AIRCRAFT ACCIDENT AND INCIDENT INVESTIGATION AND PREVENTION BUREAU (AIB GHANA)

REPORT ON CABIN DEPRESSURISATION SERIOUS INCIDENT INVOLVING AFRICA WORLD AIRLINES AIRCRAFT, 9G-AET

2ND FEBRUARY 2024

AIRCRAFT SERIOUS INCIDENT REPORT
AIB/2024/02/02/SINCID

About the Aircraft Accident and Incident Investigation and Prevention Bureau

The Aircraft Accident and Incident Investigation and Prevention Bureau (AIB Ghana) is a standing Bureau of investigation and an independent entity responsible for inquiring into aviation accidents, serious incidents and incidents for Ghana, and coordinating and co-operating with other accident investigation organisations overseas.

The principal purpose of its inquiries is to determine the circumstances and causes of the occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Bureau carries out its purpose by informing members of the transport sector and the public, both domestically and internationally, of the lessons that can be learnt from aviation accidents, serious incidents and incidents.

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Published: 21st October 2024

Table of Contents

Important notes

Nature of the final report

This final report has not been prepared for the purpose of supporting any criminal, civil or regulatory action against any person or agency. The Aircraft Accident and Incident Investigation and Prevention Bureau Act 2020, Act 1028 makes this final report inadmissible as evidence in any proceedings with the exception of a Coroner's inquest.

Ownership of report

Citations and referencing

Information derived from interviews during the Bureau's investigation into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Right of Information Act, 2019, Act 989 have been referenced as footnotes only. Other documents referred to during the Bureau's investigation that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Bureau.

Verbal probability expressions

The expressions listed in the following table are used in this report to describe the degree of probability (or likelihood) that an event happened or a condition existed in support of a hypothesis.

Table 1. Verbal Terminologies

Terminology	Likelihood occurrence/outcome	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

Figure 1. PHOTOGRAPH OF EMBRAER 145 LR.

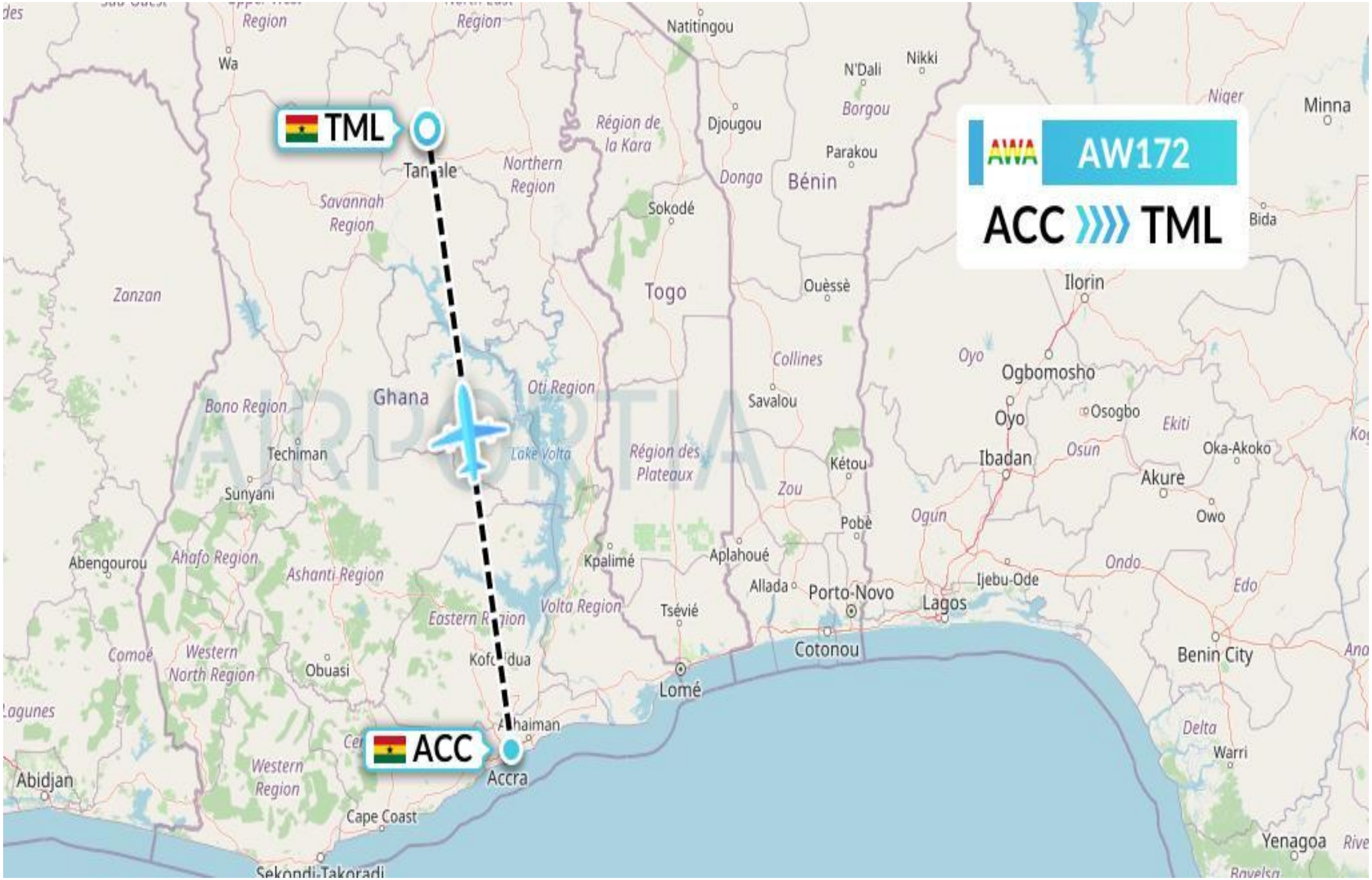

Figure 2. Flight Route of 9G-AET

ABBREVIATIONS

AWA	Africa World Airline
AMM	Aircraft Maintenance Manual
APU	Auxiliary Power Unit
ATC	Air Traffic Control
BACV	Bleed Air Check Valve
ECU	Environmental Control Unit
FDC	Flight Deck Crew
FDR	Flight Data Recorder
FLB	Flight Logbook
FT	Feet
KIA	Kotoka International Airport
GCAA	Ghana Civil Aviation Authority
HSV	High Stage Valve
MEL	Minimum Equipment List
PACK	Pressurisation and Air-condition Kit
PIC	Pilot In Command
QRH	Quick Reference Handbook
EICAS	Engine Indicating and Crew Alerting System
TUC	Time of Useful Consciousness

GLOSSARY

altitude	the height above mean-sea level
annunciator	a captioned light that provides information on the state of a system
bleed air	air tapped off one or more compressor stages of a turbine engine and used to supply some other systems
cabin altitude	the pressure of the air inside an aircraft cabin expressed as the altitude in the atmosphere at which the same pressure would be found
Cross bleed valve	valve that directs bleed air between two engines
differential pressure	the difference between cabin pressure and the ambient pressure
pack system	an air-conditioning system unit

DATA SUMMARY

Aircraft particulars

Aircraft registration:	9G-AET
Type and serial number:	Embraer 145 LR/14500992
Number and type of engines:	2xRR AE3007A1/1
Year of manufacture	2007
Operator:	Africa World Airline
Type of flight	commercial
Persons on board	45
Pilot in command's licence	Airline Transport Pilot License
Pilot in command's age	44
Pilot in command's total flying experience	2407:29
Date	2nd February 2024
Location	In-flight en-route, Accra to Tamale
Injuries	Nil
Damage	Nil

1.0. EXECUTIVE SUMMARY

1.1. On 2nd February 2024 an Embraer 145 LR aircraft operated by Africa World Airlines was on a commercial service between Accra and Tamale. After the aircraft climbed to an altitude of 22,000ft, it encountered slight icing. At 24,000ft, the aircraft was out of icing and the flight was progressing normally until the captain spotted the Cabin pressure at 8,600ft showing amber. The pilots commenced the relevant emergency procedures and made a normal landing at Kotoka International Airport. No one was injured and the aircraft was not damaged.

