Ventilation for buildings — Terminals — Performance testing of louvres subject to simulated sand

The European Standard EN 13181:2001 has the status of a British Standard

ICS 91.140.30

National foreword

This British Standard is the official English language version of EN 13181:2001.

The UK participation in its preparation was entrusted to Technical Committee RHE/2, Air distribution and air diffusion, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Ventilation des bâtiments - Bouches d'air - Performances des grilles soumises à une simulation de sable

Lüftung von Gebäuden - Endgeräte - Leistungsprüfung von Schutzblenden unter Einwirkung von simuliertem Sand

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 156 "Ventilation for buildings" the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2002, and conflicting national standards shall be withdrawn at the latest by February 2002.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Warning

Attention is drawn to the possible risks associated with static electricity charge build-up, when using vacuum cleaners with plastic dust containers during sand trap louvre testing, in order that appropriate precautions are taken to safeguard the health of those involved.

1 Scope

This European Standard specifies a method for measuring the sand rejection efficiency of sand trap louvres subject to simulated sand and with inlet air flow through the louvre under test. The Standard considers a 1000 mm × 1000 mm section of sand trap louvre, or the nearest possible blade increment, for evaluation purposes.

The purpose of the tests incorporated in this European Standard is as follows:

a) Sand Rejection Effectiveness

To establish the sand rejection effectiveness when subjected to various air flow rates through the assembly.

b) Entry loss coefficient/Pressure requirements

To establish the air pressure loss through the sand trap louvre at various air flow rates and by calculation Discharge Loss Coefficient.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

CR 12792, *Ventilation for buildings — Symbols and terminology*

EN 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. (ISO 5167-1: 1991)*

ISO 3966*, Measurement of fluid flow in closed conduits - Velocity area method using Pitot static tubes*

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

ISO 5801, *Industrial fans - Performance testing using standardized airways*

3 Terms and definitions

For the purposes of this European Standard the terms and definitions given in CR 12792, together with the following, apply:

3.1
sand trap louvre
device intended to allow the passage of supply or exhaust air while minimising the ingress of airborne sand

NOTE Sand trap louvres are air terminal devices for use in desert-like conditions or other conditions where airborne sand is present. They are usually positioned on the inlets to air distribution systems or parts of a building, to alleviate the load on the main filtration of air conditioning and similar systems.

3.2
sand trap louvre core area
product of the minimum height and minimum width of the front opening in the sand trap louvre assembly with the louvre blades removed (see Figure 5)

3.3
entry loss coefficient of a louvre
actual air flow rate divided by the theoretical air flow rate at a given pressure difference across the louvre

3.4
theoretical air flow
product of the louvre core area and the air velocity calculated using the pressure difference across the louvre as the velocity pressure, assuming $C_E = 1$ (see clause 4)

3.5
sand rejection effectiveness
quotient resulting from the total weight of sand rejected divided by the total weight of sand injected, at any velocity through the louvre

4 Symbols and subscripts

4.1 Symbols

Symbol	Quantity	Unit
A	Louvre core area	m^2
C_E	Entry Loss Coefficient	-
m_i	Sand supply to the injector	kg
m_u	Sand collected upstream of the test louvre	kg
p_{sa}	Absolute static pressure	Pa
p_a	Atmospheric pressure	Pa
p_d	Dynamic (Velocity) pressure $½\,\rho \cdot v^2$	Pa
p_{ta}	Stagnation or absolute total pressure	Pa
p_s	Static gauge pressure (p_{sa} - p_a)	Pa
p_t	Total pressure (p_{ta} - p_a)	Pa
Δp	Flow meter pressure difference	Pa
Δp_t	Conventional total pressure differential for an air density of 1,2 kg m^{-3} at the inlet to the sand trap louvre under test	Pa
q_v	Volume rate or air flow at the flow meter	$m^3 s^{-1}$
v	Core Velocity	m s^{-1}
ε	Effectiveness	%
ρ	Air density	kg m^{-3}
ϑ	Temperature	°C

4.2 Subscripts

Subscript	Description
l	outlet of the sand trap louvre under test
m	measuring point at the flow meter
n	value at selected point of flow rate/static pressure curve

5 Instrumentation

5.1 Air flow rate measurement

The air flow rate shall be measured using instruments and techniques in accordance with EN ISO 5167-1, ISO 5221, and ISO 5801.

Air flow meters shall have the ranges and accuracies specified in Table 1.

Table 1 — Ranges and accuracies of flow meters

Range $m^3 s^{-1}$	**Uncertainty of Measurement** %
from 0,07 to 7	± 2,5
from 0,007 to 0,07	± 5

NOTE Flow meters can be calibrated in situ by means of pitot static tube traverse techniques described in ISO 3966.

Flow meters shall be checked at intervals as appropriate but not exceeding 12 months. This check can take the form of one of the following:

a) a dimensional check for all flow meters not requiring calibration;

b) a check calibration over their full range using the original method employed for initial calibration of meters calibrated in situ;

c) a check against a flow meter which meets the flow meter specification described in ISO 5221.

5.2 Pressure measurement

5.2.1 Pressure in the duct shall be measured by means of a liquid-filled calibrated manometer, or any other device conforming to 5.2.2.

5.2.2 The maximum scale interval shall not be greater than the characteristics given in Table 2 for the appropriate range of manometers.

Table 2 — Range and scale interval for manometers

Range	**Max. scale interval**
Pa	Pa
≤ 25	1,0
> 25 to ≤ 250	2,5
> 250 to ≤ 500	5,0
> 500	25,0

5.2.3 For air flow measurements, the minimum pressure differential shall be:

a) 25 Pa with an inclined tube manometer or micro-manometer;

b) 500 Pa with a vertical tube manometer.

5.2.4 Calibration standards shall be as follows:

a) for instruments with the range ≤ 25 Pa, a micro-manometer accurate to ± 0,5 Pa;

b) for instruments with the range > 25 to ≤ 500 Pa, a manometer accurate to ± 2,5 Pa (hook gauge or micro-manometer);

c) for instruments with the range > 500 Pa, a manometer accurate to ± 25 Pa (vertical manometer).

5.3 Temperature measurement

Measurement of temperature shall be by means of mercury-in-glass thermometers, resistance thermometers, or thermo-couples. Instruments shall be graduated to give readings in intervals not greater than 0,5 K and calibrated to an accuracy of 0,25 K.

