INTERNATIONAL STANDARD

ISO 10294-3

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Fire resistance tests — Fire dampers for air distribution systems —

Part 3:
Guidance on the test method

Essais de résistance au feu — Clapets résistant au feu pour systèmes de distribution d'air —

Partie 3: Lignes directrices sur la méthode d'essai

Reference number
ISO 10294-3:1999(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

International Standard ISO 10294-3 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire resistance*.

Preparation of this part of ISO 10294 was necessary because of the need to provide a background to the test method and a rationale to the procedures and the criteria selected with respect to the testing of fire dampers as given in ISO 10294-1:1996.

ISO 10294 consists of the following parts, under the general title *Fire-resistance tests — Elements of building construction:*

— *Part 1: Test method*

— *Part 2: Classification, criteria and field of application of test results*

— *Part 3: Guidance on the test method*

— *Part 4: Thermal release mechanism test*

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Fire resistance tests — Fire dampers for air distribution systems —

Part 3:
Guidance on the method

1 Scope

This part of ISO 10294 gives guidance on the application of the test method specified in ISO 10294-1:1996.

This test method is concerned with the assessment of a fire damper to prevent the spread of fire and hot gases from one compartment to another. It is not intended for dampers used only in smoke control systems.

It is applicable to fire dampers included in an air distribution system.

The test is not designed to test fire protection devices which only deal with air transfer applications, or when a damper is used in suspended ceilings as the installation of the damper and duct may have an adverse effect on the performance of the suspended ceiling and other methods of evaluation may be required.

NOTE "Air transfer" is a low-pressure application through a fire separation door (or wall, floor) without any connection to an air duct.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10294. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10294 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 834-1:—[1)], *Fire-resistance tests — Elements of building construction — Part 1: General requirements*.

ISO 10294-1:1996*, Fire resistance tests — Fire dampers for air distribution systems — Part 1: Test method.*

ISO 10294-2*, Fire resistance tests — Fire dampers for air distribution systems — Part 2: Classification, criteria and field of application of test results.*

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices — Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full.*

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1) To be published.

3 Philosophy

3.1 General

The test described in ISO 10294-1:1996 is designed to measure the ability of a damper to:

a) close in the event of a fire under dynamic conditions;

b) to resist the spread of fire and gases from one compartment to another through an air distribution system.

During the early stages of developing the test, the requirements for air distribution systems in various countries were examined in relation to spread of fire, and it became clear that the design philosophy (see also clause 4 of ISO 10294-1:1996) varied considerably from country to country. The principle differences in philosophy and practice that were identified are as given in 3.2 to 3.5.

3.2 Fan on/off

Design philosophies vary. In some applications, air distribution systems are designed so that in the event of a fire occurring the fans switch off. Others are required to continue to provide air handling to parts of the building remote from the fire. In such a situation, the dampers have to close under dynamic conditions and, once they are closed, they may be subjected to high underpressures with a corresponding higher risk of leakage and consequently with potentially more rapid spread of fire.

It cannot be guaranteed under fire conditions that a fan will be off and therefore a dynamic condition may exist. A system failure can occur and the fan may not switch off. Therefore it is considered to be important to test the damper under dynamic conditions. The standard underpressure of 300 Pa was chosen as it corresponded to the underpressure used in ISO 6944:1985. This was considered adequate to cover most applications. It was recognized that for special industrial applications dampers may be designed to withstand higher underpressures. To allow for these special applications, allowance has been made to allow the test to be undertaken at increased underpressures.

The 0,15 m/s fire test velocity is a compromise between the need for a dynamic air flow test and fire safety within the fire test laboratory. For these safety reasons, closure testing at higher velocities/pressures, if considered necessary, should be carried out under ambient air flow conditions and not when the furnace is ignited at high temperatures.

It must be recognized that dynamic conditions at the damper can result from mechanical sources or a combination of temperature and stack effects, hence all fire dampers shall be tested to the requirements of ISO 10294-1:1996.