1.2. The Aircraft Accident and Incident Investigation and Prevention Bureau (AIB Ghana) was unable to identify the cause of the depressurisation despite extensive testing and a specialist examination of the pressurisation system.

1.3. The Bureau made **findings** relating to the following **safety issues**:

- non-adherence to the published emergency checklists for a loss of cabin pressure.
- the training of cabin crew in the use of emergency oxygen equipment and the cabin depressurisation procedure.

1.4. The operator acted to correct these issues. Therefore, the Bureau made three safety recommendations regarding them.

1.5. In addition, the investigation recommended the demonstration for the chemical oxygen generator and the deployment of the oxygen masks to be tested manually and automatically. AWA informed the Bureau that the automatic test can not be conducted due to the possibility of damage to aircraft and personnel.

1.6. The **key lessons** identified from the investigation into this occurrence were as follows:

- An unexpected loss of cabin pressure in any aircraft is a serious event that can cause both passengers and crew to lose consciousness rapidly from a lack of oxygen. In such an event the appropriate emergency actions must be undertaken immediately. Where oxygen masks are fitted, passengers and cabin crew must put on their masks and await further instruction from the flight crew.

- The purpose of emergency procedure checklists is to ensure that crew members do not miss an important action at a critical time of high workload. Therefore, unless the captain has an exceptional reason to deviate from a checklist, it should be performed from beginning to end, if possible without interruption, and without omitting any step.
- Crew members must be thoroughly trained in and familiar with all emergency equipment and procedures because the equipment and procedures are for their own protection as well as that of the passengers. They need to be alert for emergency situations that differ from the standard scenarios that are practiced and demonstrated repeatedly.
- Special care must be taken with the maintenance of aircraft emergency equipment, such as oxygen systems.

2.0. CONDUCT OF THE INVESTIGATION

2.1. Shortly after the aircraft landed at KIA, Africa World Airlines (the operator) notified the Aircraft Accident and Incident Investigation and Prevention Bureau (AIB Ghana) directly of the occurrence. The operator promptly quarantined the aircraft and its flight recorders. The Bureau opened an investigation and notified the Ghana Civil Aviation Authority (GCAA) and the operator. (See Appendix 1)

2.2. The Quality, Safety, and Engineering officers were interviewed on the 22nd of March 2024. The pilots and a member of the cabin crew were interviewed on the 27th of March 2024.

2.3. On 3rd April 2024 the Commissioner issued safety recommendations as part of preventive and safety measures to the AWA in respect to all the aircraft in its fleet.

2.4. The completion of the investigation report was delayed by higher-priority investigations. In addition, it was apparent early in the investigation that the cause was unlikely to be determined.

2.5. On July 2024 the Commissioner approved a draft report for circulation to interested persons for comment.

2.6. Submission was received from the operator. The Commissioner has considered all submissions and any changes as a result of those submissions have been included in this final report.

3.0. FACTUAL INFORMATION

3.1. Introduction – the need for cabin pressurisation and emergency oxygen

3.1.1. Turbine-powered aircrafts generally fly at high altitudes because their performance is more efficient in the less dense air. As altitude increases the atmospheric pressure decreases. However, above about 10,000 feet (ft) (3,000 metres), the lower atmospheric pressure is detrimental to people because their lungs do not absorb sufficient oxygen. As the oxygen content of blood decreases, one's ability to think and act efficiently becomes impaired. In severe cases, unconsciousness and death can occur.

3.1.2. This problem is avoided for aircraft passengers by pressurising the aircraft, using the conditioned air that is pumped into the cabin. Aircraft that fly above 10,000 ft will usually be pressurised. The cabin air is normally maintained at a pressure that is equivalent to that found between 5,000 and 8,000 ft in the atmosphere. Therefore, when the cabin is pressurised, the 'cabin altitude' is lower than the 'flight altitude'. (see Figure 3).

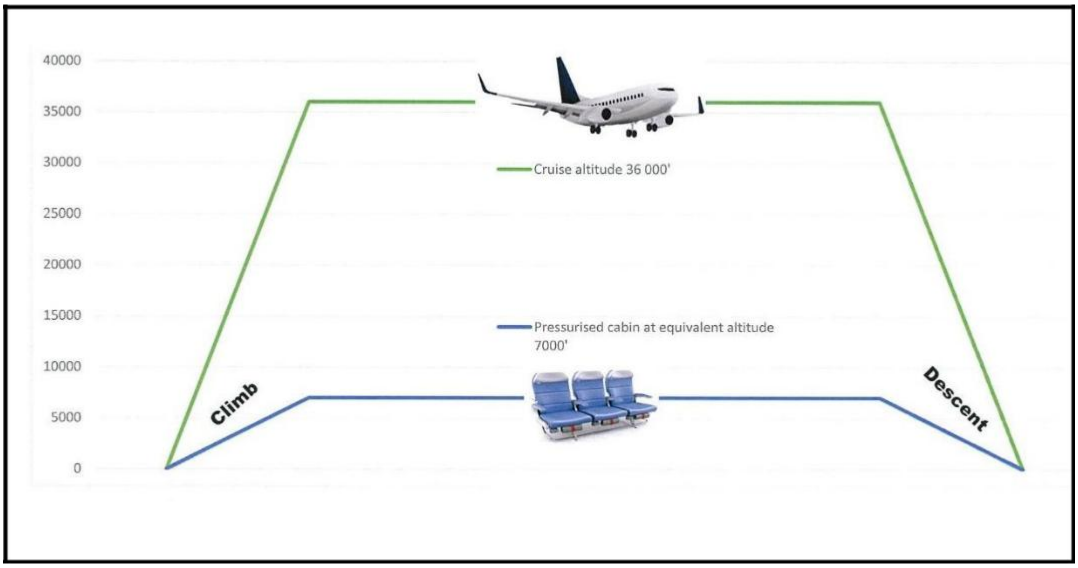

Figure 3. Cabin altitude compared with flight altitude (illustrative only)

3.1.3. Civil aviation rules, in general, require pressurised aircrafts to have emergency oxygen available in case cabin pressure is lost at high altitude. Typically, the emergency oxygen is supplied automatically from units above the seats (and in the toilets) before the cabin pressure decreases to an unsafe level. The pilots have a separate oxygen supply, but the supply for pilots and passengers is limited. Therefore, in the event of a loss of cabin pressure, the aircraft must descend quickly to an altitude where there is adequate oxygen.

3.1.4. A loss of cabin pressure is a rare event, but if mishandled it can cause injury or death. Prompt and correct action on the part of the pilots may mean that control of the cabin pressure is regained and the need for an emergency descent averted. However, if oxygen masks appear in the cabin everyone must fit their mask immediately and keep it on until instructed otherwise.

3.2. The incident

3.2.1. On Friday 2nd February 2024 an Embraer 145 LR, registered 9G-AET, operated a commercial flight between Accra and Tamale. The crew comprised two pilots, one captain and co-pilot, and two cabin crew. The aircraft was dispatched on MEL with PACK 1 unserviceable. The Pilot's filed cruising altitude of 24,000ft which was the highest altitude they could fly on our route PACK 1 unserviceable. The aircraft departed Accra with 45 passengers and climbed to a cruise altitude of 24,000ft.

