

# INTERNATIONAL STANDARD

# ISO 19426-4

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## Structures for mine shafts —

### Part 4: Conveyances

*Structures de puits de mine —  
Partie 4: Moyens de transport*

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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](http://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](http://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](http://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.

This corrected version of ISO 19426-4:2018 incorporates the following correction:

- in [11.4.3.3](#), a), paragraph below [Formula \(33\)](#), the wording and value have been corrected to read "but the rock size shall not be taken as less than 0,02 m<sup>3</sup>".

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](http://www.iso.org/members.html).

## 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. It is also recognised that typical equipment varies from country to country, so the clauses in ISO 19426 do not specify application of the principles to specific equipment. However, in some cases examples demonstrating the application of the principles to specific equipment are provided in informative Annexes.

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# Structures for mine shafts —

## Part 4: Conveyances

### 1 Scope

This document specifies the loads, the load combinations and the design procedures for the design of the steel and aluminium alloy structural members of conveyances used for the transport of personnel, materials, equipment and rock in vertical and decline shafts. The conveyances covered by this document include personnel or material cages (or both), skips, kibbles, equipping skeleton cages, inspection cages, bridles, crossheads and counterweights.

This document is not intended to be used for the design of ropes, sheaves or attachments. Rope sizes are determined in accordance with other standards.

This document does not cover chairlifts.

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

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

ISO 10721-2, *Steel structures — Part 2: Fabrication and erection*

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

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

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

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

EN 1999-1-1, *Eurocode 9 — Part 1: Design of aluminium structures — Part 1: General structural rules*

EN 1999-1-3, *Eurocode 9 — Part 1: Design of aluminium structures — Part 3: Structures susceptible to fatigue*

EN 1999-1-4, *Eurocode 9 — Part 1: Design of aluminium structures — Part 4: Cold-formed structural sheeting*

### 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

|                 |   |
|-----------------|---|
| $A_o$           | operating winder system acceleration/deceleration load (N)  |
| $A_t$           | trip-out winder deceleration load (N)   |
| $a_D$           | maximum permitted deceleration of the conveyance when the dogging system activates ( $m/s^2$ )                    |
| $a_o$           | operating winder system peak acceleration/deceleration ( $m/s^2$ )  |
| $a_t$           | trip-out winder system peak deceleration ( $m/s^2$ )  |
| $C$             | impact load during loading of the conveyance (N)  |
| $C_h$           | horizontal impact load from rolling stock (N)   |
| $C_v$           | vertical impact load from rolling stock (N)   |
| $C_y$           | conveyed load ( $P, \Sigma M, U$ or $R$ , as appropriate) (N)   |
| $D$             | dogging system load (N)   |
| $d_i$           | deformation of the skip door (m)  |
| $E_j$           | emergency dropback load (N)   |
| $E_r$           | rope emergency load (N)   |
| $e$             | maximum moving beam misalignment of the guide (m); lateral flare dimension (see <a href="#">Figure 1</a> )        |
| $F$             | design load, or load effect (N, Nm)   |
| $F_v$           | friction induced vertical load (N)  |
| $G_1$ and $G_2$ | are the permanent loads, including the self-weight of the structure and the structural components, in newtons (N) |
| $G_c$           | conveyance self-weight load (N)   |
| $g$             | acceleration due to gravity ( $m/s^2$ )   |
| $H$             | lateral imposed load (N)  |
| $H_r$           | rubbing block load (N)  |
| $H_s$           | lateral slipper plate load (N)  |
| $h_d$           | length through which the rock falls (m)   |
| $h_h$           | height to which the skip is filled above the lowest point of the skip door (m)                                    |
| $K$             | station-mounted holding device engagement load (N)  |

|                |   |
|----------------|---|
| $K_c$          | conveyance-mounted holding device load (N)  |
| $K_g$          | lateral stiffness of the steelwork at the guide mid-span or at the end of the flare (N/m) |
| $K_s$          | buffer spring stiffness (N/m)   |
| $L$            | guide span, buntion to buntion or the length of the flare guide (m)                       |
| $L_1$          | distance between the pivot and the centre of gravity of the skip, or the radial door (m)  |
| $L_2$          | distance between the pivot and the return-stop (or the tipping roller) (m)                |
| $L_T$          | length of the crawler track (m)   |
| $M$            | load from each item of rolling stock or equipment (N)                                     |
| $M_1$          | heavier axle load (N)   |
| $m_c$          | conveyance mass including all attachments, excluding rope attachments (kg)                |
| $m_r$          | mass of largest rock that will be loaded into the skip (kg)                               |
| $P$            | load from personnel (N)   |
| $p_0$ to $p_3$ | skip pressures (N/m <sup>2</sup> )  |
| $Q_1$          | dominant imposed load or load effect (N, Nm)  |
| $Q_2$ to $Q_n$ | are the additional independent imposed loads, or load effects (N, Nm)                     |
| $Q_e$          | emergency load or load effect (N, Nm)   |
| $R$            | static rock or slurry load (N)  |
| $R_d$          | bridle and top transom load during filling (N)  |
| $R_f$          | friction load on the skip door (N)  |
| $R_i$          | single rock impact vertical load on the skip door (N)                                     |
| $R_k$          | single rock impact horizontal load on the skip sides (N)                                  |
| $R_s$          | load on skip return-stops (N)   |
| $R_t$          | load on tipping rollers (N)   |
| $T$            | load due to the tail rope (N)   |
| $U$            | load due to underslung equipment (N)  |
| $z$            | maximum depth of rock or slurry contained in the conveyance (m)                           |
| $Z_i$          | impact energy of the falling rock (J)   |
| $\alpha_d$     | dynamic impact factor   |
| $\alpha_h$     | horizontal load impact factor   |
| $\alpha_k$     | holding device impact factor  |
| $\alpha_p$     | rock impact factor  |

