Solvable mystery?

By John Morris

It is unfortunate that it usually takes an accident or incident to start a discussion within the aviation community regarding safety. I myself would rather discuss *normal*, FUN operations of the PC12. But after reading about and talking with clients about the aircraft incident in September involving the apparent loss of pressurization at a Flight Level and the subsequent incapacitation (Hypoxia) of the pilot and passenger, and the resultant reactions by media and pilots I feel the need to respond. This is in part due to the general post-incident reaction of what "they" would have done differently, and in part because the vast majority of the reactions were based on normally un-pressurized general aviation aircraft, including the addition of non-standard safety items in the cockpit to preclude the onset of Hypoxia.

I will discuss the pressurized side of the story, which is more mysterious, in relation to the September incident, since the Federal Aviation Regulations regarding pressurized aircraft would appear to make it near impossible for the Pilot and passengers to lose consciousness due to loss of pressurization and lack of oxygen.

A part of the on-going discussions has been database information on past similar hypoxia related incidents. Again the information published appears to be of non-pressurized aircraft. So I did an NTSB database search looking for pressurized aircraft having hypoxia / pressurization and possible Carbon Monoxide poisoning (from combustion heaters) for the past 20 years (see table).

TABLE			
Pressurized Aircraft	Phase of flight		
	Climb	Cruise	Descent
Piston-ME	1997	2000(1), 2012(#)	
Turboprop-SE		2014(#)	
Turboprop-ME	2008	1998*, 1999, 2001, 2009	
Turbojet	1999(#)		2001, 2003

All fatal outcomes

(1) Carbon Monoxide – survived
(#) Observed by other aircraft
* Very similar to September, 2014 incident

Note: During the same 20 year period 25 non-pressurized aircraft were reported as an Hypoxia event with similar outcomes.

Twelve events in 20 years! With the regulations, how can there be any hypoxia events? What is missing? Here is a condensed list of FAR's regarding pressurized flight operations above FL250 up to and including FL300.

FAR Part 23.841 (condensed) for aircraft certified for operations above 25,000 feet, requires instruments to indicate to the pilot cabin pressure differential, cabin altitude and rate of change of cabin pressure altitude. Warning indications are required for cabin pressure differential exceedence and if cabin pressure altitude exceeds 10,000 feet. This regulation also takes into account a possible need for an emergency descent and the flight crew reaction time line during a cabin decompression. The PC12 family has progressively grown in safety warnings/alerts since 1994 meeting and exceeding the FAR requirements.

FAR Part 91.211 (condensed) requires supplement oxygen for operations above 25,000 feet of at least a 10-minute supply for all occupants for use in the event that a descent is necessitated by loss of cabin pressurization. All PC12's carry the oxygen supply system requirement and offer a larger oxygen supply for extended duration.

FAR Part 23.1441/1447 (condensed) for aircraft certified for operations above 25,000 feet to 30,000 feet requires supplemental oxygen dispensing for passengers (immediately available wherever seated) and flight crew (quick-donning immediately available at their station). All PC12's come with a manual/auto controlled, continuous flow airline style masks, for passengers and quick-donning, pressure-demand masks for the flight crew.

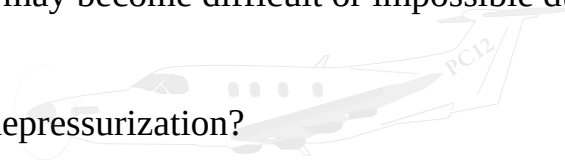
If the multiple required warning systems and indicators are working then how can there not be a reaction to the loss of pressurization, thus avoiding Hypoxia?
Lets start with the Warning Systems. I am using the PC12 as reference but generally all pressurized aircraft systems are designed the same.

- Cabin Differential pressure (switch) is tied into the Static system along with the Cabin Differential pressure gauge/indicator located at the Pressurization Control/ Environmental window. It is linked to the CAWS/CAS for warnings [additional voice callout Series 10].
- Cabin Altitude gauge/indicator is located at the Pressurization Control/Environmental window. An independent barometric unit located in the cockpit senses Cabin Altitude. It is linked to the CAWS/CAS for warnings [additional voice callout Series 10/NG].
- Cabin Pressurization (Environmental Control System) ECS/ACS (Air Cycle System) are sensed at the engine for bleed air temperature and pressure. If either exceeds design limits the ECS/ACS will be shut off at the Primary Shut-Off valve resulting in loss of pressurization air. It is linked to the CAWS/CAS for warnings [additional voice callout Series 10/NG].
- Passenger Oxygen-Auto. This is not a warning system, however when the CAWS green [PASS OXY] or Environmental window green [PAX OXY] illuminates, this should be an indication of Cabin Altitude at/or above 13,500 feet.

