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Structures for mine shafts —

Part 2:
Headframe structures

Structures de puits de mine —

Partie 2: Chevalements

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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).

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For an explanation on 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 the following URL: 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.

Introduction

Many mining companies, and many of the engineering companies which 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 2:
Headframe structures

1 Scope

This document specifies the design loads and the design procedures for the structural design of headframe structures of mine shafts and their components for permanent and sinking operations. The headframe includes all structures and their foundations, that are required at the head of all vertical and decline mine shafts for the purposes of supporting and installing winding and sinking ropes, conveyance guides, rope guides and rubbing ropes, equipment for loading and unloading conveyances, safety devices, as well as ancillary sinking and maintenance equipment. The headframe also includes the bank and sub-bank levels.

This document does not cover matters of operational safety or layout of the headframe.

This document adopts a limit states design philosophy.

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 2394, *General principles on reliability for structures*

ISO 3010, *Bases for design of structures — Seismic actions on structures*

ISO 12122-1, *Timber structures — Determination of characteristic values — Part 1: Basic requirements*

ISO 10721-1, *Steel structures — Part 1: Materials and design*

ISO 19338, *Performance and assessment requirements for design standards on structural concrete*

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

ISO 19426-3, *Structures for mine shafts — Part 3: Sinking stage*

ISO 19426-4, *Structures for mine shafts — Part 4: Conveyances*

ISO 22111, *Bases for design of structures — General requirements*

3 Terms and definitions

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

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

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

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

4 Symbols

D	rope or conveyance installation load (N)
D_{dd}	winding rope doubling-down load (N)
D_g	rope guide or rubbing rope installation load (N)
D_h	winding rope installation load (N)
D_t	tail rope installation or replacement load (N)
D_v	conveyance change-over load (N)
E	emergency load (N)
E_r	rope emergency load (N)
E_{r1} and E_{r2}	tensions in the ropes on each side of the winder drum (N)
E_{re}	energy release load following rope break (N)
E_{st}	short circuit torque (Nm)
E_{wb}	winder brake failure load (Nm)
e	base for natural logarithms (mathematical constant)
F	design load or load effect (N, Nm)
F_{ag}	pre-tension load of the crash-beam-anchor guy (N)
F_k	kibble load applied to the bank doors (N)
g	gravity acceleration constant (m/s^2)
G	permanent load or load effect (N, Nm)
G_a	additional permanent load or load effect from rope guides and rubbing ropes (N)
G_c	conveyance self-weight (N)
G_r	weight of the relevant length of winding rope, rope guide or rubbing rope (N)
G_t	weight of the relevant length of tail rope, rope guide or rubbing rope (N)
L	full length of the rope guide or rubbing rope (m)
m_r	unit mass of the rope guide or rubbing rope (kg/m)
n	number of winding ropes
P	payload used during doubling-down (N)
Q	imposed load or load effect (excluding rope load) (N, Nm)
Q_2	dominant imposed load or load effect under consideration (N, Nm)
Q_3 to Q_n	additional independent imposed loads or load effects (N, Nm)
R_h	varying rope guide or rubbing rope horizontal load under operating conditions (N)

R_v	varying rope guide or rubbing rope vertical load under operating conditions (N)
R_1 to R_n	rope operating loads (N)
T_r	minimum tension in a rope guide or rubbing rope, or the weight of the suspended tensioning block (N)
T_{st}	short circuit torque (Nm)
W_K	weight of kibble and payload (N)
α_c	rope or conveyance impact factor
α_{ch}	horizontal impact factor
α_{cv}	temperature factor
α_{st}	short circuit torque impact factor
α_v	vertical impact facto
μ	coefficient of friction between winding rope and winder drum
γ_e	partial load factor for all loads when combined with the rope emergency load (= 1,05)
γ	partial load factor for permanent load
γ_{f1}	partial load factor for rope-operating load
γ_{f2}	partial load factor for the dominant imposed load
γ_{f3} to γ_{fn}	partial load factors for imposed load
$\sum R$	governing combination of rope-operating loads under consideration
θ	angle of wrap of winding rope on winder drum
Ψ_3 to Ψ_n	load combination factors.

5 Materials

The materials used in the construction of headframes shall be structural steel complying with ISO 10721-1, structural concrete complying with ISO 19338 or structural timber complying with ISO 12122. The material used shall be specified on the structural drawings.

6 Nominal loads

6.1 Permanent loads

6.1.1 General

The permanent loads, G, shall be as given in ISO 22111, except as specified in 6.1.2 and 6.1.3.