|                                 |   |
|---------------------------------|---|
| $\alpha_t$                      | tipping impact factor.                                |
| $\alpha_v$                      | vertical load impact factor                           |
| $\beta$                         | rope emergency factor                                 |
| $\gamma_e$                      | partial load factor for emergency loads.              |
| $\gamma_{fi}$                   | partial load factor for imposed loads                 |
| $\gamma_{g1}$ and $\gamma_{g2}$ | partial load factors for permanent loads              |
| $\gamma_{f1}$ to $\gamma_{fn}$  | partial load factors for imposed loads                |
| $\gamma_{gi}$                   | partial load factor for permanent loads               |
| $\mu$                           | friction factor between the skip payload and the door |
| $\rho$                          | bulk density of rock (kg/m <sup>3</sup> )             |
| $\Psi_2$ to $\Psi_n$            | load combination factors                              |

## 5 Materials

### 5.1 Steel

The materials used for structural steel members should comply with the requirements of EN 10025-1 and EN 10025-2.

#### 5.1.1 High strength steel grades

The materials for high strength steel members should conform to the requirements of EN 10025-6, EN 10149-1, EN 10149-2, or EN 10149-3.

#### 5.1.2 Cold temperature operation

Where necessary due to possible brittle fracture in cold operating temperatures, bridles, top transom and bottom transom members and fall back arrestors and their supports should have a minimum Charpy V-notch impact value of 27 J at 0 °C.

### 5.2 Aluminium alloys

The materials used for aluminium alloy members should comply with:

- for extrusions: the requirements of EN 515, EN 573-3, EN 755-1, EN 755-2, EN 755-3, EN 755-4, EN 755-5, EN 755-7, or EN 12020-1 and EN 12020-2;
- for rolled products: the requirements of EN 485-1, EN 485-2, EN 485-3 or EN 485-4 or IEC 60079.

In addition, extrusions and rolled products used for the fabrication of bridles and top transom and bottom transom members should be individually identified and should be the subject of quality systems.

## 6 Nominal operating loads

The nominal operating loads shall be as given in [Clauses 7](#) to [10](#). The nominal emergency load shall be as given in [Clause 11](#).

## 7 General operating loads

### 7.1 Permanent loads

Permanent loads shall be as defined in ISO 22111.

The permanent load,  $G_c$ , shall be taken as the total self-weight of the conveyance structure and all attachments, excluding rope attachments. The permanent load,  $G_c$  (N), shall be calculated using the following Formula:

$$G_c = g m_c \quad (1)$$

where

$g$  is the acceleration due to gravity ( $m/s^2$ );

$m_c$  is the conveyance mass including all attachments, excluding rope attachments (kg).

### 7.2 Vertical imposed loads due to holding devices

#### 7.2.1 Holding device engagement load

The holding device engagement load,  $K$  (N), shall be calculated using the following Formula:

$$K = \alpha_k (G_c + C_y + T) \quad (2)$$

where

$\alpha_k$  is the holding device impact factor, which may be taken as 1,5 in the absence of better information, and provided the conveyance is not travelling at more than creep speed (0,5 m/s) when the devices are engaged;

$C_y$  equals  $P$ ,  $\sum M$ ,  $U$  or  $R$ , as appropriate (N);

$T$  is the load due to the tail rope or ropes (N).

NOTE Some holding devices are only applied after the conveyance has stopped completely. In this case the load specified here does not apply.

#### 7.2.2 Holding devices securing load

The holding device securing load,  $K_c$  (N), shall be calculated using the following Formula:

$$K_c = \alpha_k C_y \quad (3)$$

where

$\alpha_k$  is the holding device impact factor, which in the absence of better information may be taken as:

1,0 for personnel loading;

2,0 for materials loading;

1,5 for rock loading;

$C_y$  equals  $P$ ,  $\sum M$ ,  $U$  or  $R$ , as appropriate (N).

## 7.3 Lateral imposed loads

### 7.3.1 Fixed guide systems in vertical shafts

The lateral loads imposed on conveyances running on fixed guide systems in vertical shafts shall be taken as equal to the lateral loads imposed on shaft steelwork, as defined in ISO 19426-5.

### 7.3.2 Rope guide systems

7.3.2.1 Only one of the loads given in 7.3.2.2 to 7.3.2.4 shall be engaged at any one time.

7.3.2.2 Whilst running in rope guides, the rubbing block load,  $H_r$ , may, in the absence of better information, be taken as:

$$H_r = 0,01 (G_c + C_y) \quad (4)$$

This load may be distributed amongst all the rubbing blocks.

7.3.2.3 While entering the fixed flare guides or spear guides near stations, the slipper plate load,  $H_s$ , shall be calculated in accordance with ISO 19426-5, for fixed guide systems, but with the following modifications:

$L$  is the length of the flare (see Figure 1) (m);

$e$  is the lateral flare guide or spear guide dimension (see Figure 1), unless a rational analysis shows otherwise (m);

$K_g$  is the steelwork stiffness at the end of the flare (N/m).

7.3.2.4 While running in fixed guides at stations, the slipper plate load,  $H_s$ , shall be as defined in ISO 19426-5, for fixed guide systems.

