SLOVENSKI STANDARD
SIST-TP CEN/TR 17838:2022

01-november-2022

Uporaba čepov iz sipkega materiala v polžastih transporterjih in sprejemnikih izdelkov za namene eksplozijske izolacije

Use of plugs of bulk material in screw conveyors and product receivers for explosion isolation

Schneckenförderer Explosions-Entkopplungssysteme

Utilisation des bouchons de matériaux en vrac dans les convoyeurs à vis et les bacs de réception à des fins d'isolation contre les explosions

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13.230	Varstvo pred eksplozijo	Explosion protection
53.040.20	Deli za transporterje	Components for conveyors

SIST-TP CEN/TR 17838:2022 **en,fr,de**

TECHNICAL REPORT

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Use of plugs of bulk material in screw conveyors and product receivers for explosion isolation

Utilisation des bouchons de matériaux en vrac dans les convoyeurs à vis et les bacs de réception à des fins d'isolation contre les explosions

Schneckenförderer Explosions-Entkopplungssysteme

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European foreword

This document (CEN/TR 17838:2022) has been prepared by Technical Committee CEN/TC 305 “Potentially explosive atmospheres - Explosion prevention and protection”, the secretariat of which is held by DIN.

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Introduction

Screw conveyors are mechanical devices for the continuous movement, discharge or variable rate feeding of bulk materials in form of powder, granules or grain. They are often used horizontally or at a slight incline to discharge or feed silos, storage bins, filter units, mills or other equipment in many bulk handling industries.

Product receivers are silos, bins and hoppers used for temporary storage of bulk materials. The design of product receivers is determined by parameters such as storage capacity, throughput and overall height but also products properties such as powder cohesion, coefficient of sliding friction and permeability.

Both screw conveyors and product receivers can under certain conditions act as explosion isolation devices/systems in combination with the bulk material being handled by these pieces of equipment. This document presents the aforementioned conditions that are necessary to ensure explosion isolation. These conditions include dust properties and dust explosion properties, dimensions of the equipment and minimum requirements regarding the dimensions of the bulk material plugs.

1 Scope

This document describes the recommendations for the design and use of screw conveyors and product receivers which can in addition be used as a means for explosion isolation to prevent a dust explosion transmission into connected plant items by using the bulk material which is inside.

The recommendations given in this document are procedural measures since the properties of the bulk material affect the efficacy of this measure essentially (e.g. flow and explosion characteristics). Product receivers and screw conveyors cannot be considered as protective systems under the scope of the ATEX Directive.

As far as screw conveyors are concerned, the scope of this document is limited to rigid, tubular, singular screw conveyors which consist of a spiral blade coiled around a shaft held by external bearings (the rotating part of the conveyor is sometimes called “auger”).

NOTE Additional internal bearings can be necessary if the tubular screw conveyor exceeds a certain length.

This document includes limits of application where a plug of bulk material in a screw conveyor is not possible/sufficient to achieve explosion isolation and also application ranges where a plug of bulk material is not necessary to achieve explosion isolation.

This document does not address the mandatory risk analysis and ignition hazard assessment, which are performed for the application of the screw conveyors and product receivers. The mandatory risk assessment includes start-up and shut-down conditions, when potentially no plug of material is present to prevent explosion propagation. To mitigate this residual risk, it is possible to use as an extra measure, e.g. a traditional gate valve which prevents flame transmission and is able to withstand the expected maximum explosion pressure.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
screw conveyor
mechanical device for the continuous movement, discharge or variable rate feeding of bulk materials in form of powder and/or granules

Note 1 to entry: Screw conveyors are often used horizontally or at a slight incline to discharge or feed silos, storage bins, filter units, mills or other equipment in many bulk handling industries.

3.2
product receiver
enclosure such as silo, bin or hopper used for temporary storage of bulk materials

3.3
fluidity factor
ffc
dimensionless characteristic parameter of the flowability of bulk materials calculated from the ratio of the consolidation stress to the compressive strength

Note 1 to entry: See ASTM E 6773-02, Standard shear test method for bulk solids using the Schulze ring shear tester [10].

3.4
compressive strength
σ_c
resistance of a material to breaking under compression

Note 1 to entry: See ASTM E 6773-02, Standard shear test method for bulk solids using the Schulze ring shear tester [10].

3.5
consolidation stress
σ_1
decrease in volume of the bulk material from applied stress (force per unit area) under defined conditions

Note 1 to entry: See ASTM E 6773-02, Standard shear test method for bulk solids using the Schulze ring shear tester [10].

EXAMPLE A hollow cylinder filled with bulk material and applied stress on the end side of the cylinder.

