Optimizing the technical verification process of cylinders

Cosmin Ilie*, *George Artur* Găman, *Daniel* Pupăzan, *Cristian* Nicolescu, and *Andrei* Gireadă

National Institute for Research and Development in Mine Safety and Protection to Explosion – INSEMEX Petroşani, 32-34 G-ral Vasile Milea Street, Postcode: 332047, Petroşani, Hunedoara County, Romania

Abstract. The decisive factor in the process of technical verification of cylinders is conditioned by correct choice of the inspection method, in order to attentively catch possible imperfections caused by the wear and tear resulting from long term use. Emphasis is placed on safety conditions of cylinders, which include mandatory minimum technical requirements for periodic inspection of liquefied or compressed gas cylinders. Cylinders are an assembly consisting of: under pressure receptacles with a volume of 0,5 to 150 litres, serving for transport and storage of liquefied or compressed gas; the associated casing, which may be: a filling and drainage device, a security device, a pressure relief device, a measuring device, a valve coupling element, a fastening element fitted on the container, a setting and protection element and a protection to heat device. The current paper presents the optimal method of inspection and verification of cylinders for compressed, liquefied or dissolved under pressure gases, represented by the use of the hydraulic sample stand in accordance with international principles and practices.

1 Introduction

Cylinders for compressed, liquefied or pressure-diluted gases will be subjected to technical inspections, according to SR EN 11623 [1]:

- after making a repairs to the container;
- periodically (at the due date indicated on the container);
- when a fault is found that may affect safety of functioning.

Periodic technical inspection of a compressed and liquefied gas cylinder consists of:

- inspection of the cylinder's general condition (internal and external inspection);
- capacity and mass inspection;
- hydraulic pressure test.

If the results of these technical inspections are appropriate, the economic operator who carried out the verification shall mark the month and year of the next periodical technical inspection, along with the stamp of the person responsible for supervising activities within the authorized economic operator [2].

* Corresponding author: cosmin.ilie@insemex.ro

The activity of technical verification of the cylinder for compressed gases, liquefied or dissolved under pressure is carried out exclusively by personnel trained and authorized in this direction, personnel who use specialized equipment for performing technical checks authorized by the State Inspection for the Control of Boilers, Containers. and Pressure Lifting Systems - ISCIR.

2 Examination and inspection of cylinders for compressed, liquefied or pressure-diluted gases using the hydraulic experiment stand

The hydraulic experiment stand (fig. 1) is used for the hydraulic testing of cylinders, the maximum test pressure being 450 bar. The installation can be used for hydraulic testing, for pressures of less than 450 bar, of any piece that can be coupled through a stand adapter (tap valves, pipes, crimped hoses, etc.) [3]. The working agent used for increasing the pressure in the piece subjected to hydraulic testing is softened water, without impurities [4].

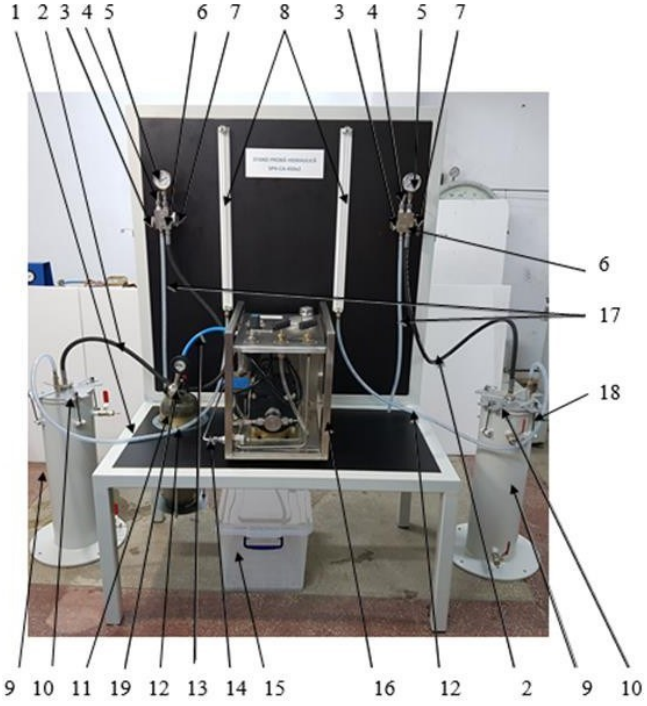

Fig. 1. Hydraulic experiment stand

The use of the hydraulic test stand leads to the development of the field of inspection and verification of the cylinder for compressed gas, liquefied or dissolved under pressure, by the hydraulic testing at high pressure as well as to the increase of the level of safety and health at work, through the use in the verification process technique of the cylinders the innovative high pressure technical verification method.

