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LABORATORY TESTING AND RATING OF SAND TRAP LOUVRES WHEN SUBJECTED TO SIMULATE SAND

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LABORATORY TESTING AND RATING
OF SAND TRAP LOUVRES
WHEN SUBJECTED TO SIMULATE SAND

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1.0 SCOPE

This EUROVENT Document specifies a method for measuring the sand rejection efficiency of sand trap louvres subject to simulated sand and with air flow through the louvre under test. For the purpose of this test, a 1000 mm x 1000 mm section of sand trap louvre or the nearest possible blade increment, is to be tested

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

The tests incorporated in this EUROVENT Document are :

1.1 <u>Sand Rejection Effectiveness</u>

This establishes the sand rejection effectiveness when subjected to various air flow rates through the assembly.

1.2 <u>Discharge Loss Coefficient/Pressure Requirement</u>

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

2.0 SYMBOLS AND SUFFIXES

2.1 Symbols

Symbol	Quantity	Unit
A	louvre core area	m^2
C_D	Discharge Loss Coefficient	
C_E	Entry Loss Coefficient	
p	Absolute static pressure	Pa
p_a	Atmospheric pressure	Pa
p_d	Velocity pressure $^1/_2 \rho v^2$	Pa
p_r	Stagnation or absolute total pressure	Pa
p_s	Static gauge pressure $(p - p_a)$	Pa
p_t	Total pressure $(p_r - p_a)$	Pa
Δp	Flow meter pressure difference	Pa
Δp_t	Conventional total pressure differential for an air density of 1.2 k g m^{-3} at the inlet to the sand trap louvre under test	Pa
q_v	Volume rate or air flow at the flow meter	$m^3 s^{-1}$
M_i	sand supply to the injector	kg
M_u	sand collected upstream of the test louvre	kg
ρ	Air density	kg m^{-3}
θ	Temperature	^0C
E	Effectiveness	%
v	Velocity	m s^{-1}

2.2 Suffixes

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

3.0 DEFINITIONS

The definitions of terms used in this document are in accordance with ISO 3258 and as follows :

Sand Trap Louvre

Sand Louvres - are devices intended to allow the passage of intake or exhaust air while minimising the ingress of airborne sand.

Sand Trap Louvre Core Area

The product of the minimum height (H) and minimum width (W) of the front opening in the sand trap louvre assembly with the louvre blades removed (see figure3).

Discharge or Entry Loss Coefficient of a Louvre

The discharge or entry loss coefficient of a sand trap louvre is equal to the actual air flow rate divided by the theoretical air flow rate at a given pressure difference across the louvre. For louvres tested with air flow in the reverse direction then the coefficient of discharge becomes the coefficient of entry.

The Theoretical Air Flow

The theoretical air flow rate is the product of the louvre core area and the air velocity calculated using the pressure difference across the louvre as the velocity pressure, assuming C_D or C_E = 1.

Sand Rejection Effectiveness

The effectiveness of a sand trap louvre, at any velocity through the louvre, is the total weight of sand rejected (M_u) divided by the total weight of sand injected (M_i).

4.0 INSTRUMENTATION

4.1 Air Flow Rate Measurement

The air flow rate shall be measured using instruments in accordance with ISO 5221.

4.1.1 Air flow meters shall have the following ranges and accuracies:-

Table 4.1

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

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

4.1.2 Flow meters shall be checked at intervals as appropriate but not exceeding 12 months. This check may 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 or meters calibrated in situ;

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

4.2 Pressure Measurement

4.2.1 Pressure in the duct shall be measured by means of a liquid-filled calibrated manometer, or any other device complying with section 4.2.2.

4.2.2 The maximum scale interval shall not be greater than the characteristics listed for the accompanying range of manometers.

Table 4.2

Range Pa	Max. scale interval Pa
≤ 25	1,0
$> 25 \leq 250$	2,5
$> 250 \leq 500$	5,0
> 500	25,0

4.2.3 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.

4.2.4 Calibration standards shall be:

a) for instruments with the range $\leq$ 25 Pa, a micro-manometer accurate to $\pm$ 0,5 Pa;

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

c) for instruments with the range > 500 Pa and upwards, a manometer accurate to $\pm$ 25 Pa (vertical manometer).

4.3 Temperature Measurement

4.3.1 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 0,5K and calibrated to an accuracy of 0,25K.

4.4 Weighing Equipment

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

4.5 Timers

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

5.0 TEST APPARATUS

5.1 Aerodynamic Sand Trap Louvre Test Facility

5.1.1. 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 s^{-3} to 3,5 m s^{-3}, simulating blown sand, and measuring pressure losses.

The various elements are described as follows:-

5.2 Sand Injector Equipment

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

5.2.2 The sand injector equipment shall be constructed as shown in figures 2a and 2b.

5.2.3. It shall be positioned such that its outlet is centrally located at the top of the approach duct and 1,5 m from the device under test.

5.2.4. The injector fan shall be capable of creating a velocity of 20-25 m s^{-1} in the distribution tube.

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

5.2.6. The sand feeder cone shall be positioned vertically and penetrate the distribution tube by approximately 1 mm.

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

5.3 Aerodynamic Measurement Section

Typically illustrated in figure 7.

5.3.1 The air flow rate is measured by means of a conical inlet positioned at 600 mm from the discharge end of the section. To achieve a uniform flow approaching the conical inlet, resistance screens should be fitted.

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 apart and with 60%, 50% and 45% free area successively in the direction of flow may be expected to secure the required flow uniformity.

Other air flow rate meters complying with 4.1 may be used.