5.4 Weighing equipment

The mass of sand shall be measured by means of a balance or similar device which shall have an accuracy of + 0,5 % of the indicated weight.

5.5 Timers

Timers for determining sand flow rates shall have a minimum accuracy of + 0,2 s.

6 Test apparatus

6.1 Aerodynamic sand trap louvre test facility

The test facility shall be constructed from a number of separate sections as illustrated in Figure 1. It shall be capable of producing an air flow rate through the sand louvre under test over the range of $0,5\ m^3\ s^{-1}$ to $3,5\ m^3\ s^{-1}$, simulating blown sand, and measuring pressure losses.

The elements are described in 6.2 and 6.3

6.2 Sand injector equipment

The sand injector equipment shall consist of a fan, injector tube, main funnel, feeder cone, distribution tube and spreader plate.

The equipment shall be constructed as shown in Figures 2 and 3.

The equipment shall be positioned such that its outlet is centrally located at the top of the approach duct and 1,5 m from the sand trap louvre under test.

The injector fan shall be capable of creating an air velocity of 20 $m.s^{-1}$ to 25 $m.s^{-1}$ in the distribution tube.

The main funnel shall be capable of holding at least 2 kg of sand and be positioned directly above the feeder cone.

The sand feeder cone shall be positioned vertically and penetrate the distribution tube by approximately 1 mm. The included angle of the cone should be between 30^o and 45^o.

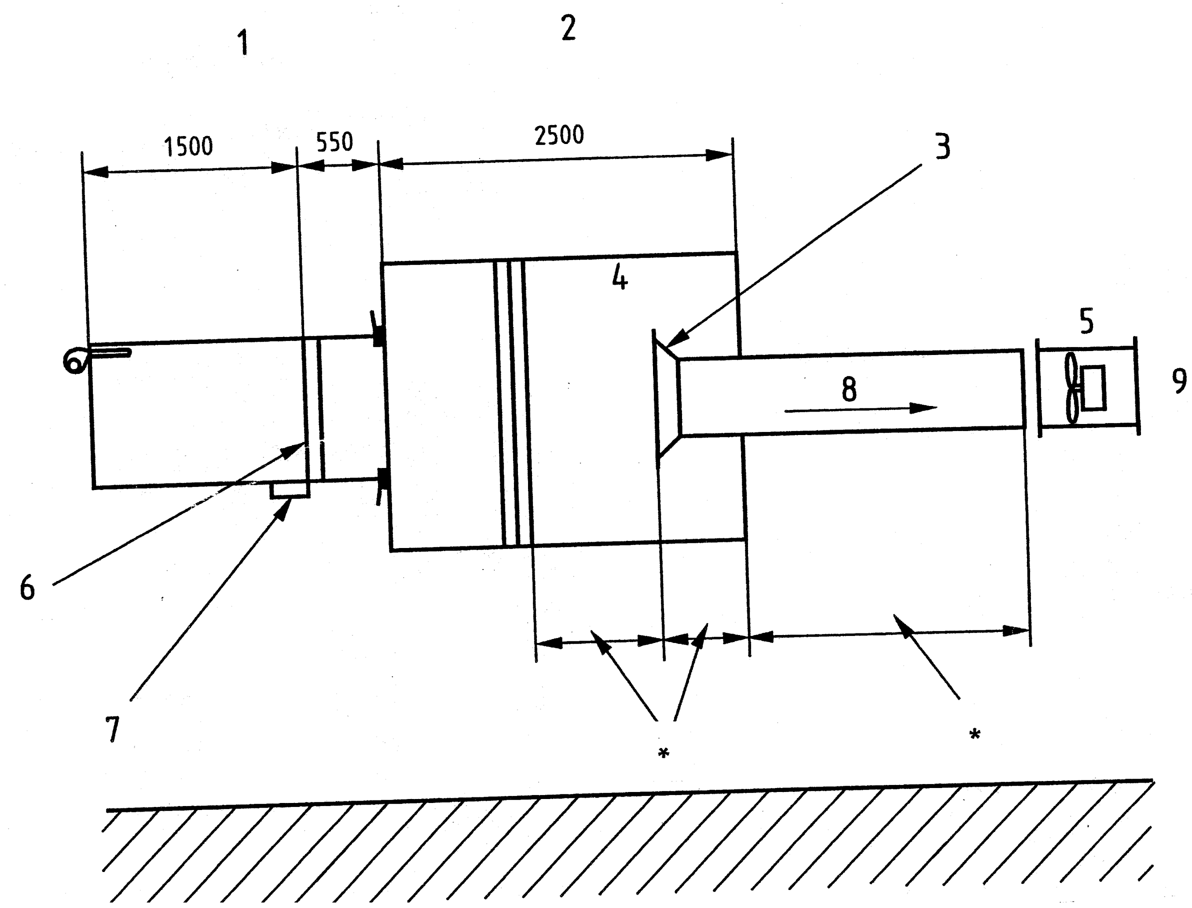
The sand feeder cones shall be calibrated for the required rate of feed.

6.3 Aerodynamic measurement section

A typical arrangement is illustrated in Figure 4.

The air flow rate shall be measured using an inlet cone or similar device positioned at the end of the discharge section. To achieve a uniform flow approaching the measurement device resistance screens should be fitted.