The hydraulic experiment stand consists of:

Hydraulic pump (pos.16) placed on the stand's body (pos.1) and connected via steel pipes to the distribution grid and by hose to the air source.

Distribution network with two testing posts, designed to distribute the pressurized

agent toward the exanimated assemblies (inspection posts) respectively toward the water tank, in case of purging. The distribution network consists of two hydraulic distributors (pos.6), a supply line (pos.14) and two distribution pipes (pos.4) connected by a T-connection, two hoses for connecting the cylinders (pos. 2), two purge hoses (pos.17). The hydraulic distributor has a dispensing body, two valves, one for intake (pos.7) the other for purging (pos.3), a 600 bar manometer (pos.5), connections for distribution and purging hoses and piping.

Stand body (pos.1) on which the main components of the stand are fitted.

Water jacket made of water container (pos. 9), cover (pos. 10) and cap fastening system with braces (pos.18).

- The water container (pos. 9) is equipped with 2 valves, a filling one, positioned on top and a drainage one, positioned at the bottom and a closing system (pos.18). The container bears the water required to measure volumetric expansion and provides protection in case of accidental spillage of the cylinder;
- The lid (pos. 10) is equipped with a M18x1.5 socket for fastening the cylinder to be checked, a G5/8 socket for connecting the connecting hose to the cylinder (pos.2), a quick coupler for connecting the burette hose, O ring for tight seal of the tank.

The burette (pos.8) is connected by means of a hose (pos.12) fitted with a quick coupler at the lid of the water container and is designed to measure the amount of water flowing from the container into the burette as a result of volumetric expansion of the cylinder under inspection.

The stand is equipped with two burettes, one for each workstation.

Medium-pressure air source consisting of:

- Air cylinder with max. pressure of 300 bar (pos.11), which supplies the air necessary for pump operation. The cylinder is equipped with a M18x1.5 socket for connection to the cylinder and a G5/8 socket for connection to the expansion valve.
- Medium expansion valve (pos.19) equipped with:
  - High pressure gauge indicating the pressure in the air cylinder;
  - Overpressure and purge device;
  - A whistle for warning that the cylinder pressure drops below 50 bar;
  - Medium pressure hose (item 13);

Purging tank (pos.15) where water is collected from the plant, during purging.

The stand can be used for hydraulic testing for: cylinders (including those made of composite), tap valves, pipes and hoses with crimped connections. With the help of this stand the deformation occurring at the time of the test as well as the residual deformation can be established.

The air-driven liquid pump is equipped with an air control unit combined with a water separator, pressure regulator valve, pressure gauge and manual valve.

Pneumatically-operated hydraulic pump (pos. 16) is a device that uses compressed air as a power source to create force. This force acts on a hydraulic pump that creates the high test pressure of the test liquid in the device.

Thus, the hydraulic output pressure is controlled by adjusting the pneumatic inlet pressure, the ratio of outlet pressure to inlet air pressure is 175: 1. When the air pressure and the pressurized water pressure reach equilibrium, the liquid pump will stop the pressure and the outlet pressure will be stable at the pre-set pressure.

The working method is as follows:

Check the technical parameters of cylinders by performing tests and measurements in accordance with ISCIR Technical Requirements C5 [5].

The checks are to establish whether the container falls within limits set by in force laws, as prescribed by ISCIR PT C5.

Cylinders are brought to the checking room, where an external inspection is performed.

This external inspection consists of inspecting the outer surface of the cylinder and checking for markings. This inspection is intended to identify nonconformities that do not allow the cylinder to be used safely.

The cylinder can be admitted to external maintenance only if the following conditions are met:

a. the protective paint coating is not damaged, the paint must not impede visualization of inscriptions, the outer surface of the container, the cylinders must be dyed in the marking colours indicated in specific standards;

b. The valve tap is in a very good state of operation, ensuring sealing regardless of container position; it is recommended that after every inspection of the cylinder container's interior the valve to be replaced with a new one. Screwing the tap into the cylinder body shall be performed at the torque prescribed by manufacturer using a torque wrench with the appropriate working range.

c. The permanent inscriptions must appear on each cylinder:

For mass and capacity measurements, cylinders must be cleaned inside and outside to completely remove impurities. Mass of the container shall be established by weighing with an accuracy of ± 0,1 kg. The cylinder is filled with water, the internal volume of the cylinder in litres being established by the difference between the mass of the cylinder filled with water and the mass of the empty cylinder. Capacity shall be established with an accuracy of ± 0,1 litres.

2.1 Test of resistance to pressure (fig. 2)

Thread a valve into the container and subject it to the hydraulic pressure, at a pressure of 1.5% of the filling pressure.

