AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/8541
Aircraft Registration	**ZS-OZM**	**Date of Accident**	30 August 2008	**Time of Accident**	1407Z
Type of Aircraft	Ayres S2R-T34 Fixed Wing Aircraft		**Type of Operation**	Aerial Fire Fighting	
Pilot-in-command Licence Type	Commercial Pilot	**Age**	68	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	23163		Hours on Type	Unknown
Last point of departure	Kataza Aerodrome, Melmoth, Kwazulu-Natal				
Next point of intended landing	Kataza Aerodrome, Melmoth, Kwazulu-Natal				
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)					
In a tree plantation in Havemanshoogte area, Melmoth, Kwazulu-Natal GPS S28°30.349 E031°15.611 at 3589 feet elevation.					
Meteorological Information	Temperature: 25.4°C; Dew point: -15°C; Wind: 300°/15-35knots; Cloud cover: None; Visibility: 3km				
Number of people on board	1	**No. of people injured**	0	**No. of people killed**	**1**

Synopsis

On 30 August 2008, at 1407Z, an Ayres S2R, ZS-OZM, impacted the ground in a nose down attitude into a forest shortly after departing Kataza Aerodrome, Melmoth, Kwazulu-Natal. The pilot was operating the airplane under the provisions of Part 135 and Part 137 as a local aerial application flight. The commercial pilot, the sole occupant, sustained fatal injuries; the airplane was destroyed on impact. Visual meteorological conditions prevailed during the flight with strong surface wind conditions between 15 to 35 knots.

According to witnesses, the accident flight was to be the pilot's third flight of the day in the accident aircraft.

Post mortem toxicology results indicated that the blood specimen of the pilot contained 21.3% carbon monoxide. The blood specimen tested negative for alcohol and narcotics.

Probable Cause

The pilot loss of control of the aircraft due to the effects of hypoxia.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner/Operator	**:** Osmond Aerial Spray (PTY) LTD
Manufacturer	**:** Ayres
Model	**:** S2R-T34
Nationality	**:** South African
Registration Marks	**:** ZS-OZM
Place	**:** Havemanshoogte area, Melmoth, Kwazulu-Natal
Date	**:** 30 August 2008
Time	**:** 1407Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation :

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to establish legal liability****.*

Disclaimer:

This report is given without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 During August 2008 fires were ravaging Kwazulu-Natal province and destroying homes, livestock and vegetation. At the height of the disaster, Kwazulu-Natal was battling 40 raging fires. Wildfires were destroying the landscape at a rate of 90 km/h at their peak.

1.1.2 Aerial fire fighting was used as an effective fire fighting method due to the nature of the plantations and landscape. During aerial fire fighting operations a spotter pilot would identify areas to dump water and relay the information to the fire bomber pilots. Water treated with fire retardant, was then released on the fire (fire bombing) from the aircraft hopper.

1.1.3 On 30 August 2008 a spotter pilot and two fire bomber pilots were on fire fighting duty at Kataza Aerodrome in the Melmoth district. According to a witness report the spotter pilot expressed his reluctance to fly in the prevailing wind conditions, stating that he was not accustomed to flying in extreme weather conditions. The witness also stated that the deceased pilot (fire bomber pilot), a Canadian citizen, also expressed his reluctance to fly stating that he was also not accustomed to extreme low level bombing in the wind conditions that prevailed. The other fire bomber pilot however stated that he was used to the weather conditions and was prepared to fly.

1.1.4 At approximately 1325Z a fire was reported in the Havemanshoogte area, half way between Melmoth and Babanango. The spotter pilot contacted the Fire Protection

Officer who was also the Operations Manager and operational air attack pilot from the local aerial fire fighting operator and said that he was reluctant to fly in the prevailing wind conditions. The Fire Protection Officer then dispatched from Kwambonambi to the fire in order to take over aerial firebombing operations from the spotter pilot. The fire bomber pilot stated that on the way to start his aircraft he observed the deceased pilot also making his way to ZS-OZM, the Ayres S2R-T34 aircraft.

1.1.5 The fire bomber pilot started loading water in his aircraft at approximately 1335Z. Both pilots took off from runway 32 at Kataza Aerodrome with the deceased pilot in ZS-OZM, following the bomber pilot. The bomber pilot stated that once airborne he found the flying conditions to be typical of firebombing operations i.e. strong gusting winds, severe low level turbulence and difficult take offs and landings. They arrived overhead the location of the fire ahead of the Fire Protection Officer (spotter pilot) and was told to place their loads at own discretion until the spotter pilot arrive. The subsequent loading times of the fire bomber pilot were 1345Z, 1400Z and 1410Z with the loading times of the deceased pilot in between. The Fire Protection Officer (spotter pilot) arrived at approximately 1354Z overhead the fire.

