

PROTECTION DEVICE AGAINST PRESSURE AIR BLASTS

The invention relates to a protection device with means for reducing the air blast of pressure waves in ventilation systems of closed rooms. The invention also concerns the use of the protection device.

Protected rooms for persons and/or equipment, containments for nuclear power stations and other, offshore, equipment must firstly be ventilated and secondly resist pressure air blasts. Depending on the strength of the air pressure waves expected and the use of the closed rooms, appropriate protective devices are fitted.

Explosion protection valves are used for the pressure-resistant closure of supply and extraction air openings in protected rooms or in other exposed objects. These provide effective protection for people and equipment against the effects of nuclear and conventional explosions including the suction following each explosion, as a valve seat is arranged on both sides of the valve closing body.

In the valve housing, the valve closing body, usually structured in the known manner as a valve disc, valve ball or valve plate, is suitably suspended on radial or tangential springs (cf. for example CH-PS 482964) with a large annular section clear from the valve housing. When a strong pressure wave occurs, the valve closing body is thrown against the sealing surface on the room side by the air blast and pressed into this valve seat, preventing the passage of air after the valve has closed. With a powerful subsequent suction, the valve closing body closes in a similar manner in the opposite direction. After the short phase of excess or reduced pressure subsides, the springs automatically reset the valve closing body for normal ventilation operation. The explosion protection valve works



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passively, the valve closing body cannot be brought to the closed position by a control and/or actuator element.

Although the valve closing body is thrown into the valve seat like a projectile under a high explosion pressure, air can pass for a period of the order of one millisecond, a phenomenon known as residual air blast.

Known explosion protection valves are used both as extraction air and supply air valves. Extraction air valves in ventilation systems for protected rooms, diesel cooling systems or refrigerating plants have a degree of protection of 3 bar for example. In this case, the extraction air valves can simultaneously be used as excess pressure valves if they have a corresponding flap or similar on the room side. As supply air valves for ventilation systems of protected rooms, diesel cooling systems and refrigerating plants with the same degree of protection, explosion protection valves suitably have a downstream prefilter for dust separation in the protected rooms.

In a nuclear explosion, the air blast load with a strong excess pressure phase can last for a relatively long time, for example 10 to 500 ms. The closing phase of the explosion protection valve is at most a few milliseconds, typically 1 to 3 ms. In contrast, with conventional explosions, the phase with high excess pressure is very short, for example 1 to 10 ms. A conventional air blast load can therefore diminish during the closing phase of the valve closing body. The duration of the excess pressure phase of a conventional air blast may even be similar to the closing time of the explosion protection valve, so the mean pressure load acting on the valve during the closing process is considerably lower than in the case of nuclear explosion. Explosion protection valves developed on the basis of nuclear load data can also be used in the conventional range for essentially higher pressure loads.



Also, the requirements applicable for the nuclear load with regard to leakage are not relevant for conventional air blasts in view of the very short excess pressure period. In conventional load cases, elements and components, for example gas filters, downstream of the explosion protection valve are exposed only to load from a residual air blast defined above, but would be damaged with correspondingly strong explosion pressure waves.

To reduce the pulse and peak excess pressure occurring in the explosion protection valve as a residual air blast, pressure reducers are known which are connected upstream in relation to the direction of explosion pressure, for example in the form of baffles and/or other deflector elements. These must have an extremely high mechanical strength or they would be destroyed by the first front of an explosion pressure wave and rendered useless.

EP,A1 0489183 describes an explosion protection unit with an explosion protection valve and an upstream passive protection element which consists of a slotted inlet opening between two parallel metal elements leading to a connecting chamber. The elements are guide surfaces arranged at an angle in the direction of flow. Open longitudinal reflection chambers connect with the connecting chambers in the direction of the inlet opening and are in turn linked to an expansion chamber via a side passage opening. This expansion chamber has an outlet opening leading to the explosion protection valve. The explosion protection unit according to EP,A1 0489183 with upstream passive protection element is expensive and bulky because of the high mechanical strength required.