How can we not be alerted but become hypoxic?

Can the cabin pressure partially leak up to 9500 feet, where the warning systems would not activate, and cause hypoxia?

Not likely according to physiological studies. This is why the minimum oxygen standards of 12,500 feet (>30 minutes), unpressurized and 10,000 feet (>30 minutes), standard Part's 135/121 were set. Of course not all humans react the same to high altitudes. Other possible factors relating to hypoxia at lower altitudes are smoking/alcohol/medications and medical conditions not reported or approved by the FAA for flight as PIC.
Many highly regarded sources recommend that all pilots experience the effects of hypoxia by going to a High altitude training course including an Altitude Chamber to learn how you are personally affected and to learn the signs of hypoxia as it relates to the individual. I have not done this but agree it is a good idea with one caveat, namely that if the onset of hypoxia is slow then self-assessing may become difficult or impossible due to the possible euphoric effects.



What about rapid depressurization?

When I was researching the NTSB database there were several instances of this event that I did not include in my table because it *was* rapid, so the pilot knew it immediately. Some of the responses were not textbook but in all cases the outcome was successful. This is why the FAR's use of >FL250 as the "starting" point for oxygen requirements with pressurized aircraft. Physiological studies have established the EPT (Effective Performance Time), formerly TUC (Time of Useful Consciousness) of 3-5 minutes EPT at FL250, which should be sufficient time to supply oxygen to passengers and crew. At FL300 the EPT drops to 1-2 minutes. In either stated altitude example it would be expected that the aircraft would also initiate a descent to a lower altitude where oxygen would not be required or at least less oxygen required since most aircraft are only carrying a 10-minute supply of supplemental oxygen. The EPT at FL200 is 20-30 minutes so the lower we can get the better off we are for needing supplemental oxygen.

What then could cause loss of pressurization/hypoxia without the pilot knowing it?

Pure guess work at this point because it is one thing to have a medical event or air contamination while flying but how does that cause the pressurization to fail? The only possible way that I can think of is a rapid ascent with the pressurization never being activated. Physiological studies do indicate that a rapid ascent can have a detrimental physical effect but it usually takes some greater time to show the negative effects. My table indicates 3 events that meet that criteria but in the case of the PC12 and one aircraft in the table it is not *that* fast in a climb that the pilot should not feel the pressure changes. And what about the warning systems?

One other additional possibility is the malfunction of the Cabin Altitude sensor-switch. This ***one*** alert device is more important than the differential pressure alert-switch simply because there could be a significant loss of cabin pressure, but not enough (.8 PSI differential for example-which would be an equivalent cabin altitude of approximately 22,000 feet while cruising at 26,000 feet). This would allow the pilot to be in the 20 minute EPT range. This scenario does imply two malfunctions happening simultaneously – some kind of major leaking of the pressurization *and* the cabin altitude alert not functioning. Besides buying an additional (cabin) altimeter and/or pulse oximeter that you would monitor independently, the only way I can think to catch this is monitoring the cabin rate-of-climb/altimeter while climbing and cruising. Aren't we supposed to do that anyway?

The September aircraft event cannot be easily dismissed. The pilot appears to have been highly qualified, having owned two previous aircraft of the same type and the president of the aircraft pilot's association. What could have possibly gone wrong to not have seen this coming and reacted sooner? In opinion, I think that the pilot was already deeply affected by hypoxia by the time of requesting a lower altitude since the loss of pressurization is always an emergency. And as PIC, if needed, don't ask permission – do it! Final authority-period.

I noted on the table a similar event – 1998, PA31T1, Baker, NV. I suggest reading the report. Further information can be found at the NTSB website.

The FAA has a great document that I recommend to own/read titled
Intro to Aviation Physiology [IntroAviationPhys-FAA Medical pdf]

And check out FAA TV: Med X Press: “It’s Easy” and Flying and Hypoxia

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