1.1.6 The fire bomber pilot stated that after completing the third load and on base leg for the fourth and last load of the day, he observed the deceased pilot taking off from Runway 32 and getting airborne in ZS-OZM. He heard him call “airborne” on Very High Frequency (VHF) 123.50 MHz at approximately 1407Z and stated that all seemed normal. The Fire Protection Officer (spotter pilot) stated that as ZS-OZM had not checked in at the fire, he transmitted blindly requesting that ZS-OZM switch on all his lights or ‘click in’ on the push-to-talk (PTT). There was no response. The fire bomber pilot then took off from Kataza Aerodrome and tried calling ZS-OZM as well. Reports thereafter started coming in from the ground radios indicating someone had heard a loud explosion in the vicinity of the Kataza store and that an aircraft was involved. The aerial fire fighting operations were immediately cancelled and the spotter and bomber pilot commenced a wreckage search.

1.1.7 Approximately 1356 meters from Kataza Aerodrome fire fighting ground teams located the accident site of ZS-OZM. Emergency services as well as the local police were notified of the accident.

1.1.8 The deceased pilot, a 68 year old Canadian citizen had extensive flying experience and flew in various countries conducting fire fighting operations.

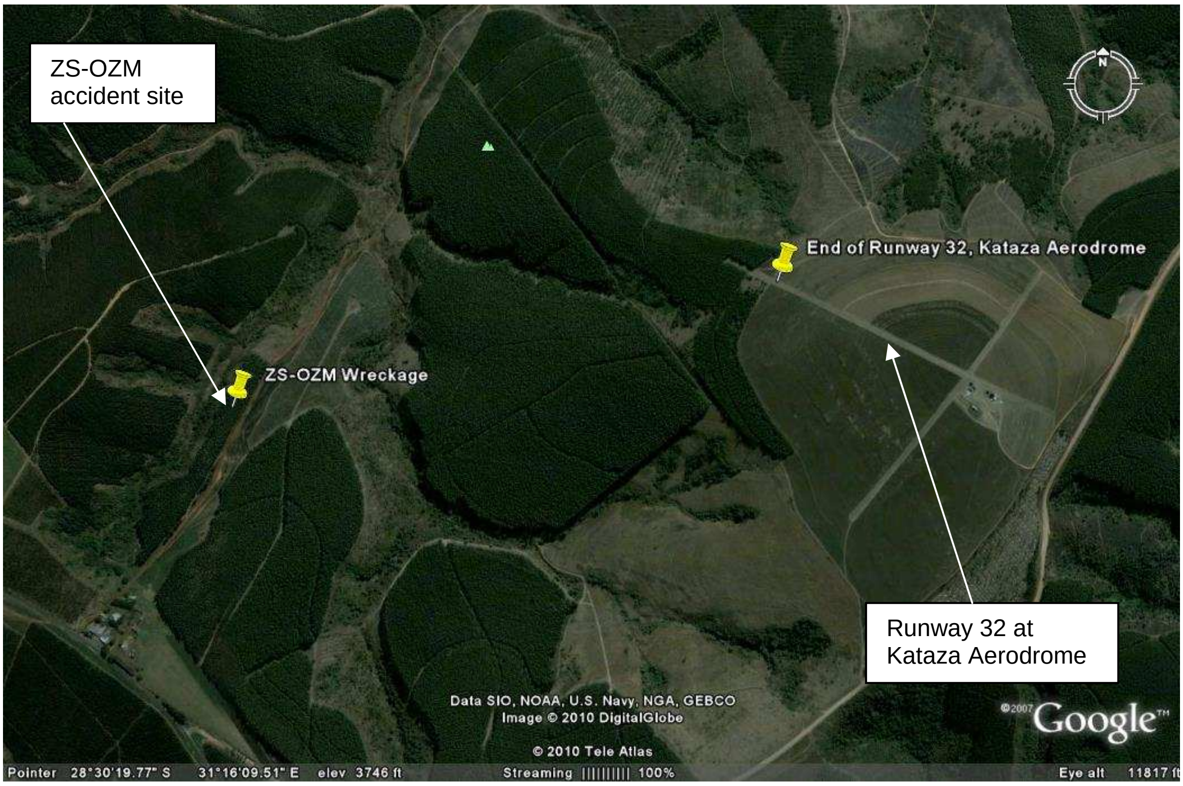


Photo 1: Google Earth photo of the accident site and Kataza Aerodrome.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	1	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	-	-	-	-

1.3 Damage to Aircraft

1.3.1 The aircraft was destroyed in the accident sequence.

1.3.2 A day after the accident of ZS-OZM, the fire reached the accident site and consumed the wreckage causing fire damage to the already destroyed aircraft.

