INTERNATIONAL STANDARD

ISO 29461-1

First edition
2013-04-01

Air intake filter systems for rotary machinery — Test methods —

Part 1:
Static filter elements

Systèmes de filtration d'air d'admission pour machines tournantes — Méthodes d'essai —

Partie 1: Éléments filtrants pour filtres statiques

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

Reference number
ISO 29461-1:2013(E)

© ISO 2013

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

COPYRIGHT PROTECTED DOCUMENT

© ISO 2013

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/0c8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

© ISO 2013 – All rights reserved

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 29461-1 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 — Test methods*:

— *Part 1: Static filter elements*

Cleanable (pulse jet) and surface loading filters, mechanical integrity of filter elements, *in situ* testing, marine and offshore environment filter systems, and cleanable (pulse Jet) filter elements will form the subjects of future parts.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

0 Introduction

0.1 Filters in power generating/compressor applications

In rotating machinery applications, the filtering system, typically a set of filter elements arranged in a suitable manner, are an important part of the whole turbine/compressor system. The development of turbine machinery used for energy production or others has led to more sophisticated equipment and therefore the importance of good protection of these systems has become more important in the recent years. It is known that particulate contamination can deteriorate a turbine power system quite substantially if not taken care of.

This event is often described as “erosion”, “fouling” and “hot corrosion” where salt and other corrosive particles are known as potential problems. Other particulate matters may also cause significant reduction of efficiency of the systems. It is important to understand that air filter devices in such systems are located in various environmental conditions. The range of climate and particulate contamination is very wide, ranging from deserts to humid rain forests to arctic environments. The requirements on these filter systems are obviously different depending on where they will be operating.

ISO 29461 has based the performance of the air intake filter systems not only upon heavy dust collection but also particulate efficiency in a size range that is considered to be the problematic area for these applications. Both ultra-fine and fine particles, as well as larger particles, should be considered when evaluating turbine fouling. In typical outdoor air, ultra-fine and fine particles in the size range from 0,01 µm to 1 µm contribute to >99 % of the number concentration and to >90 % of the surface contamination. The majority of the mass normally comes from larger particles (>1,0 µm).

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e810401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

Turbo-machinery filters comprise a wide range of products from filters for very coarse particles to filters for very fine, sub-micron particles. The range of products varies from self-cleaning to depth and surface loading systems. The filters and the systems have to withstand a wide temperature and humidity range, very low to very high dust concentration and mechanical stress. The shape of products existing today can be of many different types and have different functions such as droplet separators, coalescing products, filter pads, metal filters, inertial filters, filter cells, bag filters, panel-type, self-cleanable and depth loading filter cartridges and pleated media surface filter elements.

ISO 29461 will provide a way to compare these products in a similar way and define what criteria are important for air filter intake systems for rotary machinery performance protection. The performance of products in this broad range must be compared in a good manner. Comparing different filters and filter types must be done with respect to the operating conditions they finally will be used in.

For instance, if a filter or a filter system is meant to operate in an extreme, very dusty environment, the real particulate efficiency of such a filter cannot be predicted because the dust loading of the filter plays an important role. ISO 29461-2 will address the performance of cleanable and surface loading filters.

0.2 Filtration characteristics

Initiatives to address the potential problems of particle re-entrainment, shedding and the in-service charge neutralization characteristics of certain types of media have been included in Annexes A and B.

Certain types of filter media rely on electrostatic effects to achieve high efficiencies at low resistance to airflow. Exposure to some types of challenge, such as combustion particles or other fine particles, may inhibit such charges with the result that filter performance suffers. The normative test procedure, described in Annex A, provides techniques for identifying this type of behaviour. This procedure is used to determine whether the filter particulate efficiency is dependent on the electrostatic removal mechanism and to provide quantitative information about the importance of the electrostatic removal. The procedure was selected because it is well established, reproducible, relatively fast and easy to perform.

In an ideal filtration process, each particle would be permanently arrested at the first contact with a filter fibre, but incoming particles may impact on a captured particle and dislodge it into the air stream. Fibres or particles from the filter itself could also be released, due to mechanical forces. From the user’s point of view it might be important to know this, see Annex B.

© ISO 2013 – All rights reserved

Filters with a low initial or conditioned particulate efficiency (<35 %) for sub-micron particles (0,4 µm) that do not increase their efficiency during the operation will typically not provide any major protection for the operating machinery when challenged with typical atmospheric aerosols where the majority of particles are smaller than 1,0 µm. However, in some cases with aerosols having a dominant fraction of coarse particles, filters with low efficiencies at sub-micron particles can serve as a protection for later filter stages and can also have a higher average particulate efficiency (e.g. surface loading filters) at 0,4 µm due to the dust loading. Therefore a gravimetric test can provide some information about capacity and gravimetric efficiency for those aerosols. In general, a lower total filtration level than 35 % at 0,4 µm should not be recommended for an air intake filter system for rotary machinery when the aerosol loading of the filters are not contributing to a significant increase of the efficiency during the operation.

