70 ANNIVERSARY YEARS

Efectis


70
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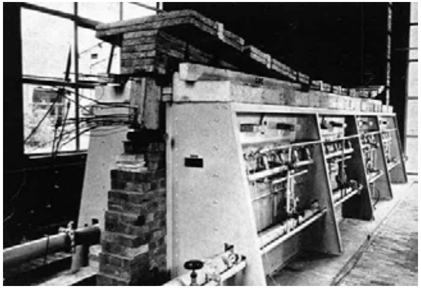
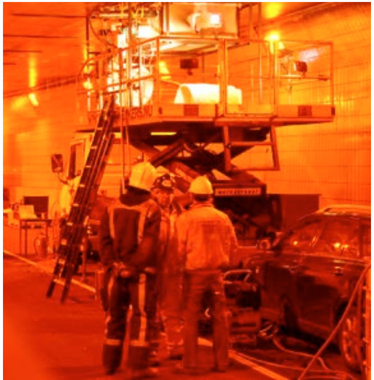
YEARS

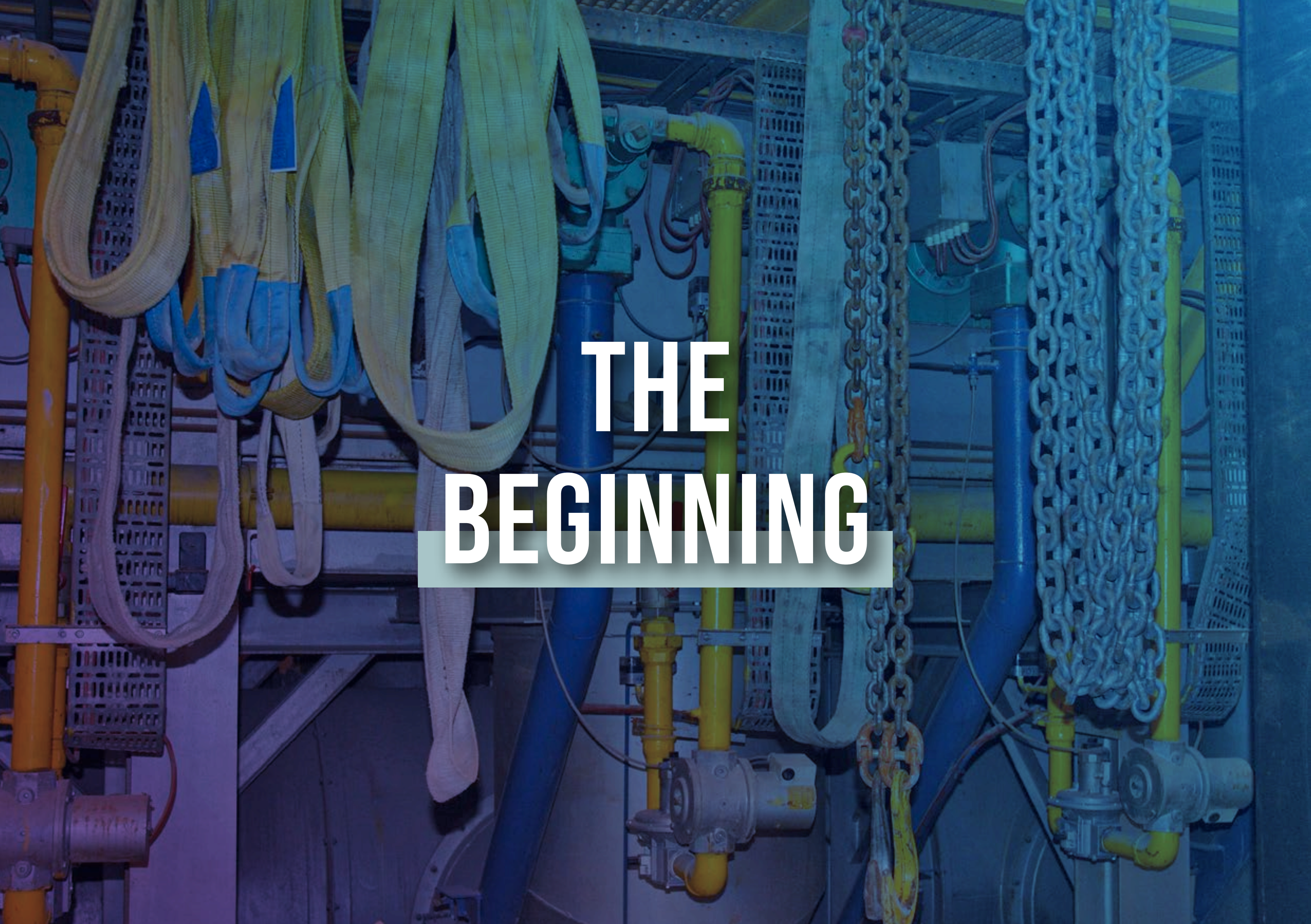
INDEX



70 Years history of fire safety at Efectis Nederland



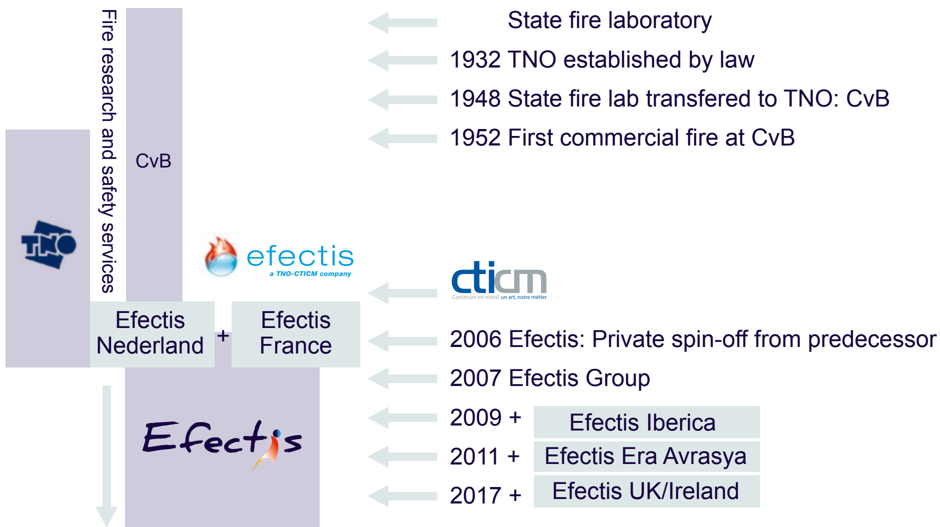
THE BEGINNING



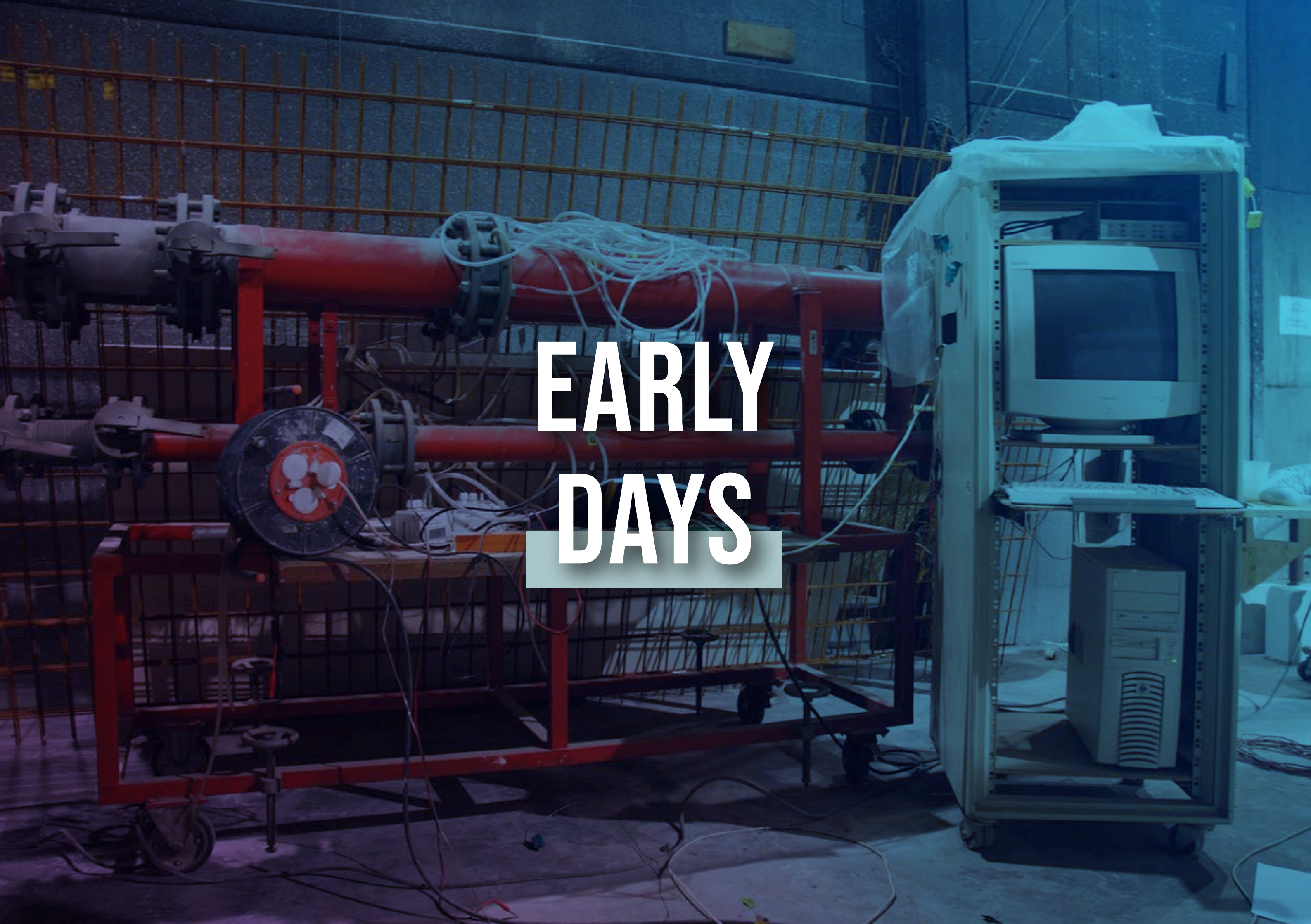
In the beginning there was darkness. Then the shimmering light of fire induced the desire for knowledge and understanding of, and in the end, controlling this phenomenon.

This knowledge has developed and increased significantly over the years. Now in 2022 Efectis Nederland celebrates 70 years of dedicated fire safety services since the first commercial test was performed in 1952.

A good opportunity to look back at the history of Efectis and its predecessors, the influences of changing markets and legislation but most of all the continuous journey to extend, share and deploy our knowledge in the field of fire safety as part of the international Efectis Group.



Now in 2022 Efectis Nederland celebrates 70 years of dedicated fire safety services since the first commercial test was performed in 1952.



EARLY DAYS

Efectis Nederland as we know nowadays is the privatized successor of the Centre for Fire Safety (in Dutch CvB: Centrum voor Brandveiligheid) of TNO.

We shall not forget that TNO is an organisation founded by a special Dutch law as early as the year 1932, known as the TNO-law. The mission was to support industry with fundamental technical research by ‘bridging’ the results to be applied in practice. TNO is therefore best translated into Institute for applied sciences. There were several other reasons for creating the TNO organisation. Coordinating the Research & Development activities would bring more efficiency and effectiveness for the stakeholders.

