Acetylene cylinder filling

New hose technology improves safety

By David Birch

Acetylene is one of the most dangerous flammable gases. Because of its molecular triple carbon bond it inherently has a great deal of stored energy able to be released either in a controlled process, such as welding and cutting, or in an uncontrolled fashion during decomposition. It will burn in air with a very wide flammable range of between 2.3% and 82%, according to EIGA document 123. Significantly it can decompose in the absence of air so rapidly that it has been categorized in the past as a gaseous explosive and hence the upper limit of 82% is almost academic for practical purposes.

Use of certain metals with acetylene is forbidden e.g. copper and silver, as metallic acetylide compounds can be formed that are unstable and explosive.

Cylinder filling

Filling acetylene cylinders is a relatively complex process compared to filling normal atmospheric gases such as nitrogen, oxygen, and argon. Because of its unstable nature acetylene is not allowed by law to be filled under simple gas pressurization into cylinders. This is because, beyond approximately 9 psig (0.62 bar), a decomposition in the gas would accelerate so quickly that a cylinder would be unable to withstand the resulting pressure rise and detonation. Acetylene is readily dissolved into certain solvents.

Normally acetone is used but occasionally dimethyl formamide (DMF) may be employed, particularly for bundle applications or in hot climates because of its reduced volatility. The solvent is contained within a gas cylinder by being soaked into a sponge-like material called the porous material or “mass”. This material has a microcellular structure such that there are no large pockets where free gas could accumulate.

Prior to the filling process, careful weighing of returning cylinders accompanied by measuring their temperature and pressure is required. Calculations are then made to determine the amount of solvent and the amount of acetylene to be added to allow a safe charge to be achieved.

Cylinders used for acetylene must undergo regular inspection to ensure that the cylinder shell is fit for purpose and that the porous material is showing no visible signs of degradation.

Influence of the filling hose

Because of the accuracy of weighing necessary prior to the filling process beginning, it is essential that an acetylene filling hose should not be too stiff, such that it affects the weighing process. The hose must be able to attach readily to a variety of cylinder sizes presented for filling, and these may well have height differences that could lead to weighing inaccuracies or leaking, if the hose is inflexible.

Hose standards and construction

Acetylene hoses have to pass an onerous acetylene decomposition test detailed in ISO 14113:2013 Annex A. This is a “normative” test. Pressures during the test can be expected to rise to more than 900 bar. The ISO standard therefore demands that acetylene hoses shall have a burst pressure in excess of 1,000 bar (14,500 psig) even though in service acetylene filling systems normally operate at pressures only up to 25 bar (363 psig). Such demands for strength can result in a very stiff hose if conventional historical hose construction “rules” are followed.

These “rules,” based around traditional hydraulic hose practice, are intended to ensure hoses have a burst pressure of 4 times design pressure. The design pressure for acetylene filling systems constructed to meet EIGA recommendations is 300 bar, therefore such conventionally constructed hoses have a burst pressure in excess of 1,200 bar. However, hoses with burst pressures even higher than this have in the past failed the ISO detonation test because of the extremely rapid rate of pressurization inherent in the test.

Some years ago it was discovered that a spiral wire running inside the hose will reduce the end-pressure during the decomposition test from its peak of 909 bar. It does this by preventing a uniform shock wave developing between the decomposed gas created by the test and the un-decomposed gas ahead of the flame front. Therefore, there is a mixing of the reacted and unreacted gases at the flame-front instead of a very rapid pneumatic pressurization of the unreacted gas to a point where it would detonate under the influence of pressure and temperature.

Use of the spiral wire means that hoses can be designed to pass the acetylene decomposition test without having extraordinarily high burst pressures and therefore remain more flexible.

If an incident occurs

During filling of acetylene cylinders, problems may arise that could result in a decomposition reaction beginning inside the cylinder. One such problem may be a "mass" that has become damaged, perhaps with a void or a crack. Another problem may be a cylinder valve that initiates a decomposition of the acetylene when being opened or closed due to friction, or material failure.

