INTERNATIONAL STANDARD

ISO 19426-7

First edition
2021-05

Structures for mine shafts —

Part 7:
Rope guides

Structures de puits de mine —

Partie 7: Guides-câbles

Reference number
ISO 19426-7:2021(E)

Contents

Page

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 Technical Committee ISO/TC 82, *Mining*.

A list of all parts in the ISO 19426 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

Many mining companies, and many of the engineering companies that provide designs for mines, operate globally so ISO 19426 was developed in response to a desire for a unified global approach to the safe and robust design of structures for mine shafts. The characteristics of ore bodies, such as their depth and shape, vary in different areas so different design approaches have been developed and proven with use over time in different countries. Bringing these approaches together in ISO 19426 will facilitate improved safety and operational reliability.

The majority of the material in ISO 19426 deals with the loads to be applied in the design of structures for mine shafts. Some principles for structural design are given, but for the most part it is assumed that local standards will be used for the structural design.

Structures for mine shafts —

Part 7:
Rope guides

1 Scope

This document specifies the design loads and the design procedures for the design of rope guides and rubbing ropes used for guiding conveyances and preventing collisions in vertical mine shafts for permanent operations. It covers personnel and material hoisting, as well as rock hoisting installations. There are no fundamental limitations placed on the size of conveyances, the hoisting speeds, shaft layout configurations, or the shaft depth.

This document can be applicable to shaft sinking operations when kibbles run on the stage ropes.

There are many reasons, based on technical, timing, and cost factors, why rope guides are selected or not for a particular application, following careful assessment at feasibility stage of any project where rope guides are considered. This document provides some comments regarding the advantages and disadvantages of using rope guides compared to rigid guides, and specific design aspects for consideration when using rope guides. However, it is primarily intended to provide the technical information required to ensure good engineering of shafts where rope guided hoisting is the chosen solution.

This document does not cover matters of operational safety.

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 19426-1, *Structures for mine shafts — Part 1: Vocabulary*

ISO 19426-2, *Structures for mine shafts — Part 2: Headframe structures*

ISO 19426-5, *Structures for mine shafts — Part 5: Shaft system structures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19426-1 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

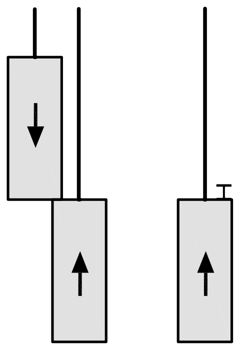
3.1
cheeseweight
stack of weights, usually steel castings, suspended from the bottom of a rope guide forming a dead weight tensioning system

3.2
direct collision
event in which a conveyance strikes another conveyance or some other surface that is essentially transverse to the direction of travel of the conveyance

Note 1 to entry: See Figure 1 a).

3.3
oblique collision
event in which a conveyance strikes a shaft side wall or some other surface that is oriented essentially parallel with the direction of travel of the conveyance

Note 1 to entry: See Figure 1 b).



a) Direct collision

b) Oblique collision

Figure 1 — Schematic of possible collision types

3.4
design clearance
static clearance
nominal distance between different conveyances, or between conveyances and fixed objects, in the shaft, as shown on the design drawings

3.5
design location
intended location of elements of the rope guided hoisting installation, as shown on the design drawings

3.6
displacement multiplier
factor by which the predicted conveyance lateral displacement is multiplied to make statistical allowance for inaccuracies in simulation and aerodynamic coefficients and construction tolerances

3.7
dynamic clearance
minimum distance between different conveyances, or between conveyances and fixed objects, in the shaft during hoisting in the shaft, which is equal to the *design clearance* (3.4) less the maximum *dynamic displacement* (3.8)

3.8
dynamic displacement
lateral displacement of conveyances while travelling in the shaft

3.9
design dynamic displacement
lateral *dynamic displacement* (3.8) of conveyances while travelling in the shaft multiplied by the *displacement multiplier* (3.6), which makes provision for simulation uncertainties and construction inaccuracies

3.10
reduced dynamic clearance
minimum distance between different conveyances, or between conveyances and fixed objects, in the shaft during hoisting in the shaft, which is equal to the *design clearance* (3.4) less the *design dynamic displacement* (3.9)

3.11
entry point
position at which a conveyance enters fixed guides at the top and bottom ends of the hoisting cycle, and at any intermediate stations

3.12
guide block
guide bush
guide slipper
attachment of a conveyance to the rope guides

Note 1 to entry: The guide block is usually made in two halves to bolt around the rope guide, and it has a guide block liner forming the rubbing surface on the rope guide.

