Novel flame retardant solutions for water based, clear wood coatings

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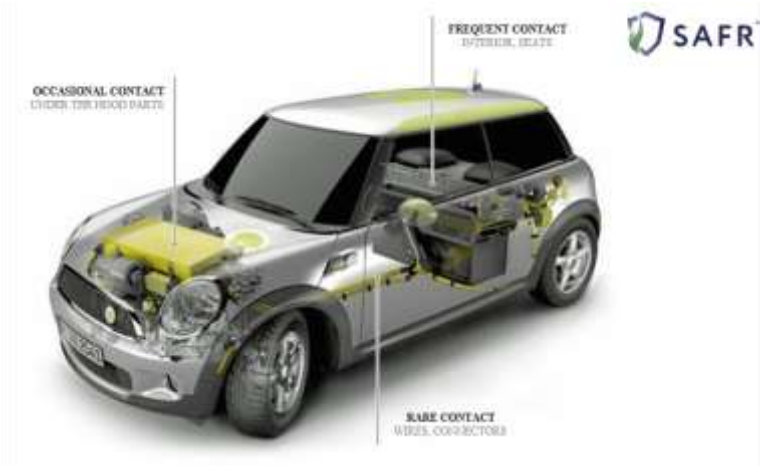
About ICL Group

- Headquartered in Israel, with plants across the globe
- Global manufacturer of fertilizer and specialty chemicals
- World's largest producer of elemental bromine
- World's leading producer of a variety of bromine, phosphorus and inorganic Flame Retardants (FRs)
- Multiple awards for sustainability efforts, inclusion in FTSE4Good and A- Carbon Score

Product Stewardship & Lifecycle by ICL

- Development - ***Sustainability Index*** for Product Development
- Production - ***VECAP*** – Voluntary Emissions Control Action Program
- Application - ***SAFR®*** – A Systematic Assessment for Flame Retardants
- End of Life - Circular Economy Initiatives – PSLoop, Plast2becleaned, etc.



PLAST2bCLEANED

PolyStyreneLoop

http://icl-group-sustainability.com/reports/product-safety-responsibility/

Why Flame Retardants?

- Building codes, Product specs require Fire Safety
- Recent major fires shine a spotlight on fire safety
- FRs are a major way in which flame retardancy is achieved
- Coating's market is well served by APP and ATH:
  - Not possible to achieve transparency
- Other options like chlorinated phosphates and phosphate esters have issues in WB systems
- Market need = **Water borne clear, FR wood coatings!**

Sustainability of Flame Retardants

FR Perception vs. Reality

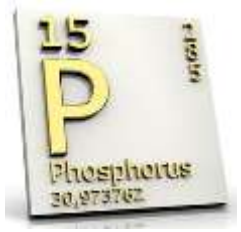
 **FR Perception:**	Halogen = BAD	Non-Hal = GOOD
 **Recent EPA restrictions:**	1 Br FR Already off the market	1 Non-Hal FR Currently in use = Business risk
 **Next EPA priority review:**	1 Br FR Reacted in use, likely no effect	1 Non-Hal FR Component of major NH FRs
 **Path forward:**	Polymeric, reactive or inorganic FRs regardless of chemistry!*	

* U.S EPA: "There is an exceedingly low probability that potential exposure to high molecular weight water-insoluble polymers, as a class, will result in unreasonable risk or injury to human health or the environment"
http://www.epa.gov/reviewing-new-chemicals-under-toxic-substances-control-act-tsca/high-molecular-weight-polymers-new

Current FR products on the market

Historically used chlorinated phosphate esters:

- Excellent compatibility and efficiency
- Problematic HSE profiles, under regulatory scrutiny



Possible replacement with traditional phosphate esters:

- Excellent compatibility but not as efficient
- Very good rheological properties for 100% solids systems

Low particle size brominated flame retardants:

- High efficiency products, polymeric preferred

FR coating development

Goal = Clear, water borne, FR solution

Developing New FR Molecules

FR Paint Formulation

Application and Small-Scale FR testing

Large scale testing

And here we are today

Development Results

Solid Brominated Polymer

- Low particle size solid
- Easily Formulated
- Translucent Film
- Suitable for water based, solvent based and 100% solids systems
- Oeko-Tex approved

