



AEROSPACE INFORMATION REPORT

AIR1204™

REV. A

Issued 1979-05
Revised 2009-06
Reaffirmed 2024-10

Superseding AIR1204

(R) Control of Water Carryover from the Environmental Control System and Condensation on the Structure

RATIONALE

This document is intended to address the issue of excess moisture on aircraft. AIR1204 was originally released in 1979. This Rev A version brings the document up to date with regard to Environmental Control System design and design best practices that have evolved since this document's original release.

AIR1204A has been reaffirmed to comply with the SAE Five-Year Review policy.

TABLE OF CONTENTS

1.	SCOPE.....	3
1.1	Purpose.....	3
1.2	Field of Application.....	3
2.	REFERENCES.....	3
2.1	Applicable Documents.....	3
2.1.1	SAE Publications.....	3
3.	BACKGROUND.....	4
4.	CAUSES OF WATER CONDENSATE.....	4
4.1	Environmental Control System.....	4
4.1.1	Entrained Moisture from the ECS Refrigeration Unit.....	4
4.1.2	Moist Air Bypassing Water Removal Devices.....	4
4.1.3	Low-pressure Water Separation Anomalies.....	5
4.1.4	Liquid Water Accumulation.....	5
4.2	Condensation on Cold Surfaces.....	5
4.2.1	Structural Condensation.....	5
4.3	Humidifiers.....	5
4.4	Occupants.....	6
5.	EFFECTS OF WATER CONDENSATE.....	6
5.1	Environmental Control System.....	6
5.1.1	Rain-in-the-plane.....	6
5.1.2	Damage to ECS Equipment.....	6
5.1.3	Collateral Damage to Equipment.....	6
5.2	Window Visibility.....	6
5.3	Structural Condensation.....	6
5.3.1	Wet Insulation Blankets.....	6
5.3.2	Water/Ice Accumulation in Bilge.....	6
5.3.3	Overboard Icing.....	7
5.3.4	Rain-in-the-plane.....	7

SAE Executive Standards Committee Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2024 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, or used for text and data mining, AI training, or similar technologies, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER:
Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
<http://www.sae.org>

SAE WEB ADDRESS:

Full document details: SAE AIR1204A

For more information on this standard, visit
<https://www.sae.org/standards/content/AIR1204A/>

Documents

Standard, visit Sharing Hub

6.	CONTROL OF EXCESS MOISTURE.....	7
6.1	Environmental Control System Water Carryover.....	7
6.1.1	General ECS Suggestions.....	7
6.1.2	Air Cycle Systems.....	7
6.1.3	Vapor Cycle Systems.....	12
6.2	Humidifiers.....	13
6.3	Structural Condensation.....	13
6.3.1	Condensation Reduction Strategies.....	13
6.3.2	Strategies for Management of Condensed Water.....	14
7.	NOTES.....	15
7.1	Revision Indicator.....	15

1. SCOPE

This Aerospace Information Report (AIR) outlines the design considerations and criteria for the control of water carryover from the environmental control system (ECS) with respect to causes and indicated corrective or preventative action. In addition, condensation on structure will be reviewed with possible preventative action described.

1.1 Purpose

This publication will discuss water carryover from the environmental control system and condensation on structures, with the following purpose:

- a. To define sources of water that may cause condensation in the aircraft.
- b. To outline means for minimizing or controlling the condensate.

1.2 Field of Application

The material presented herein is primarily applicable to multi-engine transport airplanes, but in some cases may apply to other types of aircraft, military or civil.

2. REFERENCES

All pertinent and/or reference documents are listed herein.

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale PA 15096-001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AIR1609	Aircraft Humidification
ARP147	Environmental Control Systems Terminology
ARP987	The Control of Excess Humidity in Avionics Cooling

Proceeds of Moisture Ingress in Aircraft Insulation Symposium, Abbotsford BC Canada, August 5 1993, sponsored by SAE Aerospace Continuing Professional Development Group

3. BACKGROUND

Uncontrolled moisture inside the fuselage of aircraft is a potential source of increased maintenance and expense to operators and can lead to complaints and ill will from passengers. Uncontrolled moisture can manifest itself in the following ways:

- a. Condensation dripping on passengers.
- b. Moist air condensing on exposed structure and on mechanical or electrical equipment. It can also become trapped and be subjected to freezing due to subsequent temperature reduction.
- c. Structural corrosion, electrical shorts, insulating material weight increase and loss of insulating properties result from this water accumulation.

4. CAUSES OF WATER CONDENSATE

The sources of excess moisture within an aircraft can include the Environmental Control System (ECS), condensation on cold surfaces, occupants and humidification systems.