### 7.3.3 Decline shaft conveyance wheel loads

The loads imposed on conveyances in the direction normal to the rail and transverse to the rail in decline shafts shall be taken as equal to the loads imposed on shaft rails in decline shafts, as defined in ISO 19426-5.

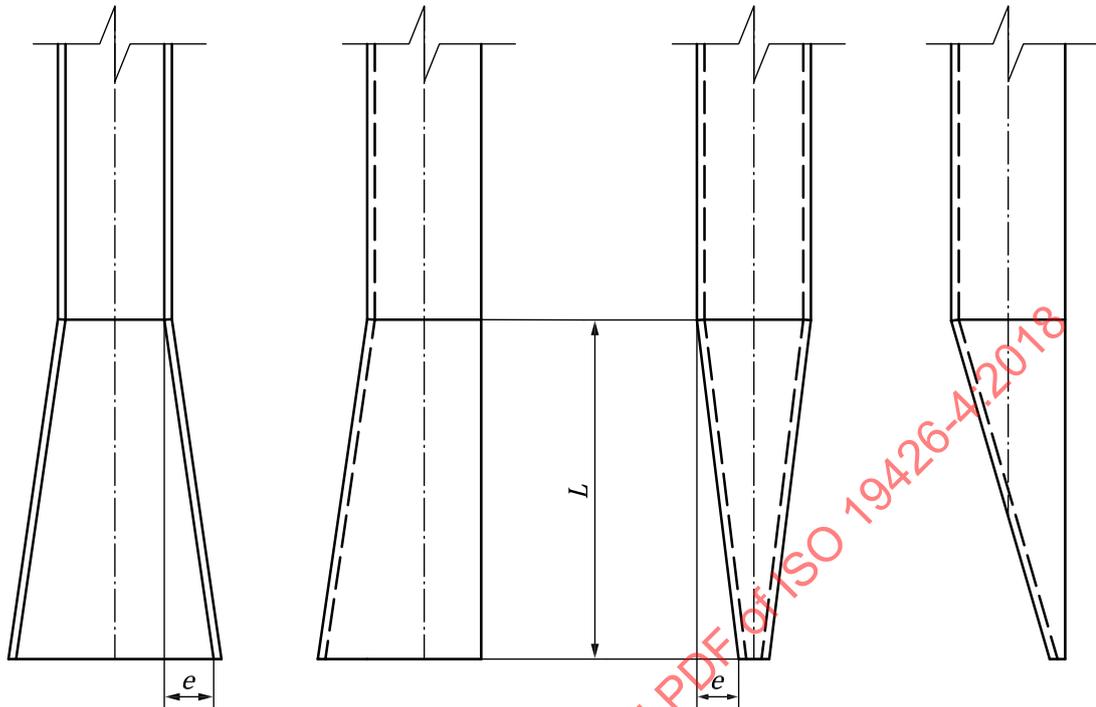


Figure 1 — Typical flare guide or spear guide arrangement

## 7.4 Winder system loads

### 7.4.1 Acceleration/deceleration load

The load,  $A_o$  (N), due to the operating acceleration or deceleration of the winder system shall be taken as

$$A_o = \frac{\alpha_d a_o}{g} (G_c + C_y + T) \quad (5)$$

where

$\alpha_d$  is the dynamic impact factor, which may be taken as 2,0, in the absence of better information;

$a_o$  is the operating winder system peak acceleration/deceleration ( $\text{m/s}^2$ );

$g$  is the acceleration due to gravity ( $\text{m/s}^2$ );

$G_c$  is the conveyance self-weight load (N);

$C_y$  equals  $P$ ,  $\Sigma M$ ,  $U$  or  $R$ , as appropriate (N);

$T$  is the load due to the tail rope (N).

### 7.4.2 Trip-out load

The load  $A_t$  (N), due to deceleration of the winder system during a trip-out shall be taken as:

$$A_t = \frac{\alpha_d a_t}{g} (G_c + C_y + T) \quad (6)$$

where  $a_t$  is the trip-out winder system peak deceleration ( $\text{m/s}^2$ ).

### 7.4.3 Tail-rope load

For friction winder systems, the load,  $T$  (due to the tail ropes), shall be determined from the winder system design requirements. Both maximum and minimum tail-rope loads shall be considered.

### 7.4.4 Vertical friction load

The vertical load,  $F_v$  (N), induced by friction during slipper plate contact on each guide, shall be taken as:

$$F_v = 0,5 H_s \quad (7)$$

where  $H_s$  is the lateral slipper plate load (N).

## 7.5 Roof loads

The roof of cages shall be subjected to one of the following:

- cages in vertical shafts with a uniformly distributed vertical load of 3 000 N/m<sup>2</sup>; or
- cages in decline shafts with a uniformly distributed vertical load of 1 500 N/m<sup>2</sup>.

## 8 Personnel winding loads

### 8.1 Standing personnel load

The load for standing personnel shall be taken as

- a vertical load,  $P$ , of 5 000 N/m<sup>2</sup>, acting on the horizontal deck area, and
- horizontal line load,  $H$ , along the sides and doors of the conveyance, of 2 000 N/m. This load shall be applied 1,5 m above the floor, acting outwards.

### 8.2 Seated personnel load

The load,  $P$ , for seated personnel, shall be taken as 4 000 N/m<sup>2</sup> of horizontal projected deck area.

### 8.3 Loading of cages

Overturning or tilting of cages during loading shall be checked by applying the loads given in [8.1](#) and [8.2](#) to any unfavourable half of the floor area of the cage.

