Reconstruction of the Rinkeby fire
Technical textiles in construction
Fires in tunnels
Fire technology is growing

It is with large expectations for the future that I write my first editorial for BrandPosten. SP Fire Technology was in a growth period when I took over from Ulf Wickström in July, and this growth is continuing at an even faster rate. We recruited 13 new members of staff in 2010, bringing our numbers to 64 at present. Six new members of staff are presented in this issue of BrandPosten, and we expect there to be another six in the next issue. At present, we are in the process of recruiting four researchers and are in fact even extending our search to cover international sources. We have built two temporary office blocks while waiting for construction of new permanent premises, and we are planning for expanded laboratory resources. We experience an increased demand for our services of more or less equal parts of research and testing and investigation. As things look at present, this growth will continue for several years. Our activities continue to be based on our vision for SP Fire Technology as one of the world’s leading fire laboratories for technical evaluation, research and innovation. This is reflected in the fact that our international activities is already approaching 50% of our total revenue, and which is one of the reasons why we are now recruiting on the international level. This is all extremely satisfying, while at the same time presenting a substantial challenge for all members of the department.

SP Fire Technology’s traditional client and research base has been the construction sector, for which we perform testing, certification, fire modelling, investigation, standardisation and the provision of expert services, at both national and international levels. This is our most important activity, in which the European harmonisation in the fire area constantly opens up new challenges. Our work in the ‘reaction to fire’ field has always been extensive, but work in the field of the fire resistance of structures is becoming increasingly important. We therefore expand our resources in this area, by recruiting two new senior research scientists and by increasing our links with European partners. One exciting working area is the future use of textiles in construction, as described in the article in this issue of BrandPosten. The revision of the Swedish Building Regulations and, on the European level, the introduction of CPR, the Construction Products Regulation are two developments that will strongly influence our future activities. The CPR could come into force within the next few years, which will then change its status from advisory to mandatory.

Sustainable development in society and an efficient transport system both require consideration of fire safety and our two competence centres, for fire safety in underground facilities, and for lightweight construction materials for use in ships, are booming. Another exciting development is that of Kockums’ design and construction of lightweight vessels in composite materials. Our projects within this area, such as LÄSS, have pioneered the way and contributed to realising this new approach by ensuring appropriate fire safety. We are proud to be associated with this technological development. Industrial protection is another area of rapid growth. Our personnel are constantly praised for their professionalism and comprehensively designed and performed experiments, which is an important reason for a large company such as Kraft Foods choosing again to entrust SP with training and demonstration trials of fire extinguishing systems in warehouses.

The ‘Fires in Vehicles’ (FIVE) conference was a major success, bringing together more than 200 delegates from 20 countries for the premiere of this conference series. This indicates a substantial interest, with the conference giving, for example, the European Commission representative a substantial body of new and valuable information. Work is already in progress on FIVE II, which will be held in Chicago in 2012. Several of our new members of staff are working on projects in these growth areas, such as analysis of fire risks in ships, on trains and in buses.

Our work is steadily moving forwards, based on the sound foundations of many years’ work by our experienced personnel. We are continuing to recruit new personnel, and have started systematic training programmes for all staff. We are also encouraging PhD students, with no less than six at present working for Fire Technology. Our links with universities and institutes of technology are very important. They are already extensive, and I am convinced that they will become more so.

Björn Sundström
Table of contents

Editorial 2
Reconstruction of the Rinkeby fire 4-6
Good protection from structures having fire resistance classifications 7
Sprinkler concept developed for IKEA’s Vertical Automated Storage System 8-10
Egolf course in heat transfer at SP 11
Kraft Risk Management Safety Seminar 12-13
Lars Boström appointed new chairman of a standardisation committee 13
Lightweight vessels of the future under construction at Kockums in Karlskrona 14
Testing of burglar resistance at SP 14-15
Contex-T – building construction using technical textiles 16-17
High interest in the FIVE conference (Fires in Vehicles) 18
Successful work on heat flux measurement 19
Technical data for CE-marking of cables - the CEMAC project 20-21
Tank fires in oil storage depots - SMC on training course in France 22-23
Ethanol tank fire fighting to be presented at a workshop 24-25
The Pellet Handbook 26
Smoke control doors in the Swedish Building Regulations (BBR) 27
Evacuation lifts – future solutions for high-rise buildings 28
Fires in tunnels during the construction stage 30-31
Calculation of ceiling temperatures in tunnels 32
New members of SP Fire Technology staff 33
New SP reports 34-35
A fire occurred on 25th July 2009 in an apartment at Kuddbygränd 12 in Rinkeby, northwest Stockholm. The fire started in a smaller bedroom, adjacent to the kitchen. Smelling smoke, the apartment’s occupants opened the bedroom door, whereupon the fire quickly spread to the kitchen and into the rest of the apartment. Escaping from the apartment, the occupants left its main entry door open, allowing the fire gases to spread into the stairwell. A total of seven persons died as a result of the toxic gases when they attempted to escape from apartments higher up in the building, using the stairwell. All the occupants of the apartment where the fire started survived. This tragic event has now been investigated by the Swedish Accident Investigation Board, supported by several experts, including input from SP Fire Technology.

Reconstruction of the progress of the fire
The Swedish Accident Investigation Board (SHK) instructed SP Fire Technology to carry out a fullscale room fire test of those parts of the apartment where the fire started. A suspected cause of the fire was an uplighter lamp in the bedroom where the fire started. The work included investigation of whether such a lamp could ignite textiles.

The purpose of the work was to reconstruct the initial ignition, the early stage of the fire and the fully developed fire as it occurred in Rinkeby, and to produce measured parameter data that could be used for computer simulation of the fire. SP therefore constructed a full-scale model of the kitchen and the adjacent bedroom on the basis of drawings of the apartment. This model was then furnished, as far as possible, with the same furniture as during the fire, as shown in Figure 1. The initial ignition process was reconstructed on the basis of information from SHK and its fire investigators. An important point was that of ascertaining which windows and doors were open when the fire started and which were opened as the fire progressed.

The heat release rate, temperatures in the rooms and openings, as well as fire gas flows, were measured continuously using the SP industrial calorimeter, as shown in Figure 2. The composition of the fire gases was analysed by FTIR technology, monitoring for toxic gases. All this data has been used by Brandskyddslaget AB for modelling the situation in the stairwell.

Summarising the results of the room fire experiment
The fire in the bedroom developed slowly, partly because it was started by a small ignition source in the form of a simulated small textile garment in a bed having a thin mattress. The fire then spread slowly from object to object in the bedroom. In general the growth of the fire was limited by little access to air. The bedroom window was ajar, but the door to the kitchen was completely closed. As a result, flammable gases accumulated in the bedroom. Opening the door from the kitchen increased the availability of air, triggering a dramatic evolution, with the flammable gases igniting and the fire spreading extremely rapidly. Flashover occurred in the bedroom within 15 seconds of opening the door. The fire then spread into the kitchen, with flashover there occurring a little over a minute later, as shown in Figure 3.

During the early stage of the fire, i.e. as an underventilated fire in the bedroom, heat release rates were low, not exceeding about 200 kW, while the temperature in the upper part of the room fluctuated between 250 °C and 300 °C. This was a relatively small fire, and it is possible for such fires to burn behind a closed door without being discovered. When the door from the kitchen was opened, the temperature was about 400 °C and flashover occurred in the bedroom.
within 15 seconds, and the heat release rate rose to about 1 MW. A developed fire such as this can spread rapidly due to its high heat release rate.

Once flashover had occurred in the kitchen, the heat release rate rose to about 4,5 MW, causing a temperature of about 1000 °C in the kitchen (see Figure 3). When we started to extinguish the fire, its heat release rate was close to the maximum possible with the amount of air that was available. At this stage, smoke at a temperature of about 900 °C, and with a mass flow rate of about 1.3 kg/s, was pouring out through the kitchen door into what, in Rinkeby, would be the rest of the apartment.

Smoke production and toxic gases
Analysis of the smoke during the trial, complemented by calculation of the gas flow rates, show that the materials in the apartment produced substantial quantities of toxic smoke, including carbon monoxide and hydrogen cyanide.

The potential toxicity of the smoke is indicated by the volume concentrations of various gases in the plume of fire from the kitchen door. The average concentration of a number of toxic gases was calculated for the time period during which the kitchen was fully enveloped by fire. In order to provide a rough comparison of the relative toxicity of the various substances, the calculated concentrations were weighted against a reference value for each gas. Table 1 shows an example of such a comparison, weighting the maximum concentration (C_{max}) of the various substances against the respective IDLH value. An IDLH value is that concentration of a substance that has a serious toxic effect. These values are published internationally and are based

<table>
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<tr>
<th></th>
<th>CO₂</th>
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<th>NO</th>
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<td>8.3</td>
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Table 1  Conversion of calculated gas concentrations of various substances in the fire plume from the kitchen door to equivalent IDLH values. The IDLH value of a substance is the concentration at which the substance presents a serious toxic risk. C_{max} is the maximum concentration of each gas.

in most cases on a 30 minute exposure.

It can be seen that the IDLH factor for hydrogen cyanide, HCN, is twelve times over the dangerous concentration, and that for carbon monoxide, CO, is eight times over the dangerous concentration. The maximum smoke flow from the kitchen into the rest of the apartment was about 1.3 kg/s, which means that large quantities of toxic smoke were being transported into other parts of the building in a short time. However, it must be noted that the gas concentrations in the fire plume from the kitchen would be diluted as they left the apartment, with the resulting concentrations and their effects on other occupants of the Rinkeby building depending on the degree of dilution and exposure times. See also the Accident Investigation Board’s report.

Ignition tests using an uplighter
The police investigation of the apartment, and of the room where the fire started, indicated that a possible initial cause of the fire was an uplighter lamp. The bulb in this particular lamp was above a concave reflector, which would mean that if the lamp was covered by, say,
Figure 4  The diagram shows the temperature at different heights in the kitchen during the experiment. When flashover occurred, less than two minutes after opening the kitchen door, the smoke temperatures reached about 1000 °C.

a piece of textile material, it would create an unventilated space in which the temperature could rise considerably. This scenario was investigated in several tests, with different types and amounts of textiles being placed on the lamp. It was found that the presence of several layers produced sufficient thermal insulation to allow the temperature around the bulb to rise significantly and create a pyrolysing fire, which could develop into a fire with an open flame.

Comparisons between the room fire experiment and the actual fire
The exact progress of the fire in Rinkeby is not known, but descriptions by witnesses and pictures taken during and after the fire make it possible to create a likely picture of the sequence of events. The time from when the bedroom door to the kitchen was opened until firefighting started was about 15 minutes, which means that the fire was intensive, producing hot toxic gases which rose upwards in the stairwell during this time.

Those who escaped from the apartment on the second storey via the building's internal stairwell stated that they felt strong heat as they passed the kitchen door. At that point, the kitchen had probably not reached flashover. If it had done, those escaping would have had to pass through the flames coming out through the door. During the model trial, flashover occurred in the kitchen about 1.5 minutes after opening the bedroom door. The progress of the fire during our test was probably somewhat more rapid than in the Rinkeby building. However, evacuation probably occurred within a few minutes of opening the bedroom door and the fire spreading to the kitchen. There were 13 persons in the apartment, and they presumably managed to escape in the very nick of time before the fire in the kitchen blocked the escape route past the kitchen door and the other escape routes that were used.

The gas flows that were measured during the trial are probably representative of those encountered in the actual fire in Rinkeby. One possible source of uncertainty is that the model was constructed only as far as the kitchen door opening to the apartment, whereas in reality in Rinkeby it opened into a hall and then on into the internal stairwell and the building's stairwell. This means that the pressure conditions would differ. The trial measured high concentrations of carbon monoxide and hydrogen cyanide in the fire gases from the apartment. Brandskyddslaget's simulations also indicated high carbon monoxide and hydrogen cyanide concentrations in the stairwell. Significant concentrations of hydrogen cyanide and fatal levels of carbon monoxide were found in the bodies of those who died in the stairwell.

