1 Scope

This document considers EGOLF procedures for the choice, use and calibration of pressure measurement devices used for measurement and control of pressure in fire resistance furnaces during fire resistance testing performed according to EN 1363-1. It is intended to be supplementary to EN 1363-1.

RESOLUTION: EGOLF member laboratories are encouraged to implement the best practice guidance given within this document, in respect of the purchase or manufacture, use and calibration of devices used for pressure measurement and control in fire resistance furnaces used for fire resistance testing according to EN 1363-1.

This document also presents a test method that establishes a procedure for measuring the response time of electronic micro-manometer transducer type pressure measurement devices intended for measurement of differential pressure during fire resistance or reaction to fire tests.

The test method is applicable to electronic micro-manometer transducer type differential pressure measurement devices used for measuring over-pressures and under-pressures, without limit of magnitude of pressure.

The test method is only applicable to electronic micro-manometer transducer type differential pressure measurement devices which have the capability of continuously recording measured differential pressure and/or those with a recording time interval not exceeding 0.2 seconds or one-tenth the expected response time, whichever is the lower.

2 References

EN 13823 Reaction to fire tests for building products. Building products excluding floorings exposed to the thermal attack by a single burning item

EN 1363 Fire resistance tests: Elements of building construction - Part 1 General requirements for fire resistance testing.
3 Introduction

EN 1363-1 describes requirements for the design, accuracy, installation and use of pressure measurement devices to be used for measurement and control of furnaces pressure in fire resistance testing.

This document aims to provide a completed harmonised furnace pressure measurement and control procedure to be used by all EGOLF members and thereby minimise performance differences between laboratories.

4 Choice of pressure sensor

The choice of pressure sensor to be used in fire resistance testing is dictated within EN 1363-1. According to this standard, pressure sensors may be “T” shaped sensors or “Tube” sensors.

Work reported in CEN TC127 N1161 shows no difference between the “T” shaped sensor defined in EN 1363-1 and “open pipe” sensors (which are not defined in EN1363-1) and recommends that either type may be used by fire test laboratories.

This document will address all 3 types of pressure sensor.

5 Pressure sensor specification

The type and dimensions of pressure sensors are only partially defined in EN 1363-1. Further definition is necessary for completeness.

5.1 'T' shaped pressure sensors

EN 1363-1 defines the internal diameter of stainless steel “T” shaped sensors as being 5-10 mm. It does not define the external diameter or dimensions of the `T` or the grade of stainless steel to be used (note: some grades will deteriorate with use).

EGOLF member laboratories propose that 'T' shaped pressure sensors should be of the following dimensions and properties:

- outside diameter of steel tube= 16 mm maximum
- length of arms of `T` (total) = (100 ± 2) mm
- length of leg within furnace = (50 ± 20) mm
- length of leg outside furnace = 100 mm minimum
- grades of stainless steel permitted = X10CrNiTi 18 10 * / X15CrNiSi 20 12 * / X15CrNiSi 25 20 *

5.2 Tube sensors
EN 1363-1 defines the internal and external dimensions of the tube and the positioning and size of holes. It does not define the length of the tube, within or outside the furnace, or indeed its overall length or the grade of stainless steel to be used (some grades will deteriorate with use).

EGOLF member laboratories propose that Tube sensors should be of the following dimensions and properties:

- length within the furnace = (50 ± 20) mm [i.e. between holes & furnace wall]
- length outside the furnace = 100 mm minimum
- grades of stainless steel permitted = X15CrNiSi 20 12 / X15CrNiSi 25 20 *

### 5.3 Pipe sensors

EN 1363-1 does not define open pipe sensors or their use, however their performance has been shown to be acceptable (CEN TC127/N1161). EGOLF member laboratories propose that open pipe sensors, where used, should be of the following dimensions and properties:

- internal dimensions of the tube = (5 ± 1) mm
- external dimensions of the tube = internal diameter + 2 mm
- length within the furnace = (50 ± 50) mm **
- length outside the furnace = 100 mm minimum
- grades of stainless steel permitted = X15CrNiSi 20 12 / X15CrNiSi 25 20 *

* As specified in EN 10095
** CEN TC127 ad hoc 14 reports that pipe length within the furnace is without effect from 0 - 100 mm.

DECISION: EGOLF member laboratories agree that they shall only use “T” shaped pressure sensors (as specified in EN 1363-1), “Tube” sensors (as specified in EN 1363-1) or “open pipe” sensors. The specification for these should be as given in EN 1363-1 and this document.

To prove conformity to these material or design specifications, new sensors or component materials should be purchased against these specifications and be provided be accompanied by Certificates of Conformity provided by the suppliers.

