



IAN WHELAN

Supplemental oxygen:

The open secret of non-compliance

by Pete Combs

George Braly will be the first to tell you: he's lucky to be alive.

Braly runs Tornado Alley, an aircraft retrofit company based in Ada, Okla. Tornado Alley develops, tests, markets and installs aircraft modifications. It was aboard one of his modified aircraft, while conducting a test flight, that Braly almost lost his life because of a kinked oxygen line.

"On the test flight, I needed to get above 18,000 feet," Braly told *AIN's The Human Factor: Tales from the Flight Deck*. "I was headed out on a round-robin flight plan over western Oklahoma that would take me to between 24,000 and 25,000 feet." Braly is no novice when it comes to flying small airplanes into the flight levels. Between 1968 and 1981 he logged 4,500 hours at high altitudes aboard a turbocharged, unpressurized Cessna twin.

But none of that experience prepared him for the moment when, alone in the Cirrus SR22, he lost consciousness. In adjusting his seat, Braly had apparently rolled over his oxygen line, stopping the flow of O₂ to his mask. As he drifted off into unconsciousness, the aircraft continued on autopilot to fly along its programmed course.

Twenty minutes later, Braly said he vaguely heard the voice that had been calling him for 15 minutes. That voice, he said with certainty, saved his life. "The next thing I remember, a very nice lady was calling my aircraft number in an urgent and anxious voice," he recalled. "I heard that while I was still not fully conscious, but it roused me." Braly was able to descend below 10,000 feet, recover from his brush with hypoxia and eventually land the airplane. The

controller had been anxious, persistent, even aggressive, Braly remembered, and he has no doubt she saved his life.

Others have not been so lucky.

- On April 5, 2012, a Cessna T182 headed from Laughlin/Bullhead International Airport, Ariz., to Santa Monica Municipal Airport, Calif., crashed near the California town of Ludlow. According to the NTSB, air traffic controllers queried the pilot after noticing he was in an unannounced descent. He responded, but it was so garbled they could not understand him. The 182 crashed, killing the pilot. The NTSB attributed the crash to in-flight loss of control as a result of the pilot's impairment by hypoxia.
- On Dec. 4, 2008, a newly painted Beechcraft King Air C90 departing Hondo, Texas, was cleared to 17,000 feet seven minutes after takeoff. The King Air began to stray from its course, prompting ATC to query the pilot several times. Despite that, the pilot was cleared to FL240. Passing through 18,000 feet, the pilot finally acknowledged the course correction. It was his last transmission. Thirty minutes into the flight, the aircraft descended to FL210, then descended rapidly until it crashed near the Texas town of Rocksprings. The NTSB found that the 67-year-old pilot had failed to configure the King Air's pressurization controls, "resulting in his impairment and subsequent incapacitation by hypoxia." The pilot, who was alone in the aircraft, died.
- After two Learjets crashed—one on Oct. 1, 1981, and the other on May 6, 1982—the NTSB asked the FAA to establish for use at pilot schools a minimum training curriculum that would cover "special considerations involved in a pilot's initial transition into general aviation jet airplanes, including the aerodynamic, meteorological and physiological aspects of high-performance, high-altitude flight."

The NASA Aviation Safety Reporting System (ASRS) contains 1,195 reports submitted between January 1988 and May 2005, outlining incidents in which cabin pressure was a factor. In many cases,



George Braly safely landed the airplane he was test flying when he suffered hypoxia as the result of a kink in his oxygen line.

pilots did not use supplemental oxygen while troubleshooting cabin-pressure problems. In one case, according to an NTSB letter dated Dec. 20, 2000, several crewmembers aboard a Boeing 727 lost consciousness. The cabin's altitude warning sounded as designed. The crew simply failed to put their masks on as they tried to troubleshoot the cabin-pressure problem.