Brominated Acrylic Copolymer

- A submicron water-based dispersion
- Creates a clear film
- High compatibility with water-based resins and paint components
- Acts as co-binder in the paint

ICL patented products

Product Appearance

	NO FR, WB	Solid Br Polymer	Br Acrylate
pH as is	7.2	7.3	7.1
Viscosity (63S, 100 rpm, RT), cp	921	158	78*
Gloss (20°, 60°, 85°)	11.4, 68.8, 80.5	1.2, 9.1, 20.8	15.5, 55.3, 64.1
Transparency (40 m thickness)	99.1	76.5	98.3

* (61S, 60 rpm, RT)

Small Scale NFPA 701 testing

No FR, WB Acrylic

Fail = Full burn

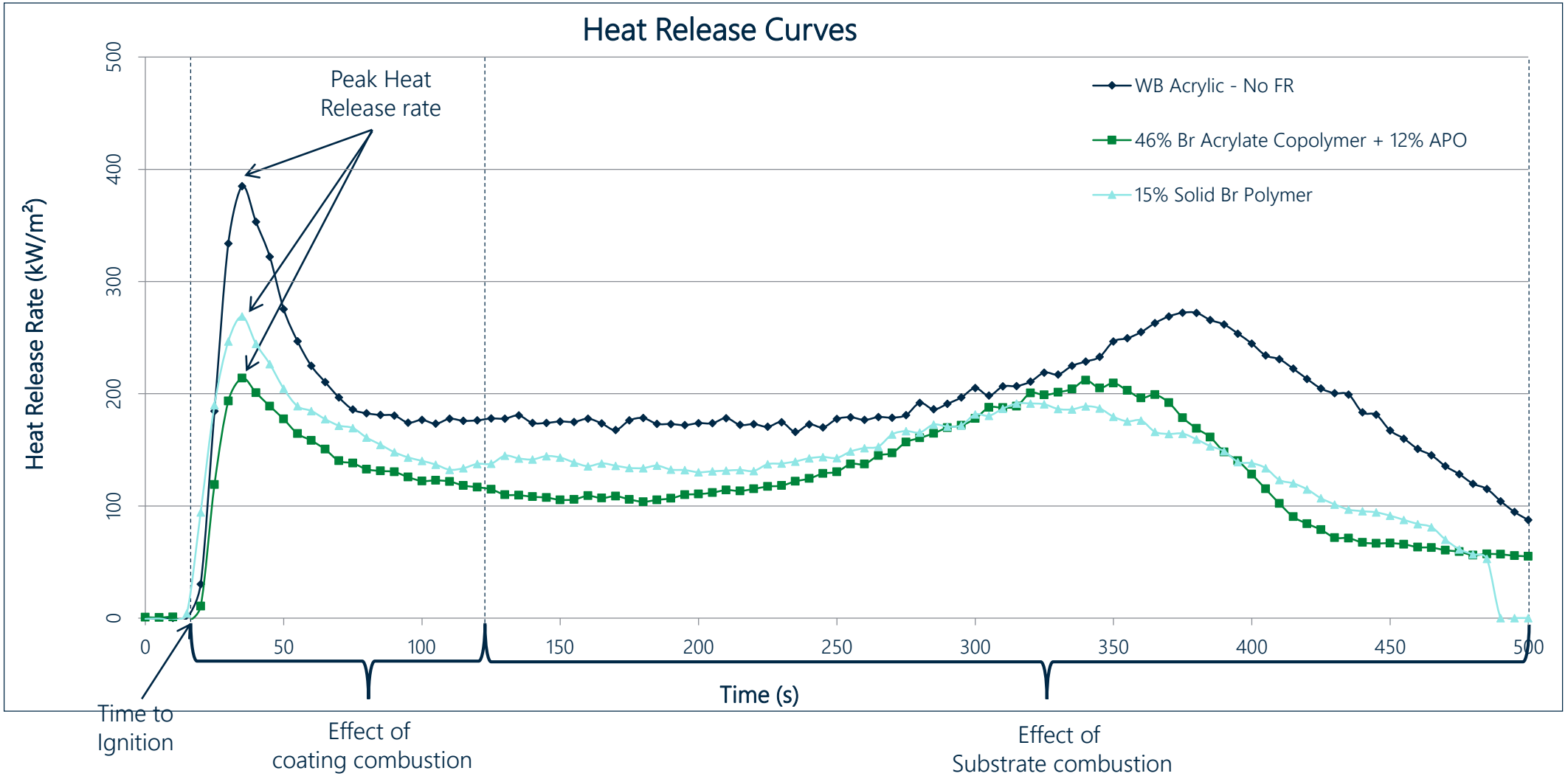
WB Acrylic + Br Polymer

