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DRAFT CURTAIN FOR SMOKE CONTROL



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Field of the Invention

- 5 This invention relates generally to a Draft Curtain. In particular, this invention relates to Draft Curtain used for smoke control purposes.

Background

- 10 In the event of fire, the fire effluents will plume from the fuel source, and spread beyond the room of origin to affect other areas. If the fire effluents are allowed to flow unimpeded, it will rapidly lose its thermal buoyancy and causes smoke logging. This will reduce visibility for Occupants trying to evacuate from the Building. To prevent this, Draft curtains are used to control the spread of smoke so that thermal buoyancy is maintained, smoke can be vented out, and Occupants in non-affected areas can
- 15 escape with ease. This risk is most pronounced in large enclosed spaces such as shopping malls and atriums. The solution to this problem has been to install draft curtains typically of vertical plane as a form of smoke barrier to obstruct the smoke flow from one space to another, or to direct the flow of smoke by channeling them. These barriers may be constructed of a material that is non-combustible and impervious to fire effluents and does not contribute to the fire. They are suspended from the underside
- 20 of structure extending downwards to a depth that preferably provides reasonable headroom for Occupants to transgress and escape. They may include a primary member that forms the vertical plane, and secondary members which forms the inclined/ horizontal plane or a combination of both. The secondary member which is either fixed or movable, shall descend to a height below the depth of the flowing smoke layer depth as prescribed in technical documents such as NFPA 204M. The associated
- 25 problem with vertical Draft Curtains is that they causes an abrupt change of direction in the smoke (incompressible) flow, and the inertia created by the flowing smoke layer, may result in smoke spilling under the vertical Draft Curtains, thus rendering them ineffective. A very deep Vertical Draft Curtain may not be practical, as this will obstruct the headroom, which Occupants may walk below. It will also obstruct the sprinkler spray pattern, preventing effective control of fire. Thus a need clearly exists for a
- 30 draft curtain system, which is able to prevent the smoke spill under the draft curtains. Accordingly this invention seeks to provide such a Draft Curtain whereby the above problems are able to ameliorate.

Summary

- 35 1) In accordance with a first aspect of this invention, there is provided a smoke barrier means for smoke control purposes, comprising of a vertical Draft Curtain known hereinafter as the primary member, which is fixed to the Building's structure along the top and sides of the curtain; a horizontal / inclined Draft Curtain known hereinafter as the secondary member/s. The combination of smoke barrier means consist of a horizontal Draft Curtain that is mounted on and along the intermediate or bottom
- 40 edge of the vertical Draft Curtain, and/ an inclined Draft Curtain that is mounted on and along the bottom edge of the vertical Draft Curtain. Wherein the Draft curtain consist of a non- combustible material, which is preferably non-rigid, impervious to the fire effluents and does not contribute to the fire. The secondary member of the smoke barrier means may be of retractable and/ foldable type that may descend upon receiving a fire signal, to form the desired smoke barrier means, to prevent the
- 45 spread of fire effluents to non-affected area. The first smoke barrier means is preferably a vertical Draft Curtain and a horizontal Draft Curtain. The vertical Draft Curtain and the horizontal Draft Curtain are preferably attached together along the length of both Curtains, at intermediate or bottom edge of the vertical Draft Curtain. Still the vertical Draft Curtain will extend the full length of the given span of an enclosure demarcated as the smoke boundary, forming a "L-shape" pelmet like object, with the
- 50 horizontal Draft curtain in the direction of fire risk.

