ISO/TC 142/WG 9
Particulate air filter intake systems for rotary machinery and stationary internal combustion engines

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# Air filter intake systems for rotary machinery -- Test methods -- Part 6: Cleanable (Pulse Jet) filter elements

*Systèmes de filtration d'air d'admission pour machines tournantes -- Méthodes d'essai -- Partie 6:*



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# 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 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 29461-6 was prepared by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*.

ISO 29461 consists of the following parts, under the general title *Air intake filter systems for rotary machinery*:

— *Part 1: Test methods: Static filter elements*

— *Part 2: Test methods and classification for cleanable (pulse jet) filter systems*

— *Part 3: Test methods for mechanical integrity of filter elements*

— *Part 4: Test methods for in-situ testing of filter systems*

— *Part 5: Test methods for static filter systems in marine and offshore environments*

— *Part 6: Test methods: Cleanable (Pulse Jet) filter elements*

 

# Introduction

Existing standards for flat media like the German VDI guideline 3926, Japanese JIS, or ASTM standards generally consist of a filtration step, followed by an ageing step, followed by a filtration step, and the final evaluation. Typically, from these standards only two „data sets“ of beginning and end are generated; no information about development during the course of the test procedure is generated.

Existing standards for full dust filtration units or systems, like e.g. the ARAMCO test, simulate the full dust removal unit in real life behaviour, and hence are large scale experiments, time consuming, and heavy on resources.

The customer, who wants to compare and buy filter elements for an existing pulse-jet filtration unit and also the filter element manufacturer for development purposes are interested in a quick evaluation of products; not necessarily full scale equipment (suitability of filter element, not of filter unit).

The following basic consideration lead to the test method described in this standard:

1) In existing test Standards the filtration step focuses rather on supporting function of dust cake and release; the main interest however is the filter media ageing and the pleat/cartridge configuration.

2) Experience from dust removal applications teaches us: fine dust, low concentration, frequent (time-controlled) regeneration leads to rapid ageing/blinding of filter media (e.g. welding fume), and therefore represent the worst case conditions. Therefore, these conditions shall be applied in a test procedure.

3) A test method should describe the course of ageing and not only two points at the beginning and end of the dust loading procedure. Therefore, the pulsing procedure is interrupted to determine pressure differentials in the course of the testing procedure.

4) Not only the filter medium, but also the conversion technique and filter design (pleat spacing, pleat design, etc.) needs to be evaluated with this test procedure. As dust deposits in-between pleated media, the procedure also needs to incorporate an off-line cleaning operation. Hence, the test procedure consists of a combination of on-line and off-line cleaning operations.

# Air filter intake systems for rotary machinery -- Test methods -- Part 6: Cleanable (Pulse-Jet) filter elements

## 1 Scope

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[to be edited]

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 29464 and the following apply:

### 3.1 Arrestance and efficiency

**3.1.1**
**gravimetric arrestance**
measure of the ability of a filter to remove a standard test dust from the air passing through it, under given operating conditions

NOTE: This measure is expressed as a weight percentage.

**3.1.2**
**initial gravimetric arrestance**
value of arrestance determined after the first loading cycle in a filter test

NOTE: This measure is expressed as a weight percentage.

**3.1.3**
**average gravimetric arrestance**
ratio of the total amount of loading dust retained by the filter to the total amount of dust fed up to final test pressure differential

**3.1.4**
**efficiency**
fraction or percentage of a challenge contaminant that is removed by a filter

**3.1.5**
**fractional efficiency**
ability of an air cleaning device to remove particles of a specific size or size range

NOTE: The efficiency plotted as a function of particle size gives the particle size efficiency spectrum.

[Source: ISO 29464:2011; 3.1.61]

### 3.2
### filter elements

**3.2.1**
**filter element**
structure made of the filtering material, its supports and its interfaces with the filter housing

**3.2.2**
**test filter cartridge**
cylindrical structure made of pleated filtering material, its supports and its interfaces with the filter housing subject for testing

### 3.3 Air flow rates

**3.3.1**
**air flow rate**
$q_v$
volume of air passing through the filter per unit time

[Source: ISO 29464:2011; 3.2.38]