Pass = Self Extinguish

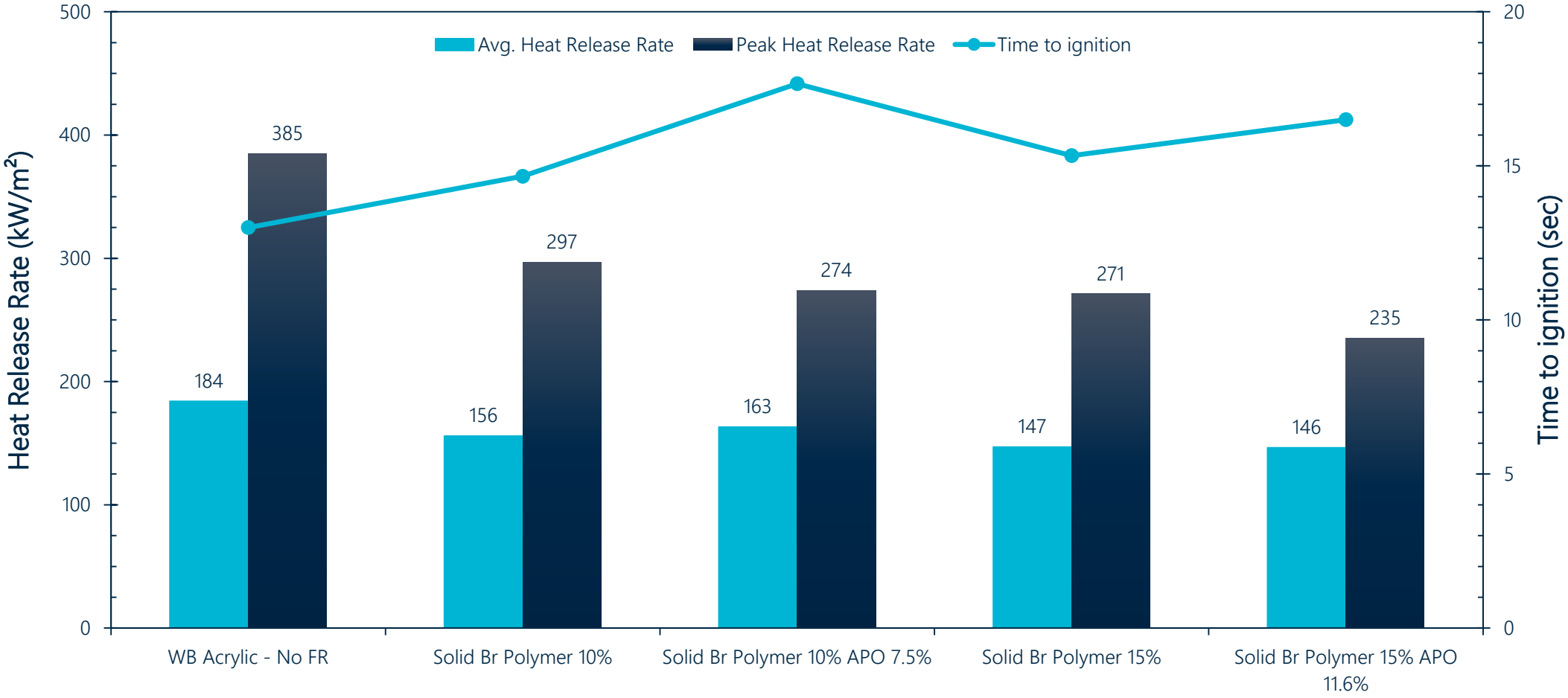
WB Acrylic + Br Acrylate

Pass = Self Extinguish

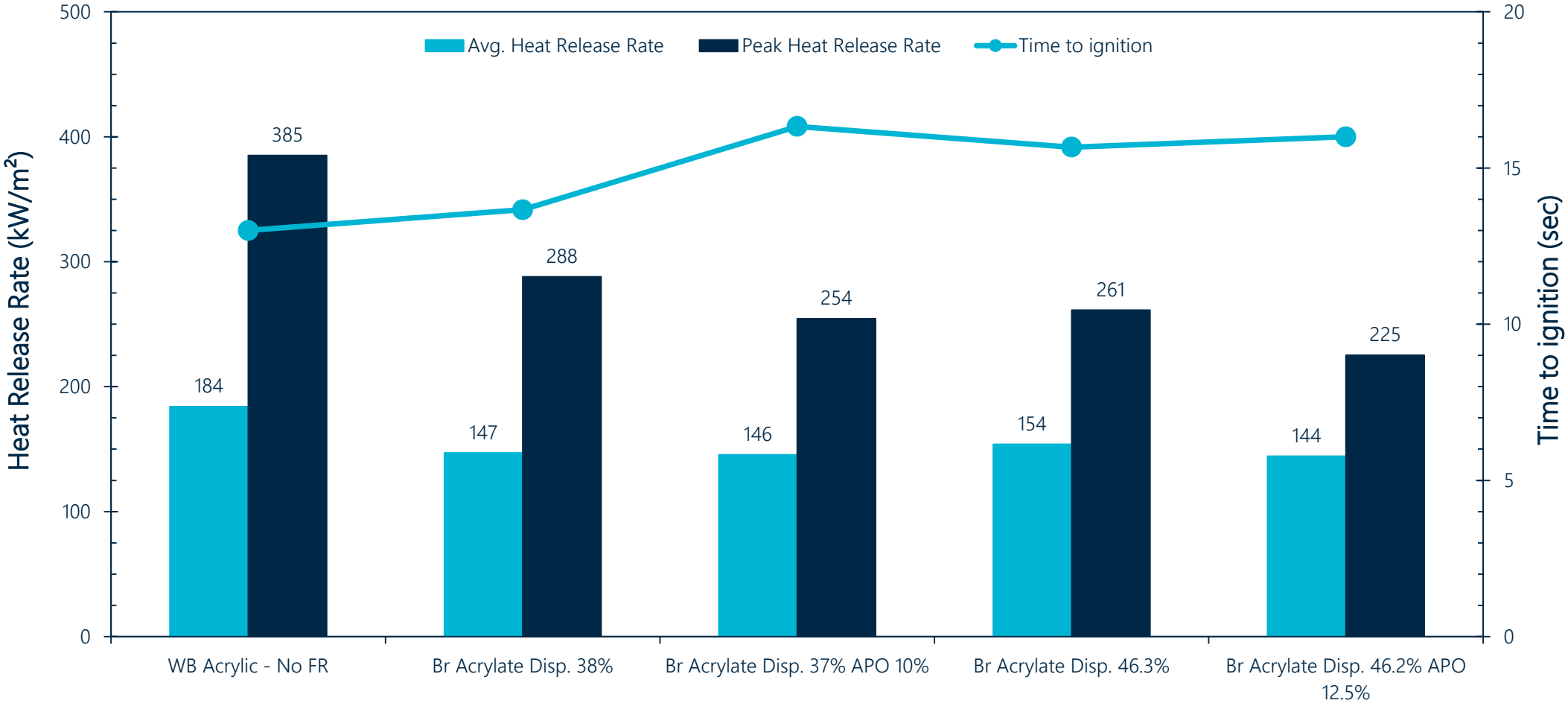
Small Scale Cone Calorimeter testing



Cone Calorimeter results – Solid Br Polymer



Cone Calorimeter results – Br Acrylate