- 2) In accordance with the first aspect of this invention, there is provided a smoke barrier means where the depth of the vertical Draft Curtain is such that it will exceed the depth of both flowing smoke layer (core region) and/ turbulence layer (shear region) so that it can receive the full impact of the flowing smoke layer and cause the abrupt change in the flow direction (impinging wall jet region) once the smoke layer comes into contact with the vertical Draft Curtain which will compress the smoke layer upwards or downwards, against the boundary layer. The horizontal Draft Curtain attached to the lower edge of the Vertical Draft Curtain shall receive the vortices and downward velocities so that they do not underspill below the bottom edge of Vertical Draft Curtain but the reversed/ cross flow field is channel back towards the fire zone. In addition, the surfaces of the horizontal Draft Curtain provide a boundary layer, which will resist any flow under them, thus preventing smoke spill. The sides of the horizontal Draft Curtain shall also be attached to the Building structure with minimum wall gap to prevent leakage. In accordance with the second aspect of this invention, there is provided a smoke barrier means using a inclined Draft Curtain and a vertical Draft Curtain. The top edge of the inclined Draft curtain shall be may be attached to the lower edge of the vertical Draft curtain, forming a "J-shape" pelmet like object, in lieu of the horizontal Draft Curtain aforesaid. As the vertical Draft Curtain will receive the full impact of the flowing smoke layer and result in abrupt change of flow direction, which will force the compressed layer downward. The inclined Draft Curtain will facilitate in reducing vortices at the interface between the vertical Draft Curtain and the inclined Draft Curtain, and redirect the reverse flow field back to the direction of the fire risk, so that they do not underspill below the smoke barrier.
- 3) In accordance with the third aspect of this invention, there is provided a smoke barrier means using a inclined Draft Curtain, a horizontal Draft Curtain and a vertical Draft Curtain. The inclined Draft Curtain shall be attached to the vertical Draft Curtain aforesaid, and the lower edge of the inclined Draft Curtain shall be attached to one edge of the horizontal Draft Curtain, forming a "J-shape" pelmet like object.
- 4) In accordance with the all preceding aspects of this invention, the top and side edges of the Draft Curtains is preferably in direct contact with the Building Structure using steel members along the perimeter and secured to the Building structure with regular fixing with steel nuts and masonry anchors.
- 5) In accordance with the fifth aspect of this invention, the secondary member being an inclined and/ horizontal Draft Curtain or combination of shall be formed by a retractable roller system, whereby the smoke barrier may be wound over a roller; roller incorporating a rotary mechanism. The housing for the retractable roller mechanism may be mounted to the lower edge of the fixed vertical Draft Curtain and is fully retracted during normal circumstances. Upon receiving the alarm signal, the smoke barrier shall unwind from the roller and extend downwards following the inclined and or/ horizontal plane, assisted by the side guide rails to the desired location and position.
- 6) In accordance with all preceding aspect of this invention, the secondary member being the horizontal and/ inclined Draft Curtain is preferably attached to along the transverse and lower edges of the vertical Draft Curtain, forming an inverted "T" pelmet whereby the fire risk is at both sides of the smoke barrier, in lieu of the "L-shaped"/ "J-shaped" pelmet designed to deal with fire risk from one direction, aforesaid.
- 7) In accordance with Claim 1,2 and 3 of this invention, the secondary member shall consist of a equal or smaller Draft Curtain than the primary member and shall be attached to the bottom edge of the primary member by means of a continuous piano hinge. The top edge of the Draft Curtain shall be attached to an electro-magnetic device fixed onto the primary member that is constantly energized, which will be de-energized upon receiving a fire signal, allowing the secondary member to be lowered by means of acceleration of gravity forces, to the intended horizontal/ inclined position, the final obtrude angle controlled by a steel chain fitted to the top of both the primary and the secondary members.
- 8) In accordance with all preceding aspect of this invention, there is provided a fixing means in which fire sprinkler, automatic fire detectors, light fixtures, signage, etc are able to be installed to the lower / bottom edge of the primary and/ secondary members.

- 9) In accordance with the ninth aspect of this invention, there is provided a smoke buffer means of a shorter height vertical fixed smoke buffer where the lower edge of the buffer is to intercept the top portion of the core region of the flowing smoke layer. The smoke buffer shall be affixed at a distance upstream from aforesaid smoke barrier so that it will form a physical barrier to limit the velocities of the oncoming core jet so that the resultant flowing smoke layer has a lower kinetic forces and will be prevented from underspill below the smoke barrier when the smoke layer comes into contact with the smoke barrier. The top edge and sides of the smoke buffer shall be attached to the Building structure.
- 10) In accordance with tenth aspect of this invention, the smoke buffer shall be an inclined Draft Curtain in lieu of a vertical Draft Curtain and the lower edge of the inclined fixed barrier shall be closer to the fire source.
- 11) In accordance with the tenth aspect of this invention, there is provided a smoke buffer means of a short height inclined fixed smoke buffer which is suspended from building structure by means of structural steel support and form a vertical gap between the underside of the Building structure and the top edge of the smoke buffer, instead of being attached directly to the Building structure, aforesaid. The inclined smoke buffer is within the lower portion of the core region of the flowing smoke layer such that the majority / part smoke layer is directed by the inclined face of the smoke buffer upward, and compressed on the soffit of the Building structure thus reducing the velocities of the core jet.
- 12) In accordance with all preceding aspect of this invention, there is provided a steel fixing plate connected to the steel members fixed to the soffit of the Building, such that it will help to resist the cantenary action of the unprotected steel section when subjected to fire.
- 13) In accordance with all preceding aspect of this invention, there is provided a smoke venting means of a horizontally / inclined mounted ventilation opening placed near the edge of the Vertical Draft Curtain and above the inclined/ horizontal Draft Curtain. It is provided the upward flow of the impinging wall jet will eradicate the vortices and compression region at the top edge of the vertical Draft Curtain and the Building Structure, allowing for better ventilation rates due to the summation of pressure field formed by the wall jet and depth of the smoke layer.

