INTERNATIONAL STANDARD

ISO 4174

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Cereals, oilseeds and pulses — Measurement of unit pressure loss in one-dimensional air flow through bulk grain

Céréales, graines oléagineuses et légumineuses — Mesurage des pertes de charge unitaires dans un écoulement d'air unidimensionnel à travers une charge de grains

ISO 4174:1998(E)

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 4174 was prepared by Technical Committee ISO/TC 34, *Agricultural food products*, Subcommittee SC 4, *Cereals and pulses.*

This second edition cancels and replaces the first edition (ISO 4174:1980), which has been technically revised.

Annex A of this International Standard is for information only.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@isocs.iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

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Introduction

Application of the law proposed by Kozeny-Carman for flows within a porous medium has been considered for grain (in particular for cereals and pulses), and such application appears to be sufficiently well verified.

The value of the unit pressure loss depends on the dimensions, porosity, moisture content and apparent density of the grain at a specific point, as well as the temperature, relative humidity, density and entering velocity of the air.

Experiments carried out by dimension categories allow two parameters to be eliminated: the moisture content and the shape (granulometry). The parameters that remain enable the characteristic coefficients of the medium to be determined: porosity and specific area. The results obtained may be used to predict the pressure losses for various densities at a specific point.

Cereals, oilseeds and pulses — Measurement of unit pressure loss in one-dimensional air flow through bulk grain

1 Scope

This International Standard specifies a method of measuring unit pressure loss in one-dimensional air flow through bulk grain, permitting calculation of the total pressure loss of a ventilation unit. This is equal to the sum of the pressure losses

a) in the ventilation system (ducts, etc.);

b) in the grain (which is the subject of this International Standard);

c) due to the passage of the air from the duct into the grain.

The pressure losses in the ventilation system and those due to the passage of the air from the duct into the grain can be considered as negligible in relation to the pressure losses in the grain if the air flow velocity does not exceed the following limits:

— 8 m/s to 10 m/s in the main duct;

— 4 m/s to 5 m/s in the secondary duct;

— 0,25 m/s when entering the grain.

If, for economic reasons, air velocities are higher than those indicated above (up to 30 m/s in the main duct), then, following pertinent literature, the pressure loss caused by the air distributing and discharging system has to be calculated.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3507:1976, *Pyknometers.*

3 Principle

An air flow through a mass of grain under uniform conditions gives rise to a pressure loss per metre of the grain passed, which can be expressed as a function of the velocity at which the air enters the grain.

The flow equation, which gives the unit pressure loss through the grain, is determined from the experimental curve.