Dimensions in millimetres



Key

1 Sand injection section
2 Aerodynamic measurement section
3 Inlet cone or alternative air flow measuring station
4 Resistance screens
5 Mechanical Ventilation screen
6 Sand trap louvre under test
7 Sand collection trough
8 Ventilation air
9 Ventilation fan

* Dimensions determined from ISO 5221

Figure 1 — Sand trap louvre aerodynamic test facility

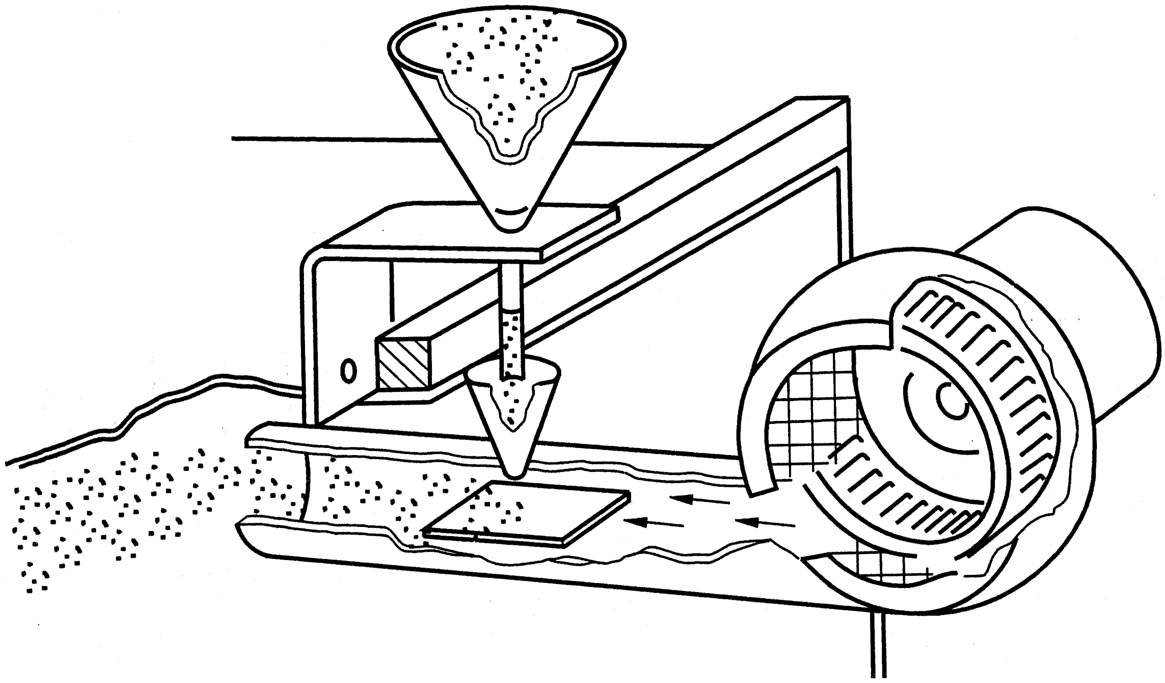
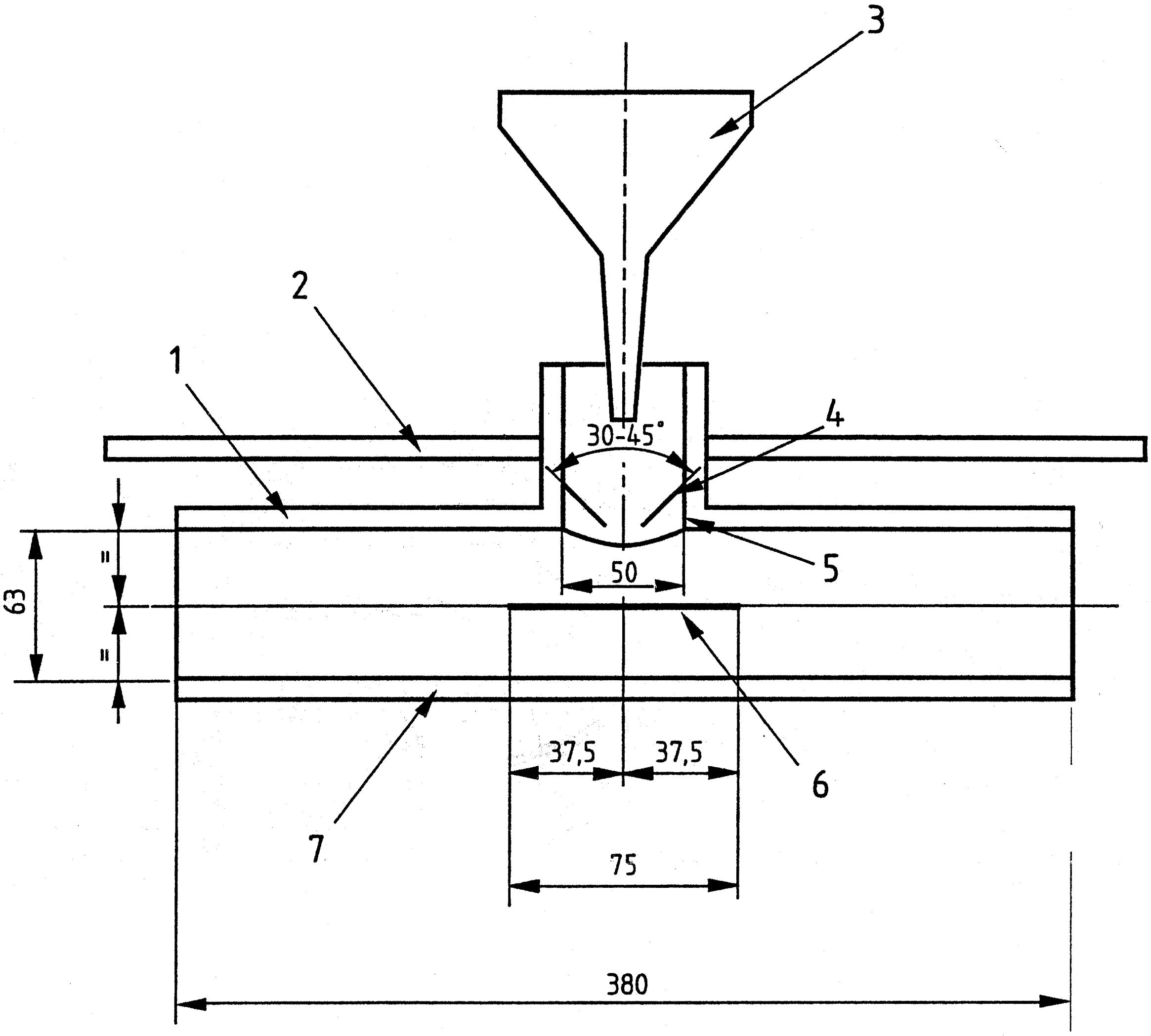


