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BLAST PROTECTIVE DOOR

FIELD OF THE INVENTION

The present invention relates to blast protective doors and door assemblies generally.

BACKGROUND OF THE INVENTION

Various types of blast protective doors and door assemblies are known. Generally, such doors are of massive rigid construction, and are arranged to open outwardly of a protected volume, such that the force of the blast may be transferred to the door frame along at least three edges of the door. Such doors are designed insofar as possible to resist deformation due to the force of a blast.

In general, the conventional wisdom with regard to the construction of blast resistant doors requires that the doors and the door frames onto which they are mounted be resistant to deformation in response to the force of the blast.

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SUMMARY OF THE INVENTION

The present invention rejects the conventional teachings of the prior art with respect to the construction and installation of blast protective doors.

The present invention seeks to provide an improved light weight door which is readily deformable when exposed to the force of a blast, and which, by virtue of its deformability is mountable so as to open inwardly into a protected volume.

There is thus provided in accordance with a preferred embodiment of the present invention a door formed of first and second sheets of metal enclosing a layer of a high strength, high density foamed engineering resin, preferably a polystyrene resin.

Preferably, the door does not include any reinforcement between the first and second sheets and is arranged to bow in response to the force of a blast, thus absorbing a substantial amount of the force of the blast and transmitting a relatively small amount of the force of the blast to a door frame to which it is attached.

There is additionally provided in accordance with a preferred embodiment of the invention a blast resistant door assembly useful with a protected volume including a door frame mounted on a wall of the protected volume and a blast resistant door hingedly mounted on the door frame and arranged to open inwardly towards the protected volume.

In accordance with a preferred embodiment of the present invention, there is provided a gas impervious seal

between the door frame and the wall of the protected volume and a gas impervious seal between the door and the door frame.

Further in accordance with a preferred embodiment of the present invention, there is provided a multi-bolt lock selectably locking the door onto the door frame.

Preferably, the multi-bolt lock is operative in two operative modes, a gas impervious sealing mode which can be opened from both the interior and the exterior of the protected volume without requiring a key, and an ordinary locking mode which is lockable from both the interior and the exterior of the protected volume and which can be unlocked from the exterior of the protected volume only with a suitable key.

Additionally in accordance with a preferred embodiment of the present invention, the door frame may be mounted into the wall of the protected volume by employing a plurality of elongate rods extending transversely into the wall at a plurality of disparate locations.

Preferably, the door is formed of first and second sheets of metal enclosing a layer of a high strength, high density foamed engineering resin, preferably a polystyrene resin. A preferred resin is a GECET expandable engineering resin, which is commercially available from GE Plastics of Pittsfield MA, U.S.A.. The precise density and thickness of the resin employed is determined empirically by operational requirements, including the size of the container.

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BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a partially cut away simplified illustration of a blast protective door constructed and operative in accordance with a preferred embodiment of the present invention;

Figs. 2A, 2B, 2C and 2D are simplified pictorial illustrations of a door constructed and operative in accordance with one preferred embodiment of the present invention, respectively prior to a blast, bowed in response to the force of the blast, further deformed in response to the rebound force and in a final post-blast orientation;

Figs. 3A, 3B, 3C and 3D are simplified sectional illustrations of the door of Figs. 2A - 2D, respectively prior to a blast, bowed in response to the force of the blast, further deformed in response to the rebound force and in a final post-blast orientation;

Figs. 4A, 4B, 4C and 4D are simplified pictorial illustrations of a door constructed and operative in accordance with another preferred embodiment of the present invention, respectively prior to a blast, bowed in response to the force of the blast, further deformed in response to the rebound force and in a final post-blast orientation;

Figs. 5A, 5B, 5C and 5D are simplified sectional illustrations of the door of Figs. 4A - 4D, respectively prior to a blast, bowed in response to the force of the blast, further deformed in response to the rebound force and in a final post-

blast orientation;

Figs. 6A, 6B and 6C are simplified pictorial illustrations of the locking mechanism of a preferred embodiment of the door assembly of Figs. 1 - 5D in respective locked, unlocked and gas-tight sealed orientations;

Figs. 7A, 7B and 7C are simplified sectional illustrations taken along respective lines VIIA - VIIA, VIIB - VIIB, and VIIC - VIIC in Figs. 6A, 6B and 6C, and showing the locking mechanism of a preferred embodiment of the door assembly of Figs. 1 - 5D in respective locked, unlocked and gas-tight locked orientations; and

Figs. 8A, 8B and 8C are simplified illustrations of three alternative door mounting arrangements useful in accordance with a preferred embodiment of the present invention.

