



AEROSPACE RECOMMENDED PRACTICE	ARP987™	REV. B
	Issued	1970-03
	Revised	2010-06
	Reaffirmed	2015-10

(R) The Control of Excess Humidity in Avionics Cooling

RATIONALE

ARP987B has been reaffirmed to comply with the SAE five-year review policy.

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1. SCOPE

This Aerospace Recommended Practice (ARP) outlines the causes and impacts of moisture and/or condensation in avionics equipment and provides recommendations for corrective and preventative action.

1.1 Purpose

The purpose of this document is threefold: (1) to review the issues associated with moisture in avionics equipment, (2) to outline methods for correcting conditions of excess moisture in existing avionics installations, and (3) to recommend design practices for new avionics cooling system installations which will minimize the occurrences of excess moisture in avionics.

This document does not address all moisture-related requirements which may be applicable to the avionics installation. For instance, when the air conditioning system is inoperative when the aircraft is parked or stored, or if an avionics ground cooling fan is employed, the aircraft and its equipment will be exposed to and must withstand the effects of the outdoor environment (e.g., high humidity, fog, rain, and surface condensation).

1.2 Field of Application

This document is intended to apply to design of airborne avionics equipment cooling systems.

2. REFERENCES

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 the 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 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AIR1277 Cooling of Military Avionic Equipment

ARP731 General Requirements for Application of Vapor Cycle Refrigeration Systems for Aircraft

AIR1204 Control of Water Carryover From the Environmental Control System and Condensation on Structure

2.1.2 US Government Publications

The following are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, <http://www.ntis.gov/>.

U.S. Air Force, Project ADC/73AD/61-11 "F-106/MA-1 Moisture Investigation", 4750th Test Squadron, Tyndall AFB, Florida

U.S. Air Force AFCRL-TR-74-0603 World-Wide Extremes of Humidity with Temperatures Between 85 °F and 120 °F

U.S. Air Force AFSCM80-9 Environmental Engineering, Vol. V

The following is available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch>.

MIL-E-18927E Environmental Control Systems, Aircraft, General Requirements for

2.1.3 EASA Publications

Available from European Aviation Safety Agency, Postach 10 12 53, D-50452, Koeln, Germany, Tel: +49-221-8999-000, www.easa.eu.int.

CS-25 Certification Specifications for Large Aeroplanes

2.1.4 FAA Publications

Available from Federal Aviation Administration, 800 Independence Ave., SW, Washington, DC 20591, Tel: 866-835- 5322, www.faa.gov/.

14 CFR Part 25 Airworthiness Standards: Transport Category Airplanes

2.1.5 Other Applicable References

ARINC Specification 600-16 – “Air Transport Avionics Equipment Interfaces”, Aeronautical Radio, Inc., 2551 Riva Rd, Annapolis, Md 21401-7435 USA, <http://www.arinc.com/>

Computer-Aided Life-Cycle Engineering (CALCE) Electronics Products and Systems Center, [2002], Moisture Diffusion and Corrosion in Electronics Webbook

Elliott, D.K., [1961] - "Wet-Wire Fires", Conference on Electrical Insulation, National Academy of Sciences 1963 Annual Report (Pub. No. 1141).

Elliott, D.K., [06/65] - "Wet Electric Faults", IEEE Transactions on Aerospace, Vol. AS-3, No. 2

U.S. Department of Commerce, National Climatic Data Center, Asheville, North Carolina, <http://www.ncdc.noaa.gov/oa/ncdc.html>

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

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AIR1957 Heat Sinks for Airborne Vehicles

3. SUMMARY OF THE PROBLEM

3.1 The Effects of High Humidity and Moisture

Moisture ingress into electronic assemblies can have many deleterious effects. In plastic encapsulated microelectronics (PEM), moisture can cause or attribute to reliability problems such as pop-corning, cracking, delamination and corrosion of the metallization at the die surface. Moisture in printed wiring boards can lead to corrosion, oxidation, and dendritic growth. Corrosion can cause degradation in electrical and mechanical performance of the electronic systems, and eventually, opens or shorts. (Ref. CALCE 2002) Ever-smaller feature sizes with lower and lower signal levels and higher frequencies are all working to increase the vulnerability of avionics to moisture and contaminants.

