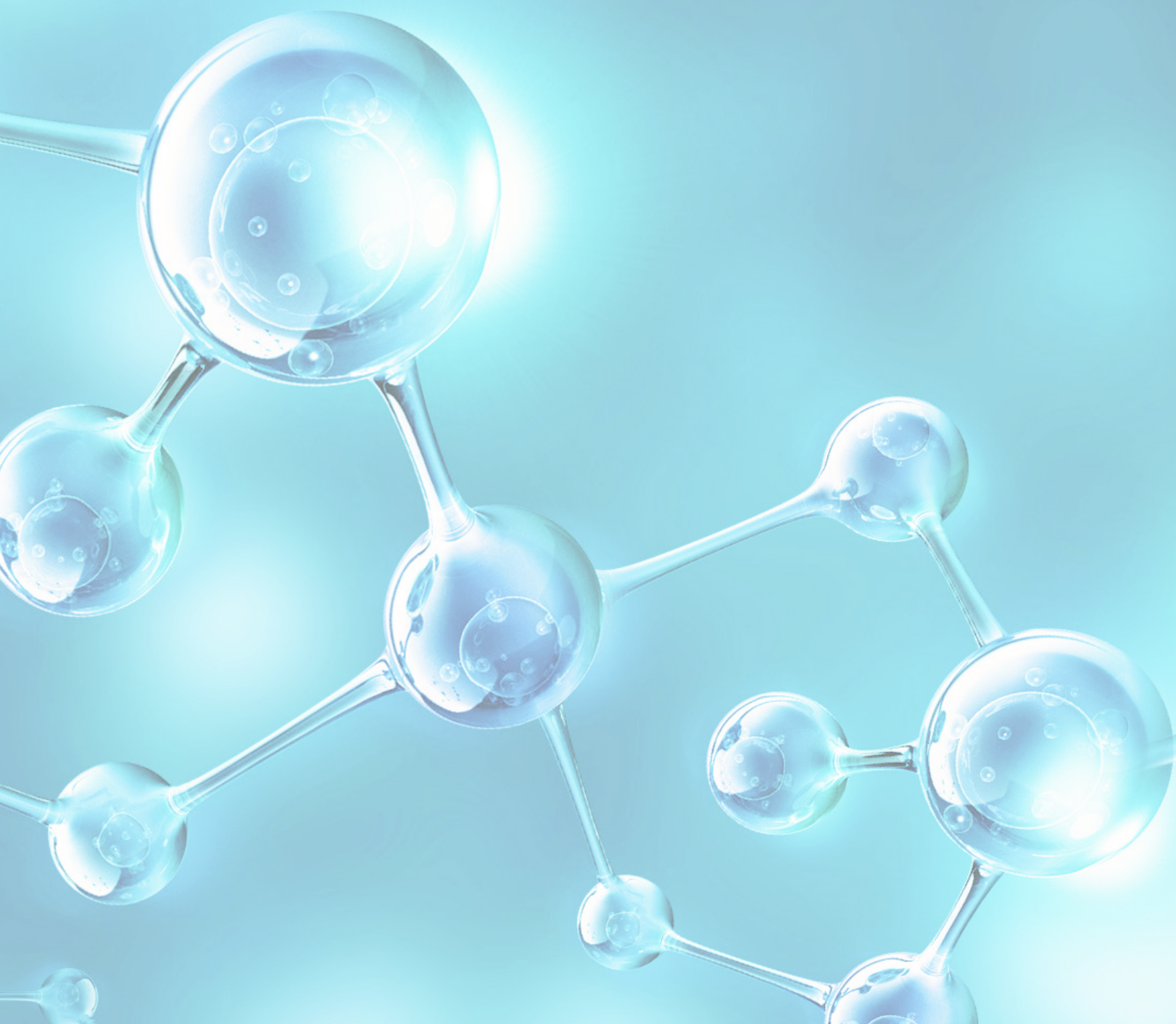
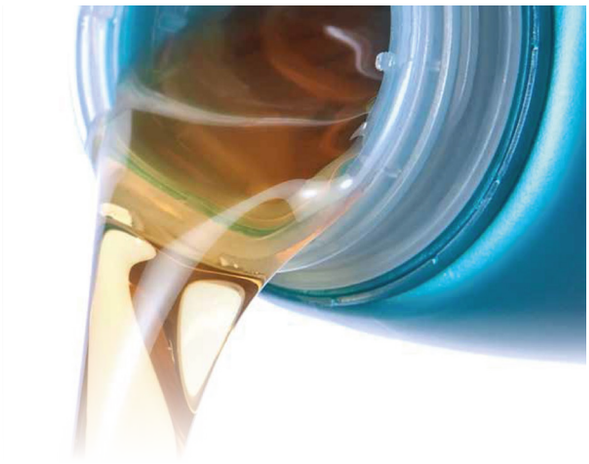
Resins
Fire Retardant



