

NEW SOLUTIONS FOR FLAME RETARDANT POLYOLEFINS

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Fire Resistance in Plastics
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We are a business of Chemtura Corporation

- ◆ Global specialty chemical company listed on the New York Stock Exchange / EURONEXT (“CHMT”)
- ◆ \$2.2 billion in revenues
- ◆ Roughly 3,300 employees worldwide
- ◆ Global headquarters in Philadelphia, USA
- ◆ Regional headquarters and shared service centers in Sao Paulo, Brazil; Shanghai, China; Middlebury, Connecticut, USA; and Manchester, United Kingdom

**Industrial Performance
Products**



**Industrial Engineered
Products**



Recognized global leader in the innovation, manufacture and marketing of flame retardant solutions

❖ We serve the following major segments:

Electrical & Electronic

- ◆ Printed Wiring Boards
- ◆ TVs and Computers
- ◆ Electrical Connectors

- ◆ OEMs Demand Greener Innovation
- ◆ Emerging Market TV Growth
- ◆ Solution: Emerald Innovation™ 1000

Insulation

- ◆ Expanded Polystyrene (EPS)
- ◆ Extruded Polystyrene (XPS)
- ◆ Rigid PU foam

- ◆ Regulators Demand Greener Innovation
- ◆ Energy Efficient Thermal Insulation Growth
- ◆ Solution: Emerald Innovation™ 3000

Automotive

- ◆ Flexible PU foam
- ◆ Electronics / Wiring
- ◆ Under the Hood

- ◆ Greener Alternatives in Automotive Foam
- ◆ Evolving Fire Safety Standards
- ◆ Solution: Emerald Innovation™ NH-1



What does greener innovation mean to us?

A life cycle approach

- Continually assessing opportunities to improve our portfolio
- Improving EH&S profile of our products, processes and supply chain
- Applying the Principles of Green Chemistry and Green Engineering

Designing sustainable solutions

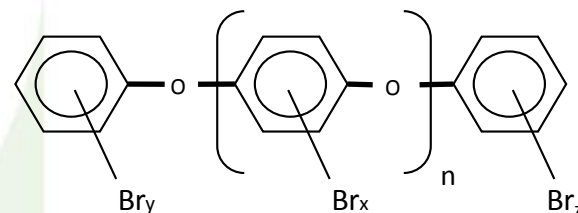
- Design products that are inherently safe by molecular design
- Ensure responsible handling and use throughout the supply chain

Molecular engineering for sustainability

EMERALD INNOVATION™ 1000 TYPICAL PROPERTIES

EMERALD INNOVATION™ 1000 IS DESIGNED FOR USE IN A BROAD SPECTRUM OF APPLICATIONS

Property	Emerald Innovation™ 1000
Appearance	Off-white powder
Bromine, %	~78
Average particle size, (μm)	4
5% wt loss, °C (10 °C/min, N ₂)	410
T _g , °C	154



**BROMINATED POLYPHENYL ETHER
(BR-PPE)**

High bromine content with excellent thermal stability

POLYOLEFINS APPLICATIONS

- Emerald Innovation™ 1000 is an efficient, sustainable replacement for decabromodiphenyl oxide and decabromodiphenyl ethane providing comparable or better properties
- The high bromine content of Emerald Innovation™ 1000 makes it more efficient than other alternatives
- Emerald Innovation™ 1000 offers an excellent balance of physical properties, flammability performance and processibility in HIPS & ABS
- The present study addresses the use of Emerald Innovation 1000 in Polyolefins such as PP, HDPE and EPDM for automotive, electrical and housing applications