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DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is now made to Figs. 1 - 8C which illustrate a blast protective door constructed and operative in accordance with a preferred embodiment of the present invention and more particularly to Figs. 2A - 3D which illustrate the door mounted with respect to a protected enclosure so as to open towards the outside of the enclosure.

The blast protective door of the present invention preferably comprises first and second sheets 10 and 12 of metal (Fig. 1), enclosing a layer 14 of a high strength, high density foamed engineering resin, preferably a polystyrene resin. A preferred resin is a GECET expandable engineering resin, which is commercially available from GE Plastics of Pittsfield MA, U.S.A.. The precise density and thickness of the resin employed is determined empirically by operational requirements. Alternatively, any suitable material may be used for layer 14. Preferably, the first and second sheets 10 and 12 are of thickness 1.2 - 1.6 mm, while the layer 14 is of thickness approximately 3 cm.

The door is preferably formed with a multiple bolt locking mechanism, indicated generally by reference numeral 16, and which includes horizontal bolt assemblies 18, 20 and 22 and a vertical bolt assembly 24, all of which are operated by a lock 26, such as a MUL-T-LOCK Model 270, having associated therewith a locking handle 28 and a latch 30.

It is a particular feature of the present invention and a radical departure from prior art teachings regarding blast protective doors that rather than being massive and rigid in

response to a blast, the blast protective door of the present invention is relatively readily deformable, such that the deformation absorbs a substantial portion of the force of a blast.

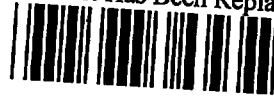
Accordingly, in accordance with a preferred embodiment of the present invention, the door does not include rigid reinforcement between the first and second sheets 10 and 12 and is arranged to bow in response to the force of a blast, thus absorbing a substantial amount of the force of the blast and transmitting a relatively small amount of the force of the blast to a door frame to which it is attached.

The intended deformability of the door, which is a particular feature of the present invention is illustrated particularly in Figs. 2A - 2D and 3A - 3D which correspond thereto. These figures show a door 50, which may be identical to the door of Fig. 1, and is hingedly mounted onto a door frame 52 by hinges 53. Door frame 52 is located in a wall 54 of an enclosure to be protected and is arranged to open outwardly of the enclosure.

Figs. 2A and 3A illustrate the door prior to a blast. It is noted that gas-tight sealing protection may be provided by means of a sealing strip 56 disposed between the frame 52 and the wall 54 and of a peripheral seal 58 mounted between the door frame 52 and the door 50.

Figs. 2B and 3B illustrate the door under deformation due to the effect of a blast, indicated by arrows 60. It is seen that the door bows inwardly towards the interior of the





enclosure, thus absorbing a significant portion of the force of the blast via the deformation itself. Inasmuch as a relatively small part of the blast force is transmitted from the door to the frame 52, substantially no deformation of the door frame results.

Figs. 2C and 3C illustrate the door under deformation due to the effect of the blast rebound force, indicated by arrows 66. It is seen that the door bows outwardly away from the interior of the enclosure, thus absorbing a significant portion of the force of the blast rebound via the deformation itself. Inasmuch as a relatively small part of the blast rebound force is transmitted from the door to the frame 52, the door is retained in the frame by means of the bolt assemblies of the locking mechanism 16 and the hinges 53.

Figs. 2D and 3D illustrate the door following the blast. It is seen that the door 50 is deformed and damaged but remains intact in frame 52 and operative. It is appreciated that as the result of the deformation the gas tight sealing cannot be expected to be retained.