POLYNT COMPOSITES

Global leader
for thermoset composites



Contents

Polynt Reichhold Group

After the merger on May 2017 the new Polynt-Reichhold Group is a global Company in the Intermediates, Coating and Composite Resins, Thermoset Compounds, Gel-coats and niche Specialties.

This combination enhances the Group's leading position as a global vertically integrated specialty chemicals player, with significant global presence in Europe, North America and Asia, a strategy initiated by Polynt with the successful integration of PCCR and CCP in the last years and now further reinforced by Reichhold's global scale, extensive product portfolio and R&D competencies.

Polynt-Reichhold Group is known for its superior quality and impressive range of products and with its excellent distribution network it can provide first-class service to customers whatever their market. Customer Service and Technical Service teams are renowned for their customer focus, offering the best service even after products have left manufacturing.

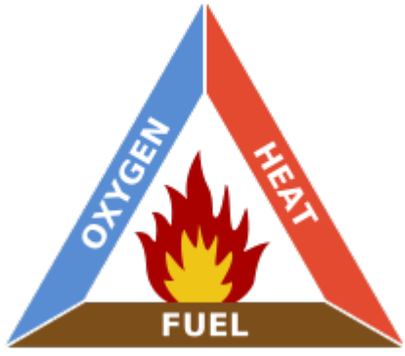
The Group strives to keep customers satisfied, assisting them in producing premium quality products every time they use its products.

Product innovation is important for the Group's business and it's the reason for which it constantly works with customers to find solutions to problems.

Introducing new or improved products ensures that Polynt-Reichhold Group continue not only to deliver what the market wants and needs, but also when it is wanted and needed.

Introduction to the Fire Retardant System

Fire triangle



The triangle illustrates the three elements a fire needs to ignite: heat, fuel, and oxygen. A fire occurs when those 3 elements are present and combined in the right mixture. A fire can be extinguished by removing any one of the 3 elements.

As a result, different physical processes need to be considered for fire retardant:

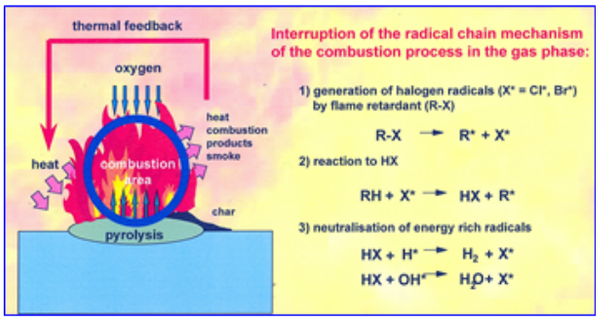
- Cooling: endothermic decomposition reaction of the flame retardant additive that causes a decrease in the temperature needed to maintain combustion, thus limiting the emission of combustible gas by the polymer.
- Dilution: a release of inert gases (CO_2, NH_3, H_2O, etc.) from the thermal decomposition of additives contributes to the dilution of combustible gases below the ignition threshold.
- Formation of a protective layer: some flame retardants lead to the formation of a solid protective layer limiting the transfer of heat and mass between the polymer and the flame.

The fire retardants and their mode of action

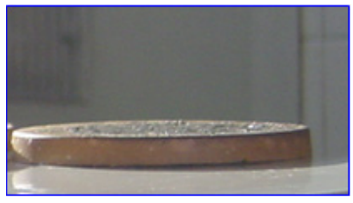
There is no single solution for fireproofing materials. Different options can be used alone or in combination (cooling, inhibition of combustion reaction, thermal protection) in order to achieve the target. However, it is important to find the best compromise between improved fire resistance and other requirements such as mechanical properties, weather resistance (water, UV), economic feasibility and environmental issues.