High humidity, moisture, and chemical reaction of pollutants in water (e.g., sulfuric acid), cause electrical current leakage which in turn can cause malfunctions ranging from erroneous signals (Ref. USAF Project ADC/73AD/61-11) to overheating and fire (Ref. Elliot, 1961 and 1965). Malfunctions may be of a temporary nature which do not occur when the equipment is dry, or may be permanent, depending on the magnitude and duration of the current leakage. Faults may cause erroneous signals which may be difficult to detect.

A familiar example of temporary disablement can be found in compact, high impedance computer circuits where microvolt level signals may be carried through multi-pin connectors. Due to high impedance, it is possible to generate an enormous error in the low level signal circuit with a very small current leakage between the connector pins in the presence of moisture. Although the circuit may recover when dry, function normally, and exhibit no permanent damage, repeated exposures to moisture may eventually cause permanent malfunctioning as a result of metallic corrosion or deterioration of electrical insulation.

If the current leakage in a DC circuit is sufficiently large, a permanent electric fault may be produced in the dielectric material by bridging it with electro-deposited metal. (Ref. Elliot, 1965) The fault may destroy one or more components as a result of excessive temperature.

3.2 Sources of Moisture

A condition of excessive humidity exists whenever (1) the relative humidity of the cooling air is near saturation, or (2) the cooling air contains entrained liquid moisture, or (3) the surface temperature of the avionic equipment is below the dew point of the cooling air, causing condensation to form directly on the surfaces of the equipment.

Examples of conditions (1) and (2) are commonly found in aircraft forced-air cooling systems. At low flight altitudes, vapor cycle refrigeration systems usually deliver chilled air at high relative humidity. Air cycle refrigeration can deliver air with entrained liquid that typically runs on duct surfaces.

An example of condition (3) is found where the cooling air temperature in flight at high altitude is below the ambient dew point encountered at ground level. Thus, parts of the equipment which produce very little heat may become "cold soaked" in flight, and when the aircraft descends to ground level, the equipment is exposed to moisture-laden air causing surface condensation. Though the exposure of "cold soaked" equipment to moist ambient air is a transient condition, a thorough wetting of the equipment can occur, and the moisture may not evaporate for some time after the exposure.

Condensation can also occur on the external surfaces of equipment during low altitude operation during or after ground checkout if the cooling air temperature is below the ambient dew point. The natural environment may also expose the avionics equipment to damaging "wet" conditions. A comprehensive discussion on the control of condensation and water carryover from the environmental control system can be found in AIR1204. Commercial airplane electronics equipment should consider condensing water proof testing as part of the qualification testing.

4. NATURAL AND INDUCED ENVIRONMENTS

4.1 On-Aircraft Storage

The natural environment prevails when the aircraft is parked out-of-doors and when the installed avionics equipment is exposed to the humidity of the ambient air. Weather data indicate that high relative humidity is a common state of the atmosphere in almost any climate, cool or warm, particularly during the night (Ref. National Climatic Data Center). The typical cycle consists of high relative humidity during pre-dawn hours and reduced relative humidity during the day. The relative humidity cycles are usually generated by the daily variation in air temperature (dry bulb), and not by large changes in the moisture content of the air, because the dew point temperature, which is the index of absolute moisture content of the air, is very nearly constant night and day. Condensation can form on the avionics if the mounting rack can cold soak along with the external structure. Avionics may also be subject to dripping condensation if located directly under uninsulated external structure. Commercial airplane electronics equipment should pass humidity and moisture testing of a severity appropriate for its installation.