0.3 Organization of ISO 29461

The methods and procedures for determining particulate efficiency, pressure drop and the corresponding reporting formats are the same for all types of static filter element.

The test methods concerning particulate efficiency, pressure drop and reported values are the same for all filters, except for loading characteristics and cleaning procedure, which are different for cleanable surface loading filters. These filters incorporate cleaning procedures and have different loading characteristics; therefore, they require appropriately modified test methods, which will be defined in Part 2.

Part 3 will provide methods for determining the mechanical integrity of filters under conditions that may be encountered in abnormal operating environments.

Part 4 will describe methods of testing installed filters under in-service operating conditions (*in situ* testing).

Part 5 will cover test methods for the specific requirement of offshore and marine application, and specify methods for determining the sea salt removal efficiency of individual filters and/or complete filter systems.

Part 6 will cover test methods for cleanable filter elements, and will not cover the system testing (e.g. cleaning device) as in Part 2.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

This part of ISO 29461 describes the test methods for static filter units, typically of the depth loading type (see definitions 3.43 and 3.44). All filters can be tested in the same manner, thus obtaining comparable results. However, for surface loading filters, reverse pulse filters, marine and offshore filter systems, as well as other filter systems that are not regarded as static filter units, the appropriate part shall be used.

For multi-stage systems that use a number of components (e.g. equipment for cleaning, filters), this part of ISO 29461 may be used as long as the qualification requirements of the test rig can be fulfilled. In cases where this is not possible, Part 4 (*in situ* testing) procedures may be applied.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

Air intake filter systems for rotary machinery — Test methods —

Part 1:
Static filter elements

1 Scope

ISO 29461 specifies methods and procedures for determining the performance of particulate air filters used in air intake filter systems for rotary machinery such as stationary gas turbines, compressors and other stationary internal combustion engines. It applies to air filters having an initial particle efficiency up to 99,9 % with respect to 0,4 µm particles. Filters with higher initial particle efficiencies are tested and classified according to other standards (e.g. EN 1822). These procedures are intended for filters which operating at flow rates within the range 0,25 m^3/s (900 m^3/h) up to 1,67 m^3/s (6000 m^3/h).

This part of ISO 29461 refers to static (barrier) filter systems but can be applied to other filter types and systems in appropriate circumstances.

Two methods of determining the efficiency are used in this part of ISO 29461:

iTeh STANDARD PREVIEW
(standards.iteh.ai)

— particulate efficiency (measured with respect to particle number and size);

— gravimetric efficiency (percentage weighted mass removal of loading dust).

ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

Also a flat sheet media sample or media pack sample from an identical filter is conditioned (discharged) to provide information about the intensity of the electrostatic removal mechanism.

After determination of its initial particle efficiency, the untreated filter is loaded with dust in steps until its final test pressure drop is reached. Information on the loaded performance of the filter is then obtained.

The performance results obtained in accordance with this part of ISO 29461 cannot be quantitatively applied (by themselves) to predict performance in service with regard to efficiency and lifetime. Other factors influencing performance to be taken into account are described in the annexes.

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.

ISO 2854, *Statistical interpretation of data — Techniques of estimation and tests relating to means and variances*

ISO 5167 (all parts), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full*

ISO 12103-1, *Road vehicles — Test dust for filter evaluation — Part 1: Arizona test dust*

ISO 14644-3:2005, *Cleanrooms and associated controlled environments — Part 3: Test methods*

ISO 21501-1, *Determination of particle size distribution — Single particle light interaction methods — Part 1: Light scattering aerosol spectrometer*

ISO 21501-4, *Determination of particle size distribution — Single particle light interaction methods — Part 4: Light scattering airborne particle counter for clean spaces*

© ISO 2013 – All rights reserved

ASHRAE 52.2:1999, *Method of testing general ventilation air-cleaning devices for removal efficiency by particle size*

IEST-RP-CC014, *Calibration and Characterization of Optical Airborne Particle Counters*

JIS Z 8901:2006, *Test powders and test particles*

JACA No.37:2001, *Guideline of Substitute Materials for DOP*

3 Terms and definitions

3.1
test airflow rate
volumetric airflow rate used for testing

[Source: ISO 29464:2011; 3.1.106]

3.2 Velocity

3.2.1
filter face velocity
airflow rate divided by the filter face area

[Source: ISO 29464:2011, 3.1.84]

3.2.2
media velocity
airflow rate divided by the effective filtering area

Note 1 to entry: Expressed at an accuracy of three significant figures.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

3.3 Efficiency

3.3.1
particulate efficiency
percentage particulate removal efficiency of the filter at specified particle sizes measured with a particle counter in the range of 0,3 µm to 3,0 µm

3.3.2
initial efficiency
particulate efficiency of the clean filter operating at the test airflow rate

Note 1 to entry: A clean filter is a filter not exposed to any test aerosol or substance prior to the efficiency test.