The Accident Investigation Board's full report, RO 2010:01 (in Swedish), can be downloaded from www.havkom.se. The web site also includes a total of 14 recommendations to the authorities in order to avoid similar tragedies in future. They include two important questions to the National Board of Housing, Building and Planning. The smoke gases spread into the stairwell through an open door, which raises the question of whether automatic door closers might be appropriate on apartment doors. The second question relates to automatic smoke ventilation of stairwells in apartment buildings: calculations indicate that this would have been effective in Rinkeby.
Good protection from structures having fire resistance classifications

In general, structures of approved design and made from materials having appropriate classifications provide excellent protection. However, this may not be the case if the product is used incorrectly, or has not been modified for the particular application. To achieve the desired degree of protection against fire, it is necessary to know what type of protection and what level of safety any particular fire resistance class provides.

Structure fire classes
There are essentially three fire classes used for structures: R, E and I in accordance with EN 13501-2. These class indicators are then complemented by a number which indicates the time in minutes for which the fire class will be maintained. A class R structure has a certain load-carrying capacity when exposed to fire: the load that the structure is capable of carrying is defined by the manufacturer. Certificates or similar documents must then show the load that the structure is capable of withstanding in fire conditions.

A class E structure has a certain level of integrity, i.e. a fire cannot penetrate the structure. There are three aspects that must be considered:

- Holes or cracks in the structure. Failure is defined as the formation of a hole with a diameter greater than 25 mm, or cracks with a width of 6 mm and length of 150 mm or more.
- Hot gases. Penetration of hot gases is measured by means of cotton wool pads applied to areas that are judged to be the most likely to provide indication. The tufts must not catch fire or start to glow.
- Flames on the side not exposed to fire. A single flame is permitted, if it does not exist for more than ten seconds.

It should be noted that, when classification testing a class E structure, the results of the cotton wool pad test need not be considered, although this particular element of the test must always be performed. This means that there are no requirements applicable to the maximum permissible temperature on the unexposed side: it can, in principle, be as high as the temperature in the fire test furnace.

A class I structure provides thermal insulation, i.e. the average temperature on the unexposed side of the structure must not rise by more than 140 °C during the length of time for which the classification applies. There is also a requirement that the temperature may not rise by more than 180 °C at any individual point.

Classes W, S and C are important additional classes. Class W structures can withstand a maximum thermal radiation of 15 kW/m² at a distance of one metre. Class S is used for doors, to indicate that they do not permit the leakage of smoke. Class C is also used for doors, indicating that the door is fitted with, or incorporates, an automatic closing device that fulfils certain requirements.

When can the different classes be used?
According to the Swedish Building Regulations, fire cell separating structures must normally be of class EI, although class E can be accepted if the distance to evacuation routes and to flammable materials is sufficient. If the simpler solution is chosen, i.e. a class E structure instead of a class EI, the resulting implications must be considered. There can be substantial differences between products: if, for example, two glazed doors having the same class E classification are compared, with one having a small window opening and one having a large window opening, radiation through the door with the large glazed area will be considerably higher.

Figure 1 shows how a pad of cotton wool at a distance of 1.5 m from a class E structure catches fire. In this situation, radiation levels of 70 kW/m² can be noted up to 1 m from the item under test, which is sufficient to ignite most materials. Radiation of 15 kW/m², for example, is sufficient to cause blisters on the skin after five seconds. This is something that the purchaser must be aware of: it may be acceptable in some cases, but more dubious in others. If there is any uncertainty as to the suitability of class E, it can be replaced by a class EW solution, which also includes a requirement in respect of maximum radiation.

Class E and Class EI structures are not smoketight
Figure 2 shows a wall section under test, with smoke clearly passing through it. Class E and class EI structures have no requirements in respect of smoketightness: the only requirement is that any holes or cracks must not be too large (a diameter of 25 mm or a length of 150 mm and width of 6 mm). Here, too, it is necessary to consider the type of protection required. Specifying only class E or class EI does not mean that the resulting structure will be smoketight. However, there will be some protection against the spread of smoke, as the structure will resist the spread of fire. However, there are situations where this degree of smoketightness is insufficient: examples include archives or computer areas with sensitive materials or equipment. Another example is that of evacuation points for older or disabled persons who would need assistance in evacuating the building.

Can we trust fire protection?
In general, we can trust protection against fire if approved and properly thoughtout designs have been used. However, there can be cases that require more specific consideration before deciding on a particular fire protection solution.
Sprinkler concept developed for IKEA’s Vertical Automated Storage Systems

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The Department of Fire Technology at SP Technical Research Institute of Sweden has recently conducted sprinkler tests inside a VASS (Vertical Automated Storage System) unit for IKEA Services AB. The objective of the tests was to determine whether sprinklers installed at the top of the unit are able to protect the integrity of the unit during a fire and thereby limit the risk for fire spread to adjacent objects or building parts.

The concept of VASS units
A VASS unit is an enclosed system of vertically arranged trays, an extraction platform and a series of computerized controls that delivers items to an ergonomically positioned workstation. The unit automatically locates and retrieves stored items with the push of a button or scan of a bar code. The trays handled by the system can be equipped with partitions and dividers, totes and containers, cases and cartons, etc. The benefits of this storage concept include maximum use of available space, increase productivity and improved worker safety.

The storage inside a unit is very compact. Technology is used to scan every tray’s height and the trays are automatically stored in the optimal space in the unit. A built in weight scale automatically checks a tray’s weight to protect against overloading of shelves.

It should be emphasised that the probability for a fire inside a VASS unit is low. The primary sources for fire ignition are related to computer control and the electrical motors associated with the extraction platform. Unauthorised personnel do not have access to the unit. Despite the high level of intrinsic safety, a built in fire protection system is often required.

The VASS unit used by IKEA
The VASS units used by IKEA are designed to fit their specific needs regarding the dimensions of the trays and the overall capacity. The trays are constructed out of steel, with solid side plates. The individual trays measure 4 m × 0,8 m (W × D). The rim height is 250 mm and, in the tests, two dividers were installed such that three compartments were formed per tray. The unit used in the fire tests had a total of 45 trays, 25 trays on the back wall and 20 trays on the front wall.

In practice, the most common commodities stored in VASS units at IKEA are products, e.g. kitchen articles, doors, drawers and textiles, or similar items. Products from unexpanded plastics are not as common and products from expanded plastics are prohibited.

The unit used for the tests measured approximately 8 m in height, 4,4 m in length and 3 m in depth. The unit was supplied by Kardex, Bellheimer Metallwerk GmbH and installed inside the fire test hall at SP by personnel from Kardex Scandinavia AB. The installation of the unit is shown in figure 1.

Objective of the tests
Prior to the tests, it was concluded that the use of solid trays (with solid side plates) will prevent water from sprinklers at the ceiling to reach the seat the fire. Therefore, fire extinguishment or fire suppression by the activation of sprinklers installed at the top of the unit was not expected. Additionally, the trays are fitted with holes in the ends of each tray that will drain water to the sides. This feature is designed to prevent the top trays from being filled with water, jeopardizing the stability of the unit.

It was also understood that the enclosed construction of the VASS unit and the solid design of the trays will in itself delay the spread and intensity of a fire. The steel trays restrict the possibilities for vertical fire spread and the compact storage restricts air movement, which limits the oxygen concentration at the seat of the fire. When filled with combustion gases, the oxygen concentration inside the unit as a whole is reduced, which will reduce and possibly even quench a growing fire.

Therefore, it was recognized that the limitation of the fire size will primarily be an effect of a reduction of the oxygen concentration by the fire itself and to some extent by the formation of water vapour. In order to facilitate the desired reduction of oxygen, it was therefore deemed essential that the structural integrity of the VASS unit remains intact during a fire. As a result, the following criteria were set...
up as minimum requirements to judge the test results as acceptable: 1) the VASS unit must remain structurally intact, 2) no full or partial rupture of any of the wall/ceiling panels or joints between these panels is allowed, 3) no rupture of the hatch for the front opening is allowed, and 4) no fire spread to adjacent objects or combustible material is allowed.

The sprinkler system
The sprinkler system was intentionally designed to be relatively simple. The system pipe-work was laid out on top (outside) of the ceiling with drop nipples to the individual sprinklers. Four pendent, standard coverage, quick-response sprinklers were installed. The sprinklers were installed to ensure wetting of the inside surface of the walls of the unit.

An optical – photoelectrical – type smoke detector was installed at the ceiling of the unit. The response time of the detector was recorded in order to provide a comparison with the activation time of the sprinklers.

Instrumentation and measurements
Thermocouples were installed inside the unit in order to document the potential fire spread. Additionally, the surface temperatures on the outside of the unit were measured using thermocouples that were spotwelded directly to the outer steel panels. A thermal imaging camera was positioned behind the back wall with the intention of documenting the thermal exposure in the area where the fire was initiated. The concentration of Oxygen ($O_2$) was measured at the centreline of the unit and 1.3 m and 3.2 m, respectively, above floor level. The lowest position (1.3 m) was at the level of the tray where the fire was initiated.

Standard and authentic IKEA commodity used
The EUR Std Plastic commodity was used in the tray where fire was started and in the trays directly above. This commodity is similar to the FM Global Standard Group A Plastic commodity, which has been widely used in the fire protection community to create a representative “benchmark” warehouse fire hazard for the evaluation of sprinkler fire protection performance in large-scale fire tests since the 1970’s. Authentic IKEA commodities (pillows of synthetic material and plastic crates) were used below and above these trays. All other trays were filled with packages of particle board or packages with kitchen doors from IKEA’s product line. This commodity represented a realistic load and acted as an indicator of fire spread. Figure 2 shows the EUR Std Plastic commodity that was used in the tray where the fire was initiated.

Two tests were conducted
Two tests were conducted. In both tests, the fire was initiated in one of the bottom trays at the back wall of the unit. For the first test, the unit was loaded as would be expected under normal conditions, i.e. the density of the loading of the trays was high. The fire growth rate during the test was extraordinarily slow, due to the solid design of the steel trays that restricted the possibility for vertical fire spread. It is also clear that the compact storage (the minimum free vertical distance between individual trays was 25 mm) restricts air movement and limits the oxygen concentration at the seat of the fire. The fire detector at the ceiling responded at 07:15 [min:sec] but the first (and only) sprinkler did not activate until after more than an hour. The oxygen concentration inside the unit at the activation of the sprinkler was approximately 13.5 vol%. The oxygen concentration increased after the activation, probably due to mixing effects and a pressure reduction due to cooling by the water droplets, which drew fresh air into the unit. As the fire continued to burn, the oxygen concentration was further reduced and did not increase until manual fire fighting was undertaken, 30 minutes after activation of the sprinkler.

The surface temperature at the wall panel closest to the fire was approximately 200°C at the activation of the sprinkler; however, the application of water did not immediately reduce the surface temperature at this position. Rather, the temperature continued to increase and peaked at 405°C. The closest thermocouple, 1.1 m above this point, was reduced from approximately 110°C to approximately
80°C by the application of water, which indicates that the high temperature exposure was very local. Figures 3 through 5 shows the thermal image of the back wall during the test. The thermal images may be compared with figure 6, where the burn marks can be seen on the back wall after the fire test.

