



# PROMETHEUS DEVELOPMENTS LTD

Unit 9 Langley Park  
North Street  
Langley Mill  
Nottingham  
NG16 4BS

Tel: +44 (0)1773 764206  
Fax: +44 (0)1773 765048  
E-Mail david.aslin@  
prometheusdevelopments.com

*For the answers you won't have thought of*

## **Phyrolex™ LFR (patent pending)**

Phyrolex LFRs are a range of liquid halogen free intumescent flame retardants with multiple applications.

Obviously, if the resinous system is a single phase with the flame retardant dispersed throughout, then both the fire protection will be more efficient and processing unaffected. This feature overcomes the problems associated with particulate flame retardants such as APP and ATH.

Phyrolex LFRs are neutralised oligomeric partial phosphate esters of carbonific polyols. The products are novel, but non hazardous, and outside the requirements of REACH.

However, if the Phyrolex LFR is to be useful it must be mutually soluble into the intended resinous species to which it is applied.

Phyrolex LFRS are pale yellow very high viscosity liquids which may be provided neat or dispersed in water. The products are water soluble, but as both the molecular weight and viscosity are very high, once incorporated, leaching has not been observed.

Variants of the Phyrolex LFRs are recommended for different applications as indicated in the guideline formulations below.

In order to understand the guideline formulations below, the products are coded Phyrolex LFR NOPPX; where N indicates which of the complex partial phosphate esters the product is based on, O indicates the degree of neutralisation, and PP is a number which represents the dilution. 00 would be 100% solids, 85 is 85% solids. X represents the diluents. If no suffix is present and the PP is different to 00, then the system contains water. If a suffix is present (ie D) then a chemical diluent has been added. For this purpose D represents Diethylene Glycol.

### **Single Pack Fire Retardant Varnish**

Phyrolex LFR 2L85 can be incorporated into a solution of Dowanol PM and Cellulose Acetate Butyrate to create a hard, single pack intumescent varnish.

Dowanol PM	180
CAB 0.4	80
LFR 2L85	60
Byk Silclean	1.5

This film is water resistant; however standing water can cause minor defects. This can be avoided by the use of a top coat.

### **Modification of Thin Film intumescent coatings for structural steel**

In many water based thin film intumescent formulations, a short chain monomeric phosphate ester is used as a plasticiser to alter the melt viscosity of the intumescent char to control expansion.

Monomeric phosphate esters may contain chlorine and/or will always produce flammable fractions as they are exposed to the fire regime.

Phyrolex LFR1H85 may be substituted for the short chain phosphate esters as a plasticiser. The Phyrolex LFR cannot produce flammable fractions, and because it activates before the APP/melamine/pentaerythritol system, the char formation is enhanced. Significant enhancements in fire protection time have been recorded with this modification.

Structural steel protection formulations require extensive and expensive certification procedures that prevent formulation modification without retesting. However, as these formulations are regularly revised consideration of the inclusion of the Phyrolex LFR in the trial formulations could be advantageous.

## **Flame Retardant surface surfactants and Impregnation for Timber**

Phyrolex LFR1H25 wet applied to the surface of native timber, both hard and soft woods, will absorb into the surface and dry to an almost imperceptible film.

The resultant dried timber will show enhanced fire resistance, dependant on the species and its surface porosity.

Some timbers form more resistant chars and hence the actual fire resistance is a combination of species and application rate. Likewise, Phyrolex LFR1H25 can be used under vacuum impregnation.

This system cannot be applied to particle boards and plywoods as the adhesives used in manufacture block the pores. Likewise veneers will absorb the adhesive from to the substrate.

## **Polyurethanes and Polyisocyanurates**

Phyrolex LFRs may be used to provide flame retarded polyurethane materials in all their multiple forms.

The Phyrolex LFRs, either as 100% solids, or diluted in water or glycols are compatible with all polyols used in polyurethanes and polyisocyanurates.

