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Replacing GB/T 15605-1995

Guide for pressure venting of dust explosions

粉尘爆炸泄压指南

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Foreword

This standard replaces GB/T 15605-1995 “Guide for pressure venting of dust explosions”.

This standard is revised from GB/T 15605-1995.

The consistency between this standard and VDI 3673 “Pressure venting of dust explosions” (English version 2002, hereinafter referred to as the original text) not equivalent, the main differences are as follows:

- DELETE the theoretical knowledge introduction and the interpretational descriptions of relevant provisions from the original text;
- DELETE the references and the attached drawings which are not highly associated with the main contents of the standard from the original text;
- MODIFY the expression methods into the form applicable to Chinese standard;
- ADD the normative references (SEE chapter 2);
- COMBINE the chapters 3, 4, 5, 11, and 12 of VDI 3673 into chapter 4 of this standard;
- ADJUST the chapters 7, 8, 9, 10 of the original text into the chapters 5, 6, 7, 8 of this standard; ADJUST the chapter 13 of the original text into chapter 9 of this standard; ADJUST the chapter 6 of the original text into chapter 10 of this standard;
- The main contents of chapter 11 of this standard are revised mainly with reference to GB/T 15605-1995, which contains the contents of chapter 14 of the original text;
- CHANGE the pressure unit to the international system of units.

As compared with GB/T 15605-1995, the main changes of this standard are as follows:

- MODIFY the terms and definitions, DELETE some of the terms and definitions which have been given in the basic terminology standards, ADD the terms and definitions related to flame and pressure hazards (chapter 3 of 1995 version; chapter 3 of this version);
- Explosion pressure venting application: this version uses the contents of chapters 3, 4, 5, 11, and 12 of VDI 3673, to respectively specify the

applications in different place pressure venting such as containers, buildings, pipelines, systems connected to pipeline, and so on. DELETE the chapter 6 and chapter 7 of the 1995 version, and COMBINE the contents with chapter 4 of 1995 version into chapter 4 of this version (chapter 4, 6 and 7 of the 1995 version; chapter 4 of this version);

- Venting area calculation method: the 1995 version mainly uses the calculation method of NFPA 68:1988, whilst this version uses the calculation method of VDI 3673:2002 (chapter 5 and chapter 8 of 1995 version, chapter 5 of this version);
- This version no longer uses the venting area Nomogram, but uses the fitting formula (chapter 5 and chapter 8 of 1995 version, chapter 5 of this version);
- ADD the hazards of flame and pressure as well as the recoil force calculation in the venting process (SEE chapters 6 and 8);
- Independently LIST the relevant design of the pressure venting tube (clause 5.3 of 1995 version, chapter 7 of this version);
- MODIFY the combustible mixture pressure venting design (chapter 9 of 1995 version, chapter 9 of this version);
- MODIFY the chapter 10 Pressure venting device, DELETE the technical provisions on the pressure venting device, ADD the anti-vacuum suction valve area calculation Nomogram (chapter 10 of 1995 version; chapter 10 of this version);
- DELETE the chapter 11 Determination of activation pressure;
- DELETE Appendix A "Explosion pressure venting of pipeline, channel, and long container", Appendix B "Basic principles of dust explosion pressure venting", and Appendix C "Explosion of combustible dust";
- ADD the normative Appendix "Venting area calculation for special delivery system" (SEE Appendix A), informative Appendix "Design example" (SEE Appendix B), and informative Appendix "Length diameter ratio of protected container/bin as determined during venting area calculation" (SEE Appendix C).

Appendix A of this standard is normative, Appendix B and Appendix C are informative.

This standard was proposed by the State Administration of Work Safety.

Guide for pressure venting of dust explosions

1 Scope

This standard gives the basic method for explosion pressure venting design in the places in presence of combustible dust and mixture.

This standard applies to general industrial dust.

This standard does not apply to toxic and corrosive dust, explosives or energetic materials.

This standard does not apply to the equipment that subject to detonation disaster.

The explosion pressure venting technology of this standard is permitted only if it does not seriously endanger the environment and does not cause injury to personal safety and health.