DE,A1 3627490 describes an explosion protection valve for ventilation pipes to protected rooms which consists of a combination of a pressure impact protection with path



deflection and extension on one side and a dust filter on the other side. The path deflection and extension is used to extend the duration of the impact front occurring on the valve closing body. This air guide is designed as a multicyclone with a number of mutually parallel cyclones, but this secondary function is of no further interest for the present invention. The explosion protection valve to DE, A1 3627490, in which the valve closing body is closed by the main blast of the pressure wave, is expensive and complex with regard to the reduction of the residual air blast.

The task of the inventor is therefore to create a protection device of the type described above, which reduces the air blast of pressure waves in an explosion or similar occurrence. In co-operation with the preceding explosion protection valve, this protection device simply, safely and practically completely eliminates the pulse passing through before its closure, and the peak excess pressure of the residual air blast of explosion pressure waves, in particular those of conventional nature, which occur in strong to very strong explosions. The explosion protection valve comprises a valve housing with an inlet and an outlet connector, a dimensionally stable, mobile valve closing body with peripheral annular sealing surfaces, fixing elements for floating positioning of the valve closing body and annular valve seats arranged on both sides of this in the direction of the inlet and outlet connectors.

The task is solved according to the invention in that mechanically strong means are mounted downstream in relation to the pressure direction of the ventilation device and are designed as basket-like air-permeable chicanes which retard the air blast. Special and further design forms of the explosion protection valve according to the invention are the subject of dependent patent claims.



Under strong pressure air blasts, in cooperation with the protection device, an explosion-protection valve to prevent damage preferably comprises mechanically strong basket-like chicanes to reduce the residual air blast, which are arranged at least partly downstream of the valve closing body in relation to the explosion direction.

The basket-like chicanes arranged downstream of the ventilation opening or valve closing body to reduce the air blast, in particular the residual air blast, are preferably attached with flanges. All other known removable and permanent fixing methods can also be used. The mechanical strength of the basket-like chicane must correspond to that of the other parts of the explosion protection valve where applicable.

The air molecules are reflected or deflected in the basket-like chicane, which reduces the energy content of the quantity of air; in particular the residual air blast, during the short closing time of the valve closing body, is reduced.

As special design forms, the basket-like chicanes may for example consist of perforated sheets, slotted sheets or fine wire mesh baskets which can be formed with one or more layers. The clear cross-section is preferably a maximum of 50%. The geometric shape of the basket may for example be cylindrical, truncated conical, spherical or hemispherical. Irrespective of the geometrical shape and design of the passage openings, the chicane must have an essentially higher mechanical strength than for example a conventional prefilter. However the mechanical strength of chicanes arranged downstream of the valve closing body may be considerably lower than that of upstream protective elements which are exposed to the full destructive power of unretarded explosion pressure waves.



The downstream chicanes can be optimised with regard to their size and shape, the size and shape of the holes, the distance between the holes etc. by experiment.

In addition to a downstream chicane, a simple protective element can also be mounted upstream of the valve closing body, for example in the form of a baffle plate with side inlet openings for an explosion pressure air blast.

In a variant of the invention with an explosion-protection valve, a small part of the explosion pressure wave may activate means which act directly on the valve closing body and press this into the corresponding valve seat. The main impact of the explosion pressure waves thus occurs only when the valve closing body has already closed partly, almost completely, or completely. This means a significant reduction in the residual air blast. By combining the measures described above, this residual air blast can be reduced still further.

To activate the means acting directly on the valve closing body, preferably approximately 1 to 10%, in particular approximately 2 to 6% of the explosion pressure wave acting on the inlet connectors can be deflected.

With the explosion protection valve equipped according to the invention, the residual air blast, in particular of conventional explosions, can be reduced. In this way the pulse passing before complete closure and the peak excess pressure are diminished such that there is no harmful effect on humans, animals and/or equipment. Known technical measures can be used to equip an explosion protection valve according to the invention with an excess pressure flap or a downstream prefilter depending on the specific application.

The explosion protection valves preferably used according to the invention are wear-free and practically maintenance-



free. They can be supplied with an effective corrosion protection. The entire closing mechanism consists of known materials of high impact resistance, for example chromium nickel or chromium molybdenum nickel steel. Materials of low density which have a shorter closing time and lower impact energy of the valve closing body on the valve seat are of particular importance. Valve closing bodies made at least partly of titanium, a titanium alloy or a composite material for example with aramide fibres (KEVLAR) have achieved very good results.