The central organisation of TNO governs multiple topics for which at that moment five different departments were defined. One of them was the ‘Nijverheidsorganisatie T.N.O.’ under which several more topic dedicated institutes were defined. Until then, fire testing was performed in the Brandtechnisch Laboratorium under the direct responsibility of the ministry of Interior Affairs.

In 1948 the ‘Brandveiligheidsinsituut T.N.O. i.o.’ was initiated to become fully incorporated within the TNO organisation including the intention to integrate the before mentioned Brandtechnisch Laboratorium.

The main activities at that moment were forensic fire research and research assignments from authorities. Amongst them were fire extinguishing possibilities and identification of fire risks. The latter in respect to determine preventive measures. The first certification criteria for liquid fuel heating systems were developed and tests were successively performed to verify compliance to the criteria.

Appliances have been innovated, or further developed, some risks present in the original products do no longer apply.

It may seem surprising that the attention for the risk of scalding during storage of natural fibres was in those days already present. Also, some other research projects addressed topics which are still very actual, like fire retardant or resistant coatings. While other fields of investigation have been reduced or even became obsolete. Appliances have been innovated, or further developed, some risks present in the original products do no longer apply.

The use of some dangerous substances is nowadays discontinued or even forbidden. Interest in fire research had grown and so had the need for a wider range of activities. As a result, the testing equipment had to be state of the art, sometimes even newly determined and designed. Not only based on own insights, developments,

OLD LAB IN RIJSWIJK 1986

and inventions but simultaneously considering similar developments abroad.