If the actual test proved that it can ensure the same level of safety obtained with this standard, then the method used and the calculated pressure venting area are allowed to deviate from this standard.

2 Normative references

The provisions in following documents become the provisions of this Standard through reference in this Standard. For the dated references, the subsequent amendments (excluding corrections) or revisions do not apply to this Standard; however, parties who reach an agreement based on this Standard are encouraged to study if the latest versions of these documents are applicable. For undated references, the latest edition of the referenced document applies.

GB/T 15604 Terminology for dust explosion prevention

GB/T 16426 Determination for maximum explosion pressure and maximum rate of pressure rise of dust cloud (GB/T 16426-1996, eqv ISO/DIS 6181-1)

3 Terms and definitions

The following terms and definitions apply to this standard.

3.1

Explosion pressure venting

A method of restraining the pressure of explosion by opening a pre-designed venting port to release the unburned mixture and the products of combustion, so as to prevent the pressure from rising beyond the design strength, and to protect the container, which is referred to as explosion venting or pressure venting.

3.2

Activation overpressure

3.2.1

Static activation overpressure, p_{stat} , MPa

The pressure at which the pressure venting device opens by slowly rising pressure.

Note: The pressure shall be pressure-strength, which is used to be called pressure. The unit is MPa (Megapascal).

3.2.2

Dynamic activation overpressure, p_{dyn} , MPa

The pressure which opens the pressure venting device during explosion. It may be higher than the static activation overpressure.

3.3

Reduced explosion overpressure, p_{red} , MPa

The maximum pressure produced at the time of explosion pressure venting of the mixture of a certain concentration dust and air in the pressure venting protected container.

3.4

Reduced rate of pressure rise, $(dp/dt)_{\text{red}}$, MPa • S⁻¹

The rising rate of the maximum pressure as produced at the time of explosion pressure venting of a certain concentration of dust-and-air mixture, in the pressure venting protected container.

3.5

Maximum reduced explosion overpressure, $p_{\text{red,max}}$, MPa

4 Explosion pressure venting application

4.1 Explosion pressure venting for containers, silos and equipment

4.1.1 The maximum reduced explosion overpressure shall not exceed the design pressure of the equipment. All components of the equipment subjected to explosion pressure, such as valves, sight glasses, access holes, cleaning ports and pipelines, shall have this design strength.

4.1.2 Pressure venting devices shall be installed to avoid the personnel from risk of explosion hazards, and shall not affect the equipment operation with safety significance.

4.1.3 If the equipment to be protected is located in a building, a vent duct shall be used to lead the pressure venting port outside the building, or otherwise the pressure venting device that does not produce flame or spark shall be used.

4.1.4 For situations where the dust explosion index is large and sufficient pressure venting area cannot be provided on containers, silos and equipment, consideration may be given to the integrated application of explosion pressure venting and other explosive control technologies such as explosion suppression and explosion resistant design.

4.2 Explosion pressure venting for buildings

4.2.1 All parts of the room or building in danger of dust explosion shall be protected by explosion pressure venting method, Pressure venting can be achieved by using windows, facades or roofs of rooms.

4.2.2 A sufficient safety zone shall be provided near the pressure venting port so that personnel are not compromised, and the operation of the relevant safety equipment and main equipment is not affected.

4.2.3 When using the side pressure venting mode, it shall set up strong railing to prevent personnel fall. It shall use the materials that do not form large fragments with sharp edges. Ordinary glass or similar fragile material shall not be used as a material for pressure venting devices. If safety glass is used, safety precautions shall be taken to prevent debris flying out.

4.3 Explosion pressure venting for pipeline

4.3.1 Each segment of the pipeline shall use radial pressure venting, AND the pressure venting area shall not be less than the cross-sectional area of the pipeline.

5 Pressure venting area calculation

5.1 General provisions

5.1.1 The maximum explosion pressure, $p_{\max}$, and explosion index, $K_{\max}$ (also denoted as K_{st}) shall be measured in accordance with the method specified in GB/T 16426.