3.3 Installation practice

Some countries and some design practices require that the dampers be installed within the plane of the wall and floor and do not permit the damper to be remote from the separating construction. Other countries or design practices allow the damper to be installed either on the face or remote from the wall or floor. The test method provides guidance for testing all such possible installations but it is only necessary to test the installation method(s) applicable to the individual country concerned.

3.4 Insulation

Dampers are available both insulated and uninsulated. The method provides for the testing of all types of dampers.

3.5 Integrity

Measurement of integrity is based on measurement of gap leakage through the damper, together with conventional integrity measurements around the outside perimeter. The dynamic leakage measurements of ISO 10294-1:1996 give a more precise indication of integrity performance.

4 Principles of test

The basic philosophy behind the test is described in 3.1.

Prior to the determination of leakage the damper is subjected to 50 opening and closing cycles. This is intended to represent approximately two inspections per year on an installed damper to check its correct operation. This number of cycles may be inadequate for dampers which provide an air flow control function.

The fire test is started with the damper in the open position. This is intended to test the primary actuating mechanism attached to the damper. Secondary control devices remote from the damper are not covered by this test. It is considered important to start the test in this way as not only does it test the actuating mechanism, but it also checks that during the time that the damper remains open it does not distort and prevent closure once the actuating mechanism operates.

Whilst some difficulties may be experienced in controlling the furnace temperature and pressure whilst the damper is open, there is adequate time provided the damper closes within the specified time of 2 min, to be within the defined limits of the time-temperature curve defined in ISO 834-1 at 5 min.

See also clause 4 of ISO 10294-1:1996.

5 Apparatus

5.1 General

In general the information on furnace conditions and temperature measurements given in ISO 834-1 are adequate and require no further elaboration. However, some additional elaboration is needed with respect to flow measurements in ISO 5167-1 and ISO 5221 and this is detailed in 5.3. See also clause 5 of ISO 10294-1:1996.

5.2 Connecting duct

It is considered important to relate the length of the connecting duct to the diagonal dimension of the damper as differences in performance could occur under some circumstances.

In practice most sizes of dampers tested would mean that the length of the connecting duct would equal the diagonal dimension of the damper. However, the maximum length limit of 2 m was included to take into account size limitations within the test laboratory.

See also 3.4 and 5.1 of ISO 10294-1:1996.

5.3 Measuring station

5.3.1 General

See 5.2 of ISO 10294-1:1996.

5.3.2 Volumetric flow

For the measurement of the volumetric flow in accordance with ISO 5167-1 and ISO 5221, the density of the fluid is needed.

5.3.2.1 Flue gas

The flue gas from a furnace contains N_2 and CO_2 as well as H_2O in unknown concentrations.

However, for calculation purposes the gas may be treated as dry air and the density may be calculated from the law of ideal gases:

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

where

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

V is the specific volume, in m³/kg;

ρ is the density of dry air at absolute pressure p and absolute temperature T.

From this follows:

$$\rho = \rho_0 \times \frac{p}{p_0} \times \frac{T_0}{T} \qquad (2)$$

where ρ_0 is the density of dry air at absolute pressure p_0 and absolute temperature T_0.

Generally the condition index "0" is defined as 0 °C (T_0 = 273,15 K) and p_0 = 1 013,25 hPa (=760 torr), so that ρ_0 = 1,293 kg/m³ shall be used.

5.3.2.2 Absolute pressure (barometric pressure)

The barometric pressure shall 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 does not exceed 500 m, the use of the mean value of barometric pressure according to the following formula is recommended:

$$p_a = 1013 - \frac{Z}{8} \text{ hPa} \qquad (3)$$

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.).

5.3.2.3 Viscosity

The actual viscosity is required when the Reynolds number Re needs to be calculated.

The kinematic viscosity ν depends on temperature and pressure. The dynamic viscosity μ is independent of pressure. It only depends on temperature.

