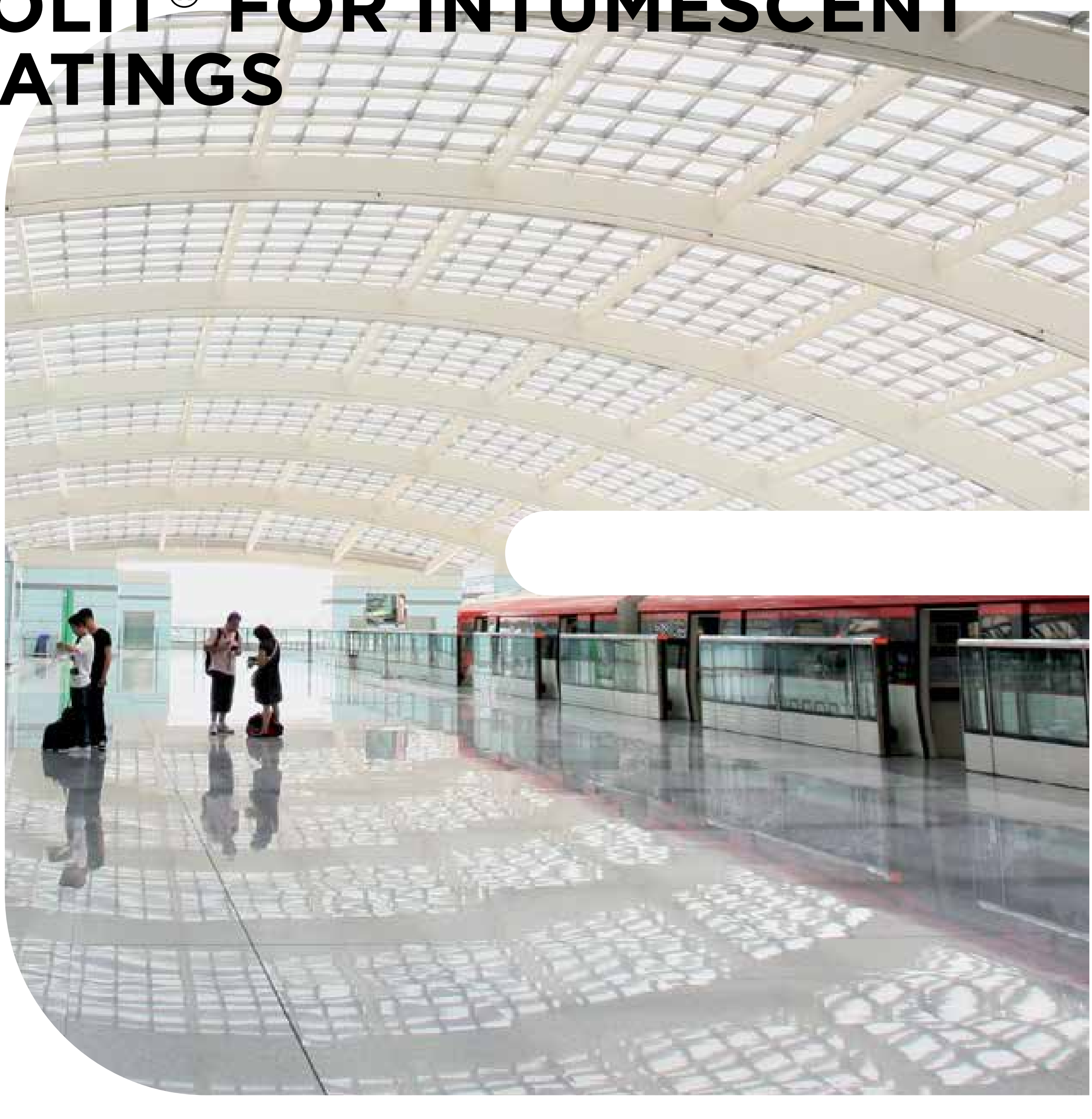
CLARIANT

Flame Retardants for Fire Protection Systems
EXOLIT® FOR INTUMESCENT COATINGS



what is precious to you?