3.2.2. When the aircraft was climbing from 22,000ft, it encountered slight icing which lasted briefly. In icing the aircraft ice protection was automatically activated which triggered 3 EICAS messages: WG ANTI-ICE FAIL, ICE CONDITION A/I INOP and BLD 2 LOW TEMP followed by BLD 1 OVTEMP. At 24,000ft we were already out of icing and the flight was progressing normally until the captain spotted the cabin pressure at 8,600ft showing amber. Immediately the captain prompted the first officer.

3.2.3. The captain switched on the seat belt sign and donned the oxygen mask. The captain requested initially to descend to 19,000ft initially from ATC and immediately commenced descent. The captain announced to ATC ATTENTION CREW

EMERGENCY DESCENT. The cabin altitude rose to 12,200ft. The first officer declared an emergency descent with ATC and requested to turn back to Accra. The first officer requested to descend to 10,000ft. As they were established in the descent the cabin altitude started dropping. When they were leveled off at 10,000ft the cabin altitude levelled off at 9,900ft and descended further to 8,600ft.

3.2.4. Shortly after the water service on flight AW172, the seat belt sign was turned on again and this was followed by an announcement 'cabin crew emergency descent', whiles the aircraft was descending. The Senior Cabin Crew called out to alert the Captain that the oxygen mask had not deployed automatically, necessitating that the first officer deploy it manually. We went through the QRH for Rapid cabin depressurization and emergency descent. (See Appendix 3 – Emergency Checklist). After the masks were deployed manually, crew shouted the command for passengers to don their masks.

3.2.5. However, the masks at the forward cabin crew seat did not deploy and so the senior cabin crew used the one at seat 1A, but the mask at the forward cabin crew seat finally did deploy much later. Oxygen mask at seat 3D and 3F were half-hanging and could not be used. The affected passengers were swiftly moved to seat 17D and 18D. Also, the

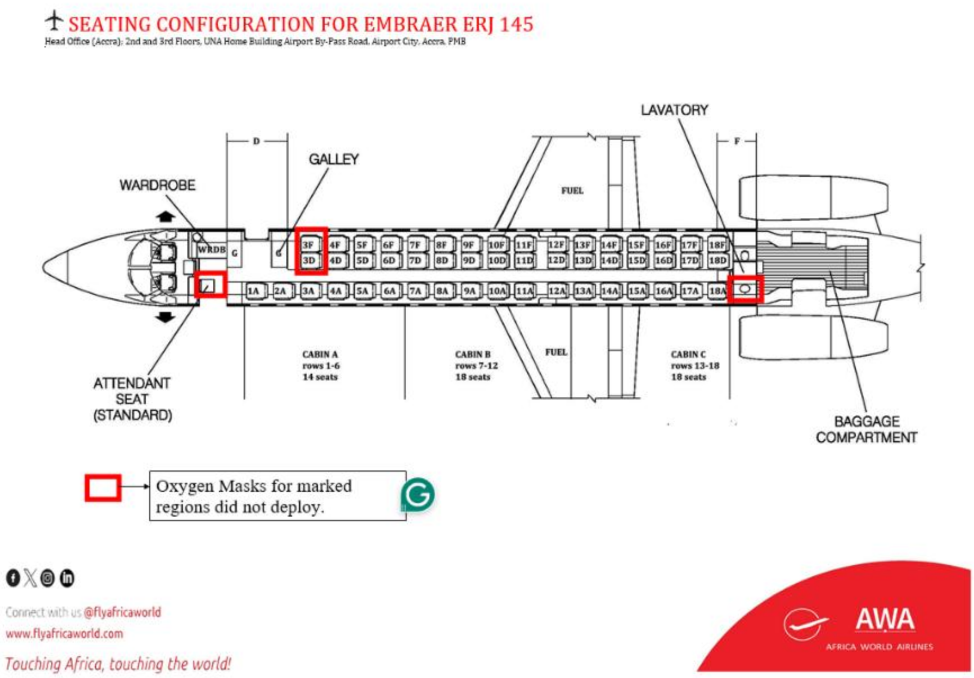

Figure 4. Seating Configuration For Embraer ERJ 145 (Seats for which Oxygen Mask did not Deploy)

oxygen compartment in the lavatory opened but did not deploy, although it was unoccupied at the time.

3.2.6. When the captain announced that we have reached a safe altitude, the cabin crew informed passengers to take off their masks. The Captain briefed the passengers to reassure them the situation was under control. Cabin crew checked on passengers and reassured them. The announcement after the incident made passengers to feel at ease. Bottles of water were offered to passengers that required it. Wet tissues were later distributed to passengers due to the mist in the cabin as well as the smell that was emitting from the oxygen generators.

3.2.7. After landing, passengers commended crew for maintaining a calm composure throughout as they disembarked. Passenger manifest and load sheet are attached.

3.2.8. The incident occurred in daylight. Some passengers reported ear discomfort. Otherwise, there were no injuries.

3.3. Personnel information

3.3.1. The pilot in command had more than 2407:29 hours' flight experience, including hours on the Embraer 145. He was employed in a fleet management role and had been on simulator training for a total duration of 8hours . He said he had been fit to fly on 2nd February 2024.

3.3.2. The Copilot had more than 4490:01 hours' flight experience, including 4327:16 hours on the Embraer 145. He was employed in a fleet management role and had been on office or simulator training for a total duration of 8hours. He said that he had been fit to fly on 2nd February 2024.

3.3.3. The senior Cabin Crew, had been employed by the operator as a flight attendant in 18 years and promoted to purser in 11th March 2019. He has received cabin crew training and holds cabin crew member certification issued on 16th June 2022 and expiring on

30th June 2027. They all considered themselves familiar with the Embraer 145 and said they had been fit to fly that day.

3.4. Aircraft information

3.4.1. The Embraer 145 LR features a new swept wing and is powered by two rear-fuselage-mounted Rolls-Royce AE 3007 A1 turbofans. The family includes the ERJ 135 (37 passengers), ERJ 140 (44 passengers), and ERJ 145 (50 passengers). The normal crew is two pilots and three cabin crew. Depending on the cabin configuration, up to 50 passengers can be carried.

3.4.2. 9G-AET had been registered in Ghana on the 28th of August 2012. Embraer entered a partnership with the Chinese aerospace manufacturer Harbin Aircraft Industry Group to jointly produce the ERJ 145 in Harbin, China.

3.5. Embraer 145 LR Pressurisation

3.5.1 The pneumatic system can be supplied by the engines, APU or a ground pneumatic source. The APU or ground pneumatic source supplies the system prior to the engine start. The engines normally supply bleed air for pneumatics after engine start.

3.5.2 The air conditioning system receives air from the pneumatic system and provides conditioned air to the cabin. The system is controlled by two Environmental Control Units (ECU). The pressurization system uses air from the air conditioning system to pressurize the airplane. Cabin pressure is controlled by modulating the outflow valves.

