EGOLF STANDARD METHOD **EGOLF / SM / 6**

April 2000

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FIRE TESTING

FIRE RESISTANCE TESTS FOR SERVICE INSTALLATIONS: METHOD FOR THE MEASUREMENT OF LEAKAGE [VOLUME FLOW RATES] TO INDICATE INTEGRITY AND SMOKE LEAKAGE

THE EUROPEAN GROUP OF OFFICIAL LABORATORIES FOR FIRE TESTING

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Foreword

This document has been prepared by EGOLF.

The method is designed to be used when performing fire resistance tests on service installations according to EN 1366 parts 1, 2, 8, 9 and 10.

The method is used where leakage [volume flow rate] measurements are required to be made to indicate integrity and smoke leakage properties of the service installation under test.

The method shall be used by all EGOLF member laboratories when performing fire resistance tests on service installations, according to EN 1366 parts 1, 2, 8, 9 and 10, where leakage [volume flow rate] measurements are required to be made.

This method is recommended to other organisations and laboratories for use when measuring leakage [volume flow rates] as part of fire resistance tests on service installations.

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1. SCOPE

The series of European Standard tests EN 1366 consists of 10 parts under the general title Fire Resistance Tests for Service Installations.

In the test methods in accordance with Parts 1, 2, 8, 9 and 10 of EN 1366 leakage [volume flow rate] measurements are required to be made to give indication of:

- integrity
- smoke leakage

This EGOLF Standard Method gives additional information and guidance to laboratories making leakage [volume flow rate] measurements in accordance with the above mentioned parts of EN 1366. It may also be applicable where similar volume flow rate measurements are to be made in accordance with standards other than those within the EN 1366 series.

The method applies only to the measurement of leakage [volume flow rates] using pressure measurement and other devices in which the flow is steady or varies slowly with time and the fluid can be considered as a single-phase (gas) fluid.

2. REFERENCES

For the purposes of this EGOLF Standard Method the following references apply.

EN 1363-1 Fire Resistance tests: General Requirements.

EN 1366-1 Fire Resistance of Service Installations: Fire Resisting Ducts.

EN 1366-2 Fire Resistance of Service Installations: Fire Resistant Dampers.

EN 1366-8 Fire Resistance of Service Installations: Smoke Extraction Ducts.

EN 1366-9 Fire Resistance of Service Installations: Single Compartment Smoke Extraction Ducts.

EN 1366-10 Fire Resistance of Service Installations: Smoke Control Dampers.

ISO 5167-1 Measurement of fluid flow by means of orifice plates, nozzles and venturi tubes inserted in circular cross section conduits.

ISO 10294-3 Fire Resistance Tests: Fire Dampers for Air Distribution Systems - Commentary Document.

3. PRINCIPLE

The need to measure leakage [volume flow rate] is defined in fire resistance tests on service installations according to EN 1366 parts 1, 2, 8, 9 and 10. The measured leakage obtained is used to indicate integrity and smoke leakage properties of the service installation under test.

The procedure for measuring pressure differential is specified in each of EN 1366 parts 1, 2, 8, 9 or 10.

The pressure differential measurement devices used may be orifice plates, nozzles, inlet nozzles, venturi tubes and other devices inserted in circular cross section conduits, running full.

Each of these devices can only be used within specified limits of volume flow, pipe size and Reynolds number and specific information is needed to be able to choose the correct pressure differential measurement device according to ISO 5167-1.

Leakage [volume flow rate] shall be calculated, from the measured pressure differential across the differential pressure measurement device, using the formulae for volume flow rate given in ISO 5167-1.

Where leakage is to be calculated from oxygen content measurements, e.g. during the fire test in EN1366-8, the leakage mass flow shall be determined in accordance with the procedures given in that part of EN 1366 in use.

Leakage (volume flow rate) shall be calculated from the leakage mass flow ÷ density of dry air.

Where knowledge of the velocity of airflow through service installations during testing according to EN 1366 parts 1, 2, 8, 9 and 10 is required this may be calculated from the measured volume flow rate.

That airflow shall be created under the defined conditions given in that part of EN 1366 in use.

3.1 Integrity

The conventional means of measuring integrity in fire resistance testing, given in EN 1363-1, is not entirely applicable to gaps and cracks (inside and outside the furnace) in service installation test specimens under test according to EN 1366 parts 1, 2, 8, 9 and 10.

The measured leakage [volume flow rate], supplemented by conventional integrity measurements around the outside perimeter of the service installation, shall be used to measure integrity in these cases.

The requirements for pass / fail of integrity, where required, may be different for each part of EN1366.

3.2 Leakage [Smoke leakage]

Measured volume flow rate shall be used to give a precise indication of leakage [smoke leakage].