Figure 2 — Typical sand injector equipment

Dimensions in millimetres

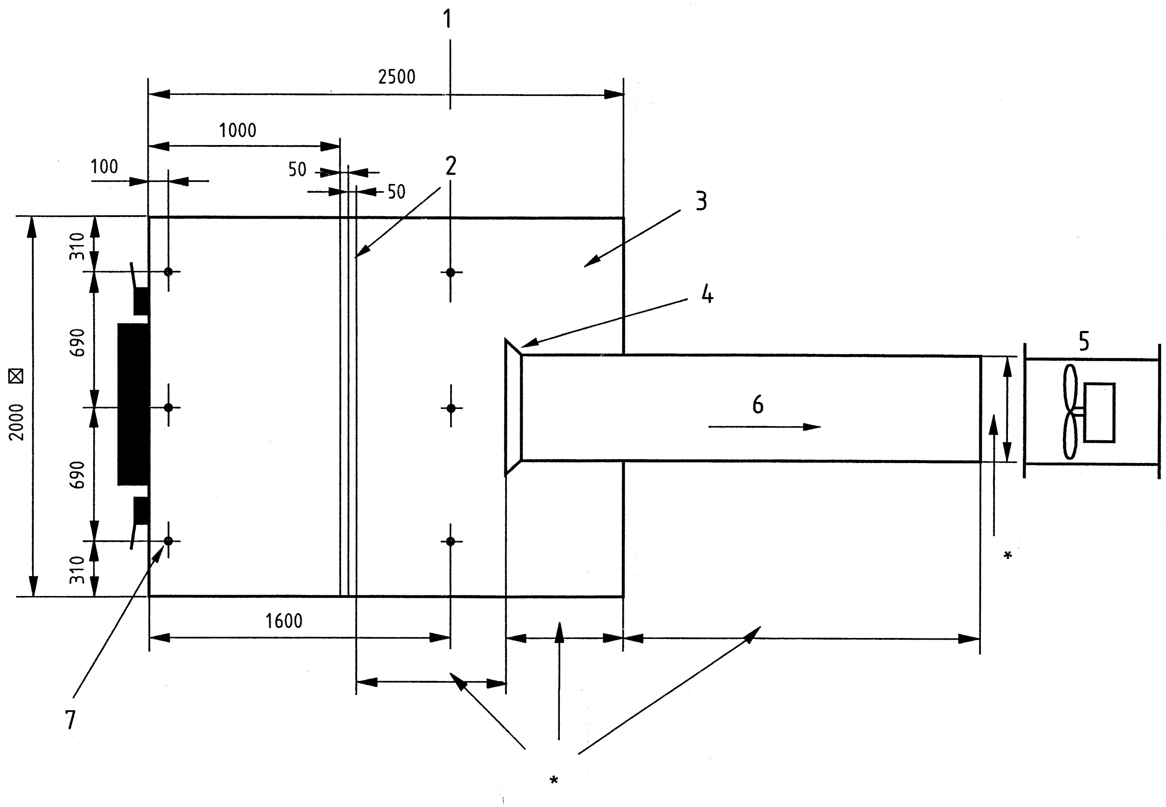


Key

1 Connection to injector fan
2 Duct wall
3 Main funnel
4 Sand feeder cone
5 Cone holding tube
6 Spreader plate
7 Distribution tube

Figure 3 — Sand injector feeder cone and distribution tube

Dimensions in millimetres



Key

1 Plane A
2 Resistance screens
3 Plenum chamber
4 Inlet cone or alternative air flow measuring station
5 Ventilation fan
6 Ventilation air
7 Pressure measuring points

*Dimensions determined from ISO 5221

Figure 4 — Aerodynamic measurement section

The required uniformity is considered to be achieved if the maximum air velocity in plane A nowhere exceeds 1,25 times the average velocity in plane A, or 2,5 m s^{-1}, whichever is greater.

Three uniform wire mesh or perforated plate screens adequately supported and sealed to the chamber spaced 0,10 m apart and with 60 %, 50 % and 45 % free area successively in the direction of flow can be expected to secure the required flow uniformity.

Other air flow rate meters complying with 5.1 may be used.

The pressure loss across the sand louvre shall be measured using static pressure measurement points positioned 100 mm behind the sand louvre on the sides of the aerodynamic test section. There shall be no obstructions within 2 m of the face of the louvre.

7 Grading of the test sand

The sand used throughout this test procedure shall be dry and conform to a mixture of the 9 size gradings specified in Table 3.

Table 3 — Requirements for Standard test sand

Grade size μm	**Mass** %
> 699	0,5
423 to 699	3,0
353 to 422	12,0
251 to 352	30,0
211 to 250	20,0
152 to 210	27,0
104 to 151	6,0
76 to 103	1,0
< 76	0,5

The specification shown in Table 3 matches very closely desert type sand and dust, and illustrates an overall grade.

Other grades of sand can also be used for the tests and are specified as follows:

a) FINE - sand between 106 and 150 μm.

b) COARSE - sand between 355 and 425 μm.

8 Pre-test of sand distribution for each test series

Nine squares of cardboard approximately 25 mm × 25 mm shall be covered with double-sided adhesive tape. Each square shall be individually identified and weighed before being fixed to the sand trap louvre in three rows of three as shown if Figure 5.

Two strips of cardboard approximately 25 mm high across the full width of the test duct shall also be covered with double-sided adhesive tape. These strips shall be fixed in an upright position at 250 mm and 350 mm from the face of the sand trap louvre as shown in Figure 6.

The specified amount of test sand shall be fed into the sand injector equipment with the primary fan off and the sand injector fan operating.

A check shall be made of the uniform distribution of sand adhering to the nine squares on the sand trap louvre. The squares shall be removed and individually weighed. The ratio of weight difference between the sand in any two squares shall not exceed 4 to 1.

A check shall be made of the strips attached to the floor of the test duct to verify that sand has adhered only to the downstream side of the strips.

Should the checks not be satisfactory, the distribution tube shall be directionally adjusted and the above tests repeated until a satisfactory distribution is achieved.

