SERIOUS INCIDENT

Aircraft Type and Registration:	Reims Cessna F406, G-RVLW
No & Type of Engines:	2 Pratt & Whitney Canada PT6A-112 turboprop engines
Year of Manufacture:	1991 (Serial no: F406-0052)
Date & Time (UTC):	6 March 2021 at 1500 hrs
Location:	North Sea
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None reported
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	34 years
Commander's Flying Experience:	4,244 hours (of which 390 were on type) Last 90 days - 64 hours Last 28 days - 10 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot was operating a cargo flight from Göteborg Landvetter Airport, Sweden to East Midlands Airport. The aircraft was at FL 180 when the pilot began to experience a headache. He then noted that his cognitive ability was declining. Realising that he may be suffering the effects of hypoxia, he checked his equipment, before noting that his oxygen saturation as displayed on his finger pulse oximeter was low. He immediately switched oxygen bottles and the symptoms resolved. The pilot was able to continue the flight to East Midlands without further incident.

History of the flight

The flight took off from Göteborg Landvetter Airport, Sweden, at 1330 hrs for a flight to East Midlands Airport. The pilot had already flown the aircraft from East Midlands to Göteborg earlier in the day. The flight time for both sectors was around three hours. With the aircraft in the cruise at FL180 over the North Sea, the pilot was alerted to a problem by a rapid onset headache, followed by being unable to find a regularly used function on the electronic flight bag. As a result of being aware these could be symptoms of hypoxia, he checked his oxygen system. He also checked his oxygen levels on his pulse oximeter, which were much lower than normal, prompting him to increase the flow of oxygen through the regulator. When this did not improve the situation, he changed the supply bottle, and within a few minutes he was feeling better and the oxygen level had recovered to a normal level.

Hypoxia

Hypoxia may be defined as a state of oxygen deficiency in the body sufficient to impair function of the brain and other organs[1]. Whilst there can be a number of medical causes of hypoxia which could occur at any time, hypobaric hypoxia is altitude related. As the altitude increases and barometric pressure decreases, the partial pressure of oxygen decreases. This reduction in partial pressure simply means there are fewer oxygen molecules per volume of air as altitude increases. It becomes increasingly difficult for the human body to supply its oxygen needs as the aircraft climbs if no supplementary oxygen is supplied.

The brain is usually the first organ to suffer from the diminished oxygen supply. Even at 8,000 ft altitude, where there is a 25% reduction in the partial pressure, it is possible to detect impairment in some mental performance. This can make it challenging for the pilot to recognise the symptoms and to act effectively. Early symptoms of hypoxia are subtle and may include rapid breathing, headache, drowsiness, nausea, behavioural changes (eg euphoria and irritability), slurred speech, and diminished thinking capacity. It is also the case that symptoms can be individual and variable.

Aircraft information

The Reims Cessna F406 Caravan II (F406) is an unpressurised twin turboprop aircraft with a service ceiling of 30,000 ft. If the pilot is required for operational reasons to cruise above 10,000 ft altitude, then the aircraft carries two 682 litre portable oxygen bottles which are fitted with regulators and a cannula to fit to the nose of the pilot. The regulator allows the pilot to select a rate of oxygen delivery suitable for the cruise altitude. The aircraft operator limited the aircraft to a maximum altitude of 18,000 ft. At this altitude, the delivery rate of oxygen is recommended by the operator to be 0.6 litres per minute giving each bottle a capacity of over 18 hours for a single user. Although the pilot elected to select an oxygen flow of 1.0 litre per minute as he found this a more comfortable setting, this would still have meant a capacity of more than 11 hours.

Both oxygen bottles were full at the start of the pilot's duty and he had completed two previous flights before the incident flight. The primary oxygen bottle had worked without incident on the previous flight and for a significant proportion of the incident flight. With the flight times, the bottle can only have been used for a maximum of 275 minutes before the incident.

The operator supplied finger pulse oximeters to allow the monitoring of oxygen levels. They provide a very rapid way of assessing the oxygen saturation in the bloodstream although they can be unreliable. They may underread the level of oxygen in the blood, especially with cold or dirty fingers, but this is considered a fail-safe condition which triggers action from the pilot to correct the perceived low oxygen level. However, they can also falsely indicate likely brain oxygenation in the presence of hyperventilation, which may be triggered by hypoxia. In this case cerebral oxygen delivery can be considerably lower (due to constriction of the cerebral blood vessels) than peripheral oxygen levels as measured by the pulse oximeters. This can produce a fail-unsafe condition which is a concern.

Footnote

[1] https://www.easa.europa.eu/sites/default/files/dfu/210635_EASA_HYPOXIA_BROCHURE.pdf [Accessed 21 May 2021]

Both the oxygen bottle and regulator were removed from the aircraft and tested at an approved maintenance facility. The function test of the regulator showed all flows to be within parameters and no faults could be found with either the bottle or the regulator.

Organisational information

As a result of a previous hypoxia event on a company F406, the operator reviewed and revised their existing standard operating procedures for the oxygen system as well as introducing an extensive training programme for its pilots in the operation of the equipment, possible failure modes as well as how to recognise the symptoms of hypoxia. The pilot commented that this training, as well as being alert to the possibility of hypoxia given the altitude of the aircraft, helped in identifying and rectifying the problem rapidly.

At the time of writing, the operator was in the process of re-instating the originally-installed aircraft oxygen system on the company F406 aircraft. It would be a fully integrated system utilising oxygen masks rather than cannulas.

Analysis

The pilot began to feel unwell when in the cruise at FL 180. The training and equipment provided by the operator allowed the pilot to recognise the problem and rectify it without delay, and the rapid response prevented a much more serious incident occurring.

Hypoxia can be subtle with symptoms that can vary between individuals. The nature of the reduction of oxygen usually affects the brain first meaning it can be difficult for the sufferer to process the problem and take the correct action. Being vigilant, using a pulse oximeter and taking quick action if hypoxia is suspected can ensure the safety of the crew and any passengers. However, it should also be noted that hyperventilation – one of the symptoms of hypoxia – may mean that a pulse oximeter does not indicate at the finger what it is purporting to ‘measure’ in the brain.

Conclusion

The pilot’s oxygen level fell, and he began to experience the symptoms of hypoxia. The problem was resolved when the pilot switched the supply bottle, and the flight was able to continue without further incident. No fault was found with either the bottle or the regulator so a cause for the reduction of oxygen supply could not be established.

Safety action

The operator began a retrofit programme to install/reactivate all Cessna F406 aircraft operating above FL100 with a fully integrated oxygen system utilising oxygen masks rather than cannulas.

BULLETIN ADDENDUM

Following publication of this report, the AAIB received correspondence containing further information about pulse oximetry. Consequently, the penultimate paragraph on page 28 and second paragraph of the Analysis section have been amended. Full details can be found on our website. The online version of this report was corrected on 12 August 2021.