Already visits were paid to laboratories in other countries where knowledge exchange meetings were held. Most of those meetings were held in surrounding countries but also in the USA. It should not be a surprise that the direct management was selected upon its strong scientific background. The acquired knowledge is so important that active participation in standardisation work is evident. One of the first examples of standardisation concerns the safe transportation of dangerous freight by air.

> **The acquired knowledge is so important that active participation in standardisation work is evident.**

Along with the expansion, the post WW-II years required to relocate the fire research activities. The construction of a new laboratory for the Centre for Fire Safety in Rijswijk started end of 1950. This had been made possible with, amongst others, the support of the Vakgroep Fire insurance and the Gas foundation.

During this period a furnace for fire resistance testing was initiated and developed. In March 1951 the lab moved to the TNO complex in Rijswijk.

Over the years the Centre for Fire Safety resorted under different TNO institutes as its work is related to many other topics within TNO like 'materials', 'safety', 'construction' and 'industry'. In 1964 the activities were positioned at TNO-Bouw where it remained until the Centre for Fire Safety was detached from TNO and changed effectively into Efectis Nederland in 2006.

FIRST LABORATORY

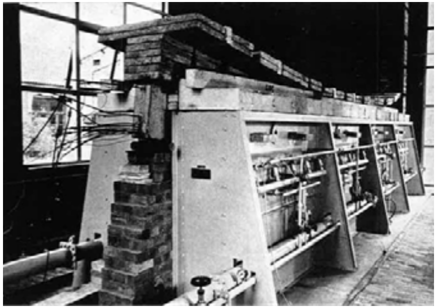
The laboratory at the TNO premises Lange Kleiweg in Rijswijk developed steadily, new equipment was acquired and installed. Significant experimentation was necessary to develop, finetune and validate systematic assessment methods.

In 1952 the installation of a vertical furnace, to assess behaviour and performances of constructions in case of fire, was completed. The public gas network could not yet provide the required fuel, therefore 'propagas' had to be used for the time being. The year 1952 is taken as the starting date of systematic fire testing and hence the celebration of 70 years history of Efectis. Nevertheless, fundamental scientific fire research remained a strong activity and continues till date.

> **The year 1952 is taken as the starting date of systematic fire testing and hence the celebration of 70 years history of Efectis.**

The desire to build a big horizontal furnace arose but turned out to be too ambitious. The horizontal furnace was finished in 1953 with the dimensions of 4 x 2 meters. The connection to the gas network was also established that year.

As part of the post WW-II reconstruction there was a need for an increased production of buildings,

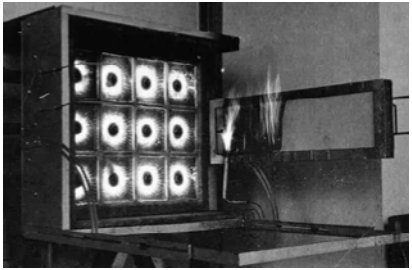


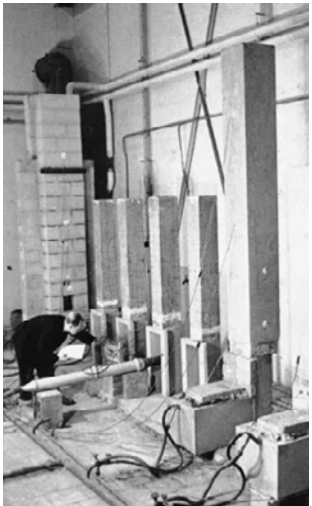
strongly supported by the ministry of Reconstruction. The business association "De Betonvereniging" wished to continue the research projects on pretensioned concrete and the behaviour in case of fire. Despite the ambition of a furnace up to 12 meters long, a testing furnace for a pretensioned loaded concrete beam with a length of 'only' 8 meters was designed and built in 1954.

A special project investigating differences in temperature development in pretensioned concrete was finished.

A fire resistance test on a bulkhead in 1956 was performed for the first time, demonstrating that fire safety is not exclusively the domain of the construction sector.

DIFFERENT STAGES OF RADIATION PANEL DEVELOPMENT





Although hardly any technical details were retrieved, it will surely have deviated from current testing standards now applied within Efectis Nederland.

The adiabatic calorimeter was improved for the research on scalding. The negative impact of fire on society, due to this cause, was considered very high. This reminds us that the real beneficiaries of fire research often lay beyond the sponsors of the research projects.

The testing possibilities were further developed and increased in the new lab. Besides the newly introduced testing of horizontal constructions, some of the equipment had to be improved. Especially the determination of ignitibility is mentioned but other equipment was also modified to respond to new criteria, insights and applications. Gas analyse equipment was added and fire extinguishing was investigated both in respect to materials and equipment used. Even water mist systems were already tested in these years.

> **The testing possibilities were further developed and increased in the new lab.**

There were some testing and assessments performed on asbestos to determine its performance in respect to fire safety of chimneys.

As we know now, despite the good performance in regard to fire, the later detected severe negative impact on human health has made this a forbidden material and the research on this material was discontinued.Obtaining the required financial resources became more difficult. In the first place, the appropriate equipment for fire testing requires significant investments which are usually far beyond the capabilities of industrial companies. In that respect the mission of the TNO organisation, facilitating industry and innovation, as basis for the TNO-law seems to be proven valid.

> **The year 1952 is taken as the starting date of systematic fire testing and hence the celebration of 70 years history of Efectis.**

Secondly, in the beginning, the level of testing standardization was not as we know nowadays. From a technical point of view the testing objectives and equipment requirements had to be determined, agreed and aligned before construction of the testing equipment could start. And even then, experience obtained had to be used to review the effectiveness and appropriateness of the methods. Participation in standardisation activities is therefore evident, at first mainly at national level but soon also rapidly growing internationally. See also the chapter International Collaboration and Standardisation.

As a result, the activities of TNO were in the beginning almost completely funded by the government (or organisations linked to it), but the need for financial contribution of commercial customers and other stakeholders increased.

The significance of the activities for stakeholders other than the government were expressed more explicitly. Nevertheless, most of the testing requests did not directly derive from individual manufacturers but from business associations serving as general point of interest for their members. And not only representing industry like the before mentioned “Betonvereniging” but also the “Vakgroep brandverzekering”, an association serving the interest of fire insurance companies. And thus the research requests increased significantly and became more complex, sometimes challenging the possibilities of the available equipment.

