines 49 CFR Part 238 the Category that we fall under is "Elastomers" and for this test the Max Flame Spread is **"N/A"**

RESULT – 595 CONFORMS

ASTM E662
Standard test method for specific optical density of smoke generated by solid materials

There is a 90 second test and a 4-minute maximum specific optical density test. Our average for the 90 second test "Flaming Mode" was **15** and the "Non-Flaming Mode" was **2** and our average for the 4- minute "Flaming Mode" was **64** and the "Non-Flaming Mode" was **46**

Looking at the test requirements specified by Federal Guidelines 49 CFR Part 238 the Category that we fall under is **"Elastomers"** and for this test the "Max Specific Density" for 90 seconds is 100 and 4- minutes is 200.

RESULT – 595 CONFORMS

Boeing test method BSS 7239 Rev A – Analysis of the products of combustion using the NBS smoke chamber and gas detector tubes to determine presence of specific products of combustion.

Results and Acceptance Criteria

Flaming mode at 4 minutes			
Combustion by Product		Average (ppm)	Suggested Maximum Limits @ 4 minutes
CO	Carbon Monoxide	145.5	3500
HF	Hydrogen Flouride	LT 2.0	200
HC1	Hydrogen Chloride	LT 1.0	500
HCN	Hydrogen Cyanide	LT 0.5	150
SO/2	Sulphur Dioxide	23.5	100
NO, NO/2	Nitrous Gases	5.2	100

Non Flaming mode at 4 minutes			
Combustion by Product		Average (ppm)	Suggested Maximum Limits @ 4 minutes
CO	Carbon Monoxide	145.5	3500
HF	Hydrogen Flouride	LT 2.0	200
HC1	Hydrogen Chloride	LT 1.0	500
HCN	Hydrogen Cyanide	LT 0.5	150
SO/2	Sulphur Dioxide	23.5	100
NO, NO/2	Nitrous Gases	5.2	100

LT = Less Than

Technical Bulletin for NFPA - 130 testing with 3M Polyurethane Window Bonder Adhesive Sealant 595

Remarks:

Program :ASTM E1354 (version 4.30)

[x] Test specimens are thermally thin , containing little mass and f uel . The small amount of fuel results in a very short burning time , e.g . the specimen under test never reaches a steady state burning condition . The small mass results in extremely small mass loss rates nearing the limit of the instrument ' s capability to measure . This results in high variability in reported results calculated with mass in the denominator, specifically SEA and Effective Heat of Combustion .

ASTM E1354 Test Report

Test Report Number : **3-25158-2-W2**
Client: **3M Company**
Specimen ID: **3M Window Border Adhesive Sealant 595**
Composition: **Polyurethane Adhesive Sealant**
Specimen Color : **Black**
Specimens Tested : **3**

Test Date : **03/27118**
Operator : **Andrew Niemczyk**
Heat Flux : **50 kW/m²**
Calibration Constant: **0.047**
Test Orientation: **Horizontal**
Retaining Wire Grid Used: **Yes**

	Specimen			
	1	2	3	Average
Test Duration (seconds)	212	217	229	219
Time to Sustained Ignition (seconds)	30	33	31	31
Peak Rate of Heat Release (kW/m²)	80.9	77.0	93.8	83.9
Time of Peak RHR (s)	46	55	60	54
Average RHR • 60 seconds (kW/m²)	51.0	54.6	66.1	57.2
Average RHR • 180 seconds (kW/m²)	25.4	26.0	28.8	26.7
Average RHR • 300 seconds (kW/m²)	15.4	15.8	18.1	16.4
Total Heat Released (MJ/m²)	4.6	4.7	5.4	4.9
Initial Mass (g)	85.4	83.0	87.1	85.2
Final Mass (g)	74.6	72.6	75.5	74.2
Mass at Sustained Flaming (g)	85.2	82.8	87.0	85.0
Mass Loss (g/m²)	1095.0	1042.0	1163.0	1100.0
Average Mass Loss Rate (g/m²-s)	5.9	5.8	6.0	5.9
Avg Effective Heat of Combustion (MJ/kg)	4.3	4.6	4.7	4.5
Caloric Content (MJ/kg)	0.5	0.6	0.6	0.6
Avg SpecificE xtinctionA rea (m²/kg)	21	9	36	22
Avg SEA@ 180 seconds (m²/kg)	13	7	35	18
Thickness (mm)	7.7	7.7	7.7	7.7
Exhaust Flow rate (m³/s)	0.025	0.025	0.025	0.025

Technical Bulletin for NFPA - 130 testing with 3M Polyurethane Window Bonder Adhesive Sealant 595

Technical Information

The technical information, recommendations, and other statements contained in this document are based upon tests or experience that 3M believes are reliable, but the accuracy or completeness of such information is not guaranteed.