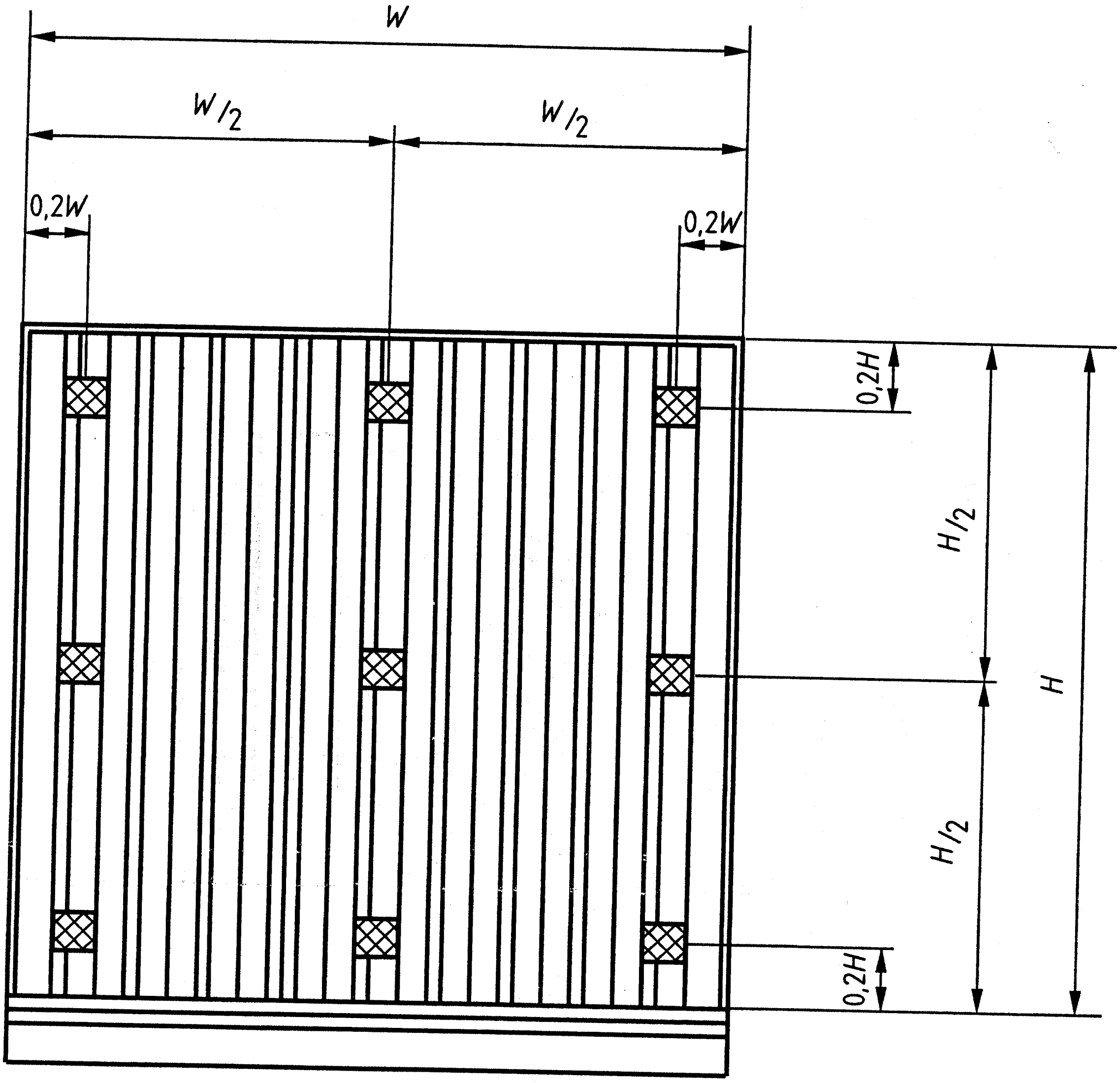


Figure 5 — Pre-test of sand distribution - Arrangement of squares

Dimensions in millimetres

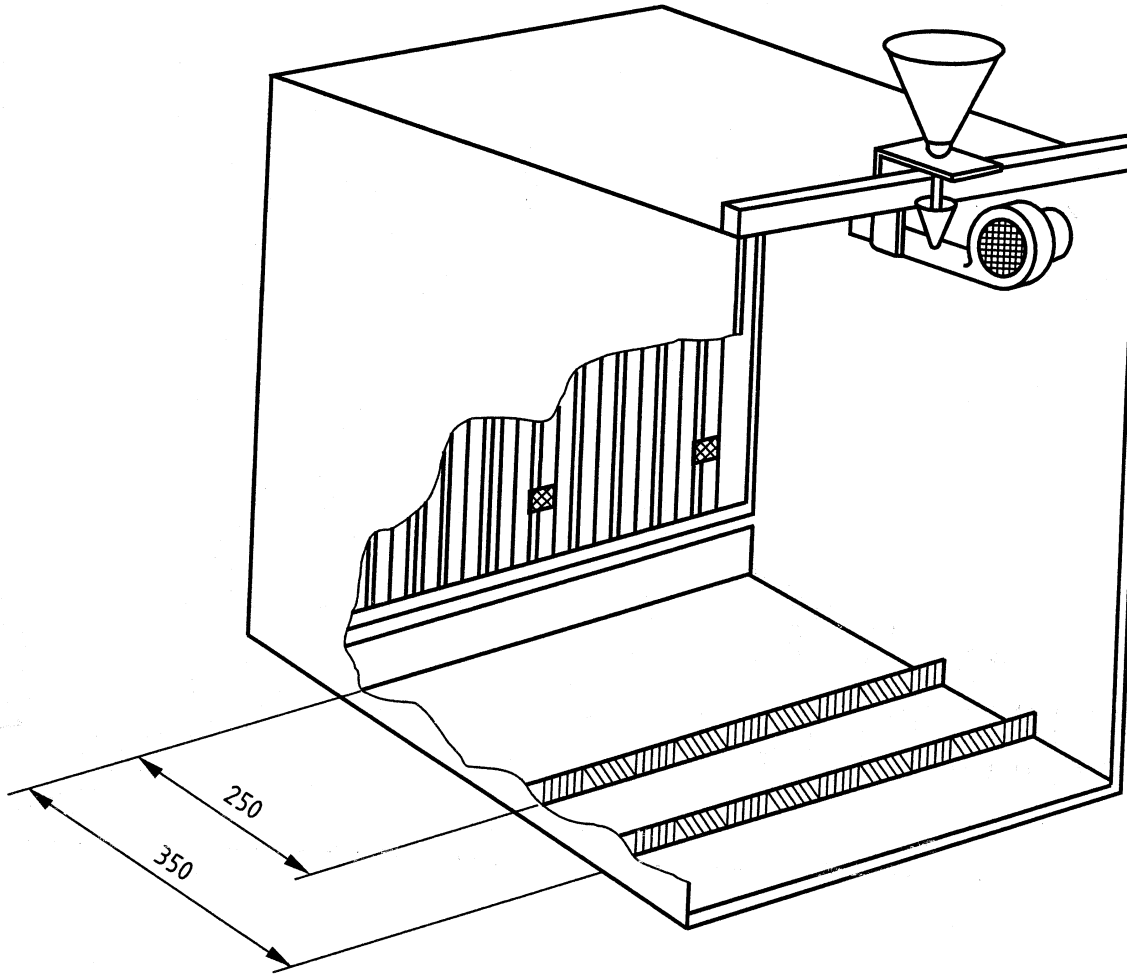


Figure 6 — Pre-test of sand distribution - Arrangement of strips

9 Test methods

9.1 Sand rejection

The sand distribution pre-test shall be satisfied in accordance with clause 8.

The test programme shall be carried out with dry sand as defined in Table 3.

Tests shall be carried out at the air velocities, weights of sand and sand discharge durations specified in Table 4.

Table 4 — Core Air velocities, weights of sand and sand discharge durations

Quantity	Tolerance	Unit	Values				
Core air velocity	± 5%	ms^{-1}	0,5	1,3	2	2,8	3,5
Weight of sand	± 5%	kg	1	1	2	2	2
Discharge duration	± 25%	s	200	75	100	70	60

With both the primary air fan and the sand injector fan operating the quantity by weight of sand relative to the air velocity as described in Table 4, shall be injected into the test duct by means of the main funnel and injector assembly.

After the measured weight of sand [m_i] has been totally injected into the test duct, the fans shall continue to run for a further five minutes.

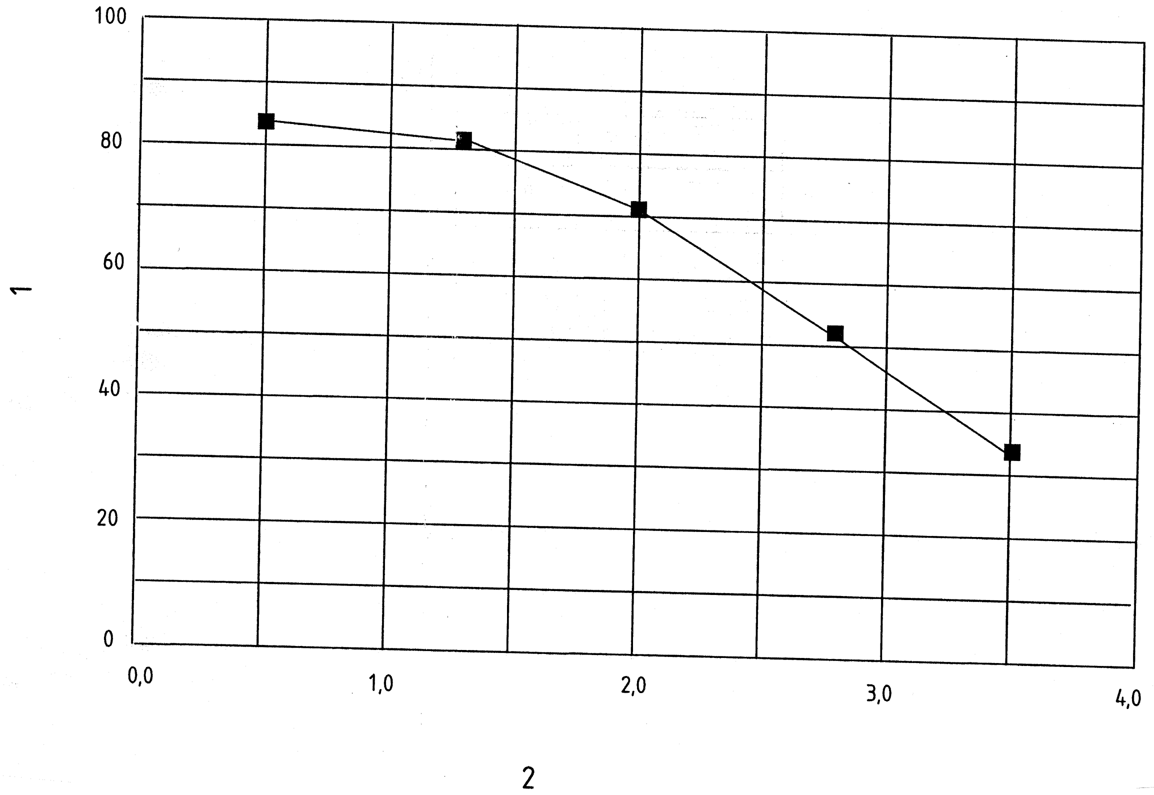
The sand which has not passed through the sand trap louvre, i.e. that lodged within the louvre plates, and that remaining in the test duct before the sand trap louvre shall be collected by means of a bag type suction (vacuum) cleaner. Test sand, once used, shall not subsequently be re-used for test purposes.

The cleaner bag shall be weighed before and after the test and a new bag shall be used for each test run.

The difference in the bag weight shall be recorded as the weight of rejected sand [m_u].

The test method shall be repeated for each air velocity listed in Table 4.

A test report shall be produced by preparing a graph of the effectiveness of the sand louvre at different velocities by plotting the velocity v calculated from $q_v \cdot A^{-1}$ against the effectiveness ε calculated from m_u / m_i at equal air flow rates as shown in Figure 7.



Key

1 Effectiveness ε in %
2 Core velocity v in m·s^{-1}

Figure 7 — Sand rejection effectiveness of louvre

9.2 Entry loss coefficient/pressure loss

The pressure loss and entry loss coefficient of the sand trap louvre shall be derived by measuring five different air flow rates q_v at the air flow rate meter. The lowest flow rate in the range shall be such that it produces a pressure difference greater than 10 Pa, and the highest shall be 3,5 $m^3 s^{-1}$.

