International Standard ISO 6584

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Cleaning equipment for air and other gases — Classification of dust separators

Séparateurs aérauliques — Classification des dépoussiéreurs

First edition — 1981-03-15

UDC 697.94 **Ref. No. ISO 6584-1981 (E)**

Descriptors : air cleaners, cleaning equipment for gases, classifications, specifications.

Price based on 5 pages

ISO 6584-1981 (E)

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 6584 was developed by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*, and was circulated to the member bodies in October 1979.

It has been approved by the member bodies of the following countries :

Australia	Finland	Japan
Austria	France	Korea, Rep. of
Belgium	Germany, F. R.	Poland
Chile	India	Romania
China	Ireland	Sweden
Czechoslovakia	Italy	

The member body of the following country expressed disapproval of the document on technical grounds :

United Kingdom

Printed in Switzerland

Cleaning equipment for air and other gases — Classification of dust separators

0 Introduction

It is not possible to cover every possible combination of dust separator because of the variety and complexity of the wide range of different types of dust separator on the market. The classification given in this International Standard is based on the main operating principles and does not attempt to specify complex or multi-component dust separators (for example, for venturi scrubbers, only the first stage of the process is considered without specifying the following stages such as droplet separation).

1 Scope and field of application

This International Standard defines a classification of dust separators, gives their operating principles and defines their characteristics.

Examples are given, for guidance, of each class of dust separator, but this list is not exhaustive. Symbols are given for each class of dust separator and these shall be used as the basis for symbols for more complex types of separator.

This International Standard will be supplemented by another International Standard dealing with the determination of the performance characteristics of dust separators.

2 References

ISO 3649, *Cleaning equipment for air or other gases — Vocabulary.*

ISO 7000, *Graphic symbols — Index, survey and compilation of the single sheets.*[1)]

3 Classification and working principles of dust separators

3.1 Inertial separators

The principles of particle separation by mass effects allow three main categories of separators to be distinguished, i.e. separators of the following types :

— gravity;

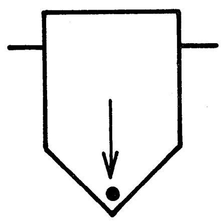
— impingement;

— centrifugal.

3.1.1 Gravity separators

Inertial separators in which the particles are sedimented under the effect of gravity.

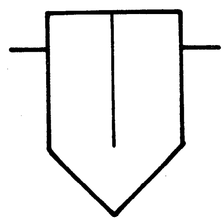
Example : Settling chambers.



3.1.2 Impingement separators

Separators in which the dust-laden flow is forced to make various changes of direction. The particles which follow less curved trajectories than the lines of the gaseous flow, move towards depositing surfaces, along which they descend by gravity to discharge hoppers.

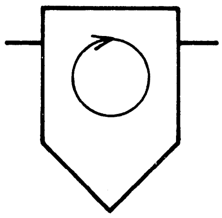
Example : Baffle chambers.



1) At present at the stage of draft.

3.1.3 Centrifugal separators

Inertial separators which employ a rotating flow. The particles are separated under the effect of centrifugal forces from the gaseous flow and are released in a radial direction.



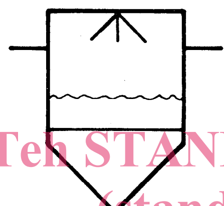
Examples : Cyclones, multicyclones.

3.2 Wet separators

Separators in which forces are applied to promote the transfer of particles from a gaseous flow to a liquid phase which is later removed from the gaseous flow by other mechanisms.

3.2.1 Bubble washers

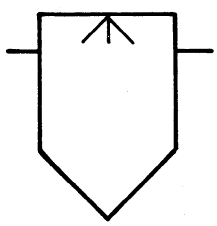
Wet separators which employ fixed or movable elements immersed in the scrubbing liquid to bring about intimate contact of the particles with the scrubbing liquid.



Examples : Turbulent scrubbers (or flooded beds), fixed or mobile packed towers.

3.2.2 Spray washers

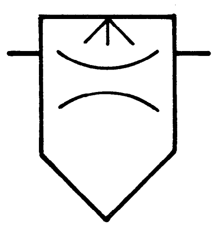
Wet separators which employ a liquid spray generated by pressure, impaction or some external energy source, to bring the particles into contact with the washing liquid.



Examples : Spray washers, wet cyclones, disintegrators, rotating paddles.

3.2.3 Restricted flow scrubbers

Wet separators in which the particles are brought into contact with the washing liquid in a restricted zone which causes a change in pressure or velocity conditions in the flowing gas.



