



IGSB-INFO 1

Fire Protection Coatings for Structural Steelwork



EDITORIAL

How would you have invited friends and acquaintances to a party 20 years ago – by invitation card or telephone perhaps? How would you have urgently mobilised hundreds of helpers in the case of a flood disaster back in those days – via appeals on radio and television? Or where would you have sourced relevant information on a complex issue? At the library or from experts presumably.

Now consider for a moment how you nowadays access the Internet and social networks as a matter of course thus enabling you to obtain a variety of information and contact different people at the click of a mouse. Who would have imagined that just 20 years ago? We live in a networked world – e-mail as a communications medium, Facebook and Twitter for exchanging news, XING and LinkedIn for networking with business partners. Our everyday lives without these new forms of communication and interaction would be unthinkable. Networks number among the success stories of the 21st century.

The reason behind this success is without doubt attributable to many factors, but one key factor is the distribution and provision of information for a huge number of users. Who of us has never obtained information from Wikipedia or researched it using search engines? Who does not use a smart phone today so that they can be contacted permanently wherever they are and even go online?

Nevertheless there is knowledge that is only relevant for quite specific target groups. This expert knowledge is made available by occupational groups and industrial associations, each of which focusing on its own specific area. The networking of different interfaces, the quick and easy exchange of information and the grouping of expert knowledge as well as innovation as the driving force are all essential to success, in steel construction too.

The benefits of using steel as a construction material are well-known. The smooth interaction of architects, steel and coating manufacturers, the relevant authorities, builders and other interfaces is however key to a project's success and the full harnessing of the benefits. Innovative thinking rigorously pushed ahead with is likewise important for opening up new applications.

As a network in which this information is grouped and made accessible is how *bauforumstahl* and its member organisations such as the Interessengemeinschaft Stahl-Brandschutzbeschichtung (IGSB) see themselves. Since its establishment in 2012, it meanwhile succeeded in attracting 13 members who exchange ideas and experiences at regular meetings, discuss current trends and group information that is helpful for the use of intumescent (in case of fire, expanding) coatings.

Why not visit our website at www.igsb.info and inform yourself about the numerous projects for which fireproofing materials have been used successfully on structural steel. Our current FAQs provide you with tips and advice in fire protection matters and related areas. A genuine fire protection network is quite simply worthwhile.

Achim Hennemann

Clariant Produkte Deutschland GmbH
Chairman of the Board at IGSB

Martin Muth

Byk-Chemie GmbH
Board Member at IGSB

| | |
|--|----|
| Introduction | 4 |
| Benefits at a glance..... | 5 |
| Composition and ingredients..... | 6 |
| Mode of action..... | 7 |
| Application requirements | 8 |
| Economic efficiency | 9 |
| Product selection and film thicknesses | 10 |
| Application and quality assurance | 12 |
| Cleaning, maintenance and repair..... | 13 |
| About IGSB..... | 15 |

Fire Protection Coatings for Structural Steelwork

IGSB-INFO 1

Publisher:

Interessengemeinschaft Stahl-
Brandschutzbeschichtung (IGSB)

Sohnstraße 65 | 40237 Düsseldorf

Tel.: +49 (0)211 6707-826

Fax: +49 (0)211 6707-829

Mail: info@igsb.info

Web: www.igsb.info

December 2014

Any reproduction of this brochure, including partial copies, is only admissible with the written consent of the publisher and clear indication of the source.

Image credits:

Cover: Clariant Produkte (Deutschland) GmbH; fig. 1-4: Rudolf Hensel GmbH; fig. 5: Clariant Produkte (Deutschland) GmbH; fig. 6: Hempel (Germany) GmbH; fig. 7: bauforumstahl e. V.; fig. 8: Schmöger, Sika Deutschland GmbH; fig. 9: Rudolf Hensel GmbH; fig. 10: Sika Deutschland GmbH; fig. 11: Rudolf Hensel GmbH; fig. 12: Clariant Produkte (Deutschland) GmbH; fig. 13: bauforumstahl e. V.; fig. 14: Hempel (Germany) GmbH & Schmöger, Sika Deutschland GmbH; fig. 15: Rudolf Hensel GmbH; fig. 16: Schmöger, Sika Deutschland GmbH

INTRODUCTION

What are fire protection coatings?