These fire retardant options are:

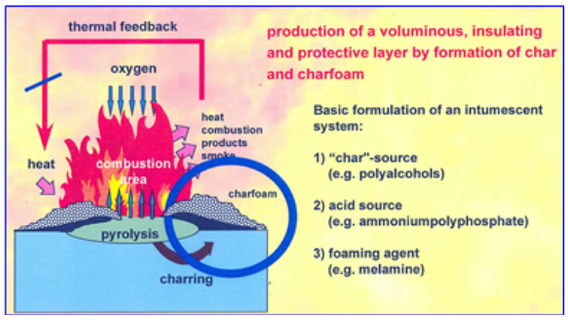
- Halogenated compounds: Brominated derivatives are the most effective. Very often associated with antimony oxides (synergy), halogenated derivatives exhibit a chemical mode of action mainly in the gas phase. Their performance, which is efficient at even relatively low content, is characterized by the generation of opaque and toxic fumes during combustion.
- Metal hydroxides: mainly aluminium trihydrate, which acts as both a flame retardant and a smoke suppressor. The resulting performance is interesting, but to be effective, these compounds must be used in very large quantities, often greater than 50% in mass, which will result in a significant decrease of mechanical characteristics and an increase in density and difficulty of wetting.
- Phosphate and nitrogen compounds: phosphorus derivatives have the ability to form a protective layer when the polymer burns, thus limiting the supply of oxygen and energy to the fuel. Ammonium polyphosphates have the advantage of combining the action of phosphoric acid with that of nitrogen in the gas phase.
- Intumescent systems: intumescence is the ability of a material to develop a carbon shield of such thickness that gas and heat transfers are limited. The recipes involve an acidic substance, an inflating agent and a carbon source that leads to the formation of a «char» when the temperature of the polymer rises. It helps to limit the spread of fire by blocking the passage of smoke, flame and heat while giving the product a lower density than common charged systems.



Inhibition in Gas Phase (smoke/toxicity)



Intumescent



Condensed Phase Carbon Char

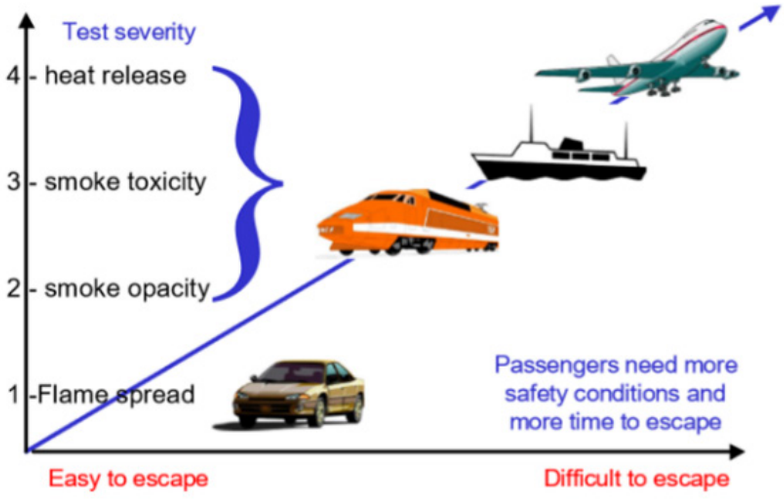
Images given by CREPIM.

The table in central pages of this brochure shows the type of fire retardant for each listed product:

- **HF -** Halogen Free;
- **H -** Halogen;
- **I -** Intumescent;
- **FI** - Filled.

Standards

A large number of standards exist because fire risk level depends on the environment the components are going to be exposed to (the risk class being related to the evacuation conditions).



A direct comparison of individual national tests and associated classifications with the European Standards is very difficult because it could be subject to different interpretations of the various ratings.