5.3.2 The pressure loss across the sand louvre shall be measured using static pressure measurement points positioned 100 mm behind the weather louvre on the sides of the aerodynamic test section (note, there shall be no obstructions within 2 m of the face of the louvre).

6.0 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 as shown in Table A.

TABLE A

GRADE SIZE MICRON	% BY WEIGHT
Greater than:	
699	0,5
422	3,0
353	12,0
251	30,0
211	20,0
152	27,0
104	6,0
76	1,0
Less than: 76	0,5

The table shown 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 microns.

B) COARSE, sand between 355 and 425 microns.

7.0 PRE-TEST OF SAND DISTRIBUTION FOR EACH TEST SERIES

7.1. Nine squares of cardboard approximately 25 x 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 figure 3.

7.2 Two strips of cardboard approximately 25 mm high across the full width of the test duct shall be covered with double sided adhesive tape. The strips shall be fixed in an upright position at 250 mm and 350 mm from the face of the device. As figure 4.

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

7.4 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.

7.5 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.

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

8.0 TEST METHODS

8.1 Sand Rejection Test

8.1.1 The sand distribution pre-test shall be satisfied.

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

8.1.3. Tests shall be carried out at the following air velocities, weights of sand and sand discharge duration.

TABLE B

Air flow Rate (± 5%) $m \cdot s^{-1}$	0.5	1,3	2	2,8	3,5
Weight of sand (± 0,5 %) kg	1	1	2	2	2
Discharge Duration (+ 25%) s	200	75	100	70	60

8.1.4. 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 B, shall be injected into the test duct by means of the main funnel and injector assembly.

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

8.1.6. The sand which has not passed through the sand trap louvre, ie, 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).

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

8.1.8. The difference in the bag weight shall be recorded as the weight of rejected sand.

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

8.1.10 Test Reporting

Prepare a graph of the effectiveness of the sand louvre at different velocities by plotting the velocity calculated from $q_V A^{-1}$ against the effectiveness E calculated from

E (vs) v see graph 1

at equal air flow rates.

8.2. Discharge And Entry Loss Coefficient/Pressure Loss

8.2.1 To derive the pressure loss and discharge or entry loss coefficient of the sand trap louvre five different air flow rates q_V shall be measured 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 $m^3 s^{-1}$.

8.2.2. If there are significant differences in the air temperature and static pressure between the flow meter and the sand trap louvre under test so that the air density ratio:

$\rho_m \cdot \rho_1^{-1}$ is less than 0,98 or greater than 1,02, then the following correction should be applied:-

$$q_{V1} = q_V \cdot \rho_m \cdot \rho_1^{-1}$$

where

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

and

$$\rho_1 = 3{,}47\ 10^{-3}\ \{(p_{s1} + p_a)(\theta_1 + 273)^{-1}\}$$

Otherwise q_{V1} may be taken as equal to q_V

8.2.3. Having measured values of p_{s1} and also determined corresponding values of q_{V1} in accordance with 8.2.2, the following functions shall be plotted on linear graph paper:

p_{s1} vs $(q_{V1})^2$

8.2.3.1 By graphical or calculation methods the best straight line through the plotted points and passing through zero should be determined (see figure 5). 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.

8.2.3.2 If groups of points fall outside the ± 5% band indicating the test results do not follow a linear relationship between q_{v1} and p_{s1} instead draw the best line (curve) through the points and zero (see figure 6). If the p_{s1} points fall within ± 5% of the line (curve) then the curve can be used for calculation in 8.2.4. If outside ± 5% of the curve then only individual test points for p_{s1} can be used in 8.2.4 and the situation made clear in reporting the test results.

8.2.4. The discharge loss coefficient C_D shall be calculated for each ventilation air flow rate used in the test. This may also apply to the entry loss coefficient C_E.

$$C_D = \frac{\text{Actual Flow}}{\text{Theoretical Flow*}}$$

$$= q_{vn} \cdot \{A \, (2 \cdot p_{sn} \cdot \rho_{1n}^{-1})^{1/2}\}^{-1}$$

where ρ_{1n} = 1,2 or corrected density in accordance with 8.2.2.

* Theoretical flow is defined as the flow with a loss coefficient $\xi = 1$

APPENDIX A1

TYPICAL TEST RESULTS

AND CALCULATION EXAMPLES

A 1.1 Coefficient of Discharge

Procedure using typical results given in Table 1
with test area A = 1,000 m^2 and ρ = 1,2 kg m^{-3}

1. Determine the best straight line between q_{v1}^2 and p_{s1}.

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

3. Using the formula detailed in 8.2.4;

$$C_D = \frac{\text{Actual flow}}{\text{Theoretical flow}} \; *$$

$$= q_{vn} \cdot \{(A\,(2 \cdot p_{sn} \cdot \rho_{1n}^{-1})^{1/2}\}^{-1}$$

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

$$C_D = 2{,}8\ \{1{,}0\ (2.110.1{,}2^{-1})^{1/2}\}^{-1} = 2{,}8\ 13{,}54^{-1}$$

$$= 0{,}207$$

By repeating this calculation for each of the flow rates in Table 1, the mean value of 0,211 can be calculated and the variance from the mean C_D established (this variance should comply with the requirements of 8.2.3.2).

