(54) Title: A VENTILATION CONTROL DEVICE

(57) Abstract: A ventilation control device (10) in the form of a stopping for directing the passage of gases, including ventilation gases, within a mineshaft is disclosed. The stopping includes a number of flexible cables (21) that extend across the mineshaft. A flexible sheet (60) is also provided within the mineshaft. The flexible sheet (60) may either be connected to the cables (21) or to the edges of the mineshaft such as the sidewalls, roof and floor, or connected to both the cables (21) and to the edges of the mineshaft. The flexible sheet (60) is positioned relative to the support members (21) so that in the event of an overpressure event within the mine, the pressure pulse causes flexure of the flexible sheet (60) toward the cables (21). Contact of the flexible sheet (60) with the cables (21) results in dissipation of the pressure pulse.
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
A ventilation control device

Field of the invention

This invention relates to a ventilation control device such as a stopping or a seal for use in passageways such as in underground mine passageways. The invention also relates to a method of installing a ventilation control device for use in a passageway.

Background of the invention

In an underground mining environment there are typically present many interconnecting passageways that form roadways. It is often desirable to control the ventilation throughout the underground mine by selectively blocking a number of the mine’s passageways. It is also desirable to isolate unused sections of the mine and this is achieved by sealing the passageways that lead to the unused sections of the mine.

Stopping is used to control the ventilation of a mine passageways. Seals are used to isolate and seal the passage of gasses within mine passageways.

It is known to provide a stopping by blocking the mine passageway opening using masonry (i.e. bricks or concrete) or metal structures which are installed at the entrance of the mine passageway. A problem with these types of stoppages is that they are rigid and tend to rupture and break due to over-pressure events, such as underground explosions, which transmit a pressure wave to the face of the stopping. Not only may these types of stoppages be expensive to maintain but they can be expensive to install. Another disadvantage associated with prior art stoppages and seals, particularly of the masonry type, include the generation of dust during construction, which can be highly problematic in enclosed underground mine environments.

It is also known that failure of rigid type seals and stoppages may occur in underground mine passageways due to strata convergence in which the rock mass surrounding the passageway imparts stresses on the structure of the seal or stopping, thereby causing rupture.

Another known type of stopping comprises flexible yielding supports that are connected to load-bearing beams. The supports are compressible rubber sleeves disposed between the beams and the walls of the passageway. Slots are also provided between the beams. In the event of an overpressure event, the shock wave absorbed by the beams is partly transferred to the rubber supports which in turn compresses and absorbs part of the shock energy of the pressure wave. The slots alter the shock wave pattern and thereby reduce the energy of the shock wave as it passes through the stopping. This type of stopping is also complicated to install as the rubber supports must be fitted to the beams and this can make the stopping expensive to install and maintain.

Stoppings may be provided with a seal to prevent passage of gasses within the mine shaft. It is known to design stoppages that include seals for containing overpressure events by combining the seal within the stopping structure. These sealed stoppages may also be time consuming and expensive to install. Furthermore, as the seals are utilised within the stopping structure, degradation and cracking of the seal makes it difficult to replace the seal in use, thereby increasing maintenance costs. For example, one known type of stopping that includes a seal within its structure comprises a plurality of elongate panels that extend vertically in side-by-side relationship from the floor to the roof of a mine passageway. After the elongate panels are installed, gaps between the panels and between the panels and adjacent surfaces of the mine are sealed by spraying foam between the elongate panels. A problem with this type of sealed stopping is that when there is an overpressure event, shifting and heaving of the mine in the vicinity of the passageway may occur, which may cause the sprayed-on foams to buckle away from the surfaces, thereby exposing cracks.
It would be an advantage if the present invention provided a ventilation control device and/or a method of installing a ventilation control device that controlled the passage of gasses within a passageway and which overcame or at least partially ameliorated at least one of the disadvantages associated with prior art stoppings and seals described above.

Summary of the invention

According to one broad aspect of the invention, there is provided a ventilation control device for controlling passage of gasses within a passageway, the ventilation control device comprising:

one or more flexible support members located within and coupled to the passageway;

a flexible sheet provided within the passageway to extend across at least a substantial portion of the passageway, the flexible sheet being coupled to the one or more flexible support members or the edges of the passageway or both the one or more flexible support members and the edges of the passageway, wherein the flexible sheet is positioned relative to or adjacent to the one or more support members such that in use, in the event of a pressure pulse being transmitted through the passageway toward the flexible sheet, the flexible sheet is adapted to flex toward and make contact with the one or more flexible support members and wherein at least a portion of the transmitted pressure pulse is dissipated by the flexed sheet as it contacts the one or more flexible support members.

