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Mining — Operator enclosures — Air quality control systems and air quality performance testing

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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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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 ISO Technical Committee 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 particulate 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 by the working group to make this an inclusive document which addresses the needs of fixed and mobile operator enclosures.

This document was developed to protect the health and well-being of personnel who work inside operator enclosures. The document 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 the standard. See Bibliography.

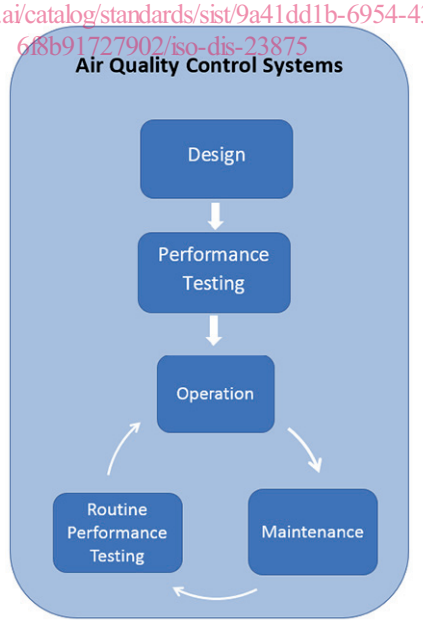

Figure 1 — Air quality control system life cycle

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 — Operator enclosures — Air quality control systems and air quality performance testing

1 Scope

This document provides requirements, best practices, and information to achieve sustained quality in the design, manufacture, performance testing, use, and maintenance of the operator enclosure air quality control system. Control of airborne particulate and dilution of CO_2 (which is generated by human respiration) within the operator enclosure are addressed in this document. Recommendations are made for operational integration of the air quality control system. Gases and vapours that may be a hazard in the work environment, outside of the operator enclosure are excluded.

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 5353, *Earth-moving machinery, and tractors and machinery for agriculture and forestry — Seat index point*

ISO/IEC 17050-1:2004, *Conformity assessment — Supplier's declaration of conformity — Part 1: General requirements*

ISO 18158, *Workplace air — Terminology*

ISO 29463-1, *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, *High-efficiency filters and filter media for removing particles in air — Part 5: Test method for filter elements*

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

[SOURCE: ISO 18158:2016, 2.1.2.3, alternative term added.]

3.1.2
hazardous to human health
quantity and/or quality of *airborne particulate* (3.1.1) or *CO2* (3.1.7) that has adverse health effects

3.1.3
contaminated area
area where *airborne particulate* (3.1.1) that is *hazardous to human health* (3.1.2) is present in the ambient air

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

[SOURCE: ISO 24095:2009, 3.1.2.1, modified]

3.1.5
Ambient CO_2 level
CO2 (3.1.7) concentration present in the air outside of the *operator enclosure* (3.2.1) to which people may be exposed

3.1.6
respirable particulate matter
applies to those materials that are hazardous when deposited in the gas-exchange region of the lungs. The median cut point for respirable particulate matter is 4.0 microns 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 operator enclosure design

3.2.1
operator enclosure
part of the machine which completely surrounds the operator, preventing the free passage of external air, dust or other substances into the area around the operator

[SOURCE: ISO 10263-4:2009, 3.1]

3.2.2
air quality control system
operator enclosure (3.2.1) which includes the structural components, external air and recirculation air systems, which are designed to protect an operator from environmental factors such as dust, heat, cold, wind, and *airborne particulates* (3.1.1) that are *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 intake is greater than the *operator enclosure* (3.2.1) 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). See Figure 2