Pressure loss Pa	Air flow Rate $m^3 s^{-1}$	(Air flow Rate) $(m^3 s^{-1})^2$	point C_D	variance from mean C_D %
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

Mean C_D = 0,211

TABLE 1 - AIR FLOW TEST RESULTS AND DERIVED DATA

A 1.2 Sand Trap Louvre Effectiveness

1 Recording Results

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

2 Rating

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

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

Test No	Air Flow Rate $m^3 s^{-1}$	Total Weight Injected kg	Total Weight Rejected kg	Core Velocity $m s^{-1}$	Louvre Effectiveness E
	q_v	M_i	M_u	$q_v A^{-1}$	%
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

TABLE 2 - SAND REJECTION TEST RESULTS

LIST OF THE MEMBER ASSOCIATIONS

BELGIUM FABRIMETAL 21 rue des Drapiers - B-1050 BRUXELLES Tel 32/2/5102518 - Fax 32/2/5102562	***ITALY*** ANIMA - CO.AER Via Battistotti Sassi, 11 - I-20133 MILANO Tel 39/2/73971 - Fax 39/2/7397316
GERMANY **FG ALT im VDMA** Postfach 710864 - D-6000 FRANKFURT/MAIN 71 Tel 49/69/66031227 - Fax 49/69/66031218	***NORWAY*** **NVEF** P.O.Box 850 Sentrum - N-0104 OSLO Tel 47/2/413445 - Fax 47/2/2202875
SPAIN AFEC Francisco Silvela, 69-1°C - E-28028 MADRID Tel 34/1/4027383 - Fax 34/1/4027638	***SWEDEN*** **KTG** P.O. Box 55 10 - S-11485 STOCKHOLM Tel 46/8/20800 - Fax 46/8/6603378
FRANCE **UNICLIMA (Syndicat du Matériel Frigorifique, Syndicat de l'Aéraulique)** Cedex 72 - F-92038 PARIS LA DEFENSE Tel 33/1/47176292 - Fax 33/1/47176427	***SWEDEN*** **SWEDVENT** Box 17537 - S-11891 STOCKHOLM Tel 46/8/6160400 - Fax 46/8/6681180
UNITED KINGDOM **FETA (HEVAC and BRA)** Sterling House - 6 Furlong Road - Bourne End GB-BUCKS SL 8 5DG Tel 44/1628/531186 - Fax 44/1628/810423	***FINLAND*** **FREA** PL 37 FIN-00801 HELSINKI Tel 358/9/759 11 66 - Fax 358/9/755 72 46
NETHERLANDS **VLA** Postbus 190 - NL-2700 AD ZOETERMEER Tel 31/79/531258 - Fax 31/79/531365	***FINLAND*** **AFMAHE** Etalaranta 10 - FIN-00130 HELSINKI Tel 358/9/19231 - Fax 358/9/624462
NETHERLANDS **NKI** Postbus 190 - NL-2700 AD ZOETERMEER Tel 31/79/3531258 - Fax 31/79/3531365	***TURKEY*** **ISKID** ARCELIK S.A. Klima Isletmesi - 81719 TUZLA ISTANBUL Tel 90/216 3954515 - Fax 90/216 4232359