In that letter, the NTSB concluded that "existing guidance and information on time of useful consciousness (TUC) is inconsistent and misleading because it does not accurately reflect the TUC for pilots trying to perform complex tasks in an emergency environment. It fails to convey to flight crews the urgency of donning oxygen masks immediately after a loss of pressurization at relatively high altitudes.

"Therefore, the Safety Board believes that the FAA should revise existing guidance and information about high-altitude operations to accurately reflect the TUC and rate of performance degradation following decompression and to highlight the effect of hypoxia on an individual's ability to perform complex tasks in a changing environment; and incorporate this revised information into both the required general emergency training conducted under Parts 121 and 135 and training and flight

manuals provided to all pilots operating pressurized aircraft.”

A STUDY IN NON-COMPLIANCE

Fast forward 15 years.

When business aviator Chris Shaver embarked on a master’s degree in safety from Embry-Riddle Aeronautical University, he decided to question his fellow pilots about a poorly kept aviation secret.

“I started to think about things that were affecting aviation safety that really weren’t on the forefront,” he said. “Maybe they were known, but not a lot of people were talking about them. And this supplemental oxygen regulation and compliance came up pretty quickly.”

Shaver was talking about the trend among his colleagues on the flight decks of business aircraft in the U.S. who en masse disregard FAR 91.211. As part of his thesis, Shaver surveyed 500 business aviators and found “the large majority of pilots—87 percent—choose not to comply with the 91.211 rule that requires them to wear an oxygen mask above

41,000 feet.”

“It has been a source of frustration for me, this one particular regulation, because there’s so much resistance about following it,” said Rick Miller, chief pilot for a corporate flight department. “It’s not just rogue pilots out there disobeying the regs,” he added. “These are highly respected professionals who don’t generally have problems following the rules. We’re talking about chief pilots, demo pilots and test pilots.”

Why do so many pilots refuse to abide by rules requiring the use of supplemental oxygen? Miller did some investigating of his own and came to the conclusion that a big part of the problem is the masks themselves.

“I had to sit down for my own sanity and figure out why this is happening,” he said. “I wrote it all down and came to this conclusion: either consciously or by gut feeling, pilots are mitigating eight other hazards encountered as they complied with 91.211. They’re just uncomfortable,” Miller said. “The mask fits very tightly. When you get on those ultra-long-range flights of, say 12 to 14 hours, we augment the flight crew with additional personnel. Each pilot is wearing the mask for three to four hours. So that means it’s basically squeezing your head for three or four hours at a time. And then there’s the health risk,” said Miller, citing the difficulty of cleaning masks properly. He pointed to the exceptionally onerous task of cleaning behind the mask’s microphone. “We do carry alcohol wipes to sanitize the mask between uses. But you’re really at the mercy of how the previous person has cleaned the mask. We do tend to pass colds back and forth between us when we use the mask,” he added.

Other pilots point out the masks are built to be used in emergencies. “They’re just not made for everyday use,” Shaver said. The wear and tear means there is a greater probability that masks might fail, he added. “Sometimes, masks that are required to be in a quick-use position to meet the FAA’s five-second rule are instead simply set aside. Donning masks in such cases often takes longer than five seconds.”



Part 91 pilots are required to wear oxygen masks above 41,000 feet, but many admit to not doing so.

NON-COMPLIANCE CONTAGION

Shaver and Miller believe the wide disregard for 91.211 has the potential to become a slippery slope. Both think that by selectively complying with the rules, some pilots might become insensitive to ignoring other rules. The NBAA Safety Committee estimates procedural non-compliance is a factor in up to 40 percent of aviation accidents worldwide that were reviewed by human-factors experts.

The International Civil Aviation Organization (ICAO) requires the use of supplemental oxygen but its rules are slightly but significantly different from those set forth by the FAA. Annex 6 of the ICAO Standards and Recommended Practices (SARPS) sets supplemental O₂ requirements according to the pressure *inside the aircraft* rather than outside, as is the case with FAA requirements.

