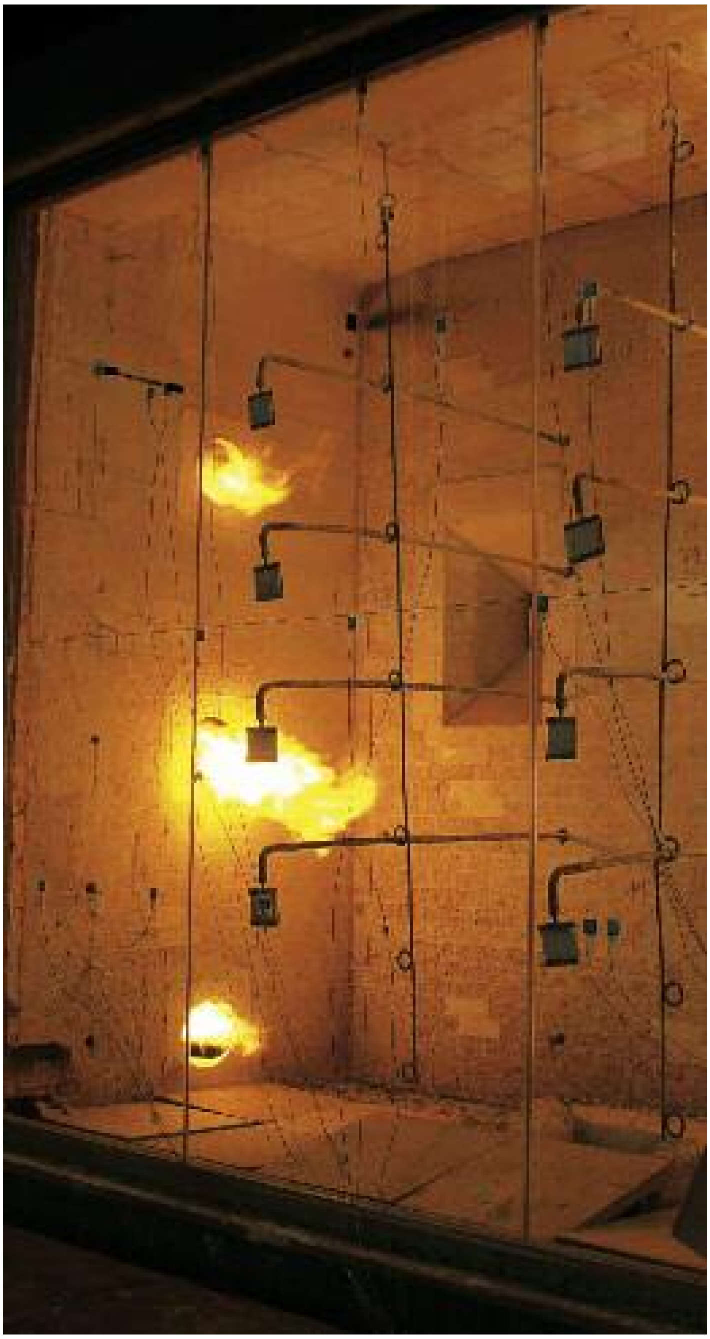
Fire in the building!

Empa has been burning for 40 years. In the Fire Technology Laboratory at Dübendorf, the most varied components are turned into ashes. This is done not just to gain knowledge about how materials and components behave when burning, but also to optimise them. In future, even computer models should help predict the materials' behaviour in the event of fire.

TEXT: Daniela Heiniger / PHOTOS: Empa



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The smell of something burning tells you right away where you are. That's even before you notice the furnace in the hall, where several men are labouring to place a massive 3x3-metre pane of glass in front of it. Empa's fire specialists are placing the last deformation sensors on the glass, which is a component of a new fire-resistant glazing. Then they attach the entire testing unit – the mounting fixture including the glass – to the furnace.

And then everything's ready to go. Giant flames shoot out from the side walls of the furnace. After only a short time there are some snapping, crackling sounds, and the glass takes on a milky discolouration. "This effect comes about because the embedded fire-protection layers foam up. In this way they contain the heat," explains laboratory head Erich Hugi. Even after prolonged exposure to the flames, the panes stand up to the fire; just a few pieces on the side facing the furnace split off.