Fire as a so-called load case poses a special challenge to the supporting structure of a building. To counter the negative implications of a fire, a fire protection concept needs to be drafted tailored to the specific usage of the building.

Steel itself is non-flammable and does not emit any noxious gases when exposed to fire. As such, it does not contribute to the fire load of a building, however the bearing capacity of the steel structural components may decline in the case of fire. If the period up until the attainment of the critical temperature of the structural component fails to comply with the fire resistance period required by the Building Regulations, protective measures must be taken.

The application of intumescent materials, or to be more precise intumescent fire protection coatings, numbers among the passive fire protection measures to be taken. They ensure that steel structures are protected when exposed to fire by extending the time they need to reach the critical temperature (T_{crit}). Depending on the type of structural component and the load to which it is subjected, this can amount to some 500 to 750 °C.

Historical development

Expanding (intumescent) coatings were already used more than fifty years ago to protect steel structures from the impact of excessive heat. Since then, they have been rigorously refined to comply with the highest design, visual, technical, health- and environment-related requirements.



Fig. 1: A water-based fire protection coating protects the steel structure of the “Berliner Bogen”, an eight-storey office building with 43,000 m² gross floor space completed in 2001.

BENEFITS AT A GLANCE

Design scope

- The coatings, only a few millimetres thick and applied in line with the profile, emphasise the filigree nature of the structural steel design.
- Fire protection coatings do not differ from conventional coatings thanks to their smooth finish.
- Architects have infinite colour scope when planning buildings. Topcoats are available in all RAL or NCS colour shades, special accents can be achieved with DB shades containing micaceous iron oxide.

Flexibility and versatility

- Depending on the system used, retrospective enhancement of the fire rating is possible, as in the case of refurbishment projects.
- Fire protection coatings can be applied in virtually all environments, even those with particularly high requirements such as swimming baths and power stations.
- For the coating of interior areas there are especially low-emission systems that even comply with the high demands required for sustainability certification.
- There are coating systems that can be applied to cast iron or galvanized structural steel components.



Fig. 2: The ten-storey building “Deichtor-Center“ in Hamburg Hafencity is protected by a R30 fire protection coating.

Technical and economic quality

- The fast-drying, impact-resistant coatings combine resistance to corrosion and fire with long periods of fire resistance of up to three hours (R180).
- The low-cost intumescent materials make a key contribution to the value retention capacity of a building.
- Coatings can be applied on site or in the workshop. Coatings applied in the workshop enable assembly work to be conducted particularly quickly and independent of the weather conditions.
- Fire protection coatings are virtually maintenance-free over their long service lives.
- Due to their low intrinsic weight, fire protection coatings do not have to be taken into account for structural load calculation purposes.



Fig. 3: Fire protection coatings, only a few millimetres thick and applied in line with the profile, emphasise the filigree nature of the structural steel design.

Good for people, good for the environment

- The numerous protective systems available enable a targeted selection to be made on the basis of health-related and ecological criteria.
- Thanks to the minor film thicknesses, material- and resource-intensive protective measures can be avoided.
- Fire protection coatings help gain time and as such save lives!

COMPOSITION AND INGREDIENTS

Several layers for perfect protection

Fire protection coatings consist of two or three perfectly mutually coordinated layers. The products required for a fire protection system are set out in the relevant German Technical Approval, the European Technical Approval (ETA) or the approval in the individual case concerned.

1. Primer

The primer serves mainly the purpose of corrosion protection while at the same time acting as a tie coat for the intumescent paint.

2. Intumescent layer

The intumescent layer forms the core of the coating system. The paint applied here guarantees the long-term bearing capacity of the structural component in case of fire. The necessary film thickness depends on the type and load capacity of the structural component and the fire resistance period required.

3. Topcoat

The topcoat finally applied serves the purpose of colouring and the protection of the intumescent layer against weathering and mechanical stress. On request, a two-layer system can be selected for interior areas, in the case of which no topcoat is applied.