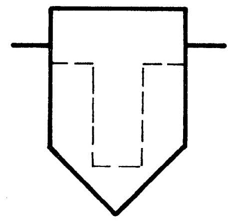
Examples : Venturi or orifice scrubbers, induced gas scrubbers, flooded disks, ejectors, electro-dynamic venturi.

3.3 Porous layer separators

Separators in which the gas passes through a porous layer which retains the particles.

3.3.1 Fibrous filter separators

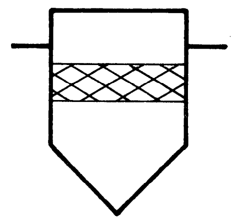
Filtering separators where the particles are separated by means of a medium consisting of natural, mineral, synthetic or metallic fibres which constitute a woven or an unwoven material. These filtering media are generally in the form of bags or pockets.



Examples : Bag filters, pocket filters, panel filters.

3.3.2 Packed tower separators

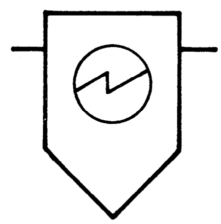
Filtering separators where the particles are separated by mineral, metallic or other materials which form a layer of packing.



Example : Gravel bed filters.

3.4 Electrostatic precipitators

Separators in which the gaseous flow is subjected to an emission of ions which charge the particles. The charged particles are attracted towards surfaces of different polarity to which they adhere. They are periodically or continuously detached from the surfaces by rapping or washing, and descend under gravity to discharge hoppers.



Example : Electrostatic precipitators, plate or tube type.

4 Definition of dust separator characteristics

4.1 Data to be established

The data to be established for a dust separator are the parameters required for determining the characteristics of the dust separator, i.e. the parameters which enable estimates to be made of the manner in which it fulfils its function. The principal data required for designing a dust separator are as follows.

4.1.1 Nature and physical characteristics of the gas at the inlet of the separator

— Chemical composition.

— Water content.

— Absolute pressure P_1.

— Absolute temperature T_1.

— Density ϱ_1.

— etc.

4.1.2 Flow rate of the gas stream at the dust separator inlet

q_{m1} (kg/s) or q_{v1} (m^3/s)

The flow rate of the gas stream at the dust separator inlet is the mass or volume of gas which passes through the inlet section of the dust separator in one second. In the case of mass flow rate, it should be specified whether or not this takes into account the mass of the suspended particles.

The volume flow rate is usually reduced to standard conditions (T_o, P_o) by two conventional methods :

a) by taking account of the dry gas only, i.e. subtracting the water content.

This defines the dry volume flow rate (q_{voD}) under standard conditions :

$$q_{voD} = q_{v1} \times \frac{(P_1 - p)}{P_o} \times \frac{T_o}{T_1}$$

b) by assuming that the behaviour of the water vapour is that of an ideal gas.

This defines the wet volume flow rate, (q_{voH}) under standard conditions :

$$q_{voH} = q_{v1} \times \frac{(P_1)}{P_o} \times \frac{T_o}{T_1}$$

where

q_{v1} is the actual volume flow rate;

P_1 is the actual pressure of the gas (absolute);

T_1 is the actual temperature of the gas (absolute);

p is the partial pressure of water vapour at temperature T_1 and pressure P_1 (absolute);

P_o is the pressure for standard conditions, 101 325 Pa;

T_o is the temperature for standard conditions, 273 K.

In all cases, it is necessary to indicate the choice made between the dry volume flow rate and the wet volume flow rate. If the flow rate is not constant, it is advisable to specify its variation over a certain time.

4.1.3 Concentration of particles at the separator inlet, C_1, C_1' or C_1''

The concentration of particles in the gas flow at the separator inlet is the ratio of the mass flow rate of these particles (q_{mc1}) to the flow rate of the gas.

Distinction is therefore made for the following situations :

a) when the volume flow rate q_{v1} of the gas at the dust separator inlet is constant :

$$C_1 = \frac{q_{mc1}}{q_{v1}}$$

expressed in kg/m^3 (practical unit : g/m^3).

When the volume flow rate is expressed at standard conditions :

$$C_1 = \frac{q_{mc1}}{q_{voD}} \text{ or } C_1 = \frac{q_{mc1}}{q_{voH}}$$

expressed in kg/m^3 dry (practical unit : g/m^3 dry) or in kg/m^3 wet (practical unit : g/m^3 wet).

b) when the mass flow rate q_{m1} of the gas at the dust separator inlet is constant :

$$C_1' = \frac{q_{mc1}}{q_{m1}}$$

expressed in kg/kg (practical unit : g/kg).

c) if the mass flow rate varies by vapour exchange, it is possible to relate the dust concentration C_1'' to unit mass of the dry gas.