A typical example is represented by below table comparing the most commonly used Standards for the Building Industry in Europe:

Euroclass	German			Euroclass	French	Euroclass	UK (Engl., Wales, N.I.)
EN 13501-1	DIN 4102-1	No Smoke	No droplets	EN 13501-1	NF P92-507	EN 13501-1	BS 476/6 BS 476/7
A1	A1	✓	✓	A1	non combustible	A1	non combustible
A2 - s1, d0	A2	✓	✓	A2 - s1, d0	M0	A2 - s1/s2/ s3/, d0/d1/d2	limited combustible
				A2 - s1/s2/s3, d0/d1	M1		
B/C - s1, d0	B1	✓	✓	B - s1/s2/s3, d0/d1		B - s1/s2/s3/, d0/d1/d2	Class 0
A2/B/C - s2/ s3/, d0			✓	C - s1/s2/s3, d0/d1	M2	C - s1/se/s3/, d0/d1/d2	Class 1
A2/B/C - s1, d0/d1		✓					
A2/B/C - s3, d2							
D - s1/s2/s3/, d0	B2		✓	D - s1/s2/s3/, d0/d1	M2	D - s1/s2/s3/, d0/d1/d2	Class 3
D - s1/s2/s3/, d1/d2				D - s1/s2/s3/, d0/d1	M4 (no droplets)		
E				E	M4	E	
				E - d2			
F	B3			F		F	

Reaction to fire classification: B - s1, d0

Main indicator; fire classification.
From highest rating A1 via A2, B, C, D, E to F being the lowest level of performance. → **B**

Additional indicator; smoke production.
From highest classification s1 via s2 to s3 being the lowest level of performance. → **s1**

Additional indicator; burning droplet foming.
From highest classification d0 via d1 to d2 being the lowest level of performance. → **d0**

Euroclass		Classification for smoke or droplets	
A1	Not inflammable	s1	No smoke
A2	Almost not inflammable	s2	Limited smoke poduction and smoke increase
B	Very difficultly inflammable	s3	No limitation on smoke production required
C	Moderately inflammable		
D	Well inflammable	d0	No droplets allowed
E	Very inflammable	d1	No droplets for longer than certain time given
F	Extremely inflammable	d2	No limitation on droplets rquired