3.5.3 The system is controlled by an automatic mode and has a manual back-up mode. System information and messages are presented on the EICAS. **See Appendix 2**

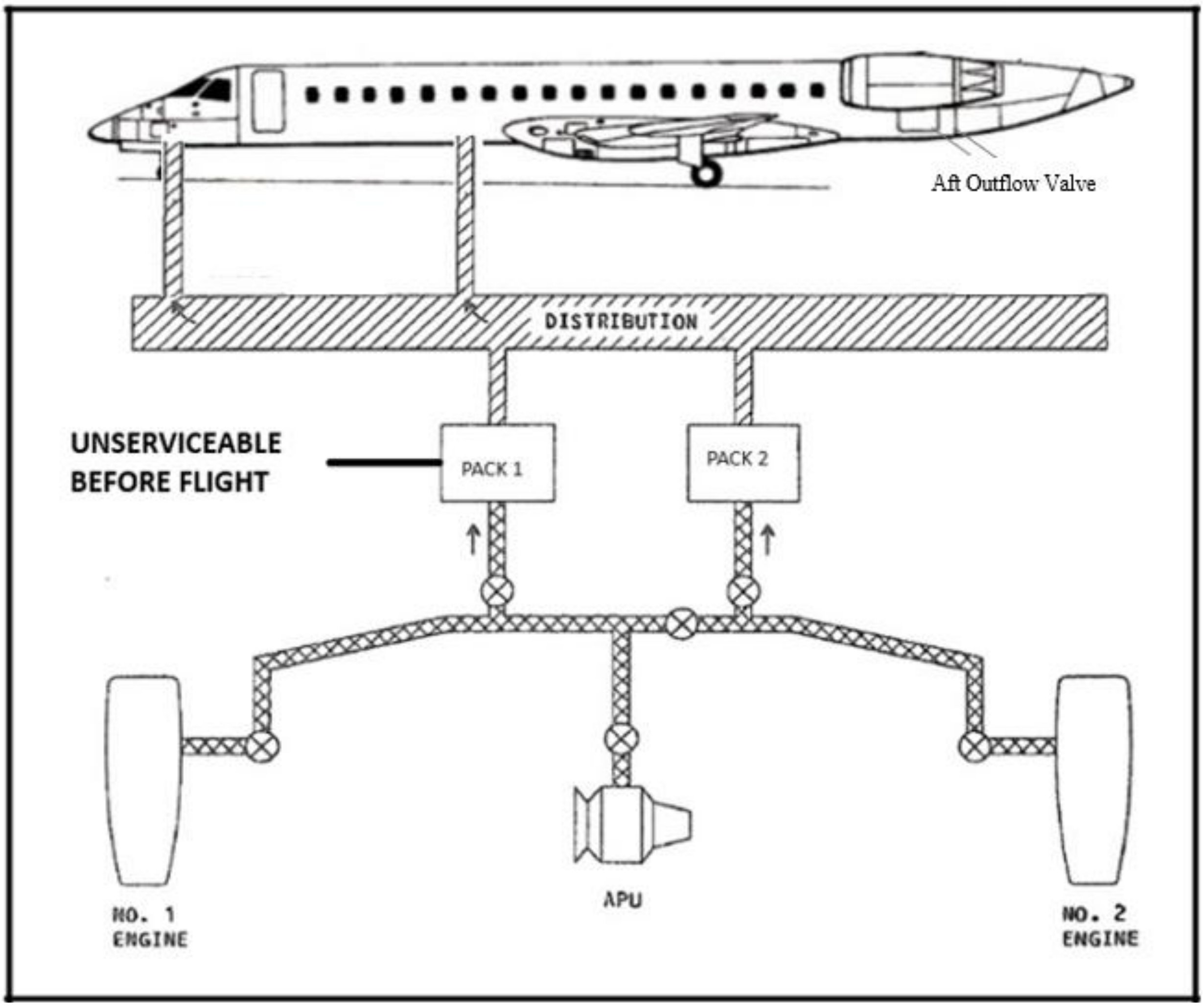

Figure 5. Schematic of Embraer 145 LR Pressurisation and Air Conditioning system

3.6. Flight recorders

3.6.1. The aircraft was fitted with a cockpit voice recorder with 30-minute recording duration.

3.6.2. The aircraft was fitted with a digital flight data recorder. However, unlike recorders on more modern aircrafts the recorder did not, and was not required to, record potentially useful parameters such as actual bleed air duct pressures and the outflow valve position.

3.7. Post-incident testing

3.7.1. The crew reported the below functions and returned to Base, landing at 1334hrs:

- wing anti-ice fail condition – FLB #00123768
- Captain report ASIR 15714

- Bleed 2 valve fail after exiting icing condition – FLB #00123768
- bleed 1 overtemp in icing condition FLB #00123770
- Cabin altitude climbed above 10,000ft – FLB #00123770

3.7.2 Investigation conducted by AWA Engineers concluded there was an erroneous assumption that the oxygen mask had failed to deploy automatically. The masks normally deploy at 14,000ft cabin altitude and not 10,000ft. The cabin altitude did not reach the threshold for automatic deployment of 14,000ft.

3.7.3. The rectification process was carried by the AWA Maintenance Department.

The defects were duly corrected in accordance with the applicable Aircraft Maintenance Manual (AMM) task instructions. Details are captured on the Mandatory Occurrence Reporting Form attached. All system operational tests performed tested OK, and the aircraft was released to service.

3.8 Initial inspection

3.8.1. Both digital pressure controllers were tested with satisfactory results before the aircraft was towed from the airport to the hangar and placed under quarantine. The results from the three EICAS messages showed that there had been an 'inflow/leakage fail' just over a minute prior to the cabin altitude aural warning. It meant there was a low inflow of air or excessive air leakage.

3.8.2. The aircraft was inspected visually for any sign of structural damage or mechanical defect, and the condition of controls and oxygen masks in the flight deck and cabin was recorded before electrical power was applied to the aircraft to allow further checks.

3.9. Test for structural breach.

The aircraft underwent detailed instructions for maintaining and inspecting the aircraft. The Embraer 145 Maintenance Manual covers various aspects, including structural checks and repairs. These include procedures for examining critical components, assessing wear and tear, and identifying any potential breaches.

3.10. Wing Anti-icing Valve

The Wing Anti-Ice system includes valves located at each wing root. When activated, the Wing Anti-Ice valve opens, preventing ice accumulation on the wings. This action ensures that the wings remain ice-free, maintaining aerodynamic performance. It was observed during the incident, the wing anti-ice fail condition – Flight Log Book (FLB) #00123768. This was rectified by anti-icing operations test performed in accordance with Aircraft Maintenance Manual (AMM II Task 30-11-01-400-801-A).

3.11. Bleed #2 Valve

The Bleed 2 Valve controls the flow of high-pressure air from engine #2 to PACK 2 system. During normal operations, the Bleed 2 Valve opens automatically providing bleed air for the pressurization of the Cabin. It was observed during the incident, Bleed 2 valve fail after exiting icing condition – FLB #00123768. This was rectified by replacing the Bleed valve with a new in accordance with Aircraft Maintenance Manual (AMM II Task 36-11-05) after which an engine run for bleed air system test was subsequently performed.

3.12. Air via Bleed #1 Valve

The 14th stage of the engine provides high-pressure bleed air. This air serves several functions such as, ice protection used for anti-icing systems, and low thrust setting during certain phases of flight, low thrust settings benefit from this bleed air. It was observed during the incident, Bleed 1 overtemp in icing condition FLB #00123770. This was rectified by Removing and replacing Fan air valve #1 in accordance with the Aircraft Maintenance Manual (AMM II Task 36- 11-03-04). An air bleed system operations test was performed in accordance with the Aircraft Maintenance Manual (AMM II Task 36-00-00-700-803-A).

3.13. Cabin Altitude Climb

The Embraer ERJ 145 has a service ceiling of 37,000 feet. This means that the aircraft can ascend to 37,000 feet above sea level, maintaining a cabin pressure equivalent to approximately 8,000 feet. It can achieve this altitude with a rate of climb of 2000 feet per minute. It was observed during the incident, Cabin altitude climbed above 10,000ft – FLB #00123770. This was rectified by running a pressurization Control system functional test in automatic mode, performed in accordance with Aircraft Maintenance Manual (AMM II Task 21-31-00-700-802-A) which tested okay.