Flame Retardants for Fire Protection Systems
EXOLIT FOR INTUMESCENT COATINGS

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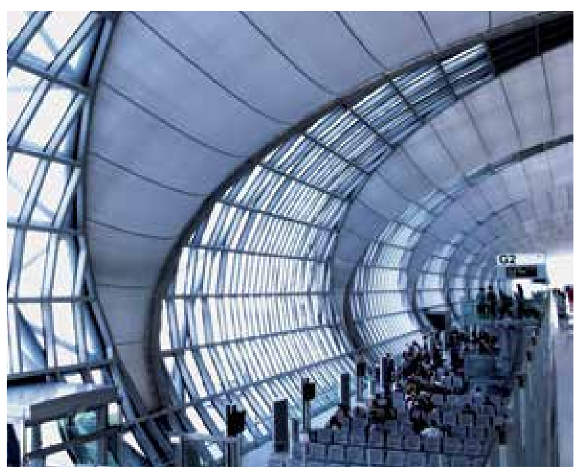
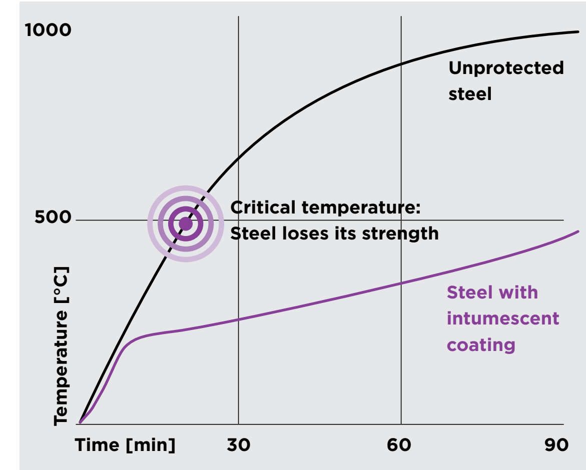
What do intumescent coatings mean for the fire protection steel protection?
Intumescent coatings are the ideal way to combine an attractive architectural appearance with fire safety. Although steel does not burn, it loses its strength when exposed to temperatures above 500 °C. As a result, steel structures become unstable due to the effects of fire, and buildings can collapse. Intumescent coating can form a highly efficient foam based on micro-porous carbon. It forms spontaneously, homogenously, and rapidly at about 200 °C.
If there are no space restrictions, the foam may be up to 100 times thicker than the original coating and has a strong heat insulation effect. Therefore, intumescent coatings are often used to protect steel structures like e.g. airport terminal buildings, shopping centers, theatres and office buildings.
Clariant supplies ammonium polyphosphate as a key raw material for intumescent coatings, marketed under the brand name Exolit AP.



Typical applications of intumescent coatings on architectural steel.

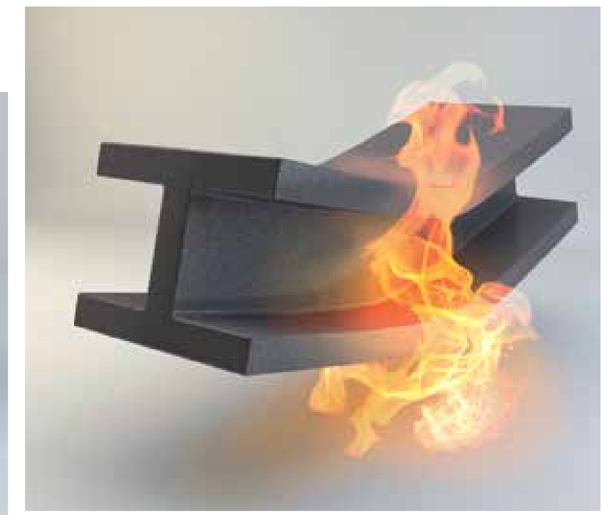
Steel structures in stadiums can also be protected by intumescent coatings.



Temperature of steel over time in a typical fire with and without intumescent coating.

Steel protected with intumescent coating

Unprotected steel



At a critical temperature of 500 °C steel loses its strength. Fire resistance ratings are only far less than 30 minutes.

Steel with an intumescent coating fulfills the official test requirements for e.g. 30, 60, 90, 120, ... minutes.

Mode of action
An intumescent system is a combination of various compounds which in the event of fire react together as a result of the temperature increase to form a carbon foam. This foam attains a thickness 10 to 100 times that of the originally applied coating and isolates the substrate material through its low thermal conductivity.

When an intumescent coating is exposed to fire, the following reactions take place:

1 On exposure to heat, the binder melts first and forms the flexible basis for foam formation.

2 The thermal decomposition of the acid donor ammonium polyphosphate (Exolit AP) results in the formation of polyphosphoric acids.