### 6 Mounting and positioning of pressure sensors

The mounting and positioning etc. of pressure sensing heads to be used for measurement and control of furnace pressure in fire resistance testing is specified in EN 1363-1. Any additional requirements particular to the fire resistance test standard in use will be defined therein.

DECISION: EGOLF member laboratories agree that they should only mount and position pressure sensors for fire resistance testing according to the methods given in EN 1363-1 or specific instructions within the test standard being followed.

### 7 Ageing and replacement of pressure sensors

The ageing and replacement of pressure sensing heads to be used for measurement and control of furnace pressure in fire resistance testing is not specified in EN 1363-1. EGOLF proposes that sensors should be subjected to visual inspection for major damage or corrosion and rejected if this is found.
DECISION: EGOLF instructs that member laboratories should subject pressure sensors to visual inspection before every test and reject any found to be badly damaged or corroded.

8 Measuring equipment - type / specification

The measuring and recording equipment to be used for controlling pressure in fire resistance furnaces is not defined within EN 1363-1, other than giving the specifications for range, (0-20 Pa), precision, (±2 Pa) and measurement frequency (continuous / at intervals less than 1 minute).

EGOLF members generally use for fire resistance testing, either, electronic micro-manometer transducer type pressure measurement devices, sloping tube (sometimes called inclined tube) manometers or U-tube type manometers (normally used for measuring under-pressure, e.g. in fire resistant duct tests and therefore not relevant to furnace control). Each type has its advantages and disadvantages.

EGOLF member laboratories propose that only electronic micro-manometer transducer type pressure measurement devices of the following specification should be used in fire resistance testing for measuring and controlling furnace pressure:

- Response time (10 ± 5) seconds

DECISION: EGOLF member laboratories should only use the electronic micro-manometer transducer type pressure measurement devices for measuring and controlling furnace pressure. These devices shall meet the specification for range and accuracy given in EN 1363-1 and, if appropriate, given in any specific EN test method in use.

9 Connection of sensor tube to pressure measuring device

The means of connecting the sensor tube to the pressure measuring is not defined in detail within EN 1363-1.

EGOLF member laboratories propose that:

- the (+)ve and (-)ve pressure points should preferably be at the same height within and without the furnace and be joined via parallel tubes to the (+)ve and (-)ve connections of the measuring device (see figure 1). If not, the individual (+)ve and (-)ve tubes shall not be exposed to different heating conditions.
- it is recommended that the (+)ve and (-)ve connections to the pressure measuring device be sealed and closed with a 2-way tap when not in use.
- the use of a condensation trap (as shown in figure 1) is optional.

DECISION: EGOLF member laboratories agree that they should only connect pressure sensors to pressure measuring devices using the procedures specified in EN 1363-1 together with those prescribed above, in this document.
10 Calibration of pressure measurement devices

10.1 General

The procedure for calibration of pressure measurement devices for use in fire resistance testing is not specified in EN 1363-1.

EGOLF member laboratories propose that the following checks or calibration actions should be applied, at the given frequencies, to electronic micro-manometer transducer type pressure measurement devices used during fire resistance tests for furnace control:

- Adjustment according to manufacturer’s instruction: Every test
- Manual zero adjustment during test 2 times minimum: Every test (unless automatically made)
- Calibration and determination of response time: Initially when new and then once per year

10.2 New equipment

EGOLF member laboratories propose that all electronic micro-manometer transducer type pressure measurement devices should be purchased with an initial calibration and response time certificate, stating the precision of the device over the required pressure range and proof of specification to the criteria of EN 1363-1.

DECISION: EGOLF member laboratories agree that they should only purchase new pressure measurement devices which have been calibrated, the response time measured and are provided with appropriate certificates in respect of these determinations.

10.3 Existing equipment

A typical arrangement of equipment for calibration of electronic micro-manometer transducer type pressure measurement devices is shown in figure 2.
Re-calibration of response time of pressure measurement devices should be done in one of two ways:

- by the laboratory, using its own “secondary standard calibration” device, pre-calibrated by the Accredited Calibration Service (ACS) - see figure 3.
- by an external Accredited Calibration Service (ACS) which holds a “secondary standard calibration” device against which the laboratory device is calibrated - see figure 4.
Pressure measurement devices used for furnace control shall be re-calibrated against the "secondary calibration manometer" at six different stepwise pressures covering the whole working pressure range of the instrument.

Simultaneous readings of pressure shall be taken for the electronic micro-manometer transducer type furnace pressure measurement device and the secondary calibration manometer when connected to the same pressure source on one side and to atmospheric pressure (or a constant pressure source at about atmospheric pressure) on the other side.

