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Air intake filter systems for rotary machinery — Test methods —

Part 2: Filter element endurance test in fog and mist environments

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

Partie 2: Essai d'endurance d'élément filtrant en brouillard et environnement brumeux

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 195, *Cleaning equipment for air and other gases*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 29461 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 29461 series provides a way to compare these products in a similar method and define what criteria are important for air intake filter systems for rotary machinery performance protection. The aim is to compare the performance of different filters and filter types with respect to the operating conditions in which they will be finally used.

Air intake filter system of rotary machinery is an important part of the whole gas turbine and air compressor systems. It usually consists of filter elements with a suitable way to be installed. The operating environment of rotary machinery including gas turbine and compressor and their air intake filtration units are complicated and challenging. Air filters intercept water mist and droplets when air passes through the air filter unit in case the equipment is working in rainy, foggy, hazy or other high-humidity environments or a local production environment which contains a large amount of water vapour, e.g. the cooling tower. If excessive water holds up, the performance of filters can be affected; pressure drop rises rapidly, causing a shut down in severe cases.

Reliability and non-break down operation of rotary machinery are regarded as a top priority for the end users, with the rapidly rising pressure drop under high-humidity conditions usually being their main concern. There are rotary machinery operating accidents caused by high-humidity conditions all over the world, whether it be inland or along the river or coastal.

To meet the requirements of production and operation, the water endurance performance of air filter elements needs to be considered besides assessing the performance of initial pressure drop, filtration efficiency and dust-holding capacity, especially when the air filter elements are used in high-humidity environments or intake air contains a large quantity of liquid droplets.

This document provides a water endurance test method for filter elements and can be used for evaluating performance variation trends of filter elements when encountering water and fog. This document can be used for:

— product development for filter manufacturers;

— supplier selection for end users;

— development of water endurance media by media manufacturers.

This document provides a repeatable, easy-to-conduct and economical test method, which is applicable to pulse-jet cleaning filter elements and filter elements for general ventilation.

Air intake filter systems for rotary machinery — Test methods —

Part 2: Filter element endurance test in fog and mist environments

1 Scope

This document specifies general test requirements, the test rig and equipment, the test materials and the test procedure and report for determining water endurance performance of air filter elements used in air intake filter systems for rotary machinery such as stationary gas turbines, compressors and other stationary internal combustion engines.

The test evaluates water endurance performance of air filter elements under laboratory conditions. The performance results obtained in accordance with this document cannot be quantitatively applied (by themselves) to predict performance in service with regard to water endurance and lifetime.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 16890-2:2022, *Air filters for general ventilation — Part 2: Measurement of fractional efficiency and air flow resistance*

3 Terms and definitions

For the purposes of this document the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Air flow and pressure drop

3.1.1
air flow rate
volume of air flowing through the filter per unit time

[SOURCE: ISO 29464:2017, 3.1.24]

3.1.2
test air flow rate
volumetric airflow rate used for testing

[SOURCE: ISO 29464:2017, 3.3.2]

3.1.3
pressure drop
difference in absolute (static) pressure between two points in a system

Note 1 to entry: Resistance to air flow is measured in Pa.

[SOURCE: ISO 29464:2017, 3.1.36]

3.1.4
initial pressure drop
pressure drop (3.1.3) of the clean filter operating at the test airflow rate

[SOURCE: ISO 29464:2017, 3.3.17]

3.1.5
final test pressure drop
maximum *pressure drop* (3.1.3) of the filter up to which the filtration performance is measured

[SOURCE: ISO 29464:2017, 3.3.15]

3.2 Filters

3.2.1
test device
filter element (3.2.2) being subjected to performance testing

[SOURCE: ISO 29464:2017, 3.1.38]

3.2.2
filter element
structure made of the filtering material, its supports and its interfaces with the filter housing

[SOURCE: ISO 29464:2017, 3.2.77]

3.2.3
upstream
area or region from which fluid flows as it enters the *test device* (3.2.1)

[SOURCE: ISO 29464:2017, 3.1.39]

3.2.4
downstream
area or region into which fluid flows on leaving the *test device* (3.2.1)

[SOURCE: ISO 29464:2017, 3.1.11]

3.2.5
static filter
air filter that will be removed (exchanged) after it has reached its *final test pressure drop* (3.1.5) 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)

[SOURCE: ISO 29464:2017, 3.3.12]

3.2.6
pulse jet filter
cleanable air filter, that typically is cleaned with air jet pulses to provide a longer service life

[SOURCE: ISO 29464:2017, 3.3.11]

3.3
test duration
period of reaching a certain *pressure drop* (3.1.3) or other termination conditions to end the test