### 8.4 Loading of cages in decline shafts

Where personnel enter from the side of cages in decline shafts, the following loads,  $P$ , shall be applied at the roof level above the entry points:

- a horizontal concentrated load of 1 000 N acting in the direction of entry into the cage shall be applied simultaneously at each entry point;
- a vertical load of 2 000 N shall be applied simultaneously at each entry point.

## 8.5 Dogging system load

Where a dogging system is used, the dogging system load,  $D$  (N), shall be taken as:

$$D = \left( 1 + \frac{a_D}{g} \right) (G_c + C_y) \quad (8)$$

where

$a_D$  is the maximum permitted conveyance deceleration when the dogging system activates ( $\text{m/s}^2$ ), which may be taken as  $19,6 \text{ m/s}^2$  in the absence of better information;

$g$  is gravity acceleration ( $\text{m/s}^2$ );

$G_c$  is the conveyance self-weight load (N);

$C_y$  is  $P$ ,  $\sum M$ ,  $U$  or  $R$ , as appropriate (N);

This load shall be rationally distributed to the elements of the dogging system.

## 9 Material and equipment winding loads

### 9.1 Floor loads

#### 9.1.1 Static load

The load,  $M$ , for each item of rolling stock or equipment shall be determined for the particular application.

#### 9.1.2 Impact loads

##### 9.1.2.1 Rolling stock load

Impact loads during loading and off-loading shall be determined using the following Formulas.

a) For the vertical axle load,  $C_v$  (N):

$$C_v = \alpha_v M_1 \quad (9)$$

where

$\alpha_v$  is the vertical load impact factor, which may be taken as given in [Table 1](#);

$M_1$  is the heavier axle load (N).

**Table 1 — Recommended values of  $\alpha_v$ , the vertical load impact factor**

| Context   | Rolling stock | Rubber-tyred vehicle | Crawler-mounted vehicle |
|---|---------------|----------------------|-------------------------|
| The conveyance in a vertical shaft is held in position during loading     | 2,0           | 1,2                  | 2,0                     |
| The conveyance is on rails in a decline shaft                             | 2,0           | 1,2                  | 2,0                     |
| The conveyance in a vertical shaft is not held in position during loading | 3,5           | 2,0                  | 3,5                     |

b) For the horizontal load,  $C_h$  (N):

$$C_h = \alpha_h M \quad (10)$$

If a buffer with spring stiffness,  $K_s$ , is used, then  $\alpha_h$  may be calculated using the following Formula:

$$\alpha_h = 0,5 \sqrt{\frac{gK_s}{M}} \text{ but not } > \text{ than } 0,5 \quad (11)$$

In all other cases,  $\alpha_h = 0,5$ .

### 9.1.2.2 Rubber-tyred, self-propelled vehicle load

Impact loads during loading and off-loading shall be determined using the following Formulas:

a) For the vertical axle load,  $C_v$  (N):

$$C_v = \alpha_v M_1 \quad (12)$$

where

$\alpha_v$  is the vertical load impact factor, which may be taken as given in [Table 1](#).

$M_1$  is the heavier axle load (N).

b) For the horizontal load,  $C_h$  (N):

1) The total horizontal braking load on the floor of the conveyance shall be taken as:

$$C_h = \alpha_h M \quad (13)$$

where  $\alpha_h$  is a braking or acceleration impact load, which may be taken as 0,1 in the absence of better information.

2) The horizontal impact load on the back wall of the conveyance shall be taken as:

$$C_h = \alpha_h M$$

where  $\alpha_h$  is the horizontal load impact factor, which may be taken as 0,2 in the absence of better information.

### 9.1.2.3 Crawler-mounted, self-propelled vehicle load

Impact loads during loading and off-loading shall be determined using the following Formulas.

a) For the vertical load,  $C_v$  (N):

The vertical load shall be taken as the most severe of the following:

1) concentrated loads at the front end and the rear end of each track, with a magnitude of:

$$C_v = \frac{\alpha_v M}{4} \quad (14)$$

2) concentrated loads at the centre of each track, with a magnitude of:

$$C_v = \frac{\alpha_v M}{2} \quad (15)$$

- 3) uniformly distributed loads along the full length of each track, with a magnitude of:

$$C_v = \frac{\alpha_v M}{2L_T} \quad (16)$$

where

$\alpha_v$  is the vertical load impact factor, and may be taken as given in [Table 1](#);

$L_T$  is the length of the crawler track (m).

- b) For the horizontal load,  $C_h$  (N):

- 1) The total horizontal braking load on the floor of the conveyance shall be taken as:

$$C_h = \alpha_h M \quad (17)$$

where  $\alpha_h$  is a braking or acceleration impact load, which may be taken as 0,1, in the absence of better information.

- 2) The horizontal impact load on the back of the conveyance shall be taken as:

$$C_h = \alpha_h M \quad (18)$$

where  $\alpha_h$  is the horizontal load impact factor, which may be taken as 0,2, in the absence of better information.

#### 9.1.2.4 Other material and equipment loads

Impact loads shall be determined for the particular circumstances, cognizance being taken of the method of loading.

## 9.2 Underslung loads or trailing loads

The load,  $U$ , due to under slinging in vertical shafts or trailing loads in decline shafts, shall be determined for the particular application in vertical or decline shafts. Consideration shall be given to vertical and induced horizontal loads during loading and off-loading.

## 10 Rock winding loads

### 10.1 Skip loads

#### 10.1.1 General

The rock pressures and loads used for the design of a skip are dependent on factors such as its shape, the method of loading, rock properties, the type of liner used, the presence or otherwise of skip holding devices, and rope elasticity. In the absence of better information the pressures and loads given in [10.1.2](#) to [10.1.8](#) may be used.