REFERENCE	Process	Type of resin	Type of Gelcoat	BUILDING								RAILWAYS					
				France		Spain	UK		USA	Germany	EUROPE	EN 45545-2-2013				CLASSIF. DIN 5510	
													ISO 5658-2	ISO 5659-2	ISO 5660		UIC Kodex 564-2 App 4
		HF (Halogen Free) H (Halogen) I (Intumescent) FI (Filled)		NFP 92-501	NFP 16-101	UNE 23.727-9	BS 476 part 6	BS 476 part 7	ASTM E84	DIN 4102	EN 13501-1	EN 45545	CFE	SMOKE CHAMBER	CONE CALORIMETER	Standards linked (DIN 53438 /5837 /4102/50050-2)	Fire prevention and fire fighting regulations for rail vehicles used in international traffic
DION® FR 7721-00	HLU-SU	FI-HF	-	M2	F1			Class 2							105	S4, SR2, ST2	Class B
DION® FR 7721-00	HLU-SU	FI-HF	NORPOL SVX								D-S3,d 0	HL3	20,3	93/45	19,7		
DION® FR 800-200	HLU-SU	FI-H	-												12		
DION® FR 820-034	Cont. Laminate	H	-												149		
DION® FR 820-080	Cont. Laminate	H	-												152		
DION® FR 820-606	INFUSION	H	-												131		
			NORPOL® MTI 10176													S 4, SR2, ST2	
			SVG														
			NORPOL® NGA X2														
DION® FR 820-M723	Cont. Laminate	H	-														
DION® FR 820-M878	HLU-SU	FI-H	-												113		
DION® FR 840-820	HLU-SU	FI-H	-	M1	F2			Class 1							67		
			NORPOL® GI 10176	M1													
DION® FR 840-850	HLU-SU	FI-H	-												71		Class A
			NGA HX3														
DION® FR 844-030	Cont. Laminate	H	-					Class 1							74		
DION® FR 850 series	HLU-SU	FI-HF	-														
DION® FR 850-700	HLU-SU	FI-HF	-													S4, SR2, ST2	
			NGA HX3					Class 2									
DION® FR 850-M850	HLU-SU	FI-HF	-												135	S4, SR2, ST2	
DION® FR 852-700	HLU-SU	FI-HF	-													S4, SR2, ST2	
			NORPOL® MTI 10176													S4, SR2, ST2	
DION® FR 9300-00	HLU - Fil. Winding	H	-					Class 2	Class 2						99		
	HLU-SU		3 % ATO					Class 1									
			35% ATH														Class A
DION® FR 9300-890	HLU-SU	FI-H	-		F3												
ENYDYNE H 68180 TA	HLU-SU	not FR	-														
ENYDYNE H 68372 TA	HLU-SU	not FR	-														
ENYDYNE H 68377 TAE	HLU-SU	not FR	-							Class B2							
ENYDYNE H 86181 TF	HLU-SU	FI-H	-	M2	F1											S4, SR2, ST2	
			POLYCOR 2335									HL2	30,0	240/141	66		
ENYDYNE H 86291 TF	HLU-SU	FI-H	-	M1	F2						B-S3, d0					S4, SR2, ST2	
			POLYCOR M1														
ENYDYNE H 89295 FA	HLU-SU	FI-HF	-	M2	F1											S4, SR2, ST2	
ENYDYNE H 89396 FA	HLU-SU	FI-HF	-	M2	F1											S4, SR2, ST2	
ENYDYNE I 69473 A	RTM	not FR	POLYCOR 2335									HL1	28,6	271/146	108		
EPOVIA KRF 2000	HLU	H	-	M2	F3												
NORSODYNE H 13372 TA	HLU-SU	not FR	POLYCOR 2335									HL1	13,0	275/160	97		
NORSODYNE H 25375 TAE	HLU-SU	not FR	-							Class B2							
NORSODYNE H 81269 TF	HLU-SU	FI - I - HF	POLYCOR 2220								B-S1, d0					S4, SR2, ST2	
			POLYCOR 2335									HL3	29,2	182/99	42		
NORSODYNE H 81381 TFA	HLU-SU	FI-I-HF	Classic Gel coat ATH												109		
			Polycor 2330	M1	F1										84		
			POLYCOR 2335	M1	F2							HL3	28,2	134/67	53		
			POLYCOR 2335+Paint*									HL2	29,0	128/82	83		
NORSODYNE H 84233 L	HLU	H	-	M2	F4												
NORSODYNE H 88203 TAF	HLU-SU	FI-H	-				Class 0	Class 1									
NORSODYNE H 88204 TAF	HLU-SU	FI-H	-					Class 1									
NORSODYNE H 88222 TA	HLU-SU	FI-H	-					Class 2									
NORSODYNE I 81268 F	RTM	FI-I-HF	POLYCOR 2335 PA + ROVICOR									HL2	32,8	173/73	69		
PRESTER 1150	HLU-SU	FI-H	UNIGEL 11M BLANCO		F1	M1											
PRESTER 1165	HLU-SU	FI-H	UNIGEL 2HL									HL2	21,0	123/63	77		

These results have be obtained on specimens. They are able to demonstrate the capability of our products to be compliant with the requirements. End users have to check the compliance of the laminates they make.