Photo 2: View of the aircraft wreckage

1.4 Other Damage

1.4.1 A few trees in the tree plantation were destroyed during the impact sequence.

1.5 Personnel Information

Nationality	Canadian	Gender	Male	Age	68
Licence Number	0272292954	Licence Type	Commercial		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	No				
Medical Expiry Date	16 December 2008				
Restrictions	Corrective Lenses				
Previous Accidents	Unknown				

Flying Experience:

Total Hours	23163
Total Past 90 Days	Unknown
Total on Type Past 90 Days	Unknown
Total on Type	Unknown

Note: The hours shown was obtained from SACAA records, and this was the number of hours on a copy of the pilot's logbook dated 04 July 2008 during the Foreign License Validation. The pilot's logbook could not be found and his exact flying hours at the time of the accident could therefore not be determined.

1.6 Aircraft Information

1.6.1 General Description

The Thrush Ayres S2R-T34 aircraft was designed especially for agricultural flying. It is a monoplane featuring a full cantilever low wing and all metal construction. The fuselage and overturn structure is constructed throughout of chrome-moly steel tubing. The fuselage comprises a welded tubular steel frame, fiberglass hopper, and detachable skins. An overturn structure forms an integral part of the fuselage frame. The airplane was configured with one pilot seat located directly in the middle of the cockpit.

The Thrush Ayres S2R-T34 aircraft is powered by the Pratt and Whitney PT6, turbine engine. The propeller has three blades mounted on a hollow hub.

In each wing, fuel is contained inside integral wing tanks (wet wing fuel tanks) just outboard of the center section subwings.

The main landing gear is made using a formed chrome-moly spring steel unit. The tail gear is a spring steel type. The spring steel construction and design allow for absorption of landing weight and common stresses associated with such, thus eliminating the need for shock struts.

A reinforced fiberglass 400 US gallon hopper is the principal part of both the solid and spray units. The hopper top forms the cowling from the cockpit forward to the firewall. Emergency jettison controls permit the entire liquid load to be dumped in approximately 6.5 seconds for the 510 gallon hoppers.

Photo 3: The aircraft prior to the accident.

Airframe :

Type	Ayres S2R-T34	
Serial Number	1153R	
Manufacturer	Ayres Corporation	
Date of Manufacture	1971	
Total Airframe Hours (At time of Accident)	11439.5	
Last MPI (Hours & Date)	11421.9	07 February 2008
Hours since Last MPI	17.4	
C of A (Issue Date)	08 May 2003	
C of R (Issue Date) (Present owner)	18 August 2003	
Operating Categories	Restricted to the category under Part 137	

Engine :

Type	Pratt and Whitney PT6A-34AG
Serial Number	PCE 56014-100
Hours since New	11157.5
Hours since Overhaul	2101.9

Propeller :

Type	Hartzell HC-B3TN-3C
Serial Number	BUA30148
Hours since New	135.0
Hours since Overhaul	TBO

1.6.2 The aircraft had a fuel capacity of 96 USG and was authorized to use Jet A-1 fuel. The amount of fuel that was in the aircraft tanks at the time of impact could not be determined. The Flight Folio was also destroyed during the accident. During discussions with colleagues (fellow pilots) of the deceased pilot who participated in the fire fighting operation it was determined that approximately 53 US gallons of fuel was onboard. A pungent fuel odour could also be smelled at the accident site after the accident and even the next day.

1.6.3 Mass and Balance

The empty weight of the aircraft was 4230 pounds. ZS-OZM had a fuel capacity of 96 US gallons. The fuel onboard the aircraft at takeoff of the accident flight was estimated to be approximately 53 US gallons (352 pounds). The weight of the pilot was 183 pounds. ZS-OZM had a hopper tank capacity of 400 US gallons. The water in the hopper tank at takeoff of the accident flight was estimated to be approximately 147 US gallons (1226 pounds). The maximum takeoff weight for the aircraft was 6000 pounds.

ZS-OZM weight at takeoff:

4230 + 352 + 183 + 1226 = 5991 pounds

The weight of ZS-OZM was considered to be within limits for the flight.

Note: The quantity of the water and fuel was provided by colleagues that conducted similar flights on the day.

1.7 Meteorological Information

1.7.1 An official weather report was obtained from the South African Weather Services (SAWS).

Weather Conditions at time of Incident
Surface Analysis (1500Z 30 August 2008):
A through of low pressure was present over the central part of the country with a coastal low on the KZN coast. A cold front was just west of the country. These conditions cause strong offshore flow over KZN, strong surface and upper wind on the eastern side of the country.