For the second test, the tray directly above that where the fire was started, was removed. The free vertical distance between the fire tray and the tray above was therefore increased from 25 mm to 300 mm. As a result, the fire growth rate was significantly higher than that in the first test. This translated to a more rapid reduction of the oxygen concentration inside the unit. The fire detector at the ceiling responded at 02:49 [min:sec] and the first (and only) sprinkler activated at 08:53 [min:sec] after ignition, at an oxygen concentration of approximately 14,5 vol%. The oxygen concentration continued to fall, as the fire was not extinguished by the application of water, and reached a minimum level around 11,0 vol% at approximately 14:00 [min:sec]. This oxygen level was low enough to quench the fire. Manual fire fighting was not necessary. The surface temperature at the wall panel closest to the fire reached 600°C. The application of water did not immediately reduce the surface temperature at this position. The closest thermocouple, 1,1 m above this point, peaked at 57°C which indicate that the high temperature exposure was very local. Figures 7 through 9 shows the thermal image of the back wall during the test. These figures show that the fire spread in both direction on the tray from the fire source and heated up the whole length of the wall panel.

**Conclusions**

As expected, fire extinguishment from an installed sprinkler system may not be guaranteed in practice due to the shielded nature of the fire. However, automatic sprinklers installed at the ceiling of a VASS unit will maintain the structural integrity of the unit during a fire and the temperature exposure to the wall panels will remain local. It was also verified that the probability for fire spread to adjacent combustible objects or material outside of the unit is very small, as only small parts of the wall were heated up.

As fire extinguishment is not guaranteed, it is advisable that a strategy, equipment and instructions for manual fire fighting are developed. The following strategy is suggested: 1) the VASS unit should NOT be opened during a fire, use water from fire hoses to cool the structure from the outside, 2) use an infrared (IR) thermal imaging camera to help locate the fire, 3) drill (small) holes and insert lances at the seat of the fire, use water to fight the fire locally, and 4) allow time for cooling before the unit is opened and ventilated.

A final word of caution is necessary. The experience described in this article is not directly applicable to other types of compact storage units. The geometry, construction and design of the units used by IKEA are unique and intended for their commodity and purposes. Other type of compact storage units that do not have the features of IKEAs units may require other types of fire protection systems or other sprinkler system designs in order to meet the desired fire protection objectives.

Should you have any further questions about your specific storage system please contact the author.

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**New product standard for loosefill mineral wool**

The product standard for loosefill mineral wool is now harmonised and ready for implementation: the co-existence period expires on 1st December 2011. SP can perform all relevant tests, surveillance of FPC (Factory Production Control) and certification.

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Egolf course in heat transfer at SP

For the first time SP arranged a two plus two days new course in basic heat transfer and temperature calculation theory. Egolf has sponsored the development of the course which is theoretical but contains important elements of demonstrations in the laboratory.

Egolf is devoted to raise the quality of the services of its members to clients. Therefore Egolf has developed so called harmonization courses for several of the most frequently used European test methods. As a matter of fact each member shall have at least one technician trained in the various test methods they work with. The new course now being offered is more general and theoretical. It aims at improving and harmonizing the understanding of temperature, heat and fundamental fire phenomena. One of the essential matters being discussed is the difference between radiation temperature and gas temperature and how they can be measured and combined into so called adiabatic surface temperature.

The first course was attended by 16 experts from nine European countries. In a questionnaire following the course they all expressed satisfaction with the course and indicated that they would recommend it to their colleagues.

HÅBECO
Fire- & Burglary Protection

HÅBECO has protected the property of companies, authorities and private citizens with our products for over 50 years. With our wide product range, we can meet almost every need when it comes to protection against fire an burglary.

Product News!!

HÅBECO has developed a series of double door document safes. These have been tested at SP in Borås and approved according to NT Fire 017, 90P.

Dealers!

We are now looking for dealers in several European countries. Please take a moment to see if our products can be interesting for your business. Contact mats@habeco.se for more information or visit our website www.habeco.com

HÅBECO document safes are tested at SP and certified NT Fire 017, 90P

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ISO 9001
In June 2010 SP had the opportunity to arrange a Safety Seminar held here in Borås on behalf of Kraft Risk Management which is part of Kraft Foods Inc. The risk and safety managers from Kraft Food’s different production facilities around Europe were invited. Lectures as well as full scale tests was part of the program.

**Kraft Foods**
Kraft Foods makes “today delicious” in 150 countries around the globe. They have 100,000 employees and have global powerhouse brands like Oreo and LU biscuits, Philadelphia cream cheeses, Jacobs and Carte Noire coffees, Tang powdered beverages and Milka, Cote d’Or and Toblerone chocolates. Kraft Foods is the world’s second largest food company with annual revenues of $42 billion.

**Need of firsthand knowledge**
The Kraft Risk Management department is in charge for handling all safety and risk aspects for the different production facilities of Kraft Foods around the world. Kraft Risk Management works closely with FM Global, which is a global commercial and industrial property insurance company as well as with Marsh, a leading insurance broker and risk adviser. The safety seminar was carried out as a joint co-operation between Kraft Risk Management, FM Global and Marsh.

**Figure 1** The commodity used during the test was cardboard boxes with a mixed content of coffee and chocolate products produced by Kraft.

**Figure 2** Flames reaches ceiling level during the sprinkler test, taken just before the first sprinkler activated.

**Figure 3** All sprinklers have activated and the fire is under control and declining.

**Figure 4** Photo taken during the free-burn test shortly after the fire spread to the single row rack.
The risk and safety managers from Kraft Food's different production facilities around Europe were invited to the seminar. The objective was to educate the managers during two days with all safety and risk issues that they can face in the light of their position as risk managers at their production facility. Issues that were discussed were for example dust explosions, handling of flammable liquids and sprinkler protection of warehouse. To visualize and demonstrate some of the risks, full-scale fire tests were carried out. A small scale test for showing the principles of a dust explosion was also carried out.

Full scale fire tests

One of the main events of the seminar was the full scale fire tests held in SP’s large fire hall. The tests were conducted to demonstrate the differences in fire behaviour in sprinkled versus non-sprinkled storage areas. Two tests, one with active sprinklers and one free-burn test were therefore performed.

The test setup consisted of one double row and one single row rack storage separated with a 2.1 m aisle (see photos) and was identical for both tests apart from less commodity being used in the free-burn test due to safety issues. The commodity used during the test was cardboard boxes with a mixed content of coffee and chocolate products produced by Kraft.

Above the racks, a 10 by 10 m suspended ceiling was positioned at a height of 5 m above the floor and a sprinkler system with 16 sprinklers was installed as well as thermocouples to monitor the ceiling temperatures. As part of the goal with the tests was to study fire spread, a plate thermometer was placed in line with the commodity on the single row rack to measure incoming radiation from the fire initiated in the centre of the double row rack.

In the sprinkler test, the fire grew rapidly during one minute with flames reaching ceiling level at approximately 30 s before the first sprinkler activated. Within 35 s after the first sprinkler activation all sprinklers were activated and the fire was suppressed and gradually declined.

During the free-burn test the same procedure was followed but the sprinkler system was inactivated. This resulted in a fire spread to the single row rack within 3 minutes from ignition and the double row rack was at this point fully involved in flames.

The differences in the level of the incoming radiation from the fire to the single row rack clearly show the impact and benefits of the sprinkler system.

The two full scale tests clearly fulfilled the purpose in demonstrating the benefits with a well working sprinkler system in storage areas.

An educational experience

The seminar went on for a total of two days with positive responses from all parties involved. Sharing of knowledge and education of personnel are among the most important factors when it comes to risk management and safety. Watching real fires is very powerful in understanding how efficient a sprinkler system can be and by providing all this, the seminar cannot be called anything but a success.

Lars Boström new chairman of CEN TC127 Swedish shadow committee

Lars Boström, of SP Fire Technology, has been appointed as the new chairman of SIS TK 181 Technical Committee for Fire Safety. He replaces Ulf Wickström, who had been the very effective chairman of the committee for several years.

TK 181 coordinates Swedish work in such areas as European standardisation (CEN) and international standardisation (ISO). The committee’s work has had considerable effect on test methods and classification rules for the Construction Products Directive (CPD). The committee includes representatives from public authorities, universities, institutes of technology and industry.

Lars Boström would like to see Swedish companies playing a greater part in standardisation work. These are important questions that are very relevant to most industrial companies. If you want to be involved, and play a part in influencing developments, or want to be updated on what is happening, you should be a member of SIS TK 181. We welcome all those wishing to play a part and influence standards before they are finally agreed.

A seminar was held in Stockholm on 20th January 2011 to present new building standards, European harmonisation and CE-marking.
Lightweight vessels of the future under construction at Kockums in Karlskrona

Will future vessels be built from materials other than steel or aluminium? Certainly some of them will: the trend is towards greater use of lightweight materials. Kockums AB in Karlskrona is in the forefront of development, having conducted research intensively for many years, with the Swedish Navy’s new corvettes, constructed from carbon fibre sandwich materials, being merely one example.

The key question for a breakthrough in the nonmilitary market has been that of fire, says Johan Edvardsson at Kockums. Composite materials based on plastics are organic, and therefore combustible. However, we’ve now found a solution in the form of a material concept that has been shown in tests to have an excellent resistance to fire. The concept has been developed in conjunction with SP Fire Technology within the framework of the LÄSS and LÄSSC projects. Development is continuing, in such areas as in the Seventh Framework programme BESST project (Breakthrough for European Shipbuilding and Shipbuilding Technologies), in which Kockums, SP and Chalmers are involved in a subproject concerning new structural materials.

The last obstacle overcome
Conclusion of the LÄSS project meant that one of the obstacles in the way of the use of composite materials using hard plastics for the construction of nonmilitary vessels has been removed, after systematic tests showed that structures made from composite materials are equally as fire-resistant, or have better fire resistance, than presentday steel or aluminium designs.

Building in glass fibre and carbon fibre instead of steel or aluminium naturally affects the speed, range and fuel consumption, but there are many other benefits from the use of lightweight materials, points out Johan Edvardsson.

As far as energy efficiency is concerned, reducing the weight of materials is presumably the most important factor in association with presentday engine and fuel systems, although there is much research into areas such as wind power/solar power, air lubrication, hull optimisation etc.

Lower life-cycle cost
Lightweight materials are also easy to maintain, as they don’t corrode, says Johan Edvardsson. In addition, fatigue is virtually negligible, particularly when compared with the fatigue characteristics of other lightweight materials, such as aluminium.

It is important to bear in mind the life cycle cost of composite vessels, including the original purchase cost, revenues from greater cargo capacities, reduced fuel consumption, reduced maintenance costs and the vessels’ service life. When this is done, it can be seen that the initially more expensive composite vessels are cheaper in the long run as a result of reduced operating costs.
Kockums CarboCAT™, highspeed catamarans in sandwich technology for 250-450 passengers, are an excellent example, with life cycle costs that are considerably better than those associated with the use of traditional materials. Kockums has recently delivered its first new build in the CarboCAT™ family – a 23 m long carbon-fibre-sandwich tender for wind farms.

The trend is towards the construction of more and larger vessels using fibre-reinforced sandwich structural materials.

One future scenario that Johan Edvardsson mentions is that of operating lightweight material vessels on inland waterways. He feels that it is only tradition and inertia that prevents such a development.

The Composite Superstructure Concept is a joint venture between Kockums AB (a member of the ThysenKrupp Marine Systems Group, with more than 35 years’ experience of composite materials in shipbuilding), DIAB (a world leader in composite materials and technology) and Thermal Ceramics (fire protection and insulation).

2005 saw the start of the LÄSS project, the aim of which is to improve the efficiency of maritime transport through the use of lightweight structures. Over a period of three years, financed by Vinnova, scientists from SP and a large number of industries and organisations in the project, including Kockums, DIAB and Thermal Ceramics, were involved in the project under the management of SP Fire Technology’s Tommy Hertzberg.

S-LÄSS lightweight network for shipping established

At a meeting at STENA Rederi in Göteborg on 13th October 2010, attended by over 40 participants from over 30 different industries and universities/research establishments, agreement was reached on forming the Swedish Lightweight Shipping Network, SLASS. The aims of the network were defined as follows:

The main aim of S-LASS is to provide a visible profile and to provide coordination and support for Swedish industrial development of lightweight structures at sea.