3 The acids react with a polyalcohol (e.g. pentaerythritol) to form polyphosphoric acid esters.

4 The decomposition of these esters leads to carbon compounds, which together with a blowing agent (melamine) give rise to an isolating carbonaceous (black) foam.

5 The carbonaceous foam is oxidized and an titanium phosphate structure is left (white foam).

> **More time for evacuation can save lives!**

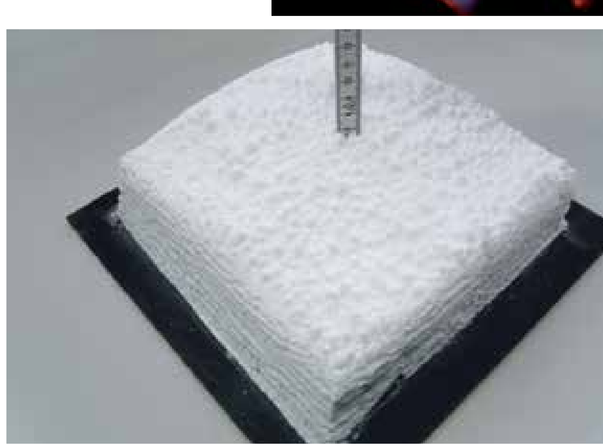
Formulations for intumescent coatings

TYPICAL COMPONENTS OF PIGMENTED, WATER OR SOLVENT BASED COATINGS FOR STEEL, CABLES, OR WOOD ARE:

FUNCTION	COMPONENTS FOR	
	water based	**solvent based**
Acid donor	Ammonium polyphosphate (phase II) (Exolit AP types)	Ammonium polyphosphate (phase II) (Exolit AP types)
Carbon donor	(Di-) pentaerythritol	(Di-) pentaerythritol
Blowing agent	Melamine	Melamine
Binder	Polyvinyl acetate copolymer	Vinyl acrylate copolymers Styrene acrylate copolymers
Pigment	Titanium dioxide	Titanium dioxide
Thixotropic agent	Xanthan gum	Styrene acrylate
Rheology modifier		Vinyl acrylate
Dispersant	Polyacrylic acid	
Plasticizer		Chlorinated paraffins
Biocide	Chlorinated xylenols	
Solvent	Water	Mineral spirits Polar solvents

The intumescent effect can be demonstrated with a Bunsen burner.

Testing of IC formulations in a special furnace.



Steel plate with intumescent coating, 1 mm dry film thickness, after the fire test: foamed to ca. 70 mm height, having shown a fire resistance of 90 minutes

Exolit AP 422, Clariant's neat ammonium polyphosphate, is being evaluated by ToxServices, Washington DC, under the GreenScreen chemical evaluation programme, developed by cleanProductionAction (http://www.cleanproduction.org/Green.php). Furthermore, a comprehensive study of flame retardants commissioned by the German Federal Environmental rotection Agency (Umweltbundesamt) in 2001 concluded that "... as a whole, seen from a toxicological viewpoint, APP is an unproblematic flame retardant."

Ammonium polyphosphate from Clariant is a white powder.

ADVANTAGES OF EXOLIT AP

EXOLIT		
in a fire	Considerably reduced smoke corrosivity Low smoke density Very effective, low addition	> Reduced attack on building fabric and installations > Longer time for escape > Complete decomposition, maximum acid formation
in processing	Solid Neutrality	> No emissions, readily dispersible > Compatibility with most binders, such as acrylates, silicones, polyurethanes, etc.
in the end product	Solid	> No migration, no emissions, no adverse facts on recycling of joined components

In order to qualify for intumescent systems, the binder must possess two properties that seem opposed to each other. On the one hand, it must be viscous enough at temperatures above 200°C to cover the substrate and have a protective effect. On the other hand, it must be highly flexible to allow the necessary expansion of the foam layer. In some cases plasticizers are used for support.

As the temperature continues to rise in an ongoing fire, the foam layer gradually chars and it would collapse if the ester compound did not release glass-like, viscous polyphosphates. They support the carbon foam and prevent it from collapsing. With more energy being fed into the process during a fire, the carbon eventually also burns. All that is left is a titanium phosphate carcass with a very low heat transfer coefficient, which ensures the flame protection that is necessary at this stage.

Additional components of an intumescent fire protection system are a primer and possibly a topcoat to protect the coating against environmental effects like moisture or just for decorative purposes.

Standards regulating intumescent coatings

Clariant flame retardants are supplied worldwide.

The organisations set standards and rules for fire testing.