Not only the materials to be tested changed, so did the building methods. The traditional way of building developed into new construction concepts but without completely replacing the existing traditions. Changes within markets and in their demands require to be prepared for the required services in time. From merely reporting what had been observed during a test, the result being a test report, a shift was made to obtain reliable information to predict the behaviour and performance of materials and constructions. To investigate what happens inside an enclosure like a room during a fire was rather new and initiated in collaboration with the Conseil International du Bâtiment (CIB), an organisation aiming at restoring and increasing collaboration of international scientific and technical contacts which had severely been disrupted by the war. In the 50's a first descriptive model on indoor air was drafted. The collaboration within CIB was continued, leading also to the "CIB-Concept for Probability Based Structural Fire Safety Design" and "The design guide (model code) for structural fire safety" in the 80's, which laid the basis for future ISO standards and Eurocodes.

> **In the 50's a first descriptive model on indoor air was drafted.**

The description of fire physics gained in interest, creating the basis for standardisation, modelling and predictions. See also the chapter on Modelling.

NEW LABORATORY RIJSWIJK

Due to the growth in amount and scope of testing activities, and consequently extension of the equipment required, the construction of a new laboratory building was highly necessary. The TNO area at Lange Kleiweg in Rijswijk provided another good location to build this laboratory.

Although the big furnace was an impressive eyecatcher, attention had also been paid to other fire testing activities including an ad-hoc testing room and the required storage and transportation means. The offices were located adjacent to the testing facilities. The official opening was performed in 1986.

> **The TNO area at Lange Kleiweg in Rijswijk provided another good location to build this laboratory.**

Repositioning the activities

In the 90's a fundamental reflection on the position of technological institutes in the Netherlands was initiated by the Dutch government. Besides the testing and research facilities within the TNO organisation, other technical institutes performing similar activities were included. As a result, the overall efficiency towards the beneficiaries (customers & stakeholders) was disputed. The Dutch government involved different formal committees, amongst other the Royal Netherlands Academy of Arts and Sciences (KNAW). Several sources of input had to be consulted and discussed in the political area[1].

One of the generic concerns addressed was the possible unfair competition by technical institutes financially supported by the government where a level playing field with competing institutes was desired (imperfect competition). By then TNO had already started to reposition such identified activities into 'TNO Bedrijven', a shareholder with a separate legal entity for commercial activities without governmental support. However, maintaining TNO in the name was confusing, the public TNO organisation and commercial TNO Bedrijven could be difficult to distinguish as separate entities.

efectis
a TNO-CTICM company

Another point of attention was strengthening the international position of the technological activities by identifying possible collaboration.

The CvB was affected by both. The standard testing activities performed in competition had significantly increased over the years and were a growing part of the turnover. Collaboration with other institutes had until then always been done by sharing knowledge and participation in standardisation. Now a formal integration with another party had to be considered. Initially Warrington Fire Research (WFR) in the United Kingdom was selected and a joint business plan was drafted. Despite the progress achieved, this collaboration process was not continued.

Another point of attention was strengthening the international position of the technological activities by identifying possible collaboration.

In 2001 collaboration was sought with the French Centre Technique de la Construction Métallique (CTICM). As a result, the CvB continued in 2006 under the new name Efectis Nederland B.V. and the Efectis group was established in 2007.

Efectis Nederland B.V.

Efectis Nederland is, contrary to its predecessor CvB, a commercial organisation. Still, it is not just a one of a kind standard fire testing institute. Some products, constructions or situations simply cannot be investigated in accordance with standardized methods or inside a laboratory. The following pages will explain why Efectis is not an ordinary testing laboratory.

NEW LABORATORY BLEISWIJK

In 2012, Efectis Nederland started the construction of its new laboratory in Bleiswijk near the city of Zoetermeer. This provided the chance to design the lab and offices according to current insights and wishes. The construction was completed in 2013, Efectis Nederland moved in, and the official opening was performed January 2014.

Leaving the TNO premises was not by any means the end of our ties with TNO, liaisons and collaboration with other TNO activities continue even today.

For the relocation a significant investment was made in testing equipment and ancillaries. A new approach on logistic processes was followed, including internal transportation regarding storage, preparation of test specimen and testing. A specific point of attention is ensuring confidentiality of customers preparing their samples in our laboratory.

The new big furnace was designed to be able to produce all known temperature curves including the RWS curve with a top temperature of 1350°C, both for horizontal and vertical constructions, and even in their combination. A unique facility enabling the testing of tunnel elements and tunnel doors in the laboratory. For further reading see the chapter Tunnel testing.

For reaction to fire testing, besides the SBI laboratory, a special room was created to host several relatively small-scale testing facilities, ranging from small flame tests to floor radiant panel equipment, from the ISO 1716 ”Caloric Bomb” to a Cone Calorimeter according to ISO 5660-1.

It allows for a wide variety of not very common testing.

And since the ad-hoc testing room in Rijswijk had proven its significance for special tests and reconstructions, this has also been continued in the new laboratory. It allows for a wide variety of not very common testing. See also the chapter Fire research.

INTERNATIONAL COLLABORATION AND STANDARDISATION

The need for standardisation and harmonisation of testing methods was growing rapidly in the 80's. One reason was the increased international trade and collaboration. Internally TNO had already started a companywide approach to formalize quality assurance, even before the availability of a predecessor of current accreditation processes.

These quality protocols were drafted to increase efficiency and comparability of results of similar products tested, including improving accuracy, now usually understood as repeatability. Customers expect reliable scientific reports of test results, fully accepted as trustworthy by other parties. This was only the beginning of a new era.

> **Free movement of goods had to be stimulated by transparent assessment processes and communication of product properties.**

Another significant impact on standardisation was the European new and global approach, within the New Legislative Framework (NLF). Free movement of goods had to be stimulated by transparent assessment processes and communication of product properties. For this, harmonized European product-standards began to be developed. Standardising test methods is part of this process, assessment results can transparently be compared with others. The benefit of a common European technical language was continuously emphasized, for which the concept of CE-marking was developed.

The Construction Products Directive[2] was the first formal step to CE-marking of construction products. Manufacturers had to assess their products no longer against national references but European standards. To allow manufacturers to put their construction products on the EU market, the manufacturer shall now use the CE-mark, demonstrating that its claims on product properties and performances are based on the European assessment standards. The development process on standardisation is still ongoing, increasing the harmonized zone, standards shall regularly be reviewed and where necessary updated.

For laboratories it means, where applicable, aligning their testing methods or national methods into transparent European methods. This also affected the collaboration and competition between laboratories. In the 90's TNO and CTICM strongly participated both together and individually in the standardisation and harmonisation processes. The EU-SMT program aimed at guiding the development of Standards, Measurements and Testing, will be explicitly mentioned in this regard[3]. As we have been involved from the beginning, it is no surprise that the CvB was soon designated as a Notified Test Laboratory for the CE-marking of construction products.