The results from the furnace manometer should be compared with those from the "secondary calibration manometer" and assessed for being within the limits (± 2 Pa) given within EN 1363-1. Any instrument outside the calibration limits should not be used for control of fire resistance furnaces.

The response time of electronic micro-manometer transducer type pressure measurement devices shall be determined according to chapter 12 below.

Notes:
- The "secondary calibration manometer" (whether ACS or fire test laboratory held) should be of uncertainty of not more than 0.6 Pa and have been calibrated against a "primary national standard manometer" (or against a manometer traceable to a "primary national standard manometer"). It should be any suitable electronic or mechanical instrument of higher precision than that to be calibrated.
- Electronic micro-manometer transducer type pressure measurement devices should be calibrated including the whole of the data measuring and recording system.
- The laboratory held "secondary calibration manometer", when also of the micropressure transducer type should be re-calibrated against a "primary calibration manometer", by an Accredited Calibration Service Laboratory, at least once every year. When of other types it should be re-calibrated against a "primary calibration manometer at least once every 10 years. This re-calibration shall be confirmed by the issue of a Calibration Certificate.

DECISION: EGOLF member laboratories agree that they should calibrate pressure measurement devices, existing in laboratories and in use for measurement of furnace pressure in fire resistance testing, using the procedures and at the frequencies specified in this document.
In addition, EGOLF member laboratories agree that they shall determine the response
time of pressure measurement devices, existing in laboratories and in use for
measurement of furnace pressure in fire resistance testing, using the procedures and
at the frequencies specified in this document.

11 Presentation of data

Unless otherwise stated, EGOLF member laboratories use immediate measured values at
the end of each interval of measurement for plotting graphs and drawing tables. If a
member laboratory performs any additional damping to the measured values, or uses
values different from those measured directly, it should be clearly stated in the test report.

DECISION: EGOLF member laboratories agree that they should use data measured
at each measuring interval in their test reports. If they use any other data (e.g. fixed
or floating average values) the character of data presented will be clearly explained in
the test report.

12 Determination of the response time of electronic micro-manometer
transducer type pressure measurement devices used for the
measurement of differential pressure

12.1 Definitions

Response time: The time taken for a pressure measurement device to respond to a step
change in pressure from an initial value to a final value.

Note: The response time of a pressure measurement device may also sometimes be
referred to as its time constant or transient response characteristic.

12.2 Symbols and designations

Symbol  Designation
e         the base of natural logarithms (e = 2.718)
P₁        starting pressure used for the calculation of the response time, [in Pa].
P₂        end pressure used for the calculation of the response time, [in Pa].
t₁        time when the starting pressure P₁ used for the calculation of the response time is
          reached, in minutes and seconds.
t₂        time at which the end pressure P₂ used for the calculation of the response time is
          reached, in minutes and seconds.
τ         Response time of the pressure measurement device.

12.3 Principle of the method

The electronic micro-manometer transducer type pressure measurement device under test
is subjected to a pressure, appropriate to the test and application for which it is to be used.

The applied pressure is accurately measured and continuously checked over a period of
time of sufficient length to ensure that it is stable.

The pressure is suddenly released.

The output of the electronic micro-manometer is recorded continuously as the pressure
falls from its initial pressure to its final pressure.
The results are graphically presented.

The time \((t_2 - t_1)\) taken for the pressure to fall from a chosen starting point \(P_1\) to a chosen end pressure \(P_2\) is determined.

From this the response time \(\tau\) is calculated according to a given equation.

### 12.4 Equipment and environment

#### 12.4.1 Test pressure source

The test pressure source may be generated by any suitable means.

The test pressure shall be accurately measured using an instrument with traceable calibration. It shall be sufficiently stable, such that any occurring fluctuations do not invalidate the test.

#### 12.4.2 Test equipment

The test pressure source and pressure measurement device should be connected to a two-way tap or other device for instantaneous isolation of the test pressure source and simultaneous exposure of the pressure measurement device to the background pressure. The complete test arrangement can be seen in figure 5.

![Description of apparatus](#)

**Figure 5. Description of apparatus (typical fire resistance use)**
The volume of pipework joining the pressure measurement device to the pressure source shall be as small as possible to avoid undue damping influence on the test result.

12.4.3 Test environment

The test room or that portion of the test room in which the test is to be carried out shall be draught free and of constant temperature of (20 ± 10) °C. Any disturbances which would cause rapid local changes of pressure and temperature during the test shall be eliminated.