Brief description of the Drawings

A preferred embodiment of this invention is described hereinafter, by way of example only, with reference to the drawings, in which

- 5 **DRAWING 1** refers to a smoke barrier formed from the combination of a primary member comprising of a Vertical Draft Curtain with a secondary member comprising of horizontal Draft Curtain attached to the lower edge of the primary member in accordance with a first embodiment of this invention. Figure 1A is the front elevation, Figure 1B is the sectional view at common intervals; Figure 1C is the sectional view at wall interface and; Figure 1D is the sectional view with the illustration of velocity field from the smoke layer acting on the smoke barrier.
- 10 **DRAWING 2** refers to a smoke barrier formed from the combination of a primary member aforesaid with a secondary member comprising of an inclined Draft Curtain attached to the lower edge of the primary member in accordance with a second embodiment of this invention. Figure 2A is the front elevation, Figure 2B is the sectional view at common intervals; Figure 2C is the sectional view at wall interface and; Figure 2D is the sectional view with the illustration of velocity field from the smoke layer acting on the smoke barrier.
- 15 **DRAWING 3** refers to a smoke barrier formed from the combination of a primary member aforesaid with secondary members comprising of an inclined Draft Curtain and horizontal Draft Curtain attached to the lower edge of the primary member in accordance with a third embodiment of this invention. Figure 3A is the front elevation, Figure 3B is the sectional view at common intervals; Figure 3C is the sectional view at wall interface and; Figure 3D is the sectional view with the illustration of velocity field from the smoke layer acting on the smoke barrier.
- 20 **DRAWING 4** refers to a smoke barrier formed from the combination of a primary member aforesaid with a retractable roller system forming the inclined/ horizontal Draft Curtains attached to its lower edge in accordance with a fourth embodiment of this invention. Figure 4A is the front elevation, Figure 4B is the sectional view at common intervals; Figure 4C is the sectional view at wall interface and; Figure 4D is the sectional view with the illustration of velocity field from the smoke layer acting on the smoke barrier.
- 25 **DRAWING 5** refers to a smoke barrier formed from the combination of a primary member aforesaid with a foldable secondary member comprising of either horizontal/ inclined Draft Curtain (final position) hinged to the lower edge of the primary member in accordance with the fifth embodiment of this invention. Figure 5A is the front elevation, Figure 5B is the sectional view with the secondary member folded up during ambient condition; Figure 5C is the sectional view with the secondary member lowered to the final position during fire condition..
- 30 **DRAWING 6** refers to a smoke barrier aforesaid including with a smoke buffer of a short height vertical/ inclined Draft Curtain with height that interrupts the core jet to reduce the velocity field; the smoke buffer being placed before the smoke barrier shown in Drawing 1-5, in accordance with a fourth embodiment of this invention.
- 35 **DRAWING 7** refers to a smoke barrier formed from a smoke barrier aforesaid including with a smoke buffer of a short height vertical/ inclined Draft Curtain with height that interrupts the core jet to reduce the velocity field; the smoke buffer being placed before the smoke barrier shown in Drawing 1-5, in accordance with a fourth embodiment of this invention.
- 40 **DRAWING 8** refers to a smoke barrier formed from a smoke barrier aforesaid including with a smoke buffer of a short height inclined Draft Curtain with being suspended at a height from the underside of the Building Structure; height interrupts the core jet to reduce the velocity field; the inclined Draft Curtain being used to direct the core jet upwards and compresses against the boundary layer on the underside of the Building structure, to reduce the velocity field flowing towards the smoke barrier, in accordance with a fifth embodiment of this invention.
- 45 **DRAWING 9 to DRAWING 12** refers to closed up view of the various details used to form the smoke barrier aforesaid.
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Detailed description

A number of embodiment of the smoke barrier and method of smoke containment are described. In the following description of the preferred embodiments, numerous details are described in order to provide
5 amore thorough description of these embodiments. It becomes apparent to one skilled in the art, however that this invention may be practiced without such details. In other instances, well-known details have not been described at length so as not to obscure the invention. The advantages of the preferred embodiments of this invention are manifold. One advantage is that the smoke layer will be contained within the fire zone and not underspill below the smoke barrier. This invention is particularly
10 advantageous for buildings with low headrooms where deep smoke barrier are necessary to achieve the same objectives. Another advantage of the embodiment of this invention is that user can reduce the height of the smoke barrier thereby allowing the functional use of tall building. Another advantage is that system designers are likely to adopt and utilize this design concept to prevent unnecessary activation of smoke control system in non-fire zone which may result in under ventilation if shared duct
15 system is used, or stressing the overall emergency power requirements.