3.14. Cabin Oxygen Generator

The oxygen system is divided into two different and separate systems a gaseous-type for crew members (pilot, copilot and observer) and a chemical generation-type one for passengers and flight attendants. It was observed after the incident that, Cabin Oxygen Generators deployed with exception of the lavatory oxygen generator. This was rectified by replacing all oxygen generators deployed with new in accordance with Aircraft Maintenance Manual (AMM II Task 35-20-01-04).

3.15. Further testing

3.15.1. After the initial fault finding, the Bureau issued safety recommendations for further testing on the chemical oxygen generator and deployment of oxygen masks on all AWA aircrafts

3.15.2. operational tests of the manual deployment systems have been successfully performed on the operating fleet and documented in FLB pages as indicated. All masks were inspected including the ones at 3D, 3F, and the lavatory, and found to be fully deployed.

3.16. Deployment of Lavatory Oxygen Mask

3.16.1. The supporting evidence in the form of a repair order from stores for servicing and calibration of the test set has been attached. (See Appendix 4).

Figure 6 : Deployed Lavatory Oxygen Mask

4.0. ANALYSIS

4.1. Introduction

4.1.1. Cabin depressurisation events are rare but potentially dangerous. The cabin pressurisation system operated normally during recent flights from Accra to other regional airports. En-route from Accra to Tamale, shortly after reaching cruise altitude the cabin pressure showed amber. The cabin pressure began decreasing at a rate equivalent to a climb rate of up to 2,000 ft per minute. A decrease in the cabin pressure is usually expressed as an increase in the cabin altitude.) Pilots would normally detect such a rapid decrease in cabin pressure through physiological changes (for example, ear 'popping'). However, in this case the cabin rate increase appears to have occurred just prior to the cabin altitude warning horn sounding, which gave no time for the flight crew to take pre-emptive action to control the pressure change.

4.1.2. In spite of extensive inspections and a detailed examination of key components of the pressurisation system, no definite cause was found for the loss of cabin pressure. The following analysis discusses a number of technical factors that might have contributed to the cabin depressurising.

4.1.3. This analysis also discusses the following four safety issues that were identified in the investigation:

- non-adherence to the published emergency checklists for a loss of cabin pressure
- the training of cabin crew in the use of emergency oxygen equipment and the cabin depressurisation procedure.
- Pressurization Control system functional test in automatic mode performed in accordance with Aircraft Maintenance Manual (AMM II Task 21-31-00-700-802-A).

- Manual and automatic testing on the chemical oxygen generator and deployment of oxygen masks on all AWA aircrafts.

4.2. Factors that affect cabin pressure

To pressurise the cabin, air is supplied continuously from the engines via the air-conditioning packs. The pressure is regulated by controlling the exit of air from the aft outflow valve. Therefore the cabin pressure is affected by the following factors:

- the inflow, or supply, of air from the engines to the cabin
- the controlled (regulated) leakage of air from the cabin
- any uncontrolled leakage of air from the cabin.

4.3. Defects that could cause reduced air supply

4.3.1. Key components of the air-conditioning and pressurisation system that are involved in the supply of cabin air are:

- the engine bleed valves.
- the packs.

4.3.2. Engine bleed air comes from the 9th (low pressure) or 14th (high pressure) engine stages depending on the system demand. The 14th stage High Stage Valve (HSV), which is electrically commanded and pneumatically-actuated, opens automatically during low engine thrust operations, engine cross bleed start and anti-ice operation. As thrust increases, the HSV closes and the 9th BACV (Bleed Air Check Valve) opens supplying bleed air to the system. There have been incidents where high stage bleed valves have had intermittent, but unidentifiable, defects. However, the operator was unaware of any defect on the high stage bleed valve.

4.3.3. The air conditioning system incorporates protection features in the temperature controllers which shut off the system in case of malfunctions (duct leakage, duct overtemperature, and pack overtemperature). On the incident flight, one pack was providing no flow when it was in automatic mode. The Minimum Equipment List (MEL) states that with PACK 1 unserviceable the aircraft dispatched could do so within a duration of Ten (10) days.

4.3.4. The engine bleed air valve #2 tested fail after the incident.

4.3.5. Summary

No individual component of the cabin pressurisation system was identified as having caused the loss of cabin pressure. The outflow valve, selector panel, and cabin pressure controller all have internal, built-in test functions that report any faults affecting the control of cabin pressure, whether intermittent or constant, to the controller, which records these faults to non-volatile memory. The non-volatile memory data for this incident was examined and no pressurisation system failures were recorded. Experience has shown that older pressurisation system components can have intermittent faults that do not show during subsequent testing. A combination of components with low or marginal performance could have caused the incident, but no such combination was identified. The Operator submitted that the cabin pressure continuing to decrease when the outflow valve was closed indicated a root cause that was related to insufficient cabin air inflow.

4.4. Response to the emergency

4.4.1. Flight Crew Actions

4.4.1.1. Pilots and cabin crew must memorise and frequently practise emergency procedures so that they react promptly and correctly. In particular, crew members must not delay putting on oxygen masks as soon as there is a clear indication of a loss of cabin pressure.

4.4.1.2. The pilot in command may take whatever action is necessary under the circumstances to ensure the safety of everyone on board. That authority extends to varying an emergency checklist if conditions require it. However, an unnecessary deviation from the published emergency procedures is a safety issue if it is done without knowing why the step was in the checklist or the potential consequences of the variation.

4.4.1.3. A loss of cabin pressure is one of the few in-flight conditions that require an immediate, memorised response by pilots. The usual training for this event is a simulated rapid decompression while at cruise altitude. Pilots frequently practise this exercise so the memorised actions counter the surprise and workload of an actual emergency, which could otherwise lead to their making errors. This incident differ from the practised scenario because the loss of cabin pressure occurred when the aircraft was already at cruise altitude. It was conceivable that the circumstance interfered with the pilots' recall and performance of the memorised actions.

4.4.1.4. Both pilots fitted their oxygen masks immediately after they recognised the cabin pressure indicator showing amber. Their actions conformed to the published procedure in the following area:

- the Quick Reference Handbook (QRH) for rapid cabin depressurisation and emergency descend

4.4.1.5. The pilot monitoring said he deployed the oxygen masks manually after being alerted by the Senior Cabin Crew that the Cabin oxygen masks did not deploy. Oxygen is not generated until a deployed mask is pulled down, so not selecting automatic or manual would prevent the generation of oxygen.

4.4.1.6. In this case the deviations were of a minor nature and did not affect the safe outcome. Nevertheless, the operator has, during annual training programmes for pilots, emphasised the importance of adhering to published checklists.

4.4.1.7. One of the pre-flight tasks of the pilot sitting in the right seat was to set the planned cruise altitude in the pressure control panel. In this case, the copilots selected altitude for the flight to Tamale at 24,000 ft instead of the normal altitude of 36,000ft. The Minimum Equipment List (MEL) required setting the cruise altitude minor error in setting the cruise altitude could have been made by any pilot because the air condition PACK 1 was unserviceable as stated in the Minimum Equipment List(MEL).

4.4.1.8. One of the pilots made a radio call to Air Traffic Control (ATC), to advise ATC of the emergency descent. He did not begin the message with the words, 'MAYDAY, MAYDAY', which are internationally recognised to mean an aircraft faces an urgent situation. The Bureau previously noted the omission of the recognised words by pilots making radio calls to advise of situations of urgency (or distress).

4.4.1.9. In view of the improvements made by the operator to pilot training, the Bureau made no recommendation regarding any of the above issues.

Finding

3. The pilots did not follow exactly the emergency checklist actions, which increased the risk of an action being omitted or a required sequence of actions being altered.