6.1.2 Equipment permanent loads

Where winders, or other electrical or mechanical equipment, are mounted in the headframe, the nominal permanent loads shall include the weight of such equipment.

6.1.3 Additional permanent loads

After installation of the rope guides and rubbing ropes, the static component of their loads, i.e. their combined weight and tension, shall be treated as an additional permanent load, G_a (N):

$$G_a = T_r + m_r g L \tag{1}$$

where

T_r is the minimum tension in the rope guide or rubbing rope, or the weight of the suspended tensioning block (N);

m_r is the unit mass of the rope guide or rubbing rope (kg/m);

g is the gravity acceleration constant (m/s^2);

L is the full length of the rope guide or rubbing rope (m).

6.1.4 Crash beam anchor guy pre-tension loads

Where anchor guys are fitted to hold down the structure in the event of a crash, the crash beam anchor guy pre-tension loads, F_{ag}, shall be taken into consideration. The crash beam anchor guy pre-tension loads shall be calculated for each anchor guy.

6.2 Imposed loads (excluding rope loads)

6.2.1 General

The nominal imposed loads, Q, including earthquake, wind, snow, temperature, settlement and thermal loads, shall be as given in ISO 22111, except as specified in 6.2.2 to 6.2.10 (inclusive).

6.2.2 Floor and platform loads

The nominal imposed load on floors and platforms shall be

a) a uniformly distributed load of not less than 5 000 N/m^2 for personnel or equipment loading platforms, or

b) a concentrated load equal to the weight of a sheave or other heavy equipment, placed in the position that produces the most severe effects in the member under consideration, when these items might be stored on the floor or placed on the floor during maintenance.

6.2.3 Bin material loads and chute material loads

The nominal imposed loads applied to the headframe by material in bins and chutes shall be calculated assuming that the bins and chutes are completely full.

6.2.4 Conveyance operating loads

The nominal loads applied by conveyances to the headframe and bank steelwork shall be as determined in ISO 19426-4.

6.2.5 Headframe-mounted winder loads

Where winders are mounted on the headframe, the following loads shall be taken into account in addition to rope loads:

a) the maximum starting torque specified by the equipment supplier;

b) the braking torque under trip-out conditions as specified by the equipment supplier.

6.2.6 Kibble loads

The kibble loads, F_k (N), applied to the bank doors shall be taken as:

$$F_k = \alpha_v W_K \tag{2}$$

where

α_v is the vertical impact factor which may be taken as 3,0 in the absence of better information;

W_K is the weight of kibble and payload (N).

6.2.7 Bank door operating loads

The loads applied by the bank door operating equipment shall be taken as the maximum force that can be exerted by such equipment.

6.2.8 Abnormal loads

All loads that arise from the handling of heavy equipment for which the winder is not specifically licensed, including wheel loads at bank level, shall be taken into account, with appropriate impact factors applied.

6.2.9 Earthquake loads

Earthquake loads shall be determined in accordance with ISO 3010.

Headframes shall be designed using a high degree of importance to ensure safe egress of persons after an earthquake event.

Headframes may be designed using the equivalent static method, except where the winder is mounted in the headframe. Where the winder is mounted in the headframe, a dynamic analysis shall be done, unless the representative peak ground acceleration for the region is less than 15 % of gravity acceleration.

6.2.10 Conveyance drop test loads

Where a drop test is performed within the headframe, the loads shall be as defined for dogging system loads in ISO 19426-4.

6.3 Rope or conveyance installation loads

6.3.1 General

6.3.1.1 The loads applied by the handling of ropes, and the installation or removal of conveyances, shall be based on a rational understanding of the specified rope handling and conveyance handling procedures. Where appropriate, the loads listed in 6.3.2 to 6.3.5 (inclusive) shall be included.

6.3.1.2 In 6.3.2 to 6.3.5 the recommended values for the rope or conveyance impact factor, α_c, given in Table 1 should be used, unless the equipment supplier, or a rational analysis, indicates a different value.

Table 1 — Recommended values of α_c

Description of context	α_c value
The rope or conveyance is in creep motion and is arrested by the structure	3,0
The rope is cut, or a pin is removed, without first releasing the tension in the rope	2,0
The rope is being moved, or tension is applied, by mechanical means or by hydraulic equipment	1,3
The rope is supported by the structure	1,0

6.3.1.3 When an installation has more than one rope and the ropes are handled individually, the impact factor specified shall be used for the rope being handled, and an impact factor of 1,0 shall apply to all ropes already anchored on the structure.