In all instances it is very important indeed to isolate, or "box up," the cylinder as soon as possible, if at all feasible. Once the cylinder is isolated so that acetylene cannot enter or leave it, the mass and solvent will react to form a thick layer of carbon surrounding the decomposition site within the cylinder and prevent more acetylene joining in the reaction. The cylinder will become locally hot but, given time and cooling water, the decomposition will peter out and the cylinder will return to a state where it can be safely moved.

If the cylinder cannot be boxed up, the outrush flow of acetylene from the cylinder through the cylinder valve may prevent the build-up of the carbon layer in the mass and fresh acetylene will keep on feeding the decomposition. Should this happen, the inherent quenching effect of the mass is negated and the decomposition may accelerate until the reaction becomes a detonation and the cylinder explodes.

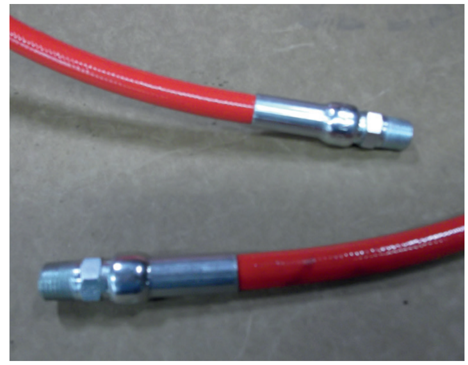
New patented hose system

LifeGuard Technologies has introduced its new LifeGuard™ Safety Hose technology designed to eliminate the consequences of the hazardous effect of a drive-away, coupling separation, hose rupture or failure during fluid or gaseous transfer operations.

In my review of this technology, I found using acetylene filling hoses equipped with the LifeGuard patented system should lead to an increase in process safety. This would be due to five factors:

1. LifeGuard hoses have an internal wire as part of the patented safety plug- off system and this, along with a spiral wire inside the hose, would promote mixing and reduce end pressure under acetylene decomposition.
2. Through the reduced end pressure, the hose (while meeting the ISO test requirements) can be made as flexible as possible to: aid ease of leak-tight connection; and, enhance the accuracy of the pre-fill checks and calculation, both of which are primary safety factors in avoiding dangerous filling conditions being created.
3. The LifeGuard plug-off device would automatically self-deploy and box up an acetylene cylinder if the back pressure in the cylinder began to rise rapidly under the influence of decomposition. This would be independent of, and without risk to, any operator. So operator intervention is unnecessary.
4. If a major incident were to occur that resulted in breaching of multiple hoses through impact, tow-away or fire, each LifeGuard hose device can be expected to self-deploy and plug-off, thereby preventing other cylinders contributing their lading (or indeed additional decompositions and detonations) to the incident.
5. LifeGuard acetylene hose metallic parts are all of stainless steel so there is no risk of the formation of explosive copper acetylide being created due to a zinc reduction in the surface of brass alloys (used by some manufacturers) that can take place through water attack. Water is an inherent part of many acetylene production process plants that use the calcium carbide route and the gas is rarely totally dry. Indeed, some major gas companies insist on a small water content to reduce the decomposition risk.

Commenting on its use of this technology, Rob Moyer of Rexarc says, "While standard industrial hoses in combination with flame arresting devices have proven safe through thousands of man-years of service life, our findings through plant auditing services show an average of 47 cylinder leads either kinked or damaged but in service within a filling operation. The LifeGuard Technologies hose is an innovative product that not only has a superior life cycle, but also has the flow stop feature which adds an additional safety factor should a damaged lead be unintentionally kept in service and fail. This feature will also help protect the entire system should an incident occur beyond an individual cylinder."



LifeGuard™ Safety Hose technology is designed to eliminate the consequences of the hazardous incidents during fluid or gaseous transfer operations.

"During filling of acetylene cylinders, problems may arise that could result in a decompostion reaction beginning inside the cylinder"

Conclusion

LifeGuard hose technology offers gas industry professionals an opportunity to improve process safety in the filling, transportation and customer use of acetylene gas. Being a self-deploying device, single incidents can be snuffed out at the earliest opportunity, escalation towards a major incident is reduced as adjacent cylinders in a fire situation would be boxed up if their hoses ruptured, and operators are not tempted to put themselves at risk to mitigate damage.

ABOUT THE AUTHOR

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