The flexible sheet may cover a cross-section of the passageway and the flexible sheet is impervious to fluids such that in use, the flexible sheet substantially seals the passageway.

The flexible sheet may be made from flame-retardant material and it may also be made from antistatic material.

The one or more flexible support members may comprise a plurality of flexible support members that are anchored to at least the roof, the floor or a side-wall of the passageway.

The plurality of flexible support members may be substantially elongate.

Optionally, the one or more flexible support members are anchored to the floor and roof of passageway.

The flexible sheet may include a manhole to allow access from one side of the flexible sheet to the other.

The flexible sheet may include sleeves adapted to receive the one or more flexible support members therein.

Optionally, the flexible sheet includes eyelets to enable attachment of the flexible sheet to an attachment means associated with the one or more flexible support members and/or the edges of the passageway.

In one embodiment, there is provided a further flexible sheet on an opposite side of the one or more flexible support members to the flexible sheet, the further flexible sheet being provided within the passageway to extend across at least a substantial portion of the passageway, the further flexible sheet being coupled to the one or more flexible support members or the edges of the passageway or both, wherein the further flexible sheet is positioned relative to or adjacent to the one or more support members such that in use, in the event of a pressure pulse being transmitted through the passageway toward the further flexible sheet, the further flexible sheet is adapted to flex toward and make contact with, the one or more flexible support members and wherein at least a portion of the transmitted pressure pulse is absorbed by the further flexed sheet as it contacts the one or more flexible support members.
In another embodiment, there is provided a further one or more flexible support members positioned relative to the one or more flexible support members and opposite to the flexible sheet, the further one or more flexible support members being coupled to the passageway;

a further flexible sheet provided within the passageway to extend across at least a substantial portion of the passageway, the further flexible sheet being coupled to the further one or more flexible support members and/or the edges of the passageway, wherein the further flexible sheet is positioned relative to or adjacent to the further one or more support members such that in use, in the event of a pressure pulse being transmitted through the passageway toward the further flexible sheet, the further flexible sheet is adapted to flex toward and make contact with the further one or more flexible support members and wherein at least a portion of the transmitted pressure pulse is dissipated by the further flexed sheet as it contacts the further one or more flexible support members.

Optionally, the one or more flexible support members are configured to extend substantially across the passageway.

Optionally, a sealant is provided between the edges of the flexible sheet and the floor, sidewalls and roof of the passageway.

In a preferred embodiment, the flexible sheet may extend completely across the passageway and is connected to the floor, sidewalls and roof of the passageway.

In another broad aspect, there is provided a method of installing a ventilation control device in a passageway, the method comprising the steps of:

installing one or more flexible support members within and coupled to the passageway

installing a flexible sheet within the passageway to extend across at least a substantial portion of the passageway, the flexible sheet being coupled to the one or more flexible support members or the edges of the passageway or both the one or more flexible support members and the edges of the passageway, wherein the flexible sheet is positioned relative to or adjacent to the one or more support members such that in use, in the event of a pressure pulse being transmitted through the passageway toward the flexible sheet, the flexible sheet is adapted to flex toward and make contact with the one or more flexible support members and wherein at least a portion of the transmitted pressure pulse is dissipated by the flexed sheet as it contacts the one or more flexible support members.

In yet another broad aspect, there is provided a kit for assembling a ventilation control device of the type described above.

The ventilation control device may be a stopping or it may be a seal.

**Brief description of the drawings**

The invention will now be described by way of example only with reference to preferred embodiments and to the accompanying figures in which:-

Figure 1 shows a schematic diagram of a roadway opening in an underground mine spanned by a plurality of cables;

Figure 2 shows a schematic diagram of lateral displacement of a cable as a result of an overpressure event;

Figure 3 shows a schematic diagram of a first cable anchoring method;
Figure 4 shows a schematic diagram of a side view of an alternative cable anchoring method;

Figure 5 shows a schematic diagram of a cable end for use in an alternative cable anchoring method;

Figure 6 shows a schematic diagram of a sheet member disposed over an opening;

Figure 7 shows a schematic diagram of a front view of a sheet fixing mechanism;

Figure 8 shows a schematic diagram of a side view of the sheet fixing mechanism of Figure 7;

Figure 9 shows a schematic diagram of a ventilation control device in use under a pressure load;

Figure 10 shows a schematic diagram of a sheet having cable attachment sleeves;

Figure 11 shows a schematic diagram of a cable attachment sleeve in an open configuration;

Figure 12 shows a schematic diagram of cable attachment sleeve enclosed around a cable;

Figure 13 shows plan cross-section of a bi-directional pressure overload containment device;

Figure 14 shows a schematic diagram of a sheet having divided sleeve sections;

Figure 15 shows a schematic diagram of an attachment of the sheet of Figure 14 to a cable;

Figure 16 shows a schematic diagram of an alternative bi-directional sheet;

Figure 17 shows a schematic diagram of an alternative bi-directional pressure overload containment device;

Figure 18 shows a schematic diagram of a pressure overload containment device having perimeter sealing;

Figure 19 shows a schematic diagram of an alternative embodiment having cantilevered support members; and

Figure 20 shows a schematic diagram of an alternative means for fixing the sheet to the passage walls.