EGOLF, the European Group of Official Laboratories for Fire, was also founded in the 80's. Again, as member of EGOLF, there is a direct link with the development and harmonisation of European standards. The displayed cover of an EGOLF meeting clearly indicates "E.E.C. Harmonisation." EGOLF still continuous to facilitate the exchange of technical knowledge amongst its members, coordinating training courses in testing and of round robins between laboratories.

> **EGOLF still continuous to facilitate the exchange of technical knowledge amongst its members.**

Notwithstanding the increasing numbers of standardized tests, the CvB continued to perform several special tests, sometimes for own or externally requested R&D, but more often to demonstrate compliance to specific requirements outside the harmonized zone. The development of the RWS procedure is an example described in more detail in the chapter Tunnel testing.

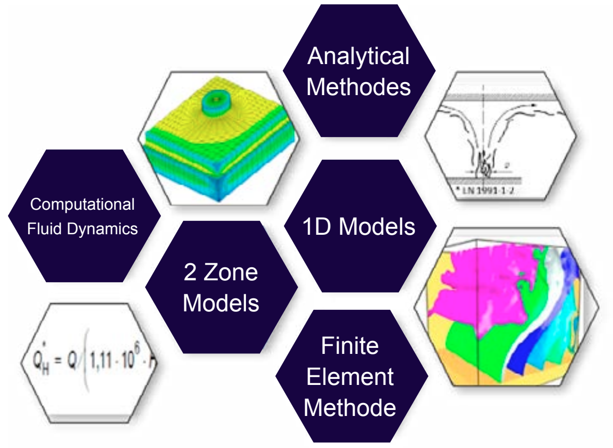
MODELLING

Modelling had become a more important aspect of the fire safety services. Modelling and testing are heavily connected. The availability of an increasing data set of test results provides the opportunity to conduct statistical analyses.

The analysis of a certain topic may serve as basis for prediction of yet untested constructions or behaviour under different circumstances. A natural approach is to define (and validate) a model for such predictions.

Compared to current modelling methods, the first models developed had a limited set of input data. Over the years, various models have been developed, increasing the number of influencing factors.

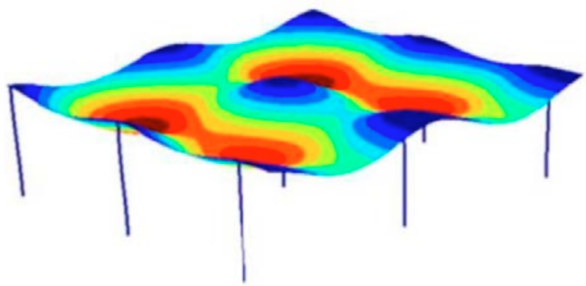
A nice publicly available example[4] is the report on the modelling of the propagation of smoke and gasses in tunnels, issued in 1982. This report was part of a bigger context. The Dutch governmental organisation Rijkswaterstaat requested support for theoretical risk assessment in road tunnels, something we would nowadays call Fire Safety Engineering (FSE). A computer model was developed, and tests already performed with burning vehicles in a road tunnel in Glasgow were simulated based on given fire load and tunnel geometry.



The computed results have been compared to actual data of the fire tests to validate the model, followed by an evaluation.

Over the years, various models have been developed, increasing the number of influencing factors.

Other models were developed and used within the CvB, ranging from a 1D approach to complex visual presentations of fire scenarios. Within another branch of TNO the DIANA model was developed in the 70's, based on the Finite Element Method (FEM) calculating temperatures in constructions, material stresses and deformations.



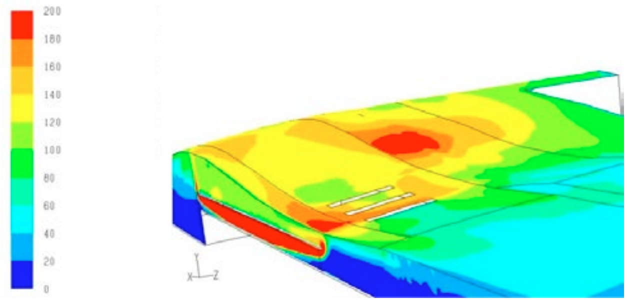
This computer model is now a full grown worldwide used simulation program. For fire safety now SAFIR has become a more dedicated and preferred tool. Recently Efectis has become involved in the development of a new pre-processor.

Over the years other computer modelling programs became available, often developed on a commercial basis. Another well-known modelling method is Computational Fluid Dynamics (CFD). Currently FDS from NIST is the most popular computer tool, replacing older programs like VESTA and Jasmine. Within the field of fire safety services, it is mainly used to calculate the flow of fluids or gasses under defined conditions, specifically in respect to smoke propagation and temperature development.

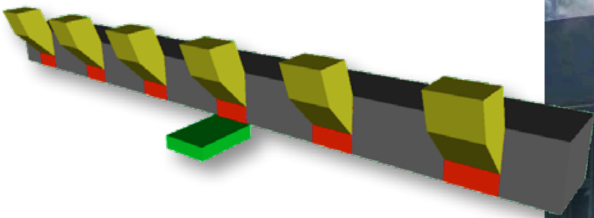
But in some cases, available modelling programs are not appropriate to present the output requested. Special models have been created internally responding to the customer requests. The prediction of flames emerging from fire in metro carriage was placed in a model together with a visualisation. The objective was to determine fire safety measures to be taken for which many different configurations, geometries and external factors had to evaluated.

