Contaminated Air in Cylinders
By
Ronny J. Coleman

Introduction

How many people today know what the term "black damp" means? I learned the term at a very young age that black damp could be deadly when you were cleaning out water wells. We were living in a relatively rural area. Many of the homes had their water supply coming from hand-dug wells. Most of these wells were about 4 – 6 feet in diameter and were either lined with stone or wood. One of the issues with having a well of that nature was that frequently roots would grow into the area and cut off the water supply.

Somebody like me was often hired to climb down a ladder into that well and cut off the root tentacles to try to restore the water flow. One of the things we learned at the very outset however was not to go below the grade to operate in spaces such as that without first checking the quality of the air. The reason was a phenomenon called black damp. Black damp describes a toxic environment that is created by a chemical reaction to things that are growing in the well.

We tested for it by dropping a lighted object from the top of the well to see if it went to the bottom and remained burning. If the burning object was snuffed out half way down, there was a possibility of a toxic atmosphere.

Stored Air

The reason for examining this phenomenon is a series of recent conversations regarding whether or not we have "stale air" in our self-contained breathing apparatus systems. The contention is that the air, if not being recycled on a frequent basis, can become contaminated. This same argument has been extended to declare that air can be contaminated in a high-pressure storage system that can result in harm to a firefighter. This has resulted in a certain amount of consternation and debate. Unfortunately, the argument seems to lack a lot of factual information. The inside of an air cylinder and the contents of a high pressure storage system are not like the bottom of a confined space. Black damp does not occur in that environment.

The air on the inside of a high-pressure cylinder is kept there under very high pressures. The only way that you can force air into that cylinder is to have a device that has more pressure than the cylinder pushing air in. If you open the valve the air will escape. The same relationship exists for a stored air pressure system that can either be on a vehicle or permanently built into a building.

It begs the question: is it possible that air can go stale on the inside of a cylinder or within a high pressure system over time? Is it very easy to introduce a contaminant into a system that has a stored pressure in the 3,000 to 4,000 pressure range?

Air Cylinders

Air cylinders are utilized in a dynamic set of circumstances. Just walk out in the apparatus room and look at the cylinders on your fire truck. You periodically are using those cylinders for training or in a fire suppression operation. This means that these cylinders are periodically emptied and refilled. Notably, if a cylinder is refilled for any purposes it has to be brought back up to pressure. In daily operations you do not purge the bottle to get rid of "bad air" because there is none. Instead what you do is cram more air back into the bottle so it gets back up to pressure and then you put the bottle back in service.

It is also true that periodically air cylinders must be hydrostatically tested. This involves completely eliminating all the air in the bottle and then attaching it to a mechanism that places the bottle under high pressure using water. Here is the protocol that is currently a best management practice as recognized by the NFPA:

1. All air pressure is released from the cylinder
2. The valve is removed from the cylinder
3. An internal visual inspection is performed
4. The cylinder is placed in a containment pit filled with water
5. The cylinder is filled with water and pressurized to 9000 psi
6. Measurements are taken to determine the amount of expansion and contraction
7. The cylinder is drained of water, then filled with 180 degree water then again drained and dried
8. The valve is re-installed
9. The cylinder receives a current date stamp which is highlight with spray paint

Breathability?

The basic question that has to be asked and answered is this: if air is put into an air cylinder, how long does it remain good enough to breathe? In searching out all sorts of documentation on the topic, I have yet to find any source that says that the air in cylinders goes bad over certain periods. It is not like the air is mixing with a contaminant exuding from the bottle. If this were true, then it would be virtually impossible to store air cylinders on apparatus such as reserves that may or may not see any action immediately or to place air cylinders in storage such as fire caches and expect them to be readily available. The same thing would apply to self-contained breathing air trailers and their onboard compressors.

The following is a definition regarding air composition that applies to what we are attempting to achieve in providing stored air for fire and emergency services personnel.