Together with Chalmers, the Royal Institute of Technology, SWEREA-SICOMP, the Swedish Marine Technical Forum (SMTF) and Kockums AB, SP will organise the next meeting in Stockholm at the beginning of March 2011, in order to continue discussions and give presentations on what Swedish industry already does and can do within the lightweight sector.

For further information on S-LASS, please contact Tommy Hertzberg, tommy.hertzberg@sp.se.

SP tests safes, cashboxes and firearm cabinets in accordance with Swedish and European standards. Police regulations concerning the storage of firearms have been tightened up; cabinets must now meet the requirements of SS 3492, or equivalent, and be certified by an accredited certification body.

In the construction sector, protection against forced entry is tested for windows, doors, roller shutters and mailboxes.

ENV 1627 – Windows, doors, shutters – Burglar Resistance – Requirements and Classification has been revised and will be issued as a pure EN standard. The revisions have been concerned mainly with the static tests. The revised standard will probably be published around the end of the year, which means that SS 81 73 45 will be withdrawn.

Within the electronics sector, tested equipment includes central equipment, alarm transmitters, detectors and acoustic alarms.
Contex-T – building construction using technical textiles

The EU Contex-T project has now been concluded, after four years’ work. The aim of the project has been to increase the number of applications and the use of technical textiles in the building sector. As one of the project partners, SP Fire Technology has provided the necessary expertise in fire technology. Much of the information regarding fire properties from the project has now been published in the form of a number of SP reports.

Textiles as building materials
Textile materials are used today in various types of buildings: one example is the Commerzbank Arena in Frankfurt (Figure 1a), which uses a textile membrane for roofing, while another is the Allianz Arena in München which uses textile membranes for both roofing and wall materials. Bangkok International Airport is another example of an advanced application of textile membranes for a permanent building. Applications in Sweden include exhibition centres, aircraft hangars and use as functional/decorative building elements, such as room dividers or floating ceilings in atria. Advantages of these materials include low weight, translucency and their potential for architectonic expression. However, a common limitation on all textile materials is their fire behaviour, which emphasises the importance of correct fire safety assessments when using such materials in building structures.

The EU Contex-T project
The EU Contex-T project, ‘Textile Architecture – Textile Structures and Buildings of the Future’, was a major ‘Integrated Project’ in the Sixth Framework programme, bringing together a consortium of more than 30 partners from ten countries. The project’s aims included development of new lightweight buildings incorporating textile structures, together with development of the necessary safety, health and cost aspects. The project included development of textile membranes with improved properties such as selfcleaning, light admission and UV stability. One exciting application, shown in Figure 1b, was that of integrating solar cells into the surface of the membrane. Other areas included the development of concrete with lightweight reinforcement, and of lightweight textile cables for supporting or staying building structures. As one of the project partners, SP Fire Technology has provided the necessary fire technology expertise. The work has covered everything from testing of materials and largescale reference trials, to development of design methods for analytical fire protection design. The Swedish Fire Research Board (BRANDFORSK) has partly financed SP’s work on the project, and has engaged Lund Institute of Technology Fire Technology, consultants Brandskyddslaget and a reference group in order to apply the information from the project for Sweden and Swedish conditions.

This article describes a number of examples from the work, while further information can be found in the reports listed in the next page.

Fire requirements for textile membranes
Prescriptive fire safety regulations which in detail regulate the design and classification of building components can exclude the use of textile materials which do not conform to the required fire rating. In such cases, a performance based approach to comply with the overall fire safety level of the building can be a valid alternative. Both these methods of fire design using textile building materials have been used in the ContexT project, with particular emphasis on textile membranes.

Textile membranes for building applications have previously been tested in accordance with various national test standards, often German or French, but are increasingly being tested by the SBI method (EN 13823) in accordance with EN 13501. However, very little was known concerning the correlation between the SBI method for these materials and their behaviour under real fire conditions. Largescale reference tests (Figure 2b) were therefore carried out, using a selection of various membranes that had previously been tested using the SBI method (Figure 2a). One conclusion of this work was that the SBI method gave a conservative classification of PVCPES (polyester) products that were tested mounted with an air gap, i.e. the products behaved better in the largescale fire test than had been indicated by the SBI tests. Another conclusion was that the method of mounting thin PVCPES membranes for an SBI test entirely determines the classification results. Installation using a ‘corner support’ is generally recommended in order to achieve correct and repeatable results.
Analytical design

When used as ceiling or wall materials, PVSPES textile membranes exposed to fire can burn through, which can change the ventilation and air supply conditions in a building fire. The project included mathematical modelling of burnthrough and hole-opening (see Figure 3a). This was done using CFD (FDS) and the ‘burnaway’ alternative, together with two different pyrolysis models. Input data for the model was taken from the cone calorimeter (ISO 5660), thermogravimetric analysis (TGA) and thermal conductivity properties (TPS). The results of the simulations were validated against fullscale experiments which investigated the behaviour of two different membranes (see Figure 3b). More practical applications of the model were investigated using two of the Contex-T project demonstration buildings, the VUB and Wagner buildings. The work showed that the simulation tool, for a given fire loading, can open up a representative hole in a textile membrane in a building fire simulation. It was, however, shown that there are several relatively substantial uncertainty factors in such modelling.

Textile cables

BEXCO, one of the companies in the project, manufactured textile cables for use as lightweight alternatives to the steel cables that are normally used to support textile building structures. These cables were made from a polymer that produced a light cable having a tensile strength equivalent to that of a steel cable of the same diameter. The tensile strength and strain characteristics of the cable were tested in fullscale furnace tests, as shown in Figure 4. The tests compared the properties of the polymer cable with those of a steel cable, and demonstrated a way of insulating the polymer cable. The results showed that the new polymer cable had excellent properties up to an ambient temperature of over 350 °C: at higher temperatures, the cable must be protected if it is to replace a traditional steel cable.

Reports

The following reports describe the work and results from the Contex-T project: all can be downloaded from www.sp.se.

- SP Report 2007:20,”A summary of fire regulations, requirements and test methods for technical textiles used in buildings”.
- SP Report 2010:23,“Fire tests with textile membranes on the market - results and method development of cone calorimeter and SBI test methods”.
- SP Report 2010:24,”Fire Safety Engineering of textile buildings following the prescriptive requirements in Sweden”.
- SP Report 2010:54,”A burn-through model for textile membranes in buildings as a tool in performance based fire safety engineering”.
- SP Technical Note 2010:03,”Large-scale fire tests with textile membranes for building applications”.

Figure 2a SBI testing of a textile membrane.
Figure 2b Large-scale reference test using textile membrane.
Figure 3a Simulation of ceiling burnthrough using FDS.
Figure 3b Validation testing of burnthrough of a textile membrane.
Figure 4a SP’s horizontal furnace, showing installed cables, before closing the furnace.
Figure 4b The top view of the furnace with load arrangements and strain gauges.
High interest in the FIVE conference
(Fires in Vehicles)

SP has established an international conference on fires in vehicles, which was held for the first time in September in Göteborg. The conference was highly successful, attended by about 230 delegates from twenty countries and four quarters of the globe. It provided a unique opportunity for the exchange of experience between industry, research institutes and universities, and particularly between different sectors of the automotive industry. One conclusion from the conference is that the level of safety requirements in respect of fires varies considerably between different types of vehicle.

Broad international conference

One of the Key Note speakers was Richard Damm from The German Federal Ministry of Transport, Building and Urban Development who described a bus fire that occurred in Hanover in November 2008, in which twenty passengers died. This fire showed the need for improved fire safety in buses. Together with Swedish, Norwegian and French authorities, Germany is keeping this area to the forefront of the UN Economic Commission for Europe (UN ECE) in Geneva. As comparison can be mentioned Bas Leermakers from the European Railway Agency, who provided a detailed description of a harmonised fire standard for trains, based on an EU directive for cross-border rail traffic and including comprehensive specifications for fire safety.

One session of the conference was devoted to statistics of fires in vehicles. One of the speakers was Marty Ahrens from the National Fire Protection Association, who described how deaths from vehicle fires in the USA have fallen. However, she emphasised that persons with limited mobility are at relatively high risk, exemplified by a bus fire in Texas in 2005 when 23 older persons with limited mobility died.

Most of the papers were presented in the session devoted to the development of fire in vehicles. It is clear that this is an area in which a lot of research is being carried out, both as experiments and by calculation. SP, for example, has carried out fullscale fire tests of buses, comparing the results with those from mathematical modelling. The same types of experiments and mathematical modelling have been performed in Germany on fires in cars.

The second day of the conference was started by Jens Stiegel from the Frankfurt Fire and Rescue Services, who described their organisation for dealing with serious vehicle accidents. The Frankfurt area has very high traffic densities, and so the city operates a sophisticated system of dealing with accidents by progressively escalating its input to suit the magnitude of the accident.

Five speakers presented papers on alternative fuels and electric vehicles. Rainer Justen from Mercedes-Benz described his work on fire safety in hybrid vehicles, particularly involving test methods in order to investigate the resistance of batteries to severe mechanical forces, such as in a collision.

Arnaud Marchais from RATP (public transport services in Paris) described fire safety in the Paris metro system, showing excellent results from fullscale fire tests in metro carriages. This was one of four papers in a session on firefighting and case studies. The conference was concluded by a session on fire detection and firefighting in vehicles.

Major differences in fire requirements between vehicle types

Based on what was presented at the conference, it is clear that much research is being done, and has been done, into fires in vehicles. However, there is a major difference between different types of vehicles in terms of how public authorities and the EU have reacted to research results. An example of this is the very primitive FMVSS 302 test method for testing the ignitability and spread of flame in materials intended for use in road vehicles. Several speakers pointed out that this method is still used – for example, for seat materials in buses – despite having long been shown to be unsuitable. In contrast to this is the rail industry, for which the coming European EN 45545 standard is based on best present-day technology, such as the ISO 5660 cone calorimeter. Many speakers described how effective a firefighting system in engine compartments can be. There is a need for an internationally accepted standard for testing firefighting systems in engine compartments in buses, and SP has just started work on preparing such a standard.

FIVE 2012 in Chicago

The next FIVE conference will be held in Chicago in September 2012. Our event partner there is the Fire Protection Research Foundation, together with several other American organisations. Further information can be found at: www.firesinvehicles.com.
Successful work on heat flux measurement

Subcommittee 1 of ISO TC92 (SC1, Fire Initiation and Growth) held its most recent meeting in London to continue its work of standardisation of test methods for reaction to fire. One of the working parties is concerned with standardised calibration of heat flux meters (radiometers). Its work over the last ten years has been successfully convened by Ingrid Wetterlund from SP Fire Technology. With Ingrid now retiring, the continuity of the work is assured by Petra Andersson, also of SP Fire Technology, when she takes over as convenor.

Continuous updating of various standards
The work of TC92/SC1 is performed by working groups that are responsible for various test methods, for instance a method for measuring heat release rate in small scale (ISO 5660), measurement of spread of flame (ISO 5638), measurement of smoke generation (ISO 5659) etc. A recurrent activity is that of Round-Robin measurements (interlaboratory comparisons) to determine the repeatability and reproducibility of the methods. Of current interest is measurement of the spread of flame on tubular products, using the ISO 5658 test method. In addition, another test under comparison is that of ISO 5660 measurement of heat release rate under reduced oxygen conditions, and an interlaboratory comparison on a largescale test of sandwich panels in accordance with ISO 13784-1.

A comparison of calibration of heat flux meters in accordance with ISO 14934-2 has also been carried out.

Some details from the work groups

WG3 Spread of flame:
Results from a completed ISO 5658 Round-Robin will be published in an amendment to the method (ISO 56582:2006 DAM 1). A new, fourth, Round-Robin (tubular products) is in progress. Sweden is participating through SP.