4.2 Proposed Design Data for the Natural Environment

The frequencies of occurrence of atmospheric humidity levels at sea level, reported by AFCRL-TR-74-0603, are indicated in Figure 1. Labels on these lines indicate the percent of time during which the coincident dew point and dry bulb temperature will be exceeded during the hottest month of the year in the hottest locations. It is apparent from these data that an atmospheric dew point between 29.5 °C (85 °F) and 31 °C (88 °F) should be adequate for most design applications based on world-wide operations.

Nominal air supply temperatures for ARINC 600 equipment are 40 °C (104 °F) on ground and 30 °C (86 °F) in flight, which is within the recommended temperature range. However, some freighter electronics equipment cooling systems use the packs as a (conditioned air) source for cooling flight deck electronics to preclude odor and smoke infiltration. The supply air temperatures to the flight deck electronics could range from ~1.7 °C (35 °F) to 40 °C (104 °F) under normal conditions. Other electronics equipment cooling systems use trim air to control flight deck electronics cooling air to 23.9 °C (75 °F) to mitigate moisture issues discussed in this ARP.

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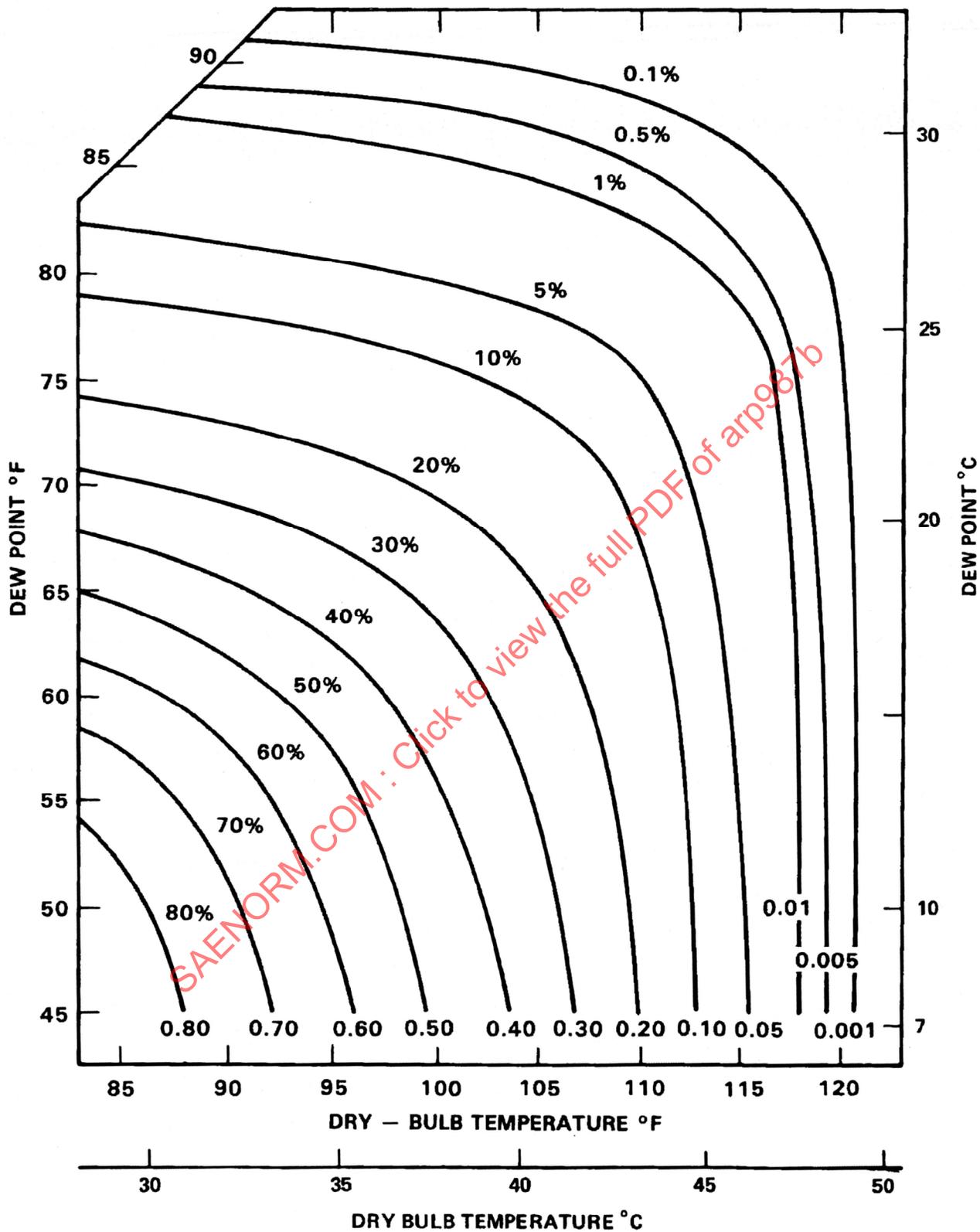