#### 10.1.2 Static rock loads

The static rock load,  $R$ , shall be based on the maximum capacity of the skip without a surcharge.

### 10.1.3 Bridle and top transom loads during filling

The bridle and top transom load during filling,  $R_d$  (N), shall be taken as:

$$R_d = \alpha_v R \quad (19)$$

where

$\alpha_v$  is the vertical load impact factor, which may be taken as 1,1 when the conveyance is held in position during loading;

$\alpha_v$  is the vertical load impact factor, which may be taken as 1,5 when the conveyance is not held in position during loading;

### 10.1.4 Reference rock pressure

The reference rock pressure,  $p_o$  (N/m<sup>2</sup>), for the design of skips shall be taken as:

$$p_o = \rho g z \quad (20)$$

where

$\rho$  is the bulk density of rock, (kg/m<sup>3</sup>);

$g$  is the acceleration due to gravity (m/s<sup>2</sup>);

$z$  is the maximum depth of rock contained in the conveyance (m).

### 10.1.5 Pressure during filling or travelling in the shaft

#### 10.1.5.1 Pressure on skip bottom ( $p_1$ )

The pressure on the skip bottom,  $p_1$  (N/m<sup>2</sup>), during filling or during travelling in the shaft shall be taken as:

$$p_1 = \alpha_p p_o \quad (21)$$

where

$\alpha_p$  is the rock pressure factor, which may be taken as given in [Table 2](#) (see [Figure 2](#));

**Table 2 — Recommended values of  $\alpha_p$ , the rock pressure factor**

| Context   | Filling skip | Travelling in shaft | Emptying skip |
|---|--------------|---------------------|---------------|
| Skip bottom or door surface   | 1,0          | 1,0                 | 1,0           |
| Skip side surface inclined at more than 60° to horizontal and on which rock impacts during filling  | 0,5          | 0,3                 | 0,3           |
| Skip side surface inclined at not more than 60° to horizontal and on which rock impacts during filling  | 1,0          | 0,3                 | 0,3           |
| Skip side surface on which rock does not impact during filling  | 0,3          | 0,3                 | 0,3           |
| Skip door or side surface within 0,3 m above and below of any location at which the rock flow direction is forced to change during emptying of the skip | —            | —                   | 1,5           |

**10.1.5.2 Side pressure ( $p_2$ )**

**10.1.5.2.1** The side pressure,  $p_2$  (N/m<sup>2</sup>), on the skip sides during filling or during travelling in the shaft shall be taken as:

$$p_2 = \alpha_p p_0 \quad (22)$$

where

$\alpha_p$  is the rock pressure factor (see [Figure 2](#)).

**10.1.5.2.2** In the absence of better information, the rock pressure factor,  $\alpha_p$ , may be taken as given in [Table 2](#).

**10.1.6 Pressures during emptying**

The side or bottom pressure,  $p_3$  (N/m<sup>2</sup>), shall be taken as:

$$p_3 = \alpha_p p_0 \quad (23)$$

where

$\alpha_p$  is the rock pressure factor which may be taken as 1,5 for an area based on a distance of 0,3 m above and below the intersection of the skip body and the discharge chute, or any other location at which the rock flow is forced to change direction (see [Figure 2](#));

it may be taken as 0,3 for all other surfaces (see [Figure 2](#)).