If significant differences in the air temperature and static pressure between the flow meter and the sand trap louvre under test are apparent such that the air density ratio $\rho_m \cdot \rho_l^{-1}$ is less than 0,98 or greater than 1,02, then the following correction shall be applied:

$$q_{vl} = q_v \cdot \rho_m \cdot \rho_l^{-1} \qquad (1)$$

where

$$\rho_m = 3{,}47 \times 10^{-3} \ \{(p_{su} + p_a)\ (\vartheta_u + 273)^{-1}\}$$

and

$$\rho_l = 3{,}47 \times 10^{-3} \ \{(p_{sl} + p_a)\ (\vartheta + 273)^{-1}\}$$

Otherwise q_{vl} shall be taken as equal to q_v

Using measured values of p_{sl} and corresponding values of q_{vl} determined in accordance with formula (1), the following functions shall be plotted on linear graph paper:

p_{sl} vs $(q_{vl})^2$

By graphical or calculation methods the best straight line through the plotted points and passing through zero shall be determined (see Figure 8). If isolated points fall outside the 5 % differential pressure band about the best mean line, repeat the tests at the relevant flow rates to check validity of test data.

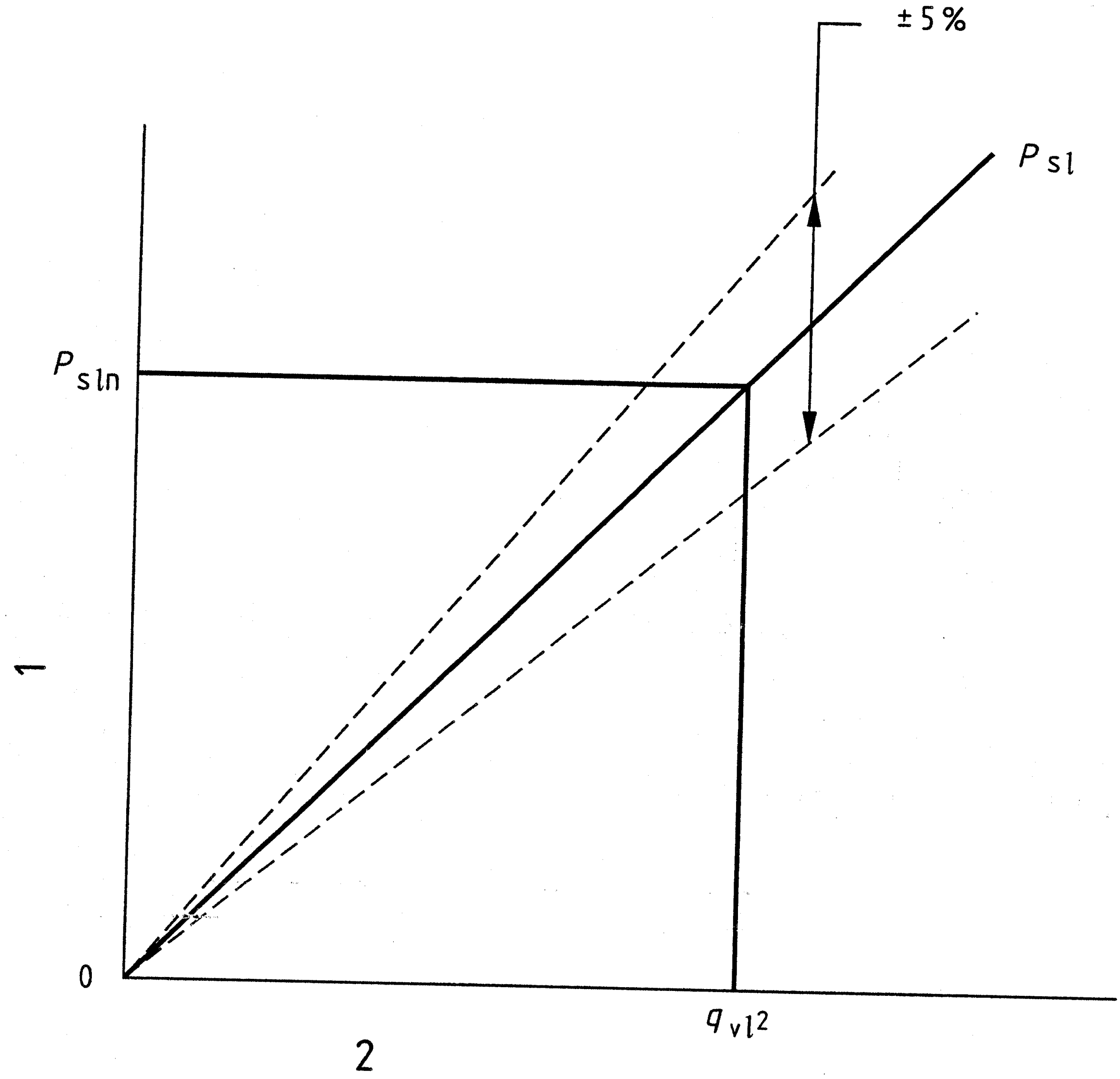
If groups of points fall outside the ± 5 % band indicating the test results do not follow a linear relationship between $(q_{vl})^2$ and p_{sl} instead draw the best line (curve) through the points and zero (see Figure 9). If the p_{sl} points fall within ± 5 % of the line (curve) then the curve can be used for calculation in formula (2). If outside ± 5 % of the curve then only individual test points for p_{sl} can be used in formula (2) and the situation made clear in reporting the test results.