Material-specific weight savings on the closing mechanism, in particular its moving parts, can be combined with design measures for weight reduction for example by the inclusion of cavities and recesses.

After an explosion, the explosion protection valves show no greater pressure loss than before the explosion.

The invention is now explained in more detail using design examples shown in the drawing which are the subject of dependent claims. The axial sections show:

- Fig 1 a mounted explosion protection valve of a known type,
- Fig 2 the explosion valve in Fig 1 with shock tube and measurement tube flanged in place
- Fig 3 an explosion protection valve with perforated sheet casing
- Fig 4 a variant according to Fig 3 with a perforated sheet basket
- Fig 5 a variant according to Fig 3 supplemented with a baffle plate
- Fig 6 a combination of Figs 4 and 5
- Fig 7 a variant according to Fig 3 with smaller perforated sheet casing



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- Fig 8 a variant according to Fig 4 with smaller perforated sheet basket
- Fig 9 a variant according to Fig 8 with baffle plate
- Fig 10 an explosion protection valve with advanced tripping of the valve closing body by a push rod
- Fig 11 an explosion protection valve according to Fig 8 with downstream prefilter
- Fig 12 a variant of Fig 11 with baffle plate
- Fig 13 an explosion protection with pneumatic advanced tripping of the valve closing body, and
- Fig 14 a wall opening for ventilation with an internal chicane.

Fig 1 shows an explosion protection valve 10, known in itself, which is installed in a wall 12 of a closed room 14. The explosion protection valve 10 comprises a valve housing 16 with an inlet connector 18 extending through the wall 12 and a short outlet connector 20 arranged on the protected room side.

The two-part valve housing 16 is attached to the wall 12 with fixings 21.

In the valve housing 16, an aerodynamically-shaped valve closing body 22 is suspended floating on several springs 24 running in a radial direction. The valve closing body 22, designed as a disc valve in the present case, consists of a solid chromium nickel steel plate approximately 2 mm thick. Between the valve closing body 22 and the valve housing 16 is a large clear annular chamber. In this normal ventilation position, the explosion protection valve 10 is sensitive neither to contamination (dust, sand) nor icing.

When explosion pressure waves occur, the valve closing body 22 is thrown in direction X, the direction of the explosion pressure, against the outlet connector 20 and pressed on a first valve seat 26 to form a seal with a peripheral annular



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sealing surface 22a. For 1 to 5 ms, the closing time of the valve closing body 22, pressurised air can penetrate the protected room 14, after which the explosion protection valve 10 closes tightly. Under the subsequent immediate suction, the valve closing body 22 moves opposite to direction X against a second valve seat 28 and is pressed against this with a peripheral annular sealing surface 22b until the vacuum is filled and the valve closing body 22 is returned by springs 24 to the rest position shown in dotted lines. The two closed positions of the valve closing body 22 are shown in dotted lines.

Fig 2 shows a test arrangement for pressure impact tests with explosion protection valves 10. On the inlet side is a shock tube 30 with a measuring sensor 32, on the outlet side a measuring tube 34 with a second measuring sensor 36 and a third measuring sensor 38. The characteristic data for the explosion protection valves 10 shown in Figs 3 to 13 were measured and evaluated with the test arrangement in Fig 2. All explosion protection valves 10 shown in these figures are variants of the invention.

According to the design form in Fig 3, the explosion protection valve 10 has on the outlet side a perforated sheet metal casing 40 which is suspended from an angled circular profile 42 and sealed with a gas-tight cap 44. The perforated sheet casing 40 and cap 44 form a downstream chicane which reduces the residual air blast according to the invention in the case of an explosion. The sharp peaks of the residual pulse of the pressure wave are smoothed.

In the variant according to Fig 4, the closing cap 44 is also designed as a perforated sheet, the downstream chicane consisting of the perforated sheet casing 40 and the perforated sheet cap 44 is known as the perforated sheet basket.



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The downstream chicanes in relation to the explosion pressure direction X of the valve closing body 22 according to Figs 5 and 6 correspond to Figs 3 and 4. On the inlet side, on flange 48 of the inlet connector 18 is mounted a solid baffle plate 46 as an upstream chicane which is supported on four triangular feet 50 and leaves large side inlet openings 52 clear. The baffle plate 46 takes the first force of the explosion front and with the downstream chicane effectively reduces the residual air blast.