Miller sees that approach as a possible solution to non-compliance among U.S. flight crews. “We don’t want to get rid of the entire rule [that requires supplemental O₂ use above FL410],” he said. What we want to do is harmonize with the ICAO Annex 6 rule.” To that end, both Miller and Shaver are part of NBAA’s High Altitude Supplemental Oxygen Working Group (HASO), an arm of the association’s Safety Committee. In collaboration with GAMA, major manufacturers and the American Medical Advisory Service, the working group started out by surveying business aviation flight crewmembers.

The HASO Working Group found that most pilots (88 percent) regard wearing an O₂ mask for extended periods as adding to pilot fatigue. Most (70 percent) also believe that mask use is behind physiological problems they have experienced, with most citing bronchial irritation as the main symptom. The vast majority (92 percent) of pilots surveyed by the working group worry about becoming sick as a result of wearing an unclear mask. Almost 90 percent of those asked believe oxygen masks interfere with crew resource management (CRM).



The design of oxygen masks makes them uncomfortable for use over several hours, as the rules require.

To support the idea of changing FAR 91.211, Miller and the working group say the aircraft they fly are demonstrably reliable—that the chances against in-flight depressurization are a billion to one. “When you do a risk analysis, cabin depressurization is considered a catastrophic event. But the chance of it happening is extremely remote. It falls under the category of ‘acceptable risk,’” he said.

The suggested solution from HASO, then, is to bring 91.211 into harmonization with ICAO Annex 6. “On the whole, it’s tougher than 91.211. But the use of supplemental oxygen is based on cabin pressure,” he said.

If the FAA will not change 91.211 to reflect the ICAO standard, Miller suggests exempting operators flying aircraft manufactured in compliance with FAR Part 25.841, which states, in part: “If certification for operation above 25,000 feet is requested, the airplane must be designed so that occupants will not be exposed to cabin pressure altitudes in excess of 15,000 feet after any probable failure condition in the pressurization

system. The airplane must be designed so that occupants will not be exposed to a cabin pressure altitude that exceeds the following after decompression from any failure condition not shown to be extremely improbable: 25,000 feet for more than 2 minutes; or 40,000 feet for any duration. Fuselage structure, engine and system failures are to be considered in evaluating the cabin decompression.”

NBAA’s HASO Working Group is in discussions with the FAA about changing 91.211, Miller said. In the process, he sees a further opening for frank talks about other issues. “What this has done is open the door to addressing other shortcomings with regulations,” he said.

In spite of the NTSB’s Dec. 20, 2000 letter to the FAA recommending additional flight crew training on the effects of hypoxia, there is no such mandatory training today, Miller said. Instead, the onus remains on pilots to seek out the training they deem sufficient, he said. Training on oxygen equipment is “the minimal amount possible. We have an opportunity to improve not only the requirements for training outlined in the regulations, but also training on the equipment required to operate at those altitudes,” he concluded.

In addition, Miller said his group is working with manufacturers to improve mask designs. Should the mask fail, there are other changes the working group would like to see, such as redundant oxygen systems and automatic descent capabilities. □

Most Frequent Pilot Complaints About FAR 91.211

- Difficulty talking with masks on: the masks muffle speech, making crew communications almost impossible.
- Difficulty with radio transmissions: pilots have trouble clearly communicating with ATC.
- Interference with vision: masks interfere with eyeglasses, especially bifocals or progressive lenses.
- Fatigue: the masks are great for emergency descent, but not for long-term, routine use.
- Depletion of the aircraft’s O₂ supply: routine use of supplemental oxygen depletes the aircraft’s supply much faster than when masks are not in use—at a rate of approximately two liters per second.
- Bronchial irritation: aviation oxygen is not humidified. Breathing in dry O₂ irritates the bronchial tube.
- Illness caused by sharing masks: while many flight crews carry alcohol wipes, there is no way to clean emergency oxygen masks completely.
- Increased maintenance: the wear and tear on masks forces operators to repair or replace components more often.

