

Safety Device for Lifts

The present invention relates to a safety device for lifts with at least one lift guide rail, securely installed in the lift shaft and a brake part, comprising at least one friction element with at least one friction surface that can be pressed against the guide rail to decelerate the lift, with the friction material of the friction element comprising a fibre-reinforced, ceramic composite material containing silicon carbide and carbon fibres as reinforcing component, as well as a procedure for producing such a friction element.

A safety device of the described type or a brake shoe for an emergency stop device for lifts is known from US-A-5.964.320.

Passenger lifts for apartment blocks, observation towers, etc. must contain an independent emergency brake or emergency brake means in addition to the operational brake. Such an emergency brake is designed as a safety stop, which in case of an emergency, i.e. when the lift car exceeds a specified maximum speed, stops the car by pressing friction linings against the guide rails in the lift shaft after a delay that is acceptable to passengers in the car and securely holds the car in the stopped, stationary position.

Modern buildings are built increasingly higher, to fully utilise the ground and space available, in particular, in cities. In order to be able to reach the individual floors in such high-rise buildings within a reasonable time, full use is made of maximum permissible speeds of up to 1500 metres per minute. This means that the kinetic energy to be absorbed in case of an emergency, during the deceleration

- of the car, also increases in line with increasing speeds so that the friction linings of the emergency brakes - functioning as linear brakes - are exposed to extreme loading. Conventional metal friction linings for emergency
- 5 brake devices in lifts are not able to withstand such an extreme loading, during which temperatures of up to 1000°C can be generated. Such conventional friction linings as described, for instance, in GB-A-2 274 827 have a friction surface structure that contains a graphite phase, a
- 10 steadite phase, a cementite phase and a perlite phase. In order to meet increasing requirements, ceramic brake linings with silicon nitride as their main component, have been suggested for emergency lift brakes in recent times.
- 15 US-A-5.503.257 discloses a lift safety device comprising ceramic brake parts, with the ceramic material consisting of aluminium oxide, silicon nitride or zirconic oxide.

Even such ceramic brake linings or respective brake shoes

20 containing such linings, are pushed to their limit in order to provide a safe function, as during the sudden locking of the brake shoes on the metal guide rails, the inherent brittleness and sensitivity to impact of these ceramics can cause the linings to brake as a result of mechanical over-

25 stressing or thermal shock.

The described ceramic brake parts made of aluminium oxide, silicon nitride or zirconic oxide have a smaller dimension than the support plate and are engaged or glued in the re-

30 taining elements of the support plate. Due to the ceramic brake parts and the metallic support plate having different expansion behaviours, it must be anticipated that the brake parts will be distorted or loosened at high friction surface temperatures. This may potentially cause the failure

of the entire brake device as a result of sheared off or broken off brake parts. Brake parts with larger surface dimensions (i.e. plate-shaped brake parts) can not be used due to their inadequate damage tolerance during the arising
5 bending load.

US-A-5.964.320 suggests a brake body for emergency lift brakes, comprising a braking surface and a multitude of brake parts that are embedded in and protruding over the
10 brake area. These protruding brake parts are made from a composite material, containing a ceramic base material, consisting of the group silicon nitride or titanium boride, sialone and silicon carbide that does not comprise less than 10 weight percent of at least one ceramic material se-
15 lected from the group that consists of silicon carbide whiskers and silicon carbide platelets. As these brake shoes or friction linings include minimum parts of SiC whiskers (acicular fibres up to a few μm in length) or SiC platelets (plate-shaped parts at micrometer scale), the ce-
20 ramics are somewhat strengthened and a small improvement in fracture resistance is achieved. In addition, these brake parts can contain 10 to 55 volume percent of long SiC, Si₃N₄, C or tungsten fibres, which are, however, in this case arranged vertical to the lining surface. The fibres
25 do, however, only provide a very low level of reinforcement. Whisker and platelet particles are respirable due to their small size and can, when given off as a result of wear and braking abrasion, also be inhaled by humans. Whiskers and platelets are consequently no longer used to-
30 day due to their toxicity and their use is illegal in most countries.

Based on the prior art described above, the present invention has the task to further develop a safety device for

lifts of the type described above in such a way that the requirements for emergency devices of lifts reaching the maximum permissible speed of up to 1500 meters per minute (equal to 25 m/s) and temperatures in excess of 1000°C at the emergency brake device, when cars are stopped during emergencies, are fulfilled.