REFERENCE	Process	Type of resin	Type of Gelcoat	MARINE			MILITARY		VEHICULE		SINGLE TESTS			
				IMO			MILITARY SPECIFICATION		FMVSS 302	UTAC n° 18-502/1	ISO 4589-2:2006 ASTM D 2863: 2013	CSE RF-3-77	NF EN ISO 11925-2	UL94
		HF (Halogen Free) H (Halogen) I (Intumescent) FI (Filled)		IMO FTPC Part 5	IMO MSC/Circ. 1006, item 3	IMO MSC/Circ. 1006, item 4	MIL R2167 / MIL R7575	MIL R24719	Flammability of Interior Materials for transportation	Interior finishing materials, showing no droplet formation and a low burning rate	Determination of burning behaviour by oxygen index	Test method radiant panel	Ignitability of products subjected to direct impigement of flame	Standard for Safety of Flammability of Plastic Materials
				Fire Test for surface flammability	Guidelines on fire test procedures for acceptance of fire-retardant materials for the construction of lifeboats		This specification covers requirements for epoxy-based, vinyl ester resins suitable for lamination of boat hulls and other Naval applications							
DION® FR 7721-00	HLU-SU	FI-HF	-											
DION® FR 7721-00	HLU-SU	FI-HF	NORPOL SVX											
DION® FR 800-200	HLU-SU	FI-H	-									Class 2		5V
DION® FR 820-034	Cont. Laminate	H	-											
DION® FR 820-080	Cont. Laminate	H	-											
DION® FR 820-606	INFUSION	H	-											
			NORPOL® MTI 10176											
			SVG											
			NORPOL® NGA X2											
DION® FR 820-M723	Cont. Laminate	H	-						Compliant					
DION® FR 820-M878	HLU-SU	FI-H	-				Grade A							
DION® FR 840-820	HLU-SU	FI-H	-											
			NORPOL® GI 10176											
DION® FR 840-850	HLU-SU	FI-H	-											V0
			NGA HX3											
DION® FR 844-030	Cont. Laminate	H	-											V0
DION® FR 850 series	HLU-SU	FI-HF	-				Grade A							
DION® FR 850-700	HLU-SU	FI-HF	-											
			NGA HX3											
DION® FR 850-M850	HLU-SU	FI-HF	-											
DION® FR 852-700	HLU-SU	FI-HF	-											
			NORPOL® MTI 10176											
DION® FR 9300-00	HLU -Fil. Winding	H	-					Compliant						
	HLU-SU		3 % ATO											
			35% ATH											
DION® FR 9300-890	HLU-SU	FI-H	-											
ENYDYNE H 68180 TA	HLU-SU	not FR	-							Type A cat 1				
ENYDYNE H 68372 TA	HLU-SU	not FR	-							Type A cat 1				
ENYDYNE H 68377 TAE	HLU-SU	not FR	-											
ENYDYNE H 86181 TF	HLU-SU	FI-H	-								LOI = 35,6%			
			POLYCOR 2335											
ENYDYNE H 86291 TF	HLU-SU	FI-H	-										Compliant	
			POLYCOR M1										Compliant	
ENYDYNE H 89295 FA	HLU-SU	FI-HF	-											
ENYDYNE H 89396 FA	HLU-SU	FI-HF	-											
ENYDYNE I 69473 A	RTM	not FR	POLYCOR 2335											
EPOVIA KRF 2000	HLU	H	-											
NORSODYNE H 13372 TA	HLU-SU	not FR	POLYCOR 2335											
NORSODYNE H 25375 TAE	HLU-SU	not FR	-											
NORSODYNE H 81269 TF	HLU-SU	FI-I-HF	POLYCOR 2220											
			POLYCOR 2335											
NORSODYNE H 81381 TFA	HLU-SU	FI-I-HF	Classic Gel coat ATH											
			Polycor 2330											
			POLYCOR 2335											
			POLYCOR 2335+Paint*											
NORSODYNE H 84233 L	HLU	H	-											
NORSODYNE H 88203 TAF	HLU-SU	FI-H	-											
NORSODYNE H 88204 TAF	HLU-SU	FI-H	-											
NORSODYNE H 88222 TA	HLU-SU	FI-H	-											
NORSODYNE I 81268 F	RTM	FI-I-HF	POLYCOR 2335 PA + ROVICOR											
PRESTER 1150	HLU-SU	FI-H	UNIGEL 11M BLANCO											
PRESTER 1165	HLU-SU	FI-H	UNIGEL 2HL											

* This has been obtained with HL2 Paint

Railways Standards

Transportation: EN 45545 Part 2 +A1: 2016 - Fire Protection on Rail Vehicles

The standard EN 45545-2 came into force in January 2018. From January 2015 to December 2017, it was possible to use the national standards to qualify materials installed in railway vehicles. Now, all new materials are tested against the European Standard in order to guarantee the same level of security whatever the location in the EU."

The standard EN 45545-2 is no longer just a simple pass/fail or a classification to a single fire test; compliance depends upon the Operation/Design Categories combined with the type of Part to be produced which then leads to a series of requirements (parameters) from the following main three tests:

1. ISO 5658-2 to measure CFE (kWm-2) or Flame Spread
2. ISO 5660-1 (50 kWm-2) to measure MAHRE (kWm-2) or Heat Release
3. ISO 5659-2 (50 kWm-2) + FTIR to measure Ds(4); VOF4 + CITG or Smoke/Toxicity

The standard calls for high performance products to be used in high risk scenarios, with a definite emphasis on passenger/staff safety.