POLYPROPYLENE, 20% TALC FILLED

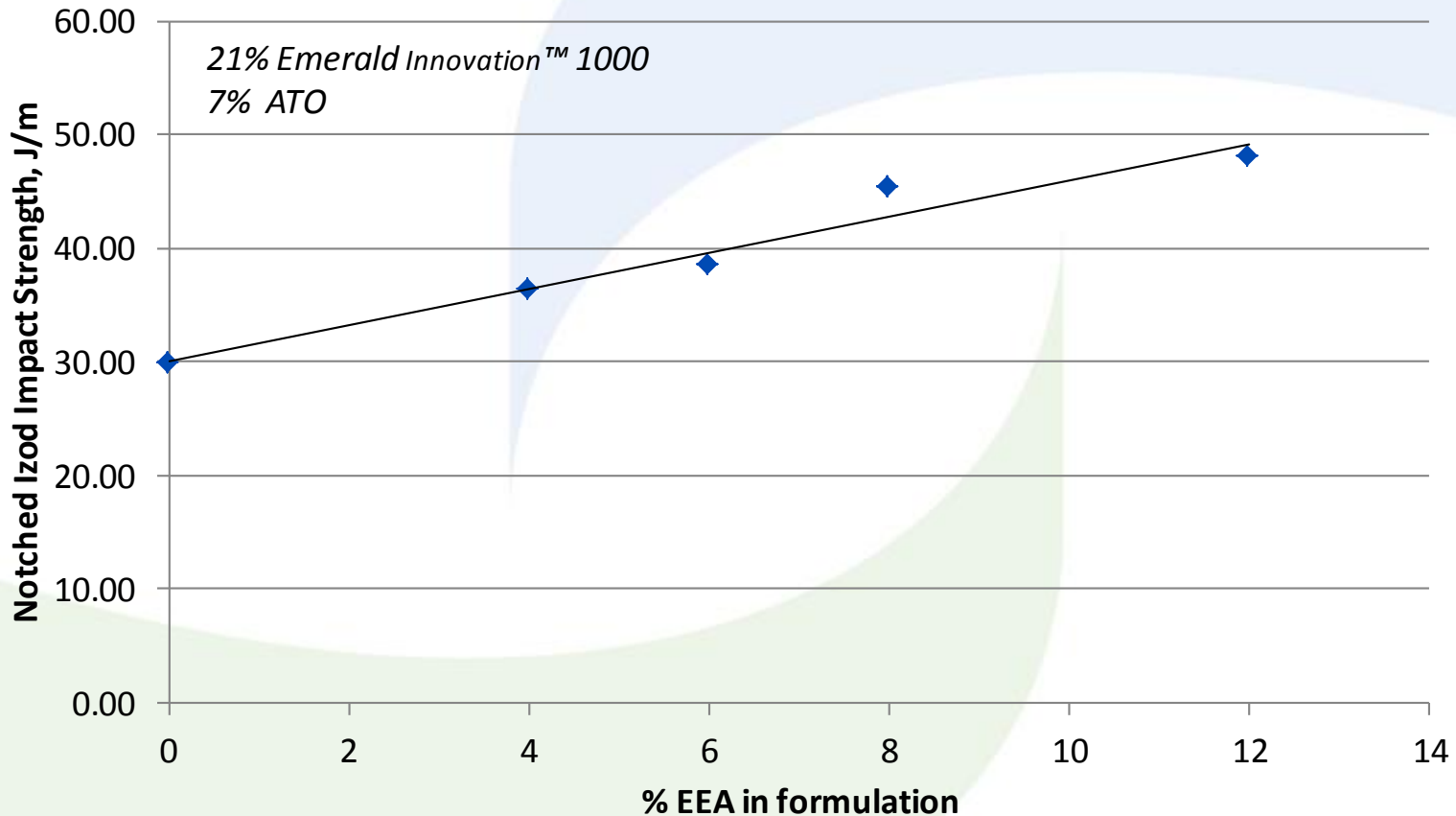
	Emerald Innovation™ 1000	FR-1	FR-2
FR %	21	21	21
ATO, %	4	4	4
Nanoclay, Charex 44PSS, %	3	3	3
UL-94 @ 1.6 mm	V-0	V-0	V-0
UL-5V @ 3.2 mm	5VA	5VA	5VA
t1+t2, sec	18	19	17
Tensile strength, MPa	24.1	22.8	22.8
Elongation at yield, %	1.72	2.01	2.07
Flexural strength, MPa	38.8	37.5	37.2
Flexural modulus, MPa	2578	2641	2663
Notched Izod Impact, J/m	30.8	35.0	35.0
MFI, g/10min, 230 °C/2.16 kg	19.9	15.2	15.1
HDT, 1.8MPa, °C	119.0	110.5	111.8