The relationship between the two viscosities is defined as

$$\nu = \frac{\mu}{\rho} \qquad (4)$$

The dynamic viscosity μ is given in the form of a table, a graph and as a formula, in Table 1, Figure 1 and equation (5).

Table 1 — Dynamic viscosity of dry air versus temperature

Temperature, t °C	**Absolute temperature,** T K	**Dynamic viscosity,** μ 10^{-6} kg/(m·s)
–50	223,15	14,7
0	273,15	17,2
20	293,15	18,2
40	313,15	19,1
60	333,15	20
80	353,15	21
100	373,15	21,8
120	393,15	22,7
140	413,15	23,5
160	433,15	24,3
180	453,15	25,1
200	473,15	25,8
250	52315	27,8
300	573,15	29,5
350	623,15	31,2
400	673,15	32,8
450	72315	34,4
500	773,15	35,8
600	873,15	38,6
700	973,15	41,2
800	1073,15	43,7
900	1173,15	45,9
1000	1273,15	48
NOTE Interpolation between values is allowed.		

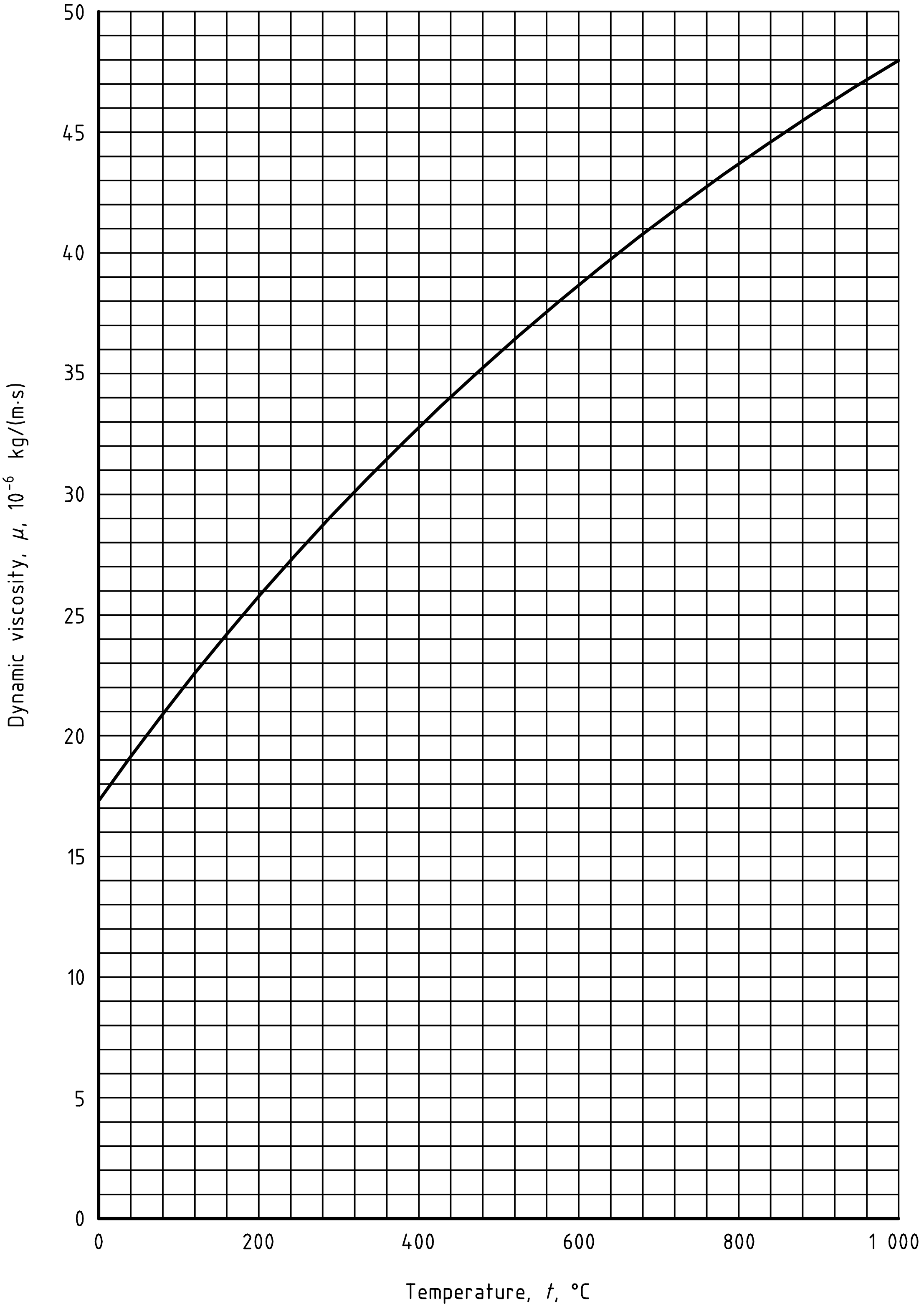

Figure 1 — Dynamic viscosity of dry air versus temperature

Dynamic viscosity of dry air versus temperature is calculated using the following polynomial formula:

$$\mu = \sum_{i=0}^{3} (a_i \times t^i \times 10^{-3i}) \text{ kg/(m·s)} \tag{5}$$

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 ⩽ +1 000 °C.

5.3.3 Different measuring device

It is possible that a different measuring device will be required to measure the velocity of 0,15 m/s than that required to measure the leakage of the damper.

It should be noted that:

— the leakage criteria S is 200 $m^3/(h·m^2)$;

— the integrity criteria E is 360 $m^3/(h·m^2)$;

— a velocity of 0,15 m/s causes a gas flow of 540 $m^3/(h·m^2)$;

— the maximum leakage of connecting duct is 12 m^3/h.

For convenience, a branched measuring duct with suitable shut-off valves could be used, one branch containing the measuring device for measuring the leakage of the damper and the other one containing the smaller measuring device for measuring the velocity of 0,15 m/s and determining the rig leakage.

5.3.4 Classifying dampers for the S classification