4.1.4 Concentration of particles at the separator outlet

The maximum concentration of particles at the separator outlet is often fixed by regulations concerning pollution of the environment or work place; it may also be fixed in relation to economic or safety constraints. These values of maximum concentration associated to parameters defined in this clause contribute to the choice of the type of separator.

4.1.5 Nature of the particles and their physico-chemical properties

— Density.

— Particle size.

— Shape factor.

— Solubility.

— Hygroscopicity.

— Abrasiveness.

— Angle of repose.

— Resistivity.

— Chemical composition.

— Flammability.

— etc.

4.2 Main characteristics of dust separators

Separators are mainly characterized by the mass of particles (m_2) at the separator outlet. If established data are known for the outlet and the inlet of the dust separator, its efficiency can be expressed by one or more of the following values.[1]

4.2.1 Overall efficiency of separation, η

The overall efficiency of separation is equal to the ratio of the mass of particles retained by the dust separator ($m_1 - m_2$) to the mass of particles which enters it (m_1) within the same time interval. (It is usually expressed as a percentage.)

$$\eta = \frac{m_1 - m_2}{m_1}$$

where m_2 is the mass of particles leaving the separator.

4.2.2 Grade efficiency, η_g

The grade efficiency, usually expressed as a percentage, is the efficiency of the dust separator for each fraction of dust of a given particle size.

4.2.3 Cut diameter

This is the diameter of particles (assumed to be spherical) at which the grade efficiency falls below 50 %. It is assumed that larger particles are arrested and that smaller particles pass through the separator.

NOTE — This is a theoretical concept which is generally not applicable to dust having a complex particle size distribution and it is not applicable to most dust separators other than certain mechanical dust separators.

4.2.4 Penetration, ψ

Penetration (or slip), usually expressed as a percentage, is equal to the ratio of the mass of particles leaving the dust separator (m_2) to the mass of matter which enters it (m_1) within the same time interval.

$$\psi = \frac{m_2}{m_1}$$

4.2.5 Amount of particles separated per unit time, q_{mc} (kg/s)

If q_{mc1} is the mass flow rate of dust at the inlet and q_{mc2} the mass flow rate of dust at the outlet, the mass of the particles separated during unit time is given by the formula

$$q_{mc} = q_{mc1} - q_{mc2}$$

4.3 Secondary characteristics

These secondary characteristics also need to be specified.

4.3.1 Flow rate of the treated gas

q_{m2} (kg/s) or q_{v2} (m^3/s)

4.3.2 Temperature at the outlet, T_2 (K)

4.3.3 Pressure drop across the separator, Δp_t (Pa)

This is the difference in total pressures between the inlet and outlet of the dust separator.

4.3.4 Power requirements (kW)

These are as follows :

— the power necessary for the functioning of devices, such as automatic shakers, rotary dischargers, etc.;

— the power absorbed by apparatus used in electrostatic precipitators, particularly high tension generators;

— the power necessary for the use of pressurized water or compressed air;

— various other forms of power.

The following also need to be considered :

a) the mean power absorbed by auxiliary units :

This is the amount of power consumed during a certain time divided by this time.

If the plant does not function continuously, but has cyclic operation (periodic cleaning units, etc.), the power consumed has to be referred to the period. Certain elements which enter into the calculation of the mean power consumption shall be stated by the user.

Example : Compressed air or pressurized water used in the distribution network of the factory.

b) the installed capacity :

The sum of the rated power of the machines which run directly all the elements required for the operation of the dust separator. This is considerably different from the mean power absorbed.

1) These characteristics refer to the total mass of dust or, in certain cases, to their chemical components (for example lead).

4.3.5 Consumption of materials required for operation

Two types of material are used in operation :

- materials for washing, moistening, cleaning, such as water, oil, compressed air, etc., which are consumed continuously;
- materials used directly in the dust collector, such as filtering media, electrodes, etc., which have to be changed periodically.

This consumption is related to a given period of time, for example m^3/h, kg/month, m^2/year, etc.

4.3.6 Storage capacity of the discharge chambers

This is the mass or volume of dust that the discharge chambers of the dust separators can retain. It is expressed in kilograms, tonnes or cubic metres. The capacities vary with the nature and state of the dust.

4.3.7 Maintenance

The periodicity of maintenance and the period of time during which the dust separator has to be stopped for maintenance, the different operations and the various materials required shall be specified.

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