The fire safety of buildings is regulated in national buildings codes and laws. These national regulations usually only define general safety requirements for buildings, like structural integrity, thermal insulation, fire safety and no health impacts from building products. The details for individual building parts are specified in technical standards which are compiled and published by national or international standardization bodies like the British Standards Institute (BSI), the German Institute for Standardization (DIN), the American Society for Testing and Materials (ASTM) or the International Standardization Organization (ISO). The product manufacturers, testing laboratories and regulators work together in the respective technical committees for these standards.

EU: Essential requirements with regard to mechanical strength and stability, safety in the event of fire, hygiene, health and the environment, safety in use, protection against noise and energy economy and heat retention.

Components such as structural steelwork are classified according to their behavior in a fire. The period of time for which they are able to perform their intended function in a fire test is measured. The fire endurance determined in this test is expressed in minutes and is divided into classes. The classification “F 60, F 90, ...” for example, denotes that a component has fulfilled the official test requirements for at least 60 minutes. Bare steel components generally achieve fire resistance ratings of only far less than 30 minutes because they heat up rapidly. Since different steel components have different fire endurance characteristics, the definition of the type of steel used is essential for fire resistance classification. Steel components being assessed for their fire behavior are defined by the profile factor which describes the ratio of the flame-exposed circumference (Hp) to the heated cross-sectional area (A) of the unclad steel component.

Steel profiles with a profile factor Hp/A -= 300 m-1 (large circumference, small cross-sectional area) have a low fire endurance and therefore need a high level of fire protection to meet the official test requirements.

Steel profiles with a profile factor Hp/A =- 160 m-1 (small circumference, large cross-sectional area) on the other hand have higher fire endurance and so require less fire protection.

Fire protection flame retardant systems based on Exolit meet fire resistance classes of F 30, F 45, F 60, F 90, and in some cases even F 120, F 180 and beyond.

This has been confirmed by fire tests conducted according to international standards.

Some important standards are listed in the following table:

ADVANTAGES OF EXOLIT AP

STANDARD	COUNTRY	COMMENTS
EN 13381-8	European Union	Replaces national standards in Europe
BS 476-20/21	United Kingdom	Commonly referred to in EU, Middle and Far East
ASTM E119	USA	Equivalent to UL 263, referred to in Middle and Far East
UL 1709	USA	Test using the hydrocarbon fire curve
DIN 4102-8	Germany	Europe, mainly German speaking countries and Middle East
WNIIPO	Russia	Also used in former Russian Federation countries
NCh 1974	Chile	
GB 14907/CNS 11728	China	
KS F2257 1, 6, 7	South Korea	
CNS 11728	Taiwan	

Beyond steel – intumescent fire protection systems are versatile!

The intumescent effect is also used in applications other than steel protection. Similar formulations are used to fire protect sealants, adhesives, cables, wood and even textiles. The same chemical mechanism as described above is exploited.

Wood

The traditional construction material, wood, suffers from the disadvantage that is a good fuel. Apart from chipboard, where flame retardants can be incorporated during manufacture, protective coatings must be used. Since wood, in contrast to steel, starts to burn at temperatures of 300°C, coatings for this material must be effective at considerably lower temperatures. At the same time, the coating should affect the appearance as little as possible. A clear coat that can protect the wood from fire would ideal. Most currently available products based on Exolit AP powder grades are slightly opaque. Flame retardant, multi-coat systems are only available as two-pack coatings that require a high level of expertise in application. Besides the requirement for good appearance, the coating must exhibit high resistance to mechanical stresses and moisture.

Performance of a fire protection coating on wood.

Sealants

Sealants are gunned into joints and must possess sufficient adhesion to the joint faces to accommodate strain, compression and shear without losing their function as joint sealants. Polymer sealants include acrylates (solvent-based acrylates and acrylate dispersions), PU (1-component, 2-component) and silicones. This sealants group also includes elastomer sealing strips.

Because they are used in the construction sector (for interior and exterior applications), sealants are also subject to the relevant fire tests. Depending on their intended application, they must meet the requirements for flammability classes.
In addition, fire resistance tests (e.g. F 30, F 60, ...) are often required. In this case the sealing compound must be tested in the assembled component (e.g. complete with sealed joint). Exolit AP formulations are frequently used in these systems.

