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FEATURE SERVICE

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Foam Jackets for Steel Columns

Sports stadiums, skyscrapers and airport terminals are just three examples of the increasing number of new buildings going up in metropolitan areas at a breathtaking rate. They predominantly feature roofs and frames made of steel, because steel skeletons have a low dead load, but a high load-bearing capacity and are usually quick and easy to assemble. However, the higher and larger the building, the greater the importance of fire protection. To prevent the steel frames of skyscrapers and stadiums from buckling within minutes during a fire, they are provided with special fire protection coatings. As the binder, a new dispersion by WACKER ensures the necessary elasticity, strength and adhesion of the protective layer.

Steel skeletons: The basis of modern construction

Come 2014 when Brazil hosts the World Cup Finals and then the Olympics in 2016, entire nations will be glued to their screens. They will see tens of thousands of fans flocking to gigantic, futuristic stadiums where sporting rivalries will be fought out against a striking backdrop of steel frames and roofs designed to convey an impression of lightness and airiness. Steel frames, or “skeletons,” have a low dead load, but a high load-bearing capacity. They are supplied prefabricated and are bolted together quickly and easily on site. This makes steel constructions statically ideal as skeletal structures for exhibition halls and airport terminals.

It’s a construction method that is especially popular for office

tower blocks in the booming cities of the Far East. But wherever people congregate in large numbers, safety aspects must play an equally “weighty” role alongside structural efficiency and esthetics.

Heat makes steel columns unstable

“Architectures are becoming increasingly more intricate and delicate. At the same time, buildings still need to meet all specified safety standards,” says Dr. Wilfried Huster, head of Application Technology for Dispersions in Europe at WACKER’s polymers division. This applies especially to those relating to fire. True, the steel columns themselves are not flammable, but this otherwise highly stable material has an Achilles heel – intense heat. When the temperature reaches 500°C, steel frames soften rapidly, and buildings are in danger of collapse. “Basically, the steel just ‘floats’ away,” says Dr. Niels Friede, process engineer and head of Emergency Services/Fire Safety at WACKER in Burghausen. Not only that, steel expands extensively in heat. “Unlike stone and even wooden walls, which undergo little dimensional change, steel columns lengthen and widen. In so doing, they force other components apart, thereby further weakening the structural stability,” adds Friede.

Special coatings enclose steel columns …

That is why fire safety is so crucial in steel-frame structures. One solution here is to boost the resistance of the columns by painting them with so-called intumescent coatings, which swell in the event of a fire and confer greater “staying power” to the metal columns. The coatings are applied like paints in thicknesses ranging from just 300 micrometers to several millimeters, the precise thickness depending on the application. Even though

these heat shields are fairly thin, they nonetheless afford substantial protection. “When a fire breaks out, the coatings swell by 10 to 100 times their original thickness to form a thermally insulating foam jacket around the steel column,” says Huster. The thermal insulation properties stem from the foam’s high density and very fine pores. The foam slows the rate at which the steel heats up, greatly delaying the time taken to reach the critical 500°C. “The buildings can thus resist a fire for much longer, and that gives the rescue teams more precious time to save lives,” adds Friede, a fire expert.

… generate an insulating foam jacket …

If the intumescent coatings are to generate the insulating foam in a fire, certain ingredients are essential. Alongside “reactive” components such as melamine, pentaerythritol and ammonium polyphosphate (such as Clariant’s Exolit® AP), they also contain organic binders made by WACKER. “The binder in a fire protection coating has far more jobs to do than simply hold the filler particles together, as it does in conventional wall paint,” stresses Huster.

… and act as a heat barrier

When the temperature reaches 250°C, the binder fuses to form a matrix in which subsequent thermochemical reactions can take place. The first reaction is decomposition of the ammonium polyphosphate, which constitutes one quarter and thus the major ingredient of the intumescent coating. The resultant phosphoric acid reacts with the pentaerythritol to form phosphoric acid esters. If the temperature keeps rising, the esters themselves start to decompose, forming residues that contain carbon and phosphorus. Meanwhile the melamine also decomposes, emitting

ammonia and nitrogen gases. These act as a blowing agent that gradually expands the carbon and phosphorus ester residues into a layer of insulating foam.