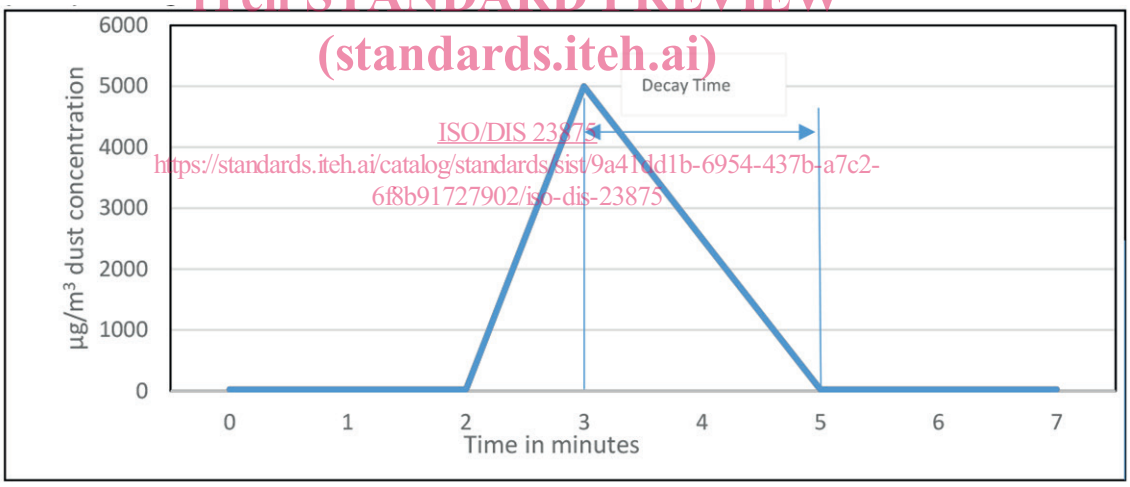

Figure 2 — Decay Time

Figure 2, as an example, showing dust concentration within the operator enclosure which starts at 7 µg/m^3 and at the two-minute interval begins to rise. At the 3-minute interval peaks at 5000 µg/m^3. At the 5-minute interval it returns to 7 µg/m^3. In this example, the decay time is two minutes.

4 Requirements for air quality control system

4.1 Performance requirements

The air quality control system design objective is to prevent ingress of respirable particulate matter from the contaminated environment through means of filtration and operator enclosure pressurization. The design specifications of this document are universal in their application and do not contemplate designing an air quality control system for specific mining environments. These design specifications are also intended to meet the identified parameters of pressurization, respirable particulate and carbon

dioxide concentrations. The performance test requirements are specific to the tests required by this document.

a) Maximum sustained CO_2: ambient level of CO_2 + 400 ppm, refer to Annex A for further information

b) Start of decay test and end of decay test maximum respirable particulate matter concentration: ≤25 µg/m^3

c) Respirable particulate decay time: maximum of 120 seconds

d) Minimum sustained pressurization, when the machine starting device is in the "on" position (activating the electrical system) shall be ≥20 Pa

e) Maximum sustained pressurization shall not exceed 200 Pa

Performance requirements shall supersede fixed external air and pressurization requirements as found in ISO 10263-4.

4.2 Engineering Design

4.2.1 Operator Enclosure

a) Machinery safety standard for the specific machine type shall be consulted when retrofitting a machine.

b) If the operator enclosure is built on the machine, attention should be paid to the interface with the machine frame. These areas 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 protective structures roll over protection (ROPS)and falling-object protective structure (FOPS), or other certified 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 exhaust system, which are prone to leakage over time, should not be near the external air system.

g) The operator enclosure shall be designed such that all ingress points will be sealed so that the system will hold pressure. Careful attention shall be given to all structural members ROPS and FOPS, weld points, stitch welds, electrical, hydraulic penetrations, windows etc. to ensure that the operator enclosure holds pressure sufficient to meet the minimum pressurization performance requirement.

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

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

b) Air quality control systems components which have been 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: 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 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 particulate 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 below are listed in order of their effectiveness in providing sustained operator enclosure pressurization when operating in dust conditions typical of mining environments.

   a. Powered precleaner using an integrated powered cyclonic separator

   b. Pressurizer blower using a non-powered cyclonic separator

   c. Pressurizer blower using a prefilter

   d. 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. Careful attention shall be given to the low-pressure system including 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) 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)

j) 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 provides 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.

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.

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

b) Recirculation airflows are not limited by this document. High efficiency filtration may restrict airflow, a factor that shall be taken into consideration in HVAC ventilation design.