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Instructional Support

SAFETY ALERT

12/2007 – Winter

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Beginning in spring 2006 I began circulating safety information from the U.S. FDA and NIOSH regarding 12 recent oxygen fueled fires and the possible source of ignition. I received several calls from concerned ski and hiking operations and made a small supply of the recommended viton o-rings available to students on the Wilderness Emergency Care (WEC) courses and Parks Emergency Responder (PER) courses that I ran over the past 2 years. Some people I spoke to seemed to show limited concern and decided not to take any remedial action. Recent events require us to revisit this issue.

This safety alert is being rebroadcast due to two more incidents in 2007 and has been broadened to include a problem with *aluminum* oxygen regulators that caused an additional 16 fires in a five year period ending in 1999. FDA and NIOSH (U.S.) issued a separate notice regarding the regulator problem in February 1999. Worldwide many more similar instances of oxygen related fires can be found.

In a January 2000 paper published by ASTM entitled *Failure Analysis of Aluminum-Bodied Medical Regulators* the authors report the following:

Many of the incidents have occurred during emergency medical use or during routine equipment checkouts. Ignition with catastrophic burnout of the regulator

has been observed in each of these cases. The active ignition mechanisms are felt to have included particle impact in some cases, contaminant promoted ignition in other cases, and adiabatic compression in at least one other. Several of the fires are believed to have been caused by particulate debris entrained in the oxygen flow stream from aluminum high-pressure cylinders.

These notices should make us all reconsider our practices regarding the relatively safe use of medical oxygen in operations such as backcountry lodges, cat skiing, heli-hiking, heli-skiing, search & rescue and EMS operations in general.

What prompted this latest Safety Alert? In December 2007 I became aware of two more very recent medical oxygen related fires, one in the US and one in a ski operation in western Canada where a fire spontaneously ignited at the regulator / cylinder interface during a routine check of the cylinder pressure.

This latter incident in particular should make us all sit up and take notice as it is in our back yard and could have just as easily involved us personally. Fortunately, this incident did not result in serious injury or death but serves as a further warning of the precautions required when handling medical oxygen.



In searching for additional data on this problem I also became aware of a 1997 medical oxygen related fire in a Bell 206-L3 helicopter on the ground in Australia. Although the cause of this particular fire differs dramatically from the issues discussed in this alert, the picture of the totally obliterated, charred hulk was most sobering. I have used this photo for shock value and to try to get rid of the complacency I have encountered with the reluctance to spend \$25 to safeguard against a fire in a multi-million dollar aircraft.

An oxygen fueled fire in a small or medium helicopter would be devastating as illustrated and may be impossible to extinguish in flight due to the oxygen enriched atmosphere that would likely be present.

The 2006 FDA / NIOSH warning pertained to the use of plastic or nylon® washers and recommended against ever re-using such washers. "FDA and NIOSH believe that improper use of gaskets/washers in regulators was a major factor in both the ignition and severity of the fires, although there are likely other contributing factors."

Any time a regulator is removed and replaced on an oxygen cylinder this constitutes re-use. For example, placing a regular on a cylinder to check the pressure then subsequently removing the regulator actually causes the plastic washer, also known as a crush gasket, to be compressed. This compression requires that further additional pressure be used on subsequent use and increases the risk of a leak at the seal.

"According to a forensic analysis supported by FDA and NIOSH, "flow friction" caused by this leakage of compressed oxygen across the surface of the crush gasket may produce enough thermal energy to spontaneously ignite the nylon gasket material."

A representative of one firm to whom I spoke also suggested that leaving a regulator in place on a cylinder and constantly moving the cylinder in and out of a vehicle or constantly tightening and loosening the regulator over a period of time may similarly cause compression of a plastic crush gasket, thus enhancing the probability of a leak.

Constantly moving an oxygen unit in and out of snowcats and helicopters is a common daily practice across the ski industry in winter. In such instances we should likely move away from using plastic gaskets entirely and move toward using only reusable washers: "The type required by many regulator manufacturers is a metal-bound elastomeric **sealing washer** that is designed for multiple use applications."

Some Facts About High Pressure & Oxygen

Oxygen cylinders should not be exposed to temperatures above 50 degrees C. Over-heating may cause the burst disk to rupture or in extreme situations for the tank to rupture if the burst disk did not fail as it designed to. Any tank that has been exposed to excessive heat should be retired or sent in for testing before use.