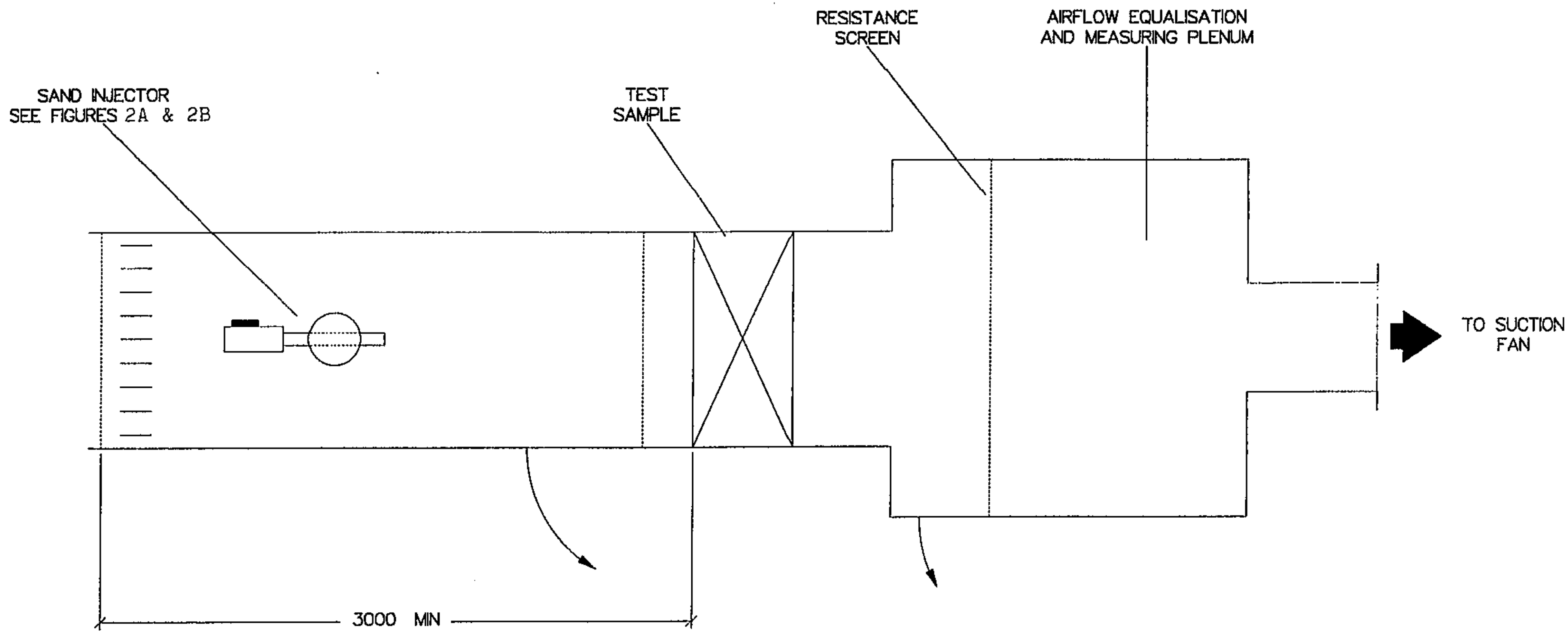


FIGURE 1A. AERODYNAMIC SAND TRAP LOUVRE TEST FACILITY
PLAN ELEVATION

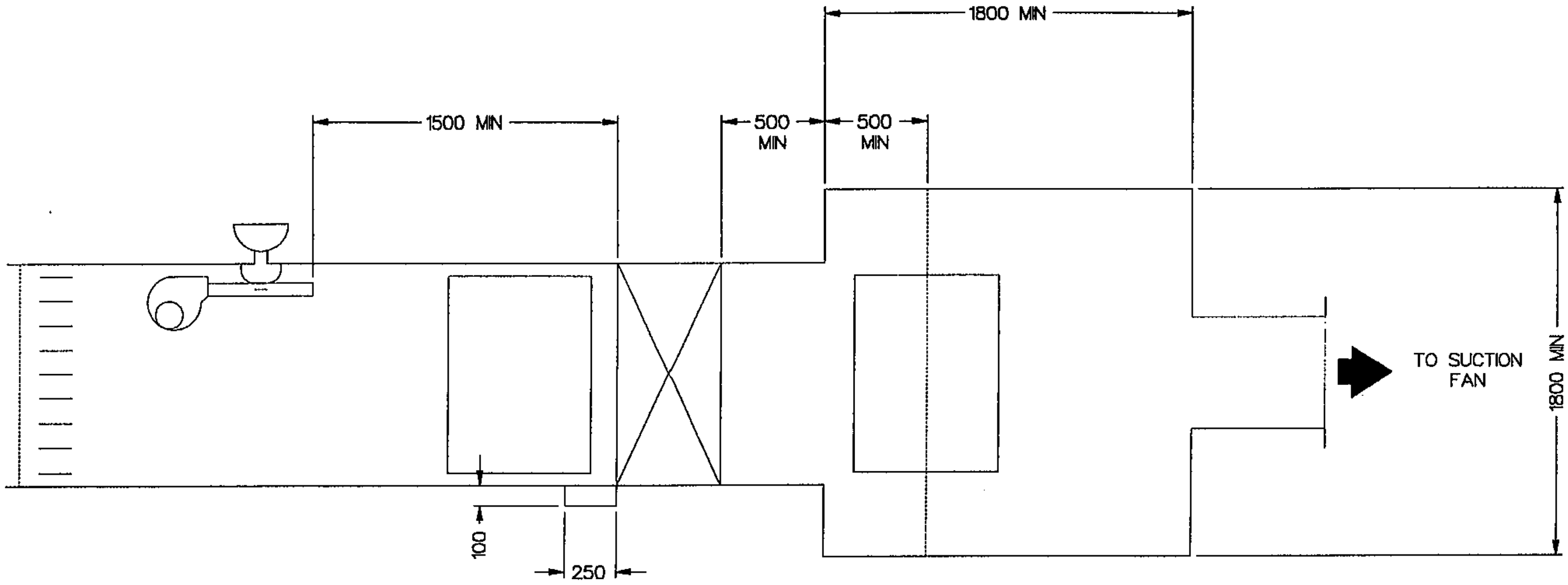