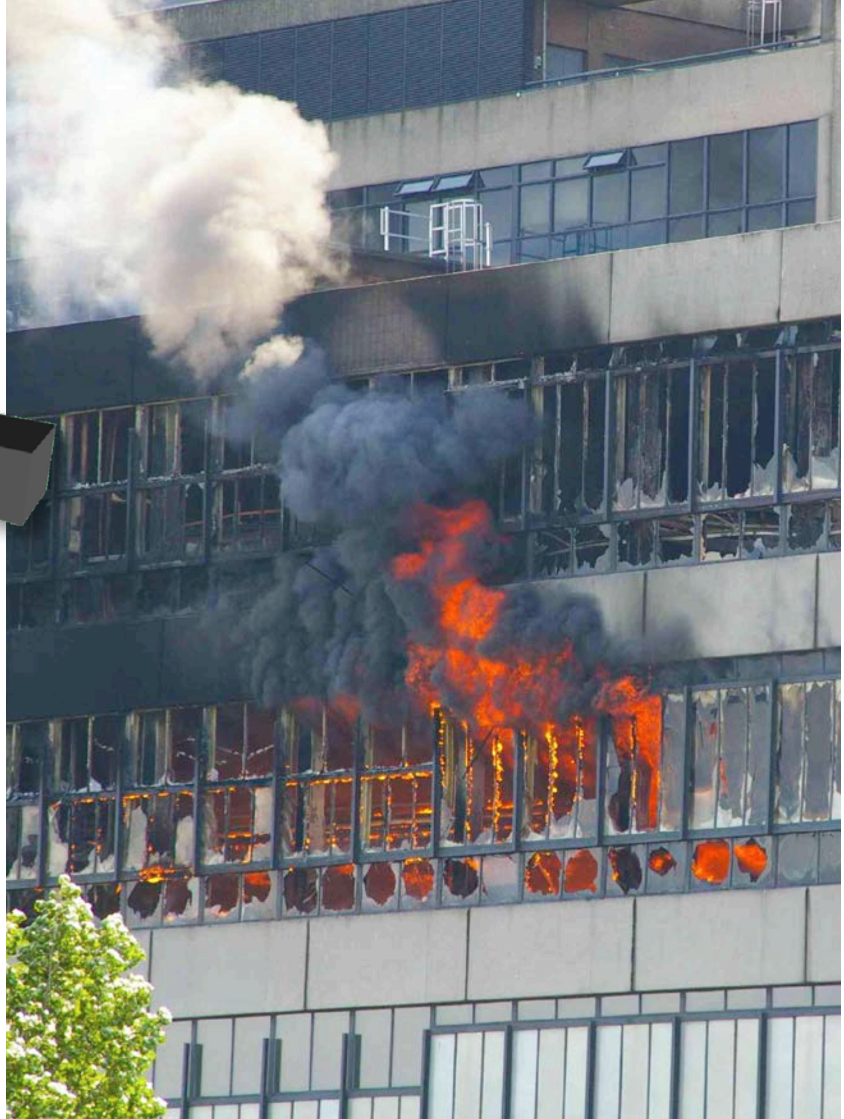
Over the years other computer modelling programs became available, often developed on a commercial basis.

Fire modelling is not only used to predict complex fire scenarios but also to analyse fire incidents. The picture below shows an example of a graphical presentation of a numerical analysis compared to a picture of a real fire.



Over the years modelling has been used quite often to analyse fire incidents and retrieve information which could not be obtained on site during or after the fire.






EXPERTISE

Having so far mainly focussed on our roots as a fire test laboratory we shall not forget other related non-testing activities. One of the services performed by the engineering team are on-site inspections of buildings, investigating compliance to applicable legislation and indicating fire related risks.

Risk assessment and design verification is also performed as desk research. This work is mostly based on drawings received from contractors, building owners and suppliers although visits on-site may be involved. For this team, besides practical experience, knowledge of building codes is speciality.

> This work is mostly based on drawings received from contractors, building owners and suppliers although visits on-site may be involved.


FIRE RESEARCH

Fire investigation

After each fire there is a need to determine the cause. The stakes can be different but are always high. Was it negligence, was the fire created intentionally (perhaps arson) or a technical failure? Besides a scientific technical approach, the investigation results are very important for different kinds of stakeholders, in the first place the direct victims and their relatives.

Determining liability is often in the primary interest of insurance companies and the insured party. A fire often brings more drama than just the technical loss of an object or construction. Besides possible fatalities or injuries, people may be without a place to live or work. Contra expertise, in case of disputes, may be requested. Efectis acts as independent fire investigator and expert. Also, upon request of authorities, the Dutch safety board and police and even in court cases for criminal prosecution.

In case of a technical failure the manufacturer or constructor should want to know how to prevent such incident for the future. In every case it is important to retrieve as much information as possible. Fire investigation has been an important service conducted by Efectis throughout its history.

Fire reconstruction

Sometimes it is impossible to determine on site what really caused a fire or how it developed. In such cases a reconstruction of a fire by means of a real test might add significant information. In the Efectis laboratory, the ad-hoc room is allocated to perform a variety of non-standard or non-regular tests. One of the most well-known reconstructions relates to the Volendam fire disaster.

In the early hours of January 1, 2001, a fire catastrophe took place in the café “het Hemeltje” in Volendam. An estimated 300 people, mainly juveniles, were celebrating the start of 2001 when the fire occurred with 14 deadly casualties and over 200 severely injured.

A formal and extensive investigation was immediately launched. This included an evaluation of the response of the rescue services, compliance to the building codes, oversight by the authorities and a technical investigation of the fire development. For the latter the fire scene was reconstructed as realistic as possible at a scale of 70%, based on witness reports of the situation during the drama. The result of the tests performed was the shocking confirmation of an extremely fast fire propagation beyond any expectation so far.

> **The result of the tests performed was the shocking confirmation of an extremely fast fire propagation beyond any expectation so far.**

These results were used not only as part of the investigation report but also to emphasize the need of adequate fire safety precautions, inspections, and enforcement by authorities.

Non-standard testing

The fire research in our laboratory also includes special tests requiring a specific test set-up. These can be fire tests under, for example, reduced oxygen or low temperature conditions, the fire resistance of aircraft containers or many other tests requested by the customers. This part of the laboratory is also used for graduation research projects of university students at Efectis.

Large scale testing

Not all tests can be performed in a laboratory of secluded space. As early as 1959 large scale fire tests were performed in houses which would soon be demolished anyway. This not only provided information regarding the fire development within those houses but also provided useful information for fire brigades for their intervention in case of fire.

Such opportunities are evidently very scarce. In 1999 however, with the support of a manufacturer of smoke ventilation systems, the Dutch Ministry of Economic Affairs and Rijkswaterstaat, an existing parking garage could be used for real life measurements. This parking garage in Amsterdam was already on the list to be demolished. The aim of the tests was to prepare a CFD model to simulate a fire test and determine a design model for forced ventilation.

Nowadays an obstacle for large scale testing is found in environmental restrictions, especially in certain crowded areas. We are fortunate to have access to several specific test locations inside the Efectis group like Saint Yan, or through good collaboration with other parties.

70 Years history
of fire safety at
Efectis Nederland

TUNNEL SAFETY

Determination of a representative fire curve

While standardisation is an important basis to compare materials, products, constructions, and their performances it is not always realistic to take existing standards for granted. A good example is provided by looking at the origin of one of the most popular tunnel fire curves, the RWS fire curve and how it came into being. A serious doubt was raised whether the standard fire curves used for tunnels were sufficiently representative for fires to be expected in road tunnels. Only after a fire in the Velsertunnel in the Netherlands in 1978, where 5 people lost their lives, attention was drawn to the vulnerability of tunnel infrastructure to vehicle fires. It was then, that Rijkswaterstaat, the Dutch Ministry of Infrastructure together with Efectis (then known as the TNO Centre for Fire Safety) started the research into determining the maximum thermal load on the tunnel structure due to the worst possible fire scenario in a tunnel. The research was conducted in the period between 1979 and 1980.