**Detailed description of preferred embodiments**

One preferred embodiment describes a ventilation control device in the form of a stopping for directing the passage of gasses, including ventilation gasses, within a mineshaft. Although a stopping is described in the preferred embodiment, it should be realised that the invention also encompasses stoppings that do not perform a stopping function in a mineshaft, such as seals. Furthermore, it should also be appreciated that although the ventilation control device described below relates to use in a mineshaft, the ventilation control device could be used in any passage that requires some form of control or sealing of gasses, including ventilation gasses, that are transmitted through passages.

The stopping described below includes a number of flexible cables that extend across the mineshaft. A flexible sheet is also provided within the mineshaft. As will be described below, the flexible sheet may be either connected to the cables or to the edges of the mineshaft (such as the sidewalls, roof and floor) or to the cables and to the edges of the mineshaft.

The flexible sheet is located adjacent to the support members so that in the event of an underground explosion transmitting a pressure pulse through the mineshaft toward the flexible sheet, due to the position of the flexible sheet relative to the cables, the pressure pulse causes flexure of the flexible sheet toward the cables. Contact of the flexible sheet with the cables by the transmitted pressure pulse results in dissipation of the pressure
pulse. The flexure of the flexible sheet contacting the cables may also have the effect of deflecting the transmitted pressure pulse from further transmission through the mineshaft.

In Figure 1 there is shown an underground passage 10 having a floor 11, roof 12 and sidewalls 13, 14. The passageway 10 provides a passage opening 20 at which a ventilation control device in the form of a stopping is to be installed. In accordance with a preferred embodiment, the stopping includes a plurality of flexible support members in the form of cables 21 that are respectively anchored at opposite ends to the roof 12 and floor 11 and thus span the passage 20. The cables 21 are mounted with sufficient length over the span distance to allow a minimum amount of lateral displacement 31 from the vertical axis of the cables (dotted line 32) as shown in side view in Figure 2. The amount of lateral displacement is described by a displacement coefficient, i.e. the amount of displacement from the straight line at the centre of the cable per unit length. For example, a three (3) metre high by five (5) metre wide passage would require a lateral displacement of at least 850mm to contain a 140 kPa (20 psi) over-pressure event.

The cables may be anchored to the floor and roof in any one of a plurality of ways. In Figure 3 there is shown one anchoring method in which a hole 15 is bored into the roof 12 or floor 11 (existing holes may be used), the cable 21 inserted into the hole 15 and then the remaining space in the hole 36 is packed with a setting material. For example, a commercially available strata bolt resin or cable bolt grout with a minimum set compressive strength of 75 mPa may be used. The bore 15 is 400mm deep and the packing material 36 provides a minimum removal force of 25 tonnes per unit.

An alternative anchoring method is shown in Figure 4 which uses a series of bolts as are commonly utilised in an underground roadway of the type described herein. In this embodiment, the ends of the cable 21 terminate in a clasp 22 as shown in Figure 5. An anchor 40 has an abutment plate 42 with an aperture 43 therein for receiving a bolt 44 disposed in the roof 12. The plate 42 is held in place on the bolt 44 by means of a nut 45.

Extending perpendicularly from the plate 42 is an anchor plate 46 having an aperture 47. Cable 21 is secured to the anchor plate 46 by fixing the clasp arm 22 through the anchor plate aperture 47.

Whilst the roof anchor is shown in detail, it will be apparent to the skilled addressee that the floor anchor can be performed in identical manner.

Referring now to Figure 6, flexible sheet material 60 is secured across the cables 21 to obstruct the passage 10. Eyelets 61 formed around the perimeter of the sheet 60 are used to secure the sheet 60 to bolts around the perimeter of the opening. One suitable sheet material uses a 12×12 per cm² double panama weave 1100 dtex polyester yarn, which is PVC coated on both sides and which has a minimum tensile strength of about 3500 N/50mm (WEFT) and about 3000 N/50mm (WARP).