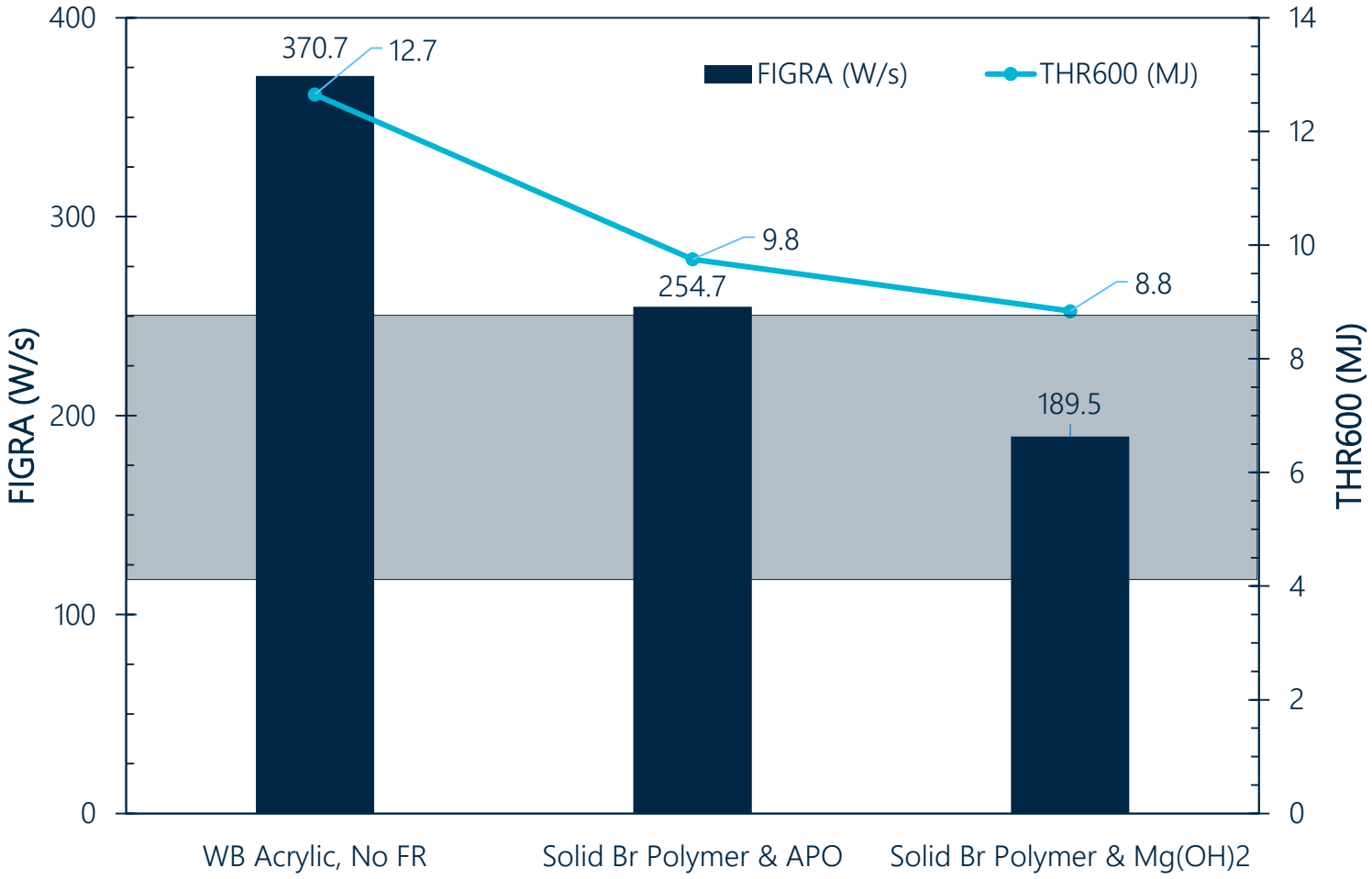
Large scale FR testing

EN 13501 (SBI)

ASTM E-84

https://blog.starcsystems.com/blog/astm-e-84-fire-rating-your-questions-answered;
http://virtual.vtt.fi/virtual/innofirewood/stateoftheart/database/euroclass/euroclass.html;
https://www.fire-testing.com/single-burning-item-sbi/