3.13
intermediate loading station
loading station between bank level or a tipping station at the top of the shaft and a loading station at the bottom of the shaft, or any loading station located more than 100 m below the top anchor point of the rope guides or more than 100 m above the bottom anchor point of the rope guides

3.15
rope guide shoe
mounting to secure the *guide block* (3.12) through which the rope guide passes to the conveyance

3.16
rubbing block
fixed guide slippers
contact point between a conveyance and the fixed guides at top and bottom of winding cycle, which can run within or outside the fixed guide

Note 1 to entry: Where the fixed guides are located close to the rope guides, the rubbing block can also serve the purpose of the rope guide shoe.

3.17
rubbing rope
rope located between conveyances running on rope guides, intended to deflect conveyances away from each other, thereby reducing the severity of a possible collision

3.18
vertical shaft cylinder
maximum circular cylinder, clear of any obstructions, that fits within the excavated mine shaft and constructed infrastructure

3.19
winder emergency braking
winder trip-out
braking of the winder under emergency conditions, such as loss of electrical power, detection of over-tension or under-tension on the hoist ropes, or accident to shaft signal

4 Symbols

a	Conveyance acceleration, m/s^2
A_C	Area of the relevant side of a conveyance, m^2
A_R	Cross sectional steel area of a single head rope, m^2
A_1, A_2	Area of specified portions of a shaft cross-section, m^2
b	Thickness of skip stiffeners, m
B_E	Distance between the conveyance centre of gravity and the geometrical centre of the set of rope guides, guiding that conveyance, m
B_X, B_Z	Plan dimensions of a conveyance, m
C_{BX}, C_{BZ}	Basic aerodynamic lateral force coefficient in appropriate direction, taken as 0,018
C_L	Aerodynamic force coefficient
C_{LX}, C_{LZ}	Aerodynamic lateral force coefficient in appropriate direction
C_{LP}	Conveyance passing buffeting force coefficient
C_Q	Torque factor applied to head ropes
C_T	Coefficient of thermal expansion of the rope guide, °C^{-1}
d_S	Shaft diameter, m
d_R	Rope diameter, m (note that this is usually given in mm in hoist rope catalogues)
D_A	Lateral conveyance displacement due to steady state aerodynamic force, m
D_B	Lateral conveyance displacement due to buffeting forces, m
D_C	Lateral conveyance displacement due to Coriolis force, m
D_{EB}	Lateral conveyance displacement at the bottom of the conveyance due to conveyance eccentricity with respect to the head rope attachment point, m
D_{EC}	Lateral conveyance displacement at the centre of gravity of the conveyance due to conveyance eccentricity with respect to the head rope attachment point, m
D_{ET}	Lateral conveyance displacement at the top of the conveyance due to conveyance eccentricity with respect to the head rope attachment point, m
D_G	General lateral displacement of the centre of gravity of a conveyance in a shaft, m

D'_G	General lateral displacement of the geometric centre of the set of rope guides guiding one conveyance in a shaft, m
D_I	Amplitude of initial rope guide motion prior to hoisting of a conveyance, m
D_M	Nominal design movement allowance between a conveyance and other objects in a shaft, m
D_N	Nominal design clearance between a conveyance and other objects in a shaft, m
D_O	Minimum dynamic clearance, m
D_P	Total combined lateral displacement of a conveyance, m
D_R	Lateral conveyance displacement due to initial rope guide motion, m
D_X	Recommended tolerance allowance, m
D_Y	Lateral displacement due to yaw rotation of the conveyance in the shaft, m
E_S	Elastic modulus of the head rope or the rope guide, Pa
F_A	Steady state aerodynamic force acting on a conveyance, N
F_C	Coriolis force acting on a conveyance, N
F_P	Peak force during buffeting of a conveyance, N
F_X	General lateral force applied to a conveyance, N
F_Y	General moment applied about the centre of gravity of a conveyance, Nm
g	Acceleration due to gravity, m/s^2
h_1	Body height of a conveyance, m
h_2	Ventilation opening height on a cage, m
H	Overall height of a conveyance, m
H_C	Height from the conveyance centre of gravity to the top of the conveyance, m
I_C	Mass moment of inertia of a conveyance about the vertical centroidal axis, kgm^2
K_H	Lateral stiffness at conveyance elevation, of a single head rope, N/m
K_L	Lateral stiffness at conveyance elevation, of the set of ropes attached to one conveyance, N/m (this includes the rope guides, the head ropes, and where applicable the tail ropes)
K_R	Lateral stiffness at conveyance elevation, of a single rope guide, N/m
K_T	Lateral stiffness at conveyance elevation, of a single tail rope, N/m
K_θ	Rotational stiffness at conveyance elevation, of the set of ropes attached to one conveyance, Nm/rad
L	Overall length of the rope guides, m
L_H	Head rope length between the conveyance and the sheave, m
L_T	Tail rope length between the conveyance and the bottom sheave, m

