

**PROPOSAL FOR DRAFT AMENDMENTS TO ECE REGULATION No. 67 (LPG)
TO IMPROVE THE BONFIRE TEST REQUIREMENTS**

(transmitted by the expert from the Netherlands)

Introduction

In revision 1 of ECE Regulation No. 67 the bonfire test for LPG containers was introduced. The general objective of the bonfire test is to demonstrate that a container complete with the fire protection system, specified in the design, will prevent the burst of the container when tested under the specified conditions.

In the Regulation an acceptable result is defined as:

“The container vents through the pressure relief device and no burst of the container takes place”

Experience by the technical service of 120 bonfire tests in the Netherlands learnt that in some cases an approval must be given although the container configuration showed such an unsafe behaviour during the bonfire test, that it should fail in the test. In these cases the containers did not burst, but high pressures in the containers during the test were measured and during investigation of the containers after the tests we found a high level of plastic deformation. The containers were close from an explosion (BLEVE).

To avoid these undesirable situations it is necessary to amend the bonfire test requirements in such a way that relevant observations are taken into account in the judgement of the test result.

The most suitable parameter to take into account in the bonfire test is the behaviour of the pressure during the test. It is therefore proposed to introduce a maximum pressure which shall not be exceeded during the bonfire test in line with the new draft regulation for liquid hydrogen (TRANS/WP.29/GRPE/2003/14).

We propose some amendments in annex 10 paragraph 2.6. on the LPG container bonfire test. The main part is Paragraph 2.6.7. (acceptable test results) where we propose an introduction of criteria to decide if the test result is valid or not.

- 1) introduce a maximum pressure level during the test and a visible inspection of the container after the test for the identification of plastic deformation.
- 2) introduce the expected behaviour of the fire protection system.
- 3) introduce the behaviour of composite containers.
- 4) introduce a test summary on every test with minimum data.

In addition to the amendments above some other amendments of the bonfire test requirements are proposed such as improvements of the container set up in paragraph 2.6.4. and in paragraph 2.6.5 concerning the temperature and pressure measurements.

In Annex 15 paragraph 10.1.2. concerning the resealing pressure of the pressure relief valves, an amendment is proposed to extend the requirements of the PRV to introduce the opportunity of an enhanced working PRV (=PRD) for the bonfire test possible.

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Annex 10.

Paragraph 2.6.1., amend to read:

“2.6.1. General

The bonfire test is designed to demonstrate that a container complete with the fire protection system, specified in the design, will prevent the burst of the container when tested under the specified fire conditions. **The manufacturer shall describe the behaviour of the complete fire protection system including the designed drop to atmospheric pressure.”**

Paragraph 2.6.2., amend to read:

“2.6.2. Container set-up

- (a) The container shall be placed **in the designed position by the manufacturer** with the container bottom approximately 100 mm above the fire source.
- (b) Shielding shall be used to prevent direct flame impingement on the fusible plug (PRD) if present. The shielding shall not be in direct contact with the fusible plug (PRD).
- (c) Any failure during the test of a valve, fitting or tubing that is not part of the intended protection system for the design shall invalidate the result.”
- (d) **Containers with a length of less than 1.65 m: The centre of the container shall be positioned over the centre of the fire source.**
Containers with a length equal to or larger than 1.65 m: If the container is fitted with a pressure relief device at one side, the fire source shall commence at the opposite side of the container. If the container is fitted with pressure relief devices at both sides, or at more than one location along the length of the container, the centre of the fire source shall be centred midway between the pressure relief devices that are separated by the greatest horizontal distance.”

Paragraph 2.6.4., amend to read:

“2.6.4. Temperature and pressure measurements

During the bonfire test the following temperatures shall be measured:

- (a) The fire temperature just below the container, along the bottom of the container, at minimum two locations, not more than 0.75 m apart;
- (b) The wall temperature in the bottom of the container;
- (c) The wall temperature within 25 mm from the pressure relief device;
- (d) **The wall temperature on the top of the container, in the centre of the fire source;**

Metallic shielding shall be used to prevent direct flame impingement on the thermocouples. Alternatively, thermocouples may be inserted into blocks of metal, measuring less than 25 mm². During the test the thermocouple temperatures and the container pressure shall be recorded at intervals of **2 seconds** or less.”

Paragraph 2.6.5., amend to read:

“2.6.5. General test requirements

- (a) Container shall be filled with 80 per cent in volume of LPG (commercial fuel) and tested in the horizontal position at working pressure;
- (b) Immediately following the ignition, the fire shall produce flame impingement on the surface of the container, along 1.65 m length of the fire source across the container;
- (c) Within 5 minutes of ignition at least one thermocouple shall indicate the temperature of fire just below the container of at least 590 °C. This temperature shall be maintained for the remaining duration of the test, namely until when no overpressure is present in the container.
- (d) Ambient conditions may not influence the result of the test.”**

Paragraph 2.6.6., delete

Paragraph 2.6.7., renumber as paragraph 2.6.6.; amend to read:

“2.6.6. Acceptable results:

- (a) A burst of the container shall invalidate the test result.
- (b) A pressure of more than 37 bar, i.e. 136 per cent of the set pressure of the PRV (27 bar), during the test shall invalidate the test result.
A pressure between 30 and 37 bar shall only invalidate the test result in case visible plastic deformation is observed.**
- (c) In case the behaviour of the protection system does not comply with the specification of the manufacturer and it leads to a mitigating test condition the result shall be invalidated.**
- (d) For a composite container a release of LPG via the surface is accepted in case of a controlled release. A release of gaseous LPG within 2 minute after the start of the test or a release capacity of more than 30 litres per minute shall invalidate the test result.**
- (e) The results shall be presented in a test summary and shall include the following data for each container as a minimum:**
 - **Description of the container configuration.**
 - **Photo of the container set-up and PRD**
 - **Applied method including time interval between measurements.**
 - **The elapsed time from ignition of the fire to the start of venting of LPG and actual pressure.**
 - **Time to reach atmospheric pressure.**
 - **Pressure and temperature diagrams.”**

Annex 15.