WG5 Methods for smallscale measurement of heat release rate:
Work on a revision of ISO 5660-1 and ISO 5660-2 is in progress. Interlaboratory comparisons of heat release rate measurement under reduced oxygen conditions has been initiated.

WG7 Methods for largescale measurement of heat release rate:
The furniture calorimeter will soon be published as ISO 12949. A Round-Robin for testing sandwich panels in accordance with ISO 13784-1 is in progress.

WG10 Radiant flux calibration:
ISO 14934-1 is completed and has been published. Ingrid Wetterlund has stepped down as convenor and been replaced by SP Fire Technology’s Petra Andersson. Work on revising ISO 14934-2 and ISO 14934-3, and on final presentation of the results from the Round-Robin, is in progress.

WG12 Smoke generation:
Work on DIS 21489 (smoke analysis) has been temporarily postponed, due to delays that have not been accepted by ISO Central Secretariat. The group at present has no current duties.
Technical data for CE-marking of cables - the CEMAC project

The European CEMAC project (CE-Marking of Cables), for which SP Fire Technology has provided technical management, has recently been concluded. The results of the work will significantly assist CE-marking of cables in Europe. The project was financed by the Europacable sector association, with the work being carried out as a joint venture by five European research institutes and several cable manufacturers.

The CEMAC project – CE-Marking of Cables

The purpose of the project has been to obtain additional technical material to assist the EU Commission in deciding on classification criteria for cables to be CE-marked in respect of their behaviour in fires. The project therefore included comparison calibrations of the EN 50399 test method and certain technical improvements that were subsequently incorporated in CENELEC’s standardisation work. Much work was put into calibration of test equipment around Europe, and into the methods of calculation for presentation of test data. However, perhaps the most important part of the work was the production of Extended Field of Application rules, EXAP, which allow a limited number of cables belonging to a larger group (‘family’) of cables to be fire-tested, with the results being extrapolated for classification of part of, or the entire, cable family. This eliminates extensive testing of individual cables in a cable family that can be expected to have the same fire behaviour. In most cases, EXAP is an essential prerequisite for CE-marking.

EU decision on reaction to fire classes

The CEMAC project builds on the results of earlier work by SP, including the development of EN 50399 for full-scale fire testing of cables. Criteria for reaction to fire classification of cables in accordance with this standard were published in the EU Official Journal of 4.11.2006, L305/9, and described in BrandPosten no. 35 of 2006.

European cables

Fire tests were carried out on 86 different power cables, comprising eleven different families of cables. The cables, which were selected by Europacable, provided a good representation of the reaction to fire properties of cables on the European market. The purpose of EXAP is to make it possible to classify the reaction to fire properties of a group of cables, based on the results of tests of a few sample cables. If this is to be possible, their behaviour in fires must be relatively predictable. However, the work showed that the reaction to fire properties of cables was difficult to predict, even for cables of a similar design, as shown in Figure 1.

Complex fire properties

Figure 1 shows the Total Heat Release, THR, for cables in a given cable family as a function of diameter. It can be seen that it is not possible to determine a reaction to fire class based on a small number of tests as, for example, one of the values in the centre of the group differs very considerably from the others. External diameter cannot therefore be used for EXAP, and in fact it was found that the behaviour of the cable family shown in Figure 1 is similar, regardless of which fundamental cable parameter is used as the x-axis. A cable family consists of a number of cables with essentially the same construction and materials, but with different diameters, number of conductors and similar details. From the point of view of the fire properties of a cable family, fundamental cable parameters are those such as external diameter, combustible volume per nominal meter of cable length, or combustible volume per meter of cable length as installed on cable ladders. A challenge of the CEMAC project was therefore to describe the cables in such a way as to provide relatively predictable fire behaviour, which was found to be the use of a composite cable parameter, c, defined as follows:

\[ \chi = \frac{c}{d^2} V_{\text{combust}} \]

where:

$c$ = number of conductors in the cable  
$d$ = external diameter of the cable, and  
$V_{\text{combust}}$ = non-metallic volume per meter as installed on cable ladders.

Using this composite cable parameter on the x-axis makes the variation in the behaviour of the cables more predictable, as shown in Figure 2, which shows the same cables as in Figure 1, but using c on the x-axis instead of external diameter.

EXAP with safety margins

It can be seen that it is easier to provide a correct forecast of the reaction to fire class of a given cable family from results as shown in Figure 2 than from those as shown in Figure 1. The extreme value is now at one end of the data range. Using the c parameter to describe
cables enables an EXAP rule to be defined, where:

\[ n_{\text{class}} \]

is the value to be used in the EXAP classification as shown in the classification table given in Official Journal 4.11.2006, L305/9, and

\[ n_{\text{max}} \]

is the maximum value of, for example, measurements of two different cables used to provide a basis for the EXAP classification, and

\[ n_{\text{sm}} \]

is a safety margin that includes compensation for the irregularities that, despite everything, occur in Figure 2.

Table 1  Safety margins, \( n_{\text{sm}} \), to be used for the EXAP-classification.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Class</th>
<th>B2</th>
<th>C</th>
<th>D</th>
<th>s1</th>
<th>s2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak HRR [kW]</td>
<td>3</td>
<td>6</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>THR [MJ]</td>
<td>1.5</td>
<td>3</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIGRA [Ws⁻¹]</td>
<td>15</td>
<td>30</td>
<td>130</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flame spread [m]</td>
<td>0.15</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak SPR [m²s⁻¹]</td>
<td>0.05</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSP [m²]</td>
<td>10</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The safety margins, \( n_{\text{sm}} \), as shown in Table 1, could be determined on the basis of the results from the CEMAC project. They vary in magnitude, depending on for which reaction to fire class the EXAP classification is to be made. It can be noted that they are equal to 10% of the respective class limits for heat release in Classes B2, C and D, and to 20% of the respective class limits for Smoke Classes s1 and s2.

High precision

Example: If the first cable (\( c = 6 \), THR = 9 MJ) and the seventh (\( c = 33 \), THR = 25 MJ) cable shown in Figure 2 are tested, the maximum result, \( n_{\text{max}} \), is 25 MJ for THR. The safety margin for THR in Class C is \( n_{\text{sm}} = 3 \) MJ, as shown in Table 1. The value to be used for classification is therefore \( n_{\text{class}} = n_{\text{max}} + n_{\text{sm}} = 25 + 3 = 28 \) MJ, which is below the limit of 30 MJ which applies for Class C. All cables in the range \( 6 \leq c \leq 33 \) are therefore regarded as lying below this class limit.

If this procedure also shows that the results for Peak Heat Release Rate, FIGRA (Fire Growth Rate parameter) and Flame Spread also meet the requirements for Class C, then all the cables in the range \( 6 \leq c \leq 33 \) range can be classified as Class C, i.e. seven cables have been classified, from the results of only two tests. In the same way, a range of cables can be classified in one of the fire smoke classes, s1 or s2.

Analysing all the results from the CEMAC project shows that the probability of an incorrect classification is negligibly small when using the safety margins given in Table 1. These EXAP rules therefore work very well, and will significantly improve the efficiency of testing power cables for CE-marking. They do not cover telecommunication cables (including optical cables), as this group is small and there was insufficient technical data. The EXAP rules will be discussed in CENELEC TC 20, and the classification classes will be published in a special standard under CEN TC 127. In addition, fire classes and test methods for fire resistance will be needed, together with publication of product standards, in order to enable CE-marking to be started. This work is well in hand, and we hope that the system will be fully in place in 2011-2012.

Further reading

The full CEMAC project report has been published on the Europable web site, under the link:

http://www.safety-during-fire.com/news/224-cemac-ii-success-delivers-sound-technical-basis-for-the-ce-marking-of-cables-under-the-cpd.html. or on www.sp.se. It describes the physical background to the \( c \) cable parameter, the test data, results of joint calibrations, statistical methods etc.
In October, about 35 persons attended a special training course held by GESIP in France (the French joint safety organisation for the petroleum and chemical industries) to learn more about fighting largescale tank fires in oil storage depots. Most of those attending the course came from the fire and rescue services in Sundsvall, Stockholm, Gothenburg and Malmö, working as coordinators or team leaders in the SMC organisation, which is owned and operated by a number of oil companies. The team leaders are those who will be the incident commanders for SMC personnel in the event of a major fire in an oil depot. To ensure that they are properly trained and prepared for their work, the course included both theoretical and practical exercises, including fighting a fire in a burning tank.

SMC – an important resource for fighting tank fires

Protection and safety work is a very important part of the activities carried out at oil depots and refineries. Preventive work has been performed to a high standard, with the result that accidents and fires are very rare. The most recent tank fire in a Swedish oil storage depot occurred as long ago as 1936, but a fire in a small storage tank at a pulp mill in 2009 provided a reminder that the risk of tank fires has not gone away. Under current legislation, it is the responsibility of the owner of any plant or facility in which an accident could cause serious harm to persons or the environment to hold equipment and maintain a reasonable level of readiness to deal with accidents.

Although tank fires are rare, the legislation means that there must be preparedness to deal with such accidents, and so in 1994 the oil companies in Sweden jointly established the company SMC AB, with the specific purpose to provide and maintain the necessary specialised equipment, and employ and train the associated personnel, to fight large fires in their oil depots. An important element in this establishment was SP's Report no. 1992:02, 'Design, equipment and tactics are critical when fighting tank and bund fires'. One of the conclusions of the work was that the best way of extinguishing a tank fire is to use largescale mobile firefighting equipment, as fixed systems may often be missing or have been damaged in connection with the start of the fire. The SMC equipment is modular, with a total of eight units, with two stationed in each region of the country (North, East, West and South). Each module consists of a dieselpowered pump with a capacity of 10 000 l/min, 2 x 800 m of 150 mm fire hose, 16 tonnes of filmforming alcoholresistant foam, mixing equipment for 3 % and 6 % admixture and a foam monitor with a capacity of 8000 l/min.

Each SMC-depot has a coordinator who is responsible for training activities, exercises and other SMC related questions within the respective region. Each site also has a number of team leaders who have received special training in tactics and strategies of tank fire fighting fires and who, when dealing with incidents, act as the local incident commander. All other SMC personnel are trained in operating the special equipment, and have also received basic training in fighting tank fires.

GESIP’s training site provided an opportunity for fullscale use of the SMC equipment

Maintenance of competence within the organisation creates a constant requirement for exercises and training, not least bearing in mind the fact that there is a steady turnover of personnel within the organisation. It is therefore important that exercises should regularly be held in the oil storage depots belonging to the oil companies owning the SMC equipment. This ensures good familiarity with the equip-
ment and maintenance of contacts with depot personnel and in the local fire and rescue service. However, environmental considerations mean that such exercises are restricted to the use of water alone. Nor, unfortunately, is there any training facility in Sweden suitable for largerscale fires or firefighting exercises.

It can be seen that there is therefore an unfulfilled demand for more practical training of the present team leaders, and so SMC in 2009 decided to arrange a major training event. After consideration of possible training sites throughout Europe, the choice fell on GESIP in Vernon in France, about 100 km northwest of Paris. This facility consists essentially of a decommissioned refinery, which is now used mainly for training petrochemical industry personnel. The facility contains training equipment to simulate both fires in process equipment and fires from spillage in bunds, tanks etc. SP, together with the SMC coordinators, has participated in listing and selecting the training sites, planning the exercises and updating the basic training material for all SMC personnel.

Two tank fires were extinguished during the practical exercises

The training lasted for a week and, in order to deliver the greatest possible benefit of the practical exercises, one SMC module was taken to France. This enabled all the team leaders to operate the equipment with foam, thus also providing invaluable knowledge of how foam admixture affects throw and sensitivity to wind etc. Finally, as the cherry on the cake, two exercises were held in which a burning tank was tackled by the SMC equipment. The week also included practical demonstrations of petrol and ethanol pool fires, demonstrations of various types of foam application systems, and extinguishing a simulated process fire.

