ATTRACTIVE FIRE PROTECTION

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discuss the role of Ammonium Polyphosphate (APP) in fire protection systems.

Fire protection systems are not a luxury but a necessity for public buildings such as stadiums, airports and train stations, libraries and hospitals, exhibition centres and shopping malls. National and European Union (EU) regulations and technical standards defining safety requirements are becoming ever-more stringent and demand careful consideration. With modern architectural trends focusing increasingly on visible glass and steel structures, reliable protection methods that meet these requirements without compromising on aesthetics are essential.

Aesthetics and Protection

Intumescent Coatings for steel are the ideal way to combine an attractive appearance with fire safety. They avoid the unsightly appearance of solid gypsum boards and provide a viable alternative to sprinkler systems.

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 so that buildings can eventually collapse. Intumescent Coatings provide fire protection to steel constructions by shielding them from the effects of heat by swelling and foaming. If there are no space restrictions, the resulting foam can be up to 100 times thicker than the original coating with a strong heat insulation effect.

Components such as structural steelwork are classified according to their behaviour in a fire. The period of time for which they are able to perform their intended function is measured in a fire test. The fire endurance determined in this test is expressed in minutes (Fire Resistance Time = FRT, with index as F or R, F is the German classification terminology, R is European standard terminology) and is divided into classes. The classification F60 or F90 for example denotes that a component has fulfilled the official test requirements for at least 60 or 90 minutes protection. Bare steel components generally achieve only a very short period of FRT 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.

Steel profiles with low fire endurance, that is those with a large circumference and small cross-sectional area, will need a high level of fire protection to meet the official fire test requirements. Steel profiles with small circumferences and a large cross-sectional

area will have higher fire endurance and so require less fire protection. The necessary dry film thickness of an Intumescent Coating layer varies in line with this.

In coating testing, if a coated steel component satisfies fire-resistance class F 60 it will withstand the heat for minimum 60 minutes. The critical temperature of the steel is not reached within this fire resistance time, buying valuable time for the evacuation of people from the building and for fire fighters to extinguish the fire. Today's modern Intumescent Coatings for steel constructions can offer flame resistance in excess of 90 to 120 minutes.

The Elements Inside

Water and solvent-based Intumescent Coatings consist of various components whose effectiveness is decisively influenced by the mixing ratios chosen and, importantly, the quality of the basic ingredients. Compromises here will affect end-product quality, performance longevity and potential shelf life.

The components with the most critical influence on the performance of Intumescent Coatings are the acid source, the binder, the blowing agent, the carbon source and the pigment.

The processes that occur in Intumescent Coatings during a fire are extremely complex. In the first stage, the binder melts and the acid source liberates polyphosphoric acid that reacts with the carbon source to form an ester. By decomposition of the ester a carbon rich structure is formed and blown up by the gases released from the decomposition process of the blowing agent. The process of swelling and foaming begins to create the ultimate protective layer. In combination with the plasticizer the binder needs to build a stable matrix for this reaction to take place. The foam chars during the increasingly high temperature of the fire but should not collapse. It is here that the polyphosphoric acid comes into play again by preventing the foam from collapsing. By reaction with the pigment a stable framework is built that supports the foam in the final stages when the carbon has been pyrolyzed at higher temperatures. The very low heat transfer coefficient of the framework ensures the flame protection that is necessary at this stage. It is extremely important for the foam to be free of cracks to ensure complete coverage and shielding of even the most complex-shaped steel structures.