Product Use

Many factors beyond 3M's control and uniquely within user's knowledge and control can affect the use and performance of a 3M product in a particular application. Given the variety of factors that can affect the use and performance of a 3M product, user is solely responsible for evaluating the 3M product and determining whether it is fit for a particular purpose and suitable for user's method of application.

Warranty, Limited Remedy, and Disclaimer

Unless an additional warranty is specifically stated on the applicable 3M product packaging or product literature, 3M warrants that each 3M product meets the applicable 3M product specification at the time 3M ships the product.
3M MAKES NO OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY IMPLIED WARRANTY OR CONDITION ARISING OUT OF A COURSE OF DEALING, CUSTOM OR USAGE OF TRADE.
If the 3M product does not conform to this warranty, then the sole and exclusive remedy is, at 3M's option, replacement of the 3M product or refund of the purchase price.

Limitation of Liability

Except where prohibited by law, 3M will not be liable for any loss or damage arising from the 3M product, whether direct, indirect, special, incidental or consequential, regardless of the legal theory asserted, including warranty, contract, negligence or strict liability.

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www.3M.com/sealants

This Industrial Adhesives and Tapes Division product was manufactured under a 3M quality system registered to ISO 9001: 2000 standards.

EN45545-2 Testing

Technical Bulletin May 2018

Technical Bulletin for European Standard EN45545-2 testing with 3M Polyurethane Window Bonder Adhesive Sealant 595

Description
Testing of 3M™ Polyurethane Window Bonder Adhesive Sealant 595 was completed to EN45545-2. The data suggests that an assembly made with 595 would pass full specification EN45545-2 testing.

The following technical information and data should be considered representative and should not be used for specification purposes. The EN45545-2 specifies the requirements for the fire behavior of materials and components in railway applications. Prior to use, full specification testing with Polyurethane Window Bonder Adhesive Sealant 595 in the final assembly should be completed.

Specimen Preparation
Specimens were prepared in the following manner. Specimen substrate was a 12mm noncombustible backing board. Each test had a specific size requirement. Specimens were cut to size using a box cutting knife. Each specimen was then covered completed with the 595 using a 1/32” notched trowel.

Results
ISO-11925-2 Reaction to fire tests. Ignitability of building products subjected to direct impingement of flame.

Description of test: Three machine and three cross machine specimens are prepared for each test exposure configuration (surface and edge) for a total of 12 specimens. The 250mm x 90mm specimens are mounted vertically in the holder with the exposed end 30mm from the end of the flame. A flame height of 20mm impinges on the specimen at the angle of 45 degrees. Filter paper is placed under each specimen. The test records: the occurrence of ignition, flame spread time, height of flame spread and whether or not ignition of filter paper occurs.

Test		Specimen	Ignition	Droplets	Time for flame spread to reach 150mm (seconds)	Height of flame spread progression (mm)
ISO - 11925-2 - Reaction to fire tests. Ignitability of building products subjected to direct impingment of flame.	**Surface Ignition**	1	No	No	0	0
		2	No	No	0	0
		3	No	No	0	0
		4	No	No	0	0
	Edge Ignition	5	No	No	0	0
		6	No	No	0	0
		7	No	No	0	0
		8	No	No	0	0

Observations - No unusual observations

Technical Bulletin for European Standard EN45545-2 testing with 3M Polyurethane Window Bonder Adhesive Sealant 595

Reaction to fire tests – heat release, smoke production and mass loss rate

Description of test: A test specimen measuring 4" x 4" maximum thickness 2" is mounted into the holder. The holder sits on a load cell. The opening of a "cone shaped" radiant heat source faces the test specimen. The heat flux (optionally 25 kW or 50 kW) is radiated onto the surface of the specimen. A spark is introduced to ignite the off-gases. While the rest of the specimen burns and decomposes, measurements are made in the exhaust system of the apparatus. Using the oxygen concentrations present during combustion, pressure flow rates and thermocouple temperatures, the mass of oxygen consumed at any given time can be calculated. Heat release values are then determined using a defined formula based on the release rate of 13.1 MJ per kg oxygen consumed. Simultaneously, the optical photometrics, or smoke obscuration measuring system, is gauging smoke release while the weigh cell is tracking specimen mass loss.