4.1 Environmental Control System

The ECS can cause uncontrolled water condensation in the following ways:

4.1.1 Entrained Moisture from the ECS Refrigeration Unit

Inefficient water separation in the ECS results in carryover of water condensate and humid air into the cabin. This problem is commonly associated with air cycle refrigeration systems.

Low design efficiency, inadequate drainage systems or failure modes of water collectors or separators will produce an unnecessarily large carryover of entrained water in the form of fog or water droplets and occasionally ice particles. Some of this water settles out in low points throughout the ducting system, including overhead areas. From there, it may accumulate until its volume, airplane attitude, etc. may cause sudden spilling of large amounts of water into the cabin, or it may subsequently re-evaporate when the supply air is less than saturated.

Visible fog streamers can occur at cold air outlets during high humidity conditions. Formation of these streamers which is usually a result of entrained moisture in the conditioned cabin supply air in conjunction with supply air temperature is cooler than the dew point at the surrounding cabin pressure.

4.1.2 Moist Air Bypassing Water Removal Devices

The air entering the cabin is not dehumidified unless it passes through the refrigeration unit and the water separator or collector. For temperature control, some refrigeration cycles bypass a portion of the hot supply air around the refrigeration unit and mix it with the refrigerated air downstream. This bypassed air, therefore, adds to the moisture left in refrigerated air that is due to the normal water separator design inefficiencies. It should be pointed out that the proportion of bypassed air to the total air is small, particularly on hot humid days at low altitudes, where maximum refrigeration is required. However, on a humid day with cooler or moderate temperature, the moisture from the bypass air will cause higher compartment humidity. As the altitude is increased and the supply air becomes colder, more air bypasses the refrigeration package. Note that the supply air becomes dryer as altitude increases. Refrigeration cycles that bypass air around the water removal devices include the conventional chilled-recirculation systems used on A320 and 767-200/300. Refrigeration cycles that do not bypass the water removal devices include the simple/bootstrap system on 747-400 and the condensing cycle system used on 777 and 767-400.

4.1.3 Low-pressure Water Separation Anomalies

Water separator anti-icing systems may malfunction or be set to maintain temperatures too close to the freezing point. In the latter case, normal control tolerances can cause continuous or intermittent freezing. Freezing of the water separator forces the moisture laden supply air through the relief valve bypass system introducing moisture in the form of water droplets and/or fog into the cabin and into direct air cooled electronic equipment. Undersized water drains plugged with lint, dirt, etc. can severely degrade low pressure water separator effectiveness.

4.1.4 Liquid Water Accumulation

Liquid water can accumulate in low points of air conditioning distribution ducting systems, pack discharge or other ducts that encounter free moisture - especially after system shutdown on the ground. To preclude this accumulation, drains should be placed at low points of ducting systems in which entrained moisture is present.

Drains should be oversized to avoid blockage. Drain hole sizes of about 3.1 mm (0.125 in.) diameter have been found to be acceptable for large commercial installations, but drain sizes should be established and verified for each application without the requirement for periodic servicing of the drain. Drains should carry water to a location where the water can go overboard. Drained water should be prevented from coming into contact with equipment that can be harmed by water.

4.2 Condensation on Cold Surfaces

Condensation forms on parts of the cold air outlets where cabin air comes in contact with cold, high conductivity (usually metal) parts. Condensation forms when relatively warm, moist ambient air comes in contact with chilled cold air ducts which are not insulated or insufficiently insulated.

4.2.1 Structural Condensation

Most condensation on the airplane structure occurs during flight when the temperature of both the outside air and the structure are very cold. Structure temperatures are usually below the dew point of the cabin air, causing condensation to form during most flights. In addition, because structure temperatures are normally below the freezing point of water, most condensation forms as frost.

Condensation results when moist air moves to the cold structure. The cabin air passes through small gaps in the insulation coverage and cools rapidly. Buoyancy forces induce a continuous flow of air and continuous movement of moisture to the cold structure.

The rate of condensation depends on the rate of buoyancy-driven air movement to the structure as well as the cabin humidity level. In-flight cabin humidity levels are low from a standpoint of human comfort (approximately 10 to 20 percent relative humidity, depending on flight conditions and occupant loading). However, the dew point of cabin air is much higher than aircraft skin temperature and most of the moisture it contains will condense as air moves over the cold structure.

Structure directly connected to the (cold) outer skin is the prime area of condensation. Leaking cold air ducting joints can also reduce the temperature of adjacent surfaces and result in condensation.

Structural or insulation blanket condensation occurs where virtually trapped volumes obtain moisture at sea level and are subject to subsequent cold soaking at altitude.

4.3 Humidifiers

Humidifiers can be a source of condensate, particularly if they are improperly operated. Operation of humidifiers at high altitude can result in frost build-up on cold structure. As the airplane descends increased temperatures and aircraft attitude changes can result in water dripping in occupied compartments.