

## Test and Calculation Method for the Determination of Temperatures and Heat Transfer Conditions in Fire Resistance Furnaces

### Key words

Fire resistance testing, heat transfer, thermal properties, temperature field calculation, extension of DIN V ENV 1363-3

### Quantities and items tested

The heat transfer conditions of fire resistance furnaces are determined by:

- a) furnace temperatures and reference element temperatures
- b) heat transfer coefficients (numerical determination of thermal properties of fire tests)

### Testing range

### Uncertainty of results

Temperatures: 0 °C – 1000 °C	from 10 K	to 10 K (after the 10 <sup>th</sup> minute)
Total heat transfer coefficients. 20 W/(m <sup>2</sup> K) – 1000 W/(m <sup>2</sup> K)	from 10 %	to 10 %

### Fields of application

Determination of heat transfer conditions of fire resistance furnaces for elements totally engulfed by fire. The results are compared with specified values. This procedure allows the classification of fire resistance furnaces with respect to their heat impact on specimens.

### Methodology and instrumentation

Reference elements equipped with thermocouples are located at specific positions in the furnace. The heating of the elements and the furnace temperatures are recorded. The heat transfer conditions of the furnace are determined by numerical analysis of the measured time-temperature curves.

The concentrations of oxygen, carbon dioxide and carbon monoxide are documented.

### Qualification and quality assurance

The performance of this procedure is significantly better than that of related standard procedures. This concerns a. o. sensitivity and reproducibility, but also data analysis using computer code developed by BAM. Extensive knowledge of the numerical analysis of temperature fields and thermal boundary conditions has been developed over more than 20 years.

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## Further information

### 1. General remarks

Fire resistance furnaces are not uniformly designed. They differ in geometry, number, type, power and position of the burners, the smoke exhaust systems and the thermal properties of the lining materials. The scatter in test results based on these differences and on individual furnace characteristics has to be evaluated.

DIN V ENV 1363-3: Fire resistance tests, verification of furnace performance - describes a method for the evaluation of furnaces applied for the test of separating elements and the mainly used temperature time curve. The standard does not say anything about the performance evaluation of furnaces used for the test of specimens totally engulfed by fire.

The method presented here has been developed for furnaces testing specimens totally engulfed by fire. High sensitivity and reproducibility are features of this method.

The heat transfer conditions are determined by comparison of measured and calculated temperatures for selected positions on the elements surfaces using the finite difference code IOPT2D. Thanks to this technique, the method provides significantly better performance than required in DIN V ENV 1363-3.

The development of ENV 1363-3 was carried out under the mandate of CEN. On behalf of DIN an expert of BAM took part in the work of the ad hoc working group in charge.

### 2. Description of the calibration procedure

The so-called 3-shell-calibration-element developed during the framework of the SMT research project „Harmonisation of Fire Resistance Testing: Thermal Aspects“ is made out of three tubes centered around a solid rod. Top and bottom are insulated with vermiculite containing caps to minimize axial heat flux. Inside the element heat is mainly transferred by radiation. All components except insulating parts are made from a heat resisting steel. An annealing procedure has been applied to obtain constant surface emissivities. Temperatures are recorded on each tube and the solid rod, respectively, during fire resistance tests in furnaces for specimens totally engulfed by fire. A computer program extensively described in [3] iteratively determines the heat transfer conditions due to convection and radiation between the calibration element and the surrounding radiating gas volume and the walls of the furnace, respectively, by bringing the measured temperatures as closely as possible into accordance with calculated temperatures. By performing fire resistance tests in other furnaces of the EU using the calibration element and computer program of BAM the thermal performance of column- and beam-furnaces with respect to harmonisation can be compared.

- [1] DIN V ENV 1363-3  
Feuerwiderstandsprüfungen;  
Teil 3: Nachweis der Ofenleistung  
September 1999
- [2] Schriever, R., Müller, R. und Rudolphi, R.:  
A Calibration Element for Fire Resistance Furnaces, Testing Specimen Totally Engulfed in Fire.  
8<sup>th</sup> International Fire Science and Engineering Conference.  
Conference Proceedings Interflam, Vol. 2 (1999) p. 1057 – 1068,  
Edinburgh, Schottland: 29.06. – 01.07.1999  
London, Interscience Communications Limited
- [3] Müller, R.:  
Ein numerisches Verfahren zur simultanen Bestimmung thermischer Stoffeigenschaften oder Größen aus Versuchen. Anwendung auf das Heißdraht-Parallelverfahren und auf Versuche an Hausschornsteinen.  
Dissertation, TU Clausthal, 1989, 130 Seiten, bzw. BAM-Forschungsbericht Nr. 185, 1992, 71 Seiten