The participants also received presentations on the specific conditions and risks associated with a fire in a process plant, such as in a refinery, and the difference in conditions between extinguishing a fire in a tank containing ethanol compared to petrol. The perhaps most interesting presentation was provided by George Hatfield, previously chief fire officer of a Canadian refinery, describing his experience from tackling a tank fire in 1996. This occurred in a petrol storage tank, over 42 m in diameter, that had been set alight by a lightning strike. After burning for almost seven hours, the fire was brought under control within ten minutes from start of foam application, although it took over three hours before the fire was completely out. This was a particularly inspiring presentation, which encouraged the team leaders that the SMC equipment provides a powerful resource for tank fire fighting. Other exercises carried out during the week included group training in connection with postulated fire scenarios. Personnel from MSB (the Swedish Civil Contingencies Agency) participated in the training by documenting the exercises, which will be presented in due course in the form of one of their 90second video productions.

The SMC equipment is a unique resource and should be more widely used

The SMC equipment and its personnel constitute a unique firefighting resource in Sweden, from which more industries could benefit. There are many industries that are covered by the Accident Prevention Act (2003:778), but which in practice do not have the necessary resources. Although SMC is owned and operated by a number of oil companies, it is possible to sign an agreement with SMC to permit the use of its equipment in the event of a fire. Entering into such agreements also gives access to regular training and exercise activities arranged by SMC. Further information is available from Per Brännström at the Swedish Petroleum Institute (telephone: +46 8667 09 25, e-mail: per.brannstrom@spi.se.)
In many countries, the use of ethanol has increased significantly as a means to fulfill climate goals by replacing fossil fuels with renewable fuels, but the use of ethanol fuels will create new risks and challenges from a fire protection point of view. In general, oil companies and fire brigades have extensive experience of fire fighting petroleum based products. However, there is a significant lack of experience concerning fire fighting of water miscible fuels, such as ethanol, especially regarding tank fire scenarios. At the initiative of SP Fire Technology and the Swedish Petroleum Institute (SPI), a proposal for a research project on ethanol tank fire fighting has been developed – ETANKFIRE Ethanol Tank Fire Fighting. The goal of the project is to develop and validate a methodology for fire fighting of tank fires containing ethanol fuels. The intention is to invite stakeholders to participate in the project. As a first step, a workshop will be held in France where the background and project plans will be presented and discussed in more detail. The workshop will take place on April 19 at the GESIP fire training facility in Vernon in France as part of a LASTFIRE Group meeting.

Background

Today, ethanol is used both for low blending in gasoline and for flexi-fuel cars running on E85. In Europe, 5% of ethanol has been used in gasoline for a number of years; but from 2011, the acceptable proportion of ethanol in low blended fuels will increase to 10%. In the US, 10% ethanol is already used in gasoline and there are ongoing discussions concerning increasing this figure to 15%. The obvious consequence of increasing the volume of low blended ethanol is that the volumes of bulk ethanol transported, handled and stored will increase dramatically in coming years. However, experience of tank fire fighting involving ethanol or other water miscible fuels, is very limited and those few tank fires that have occurred have resulted in burn out rather than extinguishment 1, 2.

Limited fire test data available for water miscible fuels

Some test data concerning foam fire fighting of ethanol fuels and other water miscible products are available, even for reasonably large scale scenarios. Unfortunately all such data relates to spill fire scenarios, i.e. relatively thin fuel layers3, 4, 5, 6 and cannot be immediately extrapolated to tank fire scenarios.

Similarly, existing test standards for alcohol resistant foam concentrates (ISO 7203-3, EN 1568-4, UL162, etc) all employ thin fuel layers and short pre-burn times, i.e. represent spill fires. Even spill fires pose serious fire fighting issues and the general conclusion from the various large scale tests and standard test methods, is that the use of alcohol resistant (AR) foams is a fundamental requirement to obtain extinguishment of water miscible fuels. However, the tests have also shown that even AR foams will fail unless gentle foam application onto the burning fuel surface can be achieved.

As tank fires are usually extinguished using large capacity foam monitors1, gentle application is not possible and therefore extinguishment cannot be expected. Further, a tank fire will present a more severe situation compared to a spill fire due to the large fuel depth and consequently, the dilution effect from the fire fighting foam will be limited. In most situations, the pre-burn time will also be longer than that expected in a spill fire, thereby increasing the temperature of the fuel and creating hot steel surfaces making extinguishment even more difficult.

A very important and related issue is that the burning behaviour of a large scale ethanol fire might be significantly different from that of a petroleum fire. Fire tests in a 200 m² pool fire4 indicate that the heat flux from the acetone/ethanol fire is approximately twice that of gasoline. The same observation was made during the Port Kembla tank fire2. This indicates that the radiation from a fire in ethanol fuels might be significantly higher compared to that generated by gasoline, which will increase the risk of escalation of a fire incident even further. Clearly, relevant experimental data is needed to validate com-
Ethanol tank fire in Port Kembla (Australia) 2004. The tank was about 32 m in diameter and contained about 4000 m$^3$ ethanol. Extinguishing attempts were started after 30 minutes using AFFF-AR foam but extinguishment was not possible to obtain until about 20 h when the ethanol was diluted to about 10%.

puter models, thereby improving our ability to make reliable risk assessments in tank storage facilities.

ETANKFIRE
The goal of the proposed ETANKFIRE research project is to develop and validate a methodology for fire fighting of tank fires containing ethanol fuels. In order to achieve this goal, it will be important to provide an understanding of the differences between conventional fire fighting of spill fires versus tank fire situations containing water miscible products. The main differences that are foreseen from a fire and fire fighting perspective are:

- increased depth of fuel
- longer pre-burn time
- difficulty in achieving gentle application of the foam

In order to optimize the test design in the project, the intention is to start with test series on a laboratory scale to investigate the relative influence of the three factors mentioned above. Based on the results of laboratory tests, the most promising extinguishing methods/media will then be selected for further evaluation and verification in a larger scale or scales. Questions regarding the burning behaviour and heat radiation from ethanol fuels will also be investigated in large scale.

ETANKFIRE Workshop
In order to present the project plans more in detail and discuss these with various stakeholders, two workshops are planned. The first will take place on April 19 at the GESIP fire training facility in Vernon in France as a part of a LASTFIRE group meeting. The second workshop is planned in US but the date and location are yet to be determined. Representatives from various organizations, companies, authorities, etc. having an interest in the project will be given the opportunity to obtain more detailed information concerning the plans thus far and to influence the planning process as we progress.

An initial Steering Committee will be formed by those willing to participate in the funding of the ETANKFIRE project in order to take part in the final detailed planning, including the choice of venue for the large scale tests. The program for the workshop and further information will be announced at www.sp.se/eng (search for etankfire), where it also will be possible to register on-line. The number of participants will be limited. Attendance of the workshop will be free of charge but signifies a real and pressing interest in ethanol tank fires, including a potential interest in sitting on the Steering Committee for the project.

References
2. Personal communication with Chief Superintendent Hans Bootsma, Port Kembla ethanol tank fire, 2004.
5. ”Foam fire fighting on gasoline with low-blending of ethanol” SRV FoU-rapport P21-41703 (In Swedish).
Environmental considerations and economic forces have resulted in a substantial increase in the demand for biofuels. Wood pellets are a practical, upgraded wood fuel that is in demand from both individual consumers and for industrial energy production. The substantial increase in largescale production and use has resulted in a need for improved knowledge of wood pellets and other types of biomass-based pellets. An important area is that of management of the new risks associated with largescale pellet production. One of these risks is spontaneous ignition and fire. The recently published ‘The Pellet Handbook’ discusses all areas associated with the production and use of pellets.

Large quantities associated with risks

Wood pellets are a popular fuel in Sweden, with indigenous production having increased from over 500 000 tonnes in 2000 to about 1 800 000 tonnes in 2010. To these quantities must be added imported pellets, mainly from Russia, the Baltic states and Canada, which at present amount to almost 500 000 tonnes. These figures come from The Pellet Handbook, which shows that this rising trend is clear in all important markets. Large-scale production and handling of wood pellets have resulted in large stocks after production and in connection with end use. In many cases, in the interests of efficient transportation of newly produced pellets to other markets, maritime transport is used. In recent years, the special risks associated with largescale storage and transports have become increasingly apparent.

Emissions and spontaneous ignition

Largescale storage has revealed problems with emissions of toxic substances and with spontaneous temperature rise. In a number of cases, the internal temperature rise in pellet stores has been sufficient to result in spontaneous ignition, fire, and total destruction. Fires due to spontaneous ignition have occurred in most types of bulk storage configurations, whether as heaped ground stores or as silos. SP Fire Technology has performed a number of research projects in recent years, investigating spontaneous ignition, emissions and extinguishing fires in wood pellet storages. The results from this work now form part of The Pellet Handbook.

The Pellet Handbook

The Pellet Handbook, which brings together contributions from leading experts in the field, is the most comprehensive book that has been published on this subject. Contributions from SP Fire Technology have come from Henry Persson and Per Blomqvist, while SP Energy Technology has provided contributions from Claes Tullin, Marie Rönnbäck, Lennart Gustavsson and Susanne Paulrud. The book provides information on characterisation of the raw material and finished pellets, production and logistics, health and safety, combustion methods, cost analysis, environmental evaluation, market reviews and current research.

The Pellet Handbook has been produced by IEA Task 32 ‘Biomass Combustion and Co-firing’, and was published in October 2010 by Earthscan Ltd (ISBN 9781844076314). It can be ordered from www.earthscan.co.uk: a 20% discount (on all Earthscan’s books) is available to BrandPost readers by entering the code: BRAND-POSTEN.
Smoke control doors in the Swedish Building Regulations (BBR)

The period of circulation for comments on proposed changes in the next edition of the Swedish Building Regulations has now been concluded. In the interests of continued harmonisation of Nordic fire resistance classes within the European system, the use of class S_2 smoke control doors is introduced in Sweden. SP Fire Technology has invested in a special furnace, as needed for this type of testing, and can test and classify smoke control doors up to 3,4 x 3,4 m in size.

Classification
Fire doors are normally classified with respect to their resistance to fire: the classes used are E, EW and EI. The European system also includes a special class for smoke control of doors, designated S, which means that there are now two types of doors for ‘fire separation’: one which separates fire, and one which separates smoke. In certain cases, but not all, a door type can serve both purposes. There are also two classes of smoke control doors: S_1 for smoke control at room temperatures, and S_2 for smoke control at 200 °C. It is class S_2 that the National Board of Housing, Building and Planning has now incorporated in the Swedish Building Regulations (BBR).

Conclusion of circulation for comments of proposed new edition of the Building Regulations
The National Board of Housing, Building and Planning has been developing and introducing new rules for fire protection into the Building Regulations for several years. This most recent proposal was circulated for comments on 9th June, for receipt of comments by 1st October 2010. The new rules are expected to come into force on 1st October 2011, with a transition period until 31st March 2012.

Class S_2 for smoke control doors, will be presented more clearly than has previously been the case with new introductions. The draft proposal for the new Paragraph 5:5:34 in the Building Regulations (Doors, Shutters and Industrial Doors) shows how this might be done. The basic requirement is that doors, shutters and industrial doors in a fire-separating structure must be so designed as to maintain the integrity of fire cell boundaries. The guidelines for this section suggest that “Doors shall normally be of a corresponding class to that of the fire cell, but may in certain cases be of class EW 30-S_2 or EI 30, except when intended for installation in activity class areas as specified. With the exception of lift (elevator) doors, doors in(to) stairwells should be smoketight, including the bottoms of the doors. Such doors should be of class S_2 in respect of control to fire gases.”