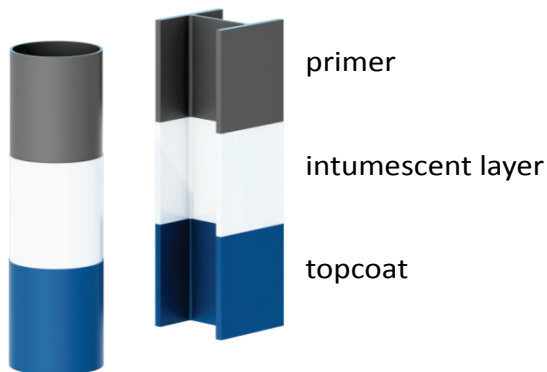


Fig. 4: A three-layer fire protection system consists of a primer, an intumescent layer and a topcoat.

Ingredients

Fire protection coatings comprise solvent-free, solvent-based or water-based coating materials. The last-mentioned type is used primarily for interior areas with enhanced air-quality requirements.

Thermoplastic, organic systems are used as binders – as a rule based on vinyl acetates, acrylics or epoxies. Active substances are added to these which react to form an insulating “carbonaceous char” when exposed to fire (cf. fig. 6).

The colouring, notably that of the topcoat, is achieved via added pigments.



Fig. 5: Non-noxious ammonium polyphosphates are among the substances intumescent coatings are based on.

MODE OF ACTION

Development of a protective intumescent layer

When exposed to fire, the intumescent paint expands at temperatures of between 120 and 200 °C, increases significantly in volume to form a stable, fine-pore, carbonaceous char. This process is called intumescence.

Due to its very low thermal conductivity, the carbonaceous char insulates the structural component such that the latter heats up more slowly and the period up to the attainment of the critical temperature (T_{crit}) of approx. 500 to 750 °C is extended.

The main product of the impact of temperature is an inorganic layer of titanium phosphates which also has very low thermal conductivity.

Carbon dioxide and water are generated as by-products. Additionally, minimal quantities of ammonia, carbon monoxide and nitrogen oxides are released in case of fire. Thanks to their very low concentrations, they can however be considered negligible as compared with the reaction products of the actual fire loads and do not constitute a threat to the environment or health.



Fig. 6: When exposed to fire, fire protection coatings form an insulating carbonaceous char that delays the heating up of the steel structural component.

To ensure that the intumescent paint is able to achieve its full efficacy in an emergency, the adjacent structural components may not hinder expansion. In order to avoid any thermal transfer, adjacent steel structures without a fire rating should likewise be coated over a length set out in DIN 4102 (min. 30 cm).

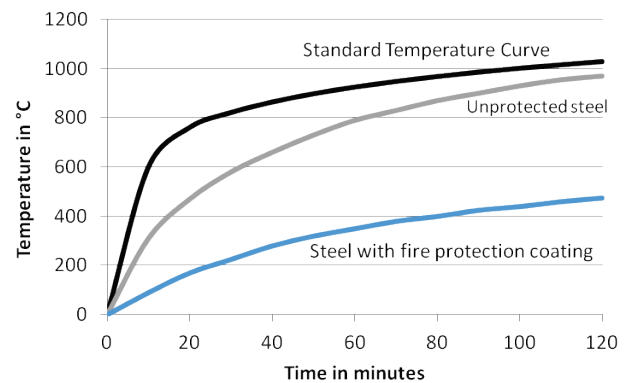


Fig. 7: The intumescent fire protection coating delays the heating up of the steel structural component (schematic representation).

APPLICATION REQUIREMENTS

Application requirements

Fire protection coatings are ideally suited to protecting both simple and complex steel structures against the impact of fire, whereby the applications are virtually unlimited.

Many coating systems are suitable for areas with strict requirements such as hospitals, nursery schools and food companies. For high-stress application areas such as power stations, petrochemical plants and swimming baths, suitable products are likewise available.

Fire protection coatings for refurbishment projects are also possible. The preliminary preparation of the steel or cast-iron structural components by way of sand or dry-ice blasting may be required. Given the appropriate product selection and preparation, existing fire ratings can even be enhanced retrospectively to comply with a building's change of usage.