1. **Operation Category:- the relationship between service, infrastructure + evacuation conditions**
   - OC1 = Typically Surface Operation with short tunnels, such as a Tramway or Heavy Rail
   - OC2 = Typically City Metro Systems or surface rail with longer tunnels, short time to safety
   - OC3 = Typically very long tunnel sections (Alps, or Channel Tunnel), longer time to safety
   - OC4 = Special Vehicles operating mainly underground with restricted evacuation routes (Channel Tunnel Motor Vehicle Transporters)
2. **Design Category:**
   - A = Automated Stock with no staff on board
   - D = Double Decked Rail Stock
   - S = Sleeping/Couchette Rail Stock
   - N = All Other (Standard) Stock

These two parameters are linked to give a required Hazard Level (HL), each of which has a set of requirements (e.g. R1, R2 + R3) that depend on the part to be produced. Where HL3 is the highest performance and is typically achievable using SMC as the application method.

Operation \ Design	N	A	D	S
OC1	HL1	HL1	HL1	HL2
OC2	HL2	HL2	HL2	HL2
OC3	HL2	HL2	HL2	HL3
OC4	HL3	HL3	HL3	HL3

The Higher the Risk, the Higher the Safety Factors required: HL3 > HL2 > HL1

There are many interior part definitions to be considered. For instance, the following all require R1 compliance: IN1; IN4; IN5; IN6A; IN7; IN8; IN10B; IN12; IN13 + IN15: a further three require R2 and one R3. The end user will be aware of these definitions.

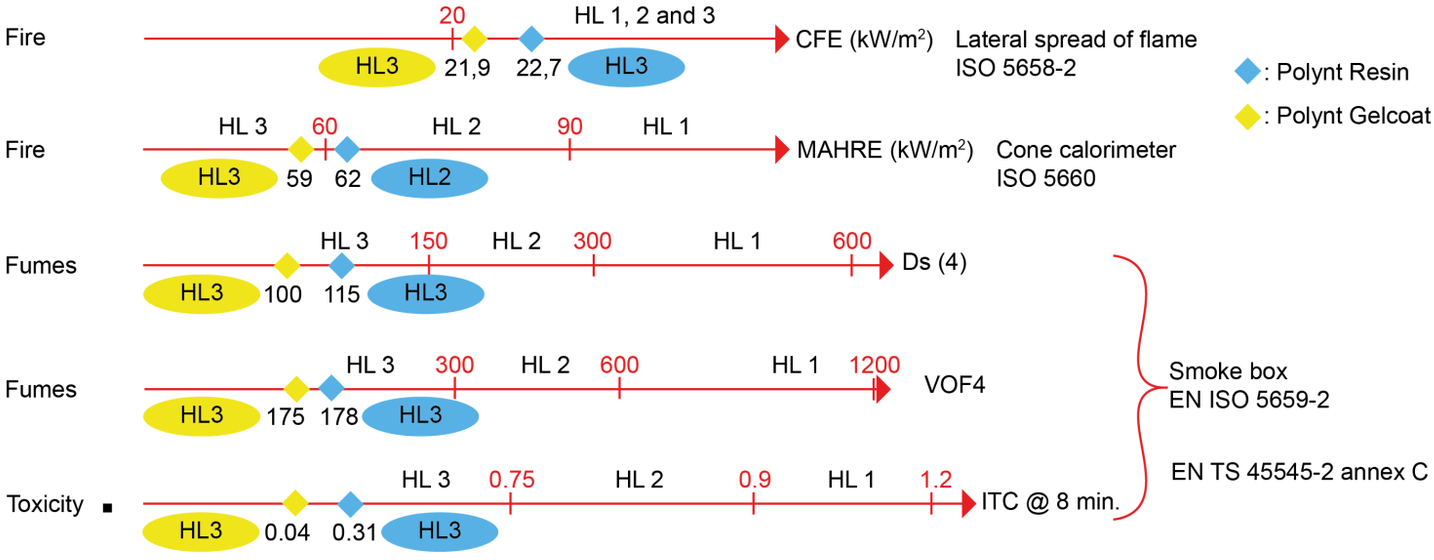
Results + Requirements

The key parameters are listed below with the requirements for each Hazard Level. Results are averages of three specimens tested to the required methods.