**Nanoclay can replace a major portion of ATO
Emerald Innovation™ 1000 confers good balance of properties**

*FR-1 decabromodiphenyloxide
FR-2 decabromodiphenylethane*

POLYPROPYLENE, 20% TALC FILLED

70% FR/ATO Masterbatch in EEA/PP

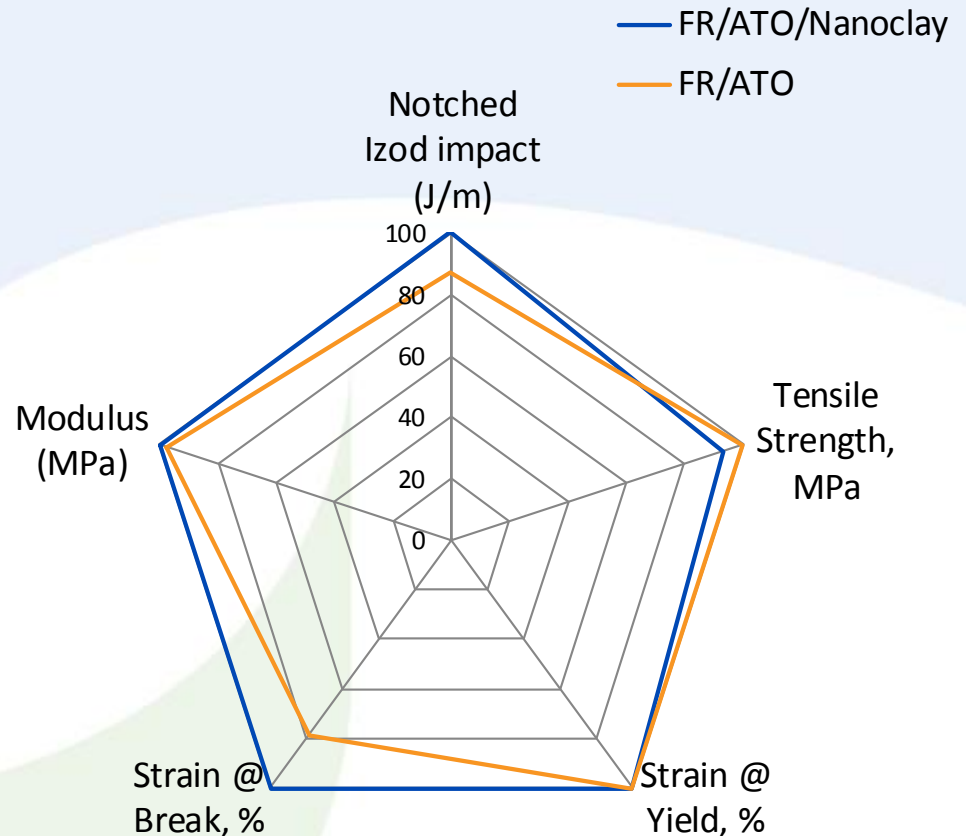


Impact strength can be significantly improved with Ethylene Ethyl Acrylate (EEA)

POLYPROPYLENE, COPOLYMER

V-0 @ 1.6mm

FR, %	26	26
ATO, %	8.7	6.7
Nanoclay, Charex 44PSS, %	-	2
Izod Impact, J/m	118.0	135.2
Tensile strength, MPa	18.2	17.0
Elongation at yield, %	2.5	2.5
Elongation at break, %	4.8	6.1
Modulus, MPa	1588	1623