As the foam shield might be too brittle …

"Extensive studies have shown that special copolymers based on vinyl acetate and ethylene – in other words, our VAE dispersions – and terpolymers based on vinyl acetate, ethylene and vinyl ester are particularly effective in promoting the formation of a stable matrix," explains Huster. Without the binder, the insulating effect of the thermal shield would be extremely difficult to achieve because the shield would be too brittle and would not adhere securely enough to the metal substrate. "Fires are usually accompanied by severe air turbulence and vibrations. It is essential then that the foam layers do not spall away," says Achim Hennemann, Key Account Manager, Intumescent Coatings at Clariant, a chemical company that produces the ammonium polyphosphate (Exolit®) that constitutes the main component of fire protection coatings.

… the choice of the binder is crucial

Although the binder plays a supporting role in intumescent coatings, it is nonetheless crucial to their efficacy, as Hennemann knows: "The quality of the binder is the key to intumescent coatings. It determines the success or failure of a good recipe." For the binder determines how fast the layer of foam forms and its thickness around the steel columns. That's why the experts from WACKER worked closely with their colleagues from Clariant as they were developing their new dispersions specifically for such applications – and success proved them right: The new dispersion VINNAPAS® LL 3112 generates foam in much a greater

yield and with an even finer, denser pore structure.

A corollary of this greater efficiency is that a lower overall coating thickness is required than in conventional systems, without sacrificing any insulating effect. Thus, thanks to the new binder, fewer coats are needed. “Intumescent coatings often need up to seven coats – and just as many drying periods,” explains Clariant manager Hennemann. “So, thinner coats that deliver the same performance, i.e. fire resistance time, will save on material, time – and costs.”

Plus for the environment: Water as basis

In VINNAPAS® LL 3112, the WACKER experts have also succeeded in complying with the increasingly stringent sustainability requirements – the new binder contains neither plasticizers nor is it produced with alkylphenol ethoxylates-containing materials. A further plus for the environment is that the dispersion is not based on organic solvents but is water-borne. “And the market for water-borne fire protection coatings has the potential to grow significantly in the next several years,” estimates Hennemann.

Stable even at elevated temperatures

Not only in the event of fire must a binder fulfill its purpose. Coatings firms usually store fire protection coatings for long periods. “The viscosity must not change during the period in storage, i.e. the product must remain stable,” stresses WACKER expert Huster. “Thanks to our new binder, products will remain stable even when stored at elevated ambient temperatures.”