Referring now to **Drawing 1**, there is illustrated a first preferred embodiment of a smoke barrier means shown in Figure 1A to Figure 1D and a means of preventing smoke underspill below the Draft Curtain in accordance with this invention. The smoke barrier means consist of a first elongated Vertical Draft
20 Curtain member 11 which forms the primary member in the smoke barrier, it is at least 1m deep and spans the entire distance of the open space of the smoke boundary in the Building. The horizontal Draft Curtain member 12 which is the secondary member shall be of equal length as the primary member. The material for the primary and secondary members are generally constructed from 6mm thick calcium silicate rigid board material which is non- combustible and impervious to smoke. A third
25 member 13 using rolled steel angle size 50x50x3mm thick, shall be installed around the perimeter of both primary and secondary members as a means of attaching them to the Building structure with M10 wall anchors 14 at regular intervals of 500mm centers to the sides and underside of the building structure 15. The lower ends of the steel frame member 16 shall be suspended and used to support the primary and secondary members. The steel angle members shall be mitered ends and shall be joined
30 together with full weld 17 so that the loads from the primary member, secondary members and the interfacing steel angle member can be transferred to the Structure 15. A fourth member using 50x3mm thick rolled steel flat 18 (Figure 1B) of equal width and length as the third member shall be used in conjunction with the steel angle frame to sandwich the Draft Curtain 11 & 12 along it's edges as well as protecting the localized area around the hole from shear failure by distributing the stress over a larger
35 area. If the Draft Curtain material is unable to extend the full length of the area to be protected, the rigid board shall be with formed abut construction or overlapped joint respectively, and any gap between the Draft Curtain 11/12 shall be sandwiched by the fifth member using two pieces of rolled steel angles 50x50x3mm thick 19 on one side and a 100x3mm thick steel flat 20 on the other side, and fixing them together with M3 self tap/ drill steel screws at 300mm centers 21. The primary and
40 secondary members are attached at the lower or bottom edge of the primary member using the inner face of a rolled steel angle member 16 with M5 self tap/ drill screws 21 at regular intervals of 300mm centers. The interface between the rolled steel angle 16 and the Draft Curtains 11 & 12 shall be sealed with an intumescent mastic 22. A 3mm thick steel gusset top plate 23 is welded to the top and another 3mm thick steel gusset bottom plate 24 bottom ends of the fifth member to provide structural stiffness
45 against any cantenary action due to the smoke layer temperature.

Referring now to **Drawing 2**, there is illustrated a second preferred embodiment of a smoke barrier means and a means of preventing smoke underspill below the Draft Curtain in accordance with this invention (Figure 2A to Figure 2D). The smoke barrier means consist of a primary member 11 aforesaid
50 and a inclined secondary member 25 of equal length but shorter depth. The materials for the primary and secondary members are generally constructed from calcium silicate rigid board material. A third member 13 using rolled steel angle size 50x50x3mm thick, shall be installed around the edges of both

primary and secondary members as a means of attaching them to the Building structure with M10 wall anchors 14 at regular intervals of 500mm centers to the sides and underside of the building structure 15. The interfacing between the primary and secondary member uses a fourth member 26 which is made of an obtruded steel angle 100mm x 3mm. The steel frame members shall have mitered ends and shall be join together with full weld 17 so that the loads from the primary and secondary members and the suspended angle member can be transferred to the Structure. A fifth member using 50x3mm thick rolled steel flat 18 of equal width and length as the fourth member shall be used in conjunction with the steel angle frame to sandwich the Draft Curtain 11 & 25 along it's edges. If the Draft Curtain 11/25 are unable to extend the full length of the area to be protected, a butt construction or overlapped joint respectively, aforesaid and any gap between the Draft Curtain 11/25 shall be sandwiched by the sixth member using two pieces of rolled steel angles 50x50x3mm thick 19 on one side and a 100x3mm thick steel flat 20 on the other side, and fixing them together with M3 self tap/ drill steel screws at 300mm centers 21. The primary and secondary members are attached at the lower or bottom edge of the primary member using the inner face of a 100x3mm thick obtruded steel angle member 26 with M5 self tap/ drill screws 21 at regular intervals of 300mm centers. The interface between the obtruded steel angle 26 and the Draft Curtains 11 & 25 shall be sealed with an intumescent mastic 22. A 3mm thick steel gusset top plate 23 is welded to the top and a 3mm thick steel gusset bottom plate 24 at the bottom ends of the fifth member to provide structural stiffness against any cantenary action due to the smoke layer temperature.

Referring now to **Drawing 3**, there is illustrated a third preferred embodiment of a smoke barrier means and a means of preventing smoke underspill below the Draft Curtain in accordance with this invention (Figure 3A to Figure 3D). The smoke barrier means consist of a primary and secondary members as described in Drawing 2 using a primary member 11 and a inclined member 25. In addition, a third horizontal Draft Curtain member 12, is attached to the lower end of the inclined member 25, forming a J-shaped pelmet. The material for the first, second and third members are generally constructed from calcium silicate rigid board material described above and a fourth member 13 using rolled steel angle size 50x50x3mm thick, shall be installed around the edges of both primary and secondary members as a means of attaching them to the Building structure with M10 wall anchors 14 at regular intervals of 500mm centers to the sides and underside of the building structure 15. The interfacing between the first and second members use a fourth member which is made of an obtruded steel angle 100mm x 3mm 26 with M5 self tap/ drill screws at regular intervals of 300mm 21. A similar material 100x3mm thick steel angle 27 is used to form the fifth member, and used to attach the second and third members together. The steel frame members shall have mitered ends and shall be join together with full weld 17 so that the loads from the primary and secondary members and the suspended angle member 27 can be transferred to the Structure 15. A sixth member using 50x3mm thick rolled steel flat 18 of equal width and length as the fourth 26/ fifth 27 members shall be used in conjunction with the steel angle frame 13 to sandwich the Draft Curtain 11/12/25 along it's edges. If the Draft Curtain 11/12/25 is unable to extend the full length of the area to be protected, a butt construction or overlapped joint respectively, aforesaid and any gap between the Draft Curtain 11/12/25 shall be sandwiched by the sixth member using two pieces of rolled steel angles 50x50x3mm thick 19 on one side and a 100x3mm thick steel flat 20 on the other side, and fixing them together with M3 self tap/ drill steel screws at 300mm centers 21. The interface between the rolled steel angle and the Draft curtains 11,12&25 shall be sealed with an mastic with an intumescent mastic 22.