The requirements for pass / fail of leakage [smoke leakage], where required, may be different for each part of EN1366.

4 PHYSICAL PROPERTIES AND ASSESSMENT OF LEAKAGE

Choice of instrumentation and calculation of leakage (volume flow rate), whether measured from pressure differential measurements or, indirectly, from oxygen content measurements and calculated mass flow rate, requires knowledge of and use of physical parameters and constants, e.g. physical properties of the fluid [density, absolute (barometric) pressure and viscosity etc. and temperatures involved.

The specific guidance given in this EGOLF Standard Method on the use of these physical properties shall be followed in performing fire tests on service installations according to EN 1366 parts 1, 2, 8, 9 and 10.

General: values and formulas given for density, barometric pressure and viscosity etc. have been taken from ISO 10294-3.

4.1 Density

For the determination of the volume flow rate in accordance with ISO 5167-1, the actual density of the fluid in use is needed.

In fire resistance tests of service installations the fluid will be air or flue gas from a furnace. Flue gas contains N_2 and CO_2 as well as water [H_2O] in unknown concentrations. However, for calculation purposes air and flue gas may be treated as dry air and the density may be calculated from the law of ideal gases:

$$p \times V = p / \rho = R \times T = \text{constant} \quad (1)$$

Where:

R is the gas constant for air, in J/(kg°K)

V is the specific volume of air, in m³/kg

ρ is the density of dry air [under conditions of absolute pressure p and absolute temperature T], in kg/m³.

From this it follows that:

$$\rho = \rho_o \times p/p_o \times T_o/T \quad (2)$$

where:

ρ_o is the density of dry air at absolute temperature T_o and absolute pressure p_o.

Generally the value ρ_o = 1.293 kg/m³ at temperature T_o = 273.15 K (0°C) and pressure p_o = 1013.25 hPa (760 Torr) shall be used.

4.2 Absolute pressure (barometric pressure)

The barometric pressure shall normally be measured by means of a barometer.

In cases where a barometer is not available and the level Z (in metres) of the laboratory above sea level is accurately known, but does not exceed 500 metres, a mean value of barometric pressure may be calculated according to the following formula and used:

$$p_a = 1013 - Z/8 \text{ [hPa]} \quad (3)$$

where Z is the level, in metres, of the laboratory above sea level.

NOTE Common weather conditions may cause deviations of about 1 % related to the mean barometric pressure. In extreme weather conditions, the deviations may rise to about 3 % (e.g. severe winds, etc.).

In cases where the laboratory is situated at greater than 500 metres above sea level the use of the calculation method is not permitted and the barometric pressure shall only be obtained by means of a barometer.

4.3 Viscosity

The actual fluid viscosity is required when the Reynolds number Re needs to be calculated (e.g. when choosing the suitable size or measuring range of a measuring device).

Kinematic viscosity [ν] depends on temperature and pressure. Dynamic viscosity [μ] depends on temperature but is independent of pressure.
The relationship between kinematic viscosity [ν] and dynamic viscosity [μ] is defined as:

$$\nu = \mu / \rho \quad (4)$$

The **dynamic viscosity** μ of dry air versus temperature may be calculated using the following polynomial formula (equation 5):

$$\mu = \sum_{i=0}^{3} (a_i \times t^i \times 10^{-3i}) \cdot 10^{-6} \, [kg/(s \cdot m)]$$

where:

a_0 = 17.22; a_1 = 48.02; a_2 = -24.73; a_3 = 7.287

t is the temperature within the range -50°C ≤ t ≤ 1000°C

The dynamic viscosity μ of dry air as a function of temperature, calculated according to equation (5), is shown in the form of a table in Table 1 and graphically in Figure 1.

5 METHOD OF LIMITATION OF THE EFFECTS OF WATER

Early proving tests in accordance with EN 1366-1 demonstrated that water will be produced by construction materials when exposed to fire and that, although the amount produced depends on the kind of material tested, it cannot be ignored.

To minimise the effects of the released water on the test result the design and use of a condenser has been specified when duct A is tested according to the test method EN 1366-1.

According to this EGOLF Standard Method, this condenser shall be used for every measurement of volume flow rate in "under-pressure" condition, which is carried out to indicate integrity and/or smoke leakage during fire resistance tests for service installations according to EN1366 parts 1, 2, 8, 9 and 10.

To ensure accurate results, the temperature condition to be used shall be that defined in

EN 1366-1.