3.4 Test materials

3.4.1
water fog
water droplets and mist generated by water spray device

3.4.2
saturated air
air that contains the maximum amount of water vapour it can hold at its temperature and pressure

3.4.3
water fog mass concentration
mass of liquid water droplets per unit volume of air

3.5
two-fluid nozzle
nozzles capable of spraying fine mists by mixing fluid and air at the same time

3.6
coefficient of variation
CV
standard deviation of a group of measurements divided by the mean

[SOURCE: ISO 29464:2017, 3.2.31]

4 Symbols and abbreviated terms

c_{wm}	water fog mass concentration, g/m^3
d	saturated wet air moisture content, g/kg
d_0	ambient air moisture content, g/kg
m_p	water mass penetrated through tested filter at the end of the test, kg
m_{tot}	total water fog generation amount, kg
m_u	sedimentary water mass upstream of filter, kg
m_{wm}	total water fog generation amount per hour, kg/h
$m_{wm,\ 1}$	water fog generation amount per hour at saturated humidifying air, kg/h
$m_{wm,\ 2}$	water fog generation amount per hour, kg/h
p	atmospheric pressure, Pa
p_a	absolute air pressure upstream of filter, Pa
p_w	partial vapour pressure of water in air, Pa
p_{ws}	saturated vapour pressure of humidifying air, Pa
q_v	volumetric flow of non-humidifying air, m^3/h
t_d	temperature downstream of filter, °C

t_0	dry bulb temperature of ambient air, °C
t_u	temperature upstream of filter, °C
t_{wb}	wet bulb temperature of ambient air, °C
T	testing time, min
T_{tot}	total testing time, min
Δp_b	filter initial pressure drop at the test air flow rate, Pa
Δp_f	filter final test pressure drop at the test air flow rate, Pa
Δp_T	filter pressure drop at the test air flow rate at the T time after spraying, Pa
η_p	water penetration ratio
ρ	ambient air density, kg/ m^3
ρ_a	air density upstream of filter, kg/m^3
ρ_s	saturated wet air density, kg/m^3
φ	relative humidity, %
φ_u	relative humidity upstream of filter, %
φ_d	relative humidity downstream of filter, %
CV	coefficient of variation

5 General requirements

Air filter systems normally use multiple stages of coarse and fine filter elements to protect the machinery. The scope of this document includes methods for a water endurance test of individual filter elements. It does not include methods for the direct measurement of the performance of entire systems as installed in service except in cases where they can meet the qualification criteria for the test assembly.

The test client can refer to the test results to rank the water endurance performance of multiple candidate filters.

6 Test conditions

6.1 Test air

Room air or outdoor air is used as the test air source. The air temperature shall be in the range of 10 °C to 38 °C (before wet equilibrium pre-treatment). The exhaust flow shall be discharged outdoors, indoors or re-circulated. Filtration of the exhaust flow is recommended when the test aerosol or loading dust is present.

6.2 Test water

The test water pH value shall be in the range of 6 to 8; alkalinity shall be no more than 50 mg/l; full hardness shall be no more than 70 mg/l. The temperature of the test water shall not be higher than the temperature of the test air.