Upper Air:
At 500hPa strong north-westerly winds were blowing over KZN.

Satellite Imagery:
The 15H00Z satellite imagery shows no cloud in the Melmoth area but it did show smoke from veld fires.

Weather Conditions in the vicinity of the Incident

No official observations are available at the time and place of the incident. The most likely weather conditions at the place of the accident are as follows:

	15H00Z
Temperature:	*27℃*
Dew Point:	*-15℃*
Surface Wind:	*300°TN 15 to 20knots*
Cloud covers:	*No cloud*
Visibility:	*Because of veld fires in the vicinity, visibility could have been down to 3km*

1.7.2 A weather report was obtained from the private weather station at Kataza Aerodrome:

	15H00Z
Temperature:	*25.4℃*
Wind:	*300°TN 15 to 35knots*

1.8 Aids to Navigation

1.8.1 The aircraft was fitted with the standard navigational aids certified for this type of aircraft. No anomalies of the navigational aids were recorded or reported prior to the accident.

1.9 Communications.

1.9.1 No defect or malfunctioning of the communication equipment was recorded or reported prior to the accident.

1.9.2 The aircraft was equipped with a VHF radio transmitter. The pilot was communicating on the VHF frequency 123.50 MHz and the last communication was after his third takeoff when he called "airborne".

1.10 Aerodrome Information

1.10.1 The accident occurred in a tree plantation in Melmoth approximately 1356 meters from Takaza Aerodrome.

<u>Photo 4 & 5:</u> View of Runway 32 at Kataza Aerodrome.
The photos was taken a day after the accident occurred.

1.11 Flight Recorders

1.11.1 The aircraft was not fitted with a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR), nor were they required by regulation.

1.12 Wreckage and Impact Information

1.12.1 The pilot took off from Runway 32 at Kataza Aerodrome. Approximately 1356 meters from Runway 32 at Kataza Aerodrome the aircraft impacted a tree plantation in a vertical attitude.

1.12.2 There was little damage to the tree canopy and the wreckage showed no sign of slide or bounce after impact. There was no sign of forward ground speed or yaw/spinning action. Some of the trees had been chopped up into sections by the propeller. One tree was cut cleanly off at the base / stump with the stem diameter about 200mm. This was indicative of the engine producing power at impact.

1.12.3 The wreckage was very compact and showed a burst pattern with the debris field all within 50m radius from point of impact. There were fuel spray patterns forward of the wings and a strong smell of fuel in the vicinity. There were pieces of the hopper and aircraft instruments up to 50m down slope. Wet water marks were found on trees indicating that the aircraft water load burst at impact. The water mark on the trees was from the fire retardant treated water as the treated water remains wet for at least 45 minutes.

1.12.4 There was no evidence of airframe failure or system malfunction prior to the accident. All control surfaces were accounted for, and all damage to the aircraft was attributed to the severe impact forces.

Photo 6: View of fire retardant treated water at the wreckage after the water load burst at impact
The photo was taken minutes after the accident occurred

Photo 7 & Photo 8: View of the trees that was chopped by the propeller

1.13 Medical and Pathological Information

1.13.1 The Post Mortem examination was performed on the deceased pilot on 4 September 2008. The cause of death was concluded to be from multiple blunt force injuries.

The Chief Post Mortem findings made on the deceased were:

- *Severely mutilated body with deceleration injury.*
- *Large vessel atheromata and minimal coronary artery disease with patent luminae. No evidence of recent myocardial infarction.*
- *Histological evidence of toxic renal tubular damage.*

After the SACAA Aviation Medical department reviewed the Post Mortem report, it was decided to wait for the toxicology results in order to determine if any medical condition could have contributed to the accident.

1.13.2 Toxicology tests were done on the blood specimen of the deceased and the Post Mortem results that included the Toxicology results were finalised on 05 September 2011.

<u>The Toxicology report stated the following:</u>

The carbon monoxide saturation of the haemoglobin in the specimen was 21.3%. This level is significant in that the range of 10-20% and above is usually related to symptoms like headache and impairment in the execution of complex tasks. Furthermore, it should be noted that in the presence of disease such as coronary artery disease with myocardial insufficiency, obstructive airway disease and even old age this may have been a fatal concentration.
The concentration of alcohol in the specimen was zero. No narcotic or medical drugs could be detected in the specimen.

The cause of death stated as "multiple blunt force injuries" remains unchanged.

1.14 Fire

1.14.1 There was no evidence of pre- or post-impact fire. The water load from the aircraft hopper burst at impact and in all probability prevented a post-impact fire. The first responders at the accident site also sprayed the aircraft's fire extinguisher on the hot engine as a precautionary measure.