FIGURE 1 – SEA LEVEL ATMOSPHERIC HUMIDITY
(FROM AFCRL-TR-74-0603)

4.3 Induced Humid Environments in Service

Many aircraft avionics units are compact assemblies with significant heat dissipation and therefore require forced-air cooling while in operation. The weight and space constraints which influence the avionics designer also press the cooling system designer to employ the lowest possible cooling air temperature to minimize airflow quantity and the associated system weight and volume penalties. However, the use of low air temperature can induce moisture problems during operation at low altitude where the ambient air dew point equals or exceeds the cooling air supply air temperature. The following paragraphs discuss different cooling system approaches and their moisture control characteristics.

Vapor cycle refrigeration is generally used in ground cooling units and in some aircraft systems for avionics or cabin cooling. Figure 2 presents an example of the temperature and moisture history of ambient air which is refrigerated by a vapor cycle system and circulated through forced-cooled avionics equipment. Ambient air at 40 °C (104 °F), 14.3 gm/kg (0.00143 lb/lb) absolute humidity and a flow rate of 2.07 kg/min (4.56 lb/min) is refrigerated from its initial state, denoted by point (1) in Figure 2 and Figure 3, to 4.7 °C (40 °F) at point (3). The temperature of the air-vapor mixture reaches the saturation temperature (dew point) of 19.5 °C (67 °F) at point (2) in the cooling process, and moisture is condensed on the cold heat exchanger surfaces during further cooling to point (3). The condensed moisture is drained off, and the air at 100% relative humidity (saturated) is delivered through the supply duct – point (3) to point (4). Heat transfer in the duct warms the air 1.7 °C (3 °F) and thus reduces its relative humidity a small amount. The refrigerated air at 6.4 °C (43.5 °F) enters the avionics equipment at 90% RH at point (4) and is warmed to 35 °C (95 °F) by 1 kW (3414 Btu/h) of heat rejected from the avionic circuits. Thus in the region of air inlet, the avionics is not only exposed to 90% RH, but non-heat producing circuits and components in this region are exposed to a temperature of 6.4 °C (43.5 °F), which is considerably below the ambient dew point of 19.5 °C (67 °F). Local condensation can be expected on external surfaces during operation, and when the avionics and the cooling air supply are shut down, local condensation from infiltrating ambient air may occur on internal surfaces. Thus, parts of the equipment which are exposed to high humidity during operation may become wet and remain damp for a period of time after operation. However, if the cooling system is operated in a closed loop and the air recirculated through the evaporator, the humidity will gradually be reduced from the startup condition, resulting in drier operation for most of the time.