5.1.2 The static activation pressure of the pressure venting device p_{stat} shall be less than the container strength p , AND the container strength shall at least reach the expected maximum reduced explosion overpressure $p_{\text{red, max}}$.

5.1.3 If it is necessary to vent the pressure to a closed space not for permanent operation but for wind shield only (for example, top of silo), this space shall also be pressure vented, generally the entire roof is pressure vented.

5.2 Pressure venting of containers, silos and equipment

5.2.1 The calculation formulas given in this clause apply to both the dusts with dust explosion classes of St1 and St2 with a maximum explosion pressure $p_{\max} \leq 1$ MPa, AND the dust with a dust explosion class of St3 with a maximum explosion pressure $p_{\max} \leq 1.2$ MPa. Under both conditions, it shall comply with the conditions that the normal operation pressure is not exceeding 0.02 MPa.

5.2.2 Container volume does not include the volume of obstacles therein. Any obstacles in the container (for example, filter bag, envelope, filter cartridge), the volume of the container shall be subtracted from the volume occupied by the filter element or the volume enclosed by the filter medium. It shall ensure that pressure venting process is not blocked by obstacles, so the filter frame shall not cover the pressure venting port. If the pressure venting port blocked by the obstacle is unavoidable, it shall use reasonable pressure venting efficiency in the venting area calculation.

5.2.3 Use the formula (4) and formula (5) to calculate the venting area A , m^2 (exceptions are as shown in Appendix A).

For $p_{\text{red, max}} < 0.15$ MPa, it is calculated as follows:

$$A = B \left(1 + C \cdot \lg \left(\frac{L}{D_E} \right) \right) \dots\dots\dots (4)$$

For $p_{\text{red, max}} \geq 0.15$ MPa, it is calculated as follows:

5.3.4 The strength of all structural components such as walls, windows, ceilings, suspended sheds and roofs shall be analyzed.

6 Hazards of flame and pressure

6.1 General provisions

6.1.1 The pressure venting process shall neither endanger persons nor restrict the operation of any safety-critical equipment.

Note: For example, upward pressure venting method can be used.

6.1.2 If upward pressure venting is not feasible, the venting port shall be located as high as possible on the side of the container. For this reason, the problem of recoil force related to overturning moment shall be considered.

6.1.3 Due to the dust spray danger, attention shall be paid to the stacking height of dust in the container. The highest material-level of the container shall not reach the lower edge of the pressure venting port.

6.1.4 Combustible material shall not be placed near the pressure venting port.

6.1.5 When the outdoor equipment is pressure vented, it shall ensure that the surroundings will not be exposed to flame and pressure.

6.1.6 For the explosion pressure venting of the equipment in the building, it shall vent pressure to outdoor along a safe direction through the pipeline (vent duct).

6.1.7 Under certain conditions, the use of certified flameless pressure venting device can prevent flames ejected from the pressure venting device.

6.2 Flame propagation

The maximum reach of flame ejected from the container is determined in accordance with formulas (11) and (12):

For horizontal pressure venting:

$$L_F = 10 \cdot V^{1/3} \quad \text{..... (11)}$$

For vertical pressure venting:

$$L_F = 8 \cdot V^{1/3} \quad \text{..... (12)}$$

- Volume: $0.1 \text{ m}^3 \leq V \leq 10000 \text{ m}^3$;
- Venting device static activation pressure: $0.01 \text{ MPa} \leq p_{\text{stat}} \leq 0.1 \text{ MPa}$;
- Maximum reduced explosion overpressure: $0.01 \text{ MPa} < p_{\text{red, max}} \leq 0.2 \text{ MPa}$,
and $p_{\text{red, max}} > p_{\text{stat}}$;
- Maximum explosion pressure: for the dust having an explosion index value
of $1 \text{ MPa} \cdot \text{m} \cdot \text{s}^{-1} \leq K_{\text{max}} \leq 80 \text{ MPa} \cdot \text{m} \cdot \text{s}^{-1}$, the p_{max} range shall be $0.5 \text{ MPa} \leq p_{\text{max}} \leq 1.2 \text{ MPa}$;
- Length diameter ratio $L/D_E = 1$.

