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Line Guide Device for Clean Room Applications

The invention relates in general to a line guide device for
10 clean room applications which is configured for dynamic and
protected guidance of supply lines, such as for example
cables, hoses or the like, in a clean room application. A
generic line guide device comprises an elongate, flexible
envelope which is displaceable to-and-fro between a first
15 connection point and a second connection point movable
relative thereto. The line guide device may typically form
two runs with an interposed displaceable deflection arc with
specified minimum radius and travel for example in a
vertical plane or in linear manner.

20 Apparatus used in clean rooms should discharge as few
particles as possible to the surroundings during operation,
and this relates particularly to mobile apparatus. With
regard to line guide devices, WO 02/086349 A1 and, as a
further development, WO 2012/131033 A1 proposed as line
25 guide devices energy guide chains suitable for clean rooms
which minimize abrasion-related release of particles by the
energy guide chain.

However, as a result of the required to-and-fro motion, not
only the line guide device but also the guided lines
30 themselves release particles over the course of the period
of operation. A line guide device improved in this respect
was proposed by the applicant in WO 2016/042134 A1. The line
guide device described therein (with reference to Figs. 3A-

3D and 12-16 of said WO 2016/042134 A1) is obtainable from the applicant under the tradename "e-skin".

This generic line guide device has an envelope, consisting of opposing shell parts, with two opposing, undoable and reclosable connection regions, for insertion or removal of a line when open. When closed, the envelope surrounds the internal inner space, which serves to receive one or more lines, in dust-tight manner. Thus, no particles with particle sizes critical for clean room applications can exit during operation. The envelope itself is also optimized for clean room use.

A considerable advantage over other previously known solutions consists in the fact that the line guide device can be opened in order, if necessary, to renew individual lines, i.e. the line guide device does not have to be completely replaced together with all the lines.

If such a line guide device or a comparable line guide device is opened for maintenance purposes, for example to replace a defective line, particles which have been released operationally in the inner space over the previous period of operation, in particular from the lines, may enter the surrounding environment, i.e. the clean room. Such contamination requires complex cleaning measures or prolongs downtimes and is thus obviously undesirable.

A first object of the present invention is therefore to propose a line guide device improved with regard to the above-mentioned contamination problem. This object is achieved by a line guide device as claimed in claim 1. The subclaims reveal advantageous further developments.

In the case of a line guide device according to the preamble of claim 1, the object is achieved simply by providing a functional material within the envelope which serves or is

effective in reducing the number of free particles in the inner space.

The reduction achieved according to the invention is to be understood in relative terms and relates to a comparison measurement carried out, in each case by aspiration of the inner space, after an identical operating period on a line guide device according to the invention and on a line guide device structurally identical thereto and with identical line filling but without functional material in the inner space. In this case, in particular the number and size of the particles per unit air may be measured according to standard DIN EN ISO 14644-1.

The reduction may in particular be achieved by two modes of action, namely by using a functional material which as it were captures or retains particles released operationally in the inner space and/or by using a functional material which counteracts the operational release of particles in the inner space, in particular by lines to be guided. The invention likewise encompasses the use of one functional material which achieves both modes of action or indeed a combination of two materials each having one of these effects.

The at least one functional material may in this case in particular be arranged or mounted separately or in addition to the actual envelope and the lines to be accommodated in the inner space.

The envelope surrounds the inner space of the line guide device in dust-tight manner both lengthwise between the two ends and in the circumferential direction. The dust-tight envelope effectively prevents particles from escaping when closed. In the present context, dust-tight does not necessarily mean hermetically gas-tight or sealed in such a

way that nothing can penetrate or escape. Rather, dust-tight means technically impermeable to the escape of particles of particle sizes critical to clean room applications, which arise for example in the case of conventional solutions through friction, abrasion or motion.

For the purposes of the invention, there are different options for introducing the generally particle-reducing functional material. An insert, an inlay, a layer, a filling, a padding or the like which comprises the particle-reducing functional material or consists integrally thereof may to this end be provided in the inner space.

Alternatively or in addition, a coating of the functional material may also be provided at least in places on the inner wall of the envelope.

In one embodiment, a functional inlay is provided in the form of a fibrous structure, in particular of a nonwoven, with a particle-attracting action and/or adhesive action. In particular, a fibrous structure with electrostatic action, preferably with polymer fibers, may be provided as functional material. An electrostatic charge, which has an attractive action with regard to particles, may in this case be achieved or maintained by operational motion of the nonwoven or the fibrous structure relative to the envelope and/or guided lines. Suitable nonwovens are known for cleaning purposes, for example. Microfibers of polyethylene and/or polyester may be considered. The fibrous structure may be provided with a coating, of pressure-sensitive adhesive for example, which is permanently tacky and intensifies the adhesive action, or allows the particles to adhere to the fibers even on decay of the electrostatic charge.