L_1	Rope guide length between the top of a conveyance and the top anchor point, m
L_2	Rope guide length between the bottom of a conveyance and the bottom anchor point, m
m_C	Conveyance mass, including mass of rope attachments and payload, kg
m_H	Mass per unit length of a single head rope, kg/m
m_P	Payload mass, kg
m_R	Mass per unit length of a single rope guide, kg/m
m_T	Mass per unit length of a single tail rope, kg/m
M_O	Overturning moment due to eccentric loading, Nm
n	An integer greater than 1
n_H	Number of head ropes for a single conveyance
n_R	Number of rope guides guiding a single conveyance
n_T	Number of tail ropes for a single conveyance
Q	Rope torque applied to a conveyance, Nm
Q_i	Rope torque from rope i applied to a conveyance, Nm
r_t	Ratio of acceleration time to natural period
R	Ratio of first force peak to second force peak used for buffeting as two conveyances pass each other, taken as 1,5
R_B	Blockage ratio for two conveyances in a shaft
R_G	Gap ratio between conveyances in a shaft
R_D, R_W	Distance and width ratios for air inflow and outflow buffeting
R_S	Shape factor for air inflow and outflow buffeting
S_A	Conveyance size factor
S_{PX}, S_{PZ}	Sidewall proximity factors
S_{SX}, S_{SZ}	Conveyance shape factors in X- and Z-directions
t	Time, s
t_P	Time taken for two conveyances to pass each other in a shaft, s
T	Tension in a rope, N
T_{BOT}	Rope guide tension at the bottom anchor point, N
T_H	Head rope tension at a conveyance, N
T'_H	Increased head rope tension at a conveyance, N
T_L	Rope guide tension at conveyance elevation in the shaft, N
T_M	Rope guide tension at mid-depth of the shaft, N

T_T	Tail rope tension at a conveyance, N
T_{TOP}	Rope guide tension at the top anchor point, N
U_i	Horizontal dimensions of the air inflow or outflow duct, m
v_D	Horizontal component of airflow velocity in a station or side duct, m/s
v_H	Hoisting speed of a conveyance, m/s
v_R	Velocity of a conveyance relative to ventilation airflow speed, m/s
W	Total eccentric payload applied to a conveyance, N
w	Width of the skip stiffener, m
x_C, z_C	Horizontal distances between the conveyance centre of gravity and the geometric centre of the shaft, m
x_{HC}, z_{HC}	Horizontal distance between the conveyance centre of gravity and the centre of hoist rope attachment, m
x_{Hi}, z_{Hi}	Horizontal distance between the conveyance centre of gravity and the centre of hoist rope number *i*, m
x_P, z_P	Horizontal distance between the payload centre of gravity and the centre of hoist rope attachment, m
x_{Ri}, z_{Ri}	Horizontal distance between the conveyance centre of gravity and the centre of rope guide number *i*, m
x_{TC}, z_{TC}	Horizontal distance between the conveyance centre of gravity and the centre of tail rope attachment, m
x_{Ti}, z_{Ti}	Horizontal distance between the conveyance centre of gravity and the centre of tail rope number *i*, m
Y_i	Vertical dimensions of the air inflow or outflow duct, m
α	A dynamic magnification factor
α_T	Winder emergency braking magnification factor for torque and eccentricity
β	Tilt angle of a conveyance subjected to an eccentric payload, rad
β_1, β_2	Angles of the top or bottom of a skip, rad
Δ_C	Change in ambient temperature, °C
Δ_T	Change in rope guide tension, N
θ	General yaw rotation of the conveyance in the shaft, rad
ρ	Air density, kg/m^3
γ_R	Displacement multiplier
ϕ	Latitude of the mine shaft site, positive north and south of the equator, deg
ϕ_A	Angle of the air inflow or outflow duct, rad