**3.3.2**
**nominal air flow rate**
$q_{v,nom}$
air flow rate specified by the manufacturer

**3.3.3**
**test air flow rate**
$q_{vt}$
air flow rate used for testing

### 3.4
### PM-efficiencies

efficiencies of an air filter to reduce the mass concentration of the three PM dust fractions. $PM_{10}$-efficiency is the efficiency to the $PM_{10}$ fraction, $PM_{2,5}$-efficiency to the $PM_{2,5}$ fraction and $PM_1$-efficiency to the $PM_1$ fraction. PM-efficiency is calculated as the ratio of the difference of the PM mass concentration upstream and downstream of the filter to the upstream concentration

### 3.5
### particle counter

device for detecting and counting numbers of discrete airborne particles present in a sample of air

[Source: ISO 29464:2011; 3.1.27]

### 3.6 Particle size and diameter

**3.6.1**
**particle size**
**particle diameter**
geometric diameter (equivalent spherical, optical or aerodynamic, depending on context) of the particles of an aerosol

[Source: ISO 29464:2011; 3.1.126]

**3.6.2**
**particle size distribution**

presentation, in the form of tables of numbers or of graphs, of the experimental results obtained using a method or an apparatus capable of measuring the equivalent diameter of particles in a sample or capable of giving the proportion of particles for which the equivalent diameter lies between defined limits

[Source: ISO 29464:2011; 3.1.128]

**3.7**
**pressure differential**
**resistance to air flow**
difference in pressure between two points in an airflow system at specified conditions, especially when measured across the filter element

**3.8**
**test dust capacity**
TDC
amount of loading dust held by the filter at final test pressure differential

[Source: ISO 29464:2011; 3.1.52]

**3.9**
**pulse-jet cleaning**
cleaning off the dust cake from a filter by a pressure pulse in reverse direction to the main filtering air flow

**3.10**
**online cleaning pulse**
pulse-jet cleaning while the main filtered air stream is flowing

**3.11**
**offline cleaning pulse**
pulse-jet cleaning while there is no main filtered air stream

**3.12**
**downstream**
area or region into which fluid flows on leaving the filter

[Source: ISO 29464:2011; 3.1.49]

**3.13**
**upstream**
area or region traversed by a flowing fluid before it enters the filter

## 4 Symbols and abbreviated terms

For the application of this Standard, the following symbols and abbreviated terms apply:

[to be edited]

# 5 General requirements

## 5.1 General

The filter element shall be designed or marked for air flow direction in a way preventing incorrect mounting.

The filter shall be designed in a way that no leaks occur along the sealing edge when correctly mounted in the ventilation duct. If, for any reason, dimensions do not allow testing of a filter under standard test conditions, assembly of two or more filters of the same type or model are permitted, provided no leaks occur in the resulting filter configuration.

## 5.2 Material

The filter element shall be made of suitable material to withstand normal usage and exposures to those temperatures, humidities and corrosive environments that are likely to be encountered.

The filter element shall be designed to withstand mechanical constraints that are likely to occur during normal use.

## 5.3 Nominal air flow rate

The filter element shall be tested at its nominal air flow rate for which the filter has been designed by the manufacturer.

## 5.4 Resistance to air flow

## 5.5 Fractional efficiency curves (Particle size efficiency spectrum)

## 5.6 Gravimetric arrestance

# 6 Test rig and equipment

The test rig as shown in Figure 1 is designed to test cylindrical filter elements with a diameter of ∅ 327 mm and a length of 660mm. It consists mainly of two sections: the upstream and the downstream section, both separated by the filter mounting plate. The filter element (test cartridge) is mounted airtight to the mounting plate from the upstream section, which incorporated the dust feeding system and dust bunker. On the downstream section, the pulse jet cleaning system is installed and a photometer to measure the clean air dust concentration.

## 6.1 Measurement of the pressure differential

The pressure differential of the tested filter cartridge shall be measured using static pressure taps located as shown in Figure 1. Pressure taps shall be provided at four points over the periphery of the duct and connected together by a ring line. The pressure measuring equipment used shall be capable of measuring pressure differentials in a range from 0 to 2500 Pa with an accuracy of 3% of the measured value.

 

## 6.2 Dust feeder

The dust is re-cycled from the dust bunker, transported into a venturi injector by means of a twin screw feeder and injected into the upstream section of the test rig through an injection pipe as shown in Figure 1. The amount of dust fed to the system shall be adjusted to the test air flow rate to provide a constant dust concentration in the upstream section of the test rig of 0,5 g/m³.

## 6.3 Pulse-jet cleaning system

The pulse jet cleaning system consists of a 17,5 l (1750 cm³) tank with pressurized air at 4 bar (400 kPa), a magnetic valve and a blowing pipe with a diameter of 1" (25,7 mm), where the opening diameter of the pipe equals to the pipe diameter. The cleaning pressure pulse is generated by opening the magnetic valve for a period of 150 ms.