—Rick Miller, NBAA High Altitude Supplemental Oxygen Working Group

What does FAR 91.211 say?

Sec. 91.211 Supplemental oxygen.

(a) **General.** No person may operate a civil aircraft of U.S. registry—

(1) At cabin pressure altitudes above 12,500 feet (msl) up to and including 14,000 feet (msl) unless the required minimum flight crew is provided with and uses supplemental oxygen for that part of the flight at those altitudes that is of more than 30 minutes duration;

(2) At cabin pressure altitudes above 14,000 feet (msl) unless the required minimum flight crew is provided with and uses supplemental oxygen during the entire flight time at those altitudes;

and

(3) At cabin pressure altitudes above 15,000 feet (msl) unless each occupant of the aircraft is provided with supplemental oxygen.

(b) Pressurized cabin aircraft

(1) No person may operate a civil aircraft of U.S. registry with a pressurized cabin

(i) at flight altitudes above Flight Level 250 unless at least a 10-minute supply of supplemental oxygen, in addition to any oxygen required to satisfy paragraph (a) of this section, is available for each occupant of the aircraft for use in the event that a descent is necessitated by loss of cabin pressurization; and

(ii) At flight altitudes above Flight Level 350 unless one pilot at the controls of the airplane is wearing and using an oxygen mask that is secured and sealed and that either supplies oxygen at all times or automatically supplies oxygen whenever the cabin pressure altitude of the airplane exceeds 14,000 feet (msl), except that the one pilot need not wear and use an oxygen mask while at or below Flight Level 410 if there are two pilots at the controls and each pilot has a quick-donning type of oxygen mask that can be placed on the face with one hand from the ready position within 5 seconds, supplying oxygen and properly secured and sealed.

(2) Notwithstanding paragraph (b)(1)(ii) of this section, if for any reason at any time it is necessary for one pilot to leave the controls of the aircraft when operating at flight altitudes above Flight Level 350, the remaining pilot at the controls shall put on and use an oxygen mask until the other pilot has returned to that crewmember's station.

What does ICAO Annex 6 say?

All Aircraft

An operator shall ensure that passengers are made familiar with the location and use of: ... d) oxygen dispensing equipment, if the provision of oxygen for the use of passengers is prescribed...

Non-pressurized Aircraft

An aeroplane intended to be operated at flight altitudes at which the atmospheric pressure is less than 700 hPa (*see Note 1*) in personnel compartments shall be equipped with oxygen storage and dispensing apparatus.

A flight to be operated at flight altitudes at which the atmospheric pressure in personnel compartments will be less than 700 hPa shall not be commenced unless sufficient stored breathing oxygen is carried to supply: a) all crewmembers and 10 percent of the passengers for any period in excess of 30 minutes that the pressure in compartments occupied by them will be between 700 hPa and 620 hPa; and b) the crew and passengers for any period that the atmospheric pressure in compartments occupied by them will be less than 620 hPa.

Pressurized Aircraft

An aeroplane intended to be operated at flight altitudes at which the atmospheric pressure is less than 376 hPa or which, if operated at flight altitudes at which the atmospheric pressure is more than 376 hPa, cannot descend safely within four minutes to a flight altitude at which the atmospheric pressure is equal to 620 hPa... shall be provided with automatically deployable oxygen equipment. The total number of oxygen-dispensing units shall exceed the number of passenger and cabin crew seats by at least 10 percent.

All flight crewmembers of pressurized aeroplanes operating above an altitude where the atmospheric pressure is less than 376 hPa shall have available at the flight duty station a quick-donning type of oxygen mask which will readily supply oxygen upon demand.

Note 1: hPa approximate altitude equivalents: 700 hPa = 10,000 feet, 620 hPa = 13,000 feet, 376 hPa = 25,000 feet

Note 2: *National or regional authorities* use the ICAO guidance as the basis for their regulations. However, these regulations may be more or less restrictive than the SARPS. Consult the appropriate documentation provided by the aircraft state of registry for specific criteria.