A more adverse environment at the avionics air inlet is provided by the use of air cycle refrigeration with low pressure water separation in lieu of a vapor cycle as described above. A cloud of condensate is produced within the air stream as the air releases its thermal energy in the expansion/cooling process through a turbine. The air/vapor mixture falls to the 19.5 °C (67 °F) dew point at the saturation line (point (2) of Figure 4 and Figure 5) and continues to cool to 4.7 °C (40 °F) at the turbine discharge at point (3) while moisture is condensing in the form of a cloud of fog droplets. The density of this fog cloud depends on the degree of cooling below the dew point, and in this example the cloud is very dense. Some coalescing of the very small droplets occurs on duct walls, elbows and obstructions, and produces flowing rivulets and some large droplets in the ducts. The water removal problem is made difficult by the size of the fog droplets, and usually only 80% of the liquid can be coalesced, trapped, and drained. Thus, in this example, 7.2 gm/kg (0.0072 lb/lb) of the 9.0 gm/kg (0.009 lb/lb) of condensate is removed in the water separator. Duct heat transfer raises the temperature to 5.6 °C (42 °F) at point (4) and re-evaporates a portion of the residual cloud. The remainder of the cloud at point (4) is delivered to the avionics with the cooling air, and its subsequent evaporation contributes to the 1 kW (3414 Btu/h) cooling capacity, which is the same as in the previous example of vapor cycle cooling. Note that the discharge temperature from the avionics is 30.5 °C (87 °F) compared to 35 °C (95 °F) in the previous example, due to the cooling effect of the evaporating moisture cloud. The relative humidity of the cooling air is above saturation in the avionic unit until about 25% of the heat rejection is absorbed from the unit.

For all Air Cycle Refrigeration Architectures, points (1) and (2) of the processes shown on the psychrometric charts are at a higher pressure than for the remainder of the states. Technically they should be addressed in a separate chart since a psychrometric chart is applicable to one pressure only. They are kept in the same chart for better visualization of the complete process.