The cylinders to be inspected are placed in the protective tanks. Cylinders are connected to the tank by means of a threaded flange. The tank shall contain water to indicate the deformation occurring at the time of the test as well as the residual deformation on graded tubes.

Prior to operating the hydraulic pump, the water in the tank shall be filled, to have sufficient reserve to prevent it from running low and to ensure the measuring limit of the pneumatically operated pump level gauge.

The caps are tightened (10) by clamps (18). Dispenser's purge valves (3) are closed.

Dispenser's intake valves (7) are opened. The air source is opened (11).

Pump is operated:

- the ball valve controlling the driving air is opened;
- air pressure is monitored on the appropriate manometer;
- the valve tap that controls the opening and closing of the high pressure is opened.

Loading pressure is followed on the pressure gauges (5). When the 450 bar is reached, the pump must stop automatically.

If the pump does not stop, the pump load tap closes fast, to avoid increased network pressure and consequently the risk of accidents.

Cylinder pressure is kept as specified in the standards for the type of cylinder inspected.

After testing, dispenser's intake valves (7) are closed and their purge valves (3) are opened; the pressure drops to full pressure discharge from the cylinder.

The pump discharge valve must remain closed, it discharges the entire system and not each individual cylinder.

The lids of the water jacket caps are opened and the caps on the cylinders are removed.

The cylinders are unloaded. Integrity of the tested cylinders is checked and a new inspection can be initiated.

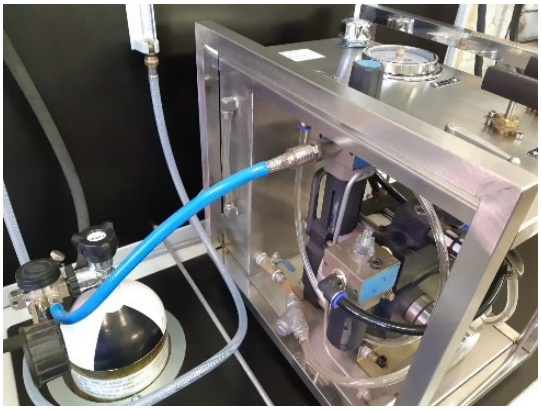

Fig. 2. Test of resistance to pressure

In the case of single cylinder testing, only the taps (purge and intake) of the workstation distributor to be tested are operated. The other workstation is insulated by keeping the purge and intake valves closed. Examination of the test container shall be carried out only after the sample fluid pressure has been reduced to atmospheric pressure.

2.2 Volumetric expansion test (fig. 3)

The principle of volumetric expansion inspection method consists in measuring the total volumetric expansion and any permanent expansion of the cylinder by measuring the amount of water displaced by the expansion of the pressure cylinder and the amount of displaced water after the pressure has been discharged. Volumetric expansion test with water jacket test requires the water bottle to be closed in a water-tight sheathing. This method measures the volume of water displaced during the test. To carry out the hydraulic test, the containers will be cleaned inside and completely filled with water. The water used as a working agent must be softened, free from impurities or other substances that may attack the cylinder container wall. The caps (10) are fitted by hand on the cylinders filled with water. The cylinders, with the caps attached, are placed in the water jackets (9) which are filled with water by opening the filling valve (located at the top of the water jacket). After filling, the filling taps are closed. The caps are tightened (10) by clamps (18). The caps must be tightly closed.

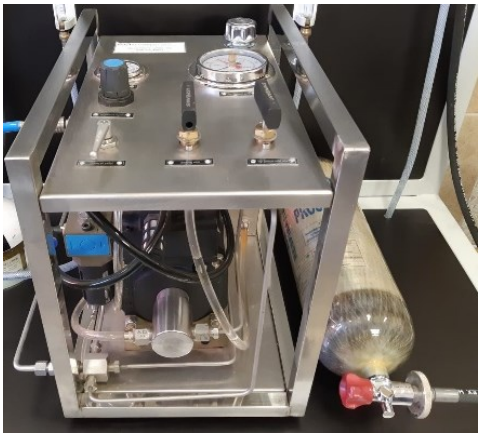

Fig. 3. Volumetric expansion test

The burette (8) is coupled to the male half-cap on the lid. The burette is adjusted to zero by handling the filling and drain taps of water jackets.

All the air from the hose connecting the burette and the water jacket must be removed. Dispenser's purge valves (3) are closed.

Dispenser's intake valves (7) are opened. Pump is operated:

- the ball valve controlling the driving air is opened;
- air pressure is monitored on the appropriate manometer;
- the valve tap that controls the opening and closing of the high pressure is opened.

Loading pressure is followed on the pressure gauges (5). When the 450 bar is reached, the pump must stop.