"Playing with fire" for more than 40 years

During such a fire experiment, at least two team members follow the action from the test station while another does so at a monitor in the control room. They examine how the heat in the flame chamber develops and how the test object reacts. They document every change and noteworthy event and also record everything on video. "The films support us during analysis. With them we can, for example, track where and why the fire-resistant glazing no longer withstands the fire," explains Hugi. On this day, the experiment runs without a hitch. Even at more than 850 degrees Celsius, the glass stands up for more than 30 minutes, enough to be classified according to Euronorm standards.

Empa's Fire Technology Laboratory has been playing with fire for more than 40 years. In this time, a great deal of expertise has been accumulated. That's why Empa is in the position to offer its partners more than just a dedicated analysis of a fire experiment. "A test object always consists of multiple components," notes Hugi. "Often it's only a single element that is responsible for failure in the case of fire. If this weak point is known, then we can perform targeted product optimisation."

This expertise is a major reason for the long waiting list which illustrates why this Empa laboratory, with more than 75 fire experiments per year, is booked up far in advance.

Burning components – to make them better

On the one hand, a successfully completed fire test is the last step for Empa clients before they can put their products to use in applications which have requirements for fire resistance. On the other hand, when viewed on a larger scale, the experiments also deliver insightful data which Empa scientists later apply to a variety of research projects with academic and industrial partners. At this year's Structures in Fire Conference (SiF'10) in the USA, the team presented three papers. SiF addresses the behaviour of structures and materials when exposed to fire, and has established itself as the international platform for researchers, engineers and fire experts.

Consider, for example, one project presented jointly by the Empa Fire Technology Laboratory and the Swiss Federal Institute of Technology in Lausanne (EPFL). It studied fire-induced changes in the load-carrying capacity of a support which is made of fibreglass-reinforced polymers and which also has an embedded water cooling system. Thanks to the findings, it was possible not only to determine how long such wall elements can withstand fire, but the experiment also delivered valuable information about the failure mechanism. This data serves as a key performance input for a numerical model and helps engineers to design construction projects so they're even more fireproof.

From building component manufacturers to the US Navy

As part of a project within the EU's Sixth Framework Programme, Hugi's group worked together with Empa's Structural Engineering Laboratory as well as with Knauf, a German drywall specialist, on a modular, earthquake- and fire-proof building using lightweight construction techniques. "Houses must, of course, first of all offer protection from further quakes," explains Hugi. But because fires frequently break out after earthquakes, the demands on fire protection are likewise very high. During various fire experiments, Hugi and his colleagues investigated the behaviour of a newly developed type of drywall in connection with a lightweight metallic structure when placed under a mechanical load. Depending on modifications, the new drywall was able to carry more load than conventional types and held up as much as half an hour longer.

In addition, the Fire Technology Laboratory is a partner in a new project being organised by the US Office of Naval Research. In order to make ships as light and manoeuvrable as possible, naval engineers prefer to avoid heavy materials such as steel. However, because the first logical candidate as a replacement – aluminium – has in the past not proved to be sufficiently fire resistant, new lightweight construction materials such as fibre-reinforced polymers are being tested. That's anything but a trivial task, even for Hugi and his team. Even just setting up the instrumentation for a test object takes an entire week. In addition, the Empa researchers must adapt the entire infrastructure to the required test conditions such as attaching high-temperature heat-flow sensors and also handling cumbersome structural adaptations with creativity and mechanical finesse. Nonetheless, all the effort was worthwhile, according to Hugi, who adds, "In six fire experiments we gained considerable knowledge on how panels deform. This information then helps us again to refine our numerical models."

Predicting behaviour in a fire

During these projects, it isn't just a matter of determining how long something can withstand a fire. In addition, comprehensive thermo-physical data about the materials in use is continuously gathered. This knowledge contributes to a better understanding of the behaviour of the applied materials in a fire. "As a result, we can develop suitable approaches for performing numeric calculations," explains Hugi. The goal is to use computer models to predict structural behaviour in case of fire. With this, components can be optimised with regard to their behaviour in fires, and the number of expensive fire experiments can be reduced. //

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Flames shoot up – a highlight after days of work on test objects and setting up experimental rigs in the Fire Technology Laboratory.

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Fire experts must also be prepared for almost anything: suddenly part of the installation collapses.

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Meticulous preparations in the Fire Technology Laboratory.

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