FIGURE 1B. AERODYNAMIC SAND TRAP LOUVRE TEST FACILITY SIDE ELEVATION

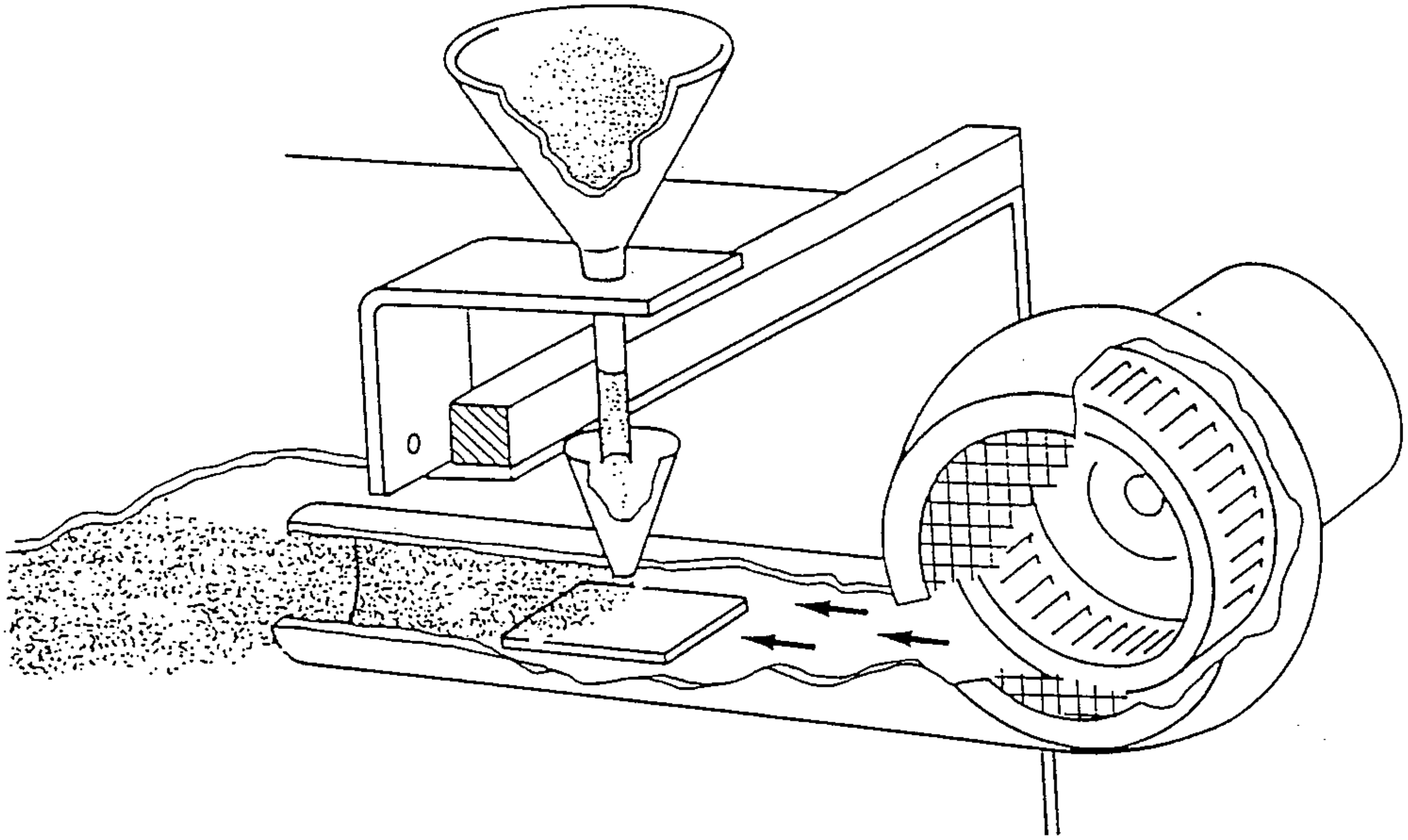
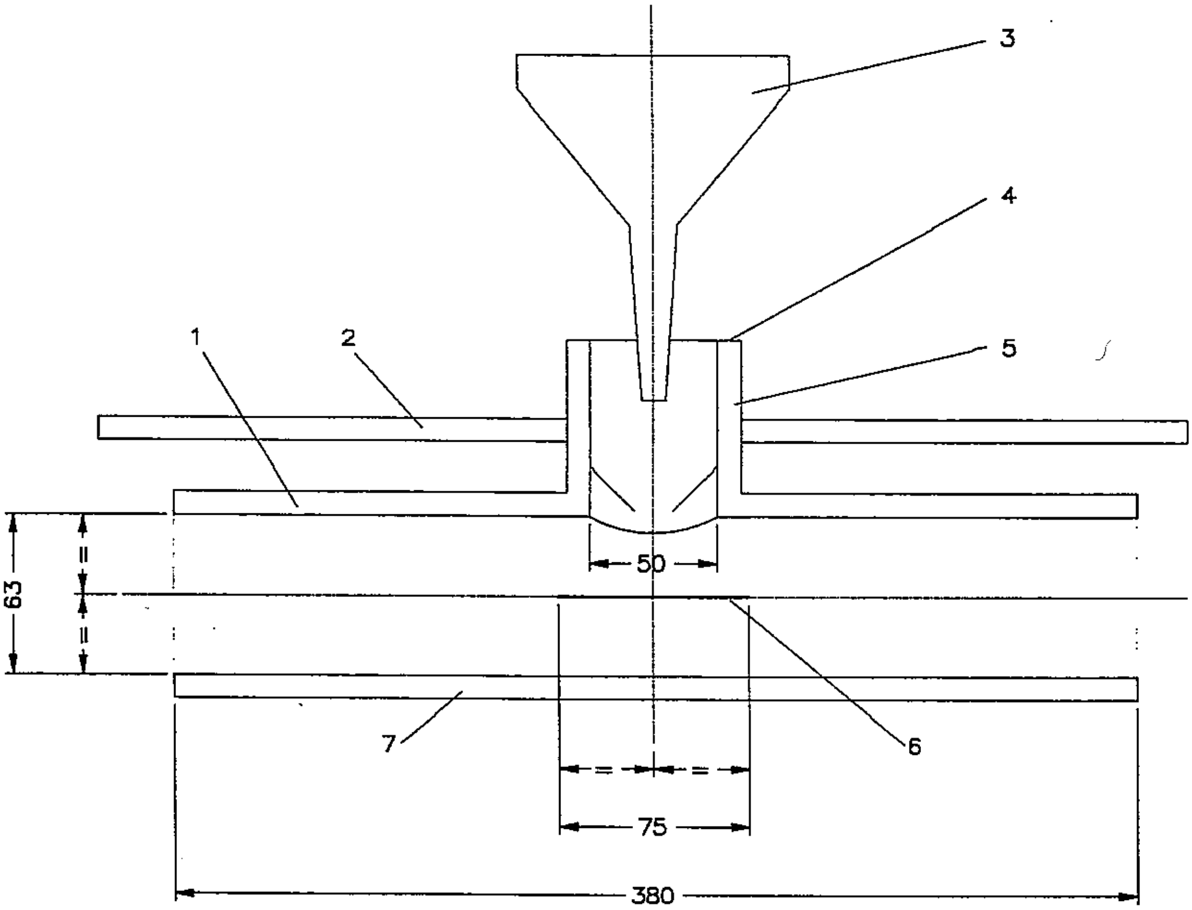