1.14.2 Approximately 24 hours after the accident the forest fire reached the accident site and consumed the wreckage causing fire damage to the already destroyed aircraft.

Photo 9: A section of the engine that was sprayed with the fire extinguisher

Photo 10: The tree plantation and wreckage was destroyed by fire a day after the accident occurred

1.15 Survival Aspects

1.15.1 The accident was not survivable due to the magnitude of the deceleration forces.

1.15.2 Although the pilot was secured with a safety harness the impact forces caused the aircraft seat to break away from the cockpit with the rear bulkhead still attached.

1.15.3 The pilot wore a helmet that fractured during the impact sequence.

1.16 Tests and Research

1.16.1 None

1.17 **Organizational and Management Information**

1.17.1 The operator was in possession of a valid Air Operating Certificate (AOC) and Air Service licence under Part 135 and Part 137. The registration, ZS-OZM was authorised for operation under the AOC. The operation was authorised to perform commercial air operations which included fire spotting, fire control and fire fighting.

1.17.2 The Aircraft Maintenance Organisation (AMO) that performed the last maintenance on the aircraft prior to the accident flight was in possession of a valid AMO Approval certificate.

1.18 Additional Information

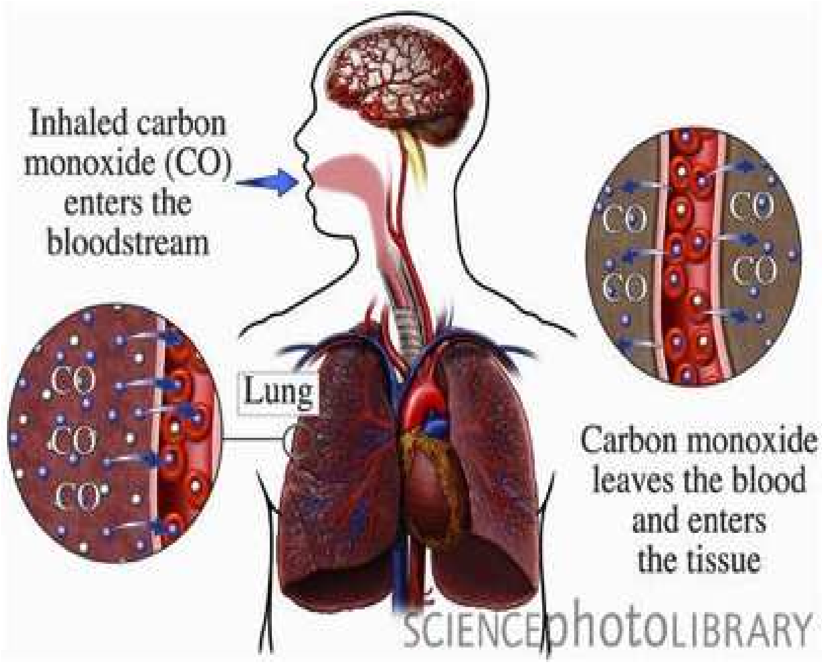
1.18.1 Carbon monoxide

1.18.1.1 Description

Carbon monoxide (CO) is a deadly, colorless, odorless, tasteless and poisonous gas. It is produced by the incomplete burning of various fuels, including coal, wood, charcoal, oil, kerosene, propane, and natural gas.

1.18.1.2 Carbon monoxide in the bloodstream

Oxygen is delivered by hemoglobin, a molecule found in red blood cells. In normal circumstances, oxygen that is breathed into the lungs is deposited on the hemoglobin molecules as blood passes through the lungs. The heart pumps the oxygen rich blood to the tissues of the body where the oxygen is unloaded to aid as a critical component to help the body’s cells metabolize glucose. When CO is breathed even in minute quantities over a period of time, it can reduce the ability of the blood to carry oxygen. Basically, it would block oxygen transport to tissues and eventually to organs like the heart. Subsequently, effects of hypoxia can occur.



1.18.1.3 <u>Symptoms of Carbon monoxide poisoning</u>

Because CO is odorless, colorless, and otherwise undetectable to the human senses, people may not know that they are being exposed. The initial symptoms of low to moderate CO poisoning are similar to the flu (but without the fever). They include:

- Headache
- Fatigue
- Shortness of breath
- Nausea
- Dizziness

High level CO poisoning results in progressively more severe symptoms, including:

- Mental confusion
- Vomiting
- Loss of muscular coordination
- Loss of consciousness
- Ultimately death

Symptom severity is related to both the CO level and the duration of exposure. For slowly developing CO problems, occupants and/or physicians can mistake mild to moderate CO poisoning symptoms for the flu, which sometimes results in tragic deaths. For rapidly developing, high level CO exposures victims can rapidly become mentally confused, and can lose muscle control without having first experienced milder symptoms; they will likely die if not rescued.