Fig. 8: The fire safety of the listed “Bikini Berlin” building that underwent comprehensive refurbishment between 2010 and 2014 is guaranteed among others by an R30 fire protection coating.

General and individual approvals

In the German Technical Approvals, for which coating systems are also subjected to an environmental and health check, the application area for fire protection coatings is clearly defined. The following application areas are not covered by the General Technical Approvals and therefore require an independent fire protection assessment and, if necessary, individual approval for:

- full sections (round and square) in the form of cross bracing, tension bars and wind bracing
- tension members as closed sections (e.g. pipes or box-shaped sections)
- tension members as open sections, the bearing capacity of which amounts to > 78 % in a cold state



Fig. 9: The office building “Dockland” in the port of Hamburg, protected by an R30 fire protection coating, projects out in the form of a parallelogram over the water like the bow of a ship.

ECONOMIC EFFICIENCY

Production costs

The following guideline prices were determined on the basis of typical buildings with an average fire load and can be used for initial orientation purposes. As many factors (e.g. accessibility, film thicknesses and application method) need to be taken into account for determining the costs, the manufacturers need to be approached for precise calculations.

| Passive fire protection in €/m ² | Target fire rating | | |
|---|--------------------|-------|-------|
| | R30 | R60 | R90 |
| Work carried out in the workshop | 15–20 | 35–55 | 65–90 |
| Work carried out on building site | 18–25 | 40–55 | 70–90 |

Table 1: Guideline prices for fire protection coatings in €/m² of the steel surface to be coated (source: bauforumstahl e. V. “Steel Construction Costs in 2013”)

Lifecycle costs

Thanks to their durability, the virtually maintenance-free coatings incur low lifecycle costs. Over the assumed service life of the building, only very few additional costs or none at all are to be expected.

Area determination

Only the areas to be coated are taken into account for cost determination purposes. Such structural components as are not exposed to fire, e.g. via their integration into a reinforced concrete ceiling or masonry, do not have to be coated. Some examples are shown in the adjacent illustrations.

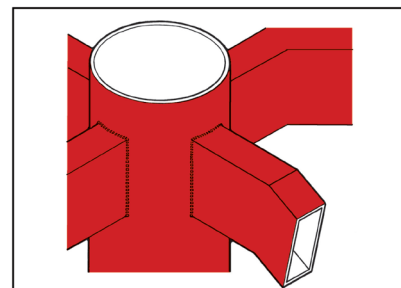
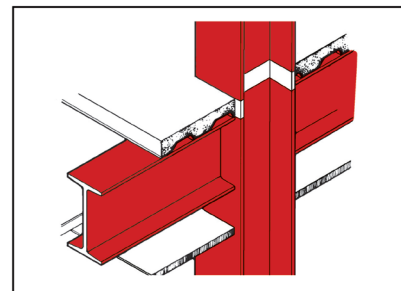
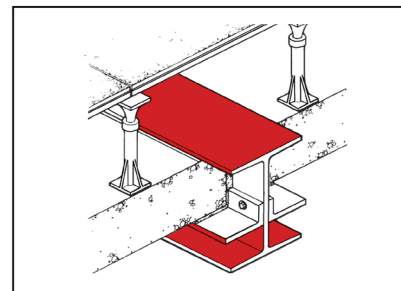
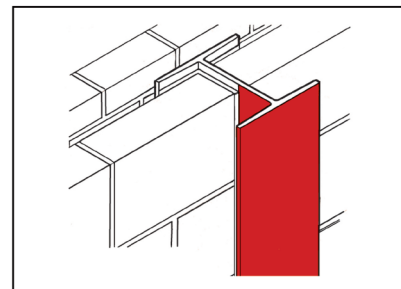
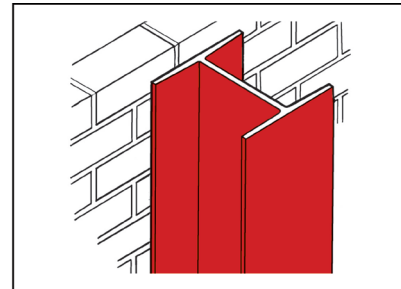


Fig. 10: Only such areas as require coating (red) are taken into account for cost determination purposes.