Air Composition

Clean, natural air is an odorless, colorless gas mixture. Excluding water vapor (H20) levels, which vary greatly, three major elements make up about 99.97% of dry air; nitrogen (N2) at 78.09%, oxygen (O2) at 20.95% and argon (Ar) at 0.93%. An important minor component of natural air is carbon dioxide (CO2) at 0.03% (300 ppm). Trace gases in clean, natural air include: methane (CH4) at 0.0002% (2 ppm) and less than 0.0001% (1 ppm) of hydrogen (H2), nitrous oxide (N2)) ozone (03) and some noble gases. Synthetic air is also used in SCBA applications. This type of air is produced by blending N2 and 02 gas in the proper proportions.[1]

Contaminated Air

Are there concerns about contamination getting into our air supply? Of course there are, that is one of the reasons why the make-up air coming into compressors must be properly evaluated and input mechanisms prevented from being placed in conditions where they could acquire products of combustion from diesel engines, discharges from other industrial processes or for that matter even dust in the air.

Liberty Mutual Group states that "the importance of clean breathing air to sustaining life and maintaining good health is well known. The dangers associated with breathing contaminated air are also well known and especially critical when using SCBA cylinders in emergency situations. The standard practices to assure SCBA air quality is to comply with NFPA 1404 (Sec 7-1.1) which requires a minimum CGA G-7.1 Grade D air quality and at least a three air sampling schedule and test record maintenance program. Many fire departments have opted to use CGA G-7.1 Grade E."[2]

Appropriate filters are utilized to assure that these types of contaminants are removed from the atmosphere before the air is pressurized on the inside of the bottle. This same set of ground rules applies to the compressor, if it is a mobile device, or a firefighter air replenishment system that is placed in as a mitigation measure to support firefighter operations.

Compared to the atmosphere on the outside of the bottle, this air is benign and certainly not toxic. You must remember that the reason firefighters wear breathing apparatus in the first place is to protect themselves from toxic atmospheres. The concept of IDLH has become much more visible in fire ground tactics and strategy and we are relying more on stored air pressure today than ever in the history of the modern fire service.

Firefighters who subscribe to the rules of air management (ROAM) know that breathing apparatus should be worn more frequently and for lengthier periods of time than we did so in the past.

[1] http://www.libertymutualgroup.com
[2] Ibid

Can you Test the Quality of Air?

Of course you can. There is instrumentation that is readily available that allows the air to be reviewed for all the various chemicals that could remain in suspension in a stored air pressure system. A good example is the protocol that addresses air quality from fire department breathing apparatus facilities and firefighter air replenishment systems. Air storage systems can be evaluated on a periodic basis by taking a sample of the air that comes out of the compression and into a cylinder and then sending it to a laboratory for analysis.[3]

Summary

Fire departments should not have to worry about that air that is contained in their breathing apparatus. Most fire departments have a requirement for testing of their system that is consistent with NFPA Standards. There is a standard for compressors that contains a requirement that the systems be tested periodically and that information be kept in the event there is such a thing as a breathing apparatus accident.[4]

In reviewing this contention, I am reminded of a a title of a play by Shakespeare - "Much Ado About Nothing!" Firefighters are much more likely to become injured as a result of not having adequate air and operating in IDLH atmospheres than being exposed to some hypothetical incursion of self-contained breathing apparatus cylinders and/or the compressor or stored air supply systems.

In researching the validity of this contention, the following entities were contacted to determine if they had any experience with a fire department finding contaminated air in their cylinders or in their storage supply of air. The answers were all negative. An internet search of the term "breathing apparatus" and "contaminated air" revealed a similar finding.

Ace Fire Equipment, 1870 W. Bayshore Road, East Palo Alto, CA 94303, 650-321-7440

River City Fire Equipment Co, 2419 Sellers Way, West Sacramento, CA 95691, 916-374-8295

ABC Fire and Cylinder Service, 1025 Telegraph Street, Reno, NV 89502, 775-856-1553

Thunderbird Cylinder Inc., 4209 E. University Drive, Phoenix, AZ 85034, 602-437-4600

[3] http://airtesting.com/compressed-air-testing/fire-service/

[4] *NFPA 1981: Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services* establishes the minimum respiratory protection and functional requirements for SCBA used by emergency services personnel.

CAN/CSA-Z94.4-02 (R2008), the Canadian Standard on the Selection, Use and Care of Respirators requires that the air in the cylinder be changed every 12 months which is a change from the previous requirement of 90 days.