Targets to be reached according to requirement

Requirement	Parameter	Definition	HL1	HL2	HL3
R1	CFE	Min	20	20	20
	MAHRE	Max	n/a	90	60
	$D_s(4)$	Max	600	300	150
	VOF4	Max	1200	600	300
	CIT_G (4 +8)	Max	1.2	0.9	0.75
R2	CFE	Min	13	13	13
	MAHRE	Max	n/a	n/a	90
	$D_s(4)$	Max	600	300	150
	VOF4	Max	1200	600	300
	CIT_G (4 +8)	Max	1.2	0.9	0.75
R3	CFE	Min	13	13	13
	MAHRE	Max	n/a	n/a	n/a
	$D_s(4)$	Max	600	300	150
	VOF4	Max	1200	600	300
	CIT_G (4 +8)	Max	1.2	0.9	0.75

Example of classification of gel coat + resin and resin alone



The data highlighted in this brochure provides an outline explanation of the final requirements for pieces manufactured for use in fire performance applications.
The data shown within this document provides an indication and examples based on our experiences and does not aim to cover all thermoset application technologies. It is the responsibility of the end users to check the compliance of their material versus the standard.

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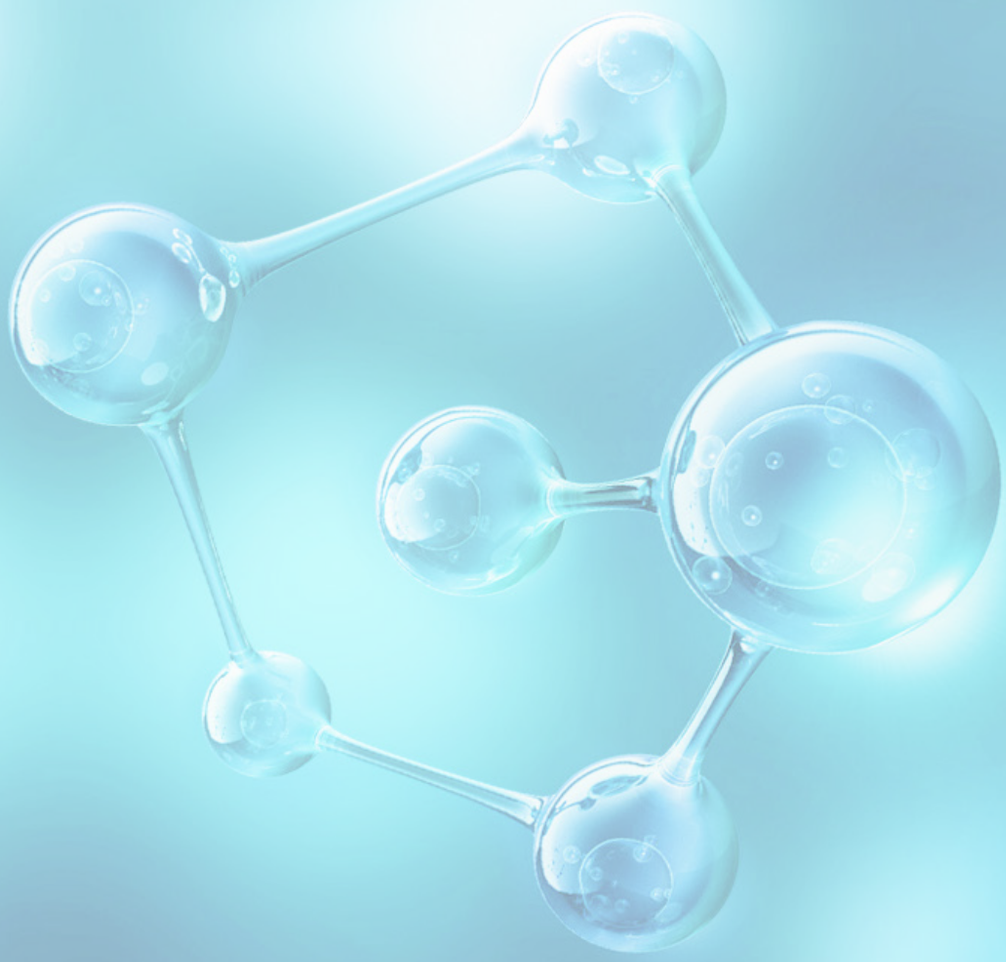

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