The material of the flexible sheet 60 is fire retarded and has sufficient strength for use in a 140 KPa (20 psi seal). For use in underground mines, the material of the flexible sheet 60 is antistatic. The flexible sheet 60 is preferably made from materials that have a high tensile strength, exhibit high tear resistance, and are impervious to fluids, particularly when the flexible sheet 60 is used in seals. It will be appreciated by persons skilled in the art however, that in some applications, lower strength materials may be used in the flexible sheet 60 provided that the number and/or strength of the cables 21 is increased to ensure that adequate dissipation and possibly deflection of the pressure pulse is accomplished for the design of the stopping.

In the embodiment of Figure 6, the perimeter of the flexible sheet 60 is folded over and joined to form double thickness side flaps 62 at least 100mm and preferably 150mm wide. Eyelets having a 16 mm internal diameter are placed in this edge every 400mm around the entire perimeter of the flexible sheet 60. In other
embodiments, the eyelets may be substituted by holes formed in the sheet 60 by welding and stamping techniques as is known to persons skilled in the art.

The flexible sheet 60 may be fitted with a manhole in the form of a door 65 to allow a person access through the passageway 10. The door 65 may be formed as a 1mx1m opening cut into the sheet 60 with oversize flaps 63 covering the formed opening front and rear. Stiffening members such as metal strips 66 are provided around the edges of the flap to give rigidity to the door 65 and to ensure that under normal operation, the door 65 seals against the door opening. The flap 63 edges are folded to a nominal 150mm around the strips and joined by welding or stitching such that no loose material edges exist. The door frame 63a consists of a matching rigid steel frame disposed in a sleeve of the sheet 60 formed by a double thickness of the sheet material. The door 65 also includes a hinge (not shown) attached to the frame.

Alternatively or in addition, the flap 63 may be secured to the sheet by a double-sided zipper or other suitable fastener without the use of rigid or semi-rigid bracing.

As will be apparent to the skilled addressee, by allowing access to either side of the stopping, ease of installation is enhanced. Further, the stopping does not provide a permanent impassable barrier.

It should also be appreciated that in other embodiments, an even larger access hole could be provided in the flexible sheet 60 to allow mine equipment and machinery access from one side of the stopping to the other. Such an access hole would of course need to be provided so that access was not hindered by one of the cables 21, or the cables 21 should be anchored within the mine passageway such that they can be easily removed and replaced.

In Figs. 7 and 8 there is shown respective enlarged front and side views of a sheet securing system in which a plurality of threaded bolts 71 (eg. having a 12 mm diameter), protrude from a side wall 13 and receive respective eyelets 61 of the flexible sheet 60. A 25mm round clamping plate 72 has an aperture 73 that is received over the bolt 71 and clamps the side flaps of the sheet member between the plate 72 and the wall 13. A fixed nut 74 secures the clamping plate 72 in position. The clamping plate 72 is formed with transitional corners and edges to provide a smooth and blunt surface to minimise tearing of the sheet 60. In an alternative embodiment, strata bolts with chemical anchors having a steel washer and nut fixing arrangement can be used. An exemplary strata bolt is a 24mm diameter threaded reinforcing bar.

It is not essential that the flexible sheet 60 be secured to the cables 21. However, the flexible sheet 60 should be disposed in the opening with sufficient lateral displacement available such that under a lateral pressure load applied from a direction on the opposite side of the sheet to the cables 21, as shown by arrow 90 (Figure 9), the flexible sheet 60 engages the cables 21 such that the pressure force is at least partially absorbed through the cables 21. The cables 21 are disposed in sufficient proximity to the flexible sheet 60 that the flexible sheet 60 bears against the cables 21 to transfer impact load to the cables 21 prior to reaching a failure point in the flexible sheet 60.

It is preferred that the flexible sheet 60 is disposed in the passageway 10 opening such that the side flaps 62 are clamped on the side of the flexible sheet 60 opposite to the cables 21. Under a pressure pulse travelling loads from the direction of arrow 90, the flexible sheet 60 will not bend to an acute angle over the edges of the clamping plate 72. Thus the risk of tearing of the flexible sheet 60 at the clamping plate 72 is minimised. By making the clamping plate 72 large and the plate/bolt spacing frequent, the edge forces on the flexible sheet 60 can be distributed over a wider area, thereby reducing loading forces. For applications in which ventilation control devices that are seals are used, a single plate or mesh 200 as shown in Figure 20 having multiple bolt holes 201
can be provided along an entire edge dimension of the flexible sheet 60. Further, it is possible for the plate to extend over the edge of the flexible sheet 60 side flaps.