## **Paints and Varnishes**

Phyrolex LFR 2L00 has been incorporated into a fire resistant large vehicle coating based on aliphatic resin and catalyst for long term exposure. This has been made available as a pigmented and non-pigmented system

	Paint	Varnish
LFR 2L00	54.6	54.6
Tioxide TR28	90	
Setalux D A365	274.2	274.2
Byk 331	1.56	1.56
Tinuvin 292	5.22	5.22
DBTL (1% in BuAc)	7.8	7.8
Tego FlowZFS 460	3.8	3.8
Tego Airex 940	5.4	5.4
Desmodur N3390	102.7	102.7

## Rubbers

Phyroxex LFRs have been used to flame retard elastomer, and PU rubber systems. The PU Rubber system has been used in trials for applications such as pipe seals, and intumescent sealant.

	Elastomer	PU Rubber
Terathane 650	100	
Eternacoll PH200D		43.7
Phyroxex LFR1L00	30	
Phyroxex LFR2L00		40
EFG 315		9.7
Tin Catalyst	0.2	
Neobi 200		0.05
Metatin Kat 730		0.05
MDI	14	16

## PIR and PU Foams

Phyroxex LFRs have been successfully integrated into standard PIR and PU foam formulations. The foams have good thermal conductance; PIR foams are >99% closed cell, and have excellent flame response.

	PIR	PU
Stepanpol PS 2352	22.9	
Lupranol 2095		41.6
Phyroxex LFR 2L00	40	
Phyroxex LFR 3L95		32.94
Metatin Kat 730		0.22
Neobi 200		0.22
Tegostab 8404		0.05
Desmorapid PP		0.11
KOH		1.25
n-Pentane	2	
Water	1	2.04
MDI	34.2	30.32

These systems are still under development, however the PIR formulation has given figures of; 0.41% open cell structure, an SG of 0.058 and a thermal value of 0.02 W/m.K . The PU system listed has also passed CRIB 5 testing.

## *Unsaturated Polyester Resins*

Phyrolex LFRs can be used to flame retard polyesters to produce fire resistant composites. There are a number of interfering factors that need to be overcome. The matter is subject to significant development effort. However, Phyrolex LFR3L00 is intended for this application.

## *Epoxy Resins*

Phyrolex LFR 2L85 is compatible with most diglycidyl ethers with an increase in viscosity.

It is not anticipated that Phyrolex LFR is an end user product. It will probably need to be supplied as an FR resin by OEMs. For prepreg manufacturers this should not provide any difficulties and should offer significant advantages.

The presence of the Phyrolex LFRs does affect the cure profile of most amide and amine curing agents. However, trimethyl hexane diamine appears largely unaffected.

The Phyrolex LFRs need to be incorporated at between 25 and 30% on total resin formulation to be effective for the fire performance requirements of marine and railway rolling stock markets.

It should be noted that the Phyrolex LFRs do not enter into the crosslinking mechanism so there is a reduction in the HDT.

Recent testing has yielded a Euroclass B on SBI, class V0 under UL94, and 37% under LOI testing.

## *Polyureas and Polyurea Hybrids*

Phyrolex LFRs may be used to produce flame retardant and intumescent flame retarded coatings composed of polyurea and hybrid polyurea/polyurethane.

The four formulations shown as examples are in all respects of their components essentially conventional except for the addition of the Phyrolex LFR. They retain the advantages of hardness, gloss and exposure resistance associated with such coatings, but in a fire retardant form.

	Polyurea		Hybrid	
	Varnish	Paint	Varnish	Paint
Amicure IC-221	17.2	29	25.8	73.6
Amicure IC-321	5.8	9.8		
Eternacol PH50			5.7	16.2
Phyrolex LFR2H85	17.2	29	25.6	73.6
Tego Airex 902W	0.8	1.4	1.2	3.4
Tego Glide 140	0.32	0.5	0.21	0.6
Rutile Titania		10		24.2
Tolonate HDT-LV2	10.2	17.2	15.3	43.6
Tolonate X FLO 100	1.8	3	2.7	7.8

Any of these formulations may be used as top coats for amino/PPE intumescent coatings (Phyrolex PD 63), thus rendering the amino/PPE coatings wear and weather resistant.

Additionally, they may be used as low smoke, flame retardant large vehicle coatings. Particularly, the varnish versions may be used as fire resistant floor coating. The Phyrolex LFRs do not enter into the curing reaction so may be varied to obtain the performance under fire to meet the requisite fire test specification.