The functional material may in particular comprise a pressure-sensitive adhesive, for example based on natural or synthetic rubber or acrylates, or indeed based on polyurethanes and silicones. A suitable pressure-sensitive adhesive should have a permanent surface tackiness (tack) over an extended period of operation (and within the application temperature ranges).

In one further embodiment, a gel, a closed-cell foam and/or a pressure-sensitive adhesive, may be introduced at least in places into the envelope as functional material. In this case, the functional material may in particular be introduced as a high-viscosity functional filling or functional layer. A filling does not in this case have completely to fill the free inner space (without lines) cross-sectionally and/or lengthwise.

A corresponding functional material, in particular a gel or foam or pressure-sensitive adhesive preferably has an adhesive action or permanent tackiness, at least under intended ambient or operating conditions, in particular at temperatures in the range from 5°C-60°C, at least from 10°C to 50°C.

Alternatively or in addition, a functional layer with particle-reducing functional material may be applied merely in places, in particular on the inner wall of the envelope. Preferably, a material separate from the envelope and the lines, i.e. not a coating bonded to the envelope inside or line outside(s), is used as functional material.

It is possible, as an example of a functional material which counteracts operational release of particles in the inner space, in particular by lines to be guided, additionally or alternatively to provide a friction coefficient-reducing tribopolymer. To keep the structure simple, this may be

provided as a functional inlay or sliding film, in particular between adjacent lines, for example centrally on the neutral axis or indeed toward the outside between lines and the inner wall of the envelope.

5 A solution which is simple in structural or manufacturing terms consists in arranging at least one elongate, tape-like functional insert or at least one elongate, tape-like functional inlay in the inner space. In this case, an existing envelope, for example according to Figs. 3A-3D or
10 12-16 of WO 2016/042134 A1 may be used without modification.

A suitable functional material may be provided in the inner space at least over a great majority of the length of the envelope, and this also continuously or without interruption between two connection points depending on the arrangement
15 within the accommodation space. Provision may however also be made, for example in the case of the use of separating webs for partitioning the interior, for the functional material to be distributed with interruptions in places in the lengthwise direction, for example as tape-like
20 individual strips.

For example, precisely one functional insert, one functional inlay, one functional layer etc. may be provided with functional material at the height of the neutral axis in the envelope or indeed for example two functional inserts,
25 functional inlays etc., which are provided in the envelope in such a way that they are opposite one another relative to the neutral axis.

The functional material preferably forms at least one functional surface which faces the inner space and/or lines
30 to be guided and for example has a particle-retaining or adhesive and/or friction coefficient-reducing mode of action.

To simplify maintenance work, the functional material is embodied so as to be detachable from the inside of the envelope and/or from the lines to be guided, in particular readily detachable by hand or without using a tool.

- 5 The functional material is preferably provided in a reusable format, for example with detachable insert, inlay etc..

With regard to the reclosable connection or a corresponding closure, the connection region preferably has two closure strips continuous in the lengthwise direction and having
10 meshing profiles. These may interact in the manner of a pressure closure, sliding closure or the like and enable opening of the envelope over the entire length thereof, wherein the closure strips are preferably arranged at substantially neutral axis height.

- 15 In one preferred embodiment, a line guide, in accordance with the principle of Figs. 3A-3D or 12-16 of WO 2016/042134 A1, is fitted or retrofitted according to the invention with functional material, for example in one of the above embodiments. In this case, the envelope is
20 undoably assembled in portions of in each case two opposing shell parts of plastics material, in particular of two shell parts with different corrugated profiles. The shell portions connected together in the lengthwise direction here delimit a continuous inner space, in which the functional material
25 is provided.

Further features and advantages of the invention may be inferred without limitation of the scope of protection from the following description of a number of preferred exemplary embodiments made on the basis of the appended figures, in
30 which:

Fig. 1 shows a schematic cross-section through a line guide device according to a first exemplary embodiment;

Fig. 2 shows a schematic cross-section through a line guide device according to a second exemplary embodiment;

Fig. 3 shows a schematic cross-section through a line guide device according to a third exemplary embodiment;

5 **Fig. 4** shows a schematic cross-section through a line guide device according to a fourth exemplary embodiment

Fig. 5A & Fig. 5B show schematic longitudinal sections for clarifying the arrangement of a functional material relative to the longitudinal direction of the line guide device.