This is a clarification to say that doors in(to) stairwells must not have any gap beneath them, even though they may have passed fire resistance tests. Doors must therefore either be fitted with sealing strips, or be of class S_2.

Testing
Testing smoke control doors calls for a special type of furnace in which both temperature and pressure can be controlled. As both the temperature and the rate of temperature rise are considerably lower than in conventional fire tests, a simpler type of furnace with electric heating can be used. The leakage past the test item is measured using a flow meter, which measures the quantity of air that has to be supplied in order to maintain a given pressure in the furnace.

Correctness of measurement is checked by measuring the recorded flow to test a completely airtight wall, which means that compensation can be made for any air leakage in the furnace itself. The door to be tested is fitted into a wall section, which in turn is fitted into a steel frame that can be fastened to the furnace. In principle, the door must be fitted in the same type of wall as that for which it is intended in practice, i.e. a lightweight stud wall with plastered finish, or a solid wall, such as of concrete. The door must also be conditioned before the actual smoke control test by opening and closing it 25 times (for most types of doors). This conditioning is described in a special standard, EN 14600. After preconditioning and measurement of the closing forces of doors having power closers, the frame carrying the wall section and door is then fitted to the furnace.

During the tests, the pressure in the furnace is controlled and the air flow into and/or out of the furnace is recorded. SP Fire Technology can test and classify doors of up to 3,4 x 3,4 m² in size.

Requirements for smoke control doors
Class S_2 testing disregards leakage under the door, which means that any gaps between the door and the threshold are sealed before testing. Leakage quantities are presented as flow per unit of door circumference, excluding the threshold length. Flow is measured at two pressure differences: of 10 Pa and 25 Pa across the door, in both directions. These values can be measured during the same test occasion, by maintaining a positive pressure in the furnace for one direction, and a negative pressure for the other direction.

The requirement in classification standard EN 13301-2 is that the maximum flow must not exceed 3 m³/h per metre length of door circumference. The rules come into force in 2011, and will be obligatory in 2012, but doors can already be classified for smoke control.

The National Board of Housing, Building and Planning’s situation review states that the change from EI 30 to EW 30-S_2 represents a lesser requirement in respect of insulation but a greater requirement in respect of tightness. It is the spread of smoke that is regarded as presenting the greatest risk of death to persons, with the new requirements providing a higher level of safety without an increase in cost. SP Fire Technology regards the introduction of smoke control door classes as positive, but sees the change from class EI doors to class EW as a major difference. Our proposal is that a combination class could be used, having an insulation performance of at least 15 minutes, such as EI 15 / EW 30 / S_2.
Egress elevators – future solutions for high-rise buildings

Evacuation of multistorey buildings in the event of fire is effected today almost exclusively via stairwells. However, the attack on the World Trade Center in New York in 2001 showed that there is a need for alternative evacuation paths when mass evacuation of buildings with many storeys is needed. This has increased interest in emergency egress elevators capable of providing the capacity needed to evacuate high buildings.

Evacuation via staircases is not ideal in very high buildings, partly due to the long egress times in these cases, and partly due to the fact that the number and size of the necessary stairwells would take up far too much space. As a result, the number of buildings depending partly or entirely on elevators for safe evacuation is increasing worldwide.

As interest in egress elevators increases, an increasing number of applications for these elevators also appear. In Sweden, evacuation of persons with restricted mobility, for example, has been the subject of considerable discussion, as alternative solutions involving safe refuge areas or evacuation with the help of the fire and rescue services does not promote a sense of security. The Swedish Parliament building in Stockholm uses an emergency egress elevator in order to provide persons with limited mobility with a means of initiating evacuation of the building in an emergency situation without the help of others. Several buildings using elevators as a means of egress are today under construction in Sweden.

Reluctance to use elevators is a problem
The arguments that have previously been applied against the use of egress elevators have until now been associated with problems regarding technical systems and uncertainty as to whether the elevators would actually be used. Technical systems to make the use of emergency egress elevators safe are now available in such forms as pressurising of lobbies and shafts, protection of electronic equipment against heat and moisture, and the provision of comprehensive information systems for monitoring and communication. The question as to how willing building occupants would be to use elevators as a means of evacuation is still somewhat uncertain, as there are still no reference cases from real situations. However, earlier incidents that have involved the evacuation, or attempted evacuation, of persons via ordinary lifts indicate that, if properly supported by information to those using them, egress elevators could be seen as an alternative to the use of stairs in an emergency situation. Existing research also indicates that willingness to use elevators as a means of egress increases with the height in the building.

Need for guidelines and regulations
Current Swedish regulations do not include any guidelines or rules governing evacuation by elevators, nor any specifications for the design of an emergency egress elevator or even when such a solution could be utilized. This means that each case has to be considered individually using analytical design. This results in high costs, and can take a long time.

There is a great need for knowledge in this area, not only for consultants but also for authorities involved. Determining the necessary capacity of an evacuation solution that involves the use of elevators is particularly important if such use is intended to replace stairwells as an evacuation path. More than one elevator may be needed for such an application, and ensuring system redundancy is of great importance.

Evacuation lifts represent the future
Egress elevators have several advantages in comparison with stairwells, when evacuating very high and/or specially designed buildings in which stairwells are not suitable. They can also considerably improve the situation for persons with reduced mobility.

If emergency egress elevators are to become an accepted and reliable means of evacuation, it is most important that the necessary competences should be developed, particularly before regulations and guidelines for determining capacities are produced. It is my personal conviction that, within a few decades, evacuation elevators will be regarded as an equally obvious means of evacuation as stairwells in high-rise buildings, and that we can learn to take advantage of the benefits with using elevators for emergency evacuations.

This article is based on a thesis written by Mattias Arnqvist and Jonas Olsson as part of their bachelor of science in fire protection engineering at Lund University. Since April, Mattias has been employed by SP Fire Technology.
Godrej, a Super Brand in India now across Europe.

Synonymous with security in India, Godrej opened the chapter on comprehensive security solutions over 100 years ago. It is now locked in with the safety and security of Europe in its endeavour to spread its wings. Godrej's dependability and trustworthiness is borne by the testimony of some of its esteemed partners across Europe.


“HABECO has collaborated with Godrej since 2006. Godrej is a strong supplier that stands for its obligation, their assortment of products constitute today a part of HABECO’s standard assortments.” - Håkan Skönvist, HABECO Protection AB, Sweden

Our collaboration in the past few years with the house of Godrej confirmed what we believed from the start. That is to say we have a reliable collaborator, not only today but also in the future, a constructive association with enormous possibilities. The large variety of products in different sizes, the exceptional quality as also the professional organization that we personally realized during our visit to their unit. They conform to our already very good opinion.

- George Metaxas, Sales Director, Nival Hellas Ltd. Greece
SP has recently concluded a research project investigating the fire safety of tunnels during the construction stage. The results show that the consequences of such a fire can be extensive in the form of injuries to persons, damage to property, delays and environmental problems. There is a need to know how to counter such risks.

The project, financed by MSB (the Swedish Civil Contingencies Agency) was carried out by SP in conjunction with Lund University and Mälardalen University. Tunnels during the construction stage are the workplace for many persons over a long period of time. Several fires have occurred in tunnels during construction, causing injuries to persons and damage to equipment and the structure of the tunnel itself. The extent of these accidents has depended on where the fires occurred, the intensity of the fires, information available to the fire and rescue services, preparedness for tackling fires, and resources in terms of personnel and equipment. Proper allowance is not always made for the risks to personnel involved in different stages of the work. The risks faced by fire and rescue personnel, too, can be very different during the construction stage from those that could be encountered in the finished tunnel.

The work has involved searches of the literature, analysis of accidents, calculations, smallscale and largescale trials, and training exercises in conjunction with the fire and rescue services.

**Particular risk before and after the breakthrough**

We have identified most of the working areas that can be improved or further developed. The single most important point is if a fire should occur in the phase immediately before or after the breakthrough. These situations affect the progress of a fire, escape conditions and conditions for rescue or firefighting.

The progress of a fire depends largely on ventilation conditions. Before the breakthrough, all fresh air is delivered to the drilling or blasting workforce through plastic ventilation ducts. This air returns to the tunnel mouth from the work position. Prior to the breakthrough, situations can arise in which a fire can be extinguished by stopping the ventilation. After breakthrough, ventilation will depend on tempera-
ture differences and the slopes and lengths of the tunnel, so that it is no longer possible to extinguish the fire by depriving it of air.

**Limited knowledge of fires in construction vehicles**

There is a lack of knowledge of fires in construction vehicles used in tunnels. Hardly any fullscale tests have been reported, and so fire tests were carried out on wheel loader tyres with the aim of finding out how quickly such tyres burn and how much smoke they produce. Experience shows that the commonest cause of fires is technical faults such as leakage of hydraulic or engine oils onto hot surfaces. This results in rapid initial growth of a fire and, depending on conditions and where the fire has occurred, presenting the risk of development to a more serious incident. This means that a burning tyre can be very serious, as a large quantity of energy can be released. Using calculations and analyses, we have been able to produce a number of fire growth curves for different types of vehicles, but such results need verification by fullscale tests.

**Evacuation is important**

The escape situation is vital for those working in a tunnel during a construction stage. There are various views concerning the need for refuge chambers. Some projects dispense with them and rely instead on escape being possible through excavated escape routes. Calculations show that escape conditions are very different, depending on whether escape is required before or after breakthrough. In the event of a fire in the rock body, with the drilling rig at the working face before breakthrough, it is possible to escape provided no time is lost. It must be possible to escape at a speed higher than that at which smoke is spreading. The calculations show that the factors that have the greatest effect on escape potential are the progress of the fire itself and the crosssection of the tunnel.

**The fire and rescue services situation**

Several work sites have been visited, including the Northern Link in Stockholm, a sewage tunnel between Partille and Lerum, the Halland Ridge tunnel in Skåne, Onkalo in Finland, where the future storage repository for spent nuclear fuel is being constructed, and the Citybanan Tunnel in Stockholm. One of the most important objectives of these visits was to identify problems associated with evacuation during the work, to identify typical evacuation scenarios, to analyse personnel safety in evacuation conditions, and see what the fire and rescue services would face.

Exercises of escapes, and of rescue services input, together with modelling of scenarios, form important parts of overall safety work. We found that different forms of contract can influence the evacuation system through factors such as overall attitudes, language problems and safety motivation.

It sometimes happens that the fire and rescue services and those attempting to escape cannot contact each other, regardless of whether those escaping are actually attempting to do so or have remained in the refuge chambers. It is essential to plan in such a way that personnel can always reach a safe position, within a given distance, through their own actions.

**Recommendations to improve fire safety**

The following recommendations have been drawn up, based on the results from the project:

- ‘Fireproof’ hydraulic oils must be obligatory in stationary equipment. Test methods are available to identify such hydraulic oils.
- Automatic firefighting systems must be obligatory in cabs, in the engine compartments of manned loaders, and in the engine compartments of buses carrying visitors.
- Buses carrying visitors must not be used in the tunnels before breakthrough unless fitted with automatic firefighting systems in their engine compartments. Calculation show that a fire in a bus not having a sprinkler system constitutes an extremely difficult scenario.
- The number of visitors allowed in the tunnel should be related to the capacity of the available refuge chambers. Breathing masks should be regarded as personal protective equipment. In the event of an alarm, visitors should return to their vehicle if possible, which should also have been parked facing the evacuation direction.
- If a refuge chamber or evacuation route is available in the vicinity of the fire, a main firefighting strategy should be to turn off the ventilation in the event of an alarm.
- Depending on the crosssection of the tunnel, refuge chambers must be placed at certain distances (i.e. not exceeding such distances) from the working position.
- A written guide manual for contractors, containing information on basic knowledge and basic concepts concerning total fire safety, and ranging from systematic fire prevention work to the performance of exercises, emergency preparedness, planning of firefighting measures and crisis management should be developed.

