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Mining — Air quality control systems for operator enclosures — Performance requirements and test methods

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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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 82, *Mining*.

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

Safety in mining operations is of concern to all involved in owning, developing, managing, and working in mining environments. Routine mining activities can generate airborne particulates which are hazardous to human health. Therefore, it is necessary to develop controls which limit the operator's exposure to airborne particulates while operating equipment from within the operator enclosure. With the rise in the number of countries regulating air quality in mining, construction, and industrial environments, machine manufacturers have become increasingly aware of the need for standard practices in the design and performance of operator enclosures. This document seeks to address the fundamental design requirements that will allow for operator enclosures to perform at a level that provides sustained air quality, reducing concentrations of respirable particulate matter and carbon dioxide that are harmful to human health. The emphasis of this document is in three areas: 1) design, 2) air quality control system performance testing, and 3) maintenance and operation instruction for the operator enclosure.

All operator enclosures, either on new machines or existing machines currently in operation, meeting the requirements of this document are expected to provide consistent air quality performance. The technical aspects of an operator enclosure are universal as are the design and performance testing methods. Therefore, every attempt has been made to make this an inclusive document which addresses the needs of fixed and mobile operator enclosures.

This document was developed to provide for the occupational health and safety of personnel who work inside operator enclosures. It primarily addresses air quality concerns by establishing parameters to determine air quality control system effectiveness. The control of these airborne contaminants is through an effective air quality control system (for both external air and recirculated air), dilution of CO_2, routine testing of the air within the operator enclosure, and effective maintenance throughout the life cycle of the operator enclosure. Extensive research and subsequent publications have produced a substantial body of knowledge around the air quality control systems and are the basis of this document. See Bibliography.

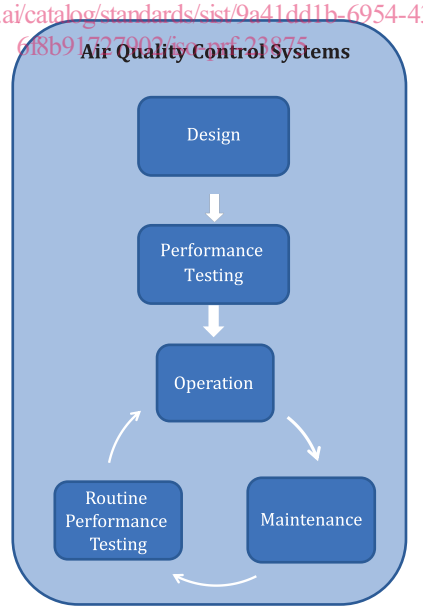


Figure 1 — Air quality control system life cycle

As illustrated in Figure 1, this document presents a life cycle approach to operator enclosure air quality control system design, performance testing, and maintenance.

Mining – Air quality control systems for operator enclosures – Performance requirements and test methods

1 Scope

This document specifies performance and design requirements for air quality control systems for operator enclosures and their monitoring devices. The design specifications are universal in their application and do not contemplate specific mining environments. They are intended to meet identified parameters of both pressurization and respirable particulate and carbon dioxide concentrations. This document also specifies test methods to assess such parameters and provides operational and maintenance instructions. Recommendations are made for operational integration of the air quality control system.

Gases and vapours that can be a hazard in the work environment outside of the operator enclosure are excluded from this document.

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 18158, *Workplace air — Terminology*

ISO 29463-1:2017, *High efficiency filters and filter media for removing particles from air — Part 1: Classification, performance, testing and marking*

ISO 29463-2, *High-efficiency filters and filter media for removing particles in air — Part 2: Aerosol production, measuring equipment and particle-counting statistics*

ISO 29463-3, *High-efficiency filters and filter media for removing particles in air — Part 3: Testing flat sheet filter media*

ISO 29463-4:2011, *High-efficiency filters and filter media for removing particles in air — Part 4: Test method for determining leakage of filter elements - Scan method*

ISO 29463-5:2011, *High-efficiency filters and filter media for removing particles in air — Part 5: Test method for filter elements*

ISO/IEC 17000, *Conformity assessment — Vocabulary and general principles*

ISO/IEC 17050-1, *Conformity assessment — Supplier's declaration of conformity — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 17000, ISO 18158, ISO 29463-1 and the following apply.