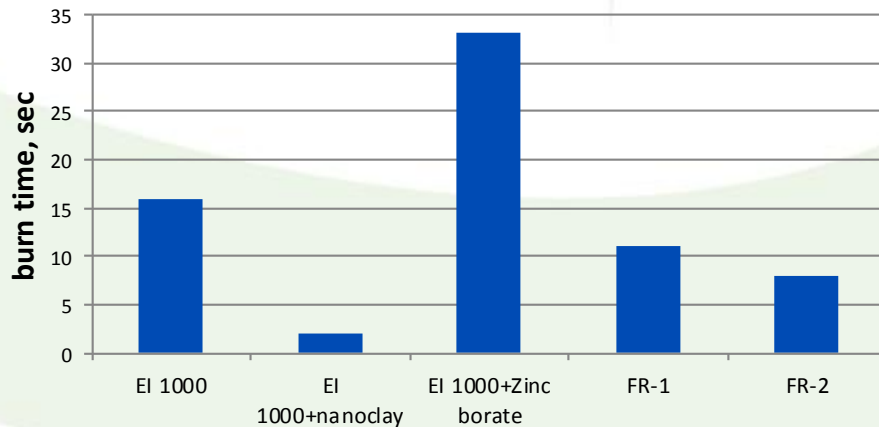


Nanoclay does not adversely affect mechanical properties

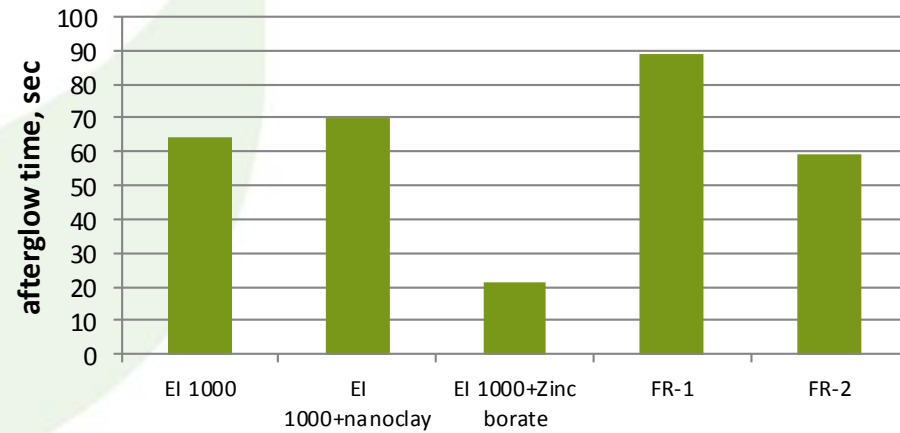
POLYPROPYLENE, 30% GLASS FILLED

	Emerald Innovation™ 1000			FR-1	FR-2
FR, %	21	21	21	21	21
ATO TMS, %	7	6	4	7	7
ZB 467, %	-	-	3	-	-
Nanoclay, Charex 44PSS, %	-	1	-	-	-
t1+t2, sec	16	2	33	11	8
afterglow (sec)	64	70	21	89	59
UL-94 @ 1.6mm	V-0	V-0	V-0	V-0	V-0

Total burn time, seconds



Afterglow time, seconds



**Nanoclay reduces total burn time
Zinc borate helps reduce afterglow**

HIGH DENSITY POLYETHYLENE

<i>Petrothene LR590005</i>	Emerald Innovation™ 1000	FR-1	FR-2	FR-3	FR-4
FR %	19.0	19.0	19.0	21.0	22.3
ATO, %	6.3	6.3	6.3	6.3	6.3
UL-94, 1.6mm	V-0	V-0	V-0	V-0	V-0
t1+t2, sec	3	0	0	3	0
Gardner Impact, J	17.8	17.1	17.7	1.5	15.2
Tensile Strength MPa	21.5	20.3	20.3	24.2	22.4
Elongation at Yield, %	8.5	10.1	8.7	5.6	6.9
Flexural Strength, MPa	23.9	22.4	22.8	29.6	26.0
Flexural Modulus, MPa	635.2	611.0	614.5	799.3	739.3
Whiteness Index, CIE	49.72	55.83	49.51	61.29	46.59
Yellowness index, D1925	8.48	8.39	11.29	8.84	14.64