The task is solved by a safety device of the type described above, in which the composite material contains a matrix of silicon carbide and carbon and the reinforcing component being formed preferably exclusively from carbon fibres with a minimum length of 10 mm and the volume content of carbon fibres in the friction element lying between 30% and 70%. Such a safety device is, in particular, characterised by 10 mm long or longer carbon fibres reinforcing the friction element; whisker or platelet reinforcing components are thus not required so that during emergency braking, no hazardous abraded dust is generated. The carbon fibres forming the reinforcement component are embedded in a matrix consisting of silicon carbide and carbon. The volume content of carbon fibres in the friction element between 30% and 70% guarantees an sufficiently high break and thermal shock resistance, with a lower volume content of carbon fibres being preferable, where extremely low rates of wear and a high thermal conductivity are to be achieved, whilst a high volume content of carbon fibres should be used, where particularly stringent requirements are made with regard to the mechanical stability of the composite material.

The amount of carbon fibres in the friction element is determined by the required mechanical stability and thermal shock resistance, improving with increasing fibre content. A minimum content of silicon carbide is required for generating adequate friction and wear resistance. Lower volume

contents of carbon fibres are preferable in case of moderate driving speeds or where the friction linings can have a respective thickness. High fibre contents should be used, where extreme driving speeds are to be achieved or, where
5 for space reasons, the friction linings must be extremely thin.

In a preferred embodiment, the carbon fibres are arranged as stacked layers of woven and/or knitted fabrics in the
10 friction elements; in this case, the carbon fibres are at least arranged in the area of the friction surface in such a way that they run parallel to it. This fibre arrangement allows the bending moments, generated during the abrupt impact of the linings onto the guide rail during emergencies
15 and when holding the car during standstill with extremely high surface pressures of up to 100/Mpa, to be absorbed. As a result of, in particular, this measure, also large-surface linings can be produced as a single piece, i.e. replacing the multitude of individual, smaller friction elements.
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Due to the high fracture resistance, these friction elements can also be produced as circular round plates apart from the rectangular linings and securing holes, cross and
25 longitudinal grooves can be applied without adversely affecting the durability of these friction elements. Consequently, all conventional designs can be used for the installation of such friction elements in safety stops.

30 Research has also shown that a high ceramic content in friction elements, i.e. a content of silicon carbide of 20 mass percent or more, in particular, in the area of the friction element proximal to the friction surface, has a positive effect on the friction coefficient and wear resis-

tance. Such high ceramic contents advantageously increase the friction coefficient, thermal conductivity and wear resistance. The content of carbon fibres in the area of the friction element proximal to the friction surface should
5 therefore only be as high that the friction heat can be dissipated by a respective thermal conductivity of the composite material with at least 10 W/mK. It was found that where the thermal conductivity was set too low in the area of the friction element proximal to the friction surface,
10 abraded metal particles would deposit on the lining surface, causing localised bonding with the guide rail in emergencies. As a result, parts of the area of the friction element proximal to the friction surface can break off or detach themselves.

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An advantageous structure for friction elements are uncoated carbon fibres with a minimum length of 10 mm. Shorter fibres convert to a large extend to silicon carbide under heat treatment and the provision of liquid silicon,
20 which increases wear resistance but, at the same time, adversely influences the material strength as a result of the conversion to SiC. In order to limit or compensate for these negative influences and in order to achieve a minimum strength of 50 Mpa, the used carbon fibres must have a
25 minimum length of 10 mm and a fibre volume content of at least 30% as adequate strength is, in particular, provided by the length of the carbon fibres and the volume content of the fibres. Fibre lengths corresponding to the longest dimensions of the friction element (i.e. length x width)
30 have, however, been found to be most advantages.

In one embodiment, the friction element can be divided into a core part and a friction part at least surrounding the friction surface. In such an arrangement, the core part and

the friction part can be adapted to the different requirements, i.e. the core part can be designed for high strength and stability of the friction body, whilst the friction part is designed for the specific requirements when locking
5 onto the guide rail during emergencies, i.e. the tribologic behaviour (constancy of friction coefficient, wear resistance and thermal conductivity) of the friction part is optimised.