When classifying dampers for the S classification, the smallest damper in the product range has also to be tested. When classifying small sized dampers (e.g. a product range from 100 mm up to 200 mm) the actual leakage may fall outside the volume flow range covered by ISO 5167-1 and ISO 5221. In such circumstances the measuring equipment shall be calibrated to the range to be used. For low flow rates and temperatures near to the ambient temperature, it is recommended to use a liquid gas meter with a suitable resolution. The meter shall be operated over a minimum time period of 3 min to establish flow per unit time.

5.3.5 Dampers installed in a floor

When testing dampers installed in a floor, it is not necessary to have the measuring duct vertical as space in the laboratory may be strictly limited. In this respect to ensure uniform procedure amongst laboratories, it is important to locate the measuring station at a distance equal to the diameter of the measuring station down from the top of the connecting duct as shown in Figure 2 of ISO 10294-1:1996.

5.4 Exhaust fan system

Whilst the dilution damper will to some extent cool the air prior to it reaching the fan, it is recommended, particularly when testing uninsulated dampers, to use a high-temperature fan which is capable of operating up to 300 °C.

Only a minimal specification of the exhaust fan system has been included to allow the laboratories maximum flexibility in the design of the system.

It is possible that a different fan may be required when testing dampers for special industrial applications requiring the higher underpressure.

See also 5.3 of ISO 10294-1:1996.

5.5 Gas temperature adjacent to flow measuring device

It was considered important to specify the thermocouple used for this measurement to avoid a large diameter thermocouple being used which could create local turbulence (see 5.4 of ISO 10294-1:1996).

6 Test construction

6.1 General

See clause 6 of ISO 10294-1:1996.