Emerald Innovation 1000 offers a good balance of physical properties

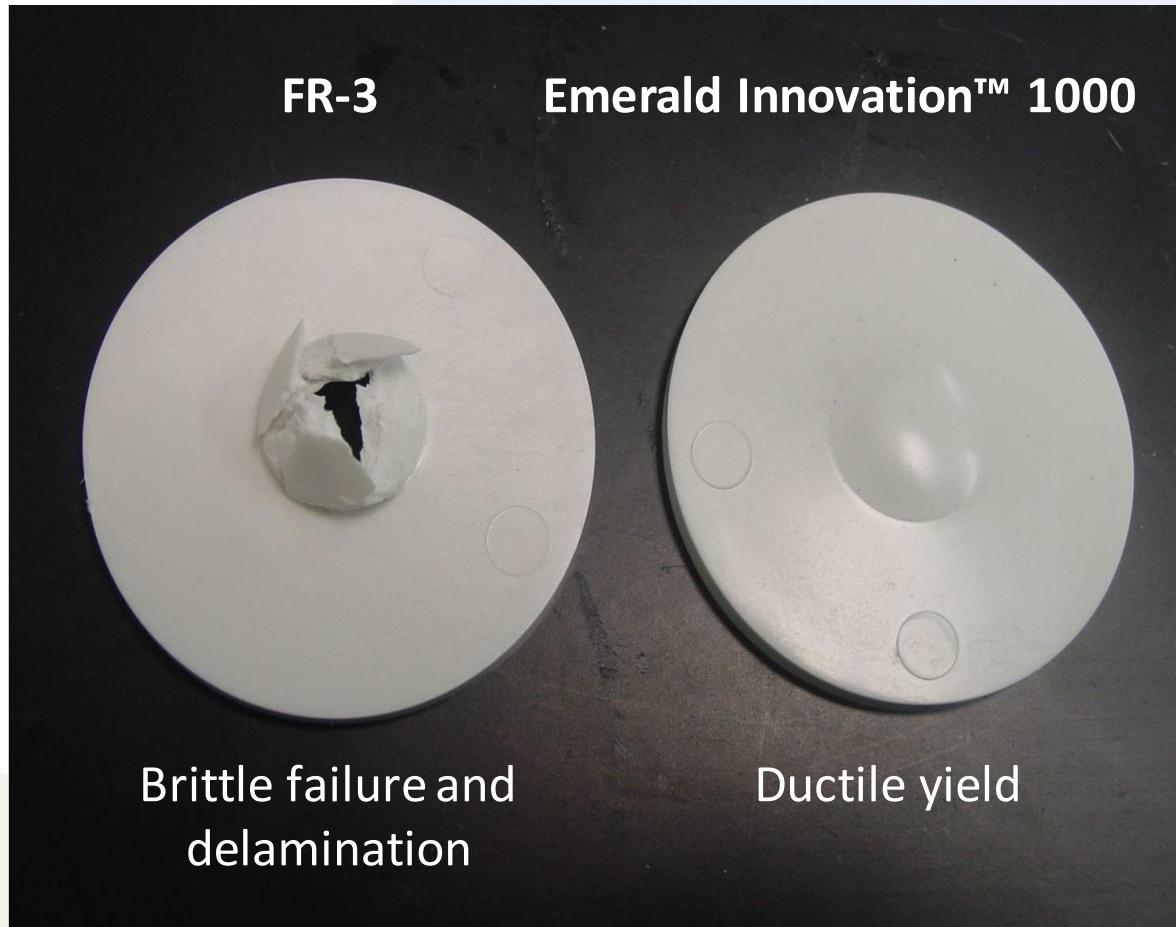
FR-1 decabromodiphenyl oxide

FR-2 decabromodiphenyl ethane

FR-3 poly(pentabromobenzyl acrylate)