ISO 5660-1	Specimen	MAHRE
tests - heat released, smoke production and mass loss rate -	1	17
	2	34
	3	16
	4	28
	5	30
	6	26
Average		26

Hazard Level		
R1	HL1	a
	HL2	90
	HL3	60

Maximum MARHE (kW/m^2)

MAHRE is Maximum Average Rate of Heat Emission

HL3 is the strictest Hazard Level (HL3). All specimens tested below the requirements

Determination of Optical Density by a single chamber method

Description of test: The 75mm x 75mm specimen is held inside a metal holder. The exposed face of the specimen measures 65mm x 65mm. The framed specimen is placed inside the test chamber in a horizontal configuration. A radiant heater sits 1" above the face of the test specimen. The heater is optionally set at 2 different flux values: 25 kW or 50 kW. A 30mm flame is introduced to the face of the test specimen in the 25 kW option. As the test specimen burns or decomposes, there will be an accumulation of smoke in the chamber. The photodetector measures the smoke obscuration which is then converted to a smoke density value. Smoke density values are reported at 4 minutes and 10 minutes. VOF4 is a calculated value based on results recorded at 1, 2, 3 and 4 minutes into the test. If the MAXIMUM Specific Optical Density value of any individual specimen exceeds by 50% the lowest MAXIMUM Specific Optical Density value of any other specimen, an additional three specimens are tested. If this does not occur, "NR" (not required) is entered for specimens 4, 5 and 6.

ISO 5659-2	Specimen	25 kW/ m2 w/pilot flame	VOF4	5 kW/m2 w/pilot flame
Determination of Optical Density by a single Chamber Method	1	30	51	40 (36)
	2	24	51	33 (29)
	3	28	46	48 (44)
	4	NR	NR	NR
	5	NR	NR	NR
	6	NR	NR	NR
		27	**49**	**40 (36)**

Hazard Level		
R22	HL1	600
	HL2	300
	HL3	150

Hazard Level 3 (HL3) is the harshest requirement of this test. Specimens 1, 2, and 3 were below the requirement. Per the specification, specimens 4, 5 and 6 were not required to be tested due to Specimens 1, 2, and 3 testing below HL3.

Technical Bulletin for European Standard EN45545-2 testing with 3M Polyurethane Window Bonder Adhesive Sealant 595

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This Industrial Adhesives and Tapes Division product was manufactured under a 3M quality system registered to ISO 9001: 2000 standards.

Technical Bulletin for European Standard EN45545-2 testing with 3M Polyurethane Window Bonder Adhesive Sealant 595

Reaction to fire tests -Spread of flame -Part 2: Lateral spread on building and transport products in vertical configuration

Brief description of test: A test specimen 155mm x 800mm is placed at a specified distance from a gas fired heater. The specimen is angled so that the near end of the specimen is close to the heater while the far end of the specimen is located further from the heater, thereby receiving a high heat flux at the near end and progressively lower heat fluxes until the far end is reached. An igniting flame is applied to the near end of the specimen. If the specimen is ignited, the technician records the time of the flame front progression as it passes benchmarks which are spaced at 50mm intervals from the point of ignition. The technician refers to a graph which plots heat flux versus distance. The heat flux value at the point where the specimen ceases flaming is entered as the CFE (Critical Flux at Extinguishment). In addition to the CFE value, burning droplets/particles are recorded when observed.

ISO 5658-2 Reaction to Fire test - Flame spread	Specimen	CFE kW/m2	Droplets	Observation	R Set	Hazard level	Min CF
	1	30.9	No	Char/Flash	R1	HL1	20
	2	34.4	No	Char/Flash	R1	HL2	20
	3	18.2	No	Char/Flash	R1	HL3	20

In two out of the 3 substrates tested we were above the minimum requirement.
All samples were prepared in the same manner with no um requirement.

Results for this test show we are in conformance. Results for the 595 show we are in conformance to EN45545-2 specification requirements.

Conclusion:
3M Window Bonder 595 fully met the requirements of EN45545-2 in standalone testing for 3 of the 4 specification tests. Reaction to fire test – spread of flame yielded two conforming results and one that did not conform. Based on sample preparation and test procedure there is no assignable cause for the nonconforming result. Data suggests if tested in a full assembly with the 595 the assembly should be in conformance with EN45545-2 specification.