There is additionally provided in accordance with a preferred embodiment of the invention a blast resistant door assembly useful with a protected volume including a door frame mounted on a wall of the protected volume and a blast resistant door hingedly mounted on the door frame and arranged to open inwardly towards the protected volume. This embodiment represents a further radical departure from the conventional design and mounting of blast resistant doors, wherein only outward opening door mountings were thought to be acceptable, in order that substantially the entire force of the blast could be

fully transferred from the rigid door to the peripheral frame and thence to the surrounding structure.

An oppositely designed door structure, wherein the door opens towards the interior of a protected enclosure and also is constructed to have intended deformability, is illustrated particularly in Figs. 4A - 4D and 5A - 5D which correspond thereto. These figures show a door 70, which may be identical to the door of Fig. 1, and is hingedly mounted onto a door frame 72 by hinges 73. Door frame 72 is located in a wall 74 of an enclosure to be protected and is arranged to open outwardly of the enclosure.

Figs. 4A and 5A illustrate the door prior to a blast. It is noted that here also gas-tight sealing protection may be provided by means of a sealing strip 76 disposed between the frame and the wall 74 and of a peripheral seal 78 mounted between the door frame 72 and the door 70.

Figs. 4B and 4B illustrate the door under deformation due to the effect of a blast, indicated by arrows 80. It is seen that the door bows inwardly towards the interior of the enclosure, thus absorbing a significant portion of the force of the blast via the deformation itself. Inasmuch as a relatively small part of the blast force is transmitted from the door to the frame 72, the door is retained in the frame by means of the bolt assemblies of the locking mechanism 16 and the hinges 73.

Figs. 4C and 5C illustrate the door under deformation due to the effect of the blast rebound force, indicated by arrows 76. It is seen that the door bows outwardly away from the



interior of the enclosure, thus absorbing a significant portion of the force of the blast rebound via the deformation itself. Inasmuch as a relatively small part of the blast rebound force is transmitted from the door to the frame 72, substantially no deformation of the door frame results.

Figs. 4D and 5D illustrate the door following the blast. It is seen that the door 70 is deformed and damaged but remains intact in frame 72 and operative. It is appreciated that as the result of the deformation the gas tight sealing cannot be expected to be retained.

Reference is now made to Figs. 6A, 6B and 6C, which are simplified pictorial illustrations of the locking mechanism of a preferred embodiment of the door assembly of Figs. 1 - 5D in respective locked, unlocked and gas-tight sealed orientations, and to Figs. 7A, 7B and 7C, which are simplified sectional illustrations taken along respective lines VIIA - VIIA, VIIB - VIIB, and VIIC - VIIC in Figs. 6A, 6B and 6C.

It is seen that in accordance with a preferred embodiment of the present invention, a protective door 90 is provided having three operative orientations, locked by latch 30, as shown in Figs. 6A and 7A, unlocked, as shown in Figs. 6B and 7B and gas-tight sealed by the bolt assemblies, as shown in Figs. 6C and 7C.

In the orientations shown in Figs. 6A, 6B, 7A and 7B the door may be locked and unlocked from both the inside and the outside by conventional key operated locking mechanisms, such as those employed, for example in the PLADELET, commercially available from Mul-T-Lock Ltd.

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In the gas-tight sealing orientation shown in Figs. 6C and 7C, the door is preferably not locked and may be opened without the use of a key from both the inside and the outside, as is required in emergency situations.

Door 90 may be of the type shown in Fig. 1 and may be mounted in any suitable manner, preferably as shown in either the embodiments of Figs. 2A - 2D and 3A - 3D or that of Figs. 4A - 4D and 5A - 5D. The operative orientation is determined by the angular orientation of a locking handle 90, which typically is in a generally horizontal orientation when unlocked or locked by latch 30, as shown in Figs. 6A, 6B, 7A and 7B.

Handle 92 operates a lock mechanism 96, which may be similar to mechanism 16 (Fig. 1), and which in turn causes axial displacement of a number of bolts, such as bolts 18 and 98, into and out of locking and gas-tight locking engagement with corresponding strikes such as strike 100 in a frame 102.

When the door is locked by latch 30 or unlocked, as shown in Figs. 6A, 6B, 7A and 7B, the bolt 98 is entirely retained inside door 90 and does not penetrate strike 100 and the handle 92 is generally horizontal. When the handle 92 is arranged typically in an upward facing vertical orientation, as shown in Fig. 6C, the bolt 98 is levered against a step 104 in strike 100, thus forcing the door against a peripheral sealing member 106, thereby compressing the sealing member 106, as seen in Fig. 7C and providing a gas tight seal between the door and frame 102.