Fig. 2A Typical sand injector equipment



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 2B. SAND INJECTOR FAN

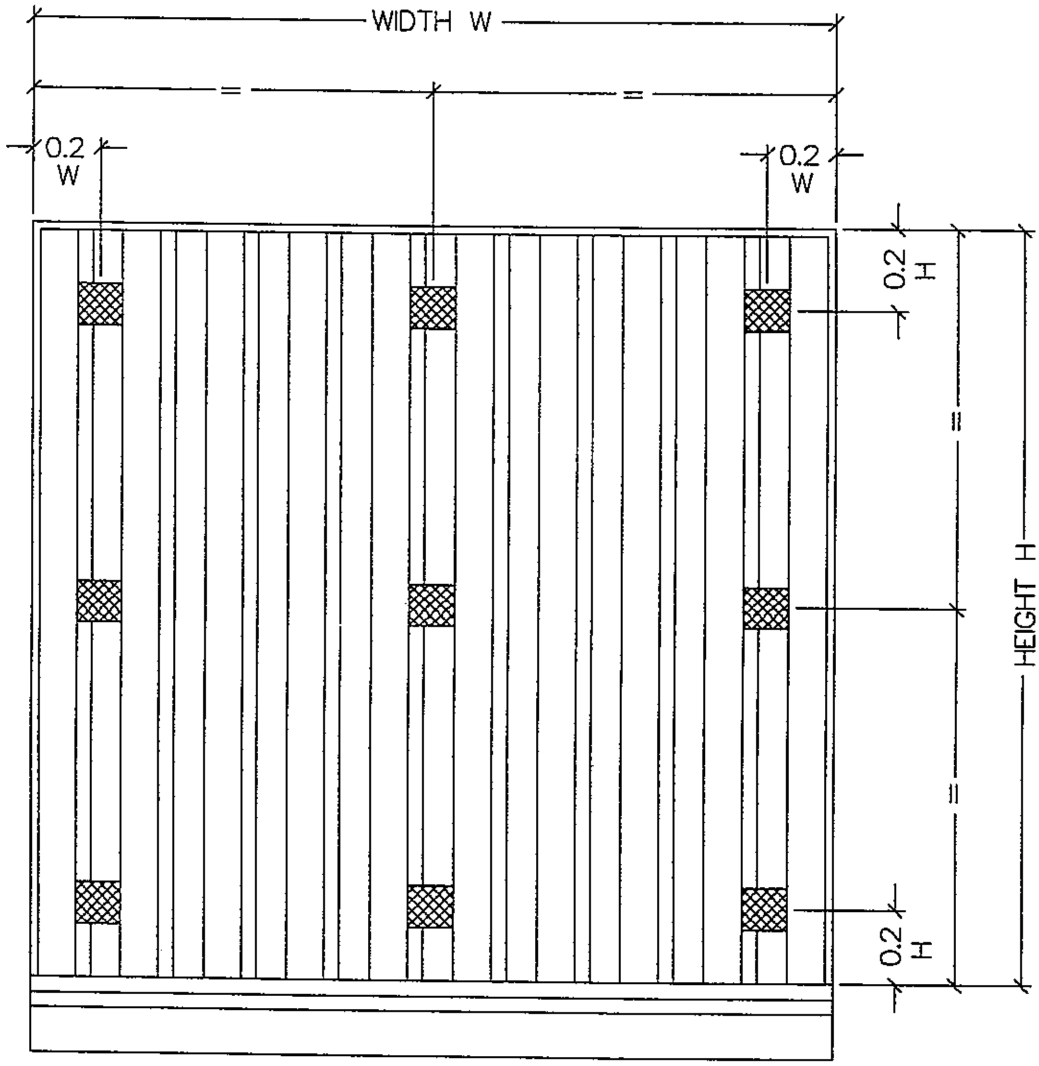


FIGURE 3. PRETEST OF SAND DISTRIBUTION ARRANGEMENT OF SQUARES