6.3.1.4 When multiple ropes are handled together, the relevant impact factor shall be applied to all the ropes simultaneously.

6.3.2 Winding rope installation load

The winding rope installation load, D_h (N), shall be taken as:

$$D_h = \alpha_c \left(G_c + P + G_r\right) \tag{3}$$

where

α_c is the rope impact factor;

G_c is the conveyance self-weight (N);

P is the payload used during doubling-down (N);

G_r is the weight of the relevant length of winding rope (N).

6.3.3 Winding rope doubling-down load

The winding rope doubling-down load, D_{dd} (N), shall be taken as:

$$D_{dd} = \alpha_c \left(\frac{G_c}{2} + \frac{P}{2} + G_r\right) \tag{4}$$

where

α_c is the rope impact factor;

G_c is the conveyance self weight (N);

P is the payload used during doubling-down (N);

G_r is the weight of the relevant length of winding rope (N).

6.3.4 Tail rope installation or replacement load

Where required, the tail rope installation or replacement load, D_t (N), shall be taken as:

$$D_t = \alpha_c G_t \tag{5}$$

where

α_c is the rope impact factor;

G_t is the weight of the relevant length of tail rope (N).

6.3.5 Rope guide and rubbing rope installation or replacement load

Where required, the rope guide and rubbing rope installation or replacement load, D_g (N), shall be taken as:

$$D_g = \alpha_c \left(T_r + G_r\right) \tag{6}$$

where

α_c is the rope impact factor;

T_r is the minimum tension in the rope guide or rubbing rope, or the weight of the suspended tensioning block (N);

G_r is the weight of the relevant length of rope guide or rubbing rope (N).

6.3.6 Conveyance change over load

The vertical load on conveyance supports during conveyance change over, D_v (N), shall be taken as:

$$D_v = \alpha_c G_c \tag{7}$$

where

α_c is the conveyance impact factor, which may be taken as 3,0 in the absence of better information;

G_c is the conveyance self weight (N).

6.4 Rope operating loads

6.4.1 General

The rope-operating loads, R_1 to R_n (where n is the number of ropes in the system), applied to the headframe shall comprise the loads given in 6.4.2 to 6.4.5, as applicable.

6.4.2 Winding rope operating loads

Each winding rope operating load shall include the rope weight (for any position of wind), the self-weight of the conveyance and its attachments, and the weight of its contents as specified in ISO 19426-4 (N).

6.4.3 Stage rope operating loads

Each stage rope operating load shall include the rope weight (for any position of the stage), the self-weight of the stage and its equipment, and the loads imposed on the stage as specified in ISO 19426-3 (N).

6.4.4 Lateral rope operating loads on sheaves

In the absence of better information, the lateral operating loads from a combination of rope fleet and rope whip (N) shall be taken as 3,5 % of the maximum operating rope load as given in 6.4.2 and 6.4.3, and shall be assumed to act at the most unfavourable point on the sheave.

6.4.5 Rope guide and rubbing rope operating loads

After installation of the rope guides and rubbing ropes, the rope guide and rubbing rope loads (N) shall be taken as:

a) $R_v = \alpha_{cv} G_a$ acting vertically downwards; (8)

b) $R_h = \alpha_{ch} G_a$ acting in any horizontal direction; (9)

where

α_{cv} is the temperature factor, which may be taken as 1,0 where gravity tensioning is used, and as 1,3 where rope ends are mechanically tensioned and clamped;

G_a is the additional permanent load from rope guides and rubbing ropes given in 6.1.3 (N);

α_{ch} is the horizontal impact factor, which may be taken as 0,05.

6.5 Emergency loads

6.5.1 Emergency rope load

6.5.1.1 Conveyances with fixed rope winders

The emergency rope load, E_r (N), shall be taken as the nominal aggregate rope breaking load or 1,15 times the estimated rope breaking load. Where a conveyance has more than one winding rope attached, it shall be assumed that all ropes break simultaneously.

6.5.1.2 Conveyances with friction winders

The emergency rope load, E_r (N), may be taken as the winding rope load obtained by a system simulation or other rational analysis.

As an upper limit, the rope load given in 6.5.1.1 may be used to give E_r, and the tensions in the ropes on each side of the winder drum are then given by E_{r1} and E_{r2},

where

$E_{r1} = nE_r$ is the total force on the side of the tight rope (N); (10)

$E_{r2} = \dfrac{nE_r}{e^{\mu\theta}}$ is the total force on the side of the slack rope (N); (11)

where

n is the number of winding ropes;

μ is the coefficient of friction between winding rope and winder drum;

θ is the angle of wrap of winding rope on winder drum (radians);

e is the base for natural logarithms (mathematical constant).

