Below: At the NASTAR Center, hypobaric-chamber-test participants (armed with their symptom checklists) signal their readiness to begin.

LEARNING ABOUT HYPOXIA IN A HYPOBARIC CHAMBER
A jumper suddenly falls off the side of a Twin Otter airplane at 24,000 feet after losing consciousness during a large-formation record attempt. He wakes up in freefall, thousands of feet lower. A pilot of a King Air jump plane crashes the plane into the ocean following repeated climbs to 18,000 feet and a final flight to 20,000 feet without using oxygen. All of the skydivers survive, but the pilot dies. These are just a few of the skydiving incidents whose root cause can be linked to hypoxia.

The air we breathe has less pressure the higher we get above the earth. Spending too much time at an altitude where the air pressure is low is one of the causes of hypoxia, or a lack of oxygen in body tissue. The lower the air pressure gets, the less oxygen it moves into the lungs (i.e., the air gets “thin”). The human body works well at the 14.7 pounds per square inch of pressure found at sea level. At 10,000 feet mean sea level, the pressure is 10.11 psi; at 15,000 feet, the pressure drops to just 8.3 psi. As altitudes rise and air pressure falls, hypoxia develops, meaning the blood no longer carries enough oxygen to the brain and other organs to keep them functioning properly. And because of the effect a diminished oxygen supply has on the brain, judgment may be the first thing to fail, often causing people to not even realize that they are impaired.

**THE EFFECTS OF HYPOXIA**

How high above the earth is too high, how much time there is too much, and how will hypoxia affect you? That depends on a lot of factors, both physical and environmental. How your body responds to hypoxia could be completely different from the person sitting next to you. Besides altitude and the time spent there, contributing causes of hypoxia include use of certain medications (especially strong pain medications that suppress respiration) and having physical issues such as asthma, lung diseases such as chronic obstructive pulmonary disease and bronchitis, heart problems and anemia. Adding more complexity to the issue, your symptoms will likely change as you age, so how your body responds to the onset of hypoxia now might be different in five years’ time.

Although the majority of skydivers jump from below 14,000 feet mean sea level—where oxygen supplies are lower than on the ground but still considered safe for short periods of time—hypoxia is still an issue skydivers should be concerned about. Most jumpers can make multiple jumps from that altitude throughout the day with no problem but may suffer ill effects if the plane needs to circle at exit altitude for long periods (for example, if the pilot is holding for traffic or the spotter is having difficulty finding a safe exit point). And some people may not handle the reduced level of oxygen very well even for short periods of time. Skydivers also need to be wary of even mild hypoxia during night jumps since night vision can begin to deteriorate at altitudes as low as 5,000 feet.

Additionally, with the recent surge in large-formation multi-point record attempts and high-altitude state record attempts, more people than ever are jumping from altitudes over 20,000 feet, at which the time of useful consciousness without using supplemental oxygen is just a few minutes or less. To minimize the chances of hypoxia causing an incident, Federal Aviation Regulation 92.211 requires flight crews to use oxygen above 14,000 feet MSL and for skydivers to have oxygen available above 15,000 feet MSL (which USPA’s Basic Safety Requirements also mandates). However, once a jumper removes his oxygen feed to prepare for exit, the clock is ticking. A longer-than-usual jump run or a malfunctioning oxygen tube can easily cause the jumper to experience a hypoxic event and even lose consciousness at the worst possible second: while exiting the aircraft. Approaching these record attempts with caution and a full understanding of the effects of hypoxia is only good common sense.

Since individuals’ responses to lack of oxygen can vary so much, experiencing the symptoms in a controlled environment can help you figure out your body’s reactions and allow you to identify the onset of hypoxia. Testing in a hypobaric chamber (i.e., an altitude chamber) is one way to learn how to identify when you’re hypoxic and need to abort a jump or get back on oxygen.

**USPA Skydiver’s Information Manual Section 6-7, “High Altitude and Oxygen Use,” states:**

1. Skydives from altitudes higher than 15,000 feet above mean sea level (MSL) present the participants with a new range of important considerations.

2. The reduced oxygen, lower atmospheric pressure and temperature, and the higher winds and airspeed above 15,000 feet MSL make skydiving more hazardous in this region than at lower altitudes.

3. Hypoxia, or oxygen deficiency, is the most immediate concern at higher altitudes.
   a. Hypoxia can result in impaired judgment and even unconsciousness and death.
   b. Hypoxia can be prevented by the use of supplemental oxygen and procedures not required for skydives from lower altitudes.