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

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

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

3.1 Terms related to air quality

3.1.1
airborne particle
airborne particulate
fine matter, in solid or liquid form, dispersed in air

[SOURCE: ISO 18158:2016, 2.1.2.3, modified — The preferred term "airborne particulate" has been added.]

3.1.2
hazardous to human health
in such a quantity and/or quality of *airborne particulates* (3.1.1) or CO_2 (3.1.7) or noise, that it has adverse health effects

3.1.3
contaminated environment
area where *airborne particulates* (3.1.1) *hazardous to human health* (3.1.2) are present in the ambient air

3.1.4
breathing zone
air space around the worker's face from where they take their breath

3.1.5
ambient CO_2 level
CO_2 (3.1.7) concentration present in the air outside of the *operator enclosure* (3.2.1), to which people can be exposed

3.1.6
respirable particulate matter
materials that are deposited in the gas-exchange region of the lungs

Note 1 to entry: The median cut point for respirable particulate matter is 4,0 µm, according to ISO 7708:1995.

3.1.7
CO_2
carbon dioxide emitted as a by-product of human respiration

3.2 Terms related to the operator enclosure design

3.2.1
operator enclosure
structure that completely surrounds the operator, preventing the free passage of *external air* (3.2.7), dust or other substances into the area around the operator

[SOURCE: ISO 10263-4:2009, 3.1, modified – "part of the machine which" has been replaced with "structure that".]

3.2.2
air quality control system
operator enclosure (3.2.1) that includes structural components, *external air* (3.2.7) and recirculation air systems designed to protect an operator from environmental factors such as dust, heat, cold, wind, and *airborne particulates* (3.1.1) *hazardous to human health* (3.1.2)

3.2.3
sustained quality
quality achieved through designs that work together to create an effective *air quality control system* (3.2.2) that allows *operator enclosure* (3.2.1) pressure and effective filtration to be maintained continuously between *planned maintenance intervals* (3.2.4)

3.2.4
planned maintenance interval
interval when routine maintenance is performed

3.2.5
operator enclosure pressurization
situation when the *operator enclosure* (3.2.1) *external air* (3.2.7) intake is greater than the operator enclosure leakage

3.2.6
operator enclosure work environment
space inside the *operator enclosure* (3.2.1)

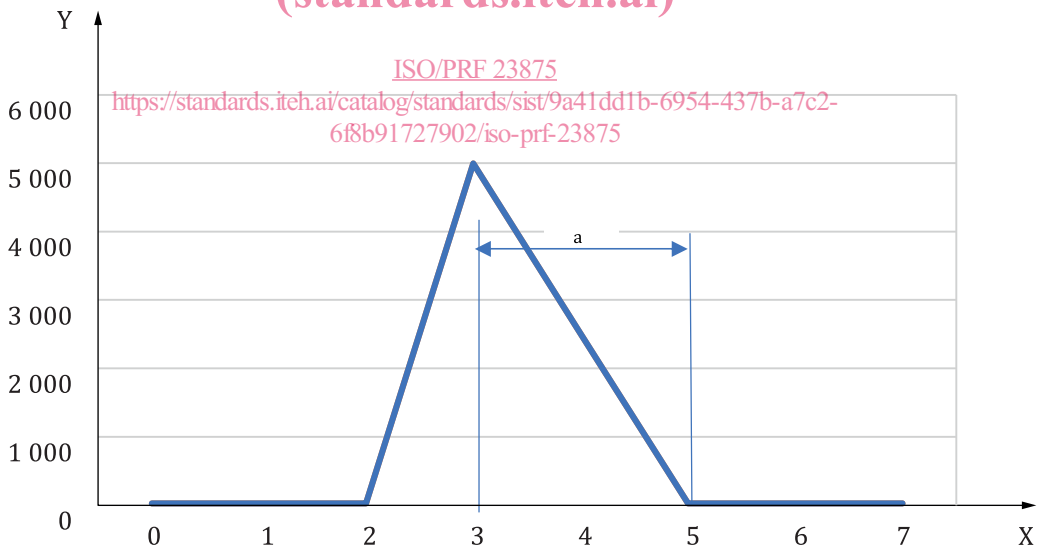
3.2.7
external air
controlled air entering the system or opening from outdoors before any air treatment

[SOURCE: ISO 16818:2008, 3.97]

3.3 Terms related to measurement

3.3.1
decay time
time that it takes for the *airborne particles* (3.1.1) to be removed from the air inside the *operator enclosure work environment* (3.2.6)

Note 1 to entry: See Figure 2.