6.1.1 Side to be tested

Where dampers are asymmetrical, they shall be tested from both sides, as it is probably not possible to determine which side will give the worse result. Symmetrical dampers will only have to be tested from one side. For purposes of determining whether a damper is symmetrical, the presence of the actuating mechanism can be ignored. However, in such a case the damper shall be installed so that the actuating mechanism is on the side away from the furnace, as this is considered to be the more onerous condition because, as it will be further from the furnace, the time to its operation will be consequently longer. See 6.1.1 of ISO 10294-1:1996.

6.1.2 Dampers installed in both walls and floors

Where the damper can be installed in both a wall and a floor, then a test should be carried out in both orientations unless it can be proved that one is more onerous. See 6.1.2 of ISO 10294-1:1996.

6.1.3 Dampers installed within a structural opening

No commentary; see 6.1.3 of ISO 10294-1:1996.

6.1.4 Dampers mounted onto a face of wall or floor

When insulated dampers are faced fixed to a wall, then two tests are required; one with the damper inside the furnace and one outside. In the case of an uninsulated damper fixed in this manner, only a damper on the inside of the furnace needs to be tested, as this is considered to be the most onerous condition. See 6.1.4 of ISO 10294-1:1996.

6.1.5 Dampers remote from wall or floor

See 6.1.5 of ISO 10294-1:1996.

6.1.5.1 Within the furnace

No commentary; see 6.1.5.1 of ISO 10294-1:1996.

6.1.5.2 Outside the furnace

In the case of an uninsulated damper, mounted on a section of a duct outside the furnace, this does not need to be tested. See also 6.1.5.2 of ISO 10294-1:1996.

6.1.6 Minimum separation between dampers

A minimum distance has been specified to reduce the possibility of one damper effecting the performance of another (see 6.1.6 and Figure 9 of ISO 10294-1:1996). The same limitation has been applied between the damper body and the furnace walls to reduce the possibility that the flames from the furnace burners do not directly impinge on the damper.

6.2 Size of specimen

See 6.2 of ISO 10294-1:1996.

The largest size damper should be fire tested and provided the damper satisfies the appropriate fire leakage criteria the results can be extended to smaller sizes of dampers whose dimensions relative to width, height and length are smaller then that tested, subject to the following verification:

> that all components, in particular the damper blade(s), are the same thickness and cross-sectional shape with respect to curtain and multi-blade dampers and blade width.

6.3 Thermal release mechanism

See 6.3 of ISO 10294-1:1996.

Generally the thermal release mechanism is not complex and if an alternative mechanism is to be evaluated it is not necessary to test beyond the point at which the damper closes as the mechanism is unlikely to effect the performance of the damper in relation to the specified criteria.

For the purposes of this part of ISO 10294, the normal release static temperature is (72 ± 4) °C.

6.4 Specimen installation

No commentary; see 6.4 of ISO 10294-1:1996.

6.5 Supporting construction

See 6.5 of ISO 10294-1:1996.

In order to reduce the number of tests to be carried out, a standard supporting construction is specified with regard to masonry constructions.

A low density material is specified as this has low thermal inertia and it is anticipated that a higher unexposed face temperature will be recorded on the damper/duct. In addition, low density material generally has lower mechanical strength and therefore can be regarded as the worse case. An additional advantage is that it will ensure a degree of uniformity amongst laboratories.

6.6 Conditioning

See 6.6 of ISO 10294-1:1996.

High levels of moisture in the damper, the supporting construction and infill material will tend to create lower temperatures on the unexposed faces. This can often be recognized by an extended temperature plateau at 100 °C. It is also important to allow sufficient time for a masonry supporting construction to reach adequate strength.

6.7 Number of tests required

See 6.1.1 to 6.1.5 of ISO 10294-1:1996.

The test method has been designed to cover as many potential applications for damper installation as possible. It is not intended that all the options have to be covered in a test programme.

Guidance is given below on the number of tests that may be required. Experience may show that not all tests will need to be undertaken, as some installation options may be found to represent the most onerous condition, in which case the number of tests required can be reduced.