6.5.1.3 Stage emergency rope load

Where the stage is supported by several falls of one or two stage ropes, the stage emergency rope load, E_r (N), shall be taken as the stage rope weight for any position of the stage, plus 3,0 times the combined self-weight of the stage, equipment, and imposed loads.

Where the stage is supported by three or more winders, the stage emergency rope load, E_r, shall consider any one rope breaking.

6.5.2 Emergency dropback loads

The downward load applied to fall back arrestors in the case of an emergency shall be calculated in accordance with the energy absorption of the support system. The calculations shall assume a falling mass equivalent to the mass of the conveyance and payload plus any underslung load or tail rope load except that, in the case of a skip, the engineer may determine whether the payload should be assumed to be in the skip or not.

As a conservative upper limit, the rope emergency load given in 6.5.1.1 may be used.

6.5.3 Crash beam and catch plate loads

The upward or downward load that results from a final overwind condition and that acts on catch plates and crash beams, where required, shall be taken as the emergency rope load, E_r, as defined in 6.5.1, provided that a more detailed investigation of the particular installation does not indicate lesser values.

6.5.4 Emergency arrestor anchor loads

The emergency arrestor structure anchor loads shall be taken as the maximum loads defined by the supplier.

6.5.5 Headframe-mounted winder emergency loads

Where winders are mounted on the headframe, the loads caused by the following fault conditions shall be considered.

a) Short circuit torque. The load short circuit torque, E_{st} (Nm), shall be taken as:

$$E_{st} = \alpha_{st} T_{st} \tag{12}$$

where

α_{st} is the short circuit torque impact factor that may be taken as 2,0 in the absence of better information;

T_{st} is the short circuit torque as specified by the equipment supplier (Nm).

b) Winder brake failure. The winder brake failure load, E_{wb}, shall be taken as the maximum braking capacity of the winder as specified by the equipment supplier.

6.5.6 Energy release loads following rope break

6.5.6.1 The energy release behaviour following rope break shall be determined by rational analysis, or in the absence of a rational analysis, the energy release load following rope break, E_{re} (N), may be taken as:

$$E_{re} = E_r \tag{13}$$

where E_r is the emergency rope load (N).

6.5.6.2 The energy release load following rope break acts in the direction opposite to the rope emergency load, E_r. It is only taken into account when both of the following conditions apply:

a) the emergency rope load occurs under a rope break condition;

b) overall headframe stability and foundation uplift are taken into account.

6.5.7 Dogging system loads

The guides and their supports within the headframe shall be designed to withstand the dogging system loads defined in ISO 19426-4 as emergency loads.

7 Design procedures

7.1 Design loads

The nominal loads for operating and emergency conditions shall be as given in Clause 6.

Structural reliability shall be ensured to the extent envisaged in ISO 2394. This can be achieved by the application of partial load factors and load combinations in accordance with ISO 22111 together with appropriate resistance factors.

See Annex A for additional guidance.

7.2 Design standards

The design of components of headframe structures shall be in accordance with the requirements given in ISO 19338, ISO 10721-1 and ISO 12122-1.

7.2.1 Design for emergency rope loads

When designing for emergency rope loads, slip of connections can be tolerated, so that the bearing resistance of bolted connections may be used.

7.3 Overall stability

The structure as a whole and its parts shall be designed to resist overturning and uplift that result from the application of the ultimate loads when the ultimate loads are acting in the most critical combination.

7.4 Serviceability limit state

7.4.1 General

A headframe structure shall be so designed that the deflection limits resulting from serviceability actions of the design loads are limited to the values given in 7.4.2 and 7.4.3. No limitations need be considered for load combinations that include an emergency load.

7.4.2 Deflection limits

7.4.2.1 Vertical and horizontal deflections of headframe components shall not exceed the recommended deflection limits specified in ISO 19338, ISO 22111 or ISO 10721-1, as relevant.

7.4.2.2 The horizontal deflection of the headframe structure shall not exceed $h/500$, where h is the height above the ground level to the point at which deflection is being assessed.

For A frame-type headframes, where the guide tower is not structurally connected to the A frame, deflection shall further be so limited as to ensure that the functionality of the guides and winding system is not compromised.

7.4.3 Headframe-mounted winders

Under design operating loads, and where required by the winder manufacturer under emergency loads, the differential deflections of components of supports to headframe-mounted winders shall not exceed the tolerances stated by the manufacturer of the winding equipment under the relevant conditions.