Referring now to **Drawing 4**, there is illustrated a fourth preferred embodiment of a smoke barrier means and a means of preventing smoke underspill below the Draft Curtain in accordance with this invention (Figure 4A to Figure 4C). The smoke barrier means consist of a primary member 11 aforesaid, and an automatic retractable smoke curtain forming the secondary member 28 of equal length. The material for the first member is generally constructed from calcium silicate rigid board which is non combustible and impervious to smoke. A third member 13 using rolled steel angle size 50x50x3mm thick, shall be installed around the edges of the primary member as a means of attaching it to the Building structure 15 with M10 wall anchors 14 at regular intervals of 500mm centers to the sides and

underside of the building structure 15. The fourth member 16 is made of a rolled steel angle 50x50x3mm thick lower ends of the steel frame 13. The automatic retractable roller is preferably made of steel slats 30, each 100mmx 3mm thick, with interlocking curves between the top and lower edges and wind over a 200mm diameter x 3mm thick steel hollow tube 31 in a rotary manner. An internal motor 32 with intricately safe function is inserted into one end of the tube and a free-rolling bearing 33 is placed at the other end. A drive wheel 34 which has dimensions that suits the inner diameter of the steel tube 31 is inserted to the end of the motor, and is attached the drive wheel 33. The entire roller and steel slats are enclosed within a steel box housing 35 of 300mm x 300mm, formed from 1.2mm thick galvanized steel sheet. The housing shall be fixed to the steel frame 13 by means of a pair of M5 bolts and nuts 36 to one side of the housing. Another steel angle 50x50x3mm thick 37 shall be attached to the opposite side of the steel housing 35 to provide a balanced support to the housing. Upon a fire signal sent to the motor 32, it will unwind in the clockwise direction, and displace the steel slats 30 off the roller tube 31. The rotary motion created by the motor 32 onto the tube 31 resulting in the kinetic forces subsequent steel slats 30 acting on the preceding steel slat, causing the latter to travel downwards, aided by the acceleration forces of gravity. The downward movement of the slats, will be controlled at both sides of the slats, using a pair of "J-shaped" steel channels guides 37.

Referring now to **Drawing 5**, there is illustrated a fifth preferred embodiment of a smoke barrier means shown in Figure 5A to Figure 5C and a means of preventing smoke underspill similar to **Drawing 1**, except that the secondary member is foldable and pivoted to the primary member. Figure 5B shows the secondary member in a folded up position during ambient condition and Figure 5C shows the secondary member in a lowered position during fire condition. The smoke barrier means consist of a primary member 11 aforesaid. The secondary member 36 shall be of equal length as the primary member. The material for the primary and secondary members are generally constructed from 6mm thick calcium silicate rigid board material which is non- combustible and impervious to smoke. A third member 13 using rolled steel angle size 50x50x3mm thick, shall be installed around the perimeter of the primary member 11 as a means of attaching the primary member to the Building structure with M10 wall anchors 14 at regular intervals of 500mm centers to the sides and underside of the building structure 15. The lower ends of the steel frame member 16 shall be suspended and used to support the primary and secondary members. The steel angle members 13 shall be mitered ends and shall be joined together with full weld 17 so that the loads from the primary member, secondary members and the interfacing steel angle member can be transferred to the Structure 15. A fourth member using 3mm thick rolled steel flat 18 (Figure 1B) of equal width and length as the third member shall be used in conjunction with the steel angle frame to sandwich the Draft Curtain 11 along it's edges as well as protecting the localized area around the hole from shear failure by distributing the stress over a larger area. The top edge of the secondary member shall be continuously attached to the lower edge of the primary member with a piano hinge 37. An aluminized fiberglass cloth 38 of equal length and 150mm width shall be attached along the piano hinge 37, to prevent smoke leakage through the movable joint. If the Draft Curtain 11/36 is unable to extend the full length of the area to be protected, the rigid board shall be with formed abut construction or overlapped joint respectively, and any gap between the Draft Curtain 11/36 shall be sandwiched by the fifth member using two pieces of rolled steel angles 50x50x3mm thick 19 on one side and a 100x3mm thick steel flat 20 on the other side, and fixing them together with M3 self tap/ drill steel screws at 300mm centers 21. The primary and secondary members are attached at the lower or bottom edge of the primary member using the inner face of a rolled steel angle member 13 with M5 self tap/ drill screws 21 at regular intervals of 300mm centers. The interface between the rolled steel angle 13 and the primary and secondary members shall be sealed with an intumescent mastic 22. A 3mm thick steel gusset top plate 24 is welded to the top of the fifth member to provide structural stiffness against any cantenary action due to the smoke layer temperature. An electro-magnetic device 38 shall be attached to the primary member and the associate steel receiver plate 39 to the top of the secondary member. An electrical current shall be applied continuously during ambient condition such that a magnetic field is created at the device will be sufficient to keep the secondary member in a restrained position to the primary member. Upon a fire alarm, the electrical current shall be terminated