The most common symptoms of carbon monoxide exposure are shown in Table 1. These symptoms are typical for an individual with normal hemoglobin at sea level. You can expect these symptoms to worsen at altitude and/or appear sooner than they otherwise would. Wide personal variations may also occur, depending on the circumstances and whether or not the individual smokes.

Percent CO in Blood	Typical Symptoms
< 10	None
10 - 20	Slight headache
21 - 30	Headache, slight increase in respirations, drowsiness
31 - 40	Headache, impaired judgment, shortness of breath, increasing drowsiness, blurring of vision
41 - 50	Pounding headache, confusion, marked shortness of breath, marked drowsiness, increasing blurred vision
> 51	Unconsciousness, eventual death if victim is not removed from source of CO

Table 1: Carbon Monoxide (CO) Blood Levels and Possible Symptoms for an individual with normal hemoglobin at sea level

1.18.1.4 Carbon monoxide in Turbine Engines

Carbon monoxide is a by-product of the incomplete combustion of carbon-containing materials. Aviation fuel contains carbon and is a ready source of carbon monoxide when burned. Carbon monoxide can be expected whenever an internal combustion engine is operating. Even though piston engines produce the highest concentrations of carbon monoxide, exhaust from turbine engines could also cause carbon monoxide poisoning.

1.18.1.5 Carbon monoxide in fires

At least three important stages of combustion exist when fuel particles are consumed (Mobley 1976; NWCG 1985): **flaming**, **smoldering**, and **residual** (also known as "glowing," "residual smoldering," or "residual combustion") (fig. 2). The efficiency of combustion is distinct for each stage, resulting in a different set of chemical compounds and thermal energy being released at different rates into the atmosphere.

Figure 2: Flaming, smoldering and residual combustion stages during a fire

- In the **flaming phase**, combustion efficiency is relatively high and usually tends to emit the least amount of pollutant emissions compared with the mass of fuel consumed. The predominant products of flaming combustion are CO_2 and water vapor.
- During the **smoldering phase**, combustion efficiency is lower, resulting in more particulate emissions generated than during the flaming stage. Smoldering combustion is more prevalent in certain fuel types such as duff, organic soils, and rotten logs, and often less prevalent in fuels with high surface to volume ratios such as grasses, shrubs, and small diameter woody fuels (Sandberg and Dost 1990).
- The **residual stage** differs from the smoldering stage in that the smoldering stage is a secondary process that occurs in fuels preheated or dried by flaming combustion, while residual is an independent process of propagation in a fuelbed unaffected by the flaming stage. This phase is characterized by little smoke and is composed mostly of CO_2 and carbon monoxide. All combustion stages occur sequentially at a point, but simultaneously on a landscape.

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1.18.1.6 Effects of Fire on Air Quality

Wildfires and prescribed burns have potentially negative effects on air quality. All forest fires emit carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, and particulate matter.

Carbon monoxide is a poisonous gas but usually only reaches toxic levels above and adjacent to prescribed fires (McMahon and Ryan 1976). Carbon monoxide can be emitted in large amounts (approximately 140 lb/ton of fuel) during forest fires (EPA 1988).

1.18.2 Hypoxia

1.18.2.1 Description

Hypoxia, or hypoxiation, is a pathological condition in which the body as a whole (generalized hypoxia) or a region of the body (tissue hypoxia) is deprived of adequate oxygen supply. Hypoxia can be the result of many factors, including some respiratory and cardiovascular conditions, pharmaceutical drugs, toxic substances, poor blood circulation, or breathing a low partial pressure of oxygen (low air pressure). Brain cells have a uniquely high oxygen demand and are most susceptible to low oxygen levels. Brain impairment, deterioration of performance, reduced visual function, unconsciousness, and death can occur as a result of hypoxia.

Vision is particularly sensitive to hypoxia. Moderate and severe hypoxia causes a restriction of the visual field, with loss of peripheral vision. There may also be a subjective darkening of the visual field. Auditory acuity (hearing sensitivity) is also reduced by moderate and severe hypoxia, but some hearing is usually retained even after other senses such as vision are lost.