Fig 7 differs from Fig 3 only in that the perforated sheet 40 is placed immediately over the outlet connector 20. The downstream chicane formed by the perforated sheet 40 and closing cap 44 has a smaller diameter and hence a smaller volume than in Fig 3. Fig 8 differs from Fig 4 in the same way, and Fig 9 from Fig 6.

In the design form according to Fig 10, the baffle plate 46 has a sleeve 54, coaxial with the explosion protection valve 10, which projects into the inlet connector 18. In this sleeve 54 is guided a piston 56 lying against the inner wall which is connected with the valve closing body 22 via a push rod 58. The length of the sleeve 54 is such that the piston 56 remains in the sleeve on maximum travel of the valve closing body 22 in the axial direction. The push rod 58 is firmly anchored in the valve closing body 22. The push rod itself is designed as a tube and, like the entire closing mechanism, is made from chromium nickel steel.

If an explosion pressure wave spreads in direction X, a part corresponding to the geometric conditions is passed into the sleeve 54. The piston 56 is suddenly pressed down and thus the valve closing body 22 brought into the closed position. The remaining explosion pressure enters the inlet connector 18 via the side inlet openings 52 in the baffle plate 46, then spreads downwards and meets the already closing valve closing body 22. The early closing movement considerably



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reduces the residual air blast. Evidently, in the design form in Fig 10, all chicanes shown in the other figures can also be used to reduce the residual air blast further.

Fig 11 shows an explosion protection valve according to Fig 7 with a downstream prefilter 60 of the known type. Without the downstream chicane consisting of the perforated sheet casing 40 and perforated sheet cap 44, the prefilter 60 would be damaged under a relatively large residual air blast.

In the design form in Fig 12, a baffle plate 46 is also provided which brings further improved protection of the downstream prefilter 60. This explosion protection valve 10 corresponds to Fig 9. With the explosion protection valves 10 in Figs 8 and 10, a downstream prefilter 60 can also be fitted if the valve housing 16 has an angled ring profile 62 on the outlet side.

The explosion protection valve according to Fig 13 is specially shaped on the inlet side. The inlet connector 18 has an end attachment with an outer pipe 64 and an inner pipe 66. The outer pipe 64 is solid and connected with the inlet connector via an apertured plate 68. Like the plate 67 which partly covers the inlet opening, the apertured plate 68 is solid. On the outer tube 64 are two apertured fixing tabs 70 which serve to fix the explosion protection valve 10.

The inlet opening of the inlet connector 18 is only partly clear for the ingress of any explosion pressure waves in direction X:

- in the peripheral area, by an annular gap 72, and
- in the central area, by an inner chamber 74 of a control pipe 76 arranged coaxially with the inlet



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connector and extending from the inlet opening to the valve closing body 22.

In the valve closing body 22 is inserted an open tube which fits over the control pipe 76. Thus the valve closing body 22 can be moved from one valve seat 26 to the other valve seat 28 along the control pipe 76. The valve closing body 22, as in all other variants, is also equipped with means for return from one or the other valve seat 26, 28 so that after an explosion or suction, the rest position can be assumed again immediately. As explained above, these means may be radial or tangential springs.

The inlet area of the control tube 76 amounts to approximately 10% of the inlet area of the annular gap 72. In an explosion, a corresponding part of the explosion pressure waves in the inner chamber 74 of the control pipe 76 is passed in a direct straight path to the valve closing body 22. This moves like a projectile in the direction of the first valve seat 26 and closes the outlet connector 20. A much greater part of the explosion pressure waves entering the annular gap 72 is deflected on the apertured plate 68 in the direction of arrow 80, repelled in the direction of the inlet opening of the inlet connector 18, there deflected again in the direction of the arrow 82 and passed to the valve closing body 22 which has already moved in the direction of the valve seat 26 or has even already reached this. The double deflection of the pressurized air blast causes a weakening and a time delay. Thus the residual air blast is considerably reduced. A further reduction is achieved if the chicanes shown in the previous figures are attached at the outlet connector 20.

The outer tube 64 is concreted into the wall 12 (Fig 1), but can also be mounted on this with corresponding design measures for reinforcement.