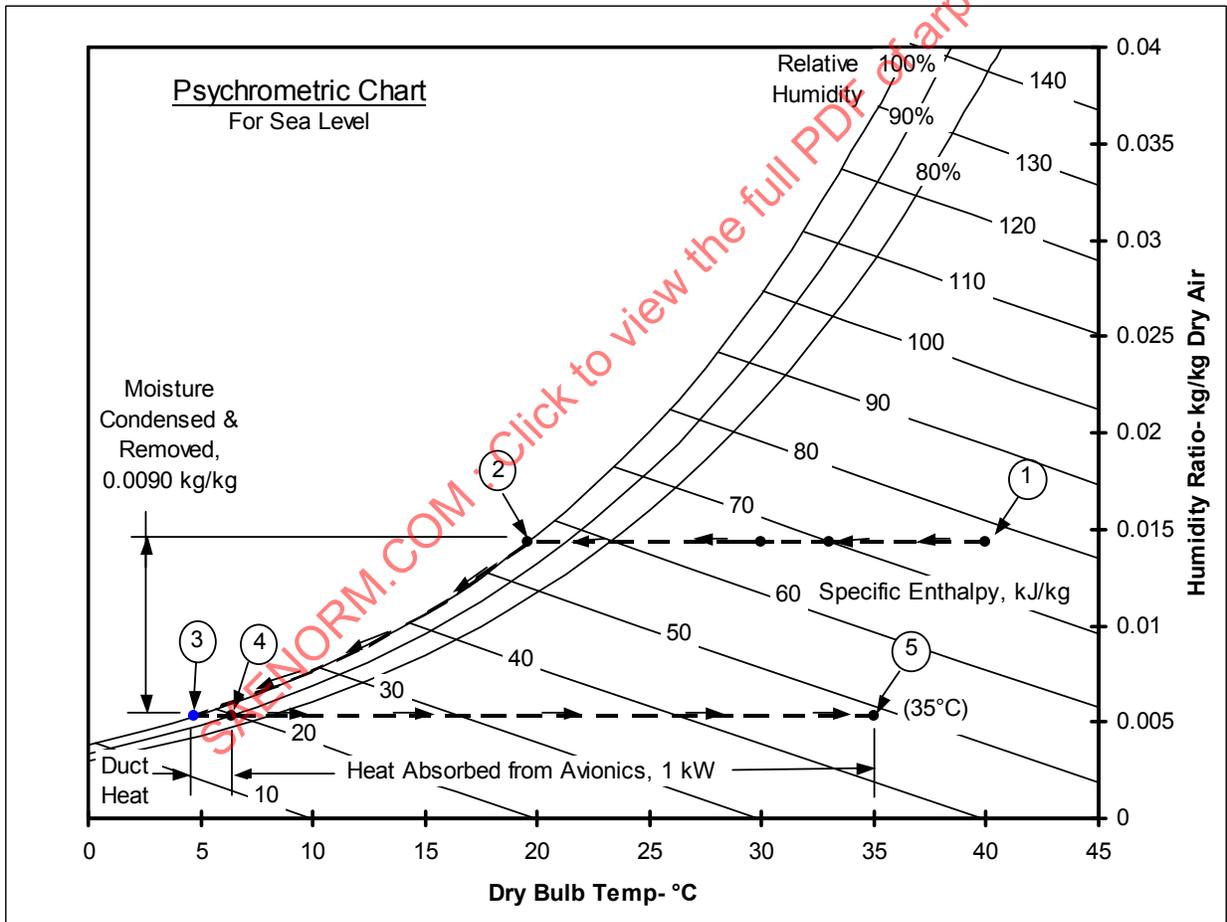
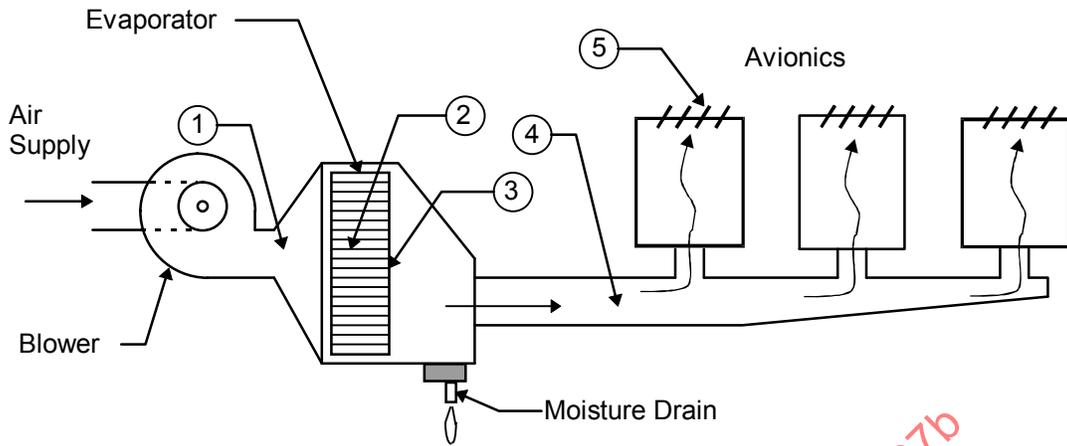