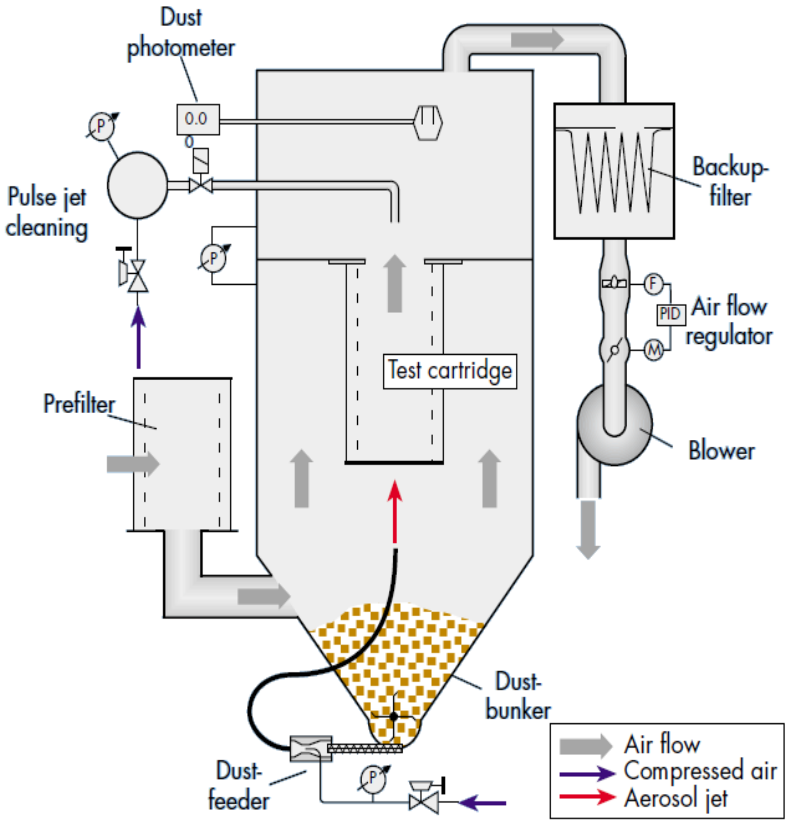


**Figure 1 — Summary section of performance report**

## 6.4 Fan

The fan shall be controlled to supply a constant volume flow rate in the range between 150 and 1500 m³/h.

## 6.5 Backup filter

As final filter stage or backup filter a pocket or rigid filter with an $PM_1$-efficiency to ISO 16890-1 of at least 80% shall be used. By weighing the final filter, the mass of dust which penetrated through the test filter cartridge can be determined.

### 6.6 Dust photometer

The dust photometer is used to determine the downstream mass concentration of the test dust.

## 7 Test materials and conditions

### 7.1 Test air

Room air or outdoor air may be used as the test air source. The test air shall be filtered. Relative humidity shall be in the range of 30 to 70 % in the tests. The air temperature shall be in the range of 10 to 38°C. The exhaust flow may be discharged outdoors, indoors or re-circulated. Requirements of certain measuring equipment may impose limits on the temperature of the test air. Filtration of the exhaust flow is recommended when test aerosol and loading dust may be present.

The compressed air for the dust feeder shall be dry, clean and free from oil.

### 7.2 Loading dust

As loading dust a white pigment Kronos Ti2160 shall be used, which is an ultra-fine dust with a rather narrow particle size distribution below 1 µm. A fixed dust concentration of 0.5 g/m³ shall be supplied by the dust feeder.

