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PROPOSALS TO ALIGN TWO PARTS OF ADR/RID COVERING THE FITTING OF SAFETY VALVES TO PRESSURISED TANKS / TANKERS

Transmitted by the European Liquefied Petroleum Gas Association (AEGPL) */

1. Reasons for the proposal

The restructured text of ADR to be published in 2001 contains two different methods of providing valves to protect vessels from over-pressure and it is necessary to align these two requirements.

6.8.3.2.8 and 6.8.3.2.9 state:

"Safety valves shall meet the requirements of 6.8.3.2.9 to 6.8.3.2.12 below:

Tanks intended for the carriage of compressed or liquefied gases or gases dissolved under pressure, may be fitted with not more than two safety valves whose aggregate clear cross-sectional area of passage at the seating or seatings shall not be less than 20 cm^2 per 30 m^3 or part thereof of the shell's capacity. These valves shall be capable of opening automatically under a pressure

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*/ Circulated by the Central Office for International Carriage by Rail (OCTI) under the symbol OCTI/RID/GT/III/2001/13.

between 0.9 and 1.0 times the test pressure of the tank to which they are fitted. They shall be of such a type as to resist dynamic stresses, including liquid surge. The use of dead weight or counter weight valves is prohibited."

6.7.4.6.1 states for portable tanks:

> "Every shell shall be provided with not less than two independent spring-loaded pressure-relief devices. The pressure-relief devices shall open automatically at a pressure not less than the MAWP and be fully open at a pressure equal to 110% of the MAWP. These devices shall, after discharge, close at a pressure not lower than 10% below the pressure at which discharge starts and shall remain closed at all lower pressures. The pressure-relief devices shall be of the type that will resist dynamic forces including surge."

6.7.4.7 deals with the sizing of pressure-relief devices and 6.7.4.7.3 and 6.7.4.7.4 state:

> "Under the circumstances described in 6.7.4.7.1 and 6.7.4.7.2 together with complete fire engulfment, the combined capacity of all pressure-relief devices installed shall be sufficient to limit the pressure in the shell to the test pressure."

The required capacity of the relief devices shall be calculated in accordance with a well established technical code recognised by the competent authority. The footnote to this section suggests CGA S-1.2-1995 as an example of a suitable technical code.

2. JUSTIFICATION

Under the current ADR requirements for safety valves on gas tankers - no more than 2 valves are allowed and the cross-sectional area of valves to be fitted must be 20 cm^2 per 30m^3 capacity or part thereof, so a 40m^3 tank will require 40cm^2 of relief valve cross-sectional area.

All of the current standards in use for sizing relief valves, including EN12252 (Equipping of LPG Road Tankers) use the formula quoted in the UN Model Regulations which is derived from CGA S-1.2 – 1995.

This formula relates surface area of the tank to required volume flow rate to be achieved by the relief valves under the conditions in which they are required to relieve. The constants and variables to use in this formula are not adequately defined in the UN Model Regulations but reference to CGA S-1.2 - 1995 will enable the UN formula entry to be clarified. The constants and variables are defined and a sample calculation is attached to this document to enable experts to check the work.

The current ADR requirement does not clearly define the cross-sectional area of a safety valve. Is it the seat area less the valve spindle area? Is it the annular area between the poppet and seat when the valve has popped? Or is it even the area of the bore of the valve casting? Manufacturers of safety valves do not attempt to calculate this area but instead do trials on each new model to determine the flow rate under relieving conditions. Each model of relief valve thus has a flow rating under defined conditions.

The flow through a given relief valve is a function of the fluid and the pressure driving the flow through the valve. The ADR requirement ignores the pressure. In reality a tank designed for low pressures should require large relief valves to release sufficient gas, whilst a tank designed for high pressure will need smaller relief valves.

The rate of vaporisation of any liquefied gas in a tank is dependent on the surface area of the tank - something which the UN formula takes into account. The ADR requirement is based entirely on the volume of the tank. The ratio of surface area to volume varies significantly with the shape of the tank.

If the area of a safety valve is defined as the seat area less the spindle area; internal relief valves are not made of sufficient size to meet the ADR requirement to fit no more than 2 valves.

3. PROPOSALS

It is proposed to align both of these methods on that used in 6.7.4.6 and 6.7.4.7 by replacing 6.8.3.2.9.with the following text:

> "Tanks intended for the carriage of compressed or liquefied gases or gases dissolved under pressure, may be fitted with spring-loaded safety valves. These valves shall be capable of opening automatically under a pressure between 0.9 and 1.0 times the test pressure of the tank to which they are fitted. They shall be of such a type as to resist dynamic stresses, including liquid surge. The use of dead weight or counter weight valves is prohibited. The combined capacity of all safety valves installed shall be sufficient to limit the pressure in the shell to the test pressure. The required capacity of the safety valves shall be calculated in accordance with a well established technical code recognised by the competent authority. (e.g. CGA S-1.2-1995)."

Appendix 1

SAMPLE CALCULATION USING CGA S-1.2-1995 TO SIZE SAFETY VALVES FOR TYPICAL PROPANE TANKS

The calculation uses the formula quoted in the UN Model Regulations and obtains the various variables and constants from a number of sources. This formula is applied "in the accumulating condition" which means the condition under which the relief valve is discharging at its rated output, which is 20% above the "start to discharge" pressure. Relief valves are marked with a start to discharge pressure and a flow rate in cubic metres of air per second at standard conditions: 1 bar and 0°C. The test pressure requirement for propane in ADR is 23 bar and it is assumed that this means 23 bar g or 24 bar absolute.

The equation is as follows:

$$Q = 12.4 \frac{F A^{0.82}}{L C} \sqrt{\frac{Z T}{M}}$$

where:

Q is the minimum rate of discharge in cubic metres of air per second at standard conditions;

F=**1** for uninsulated shells;

A= total external surface area of shell in square metres;

Z= gas compressibility factor in the accumulating condition (24 bar pressure). From API RP 520 for a paraffinic hydrocarbon of molecular weight 44 this is **0.65;**

T= absolute temperature in Kelvin at the pressure-relief devices in the accumulating condition (24 bar pressure). It is assumed that the pressure is due to external heating which will raise the temperature to 60°C for commercial propane or **333K** to achieve this pressure. (from Shell International Petroleum Company Report No 186F - The Properties of Liquefied Petroleum Gases. [Ref 1]);

L= the latent heat of vaporisation of the liquid, in kJ/kg, in the accumulating condition. At 60°C the latent heat of vaporisation of commercial propane is 64 kcal/kg [ref. 1] or **268 kJ/kg;**

M= **44** for propane;

k= **1.13** for propane [ref 1] and hence by interpolation from the table in the Model Regulations;

C= **0.635;**

Inserting these values into the formula for Q gives, for propane:

$Q = 0.1616\ A^{0.82}$.

A small LPG tanker carrying 7.1 tonnes of propane, with a tank diameter of 2.45.metres and overall length of 4.165 metres with ellipsoidal ends would have a surface area of 38 m^2. This would require a relief valve capacity of 3.19 m^3 per second at standard conditions. At this stage the specifier would turn to the technical specifications from reputable relief valve manufacturers to select suitable valves rated at this capacity and the test pressure.