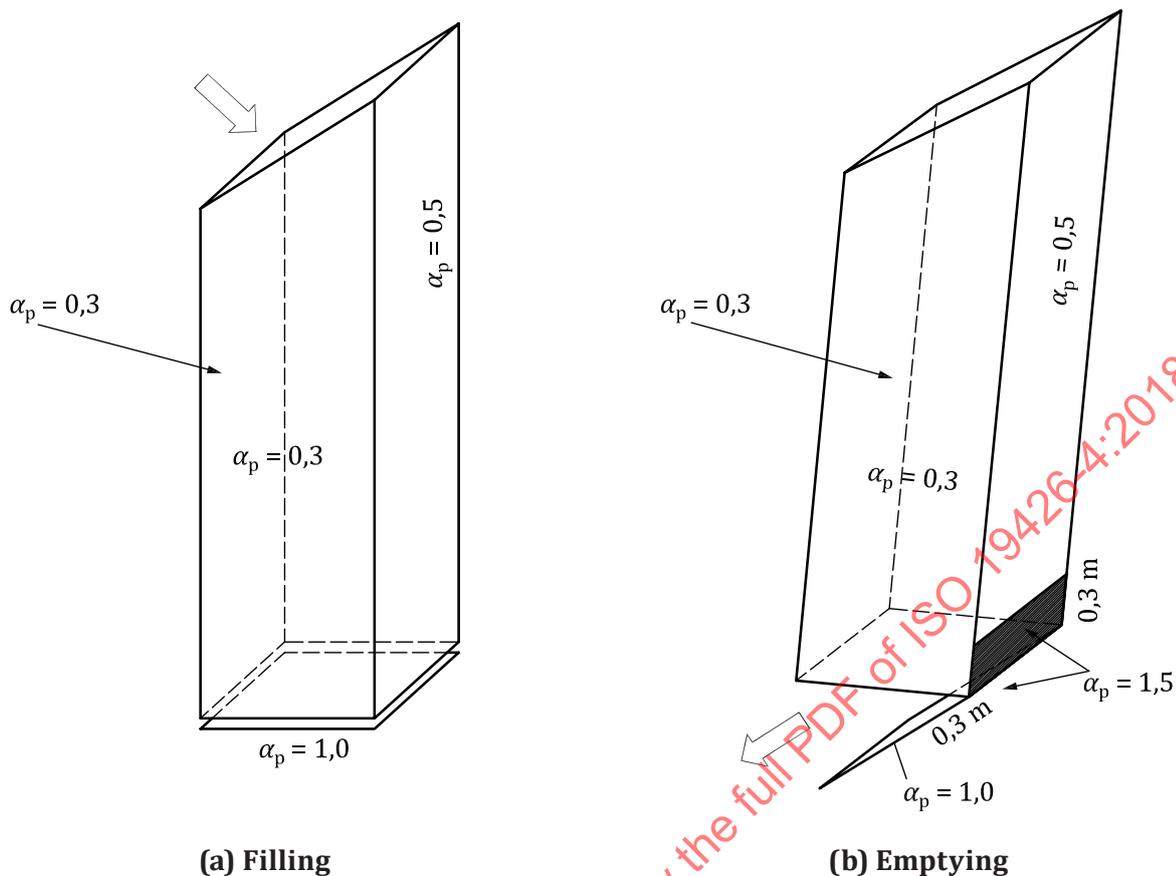


Figure 2 — Typical rock impact factors ( $\alpha_p$ )

### 10.1.7 Load on tipping rollers

The tipping roller loads shall be determined on a rational basis, depending on the skip tipping mechanism. [Annex B](#) gives specific examples.

### 10.1.8 Skip return-stop loads

The skip return-stop loads shall be determined on a rational basis, depending on the skip tipping and return mechanism. [Annex B](#) gives specific examples.

## 10.2 Kibble loads

### 10.2.1 Static rock or slurry loads

The static rock or slurry load,  $R$ , shall be based on the maximum capacity of the kibble, including the surcharge.

### 10.2.2 Reference rock or slurry pressure

The reference rock or slurry pressure,  $p_0$  (N/m<sup>2</sup>), for the design of kibbles, shall be taken as:

$$p_0 = \rho g z \tag{24}$$

where

- $\rho$  is the higher of the saturated rock density or the slurry density of the rock ( $\text{kg/m}^3$ );
- $g$  is the acceleration due to gravity ( $\text{m/s}^2$ );
- $z$  is the maximum depth of rock contained in the conveyance (m).

### 10.2.3 Pressure during filling

#### 10.2.3.1 Pressure on kibble bottom ( $p_1$ )

The pressure on the kibble bottom,  $p_1$  ( $\text{N/m}^2$ ), shall be taken as:

$$p_1 = \alpha_p p_o \quad (25)$$

where

$$\alpha_p = 1,0.$$

#### 10.2.3.2 Side pressure ( $p_2$ )

The side pressure,  $p_2$  ( $\text{N/m}^2$ ), shall be taken as:

$$p_2 = \alpha_p p_o \quad (26)$$

where

$$\alpha_p = 0,3, \text{ in the case of rock;} \\ = 1,0, \text{ in the case of slurry.}$$

### 10.2.4 Pressures during emptying

Pressures during emptying are deemed to be not greater than those during filling. However, cognizance shall be taken of the re-orientation of the kibble and its loads during emptying.

### 10.2.5 Heavy kibble payloads

Where specific heavy equipment is transported in the kibble, cognizance shall be taken of this in the design of the kibble.

## 11 Emergency loads

### 11.1 Rope emergency load

#### 11.1.1 Permanent operating conveyances with fixed rope winders

The rope emergency load,  $E_r$ , shall be taken as the actual rope breaking load. In the absence of this information, the rope emergency load,  $E_r$ , may be taken as 1,1 times the estimated rope breaking load.

#### 11.1.2 Permanent operating conveyances with friction winders

The rope emergency load,  $E_r$ , shall be assessed by a rational analysis. As an upper limit the rope load given in [11.1.1](#) may be used as defined in ISO 19426-2.

### 11.1.3 Temporary equipping, maintenance and inspection conveyances

Where occupants of the conveyance are in continuous voice contact with the winder driver, the rope emergency load,  $E_r$  (N), shall be taken as:

$$E_r = \beta(G_c + C_y) \quad (27)$$

where

$\beta$  is the rope emergency factor and shall be taken as 10 or a lower figure, as stated by the appropriate authority;

$G_c$  is the conveyance self-weight load (N);

$C_y$  is  $P$ ,  $\Sigma M$ ,  $U$  or  $R$ , as appropriate (N).

### 11.1.4 Slung equipment and conveyances

Where equipment or conveyances are slung below permanent conveyances, the rope emergency load,  $E_r$  (N), to be used for the design of the slung equipment or conveyance shall be taken as:

$$E_r = \beta(G_c + C_y) \quad (28)$$

where

$\beta$  is the rope emergency factor;

$G_c$  is the conveyance self-weight load (N);

$C_y$  is  $P$ ,  $\Sigma M$ ,  $U$  or  $R$ , as appropriate (N).

The rope emergency factor may be taken as one of the following:

- a) 5,0, where the occupants of the conveyance or a piloting conveyance are in continuous voice contact with the winder driver, and the hoisting speed does not exceed 3 m/s;
- b) 3,0, for once-off transport of heavy items of equipment and where the occupants of the conveyance or a piloting conveyance are in continuous voice contact with the winder driver, and the hoisting speed does not exceed 1 m/s.

The integrity of the heavy equipment itself, including slinging lugs and casing, shall be certified by the supplier thereof.