10 The individual layers from which such a friction element can be constructed, can be connected to each other with reaction siliconisation. As part of this process, a joining paste with a high C-content is applied to the connection area between the layers prior to ceramisation, said paste
15 reacting with the liquid silicon to silicon carbide during subsequent siliconisation.

A preferred layer structure contains three layers, allowing on one hand, high ceramic contents to be realised in the
20 area of the friction element proximal to the friction surface and, on the other hand, guaranteeing the adequate mechanical strength of the friction element by providing a strength-optimised layer with high fibre contents. Due to the different contents of carbon fibres, the two layers ex-
25 pand differently during heating, so that potentially high tensile stresses in the area proximal to the friction surface could result in failure. In order to prevent this, an additional third layer is installed between the two layers, whose expansion behaviour must be designed in such a way
30 that critical tensile stresses are prevented or reduced to an acceptable level. In particular with three layers, a composite material divided into a friction and a core part can be produced at an economical cost.

In order to achieve the aforementioned advantages, the SiC content of the matrix should increase from the core area of the friction body to the friction surface, i.e. the higher converted areas are on the outside, so that the SiC content is higher in these areas.

In order to quickly remove any abrasion from the friction surface areas during emergency braking, indentations and, in particular, grooves can be provided in the friction surface areas. Preferably, the indentations should be arranged transversely to the direction of friction or, alternatively, at an angle of 30° to 60° to the direction of friction; an advantageous angle is 45° . The indentations should also be 1 to 5 mm wide to be able to absorb enough abraded material. The area indented in the friction surface should be $\approx 30\%$ of the entire friction surface area.

A layer containing Si and SiC on the friction surface with preferably a thickness of 0.01 to 0.2 mm, can increase the wear resistance compared to uncoated friction elements. It should, however, also be ensured that the ceramic layer offers a high enough adhesion at high temperatures. A layer thickness of up to 0.2 mm is preferred, as thicker layers cause flaking and thus the failure of the friction layer.

An advantageous fibre volume content of the composite material is at least 50%; values of 50% or higher result in a particularly high strength and fracture resistance.

Where friction elements with ceramic layers are, for instance, unsuitable because of too soft counterparts (guide rail), the composite material should have an open porosity of $\pm 10\%$. An open porosity above this value can be disadvantageous as the friction coefficient decreases due to the

absorption of abraded particles, oil and fatty constituents from the guide rail, etc.

In order to achieve a sufficiently high wear resistance,
5 the SiC content of the composite material is set to at least 20 mass percent, with this value relating to the entire friction element and representing a lower limit for the friction surface area.

10 Carbon fibres formed from bundles of at least 1000 individual filaments, with the individual filaments having a diameter of between 5 to 15 μm , offer the advantage of a macroscopically even SiC distribution in the composite material. It also allows the cheaper production of friction
15 elements as numerous semi-finished fibre products with these dimensions are commercially available. In order to achieve a high level of strength for the arising abrupt stresses, provide the required safety reserves and allow the production of large-size friction elements, the composite material should have a bending strength of at least 50
20 Mpa.

A preferred composite material for friction elements is formed by liquid siliconisation of a carbon/carbon element,
25 produced by the pyrolysis of a green element bound with phenolic resin and reinforced with carbon fibres. Such a procedure can be used to produce friction elements, which, on one hand, have a sufficiently high content of C fibres and, on the other hand, have a sufficiently high content of
30 SiC. With this procedure, in particular, different C and SiC contents between areas proximal to the friction surface and the core area, can be achieved.

A preferred composite material for friction elements can be characterised by 40 to 45 mass percent SiC, 2 to 6 mass percent Si and 49 to 58 mass percent C and C fibres.

- 5 If the friction elements are structured in thickness, i.e. with a different layer structure, the friction body should be structured symmetrically to the centre plane in relation to the thickness of the friction element.
- 10 Below, embodiments of friction elements for the use in safety devices of lifts with a lift guide rail, securely installed in the lift shaft, onto which the friction bodies lock on, are described.

15 **Embodiment 1**

A friction body was constructed from a matrix consisting of 95 weight percent of silicon carbide and carbon and a fibre reinforcement consisting of stacked layers of carbon fibre
20 fabrics with the carbon fibres having a fibre orientation in the direction of 0° and 90°. The carbon fibres consisted of HTA fibres produced by Akzo, Wuppertal with a filament number of 3000.