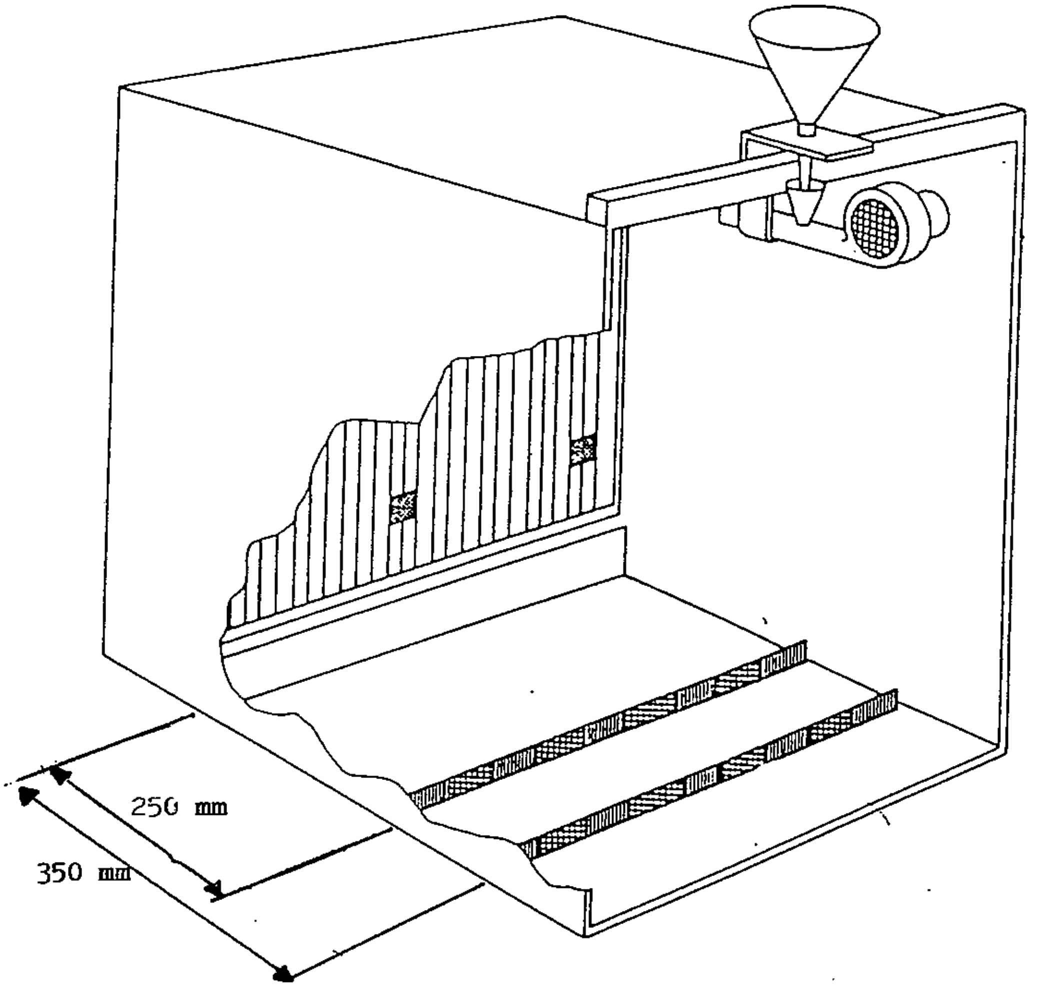


Fig. 4 Pretest of sand distribution
Arrangement of strips

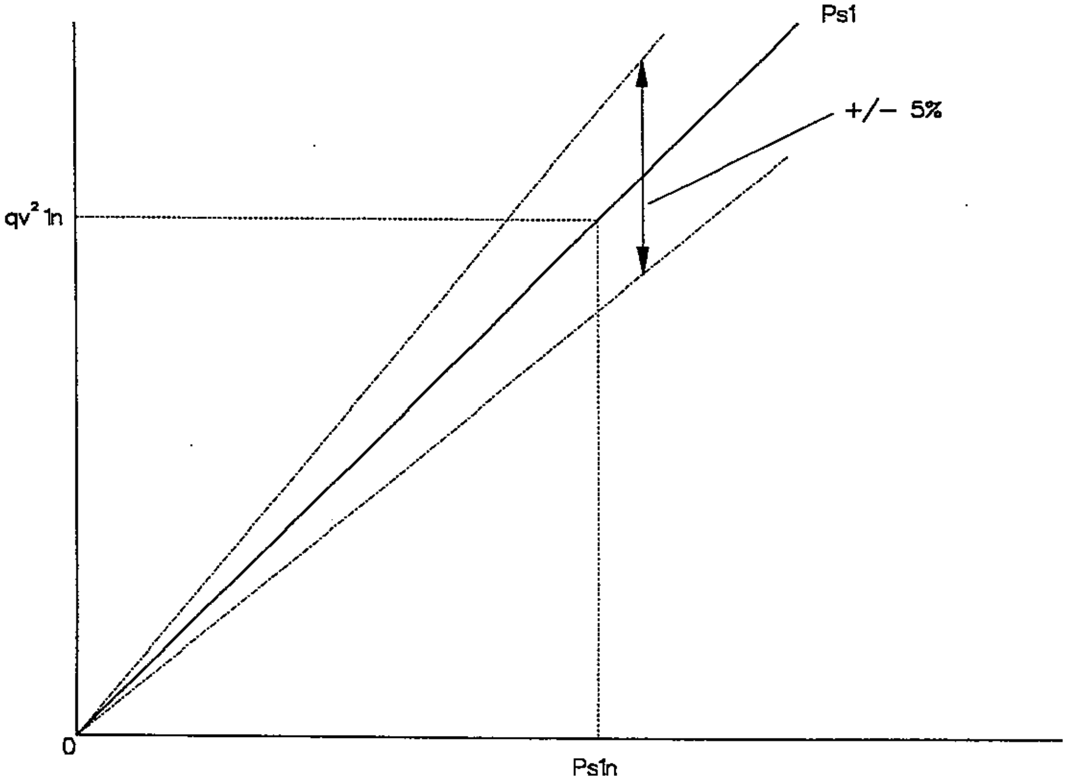


FIGURE 5 FLOW RATE/PRESSURE REQUIREMENT
STRAIGHT LINE CHARACTERISTIC FOR Ps1 vs $qv^2 1$