### 11.1.5 Kibbles and kibble cross-heads

The kibble cross-head shall be subjected to the rope emergency load,  $E_r$ , defined in [11.1.1](#).

## 11.2 Emergency drop-back loads

### 11.2.1 General

The loads applied by the fall back arrestors,  $E_j$  (N), shall be as determined using ISO 19426-2.

### 11.2.2 All permanent conveyances

The critical load bearing components of the conveyance shall be subjected to the emergency drop-back load,  $E_j$ , as defined in [10.2.1](#).

### 11.2.3 Kibbles and kibble cross-heads

The kibble, chains and cross-head shall be subjected to the emergency drop-back load,  $E_j$ , as defined in 11.2.1. The drop-back distance shall be calculated assuming that the kibble falls from the underside of the kibble cross-head until the chains tighten.

### 11.3 Roof impact loads

Unless otherwise specified by the client, cage roofs shall be designed to resist a vertical impact load equal to one of the following:

- a) cages in vertical shafts: 20 000 N, applied on an area of 0,1 m × 0,1 m, anywhere on the roof; or
- b) cages in decline shafts: 10 000 N, applied on an area of 0,1 m × 0,1 m, anywhere on the roof.

### 11.4 Skip loads

#### 11.4.1 General

The emergency rock pressures and loads used for the design of a skip are dependent primarily on the extent to which slurry or large rocks are loaded into the skip.

#### 11.4.2 Reference rock pressure

The reference rock pressure,  $p_o$  (N/m<sup>2</sup>), for the design of skips, shall be taken as:

$$p_o = \rho g z \quad (29)$$

where

- $\rho$  is the higher of the saturated rock density or the slurry density of the rock, in kilograms per cubic metre (kg/m<sup>3</sup>);
- $g$  is the acceleration due to gravity (m/s<sup>2</sup>);
- $z$  is the maximum depth of rock contained in the conveyance (m).

#### 11.4.3 Pressure during filling or travelling in the shaft

##### 11.4.3.1 Pressure on skip bottom ( $p_1$ )

The pressure on the skip bottom,  $p_1$  (N/m<sup>2</sup>), during filling or during travelling in the shaft shall be taken as:

$$p_1 = \alpha_p p_o \quad (30)$$

where  $\alpha_p = 1,0$ .

##### 11.4.3.2 Side pressure ( $p_2$ )

The side pressure,  $p_2$  (N/m<sup>2</sup>), on the skip sides during filling or during travelling in the shaft shall be taken as:

$$p_2 = \alpha_p p_o \quad (31)$$

where  $\alpha_p$  is the rock pressure factor.

In the absence of better information, the rock pressure factor,  $\alpha_p$ , may be taken as 1,0.

### 11.4.3.3 Single rock impact ( $R_i$ , $R_k$ ) during filling

The single rock impact during filling shall be as follows.

- a) The single rock impact vertical load on the skip door,  $R_i$ , during filling shall be based on energy considerations. The impact energy of the falling rock,  $Z_i$  (J), shall be taken as 50 % of the potential energy of the falling rock, namely:

$$Z_i = 0,5h_d g m_r \quad (32)$$

The single rock impact vertical load,  $R_i$  (N), shall be calculated assuming plastic deformation of the skip door, namely:

$$R_i = \frac{Z_i}{d_i} \quad (33)$$

where, in Formulas (32) and (33),

$h_d$  is the height through which the rock falls to be taken as not less than the depth of the skip (m);

$g$  is the acceleration due to gravity (m/s<sup>2</sup>);

$m_r$  is the mass of the largest rock that will be loaded into the skip (kg);

$d_i$  is the deformation of the skip door (m).

The mass of the rock,  $m_r$ , may be based on a rock size limited by physical constraints in the rock handling system, but the rock size shall not be taken as less than 0,02 m<sup>3</sup>.

The deformation of the skip door,  $d_i$ , may be taken as 5 % of the width of the skip plus 75 % of the thickness of any rubber liners.

- b) The single rock impact horizontal load on the skip sides,  $R_k$ , during filling shall be taken as:

$$R_k = 0,1 R_i \quad (34)$$

The single rock impact shall be applied to any area measuring 0,3 m × 0,3 m on the skip door, or side.

## 11.5 Emergency stopping device loads

A variety of devices can be applied to stop the conveyance in the event of an emergency in decline shafts, and in some jurisdictions in vertical shafts as well. These include braking systems in decline shafts and dogging systems in vertical shafts. The loads on these devices and their attachment to the conveyance shall be analysed on a rational basis, taking into account the mass and mass moment of inertia of the conveyance, the configuration and capabilities of the device, the expected deceleration, the hoisting speed, and any energy absorption or plastic deformation capacity of the device.

### 11.5.1 Overspeed device

In decline shafts, where a brake is activated by an overspeed device, the attachment of the brake to the control conveyance shall be designed to resist twice the braking force.

In decline shafts, where a lever to derail the conveyance is activated by an overspeed device or by loss of head rope tension, the attachment to the control conveyance shall be designed to resist twice the force required to lift and derail the conveyance.

## 11.6 Application of emergency loads

The emergency loads specified in [11.1.1](#) and [11.1.2](#) shall be applied to the conveyance in proportion to the distribution of the mass of the conveyance, its contents and any underslung or tail rope mass.

The emergency loads specified in [11.1.1](#) and [11.1.2](#) shall be applied to critical load bearing components of the conveyance. Other components need not be designed to resist these emergency loads, unless a risk analysis indicates that this is necessary.