If the maximum explosion pressure, dust explosion index or static activation pressure is less than the specified application range as specified for the above parameters, it can still use the formula (16) to make calculation, BUT it shall use the minimum value of the corresponding parameter in the above application range.

The effect of the vent duct on the maximum reduced explosion overpressure is significantly reduced with the increase of the length diameter ratio L / D_E of the container. For the case where the length diameter ratio is not 1, the maximum reduced explosion overpressure of the container with vent duct can be calculated using the formulas (17) or (18).

If the length diameter ratio $L/D_E = 6$, the increased maximum reduced explosion overpressure $p'_{\text{red, max}}$ is calculated as:

$$p'_{\text{red, max}} = 0.1 \cdot (0.0586 \cdot l + 1.023) (10 \cdot p_{\text{red, max}})^{(0.981 - 0.01907 \cdot l)} \dots\dots\dots (17)$$

For all other cases (length diameter ratio other than 1 or 6), if complying with the following conditions:

- The maximum explosion pressure of the container without vent duct $p_{\text{red, max}} \leq 0.2 \text{ MPa}$;
- Length diameter ratio: $1 \leq L/D_E \leq 6$;
- Vent duct length: $l \leq l_s$.

The formula (18) that linearly interpolates (16) and (17) can be used:

$$p'_{\text{red, max}} = 0.2 \cdot (C_1 - C_2) \left(1 - \frac{L}{D_E}\right) + C_1 \dots\dots\dots (18)$$

9.4 If the above requirements are not met, the explosion characteristics of the mixture shall be determined.

9.5 For a mixture of combustible dust and combustible gas with an explosion class of St3 ($K_{\max} > 30 \text{ MPa} \cdot \text{m} \cdot \text{s}^{-1}$), consult a specialist.

10 Pressure venting device

10.1 Rupture discs / bursting film / bursting plates

10.1.1 Dirt, snow, excessive friction, corrosion or material fatigue can damage the effectiveness of the pressure venting device AND affect the pressure venting efficiency.

10.1.2 Rupture discs shall be designed to prevent debris from flying out.

10.1.3 Rupture disc / bursting film shall be replaced within the service life.

10.1.4 If the pressure venting device is a bursting plate clamped with rubber clips or other devices, it shall use a firm cord or other restraining device to prevent the bursting plate from flying out.

10.2 Explosion door

10.2.1 Explosion doors shall be installed in accordance with the designed installation method.

Note: After the venting port of the explosion door is opened during explosion, either leave it at open state or reclose the pressure venting port as needed. The installation method of the explosion door affects its opening and closing action, AND meanwhile affects the pressure venting efficiency.

10.2.2 The venting efficiency of the explosion door shall be determined through test.

10.2.3 Suitability tests shall be carried out on explosion doors, to demonstrate that the explosion doors will function under the anticipated conditions of the explosion and that no disasters will be caused by the flyovers.

10.2.4 The recoil force caused when the pressure venting device is activated shall be taken into account in the design of the pressure venting container (e.g. using a chute).

10.2.5 Corrosion of movable components of explosion door, improper painting, and icing and snow accumulation can lead to increased activation pressure.

11 Maintenance

11.1 It is preferable for the equipment installation and maintenance to be under the guidance of experts or product manufacturers.

11.2 The using unit shall periodically inspect and maintain the pressure venting devices and components AND ensure that they function well. The checking items include:

- Whether the pressure venting device surface has dust, snow, ice or other factors that affect the normal function of the pressure venting device;
- Whether the rupture disc is damaged;
- Whether the chains, hooks, clamping devices, and gaskets of the bursting plate or explosion door are normal.

11.3 It is not preferable for the explosion vent to be used as the inspection hole or passage.

11.4 During process operation, it is not preferable to maintain the pressure venting device. If it is necessary to maintain the pressure venting device during process operation, it shall remove the dust from the work location, it shall not use hot work or take other actions such as impact or knock which may produce ignition source.