PRODUCT SELECTION AND FILM THICKNESSES

The right system for each application

Which fire protection systems are best suited to the particular application context and how thick the individual coats have to be depends on several factors. Initially the general parameters need therefore to be determined, for example on the basis of the following list of questions.

1. Interior or exterior application?

Whereas interior applications can often dispense with a topcoat, insofar as this is not desired for design reasons, the latter is absolutely indispensable for exterior contexts.



Fig. 11: The 30,000 m² of the “Europa Passage” in Hamburg completed in 2009 can accommodate 120 shops and businesses. Office space is located above the passage. The passage’s striking steel structure is protected by an R90 solvent-based fire protection coating.

2. Which fire rating is required?

Fire protection coatings enable fire ratings from R15 to R180 to be achieved. As a rule, ratings in the range from R30 to R120 are required.

3. Are there any corrosion protection requirements?

Fire protection coatings can provide corrosion protection and meet the requirements for all corrosivity categories to EN ISO 12944.

4. Which are the material characteristics?

If the structural component is galvanised, coated already or made of a special material (stainless steel, cast iron), the suitability of the fire protection system should be given due consideration.

5. Which type of section is involved?

As thin, closed sections heat up more quickly, they need a thicker coat than thick, open sections. The film thickness required for the relevant structural component is determined via the section factor (H_p/A value).

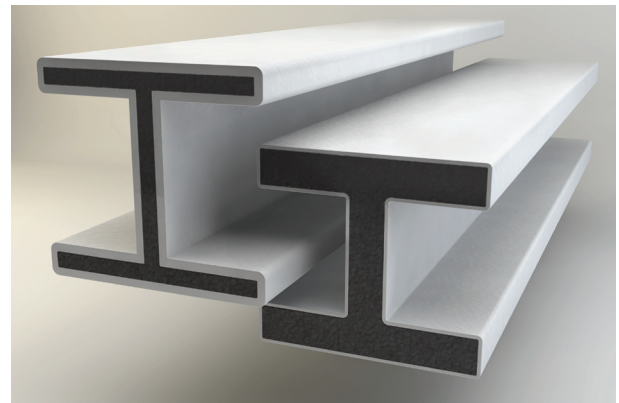


Fig. 12: The film thickness required is determined among others via the section factor (H_p/A value): thin or closed sections heat up more quickly and therefore need a slightly thicker protective coating than thick, open sections.

6. Coating off-site or on-site?

Coating off-site offers many benefits: it is unaffected by weather conditions, can be carried out parallel to the construction work and is as a rule less costly than on-site coating. Thanks to the exceptionally shock-, impact- and abrasion-resistant nature of the products, any damage in transit to be repaired retrospectively is kept to a minimum.

7. Which colour shall the component be given?

The colouring topcoat is available in all RAL, NCS and DB shades thus offering optimum design scope.



Fig. 13: As far as the colour design is concerned, all RAL and NCS shades can be selected. Moreover, special accents can be achieved with DB shades containing micaceous iron oxide.

8. Is a building certification planned?

Modern sustainability certificates place among other things high demands on the air quality in interior areas. In the certification system of the German Sustainable Building Council (DGNB – Deutsche Gesellschaft für Nachhaltiges Bauen), for example, the indoor air quality is an exclusion criterion.

Low-emission, VOC and halogen free fire protection coatings help meet these high requirements. The quality of fire protection coatings can among other things be quantitatively verified via Environmental Product Declarations (EPDs).

Support from manufacturers

The film thicknesses to be applied are product dependent and set out in the relevant approvals or data sheets of the manufacturers.

For initial calculation purposes, some manufacturers provide free computer programs for calculating the film thicknesses required.

Furthermore, manufacturers and applicators offer comprehensive project-related counselling, whereby they take on the calculation of such Hp/A values as are not included in the relevant section tables and determine the film thicknesses required on the basis of drawings or part lists.

APPLICATION AND QUALITY ASSURANCE

Application

As a rule, the airless spraying method produces particularly smooth and economical coatings. Alternatively the coating e.g. for small areas can be applied by brush or roller.