Water level in the burette is read (total expansion, Et). Cylinder pressure is kept as specified in the standards for the type of cylinder inspected. If the pressure drops, it means the circuit is not sealed.

After testing, dispenser's intake valves (7) are closed and their purge valves (3) are opened; the pressure drops to full pressure discharge from the cylinder.

Water level in the burette is read again (permanent expansion, Et).

The lids of the water jacket caps are opened and the caps on the cylinders are removed.

Permissible permanent expansion is calculated by the formula:

$$Epa = (Et / Ep) \times 100\% \quad (1)$$

Cylinders will be kept at test pressure for 2 minutes. After this period of time runs out, each cylinder shall be inspected. Testing is considered to be successful if no laceration or leakage are found, or if there no deformations after testing. After the test, pressure in the cylinder will gradually decrease without shocks. Cylinders that have leaked or are deformed will be scrapped.

The water cylinder is emptied and placed on a shelf, head down, for drying. After drying, inside inspection is performed by means of an endoscope to monitor any possible deficiencies, deteriorations or the occurrence of corrosion.

If rust is found on large surfaces or on a small surface in depth, the cylinder is invalidated.

If, after all these operations, the cylinder complies with ISCIR PT C-5/2003 requirements, the cylinder shall be marked with the check date.

Bottles are painted in colours prescribed in requirements according to the type of gas.

Oxygen cylinders should only be tested for tightness by using oxygen and for other types of gas compressed air will be used.

The cylinder tightness test will last for at least 3 minutes, the cylinder being immersed in a water recipient. If there is no air loss, the cylinder is considered to be proper.

The statement of compliance for periodical technical inspection in accordance with ISCIR PT C-5 requirements is issued.

3 Conclusions

Cylinders are any transportable receptacle in which a pressure greater than 0,5 bar may be produced or developed in a fluid (compressed, liquefied or dissolved under pressure).

According to SR EN 11623, pressed, liquefied or dissolved under pressure gas cylinders will be subjected to technical inspections:

- after making a repairs to the container;
- periodically (at the due date indicated on the container);
- when a fault is found that may affect safety of functioning.

Periodic technical inspection of a compressed and liquefied gas cylinder consists of:

- inspection of the cylinder's general condition (internal and external

inspection);

- capacity and mass inspection;
- hydraulic pressure test.

The hydraulic experiment stand is used for the hydraulic testing of cylinders, the maximum test pressure being 450 bar. The installation can be used for hydraulic testing, for pressures of less than 450 bar, of any piece that can be coupled through a stand adapter (tap valves, pipes, crimped hoses, etc.).

The decisive factor in the process of technical verification of cylinders is conditioned by correct choice of the inspection method, in order to attentively catch possible imperfections caused by the wear and tear resulting from long term use.

Emphasis is placed on safety conditions of cylinders, which include mandatory minimum technical requirements for periodic inspection of liquefied or compressed gas cylinders.

The activity of technical verification of the cylinder for compressed gases, liquefied or dissolved under pressure is carried out exclusively by personnel trained and authorized in this direction, personnel who use specialized equipment for performing technical checks authorized by the State Inspection for the Control of Boilers, Containers. and Pressure Lifting Systems - ISCIR.

The use of the hydraulic test stand leads to the development of the field of inspection and verification of the cylinder for compressed gas, liquefied or dissolved under pressure, by the hydraulic testing at high pressure as well as to the increase of the level of safety and health at work, through the use in the verification process technique of the cylinders the innovative high pressure technical verification method.

The use of the high pressure hydraulic test stand leads to a quick and efficient technical verification of the cylinders, including those of the composite material, which are used in respiratory protection devices.

References

1. C. Ilie, G.A. Gaman, D. Pupazan, A. Calamar, S. Simion, A. Irimia, Research on technical inspection of cylinders filled with compressed gases, liquefied or dissolved under pressure using ultrasonic technology, Geoconference on nano, bio and green - technologies for a sustainable future, VOL I Book Series: International Multidisciplinary Scientific GeoConference-SGEM (2014)
2. Technical Prescription PT C4, Stable metal pressure vessels – ISCIR (2010)
3. PN 18170202, Researches on improving health and safety in hazardous environments with explosive, flammable and toxic atmospheres (2018)
4. C. Dura, A.P. Păun, R.I. Moraru, Empirical Analysis on the Relationship between Corporate Health and Safety Performance and the Financial Outcome within Socially Responsible Companies, Quality – Acces to Success Journal, Vol. 19 (162) (2018)
5. Technical Prescription PT C5, Technical requirements for the use of pressurized, liquefied or pressured gas cylinders – ISCIR (2003)