TECHNICAL BULLETIN

Prepared by WG-2 TB 18/23 – September 2023

Long Time Durability of Steel Gas Cylinders

Introduction

EIGA members have received information that some countries have introduced 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 Technical Bulletin responds to the arguments for such lifespan restrictions. It describes the design principles and use of steel cylinders and those of acetylene cylinders with their associated porous material formerly referred to as porous mass.

Purpose

EIGA 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 Kelvin. For steel this 30% temperature is approximately 493 K equivalent to 220 °C. Cylinders are used 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 cylinders 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 the prototype tests for which, gas cylinder design standards criteria are chosen in such a way that under normal service conditions the cylinder will not fail in an unlimited lifespan of use. To achieve the criteria, the cylinders, are subjected to successive pressure cycles between a lower cyclic pressure (generally less than 10% of the upper cyclic pressure with an absolute maximum of 30 bar) and an upper cyclic pressure, which is equal to the hydraulic test pressure. The design standard requires that the cylinders tested under these conditions withstand 12.000 pressure cycles without failure. Considering that the majority of gas cylinders are re-filled less than 10 times per year this means that the gas cylinder could safely be refilled in excess of 1200 years without suffering a rupture due to fatigue. This is in line with EIGA members experience.
- 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 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

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be re-filled. Such prefill checks are mandatory by regulations and have been established in International Standards, e.g. EN ISO 24431 *Gas cylinders — Seamless, welded and composite cylinders for compressed and liquefied gases (excluding acetylene) — Inspection at time of filling*. Steel cylinders can also be subject to internal corrosion, when water / liquid enters inside cylinders. There are various techniques in use by gas companies to detect if internal corrosion may be present. (see EIGA Doc 62 *Methods to avoid and detect internal corrosion of gas cylinders and tubes*). 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 residual pressure valves (RPV) to prevent any liquid coming from the customer or atmosphere into the cylinder. Residual pressure valves are recommended by the Good Manufacturing Practice for medical gases and become increasingly popular for other applications. Their effectiveness in preventing internal corrosion of gas cylinders over many years has been demonstrated to the satisfaction of Competent Authorities.

- Gas cylinders are subject to periodic inspections and tests that are governed by regulations and International Standards, e.g. EN ISO 18119 *Gas cylinders — Seamless steel and seamless aluminium-alloy gas cylinders and tubes — Periodic inspection and testing*. These tests are very thorough, and fully described in standards. The periodic inspections and tests are supervised by notified bodies. Experience with these procedures has shown that cylinders which successfully pass the tests are safe for a further period of use until the periodic inspection is due. Cylinders which are rejected at the periodic inspection and test have to be rendered unserviceable 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 (formerly called porous mass). The porous material 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 risk of corrosion because there is no corrosive atmosphere inside acetylene cylinders.

Porous material

- The porous material can be damaged during operation and show cracks, discolouring or sunken. The periodic inspection and tests 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 condition of the porous material is visually not acceptable, e.g. 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 unacceptable colour, then two courses of action are possible:

- Re-massing is technically possible to remove the old, defective porous material and replace with new; or
- Scrap the complete cylinder, see EIGA Doc 05 *Guidelines for the Management of Waste Acetylene Cylinders*

Conclusion

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

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

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.

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