GERMAN WELDING SOCIETY

IndustrieGaseVerband e.V.

Welding and Pressure Gas Equipment

Recommendation for action by associations DVS, IGV and VDMA

to the topic:

Explosion pressure shock resistant design and testing of acetylene HD pipelines according to TRGS 407

Table of contents

Explanation

This information serves as a non-binding guideline for the handling of TRGS 407 "Safety-relevant properties for the assessment of hazards during activities with acetylene". The document does not claim to be complete or to be an exact interpretation of the existing legal regulations. It may not replace research into the relevant guidelines, laws and regulations. Furthermore, the special features of the respective products, their various applications and the company- and product-specific requirements during the manufacturing process must be taken into account. The content has been prepared carefully and to the best of our knowledge. The associations assume no liability for any incorrect or misleading representations.

1 Background

In practice, the strength test prior to commissioning or the one-time strength test of the design of Acetylene installations in which gaskets are used for fasteners cannot always be performed with the required test pressure of 0.9 x design pressure specified for the explosion shock pressure surge resistant design as detailed within TRGS 407, Appendix A.4.9 para. 13, which is generally to be assumed. The same applies to PED 2014/68/EU Annex 1, paragraph 7.4.

The reasons for this is that leakages occur at the seals during this high test pressure. The resulting pressure loss makes testing impossible. In addition, the high test pressure destroys both the sealing system (the elastomer seals are extruded into the gap) and the connecting threads.

The test pressures can therefore be lowered using the procedures described below.

Note:

- *According to BetrSichV § 14 and § 15, as well as according to PED 2014/68/EU Annex 1 paragraph 3.2.2, test contents, which have been tested and documented within the scope of conformity assessment procedures, do not have to be tested again before commissioning.*
- *In principle, all components must withstand the pressure specified in TRGS 407. The possible pressure mentioned there does not depend on the nominal diameter of the pipes.*

2 Safety justification for a lower test pressure

If acetylene decomposition actually occurs, no leakage at the gaskets is to be expected when applying a reduced test pressure. The dynamic, detonative pressure load is attenuated by gaps (≤ 0.1 mm) and threads in front of the gaskets. The static reference pressure at the transition point from deflagration to detonation (DDT; e.g. 1029 bar abs. at 20 °C and 26 bar abs. initial pressure) or at reflection points of a stable detonation (e.g. 1716 bar abs. at 20 °C and 26 bar abs. initial pressure) does not occur here at the same level as on the inner wall of the pipe.

The pressures occurring at the actual sealing elements are to be expected at most in an order of magnitude of the product of deflagration pressure ratio and initial pressure (e.g. for an initial pressure of 26 bar abs. as well as for a deflagration pressure ratio of 10 at 20 °C, the maximum pressure to be expected would be in the order of magnitude of approx. 10 x 26 bar abs. = 260 bar).

3 Plant part specific construction and design notes

3.1 Parts of the plant which are straight and do not represent a reflection point

These plant components include straight pipes, straight screw-in connections, straight welded connections (circumferential welds) and other straight components.

3.1.1 The calculated wall thickness for straight plant components is determined in accordance with the current standard or guideline. As design pressure, the static reference pressure at the DDT (e.g. 1029 bar abs. at 20 °C and 26 bar abs. initial pressure) shall be used (according to TRGS 407, Appendix A.4.9 Equation 11) with 1-fold safety margin against the yield strength.

3.1.2 The one-off strength test of the design is carried out in accordance with TRGS 407, Appendix A.4.9, Paragraph 13, but with 0.9 times the static reference pressure in the area of stable detonation (pstat_stable in accordance with TRGS 407, Appendix A.4.9 Equation 8), typically in the form of a hydrostatic pressure test.

This corresponds to 0,9 x 686 bar abs. = 617 bar abs.

During the one-time strength test of the design no visible deformations and leaks may occur. However, it is permissible to set the pipe connections. Afterwards these plant components are designed to be explosion pressure shock resistant.

3.1.3 When designing threaded connections, the gas paths must be considered. If the sealing element is located behind the usually very narrow gap (narrow gaps < 0.1 mm have proven to be effective in practice; the dynamic, detonative pressure load is weakened by gaps through which the decay occurs and by threads in front of the seals), the detonative pressure load acting on the sealing element is considerably lower than that acting on the wall of the pipe. A one-time verifiable pressure test of these connections with a pressure of 617 bar abs. is therefore sufficient (Requirements from 2.1.2).

3.2 Parts of the installation that represent a reflection point

Reflection points include (closed) ball valves, closed ends or T-pieces.

3.2.1 The calculated wall thickness for plant components that represent a reflection point is determined in accordance with the state of the art (standard, guideline). The static reference pressure of a reflected stable detonation (max. 1715 bar abs. at a maximum initial pressure of 26 bar abs.) must be used as the rated pressure (according to TRGS 407, equation 12) with 1-fold safety against the yield point.

3.2.2 The one-off strength test of the design is carried out in accordance with TRGS 407, Appendix A.4.9, Paragraph 13, but with 0.9 times the static reference pressure in the stable detonation range (pstat_stabil TRGS 407, Appendix A.4.9 Equation 8), typically in the form of a hydrostatic pressure test.