In a preferred embodiment shown in Figure 10, a modified flexible sheet 100 has a plurality of sleeves 101 extending vertically across the sheet 100 that can receive cables 21 for securing the flexible sheet 100 to the cables 21. The sleeves 101 may be formed as a closed sleeve such that the cable 21 is inserted through the sleeve 101 before securing the cables 21 in the opening. Alternatively, as shown in Figure 11, the sleeve 111 is formed as two open sides 112, 113 that can be enclosed around one of the cables 21 (Figure 12) in position spanning an opening, by means of press studs, hook and loop fastener or any other suitable fastening means.

The embodiments thus described are best adapted for containing pressure pulses transmitted along passageway 10 in the direction toward the flexible material 100. Pressure loads exerted from this direction cause the sheet to flex in the direction of the cables. An initial force is absorbed by the cables 21 in making them taut, with additional forces being transmitted through the cable anchors into the floor and roof of the passageway 10. Where the flexible sheet 100 is secured to the cables 21 by sleeves 101, some degree of bi-directionality is obtained in that some force can be absorbed from either direction. However pressure loads applied from the side of the flexible sheet 100 on which the cables 21 are disposed act on the weakest part of the structure such as a join or weld between the sleeve 101 and the flexible sheet 100. Hence, the weakest part of the structure is designed so that it is able to withstand the maximum design pressure loading applied to the stopping.

A more substantial system for bi-directional containment of overpressure events is shown in plan view in Figure 13. This ventilation control device has first flexible sheet member 130 and second flexible sheet member 131 disposed and secured on either side of the cables 21. The second flexible sheet member 131 may be attached to the cables 21 in the methods described above.

A first set of alternating 132 cables receiving second flexible sheet 131 on one side by sheet sleeves 134, and a second set of alternating cables 133 receiving first flexible sheet 130 on the opposite side by sheet sleeves 135. In order to provide sufficient strength to contain a pressure pulse transmitted from an underground explosion, the cable 21 spacing must be halved and twice as many cables 21 as for single directionality installed.

Referring to Figure 14, in an alternate embodiment the sheet sleeves 141 of a flexible sheet 140 may each be divided into sections. Two sheets may be secured to one set of cables by securing staggered sections of sleeves around each cable.

As shown in Figure 15, two flexible sheets 150, 155 may be secured to a single cable 21. Staggered sections 151, 152 of the first flexible sheet 150 are secured around the cable 21. Between these sections, sleeve sections 156, 157 of the second flexible sheet 155 are secured around the cable.

As shown in Figure 16, in a further alternative embodiment, a bi-directional flexible sheet 160 may be formed having two sheets 161, 162 with a common sleeve 163 set. The flexible sheet 160 may be mounted on one set of cables.

As shown in Figure 15, in a further alternative embodiment, a bi-directional overpressure seal or stopping may be provided by two adjacent single-direction stoppers or seals, each having a row of cables 171, 172 and outer sheets 173, 174.

The cable and flexible sheet parameters will be determined by the mine parameters such as the size of the roadway and the pressure rating to which the stopping or seal is to be designed. The number of cables required to seal or for use as a stopping will be dependent on the mine parameters and also the strength of the cable material.
For example, in a 140 KPa (20 psi) seal in a 5.5m wide, 3m high roadway, the cables are preferably 16.5 mm steel (minimum UTS 250KN) with six (6) cables spaced across the width of the roadway. The maximum lateral displacement (ie the displacement from the vertical at the centre of the cable) is preferably at least about 850mm.

The inventor has had fabric material evaluated at over-pressure events of 140kPa (20 psi), 69 kPa (10 psi); 34 KPa (5 psi), and 14 KPa (2 psi) to estimate the minimum number of supports and catenary 'sag' required so that the standard breaking forces of the stopping or seal are not exceeded. Additionally, an estimate of the minimum catenary sag has been determined.

The following parameters have been assumed in the evaluation:

- A 5.5m × 3m roadway, the sheet material is typically oversize at 6.5m × 3.5m to allow for a minimum lateral displacement and adequate boundary attachment.
- A fabric breaking force of 4093 N/50mm (WARP), 3547 N/50mm (WEFT).
- Cable bolt ultimate tensile strength: 250 kN (minimum).
- Cable bolt yield @ 2% elongation: 212 kN (minimum).
- A safety factor of 1.2 has been applied to the calculated loads.