Table 1: Dynamic viscosity of dry air versus temperature
(computed from equation (5); maximum deviation from ISO 10294-3, Table 1 is 0.44%)

Temperature **°C**	**Absolute temperature** **°K**	**Dynamic viscosity μ** **10^{-6} kg/s.m**
-50	223.15	14.8
0	273.15	**17.2**
20	293.15	**18.2**
40	313.15	**19.1**
60	333.15	**20.0**
80	353.15	20.9
100	373.15	**21.8**
120	393.15	22.6
140	413.15	**23.5**
160	433.15	**24.3**
180	453.15	**25.1**
200	473.15	25.9
250	523.15	**27.8**
300	573.15	29.6
350	623.15	31.3
400	673.15	32.9
450	723.15	34.5
500	773.15	36.0
600	873.15	38.7
700	973.15	**41.2**
800	1073.15	43.5
900	1173.15	45.7
1000	1273.15	47.8

NOTES: Interpolation between values is allowed

Values of dynamic viscosity μ in bold are identical to those in ISO 10294-3 table 1.

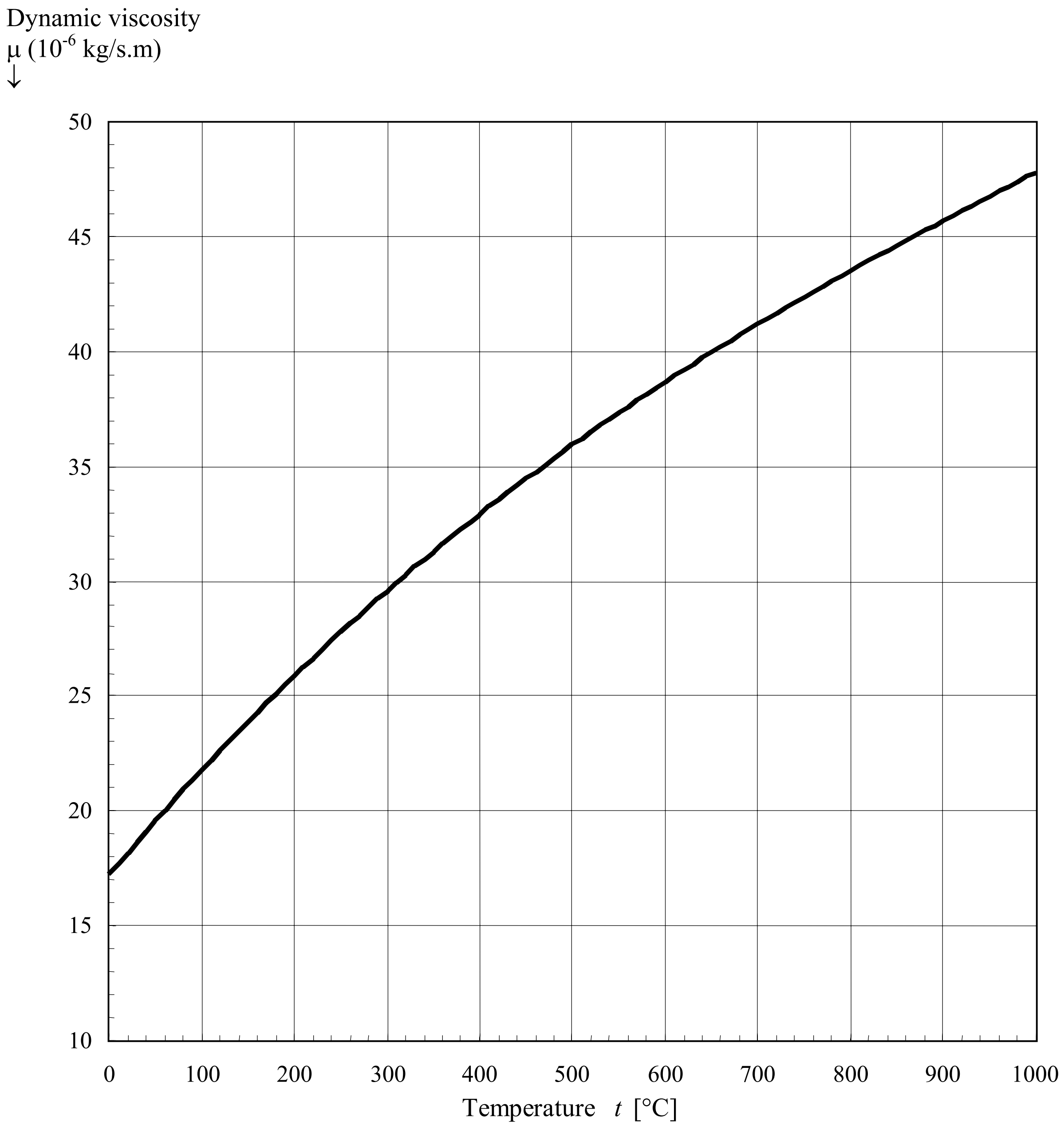

Figure 1: Dynamic viscosity μ (10^{-6} kg/s m) of dry air versus temperature