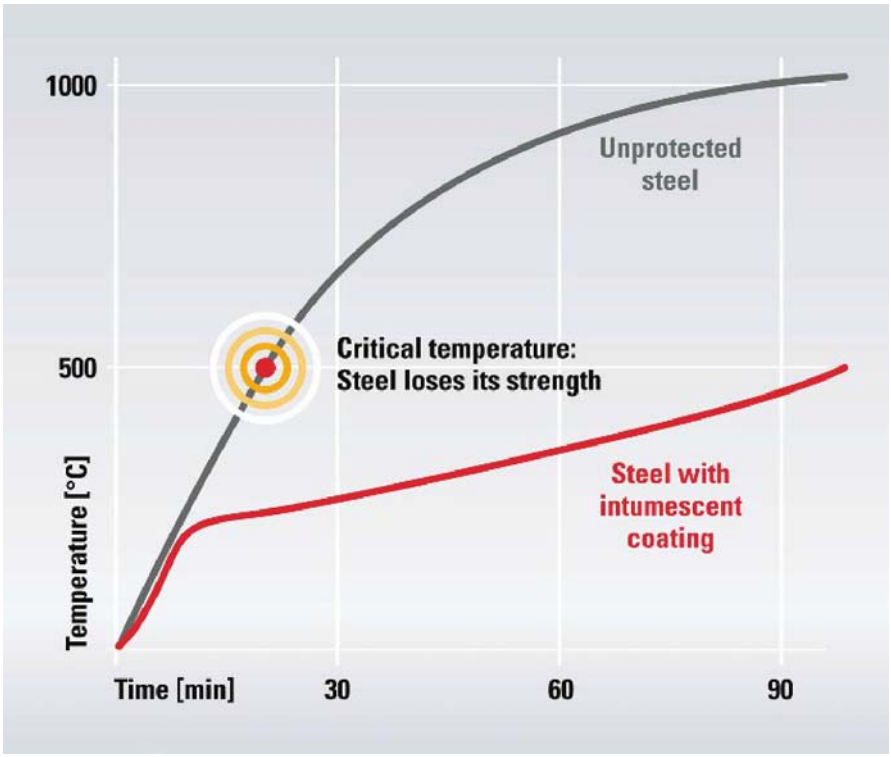
The Right Ammonium Polyphosphate (APP)

The kick-start function of the acid source or acid donor, which is Ammonium Polyphosphate (APP), makes it a key ingredient in the reaction chain for Intumescent Coatings, be they water or solvent based. Its quality can determine the performance and stability of a finished coating. As such it is important for Intumescent Coatings producers to focus on choosing the right APP to ensure their intumescent coating not only fulfills certification criteria but also maintains its quality over time when in use – between 10 and 20 years - and during long-term storage.

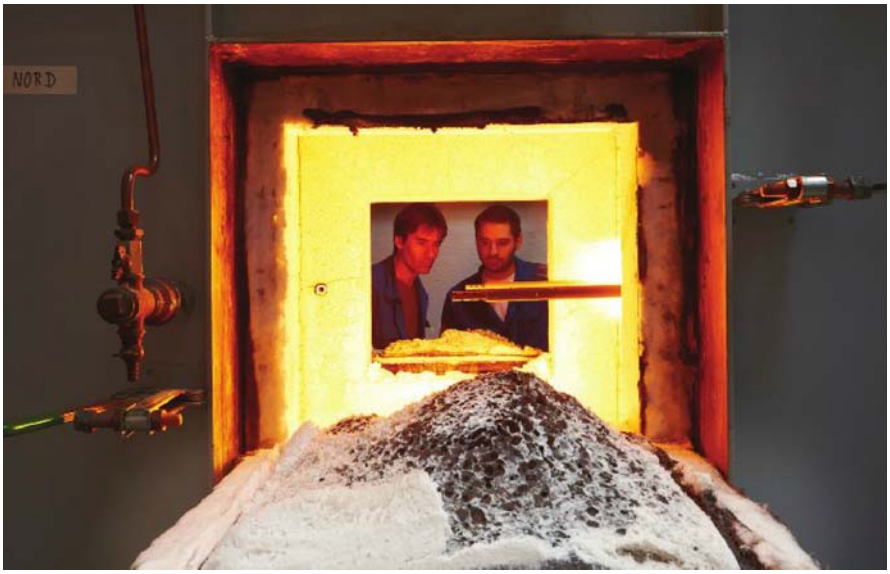
APP for the Intumescent Coating application has been our Company's area of expertise for more than 25 years. Our technical development laboratory and fire testing facilities support customers in developing new, and in improving their existing Intumescent Coatings within different test requirements and markets. As a result, we truly understand the contributory role of an ingredient like APP in determining overall coating quality.

The market has a choice of Phase I and Phase II APPs, both displaying different characteristics.