Dust concentration within the operator enclosure starts at 7 µg/m^3 and at the 2-minute interval it begins to rise. At the 3-minute interval it peaks at 5 000 µg/m^3, and at the 5-minute interval it returns to 7 µg/m^3. In this example, the decay time is two minutes.

Key

X time, min
Y concentration, µg/m^3
[a] 2 min

Figure 2 — Decay time — Example

4 Requirements

4.1 Performance requirements

The air quality control system objective is to prevent ingress of respirable particulate matter from the contaminated environment, through means of filtration and operator enclosure pressurization. The air quality control system shall meet the following performance requirements.

a) The maximum sustained CO_2 shall be the ambient level of CO_2 + 400 ppm, refer to Annex A for further information.

b) At the start and the end of the decay test, the maximum respirable particulate matter concentration shall be ≤25 µg/m^3.

c) The respirable particulate decay time shall be of 120 s maximum.

d) The minimum sustained pressurization, when the machine starting device is in the “on” position (activating the electrical system) shall be ≥ 20 Pa.

e) The maximum sustained pressurization shall not exceed 200 Pa.

4.2 Engineering design

4.2.1 Operator enclosure

The following requirements shall be met.

a) The machinery safety standard for the specific machine type shall be consulted when designing or retrofitting an operator enclosure to a machine.

b) If the operator enclosure is built on the machine, the interface with the machine frame shall be properly sealed to ensure that there are no leakage points created under vibration during machine operations.

c) Operator ingress, egress, and field of view, and operator enclosure serviceability and maintainability, shall be considered when retrofitting an operator enclosure with an air quality control system.

d) Operator roll over protective structures (ROPS) and falling-object protective structures (FOPS), or other protective structure systems, shall not be modified without permission from the machine manufacturer.

e) Consideration should be given to materials used in the enclosure to ensure that they do not accumulate particulate and are easily cleaned. Operator seats should be covered in a smooth, easily cleaned material, for example vinyl.

f) Weld joints or connections in the engine exhaust system, which are prone to leakage over time, should not be near the external intake air system.

g) The operator enclosure shall be designed such that all ingress points are sealed so that the system holds pressure. All structural members, such as ROPS and FOPS, weld points, stitch welds, electrical and hydraulic penetrations, windows, etc. shall ensure that the operator enclosure holds pressure sufficiently to meet the minimum pressurization performance requirement, see 4.1 d), e).

h) Operator enclosures with air quality control system components and plumbing that are built with attachment to two different planes shall have means to relieve the vibration stress, for example by flexible connectors.

4.2.2 Air quality control system

4.2.2.1 General

The following shall be considered.

a) The ventilation system should allow for airflows to be directed away from the operator.

b) Air quality control systems components added to the operator enclosure should be fitted such as not to impede the field of view of the operator. If visual impediment is unavoidable, an assessment shall be performed to determine the best mitigation measures, for example through the use of cameras or mirrors.

c) The air quality control system shall not create levels of noise that are hazardous to human health or that contribute to existing sources of noise, generating levels hazardous to human health.

d) Filter maintenance intervals shall be considered in the design. Sustained quality requires that the prefilter be appropriately sized so that it does not require maintenance between the planned maintenance interval.

e) Prefilters or cyclonic precleaners are recommended to remove airborne particulates from the external air prior to the primary filter. This prolongs the service life of the filter and allows for the use of high efficiency filtration. The design solutions referenced in the list below are given in order of their effectiveness in providing sustained operator enclosure pressurization when operating in dust conditions typical of mining environments:

1) powered precleaner using an integrated powered cyclonic separator;

2) pressurizer blower using a non-powered cyclonic separator;

3) pressurizer blower using a prefilter;