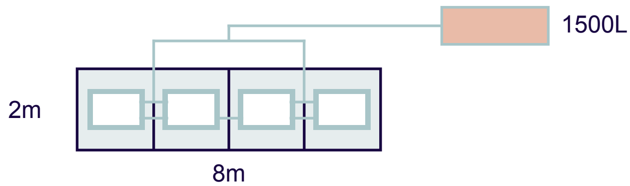
The following assumptions were made in etermining a realistic worst possible fire scenario:

- A crash with a 50 m3 petrol tanker
- A pool size of 150 m2
- Maximum heat release rate of about 300 MW
- Leakage for about 90-120 minutes

It was decided to perform scaled tests to determine what would be the expected temperatures in such a pool fire scenario.

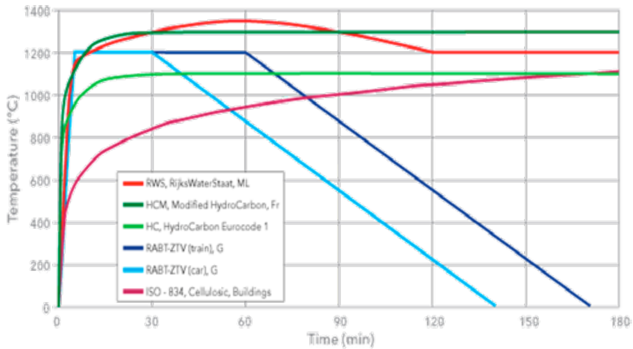
A tunnel of the size of 8 m x 2 m x 2 m (length, width, and height respectively) was constructed. The walls of the tunnel were made of aerated concrete blocks with a thickness of 0.24 m. 30 openings of the size 0.15 m x 0.1 m were made in this tunnel to ensure a sufficient supply of oxygen. These openings were made at a height of 0.5 m from the bottom of the tunnel.

The tunnel on one side was open to the outside, while on the other side ended in a room of size 3 m x 3 m x 2.5 m, which in turn led to alley of 2 m x 1 m x 2 m which opened to the outside. In other words, the tunnel was open to the outside atmosphere on both sides. The tunnel roof was made of 8 concrete slabs, placed next to each other, with dimensions 2.5 m x 1 m x 0.15 m. Passive fire protection in the form of spray mortar was applied to protect the concrete slabs.

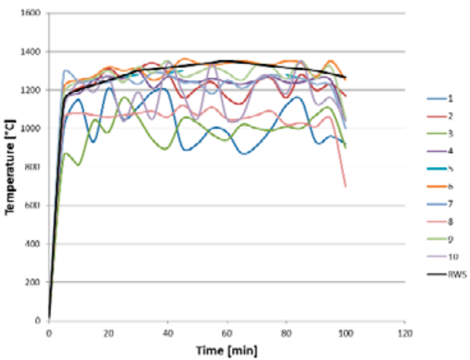


For the fuel, petrol was used. Four steel trays of approximately 1 m x 1 m were placed in the tunnel at a height of about 0.5 m and a distance of 0.65 m between the trays. The steel trays were connected to each other with pipes to ensure a uniform spread of the fuel.

A total of 10 thermocouples were used to measure the temperatures in the tunnel during the fire test.



It was noted that the theoretical burning rate of petrol with turbulent combustion is 4 litres per minute per m2 of fire area. For the test, it was calculated that for a fire duration of 90 minutes, a total quantity of approximately 1500 litre of petrol would be needed.



A total of 10 thermocouples were used to measure the temperatures in the tunnel during the fire test. Out of the 10 thermocouples, 9 were placed at a distance of 0.1 m from the concrete slabs at the ceiling, whereas 1 thermocouple (number 3) was placed at half of the height of the tunnel, hence we will observe the 9 thermocouples.

It was noted that the temperatures of all the thermocouples rose quickly to around 1000°C in 2.5 minutes. The average temperature was already around 1140°C within the first 5 minutes. Thereafter, the average temperature stayed around 1200 ± 60°C and peak temperate recorded was around 1350°C. It was noted that a few seconds before 100 minutes, the fuel was fully used up and the temperatures fell drastically in the tunnel.

The results of the temperature measurements are described in the graph on the left.

These were the first set of experiments performed for evaluating the anticipated temperatures in a tunnel with the worst-case scenario of a petrol tanker in fire. As a result of these tests, the well-known RWS fire curve was defined. In the graph below an overview of different fire curves is given. However, these were by no means the last series of experiments and testing to be performed.

> **As a result of these tests, the well-known RWS fire curve was defined.**

Unfortunately, the need to continue research tunnel safety was again demonstrated by other tunnel fire disasters of which the 1999 Mont Blanc tunnel fire is perhaps the most well-remembered. Investigations of several tunnel fire incidents demonstrated the need to identify and understand specific risks in tunnels.

A European tunnel safety research program was launched: UPTUN: cost-effective, sustainable and innovative upgrading methods for fire safety in existing tunnels[5].

In 2003, Efectis (then still TNO-CvB) was in charge of this project in which some 37 other international participants, representing governmental organisations, tunnel- and road administrations, universities, engineering institutes and other laboratories participated.

A significant part of this project involved full scale testing in the Runehamar Test Tunnel with various non-hazardous materials (timber, plastic, furniture, paper). Many valuable results were obtained with these tests, providing new information that could not be obtained by existing standard laboratory tests or, until then, due to the lack of reliable data, modelling. All these fire tests confirmed that the temperature rise and peak of the RWS fire curve is representative not only for pool fires (as demonstrated in 1979 and 1980), but also for solid fuel fires.

This procedure, its name abbreviated to the RWS procedure,

Based on the experience and information gained, an assessment procedure has been drawn up together with Rijkswaterstaat in which the specific tunnel risks in the event of fire are addressed. This procedure, its name abbreviated to the RWS procedure, has been widely recognized and is now used worldwide.

After the research and the modelling of the tunnel fires and the UPTUN project, Efectis continued its research on spalling of concrete at high temperatures, estimated as worst-case scenario in tunnels. In case of spalling the mechanical strength of the tunnel construction may be reduced beyond

mechanical safety limits. The 3rd version of the RWS-procedure was published in 2020.

Ever since the UPTUN project, Efectis has been involved in many large-scale tunnel test campaigns, often to determine the compliance of extinguishing systems to specific requirements. For each such complex test, many parameters have to be taken into account, besides the amount of extinguishing material varying from geometry, fuel, airspeed, temperatures, heat release to relative humidity and contents of O2, CO and CO_2.