Even a small increase in the percentage of oxygen in the environment increases the rate of combustion dramatically. Whenever in a closed space be sure to ensure proper ventilation.

When oxygen cylinders are emptied then refilled they expand and contract. With metals this may lead to fatigue and a weakening of the cylinder wall. Cylinders should be stored full, not empty, and are supposed to be sent in for a hydrostatic test every five years. This test ensures that the metal has not fatigued. The tank is also inspected for cracks and corrosion which can occur even in cylinders that are rarely used.

Regulators made entirely of aluminum have been found to have contributed to oxygen fueled fires. Be sure your regulator has not been subject to a recall if it appears to be aluminum. Some regulators have external aluminum components but the portion of the regulator that comes into contact with the oxygen is brass.

Although oxygen cylinders are not exceptionally fragile, portable oxygen cylinders should be treated with care as they are pressurized to 2000 PSI and dropping a cylinder onto a hard surface increases the risk of explosion and fire.

Many materials exposed to high pressure 100 percent oxygen may combust spontaneously.

Never use anything with oxygen that was not specifically designed for oxygen.

Foreign particles in a regulator have also been found to have caused fires as has rapidly opening a regulator which may have had some degree of particulate contamination.

I would suggest that all operations using medical oxygen should reevaluate their current practices and integrate some or all of the following additional information into their periodic maintenance and operational practices to avoid tank ruptures, fires and explosions when using oxygen cylinders and regulators:

1. Be sure you inspect your cylinders periodically to be sure the cylinder has not been used, the hydrostatic test date is current and the cylinder does not show evidence of physical damage.
2. Be sure oxygen is only used in a well-ventilated environment.
3. FDA and NIOSH recommend that plastic crush gaskets *never be reused*, as they may require additional torque to obtain the necessary seal with each subsequent use. This can deform the gasket, increasing the likelihood that oxygen will leak around the seal and ignite.
4. Before placing a regulator on a cylinder, inspect the regulator and seal plus cylinder and valve stem before assembly. Be sure there is only one clean, undamaged, reusable metal-bound elastomeric sealing washer or a *new* (non-reusable) crush-type gasket that is in *excellent* condition.
5. Before attaching a regulator, crack the cylinder valve (partially open the valve to allow gas to escape for a very short time)

in order to expel foreign matter from the outlet port of the valve.

6. After attaching the regulator, tighten the handle only hand tight. Do not use wrenches or other hand tools that may over-torque the handle.
7. Open the post valve slowly. If gas escapes between the regulator and valve or at the gasket or washer, quickly close the valve. Remove the regulator and ensure it was properly attached, the gasket was properly placed and is in *new* condition.
8. Carry one or more spare elastomeric washers in case the primary washer is lost or damaged. NEVER use a substitute washer of any kind that has not been specifically manufactured for use with oxygen. (Improper washers have also lead to fires!)
9. Follow the regulator manufacturer's instructions for attaching the regulator to an oxygen cylinder.
10. Be sure that the valve, regulator and gasket are free from oil, grease or petroleum products. Petroleum products have caused ignition in oxygen systems on many occasions.

The revised FDA / NIOSH notifications and recommendations regarding fires, gaskets and regulators can be found at:

<http://www.fda.gov/cdrh/safety/042406-o2fires.html>

<http://www.fda.gov/cdrh/oxyreg.html>

The FDA / NIOSH notification contains pictures of various types of washers for those who may not be familiar with the difference between crush gaskets and elastomeric washers.

About the Author: Cyril Shokoples is an internationally certified Mountain Guide and is a Past President of the Association of Canadian Mountain Guides. He received the Distinguished Service Award from the Alpine Club in Canada in 2002 and subsequently received the Distinguished Service Award from the ACMG in 2003.

Cyril has been training mountain guides and National Park Wardens in advanced first aid for 25 years. He spent 8 years as coordinator of Prehospital Care Programs at the Alberta Vocational College where he ran Alberta's first nationally accredited EMT - Ambulance program. He is also a PADI certified Divemaster and Nitrox certified Open Water Scuba Instructor. He currently resides in Edmonton and is the proprietor of the firm Rescue Dynamics, which is involved in climbing, rescue and safety instruction, as well as mountain guiding.

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