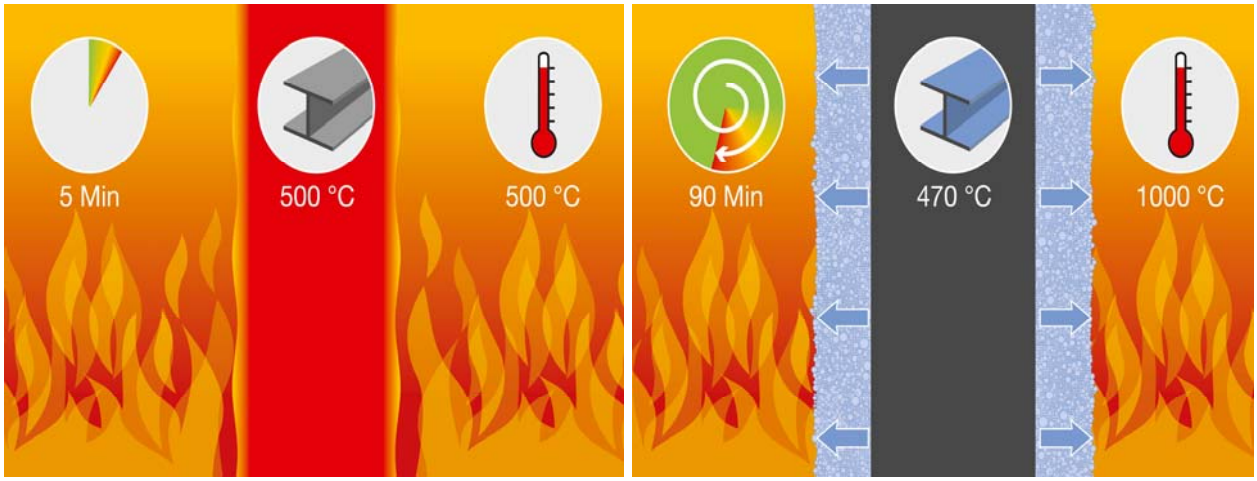
Nearly all countries specify that steel structures – whether they be all-glass, see-through exhibition halls or towering office blocks – must satisfy certain criteria governing the length of time they have to be able to resist fire. In Germany, “F 30” means that

a load-bearing steel structure must be able to withstand a fire, i.e. heat, for at least 30 minutes under standard conditions. “The thinner the steel cross-section, the thicker the fireproof coating must be to achieve the required fire rating. Nowadays, intumescent formulations are capable of achieving an F rating of two hours and longer,” says Clariant’s Hennemann.

Fire protection of up to 2 hours possible …

Coatings formulations with VINNAPAS® LL 3112 can reach top ratings here, too: Depending on the formulation, the new binder allows highly fire-resistant coatings with fire resistance class F120 to be achieved, which means heat protection for up to two hours. VINNAPAS® LL 3112 is just one example of WACKER helping to ensure that steel structures withstand fires for precious extra minutes that could save lives.

… for more safety in the event of a fire!



Modern buildings often feature steel skeletons – but when the temperature reaches 500°C, steel frames soften rapidly. To prevent them from buckling within minutes during a fire, they are provided with special fire protection coatings, allowing them to resist a fire for much longer (graphics: Wacker Chemie AG).

Fire test: Intumescent coatings encase steel girders and, in case of a fire, form an insulating foam barrier, thus protecting the steel structure from the heat – and dispersions from WACKER play a key role here as a binder (photo: Clariant Produkte Deutschland GmbH - 2013).

In case of a fire, intumescent coatings foam to tens to hundreds of times its original thickness and act as a heat barrier. The new VINNAPAS® LL 3112 binder ensures significant foam development in these coatings, coupled with improved adhesion and strength (photo: Clariant Produkte Deutschland GmbH - 2013).

Lab test of a dispersion: Depending on the formulation, VINNAPAS® LL 3112 allows highly fire-resistant coatings with fire resistance class F120 to be achieved, which means heat protection for up to two hours (photo: Wacker Chemie AG).

Note:
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The company in brief:
WACKER is a globally-active chemical company with some 16,300 employees and annual sales of around €4.63 billion (2012).
WACKER has a global network of 24 production sites, 22 technical competence centers and 53 sales offices.

WACKER SILICONES
Silicone fluids, emulsions, rubber and resins; silanes; pyrogenic silicas; thermoplastic silicone elastomers

WACKER POLYMERS
Polyvinyl acetate and vinyl acetate copolymers in the form of dispersible polymer powders, dispersions, solid resins and solutions used as binders for construction chemicals, paints and coatings, adhesives, plasters, textiles and nonwovens, as well as for polymeric materials based on renewable resources

WACKER BIOSOLUTIONS
Biotech products such as cyclodextrins, cysteine and biologics, as well as fine chemicals and PVAc solid resins

WACKER POLYSILICON
Polysilicon for the semiconductor and photovoltaic industries

Siltronic
Hyperpure silicon wafers and monocrystals for semiconductor components