4.5.2 Response in the cabin

4.5.2.1. The crew members of any pressurised aircraft must be acutely aware of the hazard of a loss of cabin pressure. The 'time of useful consciousness' remaining after pressurisation is lost or the oxygen supply is interrupted illustrates the seriousness of the hazard (see Appendix 5). The time available cannot be predicted accurately because it depends on the nature of the event and an individual's physiology and level of exertion at the time. If a rapid depressurisation occurred at 25,000 ft, the time of useful consciousness could be as little as 90 seconds. However, cognitive performance could be impaired more quickly, in which case the affected person might be unable to recall or take the required actions. Therefore it is imperative that a mask be fitted as soon as possible and remain fitted until the wearer is instructed that it may be removed.

4.5.2.2. An incident in the United States in which a Boeing 737 lost cabin pressure as a result of a structural failure provides an example of the hazard. One of the flight attendants, who thought he could get a lot more done before having to put on a mask, lost consciousness and fell, suffering a fractured nose. A passenger who was also not wearing a mask tried to help the attendant and also lost consciousness. Both regained consciousness during the descent.

4.5.2.3. On the incident flight to Tamale there was no prior indication, such as a perceptible cabin air pressure change or an announcement by a pilot, that the oxygen masks might deploy. Nevertheless, all passengers followed the standard instructions for fitting masks that are given before every flight. However, some of the oxygen masks did not deploy. A delay in fitting a mask might lead to cognitive impairment that could endanger the individual and others.

4.5.2.4. The senior Cabin Crew, moved from the forward cabin crew seat because the oxygen mask did not deploy. The Senior Cabin Crew followed the Operator Cabin Crew training and moved to the nearest front seat available and fitted on the oxygen mask. Both Cabin Crews received oxygen before moving affected passengers from seats that the oxygen masks did not deploy.

4.5.2.5. Later inspection showed that the oxygen generator at the forward cabin crew seat had been activated. Therefore senior Cabin Crew had been supplied with oxygen. It was highly likely that she saw only the edge of the flow indicator, which may be slightly visible even when there is no flow. The operator's training for cabin crew had not demonstrated how the indicator becomes fully visible when oxygen is flowing. The operator has since revised its cabin crew training to describe and demonstrate the oxygen system more accurately.

4.5.3 Crew Training and Procedures

4.5.3.1. Crew members must be completely familiar with the emergency equipment installed for the passengers' and their own safety. Senior Cabin Crew's incorrect interpretation of the oxygen mask flow indicator and delay in putting on a mask suggested some unfamiliarity with the equipment and the actions to be taken for a pressurisation incident, which indicated a need to improve the cabin crew training programme and resources.

4.5.3.2. The operator submitted that depressurisation and the associated procedures and equipment were covered in detail during initial and recurrent training for crews. The training involved lectures, videos and practical exercises. However, the operator also submitted that the observed cabin crew procedural non-conformances might have been due to the artificiality of the training scenarios. To reduce the potential for lapses like those seen in this incident, the operator instituted monthly crew briefing questions and assessments of individual competency in the depressurisation drills during the annual line checks.

4.5.3.3. In view of the improvements made by the operator to cabin crew training, the Bureau made no recommendation regarding any of the above issues.

Finding

4. The actions of some of the cabin crew during the incident showed that their emergency training had not sufficiently stressed the importance of sitting down and fitting a mask without delay and had not allowed for a range of scenarios or adequately familiarised the crew with the oxygen equipment.

4.5.4. Cabin Altitude Warning Checklist

4.5.4.1. The cabin altitude warning system alerts the flight crew when the cabin pressure altitude exceeds a safe threshold. This is essential because high cabin altitude can lead to hypoxia (insufficient oxygen) for passengers and crew. The warning typically triggers when the cabin altitude reaches a certain level above sea level (e.g., 10,000 feet or higher).

When the cabin altitude warning activates, pilots should follow established procedures to address the situation promptly. Here's a simplified checklist:

Don oxygen masks: The flight crew should don their oxygen masks immediately to ensure their safety.

Initiate an emergency descent: Reduce altitude rapidly to a safe level (usually below 10,000 feet) to restore normal cabin pressure.

Communicate with air traffic control (ATC): Inform ATC about the emergency descent and request priority handling.

4.5.4.2. The Embraer manuals did not explain that the cross-bleed valve system configuration after performing the Cabin Altitude Warning checklist could allow the cabin to re-pressurise. The operator said that the depressurisation scenario had not been anticipated before this incident, and therefore its Embraer 145 pilots had not been trained for it.

The operator submitted that, during the incident, the cross-bleed valve was in automatic mode, and as a result, bleed air from the bleed #1 valve could not reach Pack #2 to pressurise the cabin. This could have been done by selecting OPEN using the Cross-bleed knob to allow the Cross-bleed valve to receive air flow to Pack #2 directly.

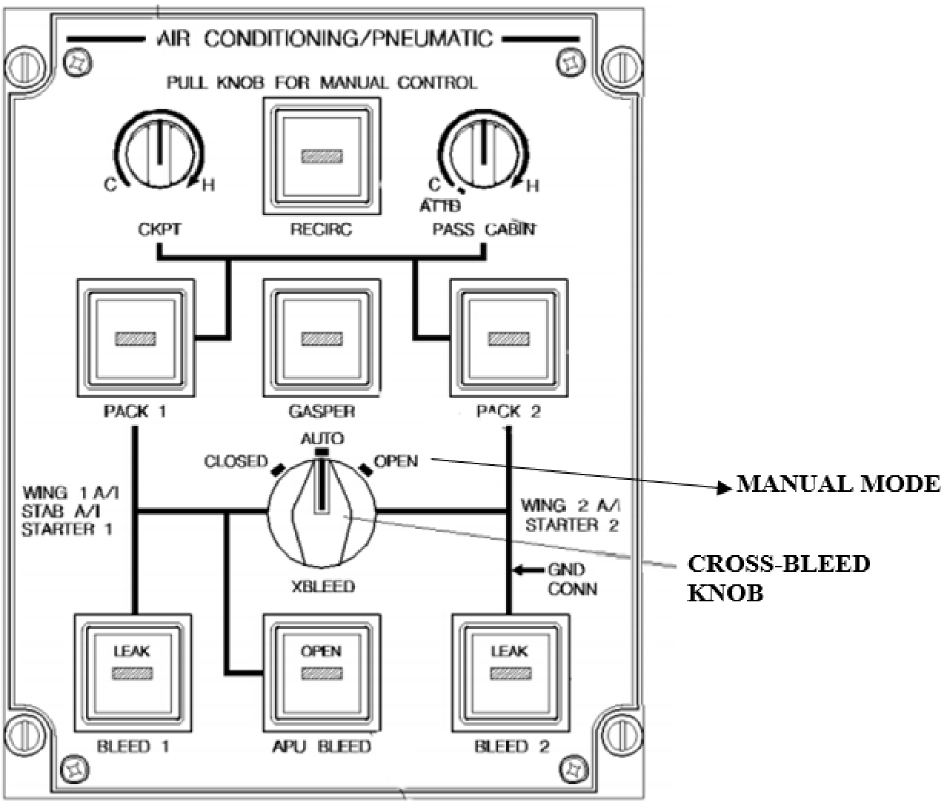

Figure 7 : Air Conditioning / Pneumatic Control Knob

5.0. FINDINGS

- The cause of the loss of cabin pressure was not determined.
- Engine #1 Bleed air was available and serviceable.
- The aircraft had been dispatched with Air conditioning pack #1 unserviceable and Air conditioning pack #2 was serviceable.
- Flight AW172 of 02 February 20024 (aircraft reg. 9G-AET) experienced a total loss of pressurisation whilst flying in cruise at 24,000 feet.
- The Cross-bleed valve closed due to the failure of bleed air valve #2.
- Flight AW172 of 02 February 2024 (aircraft reg. 9G – AET) did not experience a rapid cabin depressurization.
- The FDC went through the QRH for Rapid cabin depressurization and Emergency descent.
- The maximum cabin altitude recorded for the flight by the FDC was 12,200ft.
- The FDC manually deployed the oxygen masks because they believed the masks had failed to deploy automatically when the 10,000ft cabin altitude aural warning sounded.
- The aircraft cabin altitude aural warning indication of 10,000 feet functioned properly.
- All the cabin oxygen masks did not deploy using the manual deploy switch.
- The FDC did not go through the QRH for any of the aircraft defects noticed on the flight.
- The emergency declared to ATC by the FDC was not cancelled.
- The FDC did not enter the deployment of the oxygen masks in the FLB.
- The FDC did not advise maintenance of the following defects with the passenger oxygen system:
    a. Forward Cabin crew position masks did not deploy.
    b. Oxygen masks at seat numbers 3D and 3F were not usable because though they were hanging, they were stuck in that position and no amount of pulling by the crew was able to release the masks or trigger the oxygen generator.

c. The oxygen mask in the toilet did not deploy.

d. Passengers were relocated from 3D and 3F to 17D and 17F under depressurization conditions.