The above-described mechanism thus preferably allows emergency opening of the door from outside the enclosure without





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a key when the bolt 98 is in the gas-tight locking orientation of Figs. 6C and 7C, but requires a key when the door is locked in a normal mode, as by latch 30, thus enabling the door to function both as a security door against break-ins and as a blast and gas-protective door.

Reference is now made to Figs. 8A, 8B and 8C, which are simplified illustrations of three alternative door mounting arrangements useful in accordance with a preferred embodiment of the present invention. The door may be the door of Fig. 1, mounted in accordance with any of the embodiments of Figs. 2 - 7C.

Fig. 8A illustrates an arrangement wherein a door frame 120 is bolted or otherwise attached to a wall edge 122 by means of a bolt or rod 124. Gas tight sealing material 126 is preferably provided along all joints between the wall edge 122 and the frame 120. A gas tight sealing strip 128 is disposed peripherally of the frame, for pressure engagement with a door 130.

Fig. 8B illustrates an arrangement wherein a door frame 140 is bolted or otherwise attached to a wall edge 142 by means of a plurality of bolts 144 which fix the frame 140 via gas tight sealing material 146 to a peripheral steel plate 148, which is sealingly embedded in the wall edge 142. A gas tight sealing strip 150 is disposed peripherally of the frame, for pressure engagement with a door 152.

Fig. 8C illustrates an arrangement wherein a door frame 160 is bolted or otherwise attached to a wall edge 162 over an existing frame 163 by means of a bolt or rod 164. Gas tight

sealing material 166 is preferably provided along all joints between the wall edge 162 and the frame 160. A gas tight sealing strip 168 is disposed peripherally of the frame, for pressure engagement with a door 170.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove, but extends to modifications and variations thereof within the scope of a person skilled in the art. The present invention is thus defined by the claims which follow:

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1. A light weight door which is readily deformable when exposed to the force of a blast, thereby absorbing a substantial portion of the force of the blast directed thereto and which, by virtue of its deformability is mountable so as to open inwardly into a protected volume.

2. A door formed of first and second sheets of metal enclosing a layer of a high strength, high density foamed engineering resin.

3. A door according to claim 1 and being formed of first and second sheets of metal enclosing a layer of a high strength, high density foamed engineering resin.

4. A door according to either of claims 2 and 3 and wherein said engineering resin comprises a polystyrene resin.

5. A door according to any of the preceding claims and which does not include any reinforcement between the first and second sheets.

6. A door according to any of the preceding claims and which is arranged to bow in response to the force of a blast, thus absorbing a substantial amount of the force of the blast and transmitting a relatively small amount of the force of the blast to a door frame to which it is attached.



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7. A blast resistant door assembly useful with a protected volume including a door frame mounted on a wall of the protected volume and a blast resistant door hingedly mounted on the door frame and arranged to open inwardly towards the protected volume.

8. A blast resistant door assembly according to claim 7 and wherein said door comprises a door according to any of claims 1 - 6.

9. A door assembly according to either of claims 7 and 8 and also comprising a gas impervious seal between the door frame and the wall of the protected volume and a gas impervious seal between the door and the door frame.

10. A door assembly according to any of claims 7 - 9 and also comprising a multi-bolt lock selectably locking the door onto the door frame.

12. A door assembly according to claim 10 and wherein said multi-bolt lock is operative in at least two operative modes, a gas impervious sealing mode which can be opened from both the interior and the exterior of the protected volume without requiring a key, and an ordinary locking mode which is lockable from both the interior and the exterior of the protected volume and which can be unlocked from the exterior of the protected volume only with a suitable key.

13. A door assembly according to any of claims 7 - 12 and



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wherein said door frame is mounted into the wall of the protected volume by employing a plurality of elongate rods extending transversely into the wall at a plurality of disparate locations.

14. Apparatus according to any of the preceding claims, substantially as shown and described hereinabove.

15. Apparatus according to any of the preceding claims, substantially as shown in any of the drawings.

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