ω_E	Radial rotation velocity of the earth, 7,27x10^{-5} rad/s
ω_R	Fundamental radial frequency of oscillation of the rope guides, rad/s
ω_{RC}	Fundamental radial frequency of oscillation of the rope guides with the conveyance, rad/s
ω_{RCY}	Fundamental radial frequency of yaw rotation of the rope guides with the conveyance, rad/s
ω_{VT}	Fundamental natural frequency of vertical motion of the conveyance suspended from the head ropes, rad/s

5 Materials

The materials used for rope guides and rubbing ropes shall be materials having guaranteed mechanical properties. It is most common to use high strength steel wire ropes complying with EN 12385-6 and EN 12385-7.

6 Disturbing actions

6.1 Coriolis force

The Coriolis force always acts in a westerly direction for an ascending conveyance, and in an easterly direction for a descending conveyance. The Coriolis force acts on all the moving masses, that is the mass of the conveyance and the head and tail ropes.

The Coriolis force results from the rotation of the earth and masses moving in a vertical direction. The Coriolis force F_C is defined as:

$$F_c = 2 m v_h \omega_E \cos\phi \quad (1)$$

where m can be taken as:

$$m = m_c + n_H m_H \frac{L_H}{3} + n_T m_T \frac{L_T}{3} \quad (2)$$

where

L_H	is the head rope length between the conveyance and the sheave, m;
L_T	is the tail rope length below the conveyance, m;
m_C	is the conveyance mass, including mass of rope attachments and payload, kg;
m_H	is the hoist rope unit mass, kg/m;
m_T	is the tail rope unit mass, kg/m;
n_H	is the number of hoist ropes;
n_T	is the number of tail ropes;
v_H	is the hoisting speed of conveyance, m/s;
ω_E	is the radial rotation velocity of the earth, 7,27x10^{-5} rad/s;
ϕ	is the latitude of the mine shaft site, positive whether north or south of the equator.

6.2 Aerodynamic loads

6.2.1 Steady state

The steady state aerodynamic force acting on a conveyance F_A is defined as:

$$F_A = \frac{1}{2} C_L \rho v_R^2 A_C \tag{3}$$

where

C_L is the aerodynamic lateral coefficient, but not less than 0,02;

ρ is the air density, which may be approximated using the values in Table 1, kg/m^3;

v_R is the conveyance velocity relative to the ventilation airflow, m/s;

A_C is the area of the relevant side of the conveyance, m^2.

Values of C_L should be obtained from an appropriate level of accuracy of computational fluid dynamics analysis. However, for preliminary design only, the values may be obtained from Annex C. When C_L exceeds 0,02 it shall be taken to act in a specific direction arising from the aerodynamic flow around the conveyance. When C_L is taken as 0,02 it shall be taken to act in either direction.

Note that different values of F_A act on a conveyance in each of the two horizontal directions.

6.2.2 Buffeting

6.2.2.1 Buffeting force when two conveyances pass each other

The amplitude and time variation of the buffeting force when two conveyances pass each other in the shaft should be obtained from computational fluid dynamics analysis.

The amplitude of the buffeting force F_P is defined as:

$$F_P = \frac{1}{2} C_{LP} \rho v_H^2 A_C \tag{4}$$

where

C_{LP} is the buffeting force coefficient (see Annex C);

ρ is the air density, which may be approximated using the values in Table 1, kg/m^3;

v_H is the relative passing speed, m/s;

A_C is the area of the relevant side of the conveyance, m^2.

Values of C_{LP} should be obtained from an appropriate level of accuracy of computational fluid dynamics analysis. However, for preliminary design only, the values may be obtained from Annex C.

The time variation of this buffeting force should be obtained from computational fluid dynamics analysis. However, for preliminary design only, the time variation may be obtained from Annex C.

6.2.2.2 Buffeting in the wake of a leading conveyance

The amplitude and time variation of the buffeting force on a conveyance following closely behind another conveyance, and travelling in the same direction in the shaft, should be obtained from computational fluid dynamics analysis.