5.2. Contributory Factors

- An intermittent defect within the air-conditioning and pressurisation system could not be excluded as the cause of the loss of cabin pressure.
- The pilots did not follow exactly the emergency checklist actions, which increased the risk of an action being omitted or a required sequence of actions being altered.
- The actions of some of the cabin crew during the incident showed that their emergency training had not adequately familiarised the crew with the oxygen equipment.
- Lack of situational awareness / spatial disorientation

5.3. Causes

None

6.0. SAFETY ACTIONS

6.1. General

6.1.1. The Bureau classifies safety actions by two types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Bureau during an investigation that would otherwise result in the Bureau issuing a recommendation.

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Bureau issuing a recommendation.

6.2. Safety actions addressing safety issues identified during an investigation

6.2.1. The operator took action to improve crew performance in the following areas:

- the declaration by pilots of an emergency (distress or urgency) situation
- flight crew adherence to the published emergency checklists
- cabin crew actions in response to a depressurisation.

6.2.2. The operator took action to improve the following aspects of training:

- oxygen mask training with gas flow, and familiarity with chemical oxygen generators.

6.2.3. The operator reviewed the quality control of the packing of oxygen masks across its fleets and deemed that no further action was necessary.

6.3. Safety actions addressing other safety issues.

6.3.1. Nil.

7.0. SAFETY RECOMMENDATIONS

7.1. General

7.1.1. The Bureau may issue, or give notice of, safety recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider aviation sector.

7.2 Safety Recommendation to the Regulator (AIB/SR/2024/02)

7.2.1 The Regulator should ensure regular checks on aircraft emergency (oxygen) equipment during C-checks.

7.2.2 The Regulator should educate on urgency and distress calls to improve Pilot compliance with this requirement.

7.3 Safety Recommendation to the Operator (AIB/SR/2024/02)

7.3.1 The Operator must ensure proper procedure of communication of occurrence between the Flight Crew and the aircraft engineers.

8.0. KEY LESSONS LEARNT

8.1 The following lessons were identified during the investigation into this occurrence:

- an unexpected loss of cabin pressure in any aircraft is a serious event that can cause both passengers and crew to lose consciousness rapidly from a lack of oxygen. In such an event the appropriate emergency actions must be undertaken immediately. Where oxygen masks are fitted, passengers and cabin crew must put on their masks and await further instruction from the flight crew
- the purpose of emergency procedure checklists is to ensure that crew members do not miss an important action at a critical time of high workload. Therefore, unless the captain has an exceptional reason to deviate from a checklist, it should be performed from beginning to end, if possible without interruption, and without omitting any step
- crew members must be thoroughly trained in and familiar with all emergency equipment and procedures, because the equipment and procedures are for their own protection as well as that of the passengers. They need to be alert for emergency situations that differ from the standard scenarios that are practiced and demonstrated repeatedly
- special care must be taken with the maintenance of aircraft emergency equipment, such as oxygen systems.

9.0. CITATIONS

- FAA. (2013). Advisory Circular 61-107B, Aircraft Operations at altitudes above 25,000ft mean sea level or Mach number greater than 0.75. Washington, D.C.: Federal Aviation Authority.
- Embraer 145 LR Airplane Operations Manual.

10.0. APPENDICES

APPENDIX 1 : Commencement of Investigation in 9G-AET Cabin Depressurisation Letter

Incase of reply, the number and date of this letter should be quoted.

My Ref. No.: AIB/2024/02/02/SINCID

Your Ref. No.:..............................

AIRCRAFT ACCIDENT
AND INCIDENT INVESTIGATION
AND PREVENTION BUREAU
TEL: +233 50 239 6070
+233 57 200 0888
TOLL FREE No. +233 80 000 6007

Date: 21ST FEBRUARY 2024

Dear Sir / Madam,

COMMENCEMENT OF INVESTIGATION ON SERIOUS INCIDENT INTO DEPRESSURIZATION INVOLVING AFRICA WORLD AIRLINES AIRCRAFT WITH REGISTRATION MARKINGS 9G – AET ON FLIGHT NUMBER AW 172 THAT OCCURRED ON 2ND FEBRUARY 2024 EN-ROUTE FROM ACCRA (DGAA) TO TAMALE (DGLE).

The Aircraft Accident and Incident Investigation and Prevention Bureau (AIB –Ghana) received a notification from safetyreporting@caa.com.gh (State Safety Portal) on the 5th of February 2024 on the subject matter "Cabin Depressurization" involving Africa World Airline aircraft.

2. Accordingly, the AIB has commenced the investigation into the serious incident involving Africa World Airlines aircraft with Registration markings 9G-AET on the 2nd of February 2024, on flight AW 172. The scheduled flight operating from Accra to Tamale returned to Accra due to the Serious Incident of Depressurization.

3. In order to ensure effective management of the process, the Commissioner has appointed Ing. B.D.K Seshie as the Investigator-In-Charge (IIC). The investigation will focus on the preventive and safety measures that the Bureau considered as Safety Recommendations to be taken promptly to enhance aviation safety.

4. In view of the above, the Bureau is requesting the Africa World Airline (AWA) to provide the following:

a. Factual information on the occurrence.
b. The rectification process carried out by the Airline Maintenance department.
c. The current status of the Aircraft – whether serviceable or unserviceable.

We will expect a response within ten (10) days of receipt of this letter.

5. The AIB wishes to rely on your provision of support and cooperation for the successful conduct of the investigation. This should include the appointment of a focal person from your institution to facilitate the process.

Thank you.

Yours faithfully,

AKWASI A. PREMPEH
COMMISSIONER

DISTRIBUTION

DIRECTOR-GENERAL
GHANA CIVIL AVIATION AUTHORITY
ACCRA

THE ACCOUNTABLE MANAGER
AFRICA WORLD AIRLINES
ACCRA

APPENDIX 2 : Pressurisation and Airconditioning System

AIR CONDITIONING SYSTEM

Airplane air conditioning is provided by two Environmental Control Units (ECU) supplied by the Pneumatic System. Each side is provided with independent controls, protection devices, and cross-connected air distribution lines for the various modes of operation.

Cockpit and passenger cabin temperature selections are independent and may be controlled either manually or automatically. The left ECU the temperature in the cockpit and the right ECU controls the temperature passenger cabin. The system is normally operated in the automatic mode. In case of automatic mode failure, a manual mode is available. The pilots may transfer the passenger cabin temperature control to the Attendant Panel. The air conditioning distribution is performed by the gasper system and general outlets with cross-connection between the cockpit and passenger cabin lines.