FIGURE 2 – AVIONICS COOLING WITH VAPOR CYCLE REFRIGERATION (WITHOUT REHEAT)- SI

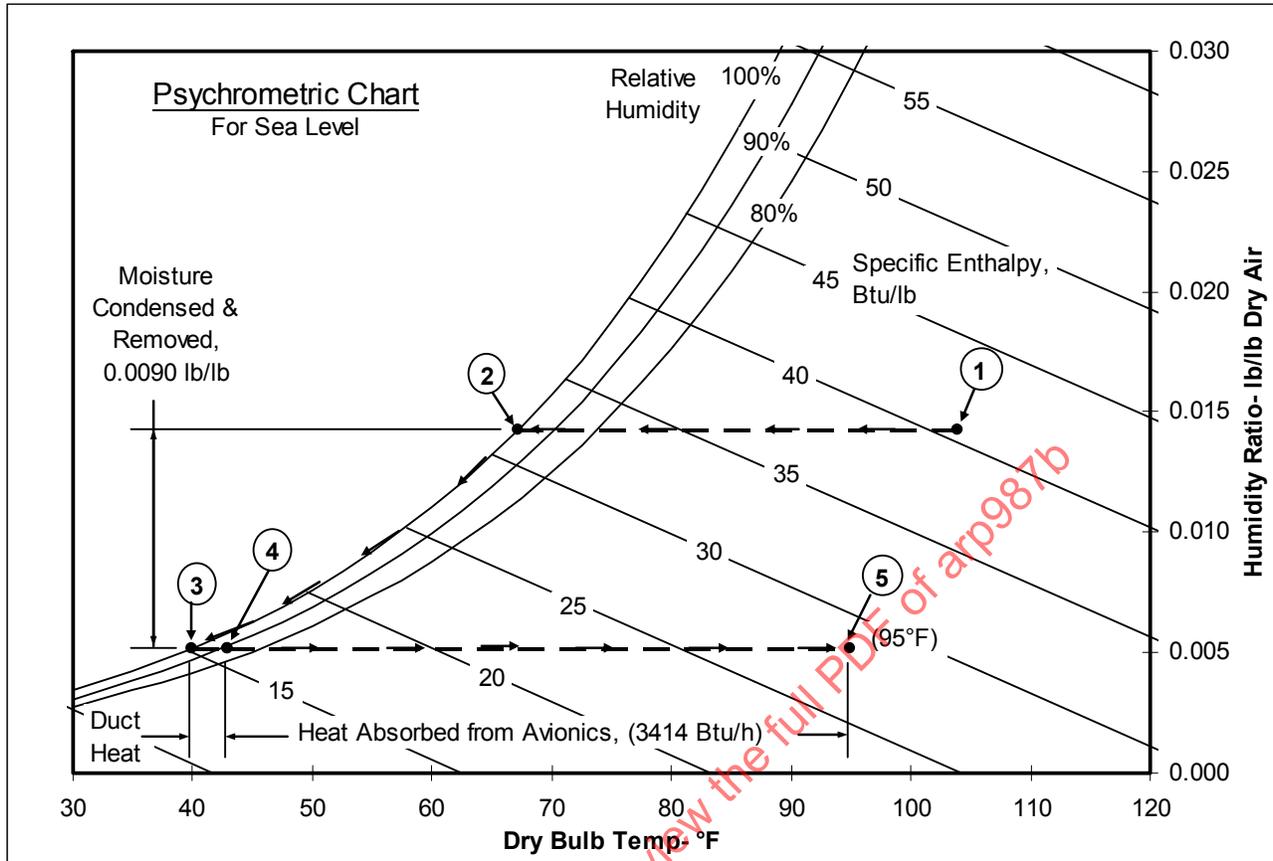


FIGURE 3 – AVIONICS COOLING WITH VAPOR CYCLE