4 Apparatus

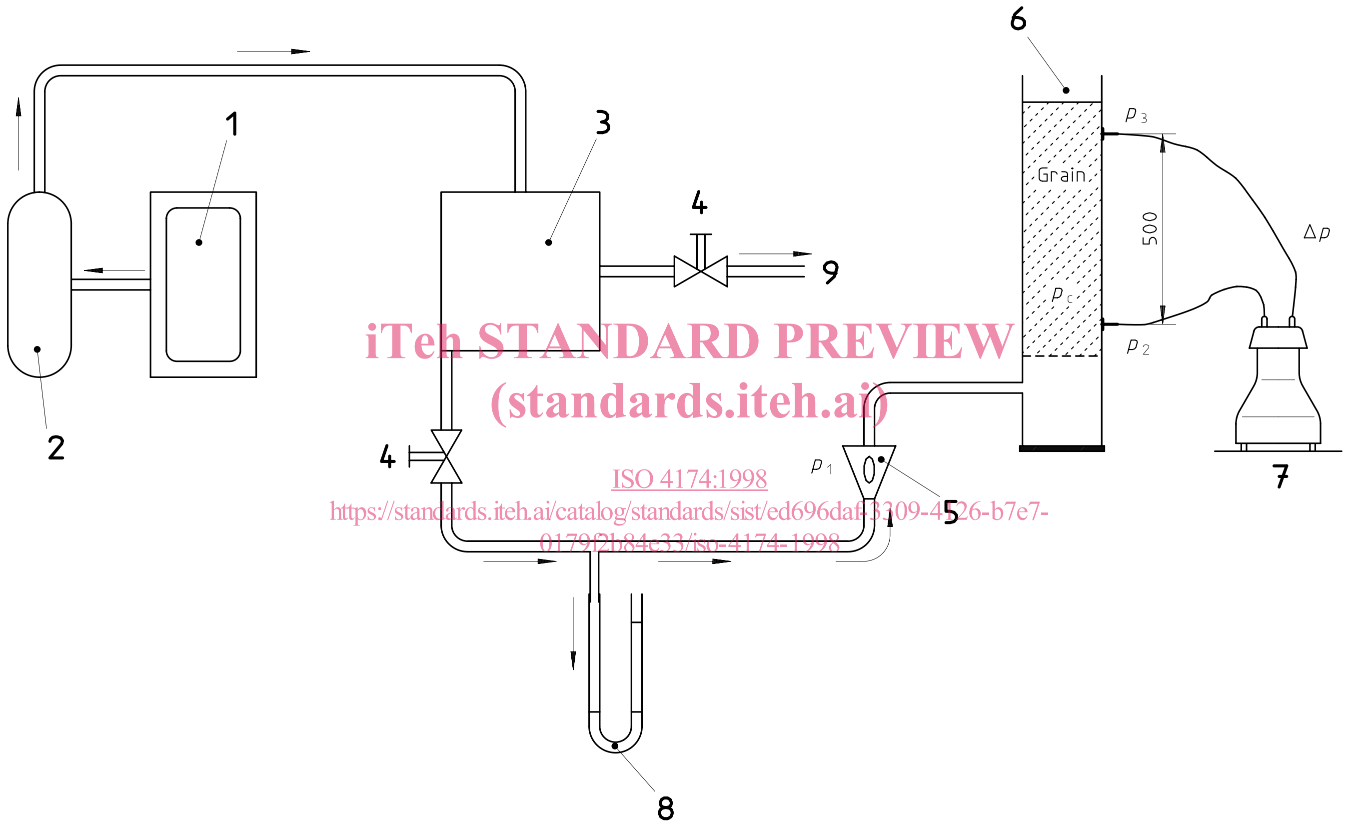
4.1 Device for measuring unit pressure losses (see figure 1)

The grain is placed in a smooth-wall cell consisting of a cylindrical tube with two pressure taps in its wall, 500 mm apart, each comprising two tubes with an internal diameter of 1 mm in contact with the grain. There is a pressure chamber at the base and a fine mesh on which the grain can be packed.

A fan, pump or compressor forces the air into a shock-absorbing bottle. The air then passes into a pressure chamber fitted with a needle-valve tap which can be opened and closed to adjust the air flow through the grain. The air flow is measured by a flow meter (e.g. a rotary meter).

Finally, the air pressure before the flow meter is measured by a manometer (e.g. manometric U-tube), and the pressure loss over 500 mm by a micromanometer (e.g. a miniscope) with an accuracy of ± 0,1 Pa.

Dimensions in millimetres



Key

1 Fan, pump or compressor (e.g. 3 m^3/h delivery)

2 Shock-absorbing bottle (e.g. 1,5 dm^3

^{3} capacity)

4 Needle valve

5 Flow meter

6 Measuring cell

7 Miniscope

8 Manometer U-tube

9 To free air

Figure 1 — Diagram of apparatus for measuring unit pressure losses

4.2 Thermometer equipped with recorder, to measure and to record the temperature of the air entering the grain.

4.3 Ventilated psychrometer, or another device with equivalent accuracy (e.g. capacitive hygrometer or dew-point meter), to measure and to record the wet- and dry-bulb temperatures of the air during the test.

4.4 Barometer, to measure and to record the atmospheric pressure (according to the requirements of this International Standard).

4.5 Pyknometer, complying with ISO 3507.

4.6 Laboratory-size grain cleaner, for cleaning the grains to be tested.

5 Procedure

5.1 Method of filling

Tests should be carried out on grain which has been perfectly cleaned by the cleaner (4.6), otherwise the types and characteristics of the impurities should be given in the test report.

Conduct separate tests with two methods of filling the test cell.

To simulate loose fill from a spout, pour the grain into a funnel held with its outlet at the grain surface in the cell. Lift the funnel slowly to allow the grain to flow into the cell with nearly zero height of fall. Add grain to the funnel continually so as to maintain grain in the funnel as it is slowly lifted.

To simulate sprinkle fill from a grain spreader, drop the grain from a 200 mm height onto a sieve with sufficiently large openings that allow only individual kernels to pass through. Slowly move the sieve upwards to maintain a drop height of 800 mm between the sieve and the grain surface to produce a packed, level bed.