1.18.2.2 Symptoms of hypoxia

The symptoms of hypoxia depend on its severity and acceleration of onset. They may develop gradually and would take a long period of time as in the case of altitude sickness. The primary symptoms are:

- headaches
- fatigue
- shortness of breath
- feeling of euphoria
- nausea
- Hot and cold flashes
- Visual Impairment

The symptoms can also occur in a very short time and become deadly. They are:

- blue discolouration of the skin (cyanosis)
- priapism
- coma
- seizures
- changes in levels of consciousness

1.18.2.3 Stages of Hypoxia

1. Indifferent Stage

   There are no observed impairments. The only adverse effect is on visual dark-adaptation, emphasizing the need for oxygen use from the ground-up during night flights.

2. Compensatory Stage

   The physiological adjustments that occur in the respiratory and circulatory systems are adequate to provide defence against the effects of hypoxia. Factors such as environmental stress or prolonged exercise can produce certain decompensations. In general, in this stage there is an increase in pulse rate. There is also an increase in fatigue, irritability, headache, and a decrease in judgment. The individual has difficulty with simple tests requiring mental alertness or moderate muscular coordination.

3. Disturbance Stage
   In this stage, physiologic responses are inadequate to compensate for the oxygen deficiency, and hypoxia is evident. Subjective symptoms may include headache, fatigue, lassitude, somnolence, dizziness, "air-hunger," and euphoria. In some cases, there are no subjective symptoms noticeable up to the time of unconsciousness.

4. Critical Stage
   In this stage of acute hypoxia, there is almost complete mental and physical incapacitation, leading to rapid loss of consciousness, convulsions, and finally in failure of respiration, and death.

1.18.2.4 Forms of hypoxia:

Hypoxic hypoxia
Hypoxic hypoxia is a result of insufficient oxygen available to the lungs. A blocked airway or drowning are obvious examples of how the lungs can be deprived of oxygen, but the reduction in partial pressure of oxygen at high altitude is an appropriate example for pilots.

Hypemic hypoxia
This occurs when the blood is not able to take up and transport a sufficient amount of oxygen to the cells in the body. Hypemic means “not enough blood.” This type of hypoxia is a result of oxygen deficiency in the blood, rather than a lack of inhaled oxygen, and can be caused by a variety of factors.

More often it is because hemoglobin, the actual blood molecule that transports oxygen, is chemically unable to bind oxygen molecules. **The most common form of hypemic hypoxia is carbon monoxide poisoning.**

Stagnant hypoxia
Stagnant means “not flowing,” and stagnant hypoxia results when the oxygen-rich blood in the lungs isn’t moving, for one reason or another, to the tissues that need it. This kind of hypoxia can also result from shock, the heart failing to pump blood effectively, or a constricted artery. During flight, stagnant hypoxia can occur when pulling excessive positive Gs. Cold temperatures also can reduce circulation and decrease the blood supplied to extremities.

Histotoxic hypoxia
The inability of the cells to effectively use oxygen is defined as histotoxic hypoxia. “Histo” refers to tissues or cells, and “toxic” means poison. In this case, plenty of oxygen is being transported to the cells that need it, but they are unable to make use of it. This impairment of cellular respiration can be caused by alcohol and other drugs, such as narcotics and poisons.

1.18.3 Related occurrences

A number of prior occurrences involving similar factors include:

i. Transportation Safety Board of Canada (TSB) Final Report A00C0059

On 17 March 2000 the crew of a Douglas DC-3 lost control of the aircraft and crashed on an ice strip on Ennadai Lake, Nunavut. The crew had been attempting to overshoot from a balked landing. Both the pilot and co-pilot sustained fatal injuries. Investigation by the TSB revealed that CO gas had entered the cockpit area from leaks in the heater shroud assembly. Toxicology tests showed that the CO might have adversely affected the crew.

ii. BASI Occurrence 199003527

In November 1990, a Beech Super King Air 200 was flying at FL310 (31,000 ft) with a cabin altitude of 18,000 ft and with the pilot breathing through his oxygen mask. Ten minutes after reaching cruise altitude, the pilot felt tingling in his fingers. After checking his mask and oxygen system, the pilot decided to descend to FL120 (12,000 ft). As the aircraft left FL310 he removed his oxygen mask. Three to four minutes later, the pilot's symptoms were rapidly getting worse, so he put his mask on again. Later describing his symptoms, the pilot said:

> *I was barely able to move my arms, legs and hands. My hands were locked solid in a fist. My face felt distorted and speech was severely impeded. I was having considerable difficulty breathing with the mask on or off. Once level at FL120 (12,000 ft) (cabin altitude 8,000 ft) it took approximately 90 minutes to return to normal.*

The investigation found that the pilot had not used the oxygen system correctly.

iii. NTSB occurrence IAD97FA060

In April 1997, the pilot of an unpressurised Cessna 337 was cleared to climb to FL250 (25,000 ft) for the purpose of taking some high altitude photographs near Hickory, Pennsylvania, USA. When the controller queried the pilot about exceeding his assigned altitude, the pilot did not respond. The aircraft was observed to climb to FL270 (27,700 ft) before it entered a rapid, uncontrolled descent and broke up. Investigation found that the aircraft's portable oxygen bottle had been filled with compressed air instead of oxygen. That resulted in the crew being incapacitated by hypoxia.