Generally, the lower the design pressure rating of the seal, the less cables are required as can be seen from Table 1, which summarises the fabric and cable loads, separation and sag dimensions for the 140kPa (20 psi), 69 kPa (10 psi); 34 KPa (5 psi), and 14 KPa (2 psi) over-pressure events:

<table>
<thead>
<tr>
<th>Pressure Rating kPa</th>
<th>No. Cable Bolt Supports</th>
<th>Fabric Load (N/50mm)</th>
<th>Cable Bolt Load (kN)</th>
<th>Support separation (mm)</th>
<th>Minimum fabric catenary sag (mm)</th>
<th>Minimum cable bolt catenary sag (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>140</td>
<td>6</td>
<td>3547</td>
<td>250</td>
<td>786</td>
<td>376</td>
<td>858</td>
</tr>
<tr>
<td>69</td>
<td>3</td>
<td>3547</td>
<td>250</td>
<td>1375</td>
<td>420</td>
<td>663</td>
</tr>
<tr>
<td>34</td>
<td>1</td>
<td>3547</td>
<td>250</td>
<td>2750</td>
<td>839</td>
<td>663</td>
</tr>
<tr>
<td>34</td>
<td>2</td>
<td>3547</td>
<td>250</td>
<td>1833</td>
<td>282</td>
<td>376</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>3547</td>
<td>250</td>
<td>2750</td>
<td>231</td>
<td>211</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>3547</td>
<td>250</td>
<td>1833</td>
<td>100</td>
<td>138</td>
</tr>
</tbody>
</table>

Table 2 below shows the estimates of the fabric and cable bolt loads for stopping having 6 cable support.
Table 2

<table>
<thead>
<tr>
<th>Pressure Rating kPa</th>
<th>No. Cable Bolt Supports</th>
<th>Fabric Load (N/50mm)</th>
<th>Cable Bolt Load (kN)</th>
<th>Support separation (mm)</th>
<th>Minimum fabric catenary sag (mm)</th>
<th>Minimum cable bolt catenary sag (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>140</td>
<td>6</td>
<td>3547</td>
<td>250</td>
<td>786</td>
<td>376</td>
<td>858</td>
</tr>
<tr>
<td>69</td>
<td>6</td>
<td>1774</td>
<td>125</td>
<td>786</td>
<td>376</td>
<td>858</td>
</tr>
<tr>
<td>34</td>
<td>6</td>
<td>887</td>
<td>63</td>
<td>786</td>
<td>376</td>
<td>858</td>
</tr>
<tr>
<td>14</td>
<td>6</td>
<td>354.7</td>
<td>25</td>
<td>786</td>
<td>376</td>
<td>858</td>
</tr>
</tbody>
</table>

It is important to note that the above figures given in Table 1 and Table 2 above are estimated loads and are shown by way of example only. It can be seen from Table 1 above, that for a 140kPa (20psi) seal, a minimum of 6 cables spaced across the width of the roadway are required; for a 69 kPa (10 psi) seal, a minimum of 3 cables spaced across the width of the roadway are required; for a 34 KPa (5 psi) seal, a minimum of 2 cables are required; and for a 14 KPa (2 psi) a minimum of only 1 cable is required.

Referring to Figure 18, depending on the pressure rating for the stopping or seal, the ventilation pressure and the condition of the boundaries, it may be advantageous to apply a sealant 181 around the perimeter of the flexible sheet 180 in order to make the seal air tight. Suitable sealants include shotcrete, anhydrous gypsum or approved polyurethane foam.

Subject to pressure rating requirements, the sealant 181 may be applied around the sheet perimeter on one or both sides of the sheet.

Referring now to Figure 19, there is shown an alternative support system in which a first pair of support members 191 are cantilevered from the roof 196 and a second set of support members 192 are cantilevered from the floor 197. The support members are each received in a sleeve 194 of a flexible sheet 193 that covers the opening. The flexible sheet 193 may be attached to the walls of the opening in any suitable manner such as the manner described previously. The cantilevered members are flexible but they do have at least some degree of rigidity in order that they maintain their shape within the sheet sleeve. Under a pressure load, the flexible sheet 193 is supported by the support members with the force being transmitted at least partially through the anchor points of the support members and into the surrounding rock structure. In a most preferred embodiment, the cantilevered support members are steel rods or strips that are resilient but deform partially under a lateral pressure load, thereby absorbing some of the initial force internally and transmitting the rest of the impact load through the anchors to the surrounding rock structure.

Because the support members 191, 192 are anchored at only one end, no rigid connection between opposing walls is present and movements in the roadway over time, eg where the roof partially collapses, can be absorbed by the support members moving in the sheet sleeves without affecting the structural integrity of the ventilation control device.