Table 2 — Fire damper standard installation application

Fire damper installation application in practice Standard application	Number of tests Asymmetrical fire damper	Number of tests Symmetrical fire damper
Installed within a wall	2	1
Installed within a floor	2	1

Table 3 — Fire damper special installation application

Fire damper installation application in practice Special application	Number of tests Asymmetrical fire damper	Number of tests Symmetrical fire damper
Installed on face of wall	2	1
Installed on face of floor	2	1
Damper mounted on section of duct in the fire compartment (wall and floor application)	1 for wall application 1 for floor application	1 for wall application 1 for floor application
Insulated damper mounted on section of duct outside the fire compartment (wall only)	1	1

7 Determination of leakage of connecting duct and measuring station

See clause 7 of ISO 10294-1:1996.

The limit of 12 m^3/h appropriate to the fire test was selected as this represented the lowest leakage that could be accurately measured in accordance with ISO 5167-1 and ISO 5221. Consideration was given to measuring an actual leakage and then deduct this value from the leakages recorded during the test. However it was considered that this approach would create problems as the leakage of the test rig might increase during the test. The approach adopted is to make the seals as tight as possible so that any increase in rig leakage during the test will be minimal. It is essential that considerable care be taken to ensure good tight seals at all joints and that a suitable high-temperature joint sealant is used.

8 Determination of leakage at ambient temperature

See clause 8 of ISO 10294-1:1996.

Leakage of the damper at ambient temperature is measured only for dampers intended to be classified to the S designation. Both the largest and the smallest sizes of dampers in a product shall be evaluated.

9 Fire test

See clause 9 of ISO 10294-1:1996.

The air velocity of 0,15 m/s was selected because experimental work indicated that at the moment a damper closes a very high underpressure can exist across the damper. This low air velocity was selected as it has been demonstrated during tests that at the point of closure the underpressure would not be substantially in excess of the required underpressure of 300 Pa.

The 0,15 m/s fire test velocity is therefore a compromise between the need for a dynamic air flow test and fire safety within the fire test laboratory. For these safety reasons, closure testing at higher velocities/pressures, if considered necessary, should be carried out at ambient air flow conditions and not when the furnace is ignited at high temperatures.

Any failure of the damper to close within the allowable time of 2 min shall be regarded as a failure. If the damper is closed manually and the test continued to determine leakage rates, such data can only be regarded as for information only as an essential requirement for a damper has not been met.

The leakage will be determined from the recorded local temperature and the recorded pressure differential from the orifice plate, venturi, etc. using formula for volume flow rates given in ISO 5167-1 and ISO 5221, and additionally the calculations in 5.3.2 of this part of ISO 10294.

Convert the volume flow rates to 20 °C ambient (laboratory) temperature using the following formula:

$$q_V = q_{V,\mathrm{m}}(20+273) / (T+273) \quad (6)$$

where

q_V is the volume flow rate under ambient (laboratory) conditions;

$q_{V,\mathrm{m}}$ is the volume flow rate under measuring conditions;

T is the local temperature at the measuring station, in degrees Celsius.

Plot q_V as function of time.

10 Test report

No commentary; see clause 11 of ISO 10294-1:1996.

11 Commentary on criteria and classification in ISO 10294-2

Tests in accordance with the test method described in ISO 10294-1:1996 were undertaken on a range of European and North American fire dampers, all of which satisfied conventional measurements for integrity. It was established that the existing products were capable of satisfying a leakage limit of 360 $m^3/(h \cdot m^2)$, and this limit was adopted for evaluation of compliance of integrity using gas flow measurements (E designation).

In relation to smoke leakage, available analytical data was examined, taking into account such parameters as acceptable concentrations of smoke, required degree of dilution, time for escape, which led to an acceptable smoke leakage of 200 $m^3/(h \cdot m^2)$ being derived. This is the limit used for checking compliance with the S designation.

Bibliography

ISO 5221, *Air distribution and air diffusion — Rules to methods of measuring air flow rate in an air handling duct.*

ISO 6944, *Fire resistance tests — Ventilation ducts.*

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