- 25 Such a friction element is shown in figure 1 with reference number 1. This friction element 1 is 120 mm long, 40 mm wide and 8 mm thick. Two fixing holes 3 are positioned on the centre line 2 with their axis running vertical to the friction surface 4. The axis of these fixing holes is posi-
30 tioned at a distance of 25 mm from the narrow side 5 of the friction element 1. The respective fixing hole 3 has a stepped cross section that allows the head of a fixing screw or rivet to be accommodated in the wide diameter area so that it does not protrude over the friction surface 4.

A friction element 1, as shown in figure 1, is produced in three steps.

- 5 First, a CFRP green element, bound in phenolic resin and with a fibre content of 50-55% is produced in an autoclave.

The CFRP green element is then pyrolysed at temperatures of up to 1650°C.

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During a third step, the porous carbon/carbon material generated during the pyrolysis, is impregnated with liquid silicon at a siliconisation temperature of at least 1420°C.

- 15 The thus produced friction element can be characterised by the following characteristic values:

- Density: 2.0 g/cm³
- Open porosity < 2%
- 20 - Phase contents in mass percent: approx. 40% SiC, approx. 5% Si and approx. 55% C and C fibres
- Short bending strength: 120 MPa.

25 The micro structure of the friction element is shown in figures 4 and 5 with figure 4 showing a cross section vertical to the friction surface 4 of the friction element of figure 1, whilst figure 5 shows a plan view of the friction surface 4 of the friction element 1 of figure 1. Figure 4 shows a 100 x, and figure 5 a 15 x magnification.

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Both figures clearly show the carbon fibres 6, which run parallel to friction surface 4, as clearly apparent from the cross section in figure 4. The white or light areas represent silicon carbide surrounding the individual carbon

fibres and filling the interstices. The friction surface therefore always provides a simultaneous SiC and C phase contact, with the C content being predominant in volume and mass.

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Figure 5 shows the woven structure of the carbon fibre shell with the fibres being arranged at 0° and 90° to each other (the surface is polished). The length of the fibres used in this embodiment corresponded exactly with the geometric dimensions of the friction element, i.e. 120 mm in 0° and 40 mm in 90° direction.

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Embodiment 2

15 A friction element was constructed from a matrix consisting predominantly of silicon carbide and carbon and a fibre reinforcement consisting of stacked layers of carbon fibre fabrics (HTA fibres produced by Akzo, Wuppertal with a filament number of 3000) with the carbon fibres having an orientation of 0° and 90° . In order to increase wear resistance and the friction coefficient, the ceramic content in the areas proximal to the friction surfaces was significantly increased compared to the core area. In order to prevent distortion, the friction linings were constructed symmetrically to a centre plane in relation to the thickness of the friction element.

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The friction lining was again produced in three steps as embodiment 1:

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First, a CFRP green element with a fibre volume content of approx. 60% was produced by a resin injection process; prior to resin infiltration, the individual carbon fabric layers were aged for approx. 20 minutes under inert condi-

tions at different conditioning temperatures of 600°C, 750°C, 900°C and 1100°C. The individual layers were 0.25 mm thick and were structured symmetrically to the central plane. A total of 26 layers were used (see figure 6).

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The thus constructed CFRP green element was then pyrolysed at temperatures of up to 1650°C.

During a third step, the porous carbon/carbon material generated during the pyrolysis, was impregnated with liquid silicon at a siliconisation temperature of 1650°C.

The thus produced C/C-SiC material can be characterised by the following characteristic values:

- 15 - Density: 2.0 g/cm³
 - Open porosity < 2%
 - Phase contents in mass percent: approx. 45% SiC, approx. 5% Si and approx. 50% C and C fibres
 - Brief bending strength: 55 MPa.

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The micro structure of the friction element is shown in figures 6 and 7 with figure 6 showing a 35 x, and figure 7 a 15 x magnification.

25 From figure 6, showing the layered structure of friction element 1, i.e. vertical to the friction surface 4, the areas of the differently conditioned carbon fabric layers are apparent. In this figure, the carbon fibres in the central area with reference number 7, are fibres thermally aged at
 30 600°C, whilst the carbon fibres in areas proximal to the surface, have reference number 8. The ageing temperatures were thus increased from the centre plane - reference number 11 - i.e. from the centre area to the edge with 600°C to 1100°C.