Paragraph 10.1.2.2., amend to read:

“10.1.2.2. The resealing pressure of a pressure relief valve before being subjected to a flow capacity test shall be not less than **50 per cent** of the initially observed start-to-discharge pressure.

Justification of the amendment

Annex 10.

Paragraph 2.6.1.

In this paragraph a text is added that information from the container manufacturer is needed.

Information concerning the behaviour of the total fire protection system and a description how the pressure in the container will be reduced to atmospheric in a controlled way.

In general the regulation describes that LPG should be vented through the PRV (spring valve or fusible plug) and leakage may not occur, but at the end of the bonfire test all containers shall leak via the seal (o-ring or gasket) of the liquid level indicator. The leakage of the seals is a normal behaviour which occurs after the cooling effect from boiling Liquid LPG has disappeared and the temperature increases at the container wall degrades the material of the seals. For a container with only a spring valve (PRV=PRD) this leakage is a part of the fire protection system and must take place to release the remaining gaseous LPG, after all the liquid LPG has been vented through the PRV. The manufacturer must describe this part also in the fire protection system. For composite containers the behaviour in a bonfire test is different. A composite container will normally not explode in a bonfire but LPG shall after a few minutes leak through the container wall. This behaviour can be seen as a controlled way of gas release when this is described in the complete fire protection system from the container manufacturer.

Paragraph 2.6.2.

- (a) The position of the container is specified in more detail to guarantee the right position of the PRD during the test (located in the gas phase) and make the test more reproducible.
- (b) For containers without a gastight housing shielding shall be used to prevent direct flame impingement on the fusible plug. This shielding may not hinder the outflow of LPG and should therefore not be in direct contact with the fusible plug.
With respect to the gastight housing no difference is made between metallic or synthetic housing, both types will prevent direct flame impingement during at least the first stage of the (bon)fire.
- (d) Since containers with a length of more than 1.65 meter might have PRDs on more than one location, it is necessary to define the position of the container compared to the fire source in order to make the test reproducible if necessary.

Paragraph 2.6.4.

- (d) The top (gas) side of the container is the most critical side with respect to a burst of the container. It is therefore of interest to measure the temperature on this side of container and not only for containers with a length of more than 1.65 meter.

In order to measure accurate temperatures and pressures it is necessary to use a short interval between measurement (≤ 2 seconds). This shorter interval is of importance since the maximum pressure is introduced as a parameter for the evaluation of the test result.

Paragraph 2.6.5.

- (d) Since the bonfire test has to be performed outdoors there are conditions that might influence the test result. For example rain will have a cooling effect on the top (gas) side of the container thus mitigating the conditions during the test.

Paragraph 2.6.6.

The text of paragraph 2.6.6. deals with the centre position of the container of the fire source is transmitted to paragraph 2.6.2 dealing with the container set-up. This is a better location.

The new Paragraph 2.6.6.

- (b) For the evaluation of the test result a maximum pressure is introduced. In accordance with the new draft regulation for liquid hydrogen (TRANS/WP.20/GRPE/2003/14) the maximum value is defined as 136 % of the set point of the PRV of 27 bar, resulting in a maximum pressure of 37 bar (rounded off upwards).
For a maximum pressure between 30 and 37 bar the container has to be inspected at the end of the test. In case visible plastic deformation of the container is observed, i.e. an increase of container diameter of 2%, the result of the test shall be invalidated.
- (c) The bonfire test should be performed under conditions that are not considered as ‘underestimating’. This means that if the test is influenced by a mitigating factor the test shall be invalidated. An example is the presence of the gastight housing. In case the manufacturer indicates that the gastight housing will be on the same position during the whole test but is blown away after the activation of the PRD, the resulting jet fire is directed away from the container not impinging on the container wall. This situation is less severe than the situation in which the jet fire is directed along the top side of the container by the presence of the gastight housing and should therefore invalidate the test result.
- (d) A release via the container wall of the composite container is not allowed in the current test regulation. In fact a release via the container wall is acceptable in case the release takes place in a controlled way. This means that the leakage will not start immediately after the ignition of the fire and will not vent too much LPG per unit of time. For steel containers the PRD is activated approximately 2 minutes after the start of the test. The amount of LPG that is vented per unit of time through the PRD is in order of 10 to 25 litres per minute. These parameters are used for the definition of a controlled release.
- (e) It should be possible to evaluate the bonfire test result based on the test report. Therefore this report should give the relevant information as defined in the proposed amendment.

Annex 15. Test procedures

Paragraph 10.1.2.2. (Start-to-discharge and resealing pressure of pressure relief valves –test No. 1.)

It is concluded that the definition of the minimum resealing pressure (90% of the start-to-discharge pressure) does not result in a desired behaviour during the bonfire test. Due to the high resealing pressure (compared to the opening pressure) the period in which the PRV is activated is short through which only a small amount of LPG is vented. A disadvantage of this behaviour is that during the main part of the test the pressure inside the container stays at an undesirable high pressure. Besides there is hardly any cooling effect (caused by evaporation of LPG) on the container wall. Therefore it is proposed to allow a lower resealing pressure.