resulting in the loss of magnetic field such that there is no more restraining forces acting on the secondary member.

Referring now to **Drawing 6**, there is illustrated a sixth preferred embodiment of a smoke barrier means shown in Figure 6A to Figure 6C and a means of preventing smoke underspill below the Draft Curtain in accordance with this invention. The smoke barrier means consist of a primary member 11 and a secondary member 12 as described in **Drawing 1**. The secondary member shall extend beyond the lower edge of the primary member such that the midspan of the secondary member rest under the primary member, forming an inverted "T-shape" pelmet, in lieu of the "L-shaped" pelmet described in **Drawing 1**, in order to cater to fire risk from both sides of the primary member. The material for the primary and secondary members are generally constructed from 6mm thick calcium silicate rigid board material which is non- combustible and impervious to smoke. A third member 13 using rolled steel angle size 50x50x3mm thick, shall be installed around the perimeter of both primary and secondary members as a means of attaching them to the Building structure with M10 wall anchors 14 at regular intervals of 500mm centers to the sides and underside of the building structure 15. The lower ends of the steel frame member 16 shall be suspended and used to support the primary and secondary members. The steel angle members shall be mitered ends and shall be joined together with full weld 17 so that the loads from the primary member, secondary members and the interfacing steel angle member can be transferred to the Structure 15. A fourth member using 3mm thick rolled steel flat 18 of equal width and length as the third member shall be used in conjunction with the steel angle frame to sandwich the Draft Curtain material along it's edges as well as protecting the localized area around the hole from shear failure by distributing the stress over a larger area. If the Draft Curtain material is unable to extend the full length of the area to be protected, the rigid board shall be with formed abut construction or overlapped joint respectively, and any gap between the Draft Curtain material shall be sandwiched by the fifth member using two pieces of rolled steel angles 50x50x3mm thick 19 on one side and a 100x3mm thick steel flat 20 on the other side, and fixing them together with M3 self tap/ drill steel screws at 300mm centers 21. The primary and secondary members are attached at the lower or bottom edge of the primary member using the inner face of a rolled steel angle member 22 with M5 self tap/ drill screws 21 at regular intervals of 300mm centers. The interface between the rolled steel angle 22 and the primary and secondary members shall be sealed with an intumescent mastic 23. A 3mm thick steel gusset plate 24 is welded to the top to provide structural stiffness against any cantenary action due to the smoke layer temperature.

Referring now to **Drawing 7**, there is illustrated a seventh preferred embodiment of a smoke barrier means aforesaid and a vertical smoke buffer as a means of reducing the flow velocities of the core jet impinging onto the Draft Curtain so that the resultant kinetic forces are not sufficient to underspill below the smoke barrier means (Figure 7A & Figure 7B). The installation of the smoke buffer shall be similar to **Drawing 1**, with the exception that the horizontal Draft Curtain and associated steel frame are not included in the specification. The material for the smoke buffer shall be the same rigid board described above. The height of the smoke buffer shall be not more than $\frac{1}{2}$ the height of the Smoke barrier aforesaid. The smoke buffer shall be placed at not less then 2m away from the smoke barrier and attached to the Building structure by means of a second member 13, using rolled steel angle size 50x50x3mm thick, which is installed around the edges of the smoke buffer as a means of attaching it to the Building structure 15 with M10 wall anchors 14 at regular intervals of 500mm centers to the sides and underside of the building structure 15. The steel frame member 13 shall have mitered ends and shall be join together with full weld 17 so that the loads from the Draft curtain and the suspended angle member can be transferred to the Structure 15. A third member using 3mm thick rolled steel flat 18 of equal width and length as the second member shall be used in conjunction with the steel angle frame to sandwich the Draft Curtain 11 along it's edges. If the Draft Curtain 11 is unable to extend the full length of the area to be protected, a butt construction or overlapped joint respectively, aforesaid and any gap between the Draft Curtain 11 shall be sandwiched by the sixth member using two pieces of rolled steel angles 50x50x3mm thick 19 on one side and a 100x3mm thick steel flat 20 on the other side, and

fixing them together with M3 self tap/ drill steel screws at 300mm centers 21. The interface between the 100x3mm thick steel flat 20 and the Draft Curtain shall be sealed with an intumescent mastic 23.