10 Figs. 1-4 and Figs. 5A-5B are schematic representations of a line guide device 1 (Figs. 5A-5B). This serves in protected guidance of cables, hoses or similar lines, denoted in general as 10 (cf. Figs. 1-4). Between an upper run 2 and a lower run 3, the line guide device 1 variably or dynamically
15 forms a deflection arc 4 with specified curvature about a deflecting axis. To avoid line breaks, the deflection arc 4 in particular has a specified, minimum radius of curvature and in this way ensures the radii of curvature do not fall below admissible radii of curvature for the guided lines 10.
20 The deflection arc 4 travels over a distance relative to the stationary connection 5 together with the connection 7, which is here movable in linear manner for example, here for example in a vertical plane. In the example shown, the mobile connection 5 is located by way of example on the
25 upper run 2 and the stationary connection 7 on the lower run 3. The upper run 2 is preferably self-supporting, i.e. has a self-supporting length.

The line guide device 1 has an envelope 11, which is embodied in the manner of a corrugated hose and has a
30 corrugated profile, which on the one hand provides flexibility and on the other hand predetermines the radius

of the deflection arc 4. The envelope 11 as such is embodied according to WO 2016/042134 A1, namely Figs. 12-16 therein, i.e. assembled in portions of two joined-together shell parts 12A, 12B.

- 5 The shell parts 12A, 12B consist of a resilient plastic with long-term bending resistance, and are preferably injection molded from thermoplastic material.

The shell parts have connecting strips 14A, 14B on both sides, arranged in each case opposingly on the neutral axis
10 13 (cf. Fig. 3), for example with teeth according to WO 2016/042134 A1. The connecting strips 14A, 14B form an undoable and reclosable connection region on both sides. In this way, the envelope 11 may be opened laterally over the entire length for insertion or removable of lines. The
15 connecting strips 14A, 14B act as a dust-tight closure.

When closed, the envelope 11 defines or delimits a continuous inner space 15 in dust-tight manner lengthwise and in the circumferential direction. The inner space 15 serves to accommodate a plurality of lines 10. In relation
20 to further structural details of the envelope 11, the teaching of WO 2016/042134 A1 (in particular Figs. 12-16 therein) is here incorporated for the sake of brevity.

In the exemplary embodiment according to Fig. 1, to reduce the number of free particles in the inner space 15, two
25 opposing tape-like functional inlays 100A, 100B are provided in places, which have a thin, flexible backing (not shown) with as functional face a functional material 101 on the surface facing the inner space. The functional material 101 may here for example take the form of a suitable pressure-
30 sensitive adhesive or the like and has an adhesive action or tack with regard to clean room-critical particles released operationally in the inner space. It should be assumed that

released particles move quasi-chaotically in the inner space on displacement of the line guide device 1, such that over a sufficiently long period the great majority of the particles are "captured" by the functional material 101 of the

5 functional inlays 100A, 100B and remain adhered thereto. This particles thus can no longer escape on opening. The functional inlays 100A, 100B may be provided over a great majority of the length of the line guide device 1, here on the inner wall of the envelope 11, or distributed lengthwise
10 over a smaller proportion, as shown schematically in Fig. 5A, such that less weight is added and the cost of materials minimized.

In the variant of Fig. 2, a nonwoven with an electrostatically attracting action with regard to free dust
15 particles is provided as functional inlay 200. The functional inlay 200 and/or adhesive action is provided. Microfibers, for example of polyethylene and/or of polyester, may here be used as functional material 201 in the nonwoven, preferably with a tacky coating for example of
20 a pressure-sensitive adhesive or the like. The functional inlay 200 in Fig. 2 is arranged centrally, in particular at neutral axis height 13, and may extend continuously for example according to Fig. 5B over the entire length of the line guide device 1 or envelope 11. A further advantage of
25 this arrangement consists in the fact that friction may be avoided between lines 10 which, as in Fig. 2, are not arranged at neutral axis height 13 (longitudinal plane which does not undergo any length modification in the deflection arc 4) and abrasion is correspondingly further reduced.

30 In the embodiment according to Fig. 3, a functional filling 300 of a gel 301 is provided as functional material. A preferred gel 301 is durably flowable, such that an incision for replacing a line closes again. In addition, the gel 301

may be embodied with tack or permanent tackiness, so as to retain particles. The gel may take the form for example of a suitable gel from the Relicon® product range from HellermannTyton GmbH (D-25436 Tornesch). Additionally, the lines may be frictionlessly held spaced apart by the gel 301. Alternatively, to reduce weight, a closed-cell, permanently tacky foam may also be used. Mixtures with a pressure-sensitive adhesive may also be considered for achieving an adhesive action or permanent tackiness.