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**Christine Roszykiewicz new secretary general of Egolf**

Christine Roszykiewicz from England has succeeded Ruth Boughey as secretary general of Egolf. Christine has earlier been working for the French steel institute CTICIM where she still keeps a part time position.

EGOLF is an organization for fire laboratories in Europe focusing on testing issues and quality of the services of its members. Membership is open to all independent, nationally recognized and accredited organizations that test, inspect or certify materials, components and products in support of legislation. EGOLF has over 50 members. It will have its next general meetings in Borås in the end of March this year.

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Calculation of ceiling temperatures in tunnels

A new method of calculating the temperatures of fire gases beneath the ceiling of tunnels has been developed, enabling temperatures to be calculated from the heat release rate, ventilation in the tunnel and the ceiling height. The method can give designers of major infrastructure projects a unique ability to investigate the effect of fire on their structures.

When a tunnel is built, standardised timetemperature curves are used to design its structural features and properties to withstand the effects of a fire that can occur in it. In the case of road tunnels, the choice is determined first and foremost by the type of tunnel and by the type of traffic. The 2004 Tunnel Regulations, which are used for Swedish tunnels, state that the structure shall be designed to withstand the effects of an HC fire curve for all tunnels in which all goods transport apart from Class 1 and Class 2 hazardous goods is permitted. If the tunnel is underwater, or passes beneath a building, an additional design assessment must be performed, making it necessary to design the tunnel to withstand an RWS fire curve. The standard ISO fire curve, shown in Figure 1, is used for local structural elements, such as wall elements, escape doors or technical rooms. The choice of fire curve is based on experience from various experts, assessing the highest ceiling temperatures that might be achieved as a result of fires in different types of vehicles. No systematic relationship between a vehicle’s realistic fire intensity and duration, and the actual temperature level that might be reached, has been presented until now.

Calculation of ceiling temperature is based on theoretical relationships and experiments

The new method of calculation is based on a theoretical and experimental analysis, taking account of all significant parameters for determining the ceiling temperature. Two areas in which ventilation plays a decisive part have been identified. With low air velocities, the longitudinal air flow does not have much effect on the temperature: instead, it is only the roof height and heat release rate $Q(t)$ that are decisive. When the longitudinal air velocity exceeds a certain value, it has considerably more effect on temperature. The report describes the mathematical relationships that can be used and presents an example of application of the method.

The model can also be used to produce a minimum heat release rate curve that corresponds to a given standard timetemperature curve. The report includes an example of calculation of a heat release rate curve corresponding to an RWS timetemperature curve under given conditions of tunnel height, ventilation and the geometry of the fire load. In the example shown in Figure 2, the tunnel ceiling height was 6 m and longitudinal ventilation velocity was 3 m/s.

A very versatile method

The new calculation model is simple to use and valid for a wide range of designs and ventilation conditions.

The parameters that have the greatest effect on maximum ceiling temperature are tunnel height, heat release rate, the geometry of the fire source and ventilation. Tunnel width is considerably less significant, and has been eliminated from the model.

The method provides considerable help for designers wanting to make their own calculations on the basis of the particular type of tunnel and the traffic that it will carry. This facilitates performance based design determination.
New members of SP Fire Technology staff

Franz Evegren
Franz has been working as a research scientist in the Fire Dynamics section since June 2010, concentrating on fire and risks in lightweight vessels. This forms part of the speciality area work of SP’s platform for lightweight structures at sea. Franz is a recently qualified fire safety engineer and also a graduate engineer in risk management and systems safety from Lund University, and has previously run his own company in the field of fire and risk management. As recreational activities he quotes music and exercise.

Per Nilsson
Per joined SP in August 2010 as a technician in the Fire Resistance section, having worked for the previous 18 years in construction and insulation. He spends his free time with his family, with a summer cottage in Mjöshult where fishing, swimming and boat trips on Lake Säven provide relaxation.

Torben Ronstad
Torben has been working as an executive officer in the Fire Resistance section since October 2010. Over the last ten years, he has been working as a service manager for systematic safety work in the safety sector. Before that, he was a project manager for the systemisation and development of a countrywide alarm communications system. Torben holds a degree in IT from Borås University College. He spends his free time with his family, on exercise and on a round of golf.

Johan Post
Johan has been working as an executive officer in the Fire Dynamics section since October 2010. He joined us from Flügger AB, where he worked as a product developer. His free time is spent on family, exercise and looking after his house.

Stefan Gabrielsson
Stefan has been working as a technician with the Fire Dynamics section since October 2010. He joined us from Marks Bostads AB, where he provided caretaking and maintenance duties. For many years, he has also been a part-time firefighter in Fritsla. In addition to his family, he spends much of his free time on music, physical training and sports cars.

Henrik Fredriksson
Henrik has been working since the end of November as a technician in the Fire Dynamics section. He joined us from Ericsson AB, where he worked as a machine/service technician. A major interest during his free time is travel, together with cars and physical training.
New SP reports

**SP report no 2010:15**
Dimensionerande brand: anlagda skolbränder (= Design determining fires: arson in school fires)
Lars-Gunnar Klasson, SP, Nils Johanson, Lund Institute of Technology, Petra Andersson, SP

Arson fires in buildings are a societal problem associated with high costs in Sweden. They are particularly problematic for school buildings as around half of all fires in these premises are deliberately lit. This report identifies a number of ignition sources and typical arson fire scenarios in schools and kindergartens. The report also presents the result of a literature survey that was carried out in order to find information on fire growth and HRR for these ignition sources. Only in Swedish.

**SP report no 2010:18**
Fire spread between industry premises
Anders Lönnermark and Haukur Ingason

A large number of fires occur every year in industrial premises, with the potential to cause very extensive damage to property. For premises not incorporating sprinkler systems, the requirement is that they should be sited and arranged so that any fire in them does not spread to adjacent buildings. The problem today is that there are no reliable methods for calculating the size and progress of fully developed fires in industrial premises. The report describes the performance of, and results from, a number of 1:10 model scale trials to investigate flame heights and radiation, and to evaluate the applicability of the calculation models used to estimate the risk of spread of fire. The results show that the size and position of openings in walls and roofs significantly affects radiation, and therefore the risk of spread of fire. A comparison between calculated and observed flame heights shows that the traditional relationships for open pool fires need to be modified for fires that have burnt through roofs, particularly in connection with the relationship with the diameter of the fire source. Finance: Swedish Fire Research Board.

**SP report no 2010:23**
Fire tests with textile membranes on the market - results and method development of cone calorimeter and SBI test methods
Per Blomqvist and Maria Hjohlman

This report presents the results of fire tests of textile membranes. The tests included small scale tests intended primarily for development using the cone calorimeter (ISO 5660), as well as SBI tests (EN 13823) and additional methods as needed for EN 13501-1 Euro classification. The tests were performed using a selection of textile membranes as used in building applications. The membranes were produced by Contex-T partners as reference products representing typical products available on the market. The intention of the work was to produce a data base of test results for present day products that could be used to provide a comparison with the development of new products. The work has been carried out as part of the EU Contex-T project 'Textile Architecture – Textile Structures and Buildings of the Future'. Finance: EU. See the article on Page 16 of this issue of BrandPosten.

**SP report no 2010:24**
Fire Safety Engineering of textile buildings following the prescriptive requirements in Sweden
Maria Hjohlman and Per Blomqvist

This report describes the design process employed when complying with the prescriptive requirements in the Swedish Building Regulations, together with the special considerations and problems that are specific to application of textile building components, and particularly to textile membranes. The report considers the special rules that apply, depending on whether the building is regarded as a temporary textile building (a tent) or a permanent building and, in the latter case, whether the textile material is to be regarded as a part of the structure or as furniture or as decoration. The process of classifying a building, the requirements applicable to the building, and the various classes of building elements and materials, are explained in the report. The report also includes a brief discussion of requirements and rules elsewhere in Europe. The work has been carried out as part of the EU Contex-T project ‘Textile Architecture – Textile Structures and Buildings of the Future’. Finance: EU. See the article on Page 16 of this issue of BrandPosten.

**SP report no 2010:33**
Sprinkler design guidelines relevant for ro-ro decks
Magnus Arvidson

In recent years, questions have been raised whether sprinkler systems on ro-ro decks on ships are capable of controlling a fire in modern cars, coaches or heavy goods vehicles. This report discusses the design and installation of sprinkler systems on ro-ro decks, starting from the recommendations given in NFPA 13 and EN 12845:2004. Although the guidelines in these standards are not directly applicable to these fire scenarios, there is sufficient material to make it possible to judge how a system should be designed and what capacity it should have in order to be effective. Financers: VINNOVA, Swedish Mercantile Marine Foundation, Swedish Fire Research Board, Swedish Transport Agency.
SP report no 2010:40
Användning av expanderat glas som brandskydd inom petrokemisk industri
<Cellular glass as a fire protection in petrochemical industry>
Henry Persson and Michael Rahm

This report summarises the presentations, demonstration experiments and discussions that were presented at a one day seminar at SP Fire Technology in 2010. The purpose of the seminar was to provide those attending with more information on what cellular glass (often also known as foam glass) is, how it is used at the present time, and what has been done in investigating its application in fire protection. The practical fire tests that were conducted demonstrated very clearly how the use of the glass could reduce the intensity of a burning fuel spill. The seminar also discussed the need for further knowledge if foam glass is to be seen as an alternative to various other means of fire protection. Finance: Swedish Fire Research Board. Only in Swedish.

SP report no 2010:54
A burn-through model for textile membranes in buildings as a tool in performance based fire safety engineering
Petra Andersson, Joel Andersson, Andreas Lennqvist, Heimo Tuovinen and Per Blomqvist

This report describes simulation of fire scenarios with textile membranes and particularly opening up a hole in them due to the fire. The work was carried out within the framework of the EU Context-T project, and the model was validated by experiments. Finance: EU and the Swedish Fire Research Board. See the article on Page 16 of this issue of Brand-Posten.

SP report no 2010:64
Fire test with a front wheel loader rubber tyre
Haukur Ingason och Rolf Hamarström

Fire tests of a tyre from a wheel loader under a mudguard were carried out by SP Fire Technology, with the aim of measuring the heat release rate from a large tyre when burning. The maximum heat release rate was 3 MW after 90 minutes. The work was carried out in connection with a project on fire safety in tunnels during the construction stage and fires in mines. Financers: Swedish Nuclear Fuel and Waste Management Company, LKAB, Knowledge Foundation and Swedish Civil Continuations Agency.

SP report no 2010:70
Verifiering av brandmotstånd för betong och sprutbetong i tunnlar
<Verification of the fire resistance of elements and shotcrete for tunnels>
Lars Boström

Tunnel walls and roofs are often clad with concrete or shotcrete. Where some particular fire resistance of the cladding is required, this has to be verified, which can be done by means of testing, calculation and/or assessment, depending on the requirements and on how well the fire resistance of the product is already documented.

One of the most important properties that needs to be verified is that of the risk of spalling, which can be done only by testing. Assessment and calculation methods can be employed for concrete having a similar composition to that of which the properties have been confirmed by testing, and where it has been shown that there is little risk of spalling.

The report presents proposals for test methods for verification testing and development testing. It also includes proposals for what can be assessed in connection with changes in the composition of the concrete. Finance: National Road Administration. Only in Swedish.

SP report no 2010:76
Brandgastemperatur i tak i tunnlar (= Fire gas temperatures below tunnel ceilings)
Haukur Ingason and Li Ying Zhen

A new method of calculating the temperatures of fire gases against the ceilings of tunnels has been developed, enabling temperatures to be calculated from the heat release rate, ventilation in the tunnel and the roof height. The method can give designers of major infrastructure projects a unique ability to investigate the effect of fire on their structures. Finance: National Road Administration. Only in Swedish.

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