3.3.3
minimum efficiency
lowest particulate efficiency of initial, conditioned or dust loaded efficiencies

3.3.4
conditioned efficiency
efficiency of the conditioned filter media (per Annex A) operating at an average media velocity corresponding to the test airflow rate in the filter

3.3.5
gravimetric efficiency
A_{50}
weighted (mass) removal of loading dust after 50 g of dust load

3.3.6
average gravimetric efficiency
A_{avg}
ratio of the total amount of loading dust retained by the filter to the total amount of dust fed up to final test pressure drop

3.3.7
dust loaded efficiency
efficiency of the filter operating at test flow rate and after dust loadings up to final test pressure differential

3.4
penetration
ratio of the particle concentration detected downstream versus the concentration upstream of the filter

3.5 Pressure drop (differential pressure)

3.5.1
initial pressure drop
pressure drop of the clean filter operating at the test airflow rate

3.5.2
final test pressure drop
maximum pressure drop of the filter up to which the filtration performance is measured

3.5.3
final test pressure drop – recommended
maximum operating pressure drop of the filter as recommended by the manufacturer at rated airflow

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

3.6 Filter area

3.6.1
filter face area
frontal face area of the filter including the header frame

[Source: ISO 29464:2011, 3.1.83]

Note 1 to entry: Typical nominal values: 0,610 m × 0,610 m (24 in × 24 in).

3.6.2
effective filtering area
area of filter medium in the filter which collects dust

[Source: ISO 29464:2011; 3.1.79]

3.7 Filters

3.7.1
static filter
air filter that will be removed (exchanged) after it has reached its final test pressure drop and that is not cleaned with jet pulses or other means in order to fully, or partially, retrieve its initial performance (pressure drop and efficiency)

3.7.2
pulse jet filter
cleanable air filter, that typically is cleaned with air jet pulses to provide a longer service life

3.7.3
surface loading filter
filter in which the dust is collected on the surface of the filter medium

3.7.4
depth loading filter
filter in which particles penetrate into the filter medium and are collected on the fibres in the depth of the filter medium

3.7.5
low efficiency filter
air filter with an initial particulate efficiency at 0,4 µm particles in the range $E < 35$ %

3.7.6
medium efficiency filter
air filter with an initial particulate efficiency at 0,4 µm particles in the range 35 % $\leq E \leq$ 85 %

3.7.7
high efficiency filter
air filter with an initial particulate efficiency at 0,4 µm particles in the range $E \geq 85$ %

3.7.8
EPA filter
air filter with a particulate efficiency at most penetrating particle size (MPPS) in the range 85 % $\leq E \leq$ 99,95 % (typically 0,05 µm to 0,3 µm size range)

3.7.9
final filter
air filter used to collect the loading dust passing through or shedding from the filter under test

[Source: ISO 29464:2011; 3.1.86]

iTeh STANDARD PREVIEW
(standards.iteh.ai)

3.7.10
charged filter
filter in which the medium is electrostatically charged or polarized

ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

[Source: ISO 29464:2011; 3.1.75]

3.7.11
untreated filter
air filter not submitted to conditioning per Annex A

3.8 Test aerosol

3.8.1
test aerosol
aerosol used for determining the particulate efficiency of the filter

3.8.2
particle size
geometric diameter (equivalent spherical, optical or aerodynamic, depending on the context) of the particles of an aerosol

[Source: ISO 29464:2011; 3.1.126]

3.8.3
mean diameter
geometric mean value of the upper and lower border diameters in a size range

3.8.4
particle number concentration
number of particles per unit volume of air

© ISO 2013 – All rights reserved

3.8.5
neutralization
action of bringing the aerosol to a Boltzmann charge equilibrium distribution with bipolar ions

3.9 Test dust

3.9.1
loading dust
synthetic test dust
synthetic dust formulated specifically for determination of the test dust capacity and arrestance of air filters

3.9.2
test dust capacity
dust loading capacity
TDC
amount of loading dust held by the filter at final test pressure drop