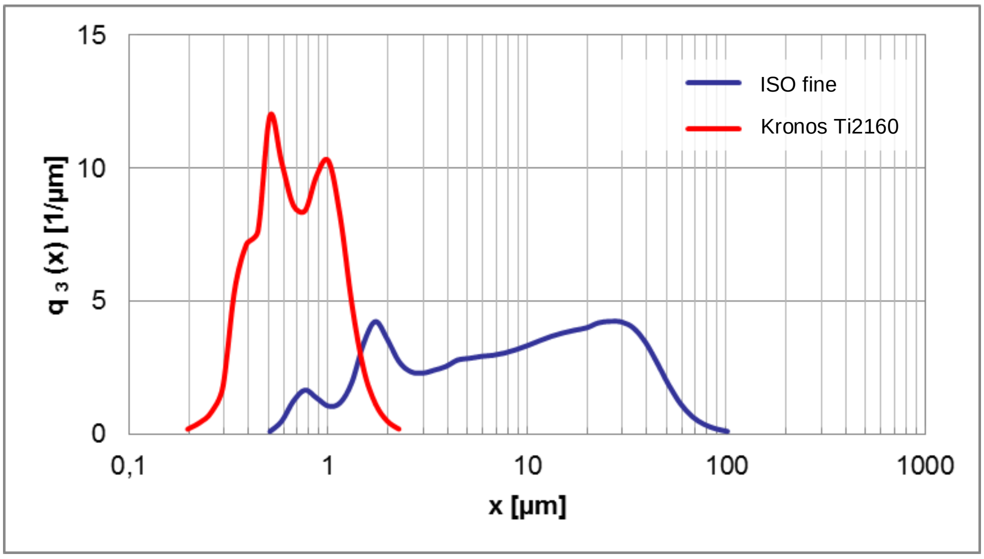


**Figure 2 — Distribution density of Kronos Ti2160 in comparison to ISO fine dust (ISO 12103-1 A2)**

## 8 Test procedure

The test cartridge is installed to the mounting plate as shown in Figure 1. The mounting plate acts as an adapter and needs to be adapted to the mounting system which the test cartridge is designed for.

After the fan has been switched on and the air volume flow rate has stabilized, the initial pressure drop is measured. In the next step, the dust feeder is turned on and the test procedure starts, which consists of 10 cycles, wherein each cycle consists of

- 500x online cleaning pulses in interval of 5s
- Pressure differential measurement
- 10x offline cleaning pulses
- Pressure differential measurement
- 100x offline cleaning pulses
- Pressure differential measurement

Hence, for each of the 10 cycles three pressure differential values are recorded. Figure 3 shows an example of measured pressure differential data generated by this test method.