The entry loss coefficient C_E shall be calculated for each ventilation air flow rate used in the test.

$$C_E = \frac{\text{Actual Flow}}{\text{Theoretical Flow}} \qquad (2)$$

$$= q_{vn} \cdot \{A\ (2 \cdot p_{sn} \cdot \rho_{ln}^{-1})^{½}\}^{-1}$$

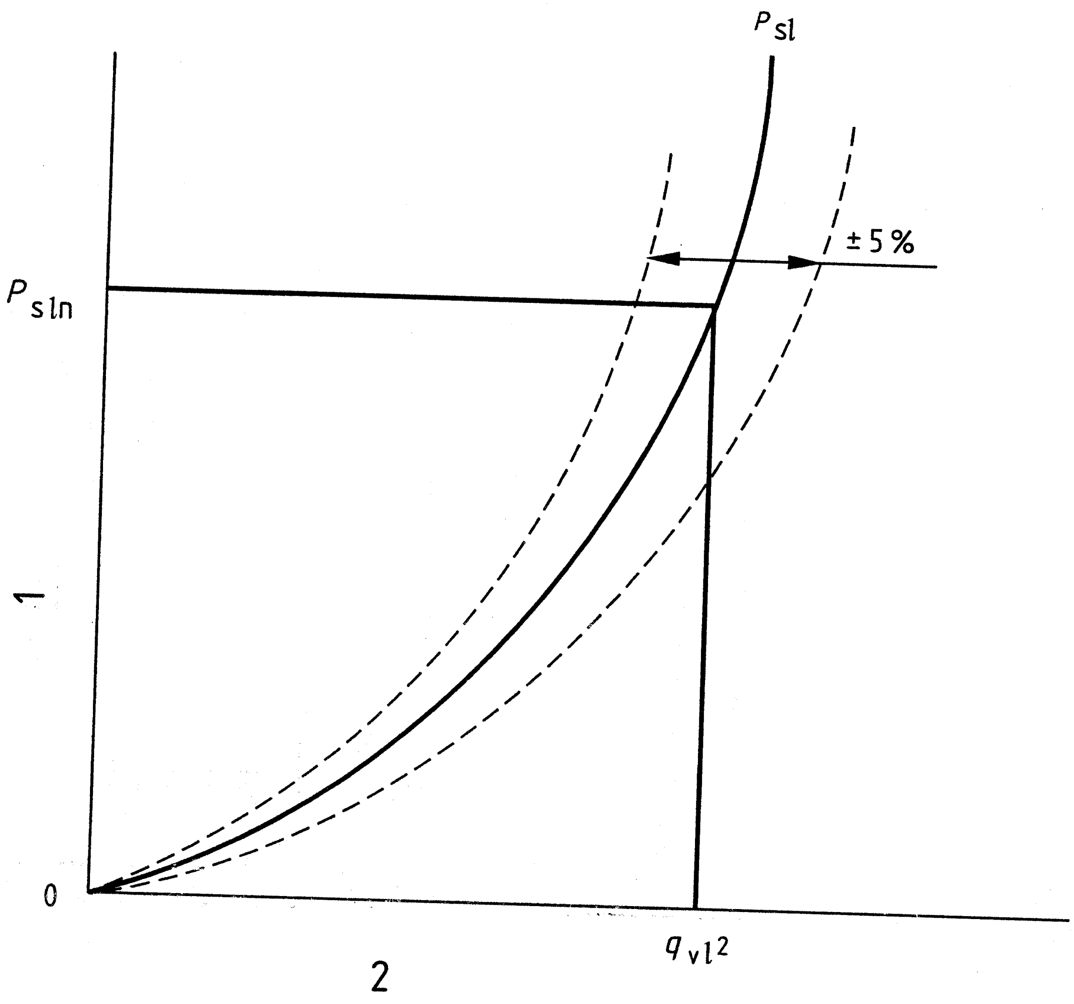
where ρ_{ln} = 1,2 or corrected density in accordance with formula (1), and Theoretical Flow is defined as the flow with a loss coefficient ζ = 1.



Key

1 Pressure
2 Air flow rate

Figure 8 — Air flow rate vs pressure loss - Straight line characteristic for p_{sl} vs q_{vl}^2



Key

1 Pressure
2 Air flow rate

Figure 9 — Air flow rate vs pressure loss - Best line characteristic (curve) for p_{sl} vs q_{vl}^2

Annex A
(informative)

Typical test results and calculation examples

A.1 Entry loss coefficient

The procedure using typical results given in Table A.1 with test area

$A = 1{,}000 m^2$ and $\rho = 1{,}2$ kg m^{-3} is as follows:

a) Determine the best straight line between q_{vl}^2 and $p_{sl.}$

b) At any actual air flow rate establish the corresponding pressure difference across the louvre p_s. (from graph - best fit line).

c) Using the formula (2).

$$C_E = \frac{\text{Actual flow}}{\text{Theoretical flow}}$$

$$= q_{vn}.\{(A\,(2.p_{sn}.\rho_{ln}^{-1})^{½}\}^{-1}$$

For example, at the maximum flow rate of 2,8 $m^3 \cdot s^{-1}$ and related pressure loss of 110 Pa from Table A.1,

$C_E = 2{,}8\ \{1{,}0\ (2 \times 110 \times 1{,}2^{-1})^{½}\}^{-1} = 2{,}8 \times 13{,}54^{-1} = 0{,}207$

By repeating this calculation for each of the flow rates in Table A.1, the mean value of 0,211 can be calculated and the variance from the mean C_E established

NOTE This variance should comply with the requirements of 9.2.

Table A.1 — Air flow test results and derived data

Pressure loss	**Air flow Rate**	**(Air flow Rate)^2**	**Value C_E 1)**	**Variance from mean C_E**
Pa	m^3s^{-1}	$(m^3s^{-1})^2$		%
13,5	1,0	1,00	0,211	0,0
55,0	2,0	4,00	0,209	-1,0
110,0	2,8	8,00	0,207	-2,0
128,0	3,2	10,25	0,219	3,0
180,0	3,6	13,00	0,208	-1,5
1) Mean $C_E = 0{,}211$				

A.2 Sand trap louvre effectiveness

A.2.1 Recording results

The test results should be recorded for each air volume and should present air velocity, total sand injection, and total sand rejected.

A.2.2 Rating

The sand trap louvre should be rated at each air flow by a rejection effectiveness defined as:

$$\frac{\text{Total weight of sand rejected}}{\text{Total weight of sand injected}} \times 100 = \varepsilon\ \%$$

Table A.2 — Sand rejection test results

Test No	Air flow rate	Total mass injected	Total mass rejected	Core velocity	Louvre effectiveness
	q_v	m_i	m_u	$q_v\,A^{-1}$	ε
	m^3s^{-1}	kg	kg	$m\ s^{-1}$	%
1	0,5	1	0,84	0,5	84
2	1,3	1	0,82	1,3	82
3	2,0	2	1,42	2,0	71
4	2,8	2	1,04	2,8	52
5	3,5	2	0,68	3,5	34

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