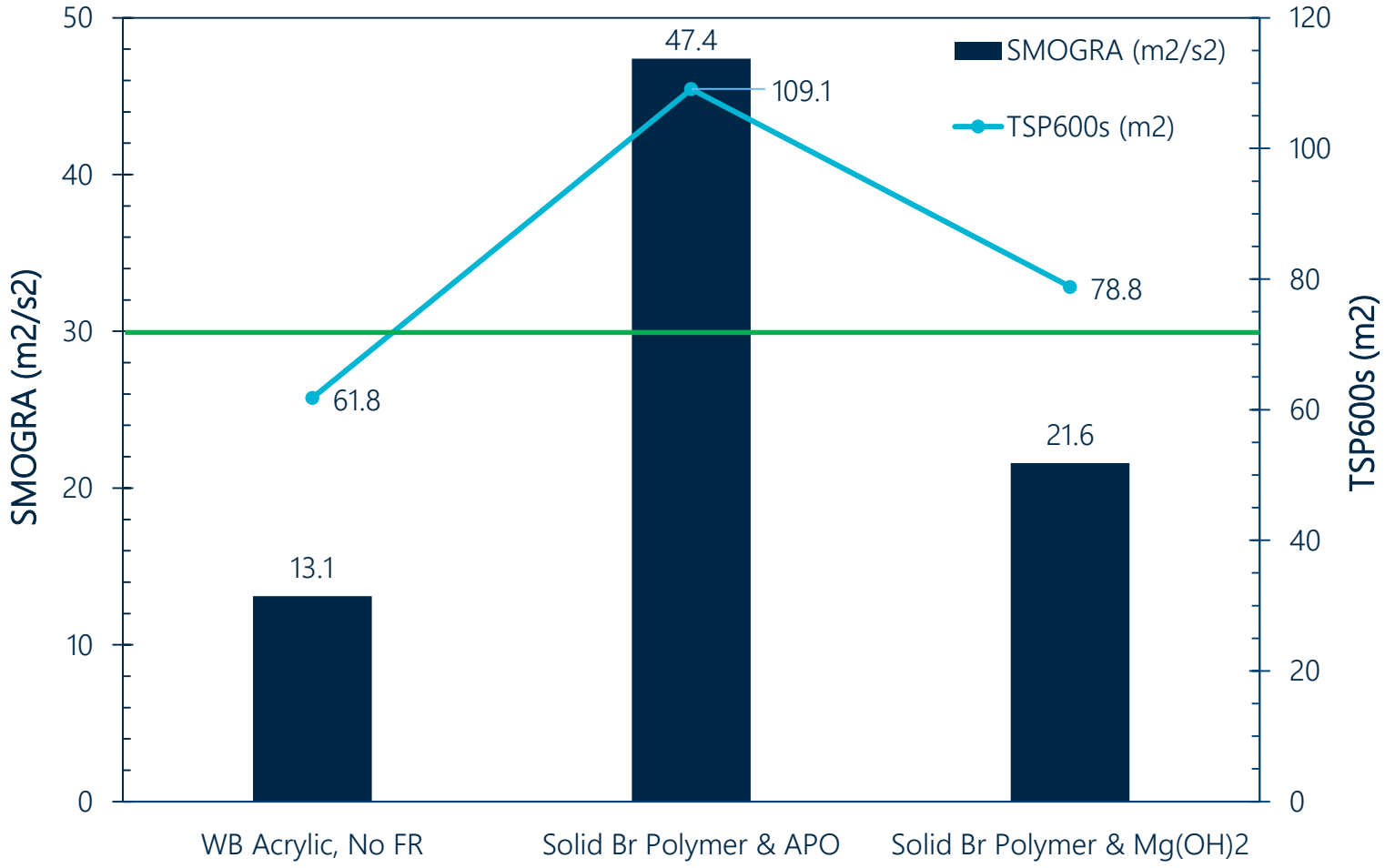
Indicative SBI results*



Addition of Br Epoxy with Magnesium Hydroxide improved the rating of the coated wood from class D to class C (~50% red. In FIGRA)