4) heating ventilation air conditioning (HVAC) blower.

f) Leakage in low-pressure areas in the HVAC system and external filtration cause airborne particulates to flow directly into the operator enclosure without passing through the external air filter. Low pressure leakage can occur for a number of reasons, including the integrity of the external air seal, mounting surfaces, plastic and metal joints, ventilation tubing and attachments.

g) External air shall be ducted directly into the HVAC mixing plenum. Putting external air directly into the operator enclosure compromises the air quality in the operator enclosure by introducing humidity and/or heat/cold directly into the operator enclosure. This makes the operator enclosure the mixing plenum and compromises the air quality control system.

h) The air quality control system shall include a means to pressurize the operator enclosure.

i) External air devices, including the pressurization fan and all filters, shall be in place and switched on when the machine starting device is in the “on” position (activating the electrical system). This electrical configuration shall provide for continuous operator enclosure pressurization through the external pressurizer or through the HVAC blower. Continuous external air, through high efficiency filtration, prevents particulate ingress into the work environment.

j) When the machine starting device is in the “on” position (activating the electrical system), the air quality control system shall continuously bring external air into the HVAC mixing plenum to continuously dilute CO_2 concentrations. CO_2 levels in the air quality control system give a clear indication of sufficient air exchange. (See Annex A.)

4.2.2.2 External air and recirculation airflow systems

Air quality is directly related to the efficiency and integrity of the external air and recirculation airflow filtration systems. The following shall be considered.

a) The air quality control system shall be equipped with an external air filter and a recirculation airflow filter.

b) High efficiency filtration can restrict airflow, a factor that shall be taken into consideration in HVAC ventilation design.

NOTE The recirculation filter is the most effective means to rapidly remove the respirable airborne particulates from within the operator enclosure. High efficiency recirculation filtration allows the particulate to be removed with a single pass through the filter. The air volume of the operator enclosure can pass through the recirculation filter several times a minute. By removing the particulate in one pass through the recirculation filter, air quality is maintained.

c) The air quality control system's external air intake shall be installed so as to minimize ingress of the machine's exhaust emissions. Placement of the external air intake should take into consideration the exhaust emissions of other machines operating in close proximity.

d) In operator enclosure designs, ventilation should direct airflow from the top half of the operator enclosure to the bottom half of the operator enclosure. The airflow pattern in the operator enclosure is a major consideration in the design of the ventilation system. The filtered air coming from the HVAC should pass over the operator breathing zone and then down to the recirculation air intake. By placing the supply ventilation in the upper part of the operator enclosure and the return airflow in the lower part of the operator enclosure, below the seat index point (SIP) as defined in ISO 5353, the particles move in a downward direction, taking advantage of gravity. The location of the recirculation filter low in the operator enclosure allows particles that are brought into the operator enclosure on the boots and vestments of the operator to be drawn into the high efficiency recirculation filter without passing over the operator breathing zone. This factor should be considered in operator enclosure ventilation design. While all ventilation configurations might not follow this recommended airflow pattern, in all cases the operator enclosure air quality performance shall comply with the performance requirements. [See 4.1 a), b), c), d), e).]

e) External air filtration and recirculation air filtration shall be manufactured, tested, and classified in accordance with ISO 29463–1, ISO 29463–2, ISO 29463–3, ISO 29463–5 and ISO 29463-4: 2011, F.1 to F.5.

f) All filters shall be marked with their filter classification.

g) Filters shall be labelled in accordance with ISO 29463-1:2017, 9.1 a), b), c), d) e), f). If applicable, ISO 29463-5: 2011, Clause B.5, shall be included as a separate document in the filter packaging. Use of a machine-readable optical label (e.g. matrix barcode) on the filter label is recommended to allow for retrieval of the filter label information.

4.2.3 Filters and filter housings

4.2.3.1 General

Filter housings provide the delivery system for the operator enclosure filtration. Protection of the filter is critical to sustained quality and operator enclosure air quality performance.

4.2.3.2 Filter housings

The following items should be addressed in the filter housing:

a) the filter cannot be installed incorrectly (e.g. reversed airflow);

b) the filter housing is easily cleaned to avoid accumulation of particles;