To enable calculation of the parameters of a ventilation control device that is to be installed, a computer program can be advantageously used. As will be understood by persons skilled in the art, in its simplest form the computer program receives the dimensions of a passageway and the maximum overpressure load from a user. The
computer program then outputs the minimum number of cables or support members to be used to stop or seal the passageway. The calculation is based on standards data embedded in the program and formulae describing the relationship between pressure loads and the breaking strength of the support members as will be understood by persons skilled in the art.

More complex calculations may be made by storing a greater range of standards data and functional relationships. The calculation algorithms may be formed to take into account the parameters. One highly desirable parameter specified in the output is a displacement coefficient that specifies the minimum amount of lateral displacement (at the cable centre) that a cable must allow per unit length of the cable. This parameter is important for ensuring that the installed ventilation control device can absorb changes in the roadway dimensions over time. The displacement coefficient may be stored in the computer program with the computer output specifying a minimum length of cable to span the passage.

Further inputs that may be provided include the type of rock, the type of support member to be used and the material strength.

The output may specify additional parameters such as the minimum size of the support members, and the spacing of support members.

It should also be realised that the it may also be possible to calculate the parameters of the ventilation control device that is to be installed by using empirical data or appropriate experimental data derived from previous testing experiments. Such calculations would be understood by persons skilled in the art.

It should also be realised that any of the embodiments described above could be sold or supplied as a kit for assembly on-site. Such a kit will advantageously include all materials and components to erect the support or seal.

It will be appreciated by persons skilled in the art, that the flexible sheet absorbs and deflects pressure loads transmitted by underground over-pressure events, causing the sheet to flex in the direction of the transmitted pressure pulse. The inherent sag of the flexible sheet becomes taut and transfers the applied load to the cables. The cables, being flexible, absorb the impact of the flexed sheet and transfer the load of the pressure pulse to the passageway. The total load of the pressure pulse may advantageously be absorbed by the stopping or seal, thereby preventing onward transmission of the pressure pulse through the mine passageway.

It will be apparent from the description that the ventilation control device is easier to assemble than the stoppings or seals described in the prior art due to its relatively simple construction.

Because the ventilation control device includes flexible parts (ie the cables and the flexible sheet) to reduce pressure pulses directed toward the device, it tends not to be as susceptible to breakage or rupture. Hence, the ventilation control device of the present invention will last longer and require less maintenance than rigid or non-flexible ventilation control devices.

It will be also appreciated that other advantages of the ventilation control device includes the ability of the device to withstand increasing overpressure events as strata convergence occurs because the material sag of the flexible material increases. This is a significant advantage over prior art devices which have been found to progressively fail under load.

It should also be appreciated that the flexible sheet does not vary in strength or thickness as the required pressure rating increases. It is therefore possible to upgrade an existing stopping to a higher rating by simply installing additional cables and possibly boundary supports to withstand increased loading.
The ventilation control device may be easily removed and the flexible sheet may be advantageously reusable.

The relative few components make transport requirements minimal (and therefore freight costs) and the materials are easy to handle, particularly due to the light weight of the sheet material.

Advantageously, the installation may be dust free depending if appropriate sealants are used.

It should also be appreciated that because the flexible material can be impervious and may be supplied as a single part, it is less costly and easier to install.

It will be appreciated by the person skilled in the art that numerous modifications and/or variations may be made to the present invention as described in the specific embodiments without departing from the spirit or scope of the invention as broadly defined. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive and all such modifications and variations are intended to be embraced herein.
CLAIMS

1. A ventilation control device for controlling passage of gasses within a passageway, the ventilation control device comprising:

   one or more flexible support members located within and coupled to the passageway;

   a flexible sheet provided within the passageway to extend across at least a substantial portion of the passageway, the flexible sheet being coupled to the one or more flexible support members or the edges of the passageway or both the one or more flexible support members and the edges of the passageway, wherein the flexible sheet is positioned relative to or adjacent to the one or more support members such that in use, in the event of a pressure pulse being transmitted through the passageway toward the flexible sheet, the flexible sheet is adapted to flex toward and make contact with the one or more flexible support members and wherein at least a portion of the transmitted pressure pulse is dissipated by the flexed sheet as it contacts the one or more flexible support members.

2. A ventilation control device as claimed in claim 1, wherein the flexible sheet covers a cross-section of the passageway and the flexible sheet is impervious to fluids such that in use, the flexible sheet substantially seals the passageway.

3. A ventilation control device as claimed in claim 1 or claim 2, wherein the flexible sheet is made from flame-retardant material.

4. A ventilation control device as claimed in any one of claims 1 to 3, wherein the flexible sheet material is antistatic.

5. A ventilation control device as claimed in any one of claims 1 to 4, wherein the one or more flexible support members comprises a plurality of flexible support members that are anchored to at least one wall of the passageway.

