POSITION PAPER

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LONG TERM DURABILITY OF STEEL GAS CYLINDERS

Introduction

AIGA members have received information that some countries are introducing limits on the service lifespan of steel cylinders. Other countries have raised the question if steel cylinders should have a limited lifespan. A further question has been raised regarding whether the lifespan of acetylene cylinders should have a specified limit.

Scope

This Position Paper will respond to the arguments for such lifespan restrictions. It describes the design principles and use of steel cylinders and also those of acetylene cylinders with their associated porous material formerly referred to as porous mass.

Purpose

To put forward an AIGA position that provides information regarding the design, in-service practices, maintenance and lifespan expectations of gas cylinders.

General principles

There are three phenomena to consider which have a direct effect on the ability of a gas cylinder to remain safely in service due to ageing through its service life:

- Corrosion;
- Creep; and
- Fatigue.

Steel cylinders for compressed and liquefied gases

- Steel cylinders are not subject to the phenomenon of creep rupture because this occurs only when materials are being used at stress levels at or near their yield stress and a service temperature at or near 30% of the material's melting point measured in degrees Kelvin. For steel this 30% temperature is approximately 493 K equivalent to 220 °C. Cylinders work at temperatures well below 220°C typically at ambient temperature that is less than 65°C.

- Rupture due to fatigue of gas cylinders is a concern that is covered through the choice of materials of construction, the equations determining minimum wall thickness for the cylinder and careful attention to the design of the transition sections of the cylinder. The transition sections are where the wall of the cylinder meets the thicker portions of the shoulder and the base. The design is proved during prototype tests which in gas cylinder design standards are chosen in such a way that under normal condition the cylinder will not fail in an unlimited lifespan of use. To achieve success prototype cylinders, have to fulfil 12.000 cycle tests from 10% up to 100% of the test pressure (1.5 times working pressure) and back without any leakage. Considering that most gas cylinders are re-filled less than 10 times per year this means that the gas cylinder could safely be refilled for in excess of 1200 years without suffering a rupture due to fatigue.

- Corrosion of steel is not related to the age of the cylinders and is under control, as explained below. External corrosion and other damage to gas cylinders can occur during operation. To detect and deal

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with such problems the gases industry has developed prefill checks carried out before each re-filling to ensure that no cylinder with external damage for example by corrosion, mechanical impact, fire, will be filled. Steel cylinders can also be subject to corrosion, when water / liquid enters inside cylinders. There are various techniques in use by gas companies to detect if internal corrosion may be present. The simplest is by turning the cylinder upside down and opening the valve to see if liquid is ejected. A more sophisticated method is to use of residual pressure valves (RPV) to prevent any liquid coming from the customer or atmosphere into the cylinder. Residual pressure valves are becoming increasingly popular and their effectiveness in preventing internal corrosion of gas cylinders over many years been demonstrated to the satisfaction of Competent Authorities.

- Gas cylinders are subject to periodic inspections and tests that are governed by regulations. See AIGA 090/14, *A Reference Guide for Requalification of Gas Cylinders*. These tests are very thorough, are fully described in standards, and subject to oversight from notified bodies. Experience with these retest procedures has shown that cylinders which successfully pass the tests are safe for a further period of use until the next test is due. Cylinders which are rejected at the periodic inspection and test have to be scrapped in such a manner that they cannot re-enter service. Analysis have proven that the rejection rate, for instant due to corrosion, does not relate to the age of the cylinder.

- Cylinders can be removed from service at any time based on specific parameters considered as important and relevant by the cylinder owner, but these reasons are not because of a risk of mechanical failure:
    - Cylinder is too heavy and inefficient;
    - Old fashioned shape and dimensions; and
    - Cylinder variant harmonisation process.

Acetylene cylinders

Acetylene cylinders contain the gas by means of it being dissolved in liquid solvents distributed into a sponge-like structure. This structure is known as the porous material (porous mass). It completely fills the inside of the gas cylinder.

There are two elements that need to be considered regarding the potential degradation of an acetylene gas cylinder.

- Cylinder shell; and
- Porous material

Cylinder shell

- The design aspects for steel cylinders are equally appropriate for cylinder shells used in acetylene service.

- Measures to reject cylinders for filling that have evidence of external damage are also the same.

- Because there is always an emission of gas from the solvent, even when notionally empty, acetylene cylinders are unlikely to suffer from water ingress. There is no trace of an oxidising atmosphere inside an acetylene cylinder so corrosive processes are not active.

Porous material

- The porous material can be damaged during operation and show cracks, discolouring or sunken. The periodic inspection and test procedure for acetylene cylinders is focussed on an external visual inspection but mainly on a visual check of what can be seen of the porous material from the top.

- If there is any problem with the external condition the cylinder will be scrapped.

- If the porous material is visually not acceptable, because of an unacceptable gap developing between the porous material and the inside of the cylinder shell or it is becoming cracked, friable or of an

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unacceptable colour, then two courses of action are possible:

- Re-massing is possible that is remove old, defect porous material and replace with new; or
- Scrap the complete cylinder, see AIGA 036/16, *Guidelines for the Management of Waste Acetylene Cylinders*

Conclusion

Gas cylinders are subjected to multiple tests and inspections during design, manufacturing, filling and regulatory periodic inspection.

The type of material of construction, design philosophies and the mandatory requirements specified in the standards, ensure safety of gas cylinders for an unlimited service lifespan.

In those cases, where cylinder design, manufacture, operation and inspection follow the required procedures cylinders can be expected to have an unlimited service lifespan.

Lifespan restriction can be justified in cases where the inspection procedures cannot be guaranteed or where a batch of cylinders are found to be defective or questionable or where there is no periodic requalification conducted on cylinders.

Gas cylinders for on-board storage of gases as a fuel for Automotive vehicles are designed for finite life service and shall not be used after predefined life time has been reached.

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