1.19 Useful or Effective Investigation Techniques

1.19.1 None

2. ANALYSIS

2.1 On 30 August 2008 a pilot took off on a fire fighting flight from Runway 23 at Kataza Aerodrome with the intention of fire bombing and landing back at Kataza Aerodrome. As the winds were gusting between 15 to 35 knots the pilot earlier expressed his reluctance to fly in the prevailing conditions. During the flight, the pilot's third fire fighting flight for the day, the aircraft crashed into the forest approximately 1356m from Runway 23 of Kataza Aerodrome. Evidence at the accident site suggests that no attempt was made the recover the aircraft during the vertical nose-dive.

2.2 A post-mortem examination concluded the cause of death of the pilot was as a result of multiple blunt force injuries. Toxicological tests however revealed that the pilot was exposed to carbon monoxide. The carbon monoxide saturation of the haemoglobin in the specimen of the pilot was 21.3%. Carbon monoxide is a deadly, colorless, odorless, tasteless and poisonous gas. It is produced by the incomplete burning of various fuels, including kerosene, coal and wood.

The level of 21.3% is significant since in the range of 20-30% the symptoms will be headache, slight increase in respirations and drowsiness. The post-mortem examination stated that the 21.3% of carbon monoxide saturation of the haemoglobin will lead to impairment in the execution of complex tasks. The post-mortem report further stated that as there was a presence of minimal coronary artery disease, such disease with myocardial insufficiency, obstructive airway disease and even old age with the presence of 21.3% carbon monoxide saturation of the haemoglobin may have been a fatal concentration.

2.3 Carbon monoxide is a by-product of the incomplete combustion of carbon-containing materials. Aviation fuel contains carbon and is a ready source of carbon monoxide when burned. Even though piston engines produce the highest concentrations of carbon monoxide, exhaust from turbine engines could also cause carbon monoxide poisoning. Forest fires also emit carbon monoxide and it can be emitted in large amounts. Therefore both the aircraft engine exhaust and forest fire could have contributed to the carbon monoxide poisoning of the pilot.

When the carbon monoxide entered the bloodstream of the pilot it reduced the ability of the blood to carry oxygen to the organs and resulted in hypemic hypoxia. The pilot entered a state of drowsiness and the aircraft went into an uncontrolled steep nose-dive descent and impacted the ground in a nose-down attitude.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot was properly licensed and qualified for the flight in accordance with existing regulations.

3.1.2 Toxicological tests revealed that the pilot was exposed to carbon monoxide.

3.1.3 The carbon monoxide saturation of the haemoglobin in the specimen of the pilot was 21.3% which resulted in hypoxia of the pilot.

3.1.4 The aircraft had a valid Certificate of Airworthiness at the time of the accident.

3.1.5 The maintenance records indicated that the aircraft was maintained in accordance with existing regulations and approved procedures and the aircraft was serviceable when dispatched for the flight.

3.1.6 There was no evidence of airframe failure or system malfunction prior to the accident.

3.1.7 Evidence at the accident site indicated that the engine was producing power at impact.

3.1.8 Wind speeds between 15 to 35 knots were recorded at the time of the accident.

3.1.9 The pilot lost control of the aircraft and crashed vertical into the ground.

3.2 Probable Cause/s

3.2.1 The pilot loss of control of aircraft due to the effects of hypoxia.

4. SAFETY RECOMMENDATIONS

4.1 After the review of CO-related accidents, various aviation regulatory bodies issued information circulars and advisories regarding detection and prevention of carbon monoxide exposure in general aviation aircraft.

It is therefore recommended that an article is published alerting the aviation public regarding the detection, prevention and hazards of carbon monoxide exposure and the advantages of CO detectors in aircraft.

4.2 On 15 September 2002 an SACAA Aeronautical Information Circular, AIC 21-34, was issued regarding the use of oxygen at 10000 feet with the objective of preventing hypoxia.

It is also recommended that a feasibility study be done regarding the use of supplemental oxygen by flying crew during fire fighting operations where heavy smoke is present and subsequent recommendations be implemented.

Compiled by:

.... Date: ……………………………..
for Commissioner for Civil Aviation

Investigator-in-charge: ……………………………… Date: …………………………..

Co-Investigator: ………..………………………… Date: …………………………