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Fig. 14 shows a simple protection device with a basket-like perforated chicane 44 to reduce the air blast of pressure waves in direction X. The free surface area factor is approximately 308.

The pressure waves to be expected in the case of a catastrophe are relatively small and do not contain harmful substances, so no explosion-protection valve is included.

A wall opening 15 for ventilation is lined with a casing 16 which is screwed to a fixing flange of the internal chicane 44 and mounted in the wall 12 with a fixing 21. If an explosion-protection valve were used, the casing would be the valve housing.

Several of the variants with an explosion-protection valve 10 shown in the preceding figures have basket-like chicanes 40, 44 which in the design form according to Fig. 14 can be flanged directly onto the casing 16 of the wall opening 15, with or without a prefilter 60 being mounted (Figs. 11, 12).

Finally, also according to Fig. 14, an external baffle plate 46 (Figs. 5, 6) with inlet openings 52 can be mounted which breaks the force of the pressure waves.





CLAIMS

1. Protection device with means for reducing the air blast of pressure waves in ventilation systems of closed rooms (14), characterized in that mechanically strong means are attached downstream of the ventilation system in relation to the pressure direction (X) and are formed as basket-like air-permeable chicanes (40, 44) which retard the air blast.
2. Protection device according to Claim 1 to reduce the residual air blast of pressure waves behind an explosion protection valve (10), which explosion protection valve (10) has a valve housing (16) with an inlet (18) and an outlet connector (20), a dimensionally stable, mobile valve closing body (22) with peripheral annular sealing surfaces (22a, 22b), fixing elements (24) for floating positioning of the valve closing body (22) and annular valve seats (26, 28) arranged on both sides of this in the direction of the inlet (18) and outlet connectors (20), characterised in that mechanically strong basket-like means of reducing the residual air blast are arranged at least partly downstream of the valve closing body in relation to the explosion pressure direction (X).
3. Protection device according to claim 1 or 2, characterised in that the basket-like chicanes (40, 44) are attached by flanges.
4. Protection device according to any of claims 1 to 3, characterised in that the basket-like chicanes (40, 44) consist of at least single-layer perforated sheet metal, slotted sheet metal or fine wire mesh which preferably has the form of a cylinder, a truncated





cone, a sphere or a hemisphere and have a free cross-section up to a maximum of approximately 50%.

5. Protection device according to claim 4, characterised in that the part of the basket-like chicane (44) lying opposite the outlet opening of the outlet connector is designed to be air-tight.
6. Protection device according to any of claims 1 to 5, characterised in that a prefilter (60) is arranged over the basket-like chicanes (40,44) to reduce the residual air blast.
7. Protection device according to any of claims 1 to 6, characterised in that a baffle plate (46) with side inlet openings (52) is arranged to cover the inlet opening of the inlet connector.
8. Protection device according to any of claims 2 to 7, characterised in that in the area of the inlet opening of the inlet connector (18) of the explosion-protection valve (10), preferably in a baffle plate (46), a coaxial sleeve (54) is held which has a small internal diameter (d) in relation to the inlet connector (18) and a length corresponding at least to the axial displacement path of the valve closing body (22), and in this sleeve (54) is guided a piston (56) connected to the valve closing body (22) via a push rod (58), where the push rod (58) is preferably designed as a tube.
9. Protection device according to any of Claims 2 to 6, characterised in that the inlet opening of the inlet connector (18) of the explosion-protection valve (10) is partly closed by a plate (67) which has a coaxial bore for a control pipe (76) of smaller internal diameter (d) extending to the valve closing body (22)



and at least one peripheral opening in an outer annular gap (72), where this outer annular gap is limited by an inner tube (66) which diverts the main flow of the explosion pressure wave in a siphon-like manner, and the valve closing body (22) has a guide pipe (78) placed over the control pipe (76).

10. Protection device according to claim 8 or claim 9, characterised in that the internal diameter (d) of the sleeve (54) or the control pipe (76) in the explosion protection valve (10) is between 0.1 and 0.3 times, preferably between 0.15 and 0.25 times the inner diameter (D) of the inlet connector (18).
11. Use of the protection device according to any of claims 1 to 10 in protected rooms for persons and/or equipment, containments in nuclear power stations and other, offshore, equipment.

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