* Patent application published

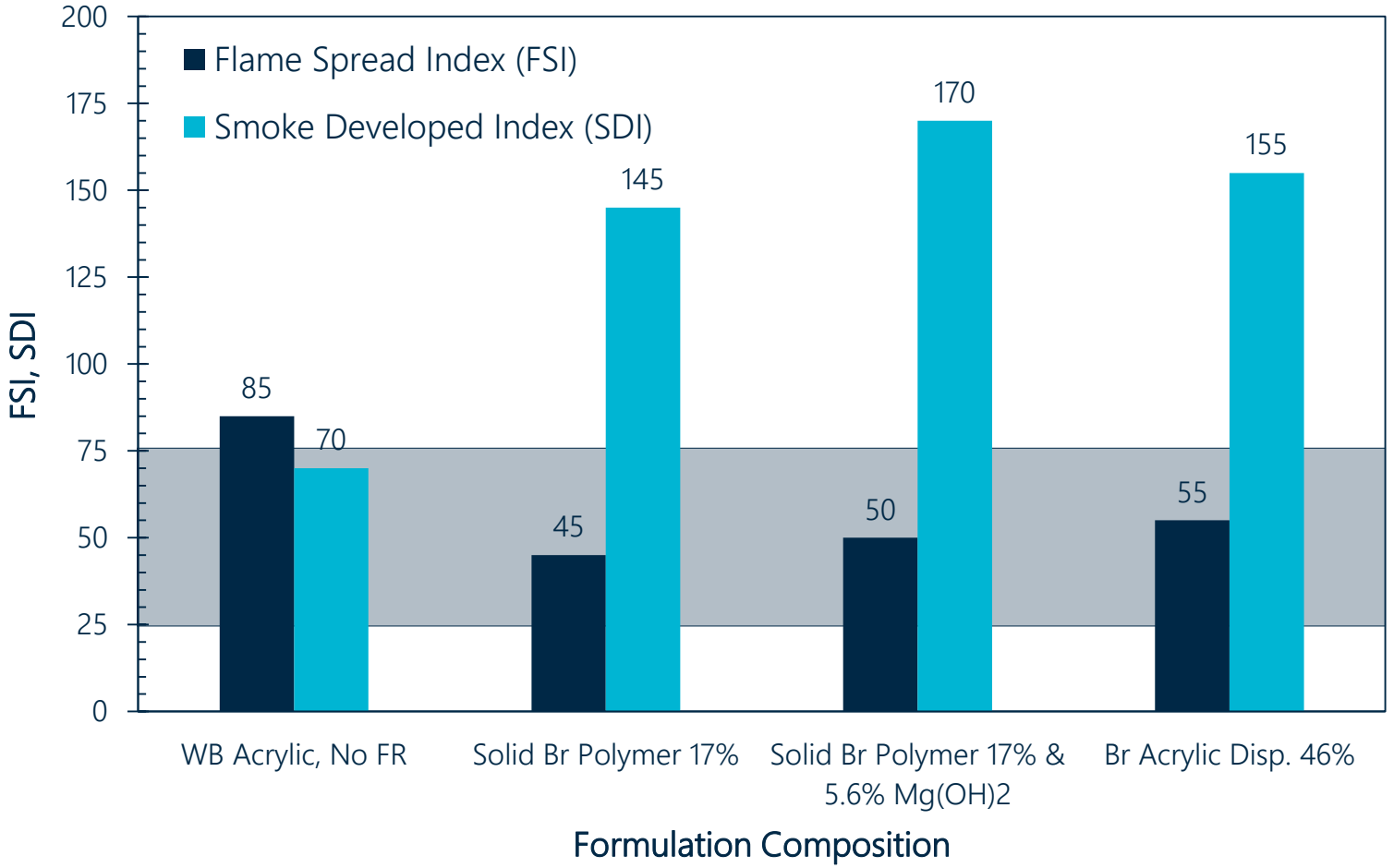
Indicative SBI results*



Addition of Br Epoxy with Magnesium Hydroxide reduced smoke, producing s2 rating with Class C FIGRA