10 In a further embodiment according to Fig. 4, three elongate functional inlays 400A, 400B, 400C are provided as functional material in the form of sliding films of a friction coefficient-reducing tribopolymer 401. A suitable tribopolymer is obtainable for example under the tradename
15 iglidur® tribo-tape liner from igus GmbH (D-51147 Cologne). According to Fig. 4, two such functional inlays 400A, 400B may in each case be provided between the inner wall 11A of the envelope 11 and guided lines 10. A further functional inlay 400C is provided centrally roughly on the neutral axis
20 13. The functional inlays 400A, 400B, 400C of tribopolymer 401 work to combat the cause of operational release of particles in the inner space, namely by largely preventing abrasion between the lines. Accordingly, the functional inlays 400A, 400B, 400C are preferably provided continuously
25 in the lengthwise direction (cf. Fig. 5B).

In an arrangement according to Fig. 4, in addition or as an alternative to one or more of the functional inlays 400A, 400B, 400C, for example in addition to the middle functional inlay 400C, a nonwoven 200 may also be used according to
30 Fig. 2 and/or a pressure-sensitive adhesive 101 may be used according to Fig. 1.

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Line Guide Device for Clean Room Applications

List of Reference Signs

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1	Line guide device
2	Upper run
3	Lower run
4	Deflection arc
15 5, 7	Connection point
10	Lines (e.g. supply cables)
11	Envelope
11A	Inner wall
12A, 12B	Shell part (of the envelope)
20 13	Neutral axis
14A, 14B	Connection strips
15	Inner space
100A, 100B; 200	Functional inlay
101; 201; 301; 401	Functional material
25 300	Functional filling
400A-400C	Functional inlay

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Line Guide Device for Clean Room Applications

Claims

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1. A line guide device (1) for lines (10), such as for example cables, hoses or the like, in a clean room application, comprising
an elongate, flexible envelope (11) which is
15 displaceable to-and-fro between a first connection point (7) and a second connection point (5) movable relative thereto, in particular forming a deflection arc (4) between two runs (2, 3),
the envelope (11) having at least one undoable and
20 reclosable connection region (14A, 14B), for insertion or removal of a line (10) when the connection region is open; and the envelope, when closed, surrounding in dust-tight manner an inner space (15) for accommodating one or more lines, **characterized in that**
25 within the envelope (11) a functional material (101; 201; 301; 401) is provided to reduce the number of free particles in the inner space (15), wherein the functional material in particular retains operationally released particles in the inner space and/or
30 counteracts the operational release of particles in the inner space.
2. The line guide device as claimed in claim 1,
characterized in that a functional insert, a functional inlay (100A, 100B; 200; 400A-400C), a functional layer

or a functional filling (300) which comprises the functional material or consists thereof is provided in the inner space (15).

3. The line guide device as claimed in claim 1,
5 characterized in that a coating of the functional material is provided at least in places on the inner wall (11A) of the envelope (11).
4. The line guide device as claimed in claim 2,
10 characterized in that a fibrous structure, in particular a nonwoven (201), with particle-attracting action and/or adhesive action, in particular with electrostatic action is provided as functional inlay.
5. The line guide device as claimed in claim 2,
15 characterized in that a gel (301), a closed-cell foam and/or a pressure-sensitive adhesive is introduced into the envelope at least in places as the functional material, in particular as a high-viscosity functional filling or functional layer.
6. The line guide device as claimed in claim 5,
20 characterized in that the gel (301) or the foam or the pressure-sensitive adhesive has an adhesive action or permanent tackiness.
7. The line guide device as claimed in claim 5,
25 characterized in that a functional layer with particle-reducing functional material is applied merely in places, in particular on the inner wall (11A) of the envelope.
8. The line guide device as claimed in claim 2,
30 characterized in that a sliding film (400A, 400B, 400C) of a friction coefficient-reducing tribopolymer (401) is provided as functional inlay.

9. The line guide device as claimed in one of the preceding claims, characterized in that at least one elongate tape-like functional insert (200; 400A-400C) or at least one elongate tape-like functional inlay is arranged in the inner space (15).
10. The line guide device as claimed in one of the preceding claims, characterized in that the functional material (201; 401) is provided in the inner space at least over a great majority of the length of the envelope.
11. The line guide device as claimed in one of the preceding claims, characterized in that the functional material (101) forms at least one functional surface which faces the inner space and/or lines to be guided.
12. The line guide device as claimed in one of the preceding claims, characterized in that the functional material (101-401) is embodied so as to be detachable from the inside of the envelope and/or from lines to be guided.
13. The line guide device as claimed in one of the preceding claims, characterized in that the connection region has two closure strips (14A, 14B) continuous in the lengthwise direction with meshing profiles.
14. The line guide device as claimed in claim 13, characterized in that the envelope (11) is undoably assembled in portions of in each case of two opposing shell parts (12A, 12B) of plastics material, in particular of two shell parts with different corrugated profiles, which delimit a continuous inner space (15).