From a comparison between the surface structure of the friction element of embodiment 1 shown in figure 5 and the surface structure of embodiment 2 shown in figure 7, it is apparent that the friction elements of figure 7 contain a considerable higher SiC content (light areas) at the outer areas, close to the friction surface. The shown surface also has the advantage of a finely distributed SiC matrix that does not damage the metal guide rail and prevents any scoring of the rail. A friction element according to embodiment 2 (figure 6), is i.e. preferable where particularly high and constant friction coefficients are required.

In figure 2, the friction lining shown in figure 1 is provided with additional grooves 9, running vertically to the friction direction, as shown by arrow 10. The grooves 9 are 2 mm wide and 2 mm deep. The friction element 1 shown in figures 2 and 3 contains three of such grooves 9. The grooves 9 prevent clogging of the friction surface 4 of the friction element 1 and guarantee a defined friction condition, i.e. wear particles generated during emergency braking are deposited in grooves 9 and do thus not adversely affect the friction coefficient. The wear particles are predominantly metal particles abraded from the metal guide rails onto which the friction elements 1 lock.



Claims

1. A safety device for lifts with at least one lift guide
5 rail, securely installed in the lift shaft and a brake
part, comprising at least one friction element with at
least one friction surface that can be pressed against
the guide rail to decelerate the lift, with the
friction material of the friction element comprising a
10 fibre-reinforced, ceramic composite material containing
silicon carbide and carbon fibres as reinforcing
component, characterised by the composite
material comprising a matrix of silicon carbide and
carbon, the reinforcing component being formed from
15 carbon fibres (6; 7; 8) with a minimum length of 10 mm
and the volume content of carbon fibres (6; 7; 8) in
the friction element lying between 30% and 70%.
2. A safety device according to claim 1,
20 characterised by the carbon fibres being
arranged as stacked layers of woven and/or knitted
fabrics with the carbon fibres (6; 7; 8) being at least
arranged in the area of the friction surface (4) in
such a way that they run parallel to it.
- 25 3. A safety device according to claim 1,
characterised by the SiC content of the matrix
being higher in the area of the friction element (1)
proximal to the friction surface than in its area
30 distal to the friction surface.
4. A safety device according to claim 1 characterised
by the friction element (1) being divided into a core



part and a friction part at least surrounding the friction surface.

5. A safety device according to claim 1,
5 characterised by the friction element (1) consisting of individual layers, the layers being connected to each other by reaction siliconisation and preferably, three layers being provided.
- 10 6. A safety device according to claim 3, characterised by the SiC content of the matrix increasing from the friction element (1) to the friction surface (4).
- 15 7. A safety device according to claim 1, characterised by the friction element (1) containing indentations (9) in the friction surface area and, in particular, grooves.
- 20 8. A safety device according to claim 7, characterised by the indentations (9) running transversely to the friction direction or at an angle of 30° to 60° and preferably at an angle of 45° to the friction direction (10).
- 25 9. A safety device according to claim 1, characterised by a layer containing Si and SiC being applied to the friction surface(4), with this layer preferably having a thickness of between 0.01 to
30 0.2 mm.
10. A safety device according to claim 1, characterised by the composite material having a



fibre volume content of at least 50% and/or an open porosity of $\pm 10\%$.

11. A safety device according to claim 1,
5 characterised by the carbon fibres consisting of bundles of at least 1000 individual filaments, with the individual filaments having a diameter of between 5 to 15 μm .
- 10 12. A safety device according to claim 1, characterised by the composite material having the following phase content in mass percent,
a) SiC: 40 to 45 %
b) Si: 2 to 6 %
15 c) C and C fibres: 49 to 58%.
13. A procedure for producing a friction element (1) for a lift brake that can be pressed against a guide rail for a lift, with the friction element (1) containing a
20 fibre-reinforced, ceramic composite material comprising silicon carbide and carbon, characterised by the composite material being produced by liquid siliconisation of a carbon/carbon element, generated by the pyrolysis of a green element bound with phenolic
25 resin and reinforced with carbon fibres.