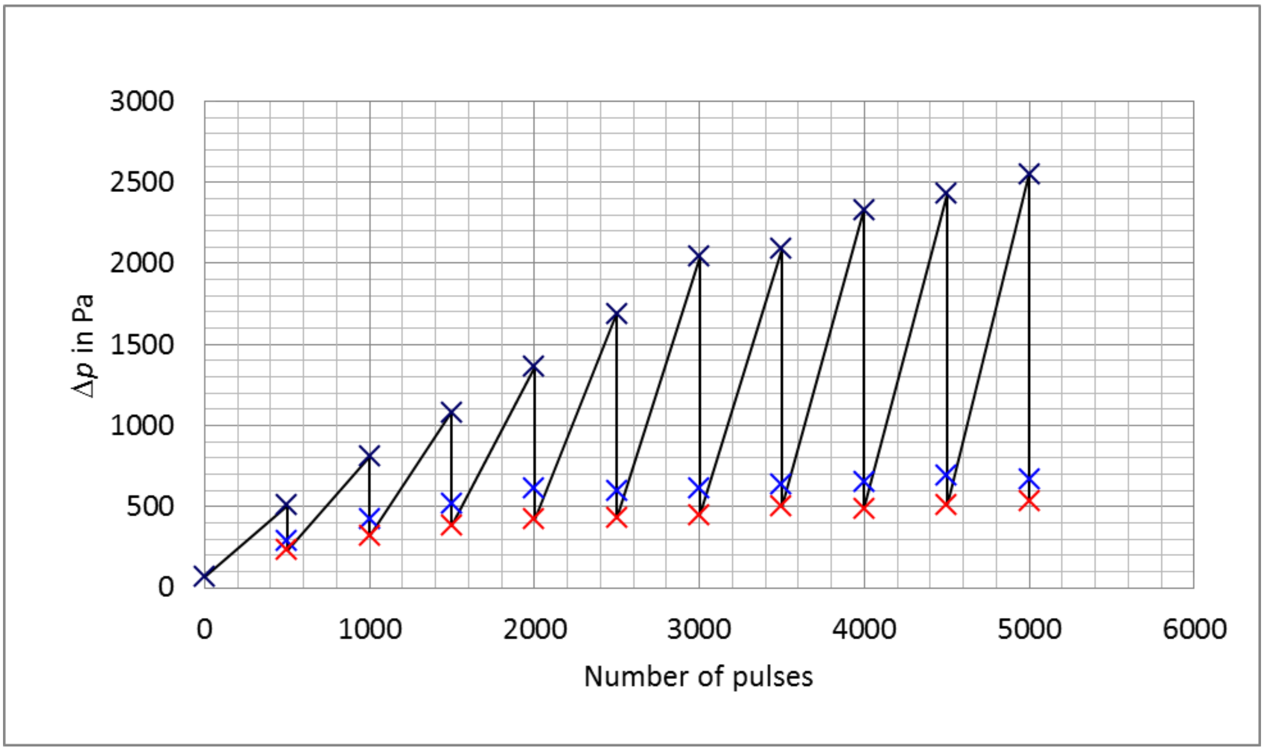


**Figure 3 — Example pressure differential curves resulting from the test procedure described in this standard**

## 9 Reporting

To finally evaluate the test data, three trend lines shall be fitted to the data points generated from the test procedure, which give information on the long term operation behaviour and the cleanability of the surface loading filter element:

1) a trend line fitted to the pressure differential values at the end of each 500 times online cleaning cycle which describes the long term operation behaviour

2) a trend line fitted to the pressure differential values recorded after each 10 offline cleaning pulses

3) a trend line fitted to the pressure differential values recorded after each 100 offline cleaning pulses

Besides the full ageing curve, there are four pressure drop values that are used in this standard for evaluation of the filter element: (1) the initial pressure drop $\Delta p_i$, (2) $\Delta p_{on}$ as the final value of the upper trend line for the long term operation behaviour, (3) $\Delta p_{off,\,10}$ as the final value of the trend line for the values after 10 offline cleaning pulses, and (4) $\Delta p_{off,\,100}$ as the final value of the trend line for the values after 100 offline cleaning pulses.

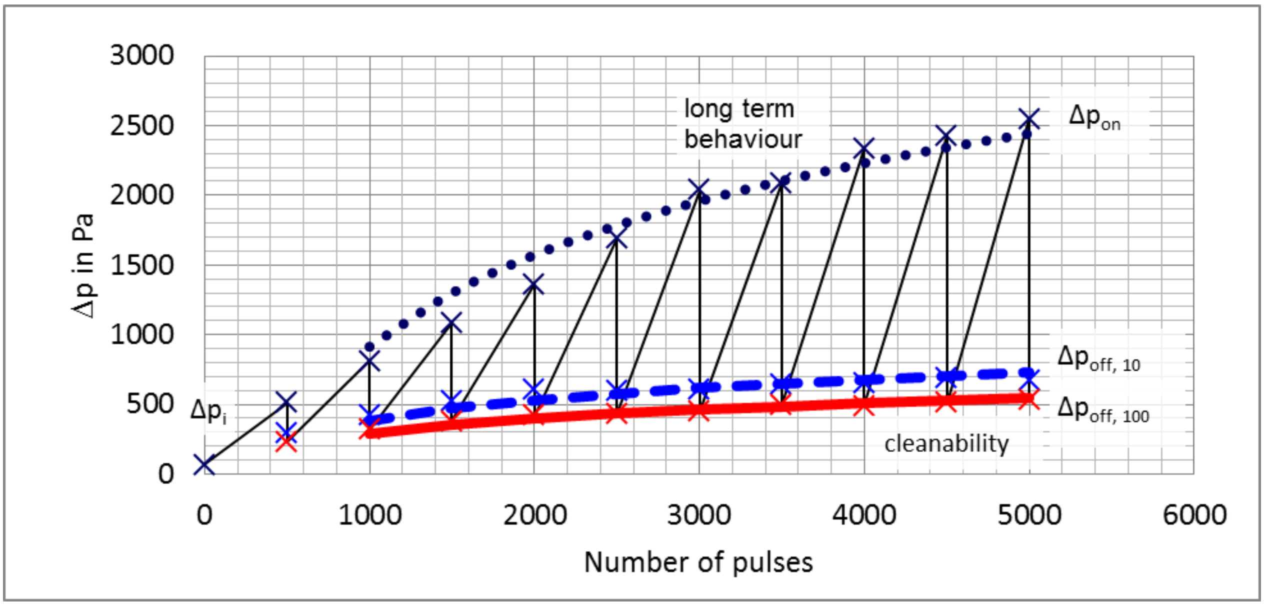


**Figure 4 — Example of curve fits to the pressure differential curves resulting from the test procedure described in this standard and the four pressure differential values used for evaluation**

## 9.1 Test report

 

# Annex A
(informative)

# Bibliography

1) ISO 16890-1, Air filters for general ventilation — Part 1: Technical specifications, requirements and efficiency classification system based upon Particulate Matter (PM)