Referring now to Drawing 8, there is illustrated a eighth preferred embodiment of a smoke barrier means with a inclined smoke buffer as a means of reducing the flow velocities of the core jet impinging onto the Draft Curtain and underspill below it, in accordance with this invention (Figure 8A & Figure 8B). The installation shall be similar to Drawing 2, with the exception that the vertical Draft Curtain 11 is not included in the specification. The material for the smoke buffer shall be the same rigid board described above. The overall vertical height of the smoke buffer shall be similar to the height of the Smoke barrier but the height of the Draft Curtain 40 and the inclination angle shall be less then 45 degree to the vertical with the lower end of the inclined Draft Curtain closer to the fire source. The smoke buffer shall be suspended in front of the smoke barrier as before described and attached to the Building structure by means of a steel frame by means of a second member 13, using rolled steel angle size 50x50x3mm thick, which is installed around the edges of the smoke buffer as a means of attaching it to the Building structure 15 with M10 wall anchors 14 at regular intervals of 500mm centers to the sides and underside of the building structure 15. The steel frame member 13 shall have mitered ends and shall be join together with full weld 17 so that the loads from the Draft Curtain 25 and the steel frame can be transferred to the Structure 15. The fixing angle of the inclined Draft Curtain 40 use a third member 26 which is made of an obtruded steel angle 100mm x 3mm with M5 self tap/ drill screws at regular intervals of 300mm 21. A 100x3mm thick steel angle 18 is used to form the fourth member, and shall be used in conjunction with the steel angle frame 13 to sandwich the Draft Curtain material along it's edges. The steel frame members shall have mitered ends and shall be join together with full weld 17 so that the loads from the primary and secondary members and the suspended angle member 27 can be transferred to the Structure 15. A sixth member using 50x3mm thick rolled steel flat 28 of equal width and length as the fourth 26/ fifth 27 members shall be used in conjunction with the steel angle frame to sandwich the Draft Curtain material along it's edges. If the Draft Curtain 40 is unable to extend the full length of the area to be protected, a butt construction or overlapped joint respectively, aforesaid and any gap between the Draft Curtain material shall be sandwiched by the sixth member using two pieces of rolled steel angles 50x50x3mm thick 19 on one side and a 100x3mm thick steel flat 20 on the other side, and fixing them together with M3 self tap/ drill steel screws at 300mm centers 21. The interface between the rolled steel angle and the first, second/ third members shall be sealed with an mastic with an intumescent mastic 23.

Claims

1. A smoke barrier system for smoke containment purposes comprising :
 - a first member being the vertical Draft Curtain, forming the primary member, further comprising of a rigid board;
 - a second member being the horizontal Draft Curtain, forming the secondary member further comprising of similar material described above;
 - a third member being the inclined Draft Curtain, inclination of 45 degree from vertical forming the secondary member, further comprising of similar material described above ;
 - a fourth member being the perimeter steel frame system further comprising of steel articles used to secure the above Draft Curtains to the Building Structure, with perforation formed at regular intervals for fixing masonry anchors, bolts and nuts;
 - a fifth member being intermediate steel frame, further comprising of steel articles used to secure the two or more pieces of Draft Curtains together at the joint;
 - a sixth member being the connection between the primary and secondary members, further comprising of a steel flat formed to obtruded shape with fixing bolts and nuts at regular intervals;
 - a seventh member being mastic sealant applied to the perimeter and intermediate joints of the Draft Curtains;

Claims

1. A smoke barrier system for smoke containment purposes comprising :
 - a first member being the vertical Draft Curtain, forming the primary member, further comprising of a rigid board;
 - a second member being the horizontal Draft Curtain, forming the secondary member further comprising of similar material described above;
 - a third member being the inclined Draft Curtain, inclination of 45 degree from vertical forming the secondary member, further comprising of similar material described above ;
 - a fourth member being the perimeter steel frame system further comprising of steel articles used to secure the above Draft Curtains to the Building Structure, with perforation formed at regular intervals for fixing masonry anchors, bolts and nuts;
 - a fifth member being intermediate steel frame, further comprising of steel articles used to secure the two or more pieces of Draft Curtains together at the joint;
 - a sixth member being the connection between the primary and secondary members, further comprising of a steel flat formed to obtuded shape with fixing bolts and nuts at regular intervals;
 - a seventh member being mastic sealant applied to the perimeter and intermediate joints of the Draft Curtains;
 - a eighth member being an automatic retractable curtain system in lieu of the secondary members, further comprising of a flexible Draft curtain material, wound over a rolled hollow tube, with an internal Electrical motor;
 - a ninth member being a pair of side guides profiles used to direct the Draft Curtain descend;
 - a tenth member being a horizontal opening in the structure designed as a smoke exhaust outlet whereby the smoke in the fire zone is extracted when a fire signal is received;
 - a eleventh member being similar to the primary member but depth of not more then $\frac{1}{2}$ of the primary member, further comprising of material and fixing method similar to the primary member.
2. A smoke barrier system according to Claim 1, whereas the Draft Curtain is formed from an aluminized coated fibre glass cloth material, weight 300g/m^2 , in lieu of a rigid board.
3. A smoke barrier system according to Claim 1, whereas the Draft Curtain is formed from a 6mm thick heat resisting glass in lieu of a rigid board.
4. A smoke barrier system according to Claim 1, whereas the primary and secondary members are of equal length, fixed to the soffit and sides of the Building structure, with the lower ends of the smoke barrier suspended and the entire smoke barrier spanning along the boundary of a smoke control zone within the Building, separating the fire zone from the non-fire zone.
5. A smoke barrier system according to Claim 1, whereas the secondary member is a horizontal Draft Curtain attached to the lower / bottom of the primary member to form an "L" shape pelmet.
6. A smoke barrier system according to any of the preceding claim, whereas the secondary member is an inclined Draft Curtain in lieu of a horizontal Draft Curtain to form an "J" shape pelmet with the primary member.
7. A smoke barrier system according to any of the preceding claim, whereas the secondary member is combination of both horizontal and inclined Draft Curtain with the latter being attached to the lower edge of the primary member and the horizontal Draft Curtain being attached to the lower edge of the inclined Draft Curtain, with the horizontal member being placed in the direction of fire risk.