7 Test rig and equipment

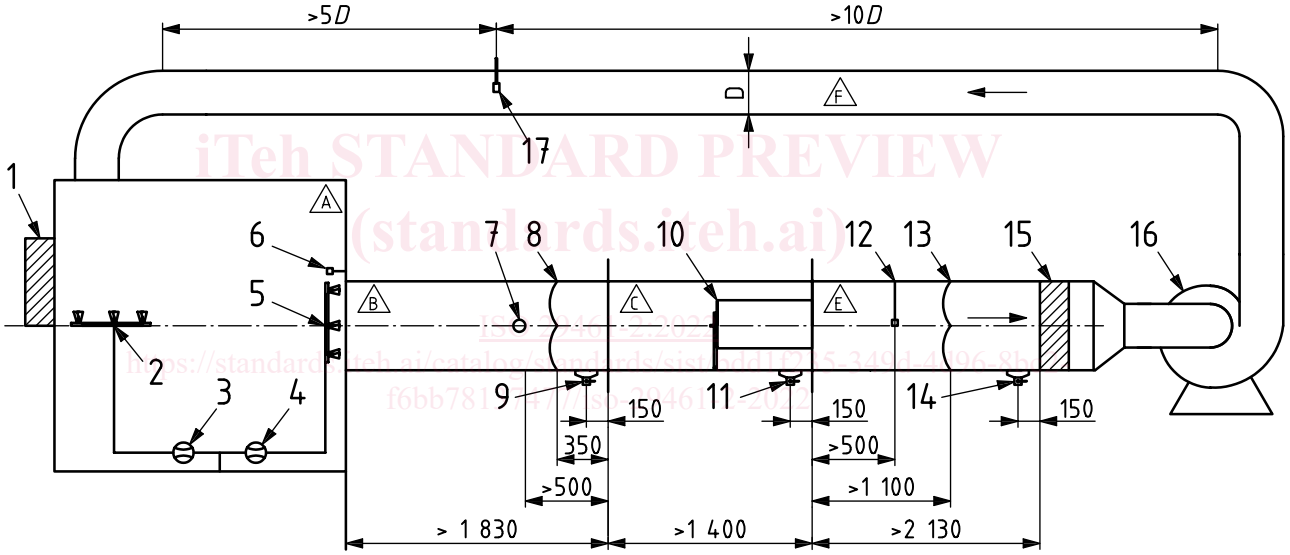
7.1 Test rig

The test rig consists of several square duct sections with typical 610 mm × 610 mm nominal inner dimensions except for the section where the filter is installed. This section has nominal inner dimensions between 616 mm and 622 mm. The length of this duct section shall be at least 1,1 times the length of the filter, with a minimum length of 1,5 m. A schematic diagram of the test rig is shown in Figure 1.

The test rig can be operated either in a negative or positive pressure air flow arrangement; and negative pressure operation is recommended. The test duct shall be sealed well to avoid water fog leakage if operated in positive pressure. A condensed water borehole should be provided at the lowest point in the fan housing in the event of formation of condensation.

The duct material shall be electrically conductive and electrically grounded and shall have a smooth interior finish and be sufficiently rigid to maintain its shape at the operating pressure. Smaller parts of the test duct can be made in glass or plastic to expose the filter and equipment to view. Provision of windows to allow monitoring of test progress is desirable.

Dimensions in millimetres



Key

A	duct section of the test rig (inlet plenum)	7	example of water droplet size instrument location
B	upstream duct section of the test rig	8	upstream pressure measuring point
C	duct section of filter to be tested	9	upstream water collecting groove
D	diameter of recirculated duct	10	filter to be tested
E	downstream duct section of the test rig	11	midstream water collecting groove
F	recirculated duct section of the test rig	12	downstream measuring point of temperature and humidity (secondary)
1	HEPA filter	13	downstream pressure measuring point
2	humidifying device	14	downstream water collecting groove
3	water mass flow metering device	15	final filter - eliminate water
4	water mass flow metering device	16	frequency converted fan
5	water spray device	17	air flow measuring point
6	upstream measuring point of temperature and humidity (primary)		

Figure 1 — Schematic diagram of the test rig

7.2 Water spray device

The water spray device is used to generate uniform water fog continuously to feed the filter to be tested during the test.

A two-fluid nozzle is recommended; and the spraying direction with respect to the inlet air flow shall be the same. The distance between the nozzle orifices and the duct section of filter to be tested shall be no less than 1 m.

The water fog particle can be adjusted by compressed air, or other means as called out by the nozzle manufacturer. The cumulative volume of water fog particles in the size range of 5 µm to 30 µm shall be more than 90 % of the total water fog volume.

Other types of water spray devices, such as ultrasonic humidifier and nozzle humidifier, can be used if these devices can achieve the same performance.

7.3 Humidifying device

The humidifying device shall maintain the required humidity in the test duct, which can be used for wet equilibrium pre-treatment. The optional humidifying devices, such as ultrasonic humidifier and atomizer, shall meet the requirements of 8.5.

7.4 Water collecting groove

The water collecting grooves shall be installed at the bottom of upstream and downstream of tested filter to collect water during the test.

8 Qualification of test rig and apparatus

8.1 Pressure system test

Carry out the pressure system test in accordance with ISO 16890-2:2022, 8.2.1.

8.2 Air leakage test

Carry out the air leakage test in accordance with ISO 16890-2:2022, 8.2.8.

8.3 Air velocity uniformity in the test duct

Carry out the air velocity uniformity test in the test duct in accordance with ISO 16890-2:2022, 8.2.9.

8.4 Pressure drop of test duct with no test filter installed

Carry out the test of pressure drop of test duct with no test filter installed in accordance with ISO 16890-2:2022, 8.2.12.

8.5 Stability of wet environment

The temperature measuring instrument used shall be capable of measuring temperature with an accuracy of ±1 °C. The relative humidity measuring instrument used shall be capable of measuring the relative humidity with an accuracy of ±2 %. The equipment shall be calibrated at regular intervals to ensure the required accuracy.

Turn on the humidifying device until the measured relative humidity of the upstream and downstream test duct exceeds 95 % at the qualification air flow rate of 3 400 m^3/h. Start to record the temperature and relative humidity of the upstream and downstream test duct every 2 min. The total test time is 30 min.