FR-4 ethylenebistetra bromophthalimide

GARDNER MULTI-AXIAL IMPACT* OF HDPE



** Tested at room temperature*

Emerald Innovation™ 1000 with HDPE results in significantly better toughness vs. FR-3 for demanding applications

MELT STRENGTH COMPARISON IN HDPE

Emerald Innovation™
1000

FR-1

FR-2

300 °C



270 °C



Test: Resistance to deformation upon exposure to glow wire apparatus at temperatures shown.

Emerald Innovation 1000 is more robust than FR-1 or FR-2

WIRE AND CABLE

- Polymers used in wire and cable insulation include primarily ethylene vinyl acetate (EVA), polyethylene (PE) and ethylene propylene diene (EPDM), to name a few.
- After coating the wire, the polymer undergoes crosslinking either chemically or by irradiation.
- A good balance of properties including flexibility, electrical and flammability is desired.

XL-EVA

	Emerald Innovation™ 1000	FR-1	FR-2	FR-4
FR, %	21	21	21	21
ATO, %	7	7	7	7
Nanoclay, Charex 44PSS, %	1	1	1	1
Talc, %	20	20	20	20
Dicumyl Peroxide, %	3	3	3	3
EVA, Elvax 470, %	48	48	48	48
UL-94 @ 2.8mm	V-0	V-0	V-0	V-0
t1+t2, sec	0	0	0	0
UL 94 5V @ 2.8 mm	5VA	5VA	5VA	5VA

Emerald Innovation™ 1000 gives strong V-0 & 5V

XL-PE

	Emerald Innovation™ 1000	FR-1	FR-2	FR-4
FR, %	21	21	21	21
ATO, %	7	7	7	7
EEA, Amplify EA103, %	5	-	-	-
Nanoclay, Charex 44PSS, %	1	1	1	1
Talc, %	20	20	20	20
Dicumyl Peroxide, %	3	3	3	3
LDPE, Dow 6201, %	43	48	48	48
UL-94 @ 2.8mm	V-0	V-0	V-0	V-0
t1+t2, sec	6	22	0	10