The coating system can be applied either off-site or on-site: if structural components are coated off-site, they then have to be protected in transit and storage against damage. Connecting elements are to be coated using a brush once the assembly work has been completed. When coating on-site, attention is to be given to ensuring that the structural components are protected against weather exposure and the site is sufficiently well aired until all coats have been applied.



Fig. 14: The airless spraying method ensures fast, even and economical coating. It can be used both off site and on site.

Quality assurance

Fire protection coatings have to function reliably in an emergency. Optimum product quality is therefore assured at an early stage via the demanding approval procedures as well as the regular monitoring of the manufacturers conducted both externally and by the companies themselves.

Coating systems may only be applied by trained, specialist staff working for certified companies. The applicator ensures that the prescribed climate conditions are complied with. He also measures the film thicknesses with a wet film thickness gauge at regular intervals and documents the results.

Once the coating has fully cured, the dry film thickness of each of the two or three coats is measured using electromagnetic gauges.

Once all the relevant work has been completed, the applicator confirms by way of a so-called “Installation Certificate” that the intumescent coating has been applied in accordance with the approval concerned.



Fig. 15: Non-destructive measurement of the dry film thickness is conducted with the aid of electromagnetic gauges.

CLEANING, MAINTENANCE AND REPAIR

Cleaning

Fire protection coatings can be cleaned very easily. Loose dust and other contamination can be easily removed by hand or mechanically by blowing, vacuuming or lightly brushing it off.

Oily or greasy contamination ought to be removed with a sponge or low-pressure water spray. Standard household detergents can be used too and then rinsed off with clean water. Depending on the product concerned, high-pressure cleaners can also be used. Before doing so however, the manufacturer and/or maintenance instructions must be consulted. Attention must be given to ensuring that the coating is not under any circumstances damaged by way of the cleaning process.



Fig. 16: Contaminated fire protection coatings can be cleaned by blowing, vacuuming or lightly brushing the dirt off. Some coatings can even be cleaned with high-pressure cleaners.

Testing and maintenance

Intumescent coatings are resistant to aging and can withstand minor mechanical stress such as slight bending and temperature expansion without difficulty. Given correct and professional application and usage, their service life is virtually unlimited. Attention must however be given to ensuring that coatings are protected against mechanical damage such as that caused by stored goods or vehicles.

For fire safety purposes property owners are obliged to have the coated structural components, which are normally identified with stickers or marked in the fire protection plans, subjected to a visual inspection at regular intervals. Depending on the stress buildings are exposed to, inspections should be conducted at intervals from 1 year (e.g. industrial buildings) to 5 years (e.g. museums). Important to note: as such structural components as are not accessible for visual inspection purposes cannot generally suffer mechanical damage, they do not need to be inspected.

Any damage identified as large as a 2-euro coin or more should be repaired professionally without delay. When repairing damage, attention should be given to ensuring that a product be selected that is compatible with the system used. By contrast, minor damage less than that stated above poses no risk in case of fire.



ABOUT IGSB

IGSB (Interessengemeinschaft Stahl-Brandschutzbeschichtung), which was set up under the umbrella of the bauforumstahl e. V. organisation in 2012, has set itself the objective of providing information on modern fire protection coating systems. It sees itself as a competence centre in all matters concerning fire protection of structural steelwork and related areas. A team of experts is available to help and advise all interested parties.

IGSB

- advises architects, engineers, fabricators and applicators in matters relevant to technologies and products
- promotes the use of modern fire protection coatings on steel
- provides design and installation support
- draws up cost-benefit analyses
- offers training and further education
- promotes and supports scientific cooperation
- provides a comprehensive offering concerning “fire protection coatings for structural steelwork” and related areas on its website (www.igsb.info)
- is a member of:



Members of Interessengemeinschaft Stahl-Brandschutzbeschichtung (IGSB)



Sohnstraße 65 | 40237 Düsseldorf
Tel.: +49 (0)211 6707-826 | Fax: +49 (0)211 6707-829
Mail: info@igsb.info | Web: www.igsb.info