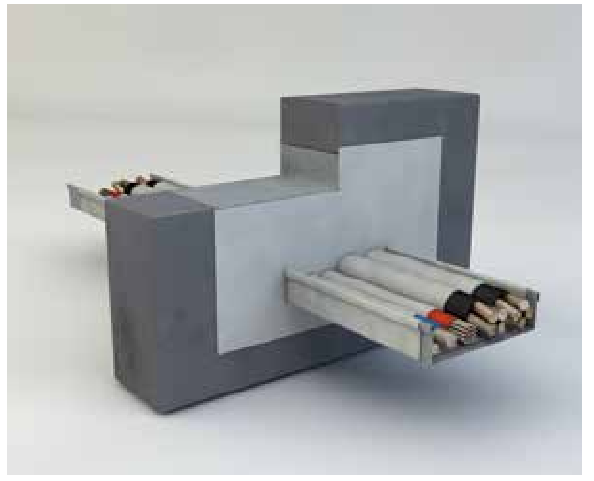
Adhesives

By definition, adhesives are used to join together widely diverse components and materials. It therefore follows that these products must meet the same requirements as the parts being joined. Adhesives are divided into physically and chemically hardening types. The first group includes hot-melt adhesives and pressure-sensitive adhesives while the second comprises two-pack adhesives, such as those based on epoxy and UP resins. These types of adhesive are used mainly in the construction and automotive sectors and are therefore required to achieve the relevant flammability ratings. Exolit AP types are readily dispersible solids, easily processable in adhesive formulations and show no migration or emissions.

The expertise and motivation of our technical staff is key to our success.

Cables

Large amounts of cable are required in buildings with extensive technical services such as power stations, industrial buildings, hospitals or offices. These cables are inherently of low flammability so that ignition is delayed. In a fire, however, they contribute significantly to the fire load and may transmit fires to other parts of the building. Particular attention is thus paid to the sealing of cable ways for the purposes of fire protection. Coatings can also make an important flame retardant contribution. Their composition resembles that of steel fire coatings (containing suitable Exolit AP types), but they are more flexible and do not foam up quite as strongly. They not only prevent the cable from continuing to burn, but also enable it to remain functioning. Intumescent coatings are also used in wall seals for cable ways. The seals must ensure inter alia that smoke must not penetrate other rooms.



A cable duct and penetration protected by an intumescent coating.

With Clariant you can develop new products and enter new markets

— The quality and performance of Clariant's products is regularly analyzed.

— ”To foam or not to foam?“ that is the question even Shakespeare would have asked when confronted with this specimen...

Clariant has decades of experience in intumescent coatings with water- and solvent-based formulations. We are very pleased to help to optimize or develop intumescent coating formulations. In our application development laboratory at Knapsack, we can undertake initial comparative studies using standard fire tests as a basis for evaluating new formulations. This can often save the cost of official fire tests for formulations that have no realistic chance of passing them. In collaboration with our customers and in internal projects, we drive current trends for intumescent coatings such as the development of epoxy-based and high solid formulation ICs, lowering of the dry film thickness, achieving faster drying times as well as eliminating chlorinated paraffins from solvent based ICs.

Exolit range of Flame Retardants for Fire Protection Systems

Clariant markets its flame retardants under the trade name Exolit, focusing on modern non-halogenated products.

SUPPLY FORMS

PRODUCT	EXPLANATION	INTUMESCENT COATINGS	EPOXY COATINGS	ADHESIVES, DISPERSIONS, SEALANTS	PAPER, WOOD	TEXTILE COATINGS
Exolit AP 420	Aqueous solution of ammonium polyphosphate (APP)				■	■
Exolit AP 422	Fine-grained white APP powder with low water solubility	■	■	■	■	■
Exolit AP 423	Micronized AP 422, especial fine powder	■		■	■	■
Exolit AP 462	Microencapsulated AP 422 with extremely low water solubility	■		■	■	■
Exolit AP 740	APP blend with synergists for light weight UP resins and gel coats	■		■	■	
Exolit AP 750	Intumescent system based on APP, especially for thermoset polymers		■			

■ Established applications

According to the present state of knowledge the Exolit AP types listed here above do not need to be labeled as hazardous substances (according to European CLP regulation EC/1272/2008, as amended).

— State of the art production processes guarantee the reliable high quality of our products.

CLARIANT INTERNATIONAL LTD
Rothausstrasse 61
4132 Muttenz
Switzerland

BUSINESS LINE FLAME RETARDANTS
FLAMERETARDANTS@CLARIANT.COM
Fon +41 61 469 78 50
Fax +41-61-469-7540

WWW.EXOLIT.COM
WWW.CLARIANT.COM