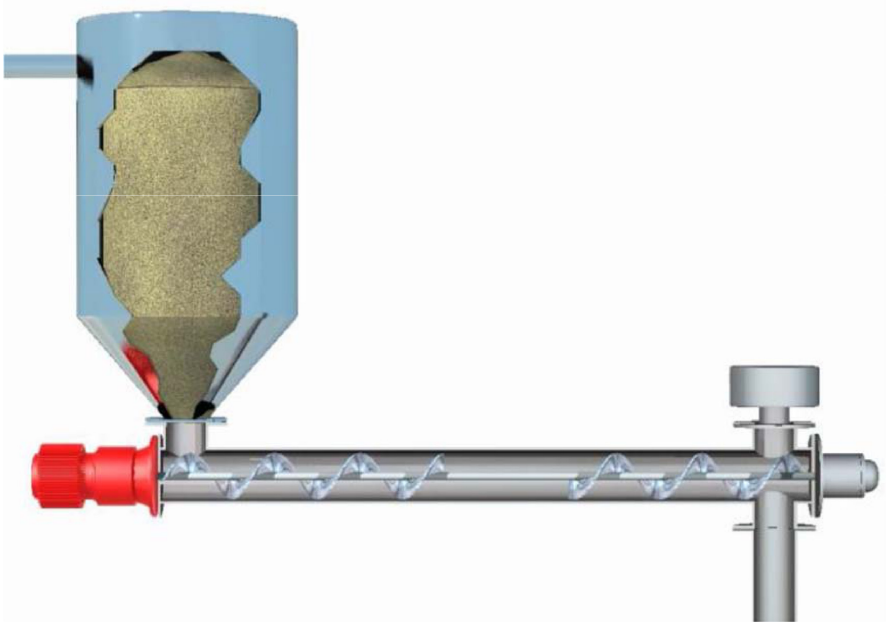
4 Tubular screw conveyors and explosion isolation

4.1 General

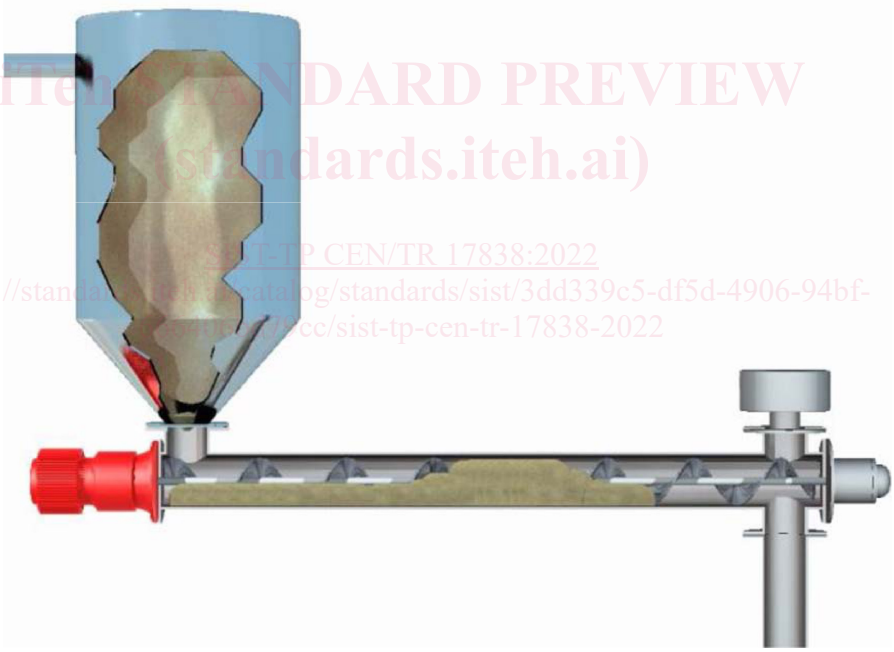
A tubular screw conveyor consists of a tube containing a spiral blade coiled around a shaft (auger), driven at one end and held at the other. It may be powered by an external electric motor with fixed or variable speed. The power transmission can happen by a clutch or a chain drive. The rate of volume transfer is proportional to the speed of the shaft. The rotational speed is typically in the range of 5 r/min to 90 r/min, the conveying velocity in the range of 0,01 m/s to 0,3 m/s.

The principle of a plug in a tubular screw conveyor used for explosion isolation is based on the removal of a small part of the spiral blade (screw) so that a plug of bulk material will remain inside the tube. The plug should remain for a sufficient time period even if the feeding of bulk material into the screw conveyor is interrupted or finished (see Figure 1). This principle was described for the first time by Wheeler [1].