4. With proper training, adequate equipment, and well-planned procedures, high-altitude skydives can be conducted within acceptable safety limits; without such precautions, they may result in disaster.”

The remainder of the section contains extensive information about jumping from above 15,000 feet MSL, including experience, training and preparation recommendations and oxygen-use procedures. Any jumper considering a high-altitude skydive should review the information thoroughly.
HYPOBARIC TESTING

Hypobaric-chamber testing has been around for decades. Mostly used by the military and commercial aviation industries for pilot training, these testing facilities are highly specialized and not as accessible to the general public as they once were due to restructuring within the military. The National Aerospace Training and Research (NASTAR) Center in North Philadelphia, Pennsylvania, is helping to fill this void. Established in 2007, NASTAR provides training for civilian and military personnel, as well as training and research for those in the commercial space flight industry.

NASTAR gears much of its program toward airplane pilots, but skydivers can also benefit from it. The experience is somewhat costly ($825 per person or $800 per person for groups of six to 12), but many jumpers may find it worthwhile, particularly if they routinely organize or participate in high-altitude jumps or simply feel that they may be more physically susceptible to hypoxia. NASTAR Director of Physiology Glenn King, a longtime jumper with thousands of skydives under his belt, is well aware of the altitude and hypoxia issues skydivers face. He has even created a simulation for those who may be interested in skydiving but want to see how the pressure changes affect their sinuses and ears.

In a standard experience, NASTAR attendees have about an hour of classroom training and then head to the chamber where all the magic happens. Everyone settles in with a helmet-mounted facemask and breathes oxygen for 30 minutes before taking a “ride” up to 25,000 feet (still breathing oxygen with the mask on). A specialist stays in the chamber to monitor the equipment and guide each person through the process. An oxygen monitor attached to each participant’s finger keeps tabs on oxygen levels in the bloodstream. At 25,000 feet, participants remove their oxygen masks and start performing simple tasks, such as tracing a maze with a pencil, to test dexterity and coordination. As the chamber reduces the oxygen level, it also reduces the atmospheric pressure, so participants experience the physical effects of being in an unpressurized airplane at 25,000 feet.

As USPA Director of Safety and Training, NASTAR invited me to participate in hypobaric testing. When my group entered the chamber, we each received a list of hypoxia symptoms and were instructed to circle them as they materialized. As soon as a participant experienced two symptoms, a technician would replace the oxygen mask so the recovery process could begin. (King explained that participants stop at two symptoms to minimize risk since there’s no benefit to testing someone all the way to loss of consciousness.) It took only two minutes without oxygen before I started to feel my first symptom, light-headedness. After three minutes, I began to feel queasy, and a monitor showed that my oxygen level was at 78 percent. The technician then put my oxygen mask back in place, and after a minute or two the symptoms disappeared as my oxygen level headed back toward 100 percent. The other participants had similar experiences, with the most common symptoms being lightheadedness, nausea and tingling sensations.

Hypobaric-chamber training is both fun and educational, and it can help skydivers learn to recognize when lack of oxygen is about to cause serious problems. But even if you don’t have the opportunity to undergo hypobaric-chamber testing, it’s wise to be familiar with the causes and effects of hypoxia so you can avoid a dangerous and unsettling experience.

Hypoxia Signs & Symptoms

According to the Federal Aviation Administration, common signs (what people notice in others) and symptoms (what people notice about themselves) of hypoxia are:

**Signs**
- Hyperventilation
- Cyanosis (blue coloration of the skin)
- Intellectual impairment
- Poor judgment
- Behavioral changes
- Delayed reaction time
- Unconsciousness

**Symptoms**
- Headache
- Dizziness
- Fatigue
- Reduced visual field
- Decreased night vision
- Drowsiness
- Paresthesia (tingling, burning or prickling skin)

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**Hypoxia testing for civilians (who must have FAA Class 3 medicals or equivalent) is available at the following facilities:**

- The NASTAR Center in Philadelphia, Pennsylvania. Information and booking is available through ETC Advanced Pilot Training at etcadvancedpilottraining.com.
- The FAA Civil Aerospace Medical Institute in Oklahoma City, Oklahoma. Visit www.faa.gov/pilots/training/airman_education/aerospace Physiology for more information.

Right: To demonstrate the effects of high-altitudes on the human body, technicians at the NASTAR Center fill a dummy with fluid at 98 degrees (to approximate body temperature), place it in the hypobaric chamber and take it up to 60,000 feet, where the fluid starts to boil from the pressure change just as human body fluids would.