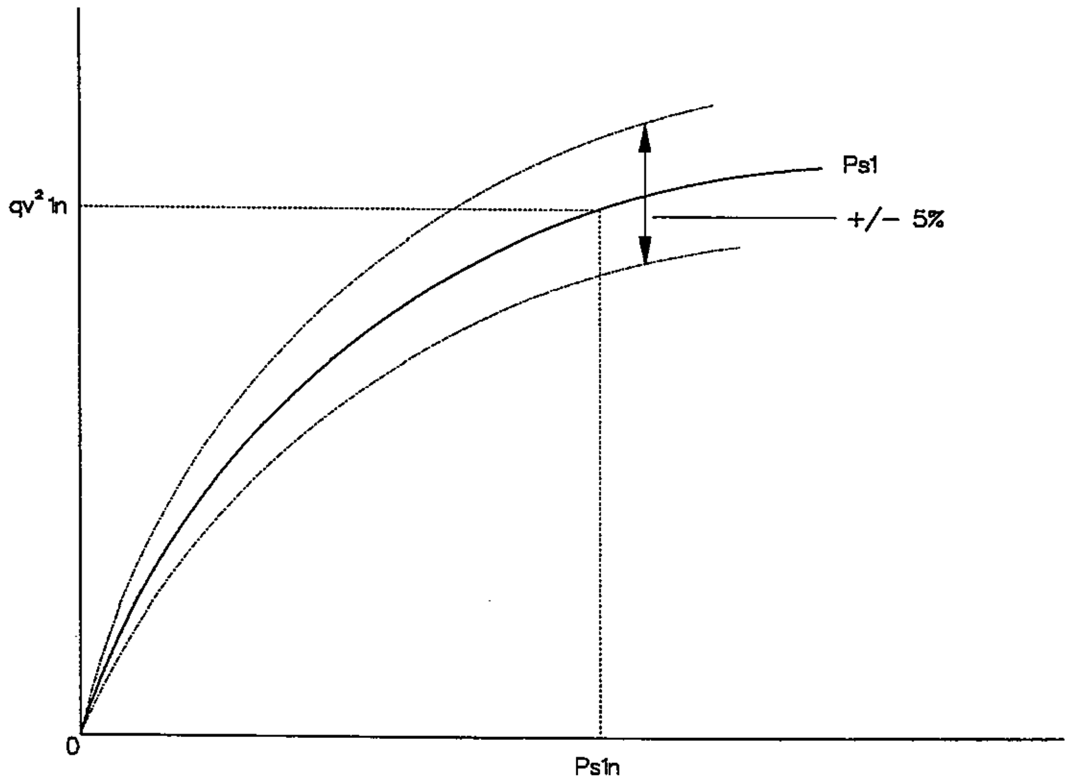


FIGURE 6 FLOW RATE/PRESSURE REQUIREMENT
BEST LINE (CURVE) CHARACTERISTIC FOR Ps1 vs $qv^2 1$

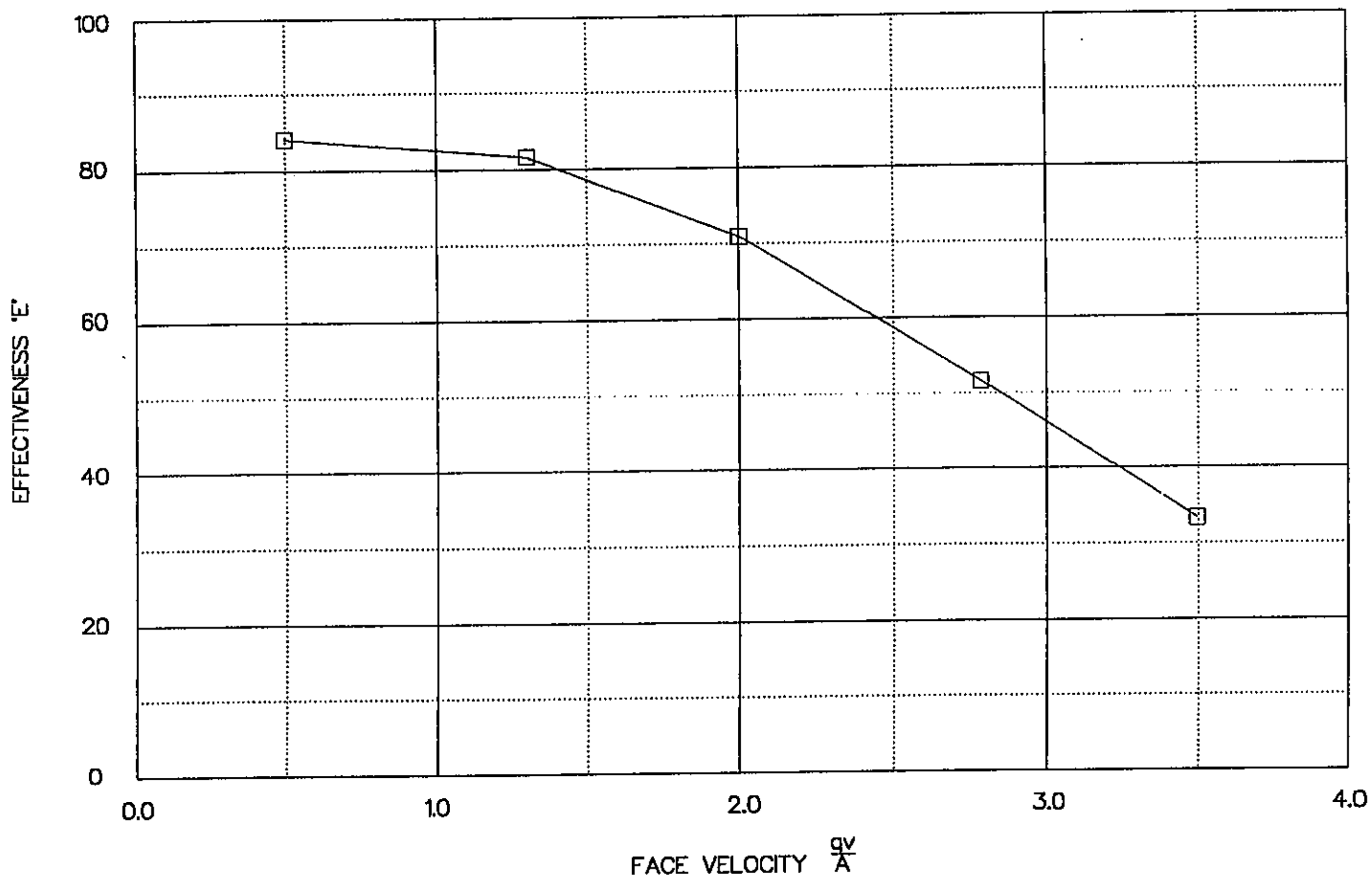


FIGURE 7 **GRAPH (1) SAND REJECTION EFFECTIVENESS OF LOUVRE**