> **This procedure, its name abbreviated to the RWS procedure, has been widely recognized and is now used worldwide.**

As indicated before, with regard to new energy carriers it will have to be assessed whether the input considerations used so far are appropriate.

Laboratory testing according the RWS curve

By defining the RWS fire curve it became possible to assess the performance of tunnel structures with or without fire protection. This was described in the RWS procedure, drafted in collaboration with Rijkswaterstaat. It was a challenge to construct a furnace that was able to create and withstand the RWS curve in a laboratory setting and we succeeded. Spalling of concrete is one of the criteria in this procedure. Important factors determining the performance of the tunnel elements are the composition of the concrete mixture and the type of reinforcement used.

Another challenge was to perform the laboratory test representative for the infrastructural projects to be built. The mechanical load in the specimen during the test has to be simulated. For this, a special loading frame was designed to apply compressive strength, and not only for flat slabs. Today, with a loading frame developed and engineered within Efectis Nederland, a load of 1000 tons can even be applied on curved elements.

Not only the concrete structural elements shall withstand the RWS curve but also other constructions in tunnels like escape doors. These are also tested at Efectis.

Existing tunnels

For quite a few existing tunnels little to no information existed about the performance of the concrete used during their construction. The need arose to determine whether additional measures had to be taken to protect tunnels to withstand what are now considered realistic fire scenarios.

A special mobile furnace (MobiFire) was developed to perform tests in-situ. It can be used for ISO and RWS curves. By design, the MobiFire can be used on vertical and horizontal surfaces.

This innovative On-Site Fire Resistance Testing Method was presented during the Chicago NFPA conference of 2013, including the experience gained from actual projects like the Maastunnel in Rotterdam, a submerged tunnel constructed in the late 30's.

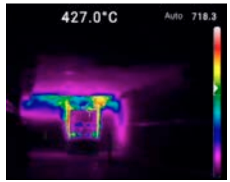
Many MobiFire tests have been performed since then, in Dutch tunnels and abroad, both road tunnels and railway tunnels.

This, over 600 m long, tunnel, has good geometry and was specially designed for fire testing and training.

The correlation between laboratory tests and the in-situ MobiFire has been determined and the MobiFire is now included in the 2020 revision of the RWS procedure.
The last decade many large-scale tests have been performed in the special test tunnel at the site of Applus+ TST in Spain. This, over 600 m long, tunnel, has good geometry and was specially designed for fire testing and training. Efectis mainly uses this tunnel for measurements on fixed firefighting systems (FFFS) such as watermist systems (WMS).

Each project is complex from a measuring point of view, as the performance criteria defined by tunnel authorities vary per project. The TST facility combined with the Efectis specific designed measurements is very well equipped test tunnel with a good communication infrastructure and an impressive control room.

Especially the delicate control over the ventilation during tests, transversely or laterally, is of great importance. The collaboration between Efectis and Applus+/TST is highly esteemed and often a prerequisite for tunnel and road authorities.




70
ANNIVERSARY
YEARS
EXPERIENCE IN
FIRE SAFETY

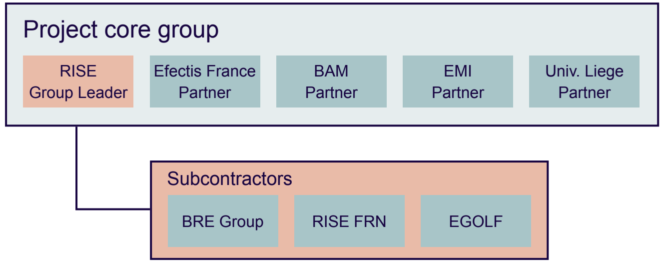
In 2022 the Efectis Nederland is still increasing its testing possibilities, developing new, and improving existing methods. Investing in people and training is a precondition for this. A great deal of knowledge is available and shared within the Efectis group, enabling international Efectis teams of dedicated experts to collaborate on specific projects.

The ambition is to provide all the testing and assessment activities desired by our customers and stakeholders, regardless of their target markets. In addition to commonly applied European test methods, we gladly offer testing on non-European or even custom protocols agreed with our customers. Our knowledge is also shared, e.g., in lectures at universities and in support of standardisation processes. Understanding fire and its mechanisms allow to identify safety risks and to some extend predict performances in practice. Our objective has been, is and will be to avert fire safety risks.

> A great deal of knowledge is available and shared within the Efectis group, enabling international Efectis teams of dedicated experts to collaborate on specific projects.

For this reason, Efectis as a group is involved in several research projects together with other institutes.

One EU funded project concerns European fire statistics. This has a close relation with our work within the European Fire Exchange Platform (FIEP) addressing toxicity of smoke and the behaviour of modern facades in fire, to share best practices. Continued involvement in the collaboration for the "Development of a new European approach to assess the fire performance of facades" is therefore evident. The structure of the involved parties is presented below:



Wherever feasible we strive to bring our testing activities under accreditation as it helps to demonstrate our professionalism, always respecting the core values of independency and impartiality, and remaining continuously prepared for changing markets, demands and legislation. As indicated before, new energy carriers are just an example to work on, the need for sustainability will most definitely affect our work.

Yet, testing is only part of the job. Testing is becoming increasingly complex and requires more detailed preparation. And so are the reports. After the test the reporting should be very specific about the results and scope of validity. For most European standard tests, a classification report needs to be drafted additionally. Sometimes the field of application can be extended based on Extended Application standards.

> **Efectis is a great group for great careers and as your partner when it comes to fire safety!**

Testing may have been the basis for the activities of Efectis Nederland, it shall not be forgotten that the results and accumulated knowledge serve a much wider range of application. Testing is in general primarily used to determine compliance to requirements set by legislation or other stakeholders.

70 years of experience in fire testing, additional research and international collaboration have brought us a leading position in fire safety research. Not because we believe we are the best but because we believe there is always more to be known, developed, and deployed. Whatever the received request is, it is linked to our social responsibility.

After all, fire research was our starting point and, despite all standardized processes, curiosity remains a part of the Efectis DNA. And that is what makes our work great. Efectis is a great group for great careers and as your partner when it comes to fire safety!

Source reference

[1] https://zoek.officielebekendmakingen.nl/kst-29338-20.html

[2] CPD, COUNCIL DIRECTIVE of 21 December1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (89/106/EEC)

[3] https://cordis.europa.eu/article/id/3848-standards-measurements-and-testing-information-package

[4] The full report can be found at https://www.cob.nl/wp-content/uploads/2018/01/JHO-125.V.04.D.pdf

[5] https://cordis.europa.eu/project/id/G1RD-CT-2002-00766

70 Years history of fire safety at Efectis Nederland

Efectis

70 ANNIVERSARY YEARS