* Patent application published

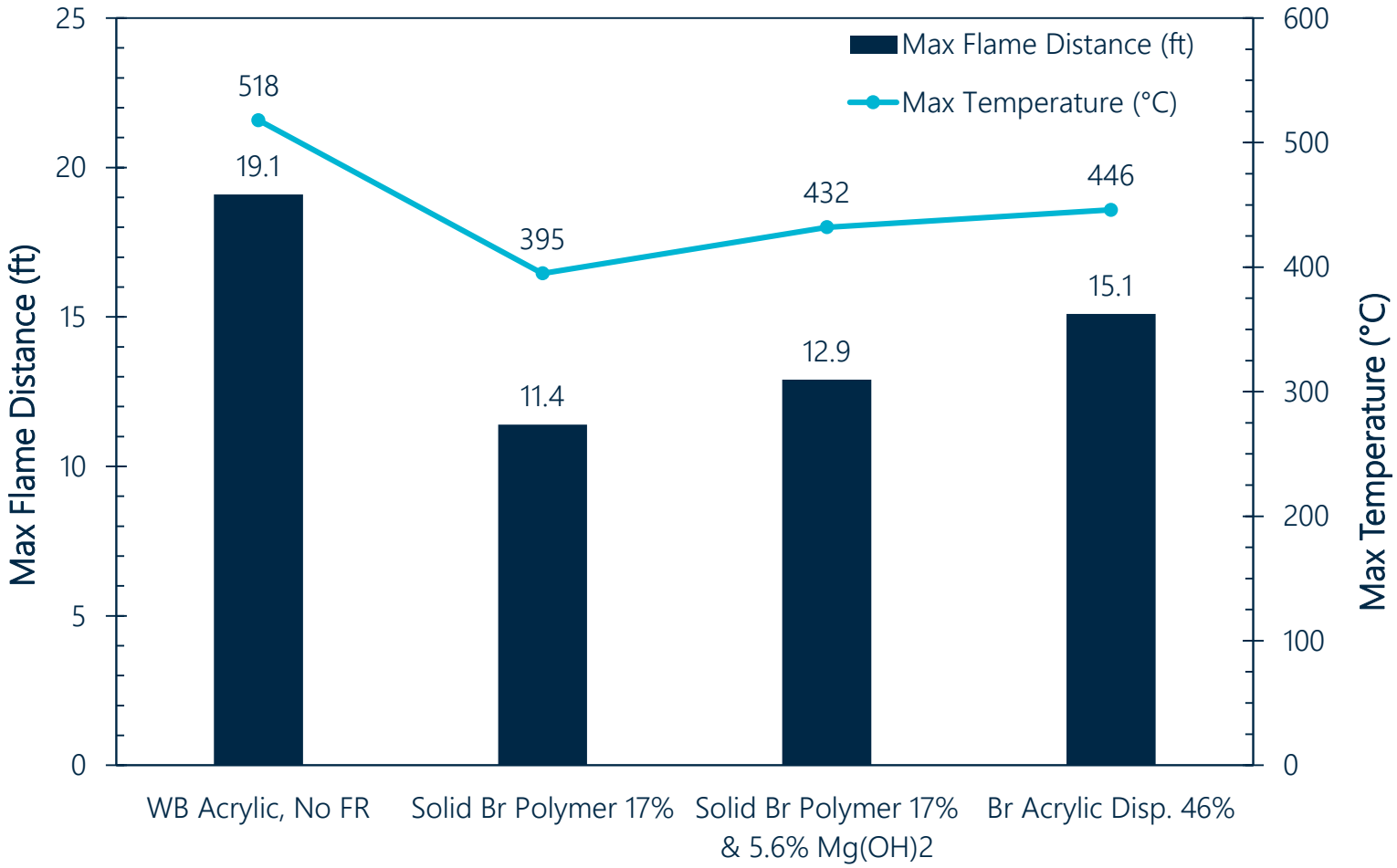
ASTM E84 Test Results



Addition of Br polymers changed the rating of the coated plywood from class C to class B

* Patent application published

ASTM E84 Test Results



Addition of Br polymers reduced flame spread and maximum burn temperature

Summary

Product formulation and appearance:

- Both Br polymers easily dispersed in water
- Br Acrylate provides superior gloss

Cone calorimeter testing:

- More than 20% improvement in peak heat release
- Magnesium hydroxide resulted in improved smoke parameters

SBI test (EU)

- Achieved Class C on FR MDF board based on FIGRA (Br FR + $Mg(OH)_2$ synergist)
- SMOGRA for s2 rating is very close to S1

ASTM E84 Test (NA):

- Achieves Class B on Douglas Fir plywood
- Large margin for Flame Spread and Smoke developed

To conclude..

- Development of and effective sustainable polymeric flame retardants for paint and coating.
- The products gained good FR results in international large-scale testing.
- All these, while maintaining paint stability and wood appearance in the application.

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