EEA functions as compatibilizer

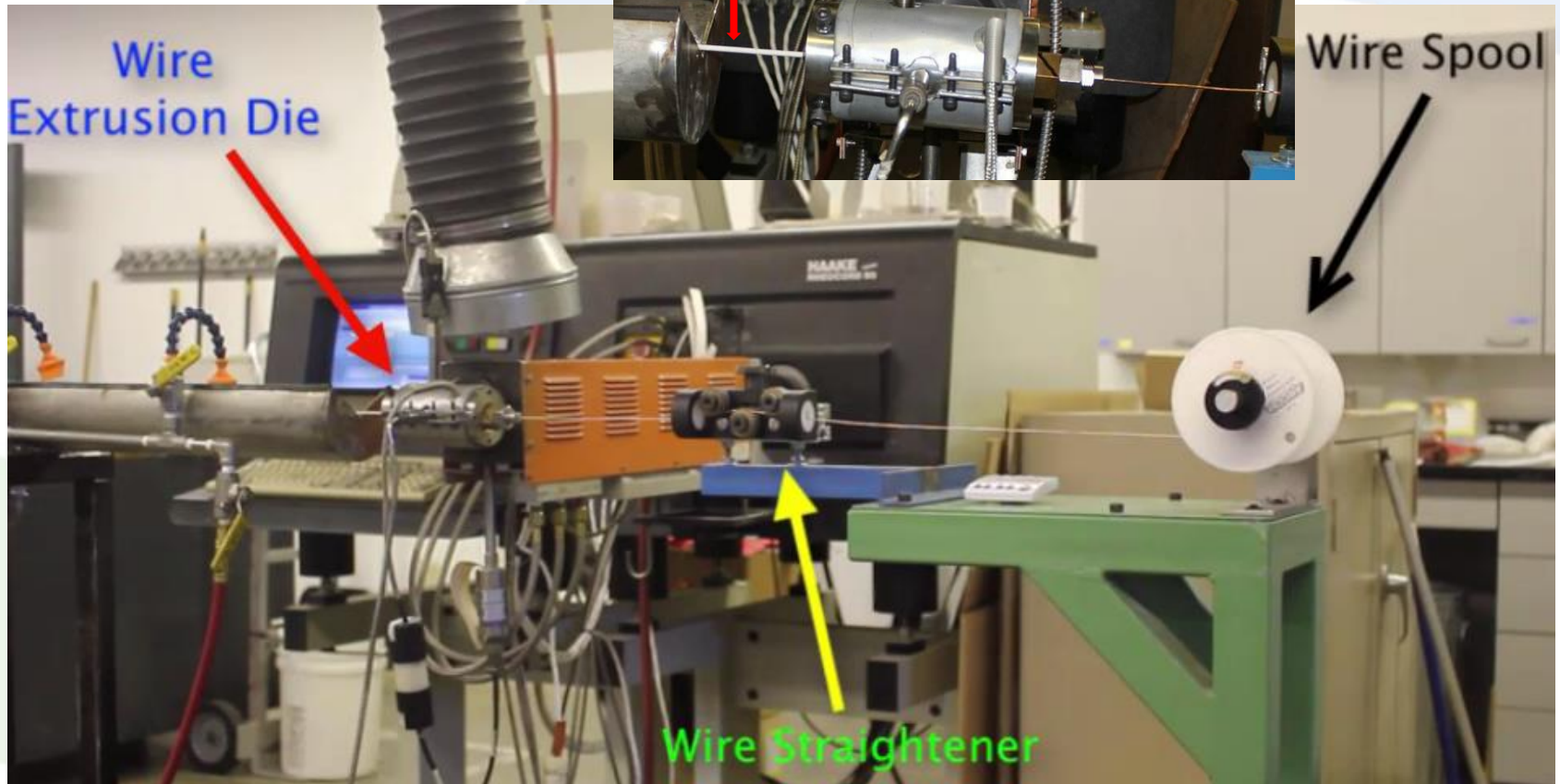
XL-EPDM

	Emerald Innovation™ 1000	FR-1	FR-2	FR-4
EPDM Royaledge 5041, phr	90	90	90	90
LDPE, Dow 6201, phr	-	10	10	10
EEA, Amplify EA103, phr	10	-	-	-
Talc, phr	60	60	60	60
FR, phr	40	40	40	40
ATO, phr	13.3	13.3	13.3	13.3
Nanoclay, Charex 44PSS, phr	2	2	2	2
Paraffin Wax, phr	2	2	2	2
Zinc Oxide, phr	3	3	3	3
Dicumyl Peroxide, phr	3	3	3	3
UL-94 V @ 2.8 mm	V-0	V-0	V-0	V-0
t1+t2, sec	7	10	22	4
UL 94 5V @ 2.8 mm	5VA	5VA	5VA	5VA

EEA can be used directly in lieu of LDPE; EEA may be added as a 80% FR/ATO Masterbatch

MAKING WIRE INSULATION

Coated wire



UL 1581 VW-1

Wire and Cable

Burner Type

Laboratory burner (Tirrill burner) with a heat output of approximately 3,000 BTU/hour (as specified in ASTM D 5025-94) (methane is specified)