8. A smoke barrier system according to any of the preceding claim, whereas the perimeter of the Draft Curtain are attached to a steel frame member at regular intervals using steel bolts, nuts and masonry anchors as a means of attaching the Draft Curtain to the soffit and sides of the Building structure.

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9. A smoke barrier system according to any of the preceding claims, whereas the interface between the primary and secondary members are connected together with a horizontal steel member suited to the angle of the inclined or horizontal Draft Curtain or both.

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10. A smoke barrier system according to any of the preceding claim, whereas the length of a Draft Curtain is not sufficient to span the required smoke boundary, hence two or more pieces of Draft Curtains are fixed together along it's seam with a vertical interface member to prevent smoke leakage.

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11. A smoke barrier system according to any of the preceding claim, whereas the depth of the primary member measured downwards from the soffit of the structure to being lower then the depth of the core region of flowing smoke layer.

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12. A smoke barrier system according to any of the preceding claims, whereas two pieces of the secondary member are attached to the lower / bottom of the primary member to form an inverted "T" shape pelmet.

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13. A smoke barrier system according to any of the preceding claims, whereas the secondary Members is not passive but consist of a retractable smoke curtain system, with a flexible Draft Curtain material wound over a roller tube and upon receiving fire alarm, will unwind downwards to extend the Draft Curtain fabric to the required position.

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14. A smoke barrier system according to Claim 13, whereas "J-shaped" steel member in the form of side guides is placed along the walls or intermediate space between retractable curtain system to guide the descend of the flexible Draft Curtain to the preferred position.

15. A smoke barrier system according to any of the preceding claims, whereas the smoke exhaust Outlet is placed before the primary member.

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16. A smoke barrier system according to any of the preceding claims, whereas a smoke buffer in form of a short vertical Draft Curtain is placed at least 2m in front of the smoke barrier system and is directly attached to the structure in the manner aforesaid using steel members along it's perimeter.

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17. A smoke barrier system according to Claim 16, whereas a smoke buffer in form of a short vertical Draft Curtain is placed in front of the smoke barrier system aforesaid but is suspended from the soffit of the structure using steel members.

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18. A smoke barrier system according to Claim 17, whereas a smoke buffer in form of a short inclined Draft Curtain is similarly placed at least 2m in front of the smoke barrier system but the lower edge of the Draft Curtain is in the direction of the fire.

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19. A method of smoke containment, comprising the step of:

- a physical barrier in the form of a smoke buffer defined in preceding Claims 17-18 is placed before the smoke barrier system will impede and reduce the velocity of the flowing smoke layer towards the smoke barrier
- the smoke buffer defined in Claim 17 being attached to the structure will impede the upper vectors of the core jet, creating turbulence which reduces the flow velocity, or

- the smoke buffer defined in Claim 18 being suspended to the structure will impede the lower vectors of the core jet, directing the core jet to flow upwards towards the soffit of the structure, compressing against the shear jet and the boundary layer which reduces the flow velocity.
- 5 • the reduced velocity of the smoke layer will be impeded by the primary member of the smoke barrier, defined in preceding Claims resulting in an abrupt change in flow direction across the face of the primary member when the core jet impinged onto the smoke barrier.
- the upward flow of the wall jet will be impeded from spilling to the non fire zone by the steel member attaching the Draft Curtain to the Structure.
- 10 • the upward flow of the wall jet will be directed into the smoke exhaust outlet defined in Claim 15,
- the downward flow of the wall jet will be impeded from underspill through the bottom of the primary member by the secondary member and channeling the flowing smoke layer back into the fire zone.