3.10 Particle sampling

3.10.1
isokinetic sampling
technique for air sampling such that the probe inlet air velocity is the same as the velocity of the air surrounding the sampling point

[Source: ISO 29464:2011; 3.1.144]

iTeh STANDARD PREVIEW
(standards.iteh.ai)

3.10.2
counting rate
number of counting events per unit time

ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

[Source: ISO 29464:2011; 3.1.41]

3.10.3
correlation ratio
downstream particle concentration divided by the upstream particle concentration (measured without filter)

[Source: ISO 29464:2011; 3.1.26]

3.11 Particle shedding

3.11.1
shedding
release to the airflow of particles due to particle bounce and re-entrainment effects and to the release of fibres or particulate matter from the filter or filtering material

[Source: ISO 29464:2011; 3.1.150]

3.11.2
particle bounce
behaviour of particles that impinge on the filter without being retained

[Source: ISO 29464:2011; 3.1.121]

3.11.3
re-entrainment
release to the airflow of particles previously collected on the filter

[Source: ISO 29464:2011; 3.1.142]

© ISO 2013 – All rights reserved

4 Symbols and abbreviated terms

A_{50}	gravimetric efficiency after 50 g dust load, %
A_{avg}	average gravimetric efficiency %
CL	concentration limits of particulate counter
C_{V}	coefficient of variation
$C_{\mathrm{V,i}}$	coefficient of variation in size range “i”
$C_{\mathrm{mean,i}}$	mean of measuring points value for size range “i”
CL_{E}	lower confidence limit of particulate efficiency (95 % confidence level)
$\overline{CL_{\mathrm{E}}}$	average lower confidence limit of particulate efficiency (95 % confidence level). Average value from repeated measurement cycles for one efficiency calculation
CL_{Nd}	upper confidence limit (95 %) of number of particles downstream of the filter
CL_{Nu}	lower confidence limit (95 %) of number of particles upstream of the filter
d_{i}	geometric mean of a size range, µm
d_{l}	lower border diameter in a size range, µm
d_{u}	upper border diameter in a size range, µm
DR	dilution ratio, when diluter is used
$\bar{E}_{\mathrm{i}}$	average particulate efficiency in a size range “i”
m	mass passing the filter, g
m_{d}	mass of dust downstream of the test filter, g
m_{50}	mass of dust fed to filter in order to test gravimetric efficiency (50 g), g
m_{p50}	mass of dust that has passed the filter (the mass gain of final filter and the dust in the duct between the filter and the final filter) after 50 g of dust loading
m_{tot}	cumulative mass of dust fed to filter, g
m_1	mass of final filter before dust increment, g
m_2	mass of final filter after dust increment, g
N	number of points
N_{d}	number of particles downstream of the filter
$N_{\mathrm{d,i}}$	number of particles in size range “i” downstream of the filter
$\bar{N}_{\mathrm{d}}$	average number of particles downstream of the filter
N_{u}	number of particles upstream of the filter
$N_{\mathrm{u,i}}$	number of particles in size range “i” upstream of the filter

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013

© ISO 2013 – All rights reserved

$\overline{N}_u$	average number of particles upstream of the filter
n	exponent
p	pressure, Pa
p_a	absolute air pressure upstream of filter, kPa
p_{sf}	airflow meter static pressure, kPa
q_m	mass flow rate, kg/s
q_V	airflow rate at filter, m^3/s
q_{Vf}	airflow rate at airflow meter, m^3/s
R	correlation ratio
R_i	correlation ratio for size range “i”
T	temperature upstream of filter, °C (°F)
T_f	temperature at airflow meter, °C (°F)
$t_{(1-\alpha/2)}$	distribution variable
U	uncertainty, % units
v_{mean}	mean value of velocity
δ	standard deviation
ν	number of degrees of freedom
ρ	air density, kg/m^3
φ	relative humidity upstream of filter, %
Δm	dust increment, g
Δm_{ff}	mass gain of final filter, g
Δp	filter pressure drop, Pa
Δp_f	Differential pressure, Pa
$\Delta p_{1,20}$	filter pressure drop at air density 1,20 kg/m^3, Pa
ΔE_C	difference in particulate efficiency between initial particulate efficiency (E_0) of media sample and conditioned efficiency (media samples) per Annex A
OPC	optical particle counter
DEHS	liquid (DiEthylHexylSebacate) used for generating the DEHS test aerosol
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASTM	American Society for Testing and Materials

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 29461-1:2013
https://standards.iteh.ai/catalog/standards/sist/8e8f0401-d28c-4d6d-8c86-1ca9c6c00e29/iso-29461-1-2013