5.2 Drawing of experimental curves to show the pressure loss as a function of the air velocity

5.2.1 General

Determination of the pressure loss (Δp) as a function of the air velocity (U_0) requires repetition of measurements while the flow is being reduced and also while the flow is being increased (refilling the cell each time).

This is necessary to take account of the slight settling that occurs during the experiment.

Repeat the experiments three times for decreasing and increasing flow rates.

5.2.2 Measurements to be made

For the various flow rates (q_0), in cubic metres per second, used during the experiment and measured by the flow meter, determine:

a) the gauge pressure of the air entering the measuring cell, P, in pascals, measured using the manometer (or manometric U-tube) (see 4.1);

b) the pressure loss, Δp, in pascals, recorded by the micromanometer (see 4.1).

5.2.3 Parameters to be determined

5.2.3.1 Parameters depending on the grain

Determine the following.

a) The apparent bulk density of the grain in the cell, ρ_s, in kilograms per cubic metre.

   Weighings shall be taken both before and after settling, and the amount of settling that has occurred shall be measured. The value adopted is the mean of the apparent bulk densities measured.

b) The particle density of the grain, ρ_v, in kilograms per cubic metre.

   This is determined using the pyknometer (4.5).

5.2.3.2 Other parameters

Determine the following.

a) The atmospheric pressure, p_a, in pascals.

This is measured using the barometer (4.4) or is given by a nearby meteorological office.

b) The dry bulb temperature of the ambient air, θ, in degrees Celsius.

This is measured using the thermometer (4.2).

c) The temperature of the air entering the grain, θ_c, in degrees Celsius.

This is measured using the thermometer (4.2).

d) The water vapour content of the air, w, in kilograms of water per kilogram of air.

This is determined using the ventilated psychrometer (4.3) and a humidity graph, or calculated with the help of the equation relating to air humidity.

e) The specific volume of the air, v, in cubic metres per kilogram.

This is determined using a humidity graph, or calculated with the help of the equation relating to air humidity.

f) The cross-sectional area of the cell, A, in square metres.

Calculate the following.

a) The density of the ambient air, ρ_a, in kilograms per cubic metre:

$$\rho_a = \frac{1+w}{v}$$

b) The corrected density of the air, ρ_0 , in kilograms per cubic metre:

$$\rho_0 = \rho_a \times \frac{T_a}{T_0} \times \frac{p_0}{p_a}$$

where

T_0 is the reference temperature, in kelvins (= 293 K);

T_a is the temperature of the air entering the duct, in kelvins (= 273 + θ);

p_0 is the reference atmospheric pressure (101,325 Pa).

5.2.4 Calculations to be made to determine U_0 and ΔP

The density of the air in the flow meter, ρ_r, in kilograms per cubic metre, is given by:

$$\rho_r = \rho_0 \times \frac{p_1}{p_0} \times \frac{T_0}{T_c}$$

where

p_1 is the pressure measured before the flow meter, in pascals ($p_1 = \rho_a + P$);

T_c is the temperature of the air entering the grain, in kelvins (= 273 + θ_c).

The real flow of the air leaving the flow meter, q_r, in cubic metres per second, is given by:

$$q_r = q_0 \sqrt{\frac{\rho_0}{\rho_r}}$$

where q_0 is the flow rate in the flow meter, in cubic metres per second.

The pressure in the cell, p_c , in pascals, is given by

$$p_c = p_3 + \frac{1}{2}\Delta p$$

where

p_3 is the pressure measured at the pressure-measuring point near the top of the grain column, in pascals;

Δp is the pressure loss over 0,5 m recorded by the micromanometer (4.1), in pascals.

The density of the air in the cell, ρ_c, in kilograms per cubic metre, is given by:

$$\rho_c = \rho_0 \times \frac{T_0}{T_c} \times \frac{p_c}{p_0}$$

The air flow in the cell, q_c, in cubic metres per second, is given by

$$q_c = q_r \sqrt{\frac{\rho_r}{\rho_c}}$$

The air velocity in the cell, U_0, in metres per second, is given by:

$$U_0 = \frac{q_c}{A}$$

where A is the cross-sectional area of the cell, in square metres.

The unit pressure loss, ΔP , in pascals per metre, is given by:

$$\Delta P = \frac{\Delta p}{0{,}5}$$

5.2.5 Presentation of results

Recorded or calculated results shall be given in a table as shown in table 1.

The unit pressure losses (ΔP) are then recorded on “log-log 2 module" paper as a function of the velocities at which the air enters the grain (U_0), or recorded by an appropriate software.