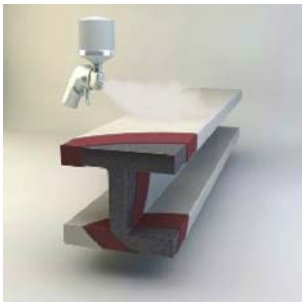
Phase I APP has high water solubility and short chain lengths, which can lead to less durable Intumescent Coatings formulations. The APP can leach out of the coating in a humid environment, reducing the performance



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



View through a test furnace at the German Federal Institute for Materials Research and Testing showing the intumescent coating sample after test



Schematic of a beam in a fire with and without an intumescent coating

of the coating over time, while the short chain structure creates less thermal stability which results in a reduced protection performance.

Phase II APP has low water solubility and long chain lengths. This helps the APP to remain as an active ingredient within the intumescent coating for a long period of time, to ensure stable storage and long-term protection of the steel structure.

Fulfilling International Standards

The fire safety of buildings is regulated in national buildings codes and laws. The details for individual building parts are specified in technical standards which are compiled and published by national or international standardization bodies, such as the British Standards Institute (BSI), the German Institute for Standardization (DIN), the American Society for Testing and Materials (ASTM), and others world-wide. The product manufacturers, testing laboratories and regulators work together in the respective technical committees for these standards.

Within the EU, essential requirements are specified with regards to mechanical strength and stability, safety in the event of fire, hygiene, health and the environment, heat retention, and so on.

Fire protection systems can meet fire resistance classes of F 30, F 45, F 60, F 90, F 120 and, in exceptional cases even, F 180 and beyond.

Fire tests conducted according to international standards confirm that our products are available to support systems in covering the full scope of these classes.

Considering these factors and standards, it is easy to see the variations and complexities facing Intumescent Coatings producers serving different countries and regions. This makes the choice of high-performing ingredients and the advisory role of the material supplier all the more important in helping producers to develop an Intumescent Coatings range that covers as many eventualities as possible.

Some important standards are listed in the following table:

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	

Market Trends

Within this environment, an experienced materials supplier can be a valued partner for Intumescent Coatings producers, providing service and support expertise on the technical and commercial side, and advice on markets and trends.

To take our own operations, Clariant's application development laboratory in Knapsack, Germany, offers a high level of support to customers by undertaking initial comparative studies in a small scale test furnace according to DIN 4102 Part 8 as a basis for evaluating new formulations and optimization of existing ones. This can contribute to saving the cost of official fire tests for formulations that have no realistic chance of passing them.

In collaboration with customers and in internal projects, we focus on current and new trends for Intumescent Coatings such as the development of epoxy-based and high solid formulation coatings for robust conditions such as high humidity environments, lower dry film thickness, and achieving faster drying times. Such advances are aimed at ultimately raising efficiency levels for Intumescent Coating producers, to add further to their competitive edge by helping product differentiation, and to address the global need for more ecologically sound manufacturing processes and products.

Intumescence – A Growing Phenomenon?

Since the inception of Intumescent Coatings in the middle of the 1980s, we have seen demand for APP grow significantly. In line with increasing regulatory standards and architectural demands, these Intumescent Coatings are becoming ever-more popular. We expect this to continue as the industry appreciates the true benefits of these Intumescent Coatings in meeting modern demands for non-toxic, environmentally-friendly and effective flameproofing, and in permitting light, elegant and sophisticated structures. The key to success is using high quality ingredients – in this case APP - to not only secure the best quality for certification purposes, but to ensure the final product maintains its stability and quality for many years. We, for one, will continue to produce the best APP to support our customers in the creation of flame retardant solutions to fulfill tightening fire safety standards.

Editor's Note:

A comprehensive study of flame retardants commissioned by the German Federal Environmental Protection Agency (Umweltbundesamt) in 2001 concluded that *"...as a whole, seen from a toxicological viewpoint, APP is an unproblematic flame retardant"* and according to Clariant, they only offer high quality Phase II APP, under the trade name Exolit® AP, as they are convinced that only the best raw materials can give an Intumescent Coating the best performance possible to ensure in case of a fire the required and certified FRT. In a fire, Intumescent Coatings with Exolit AP will produce considerably less corrosive smoke, meaning less attack on building fabric and installations, and low smoke density that allows a longer time to escape. During processing, APP produces no emissions; it is readily dispersible and is compatible with most binders, such as acrylates, epoxies, silicones, polyurethanes, etc. Because APP breaks down into a naturally-occurring product, it is considered to be one of the most environmentally-friendly flame retardants available. ■

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