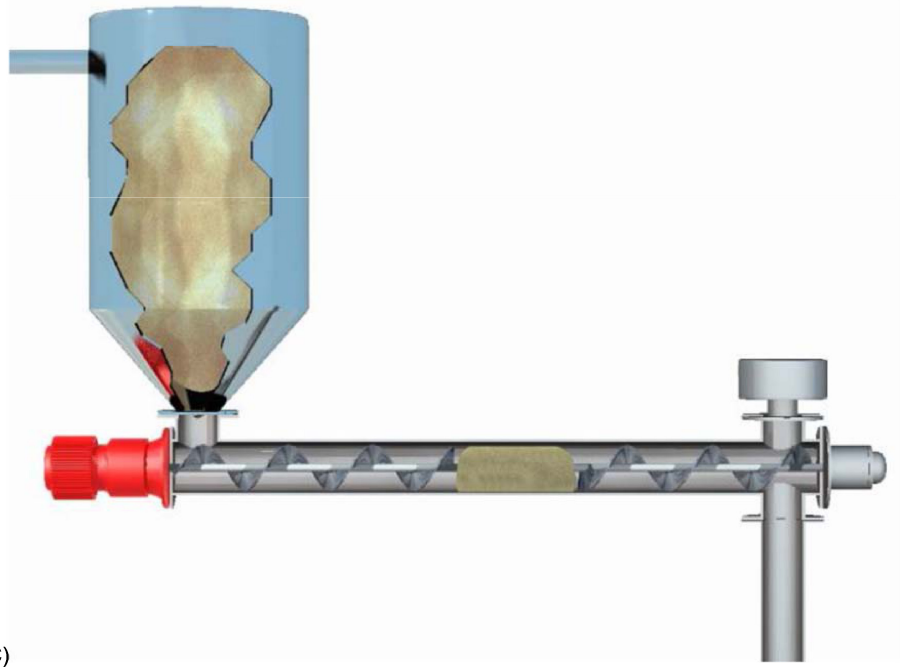
The effectiveness of tubular screw conveyors for explosion isolation according to the principle as described before has been investigated by large scale explosion tests [3-5] for a specific tubular screw conveyor limiting the range of application of the recommendations given in this document.



a) Removal of a small part of the screw (spiral blade), e.g. 1,5 turns



b) During normal operation, a plug of bulk material is formed



C)

c) Remaining plug of bulk material even if no more bulk material is fed into the screw conveyor

Figure 1 — Principle pictures of a tubular screw conveyor suitable for explosion isolation

The technical specifications of the used tubular screw conveyor are given in Table 1.

Various augers were used for the explosion isolation tests in which 1, 1,5 and 2 turns of the spiral blade were removed. Additional tests were performed with a normal standard auger (complete spiral blade).

The tubular screw conveyor was connected with a vented or closed 1 m^3 explosion vessel. In addition, all tests were repeated with a vented 26 m^3 explosion vessel. The reduced explosion overpressures were varied in the range of 0,1 bar to 2,5 bar. During all tests the screw was emptied before ignition of the dust cloud in the explosion vessel which represents the worst case as verified during testing. The test procedure to this end was as follows: the screw conveyor was operated for 60 s in normal operation. After 60 s the dust feeding into the screw conveyor was stopped to drive the screw conveyor empty. After another 30 s the dust cloud in the connected vessel was ignited. Tests were performed with the screw running as well as with the screw standing still. The results were not affected by the screw running or not. Where the flight was partially removed, a plug of bulk material remained, depending on the flowability of the bulk material (expressed by a fluidity factor ffc, see 3.3).

The explosion tests were carried out with dusts of different explosion characteristics and flow properties as shown in Table 2.

Table 1 — Technical specifications of the used tubular screw conveyor

Length from product inlet to product outlet	1 800 mm
Inside diameter	200 mm
Outside diameter of the flight (auger)	180 mm
Diameter of the shaft	50 mm
Screw pitch before location where part of flight was removed	180 mm
Screw pitch behind location where part of flight was removed	210 mm
Maximum gap between circumference of the flight and casing	10 mm
Engine power	3,0 kW
Engine speed (50 Hz)	120 r/min [a]
Conveying capacity	5,5 t/h (bulk weight 0,7 kg/dm^3)
Pressure shock resistance (overpressure)	10 bar

[a] The actual rotational speed during the tests was depending on the bulk density of the conveyed material and the filling degree of the screw conveyor (typically 45 %). Most tests were performed at a rotational speed of ca. 70 r/min resulting in a tip speed of ca. 0,65 m/s.

Table 2 — Explosion and flow characteristics of different bulk materials

Bulk material	Median diameter	p_{max}	K_{St}	MIE [a]	Bulk density	Fluidity factor
	µm	bar	bar·m/s	mJ	kg/l	ffc
Corn starch	14	9,0	200	> 3 / ≤ 10	0,64	9,78
Cellulose	17	9,0	175	> 5 / ≤ 10	0,32	2,79
Malt	20	8,4	150	> 5 / ≤ 10	0,22	6,40
Powder sugar	31	7,9	140	> 5 / ≤ 10	0,60	2,08
Milk powder	60	8,8	125	> 30 / ≤ 100	0,56	3,73
Wooden dust	72	8,5	160	> 50 / ≤ 100	0,23	4,62
Wheaten flour	51	7,5	80	> 100 / ≤ 500	0,54	2,80
Refined sugar	424	3,8	12	> 10^6	0,85	8,60
Grain	> 5 000	—	—	—	0,70	11,00

[a] Minimum ignition energy measured with inductivity in the discharge circuit [12].

4.2 Influence of the bulk material

4.2.1 General

The effectiveness of a plug in a tubular screw conveyor used for explosion isolation and the required technical specifications are depending on the properties of the used bulk materials. The flow properties of the bulk material and the minimum ignition energy of the expected dust/air-mixture have a strong influence and should be taken into consideration (see Table 2).