## 12 Design procedures

### 12.1 Design loads

The nominal loads for operating and emergency conditions shall be obtained from [Clauses 6 to 11](#). 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.

### 12.2 Design codes

Members of conveyance structures shall be designed using limit-state design procedures as given in ISO 10721-1 and ISO 10721-2, for steel components, and in EN 1999-1-1, EN 1999-1-3 and EN 1999-1-4, for aluminium components.

### 12.3 Design for emergency loads

#### 12.3.1 Steel components

Provided that the steel used is a ductile material and where it can be shown that the member will not be subject to premature failure due to local buckling or local tensile rupture, the design action effect for emergency loads may exceed the design resistance of the member by 20 %.

#### 12.3.2 Aluminium components

Design procedures shall not be modified for aluminium components.

#### 12.3.3 Special considerations

##### 12.3.3.1 Conveyance roofs

Under the action of the emergency loads, plastic deformation of cage roofs to the extent of not more than 100 mm on roof beams and 200 mm on roof plates is acceptable, provided the roof plate is not penetrated.

## 12.4 Fatigue

Members subject to fluctuating loads shall be assessed for fatigue damage in accordance with ISO 19426-5.

In general, the number of cycles for fatigue loading shall be determined from the conveyance life required and the load application frequencies as given in ISO 19426-5.

## 13 Construction requirements

### 13.1 General

All construction of conveyances shall be completed in compliance with the requirements of good engineering practice as described in the appropriate national standards and specifications.

### 13.2 Confirmation of design by testing

#### 13.2.1 Testing of operating mechanisms

Prior to dispatch to the mine, all conveyances should be suspended from the rope attachment points for the following tests to be conducted.

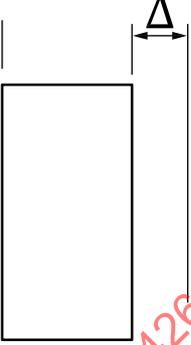
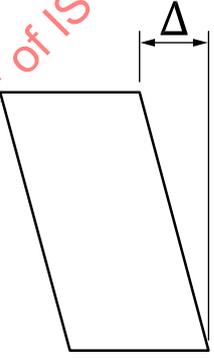
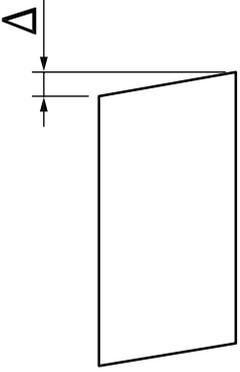
- a) Whilst suspended freely, the conveyance should hang vertical with an error of not more than 10 mm between the highest and lowest points.
- b) Whilst skips are supported in the vertical position, the door should be opened by pulling horizontally on the tipping rollers. The door opening mechanism should operate freely.
- c) Whilst cages are supported in the vertical position, all doors should be opened and closed. All doors should open and close freely.

### 13.3 Construction tolerances

All construction of conveyances shall comply with tolerances as specified by the appropriate national standards and specifications, and in addition the tolerances given in [Table 3](#).

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**Table 3 — Conveyance construction tolerances for conveyances**

| Aspect |  | Permissible deviation ( $\Delta$ )   |
|--------|--|--|
| 1      | <p><b>Mine shaft conveyance width</b></p> <p>Deviation in overall width</p>  |  <p><math>\Delta = \pm 2 \text{ mm}</math></p>                |
| 2      | <p><b>Mine shaft conveyance plumb</b></p> <p>Deviation in plumb of conveyance construction</p> <p><math>h</math> is the overall height of the conveyance</p>           |  <p><math>\Delta = \pm h/1\,000</math></p>                   |
| 3      | <p><b>Mine shaft conveyance level</b></p> <p>Deviation in horizontal level of conveyance construction</p> <p><math>b</math> is the overall width of the conveyance</p> |  <p><math>\Delta = \pm b/1\,000 &lt; 5 \text{ mm}</math></p> |

## Annex A (informative)

### Load factors and load combinations

#### A.1 General

This annex provides guidance with respect to load factors and load combinations which comply with the requirements of 12.1. The partial load factors and combination factors given in this Annex provide for the level of reliability envisaged in ISO 22111 for ordinary consequences of failure.

NOTE Throughout this annex, “load” can also be read as “load effect”.

#### A.2 Operating conditions

##### A.2.1 Partial load factors

The appropriate values of partial load factors given in Table A.1 should be used.

##### A.2.2 Load combinations

For load combinations, the design load,  $F$  (N), should be calculated using the following Formula:

$$F = \gamma_{g1}G_1 + \gamma_{g2}G_2 + \gamma_{f1}Q_1 + [\Psi_2\gamma_{f2}Q_2 + \dots + \Psi_n\gamma_{fn}Q_n] \quad (\text{A.1})$$

where

$\gamma_{g1}$  and  $\gamma_{g2}$  are the partial load factors for permanent loads;

$\gamma_{f1} \dots \gamma_{fn}$  are the partial load factors for imposed loads;

$G_1$  and  $G_2$  are the permanent loads, including the self-weight of the structure and the structural components (N);

$Q_1$  is the dominant imposed load under consideration (N);

$Q_2$  to  $Q_n$  are the additional independent imposed loads (N);

$\Psi_2$  to  $\Psi_n$  are the load combination factors.

##### A.2.3 Fatigue design loads

Fatigue design should be carried out in accordance with ISO 19426-5.

#### A.3 Emergency conditions

The design load,  $F$  (N), should be calculated using the following Formula:

$$F = \gamma_e Q_e \quad (\text{A.2})$$

where