11.5 After the explosion door is opened under explosion, it shall check whether it can be continuously used.

11.6 It shall avoid the activation pressure change of the pressure venting device due to improper maintenance such as painting or coating.

11.7 Pressure venting device installation and maintenance information shall be recorded and archived.

Appendix B

(Informative)

Design examples

In the following example, the empirical formula in chapter 5 will be used to calculate the explosion pressure venting of dust and air mixtures in containers and silos. For convenience, the calculation result is accurate to 2 digits after the decimal point. For practical applications, it is recommended to be accurate to 1 decimal place.

B.1 Container and silo pressure venting area calculation

B.1.1 Impact of container design strength on pressure venting area

The pressure venting area A of a container with a volume of 20 m^3 (length diameter ratio $L/D_E = 1$) is calculated using the formula (4) and (5) in clause 5.1. The container is free of obstacles, AND the rupture disc (pressure venting efficiency $E_F = 1$) is used to seal the venting port.

The required pressure venting area of the container with different design strength p as calculated in accordance with the condition of dust explosion class St1, maximum explosion pressure $p_{\max} = 0.9 \text{ MPa}$, AND the static activation pressure of rupture disc $p_{\text{stat}} = 0.01 \text{ MPa}$ is as shown in Table B.1.

Table B.1 -- Venting area required by containers of length diameter ratio 1 at different design strengths

($V = 20 \text{ m}^3$, $L/D_E = 1$, $p_{\max} = 0.9 \text{ MPa}$, $K_{\max} = 20 \text{ MPa} \cdot \text{m} \cdot \text{s}^{-1}$, $p_{\text{stat}} = 0.01 \text{ MPa}$, $E_F = 1$)

$p = p_{\text{red, max}} / \text{MPa}$	Venting area A / m^2
0.025	1.23
0.050	0.83
0.100	0.56
0.150	0.45

B.1.2 Impact of container length diameter ratio on pressure venting area

For containers with low design strength, the effective vent area required is significantly affected by the container length diameter ratio L/D_E . This effect decreases with increase of the maximum reduced explosion overpressure, AND it disappears at $p_{\text{red, max}} = 0.15 \text{ MPa}$.

Appendix C

(Informative)

Determine length diameter ratio of the protected container/silo when calculating the pressure venting area

When using the formulas (4), (5), (A.1), (A.3) and (A.6) to calculate the pressure venting area, it is required to determine the length diameter ratio L/D_E . L/D_E is related to the container shape and the venting port position. It is not necessary for its value to be equal to the apparent length diameter ratio of the container.

The formulas (4), (5), (A.1), (A.3) and (A.6) can be used in the worst scenario where the pressure venting port is located at the top of the container. Because in this case, the flames may reach the pressure venting port from the other end of the container through the length of the entire container before it escapes.

In the above case, if the container is cylindrical or rectangular, the length diameter ratio L/D_E can be calculated directly from the physical dimensions (length and diameter or width and depth) of the container. If the container consists of a cylindrical part and a conical part OR if the pressure venting device is placed on the side of the container, the appropriate value for the length diameter ratio L/D_E can only be determined by the design of the container or silo, the effective flame propagation distance in the container L_{eff} (the distance propagated by the flame before pressure venting), and the effective flame volume V_{eff} (the volume passed by the flame before pressure venting).

Note 1: For longitudinally placed containers, the effective flame propagation distance L_{eff} is measured in the vertical direction, AND the length contains the length of the pressure venting device. If the container is horizontally placed, it is measured along the horizontal direction (see Figure C.2).

Note 2: Do not confuse the effective flame volume V_{eff} used to calculate the length diameter ratio L/D_E with the volume of the container V . V is the protected device volume, which is the basic input parameter for calculating the venting area.

C.1 Cylindrical container with cone, pressure venting from top

Effective flame propagation distance L_{eff}

Since the flame does not extend sufficiently in the cone, the effective flame propagation distance L_{eff} is 1/3 of the height of the cone plus the height of the cylinder (see Figure C.1).

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