This feature, associated with the ram air inlets, allows the cockpit and passenger cabin to be supplied with fresh air, in case of failure of both ECUs. Recirculating air, driven by two electrical fans, is mixed to fresh air in order to improve passenger and crewmembers' comfort. A ground cart connection is available at the right-hand duct, connected to the outside through a check valve in the fuselage. The preconditioned air from the ground cart is delivered to the cabin directly through the distribution lines.

The air conditioning system incorporates protection features in the temperature controllers which shut off the system in case of malfunctions (duct leakage, duct overtemperature, and pack overtemperature). The cockpit and passenger cabin temperature indications are presented on the MFD. Caution and advisory messages are presented on the EICAS.

Source: EMB 145 LR Maintenance Manual

APPENDIX 3 : Rapid Cabin Depressurisation & Emergency Checklist

BLEED OVERTEMPERATURE

EICAS WARNING: BLD 1 (2) OVTEMP
LIGHT: Master Warning
INDICATION: Pointer on MFD may be out of view and indication may be red.

Crossbleed .... OPEN
Cross-side Bleed .... OPEN
Associated Bleed .... CLOSE
Altitude .... MAX 25000 ft MINIMUM MEA

WARNING: IF IN ICING CONDITIONS, REFER TO SINGLE ENGINE OR SINGLE BLEED OPERATION IN ICING CONDITIONS PROCEDURE.

RAPID CABIN DEPRESSURIZATION

AURAL WARNING: CABIN
CONDITION: Cabin altitude indication has exceeded 10000 ft and becomes red.

Crew Oxygen Masks .... DON
Crew Communication .... ESTABLISH
Emergency Descent .... AS REQUIRED

Passenger Oxygen .... AS REQUIRED
Altitude .... MEA OR 10000 ft, WHICHEVER IS HIGHER

EMERGENCY DESCENT

Cabin Crew	NOTIFY
Fasten Belts	ON
Thrust Levers	IDLE
Speed Brakes	OPEN
Airspeed	250 KIAS
Landing Gear	DOWN
Minimum Enroute Altitude	CHECK

CAUTION: THIS PROCEDURE ASSUMES THAT THE INTEGRITY OF THE STRUCTURE IS NOT AFFECTED. IF STRUCTURAL DAMAGE IS SUSPECTED, USE THE FLIGHT CONTROLS WITH CAUTION AVOIDING HIGH MANEUVERING LOADS AND REDUCING AIRSPEED AS APPROPRIATE.

NOTE:
- It is recommended that descent be initiated by a turn with a bank angle of 30°.
- Anti-Icing System failure messages may be presented if icing conditions are encountered during the descent. In this case, emergency descent must be completed before performing the associated failure procedure.

APPENDIX 4 : Supporting Evidence in the form of Repair Order

AFRICA WORLD AIRLINES LIMITED

REPAIR ORDER

Order No.: R0005529

SEND TO/REPAIR SHOP	BILL TO	RETURN ADDRESS
Tool Testing Lab, Inc. 11601 N. Dixie Dr. Tipp City, OH 45371 USA Attn: Katie.Berbach@ttlcal.com kevin.bryte@ttlcal.com **Phone:** (937)898-5696 **Fax:** (937)898-3037	Africa World Airlines Limited 2A Senchi Street, Off Liberation Road PMB CT67, Accra, Ghana finance@flyafricaworld.com **Phone:** (233)-(30) 2764288 **Fax:** (233)-(30) 2763994	Africa World Airlines Ltd. Airport Bypass Road, Near DHL Courier Dome KIA – Accra Ghana **Phone:**+233-57-770-2856 **Fax:**

Order Date	08/02/2024	**Ship Via**	DHL ACCOUNT # 957216390
Prepared By	Agartha Kwakye	**INCOTERM**	EXW
E-mail	materials.support@flyafricaworld.com	**Currency**	US Dollars
Priority	Critical	**RO Account#**	RO_45_RO

P/N	DESCRIPTION	S/N	BATCH No.	QTY/UNIT	EXP. DELIVERY
101-01175	DIGITAL PITOT STATIC TEST SET (DPS-1000)	01105	-	1EA	2WEEKS

COMPONENT INFORMATION

1. **COMPONENT TIME**

UNIT	TSN	TSR	TSO	CSR	CSO
CY	/	/	/	/	/
FH	/	/	/	/	/
DA	/	/	/	/	/

2. **REMOVED FROM**

A/C TYPE	ERJ-145	**A/C REG.**	N/A	**REMOVED DATE**	N/A	**MSN**	N/A	**ATA**	N/A

ITEM NOTE	**Removal Reason:** Due for calibration **Work Scope:** 1. Calibrate as required per CMM 2. Service battery pack where applicable 3. Repair where necessary (subject to customer's approval) 4. Recertify for Calibration

order No.R0005529 Wednesday, 27 March 2024

Terms:

1. Please acknowledge when the part(s) is/are received.
2. If the part is "NO FAULT FOUND" verified, it CAN NOT BE RETURNED Prior to OUR WRITTEN APPROVAL.

3. **CERTIFICATION**

   When the required work scope has been done, the part(s) must be accompanied with FAA 8130-3 Form and FAA Form 337 (if applicable).

4. **FINDINGS AND REPAIR REPORT**

   We require the findings and repair reports and hence must be enclosed with part(s).

5. **TRANSPORTATION**

   A. Please notify customer for specific collection/transportation instructions;

   e-mail: materials.support@flyafricaworld.com

   B. Due to the nature of local customs processes, we do not prefer the use of express freight forwarders, such as UPS, DHL, FEDEX. We strongly recommend: Do not use express freight forwarders when shipping parts unless directly requested by AWA.

   C. In your pick-up alert, kindly include the correct pick-up address, contact person details, invoice and packing list.

6. **SHIPPING DOCUMENTS REQUIRED AT PARTS RETURN**

   A. The customs value on the packing list/ pro-forma invoice should be the same as the price quoted on the AWA original packing list.

   B. The repair cost should be marked on the packing list/ pro-forma invoice.

   C. One copy of the packing list/ pro-forma invoice should be attached to the AWB. One more copy of the packing list/ pro-forma invoice should be enclosed with the shopping box.

   D. Soft copy of the packing list/invoice should be sent to the E-mail Addresses below before returning the part.

   E-mail: materials.support@flyafricaworld.com
   TEL: +233-(0)577702856

Approved By: ______________________

Ben Oti

order No.R0005529 Wednesday, 27 March 2024

APPENDIX 5 : Time of Useful Consciousness

Time of Useful Consciousness (TUC)

This is the period of time from interruption of the oxygen supply, or exposure to an oxygen-poor environment, to the time when an individual is no longer capable of taking proper corrective and protective action.31 The faster the rate of ascent, the worse the impairment and the faster it happens. TUC also decreases with increasing altitude. The table below shows the trend of TUC as a function of altitude. However, a slow depressurisation is as dangerous as or more dangerous than a rapid depressurisation. By its nature, a rapid depressurisation commands attention. In contrast, a slow depressurisation may go unnoticed and the resultant hypoxia32 may be unrecognised.

WARNING:
The TUC *does not* mean the onset of unconsciousness.
Impaired performance *may be immediate*.
Prompt use of oxygen is critical.

TIMES OF USEFUL CONSCIOUSNESS VERSUS ALTITUDE

Altitude (ft)	**TUC**	**Following rapid depressurisation**
18,000	20-30 min	10-15 min
22,000	10 min	5-6 min
25,000	3-5 min	1.5-2.5 min
28,000	2.5-3 min	1-1.5 min
30,000	1-2 min	30 sec-1 min
35,000	30 sec-1 min	15-30 sec
40,000	15-20 sec	Nominal

Source: FAA Advisory Circular 61-107B