12.5 Test specimen

12.5.1 Pressure measurement device

The pressure measurement device shall be that normally used for the measurement of pressure, in its entirety, including all tubes, connections, condensation trap, electronic reading and recording devices, see figure 5 above.

Note: Use of the condensation trap as shown in figure 5 is optional.

12.5.2 Micro-manometer output recording device

The micro-manometer output recording device used shall:

a) be capable of recording output data with an accuracy of better than 1.0% of its full scale reading over the required pressure range.

b) be capable of responding to a full scale reading in a time equal to or less than one half of the response time of the pressure measurement device.

c) be capable of assimilating the incoming data and producing a permanent record of the pressure at intervals of less than 0.2 second or one-tenth of the expected response time, whichever is the lower.

d) permit clear interpretation of the pressure data recorded.

12.6 Number of tests

At least six tests shall be carried out, one at each of six different stepwise pressures covering the operating range of the instrument.

12.7 Test procedure

12.7.1 Background pressure measurement

Open the two way tap and confirm the differential pressure registered by the pressure measurement device under test to be zero.

If the indicated pressure is not zero, adjust the zero or offset to give zero reading.

The causes of any non-adjustable zero reading or non-correctable fluctuations in pressure must be identified and eliminated before proceeding further with the test.

12.7.2 Background temperature measurement

Measure and confirm the acceptability of the background temperature to the criteria of clause 12.4.3.
The causes of any fluctuations in background temperature must be identified and eliminated before proceeding further with the test.

12.7.3 Application of pressure to the pressure measurement device under test

Connect the test pressure source to the pressure measurement device under test.

Apply the test pressure.

12.7.4 Stabilisation of test pressure applied to the pressure measurement device

Verify that the correct pressure is being applied to the pressure measurement device.

Monitor and confirm that the pressure recorded by the pressure measurement device is stable, according to 12.4.1.

12.7.5 Measurement procedure

Activate the micro-manometer pressure output recording device.

Confirm the continued stability of the applied pressure by monitoring the recorded pressure for a further period of at least 10 seconds.

Rapidly, in less than 0.2 seconds, release the pressure applied to the pressure measurement device under test by opening the two-way tap to the background pressure condition.

Continue to monitor the pressure registered by the pressure measurement device under test, until the output of the micro-manometer is below 2% of the applied test pressure.

Terminate the recording of pressure output data information.

12.8 Test results

12.8.1 Interpretation of data and analysis of results

The recorded data shall be graphically presented, and the following assessment method be employed.

The response time $\tau$ shall be determined from:

$$\tau = \frac{t_2 - t_1}{\ln\left(\frac{P_1}{P_2}\right)}$$

The value of $t_1$ shall be chosen such that it occurs at the top of the pressure / time curve, but after the time when the two-way tap is completely opened. The corresponding pressure $P_1$ shall be determined.

Time $t_2$ shall be determined at the bottom of the pressure / time curve, after time $t_1$ but before the output of the micro-manometer reaches 2% of the applied test pressure. Again, the corresponding pressure $P_2$ shall be determined (see figure 6).
12.8.2 Criteria for acceptance of results

The acceptability of the results shall be determined from the results obtained from the six tests carried out according to clause 12.7.

a) If the spread of results over the six tests is less than the measurement error defined in 12.8.3, then the mean value shall be used as the response time of the pressure measurement device under test.

b) If the spread of results over the six tests is greater than the measurement error defined in 12.8.3, then consideration shall be given to performing additional tests until the above criteria are met.

c) If the spread of results remains greater than the measurement error defined in 12.8.3, a statement shall be made that a response time for the pressure measurement device under test could not be established by this method.

d) If the variation cannot be explained in a systematic manner, consideration should be given to the rejection of the device.

12.8.3 Measurement errors

Measurement errors depend upon the magnitude of the measurement being made. Laboratories should determine for themselves the likely measurement errors to be expected.

The measurement error in time depends largely on where the times $t_1$ and $t_2$ were set. It should be possible that the relative error in time measurement could be better than 1%. Measurement errors in output values from the micro-manometer should be better than 2%.

Therefore, an achievable measurement error for response time is estimated at 2.5% or less.

12.9 Test report

The test report shall describe fully the pressure measurement device tested.
The test report shall describe fully the pressure source, pipework and equipment used to carry out the test, including dimensions, measured pressures and pressure checks as described in clauses 12.4, 12.5 and 12.6.

The test report shall give the temperature at which the test was carried out.

The test report shall give the results of all determinations of measured pressure response time for the pressure measurement device, including reproducibility of results, the mean value of pressure response time measured and the acceptability or any limitations to the results, according to clause 12.8.