Summary DP 105 J387359-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

17th October 2017
Our ref: 387355/7/8/9/60

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 3mm composite comprising you adhesive (product reference "DP105") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 387359
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 1
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 96
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.00

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	ND	79	ND	ND	ND	ND	ND	2
8 minutes (mg/m^3)	1	81	ND	ND	ND	ND	ND	2

WF Number: 387360
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 0
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.02

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	1	2479	ND	ND	ND	ND	ND	5
8 minutes (mg/m^3)	3	5303	ND	ND	ND	ND	ND	8

Summary VHB GPH-160 J385524-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 387355
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	0.00

WF Number: 387358
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	22.2
Time to MARHE	seconds	464

WF Number: 387357
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 7th August 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

Summary DP 8825NS J387370-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

17th October 2017
Our ref: 387367/8/9/70/1

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 3mm composite comprising you adhesive (product reference "DP8825NS") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 387370
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 1
Smoke accumulation, VOF4 = 2
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 1
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 23
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.00

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	ND	91	ND	ND	ND	ND	ND	2
8 minutes (mg/m^3)	1	98	ND	ND	ND	ND	ND	2

WF Number: 387371
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 0
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.02

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	1	2241	ND	ND	ND	ND	ND	5
8 minutes (mg/m^3)	3	4717	ND	ND	ND	ND	ND	8

Summary DP 8825NS J387370-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 387367
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m²)	Smoke Development (% minute)
≤5	≥10.8	0.00

WF Number: 387369
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m²	22.2
Time to MARHE	seconds	464

WF Number: 387368
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m²)	Heat for sustained burning, Qsb (MJ/m²)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 7th August 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

Summary DP 8425NS J387365-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

17th October 2017
Our ref: 387361/2/3/5/6

We confirm that the indicative tests in accordance with BS EN 45545-2:2013+A1:2015 on your nominally 3mm composite comprising you adhesive (product reference "DP8425NS") sandwiched between two 1mm thick aluminium sheets have now been carried out.

We consider the results of the tests indicate that the product, as tested, complies:

Requirement Set (detailed in Table 5 of EN 45545-2: 2013 + A1:2015)	Indicated Hazard Level Classification
R1	HL1, HL2 and HL3
R2	HL1, HL2 and HL3
R3	HL1, HL2 and HL3
R6	HL1, HL2 and HL3
R7	HL1, HL2 and HL3
R10	HL1, HL2 and HL3
R11	HL1, HL2 and HL3
R12	HL1, HL2 and HL3
R17	HL1, HL2 and HL3

The above is based on the following indicative results that have been achieved:

WF Number: 387365
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 50kW/m2 in the absence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 1
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 3
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 38
Critical Index of Toxicity, CIT value (4 minutes) = 0.00
Critical Index of Toxicity, CIT value (8 minutes) = 0.00

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	ND	82	ND	ND	ND	ND	ND	2
8 minutes (mg/m^3)	1	104	ND	ND	ND	ND	ND	2

WF Number: 387366
ISO 5659-2 / EN 45545-2 Annex C Smoke and Toxicity Test, Test mode: 25kW/m2 in the presence of a pilot flame

Smoke density at 4 minutes test duration, Ds (4) = 0
Smoke accumulation, VOF4 = 0
Maximum smoke density within first 10 minutes of test, Ds (max) within 10 minutes = 0
Maximum smoke density within first 20 minutes of test, Ds (max) within 20 minutes = 0
Critical Index of Toxicity, CIT value (4 minutes) = 0.01
Critical Index of Toxicity, CIT value (8 minutes) = 0.02

Gas	CO	CO_2	SO_2	HCl	HBr	HF	HCN	NO_x
4 minutes (mg/m^3)	1	2521	ND	ND	ND	ND	ND	5
8 minutes (mg/m^3)	3	5250	ND	ND	ND	ND	ND	8

Summary DP 8425NS J387365-BD170831zBS EN 45545-2 2013+A1 2015 Annex C

WF Number: 387361
BS EN ISO 9239-1 Test

Maximum Flame-out Distance (cm)	Critical Heat Flux, CHF (kW/m^2)	Smoke Development (% minute)
≤5	≥10.8	0.00

WF Number: 387363
BS EN ISO 5660-1 Test

Maximum average rate of heat Release (MARHE)	kW/m^2	28.0
Time to MARHE	seconds	634

WF Number: 387362
BS EN ISO 5658-2 Test

Critical flux at extinguishment, CFE (kW/m^2)	Heat for sustained burning, Qsb (MJ/m^2)
50.0	*

*Could not be calculated due to flame travel not reaching 180mm

The specimens were supplied by yourselves on the 7th August 2017. Exova Warringtonfire was not involved in any sampling or selection procedure.

These test results relate to exploratory investigations which utilised the test methodology given in BS EN 45545-2:2013+A1:2015 the full requirements of the Standard were not, however, complied with. The information is provided for your information only and should not be used to demonstrate performance against the Standard nor compliance with a regulatory requirement. The test was not conducted under the requirements of UKAS accreditation.

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