6. A ventilation control device as claimed in claim 5, wherein the plurality of flexible support members are substantially elongate.

7. A ventilation control device as claimed in any one of the previous claims, wherein the one or more flexible support members are anchored to the floor and roof of passageway.

8. A ventilation control device as claimed in any one of claims 1 to 7, wherein the flexible sheet includes a manhole to allow access from one side of the flexible sheet to the other.

9. A ventilation control device as claimed in any one of claims 1 to 8, wherein the flexible sheet includes sleeves adapted to receive the one or more flexible support members therein.

10. A ventilation control device as claimed in any one of claims 1 to 9, wherein the flexible sheet includes eyelets or holes to enable attachment of the flexible sheet to an attachment means associated with the one or more flexible support members and/or the edges of the passageway.

11. A ventilation control device as claimed in any one of claims 1 to 10, comprising a further flexible sheet on an opposite side of the one or more flexible support members to the flexible sheet, the further flexible sheet being provided within the passageway to extend across at least a substantial portion of the passageway, the further flexible sheet being coupled to the one or more flexible support members or the edges of the passageway or both, wherein the further flexible sheet is positioned relative to or adjacent to the one or more support members such that in use, in the event of a pressure pulse being transmitted through the passageway.
toward the further flexible sheet, the further flexible sheet is adapted to flex toward and make contact with, the one or more flexible support members and wherein at least a portion of the transmitted pressure pulse is absorbed by the further flexed sheet as it contacts the one or more flexible support members.

12. A ventilation control device as claimed in any one of claims 1 to 10, comprising:

a further one or more flexible support members is positioned relative to the one or more flexible support members and opposite to the flexible sheet, the further one or more flexible support members being coupled to the passageway,

a further flexible sheet provided within the passageway to extend across at least a substantial portion of the passageway, the further flexible sheet being coupled to the further one or more flexible support members and/or the edges of the passageway, wherein the further flexible sheet is positioned relative to or adjacent to the further one or more support members such that in use, in the event of a pressure pulse being transmitted through the passageway toward the further flexible sheet, the further flexible sheet is adapted to flex toward and make contact with the further one or more flexible support members and wherein at least a portion of the transmitted pressure pulse is dissipated by the further flexed sheet as it contacts the further one or more flexible support members.

13. A ventilation control device as claimed in any one of claims 1 to 12, wherein the one or more flexible support members are configured to extend substantially across the passageway.

14. A ventilation control device as claimed in any one of claims 1 to 13, wherein a sealant is provided between the edges of the flexible sheet and the floor, sidewalls and roof of the passageway.

15. A ventilation control device as claimed in any one of claims 1 to 13, wherein the flexible sheet extends completely across the passageway and is connected to the floor, sidewalls and roof of the passageway.

16. A method of installing a ventilation control device in a passageway, the method comprising the steps of:

installing one or more flexible support members within and coupled to the passageway

installing a flexible sheet within the passageway to extend across at least a substantial portion of the passageway, the flexible sheet being coupled to the one or more flexible support members or the edges of the passageway or both the one or more flexible support members and the edges of the passageway, wherein the flexible sheet is positioned relative to or adjacent to the one or more support members such that in use, in the event of a pressure pulse being transmitted through the passageway toward the flexible sheet, the flexible sheet is adapted to flex toward and make contact with the one or more flexible support members and wherein at least a portion of the transmitted pressure pulse is dissipated by the flexed sheet as it contacts the one or more flexible support members.

17. A method of installing a ventilation control device as claimed in claim 16, wherein the ventilation control device is of the type defined in any one of claims 2 to 15.

18. A kit for assembling a ventilation control device of the type defined in any one of claims 1 to 15.

19. A ventilation control device of the type defined in any one of claims 1 to 15, wherein the ventilation control device is a stopping or seal.
20. A ventilation control device, substantially as herein described with reference to any one of the embodiments described herein with reference to the accompanying drawings.

21. A method of installing a ventilation control device in a passageway, substantially according to any one of the examples described herein with reference to the accompanying drawings.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 7: E21F 001/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: E21F 001/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: E21F 001/14

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>AU 200172129 A1 (WILSON MINING SERVICES PTY LIMITED) 12 March 2002 See whole document</td>
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<td>A</td>
<td>AU 31408/84 A (F. J. DEWSON) 7 February 1984 See whole document</td>
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<td>A</td>
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* Further documents are listed in the continuation of Box C

See patent family annex

* Special categories of cited documents:
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Date of the actual completion of the international search 29 May 2003

Date of mailing of the international search report 12 JUN 2003

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