This corresponds to 0.9 x 686 bar abs. = 617 bar abs.

During the one-time strength test of the design, no visible deformations and leaks may occur. However, a setting of the pipe connections is permissible. Afterwards, these plant components are designed to be explosion pressure shock resistant.

3.2.3 When designing threaded connections, the gas paths shall be considered. If the sealing element is located behind the usually very narrow gap (narrow gaps < 0.1 mm have proven to be effective in practice; the dynamic, detonative pressure load is weakened by gaps through which the decay occurs and by threads in front of the seals), the detonative pressure load acting on the sealing element is considerably lower than that acting on the wall of the pipe. A one-time verifiable pressure test of these connections with a pressure of 617 bar abs. is therefore sufficient (Requirements from 2.1.2).

3.2.4 The axial expansion (load zone) due to the reflection of a stable detonation is a maximum of 5 x inner diameter starting from the reflection point. A reinforcement of the affected load zone is to be carried out if reflection points cannot be avoided completely. Within the load zone, wall thicknesses of valve housings or fittings which enclose the actual pipe can be regarded as reinforcement of the pipe wall thickness.

3.3 Plant components with deflection radii < 5 x internal pipe diameter

3.3.1 The calculated wall thickness for a deflection radius < 5 x the pipe inside diameter is determined according to the the current standard or guideline. The static reference pressure at the transition point from deflagration to detonation multiplied by a factor of 1.5 (1544 bar abs. at 20 °C and 26 bar abs. initial pressure) must be used as the design pressure (pstat_stabil TRGS 407, equation 11 as well as paragraph 7) with 1-fold safety margin against the yield point.

3.3.2 The one-off strength test of the design is carried out in accordance with TRGS 407, Appendix A.4.9 Paragraph 13, but with 0.9 times the static reference pressure in the stable detonation range (pstat_stabil TRGS 407, Appendix A.4.9 Equation 8), typically in the form of a hydrostatic pressure test.

This corresponds to 0.9 x 686 bar abs. = 617 bar abs.

During the one-time strength test of the design, no visible deformations and leaks may occur. However, a setting of the pipe connections is permissible. Afterwards, these plant components are designed to be explosion pressure shock resistant.

4 Further notes / explanations on design relevant sections of TRGS 407

4.1 Extract from TRGS 407, Appendix A.4.9 Paragraph 10

For the design pressure only the stable detonation according to equation 8 and at points of possible reflection of the pressure according to equation 12 need to be considered

1. *in the case of pipelines in filling stations based on TRBS 3145 / TRGS 745 number 4.3.1 paragraph 2 and 3 and the special measures according to TRBS 3145 / TRGS 745 number 4.3.6 paragraph 1*

2. *for battery installations for acetylene, if these comply with DIN EN ISO 14114 and the high-pressure part is located in an area to which only specially instructed persons have access.*

NOTE: When setting up systems, the customer will always be advised of this, that the acetylene plant may only be entered by instructed personnel.

4.2 Extract from TRGS 407, Appendix A.4.9 Paragraph 11

It is possible to deviate from an explosion pressure resistant design of pipelines and an explosion pressure shock resistant design can be made. In this case, after acetylene decomposition, the pipelines must be examined for visible deformations and replaced if necessary.

NOTE: The explosion shock pressure resistance of an existing pipeline can be determined retrospectively, e.g. by means of TRGS 407, Appendix A.4.9, paragraph 12.

5 Alternative to design according to design pressures: Experimental design using acetylene decomposition test

5.1 As an alternative to the design according to the calculated design pressure, an experimental design by means of acetylene decomposition test can also be performed. This can be performed, e.g., according to EN ISO 15615. During the acetylene decomposition test, no visible permanent deformation and no leaks may occur (see TRGS 407, Appendix A. 4.9, paragraph 9).

5.2 For certain plant components, the acetylene decomposition test is explicitly prescribed in relevant product standards (e.g. main pressure reducing valves according to EN ISO 7291 or high-pressure acetylene ball valves according to EN ISO 15615).

6 Summary of the design and test pressures

Design pressures and test pressures for the different detonative load scenarios

Detonative load scenario	**Rated pressure** **[at 20 °C and 26 bar abs. acetylene initial pressure].**	**Components (examples)**	**Pressure of the one-off strength test of the design or the strength test before commissioning**	**Pressure of the leak test before commissioning** **Requirement: No detectable leaks**
Transition from deflagration to detonation (DDT) in straight tube	1029 bar abs.	• straight tubes/Pipes • straight welding binding (circular seams) • other straight components • Bends with deflection radii ≥ 5 x the inner diameter of the pipe straight screw-in connections linked to various parameters (see TRGS 407, A.4.7 and A.4.8)	617 bar abs.	1,5 bar abs. and 28,5 bar abs.
Transition from deflagration to detonation (DDT) in a pipe with a radius of curvature < 5 x pipe inside diameter	1544 bar abs.	• Plant components with deflection radii < 5 x the internal pipe diameter		
at reflection points of a stable detonation	1716 bar abs.	• Ball valves (closed) • Valves • closed pipe ends • T-Pieces • T-Angel		

7 Associations

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