Sample Position and Length

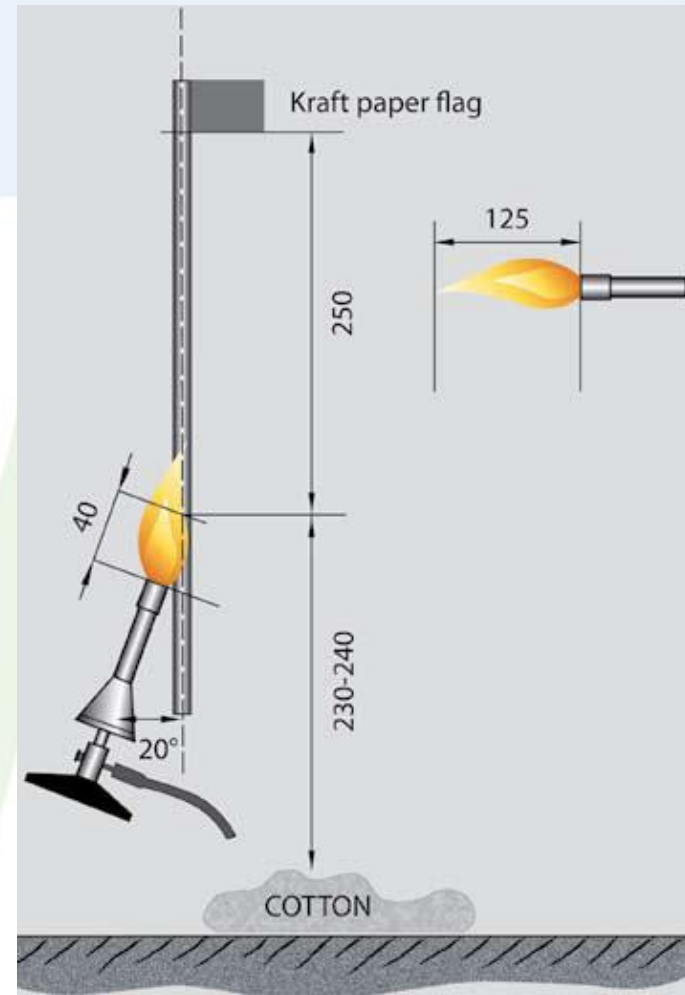
Vertical / 450 mm

Flame Duration

5 cycles, each cycle 15 sec. with a break of min.15 sec., and max. 60 sec., depends on the flame time of the specimen

Pass Conditions

- Not more than 25% of the paper must be carbonized .
- The sample must not continue to burn longer than 1 min.
- Drips should not ignite the cotton



EPDM WIRE INSULATION

Formulation	1	2	3
EPDM Royaledge 4191P-1, phr	100	90	90
EEA, Amplify EA103, phr	-	10	10
Kaolin Clay, Polyfil WC, phr	60	60	60
Emerald Innovation™ 1000, , phr	40	40	30
ATO, phr	13.3	13.3	10
Nanoclay, Charex 44PSS, phr	2.5	2.5	2.5
Paraffin Wax, phr	2	2	2
Zinc Oxide, phr	5	5	7
Dicumyl Peroxide, phr	7	7	7
UL VW-1			
Specimen 1 (t1/t2/t3/t4/t5)	0/0/3/1/0	0/2/3/0/0	0/12/1/0/0
Specimen 2 (t1/t2/t3/t4/t5)	0/1/36/0/0	1/4/4/0/0	1/21/0/0/0
Specimen 3 (t1/t2/t3/t4/t5)	0/0/22/0/0	1/5/2/0/0	2/21/5/0/0
Rating	Pass	Pass	Pass

***EEA functions as a compatibilizer
Increasing Zinc oxide & reducing FR levels maintain VW-1***

WIRE INSULATION AFTER VW-1 TEST



Indicator flag

char

Intact insulation

SUMMARY

- Emerald Innovation™ 1000 offers an excellent balance of physical properties, flammability performance and processibility for Polyolefins
- Emerald Innovation™ 1000 imparts V-0, 5V and VW-1 ratings in Polyolefins.
- Ethylene ethyl acrylate helps compatibilize Emerald Innovation™ 1000 in crystalline polymers
- Partial replacement of ATO synergist can be achieved using Nanoclay, Charex 44PSS or Zinc borate, ZB467
- For Wire and Cable applications, Emerald Innovation 1000 offers excellent processibility, mechanical and flammability properties