REFRIGERATION (WITHOUT REHEAT)- USCS

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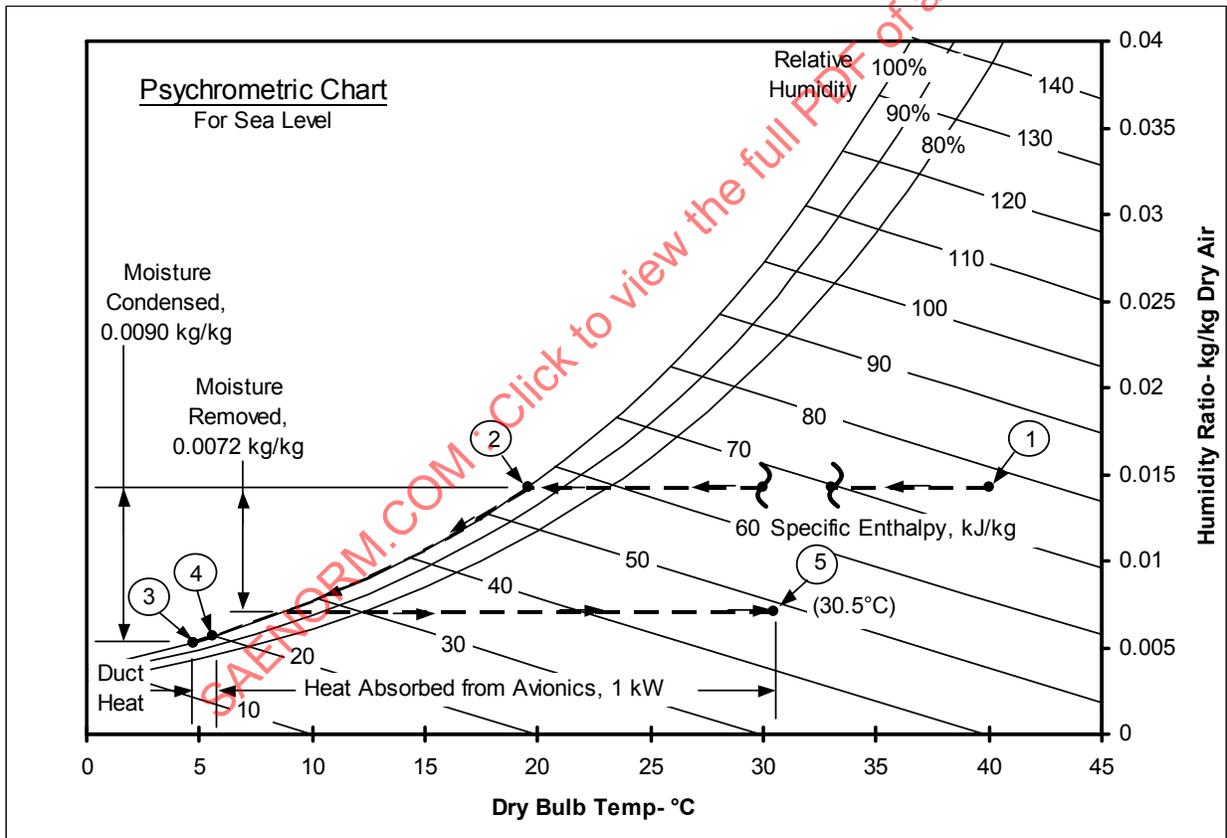
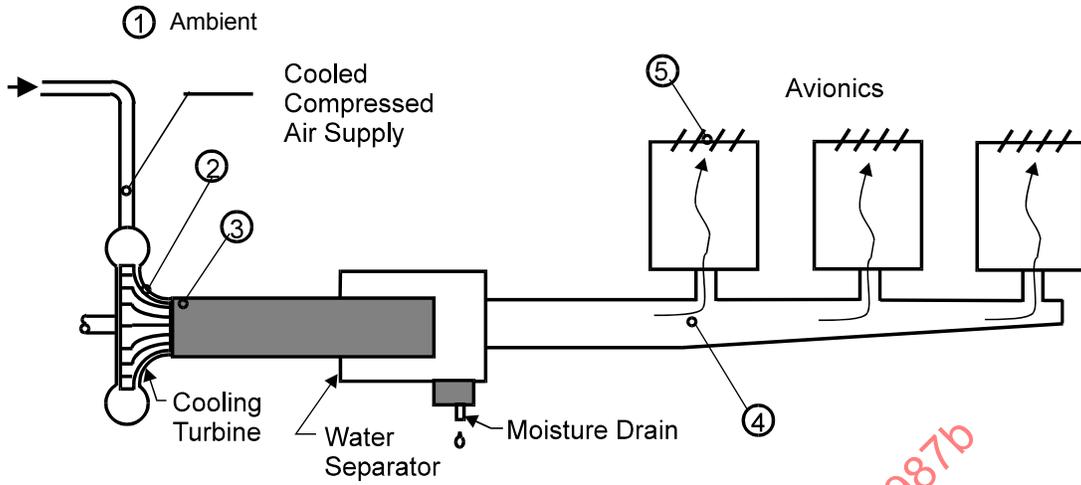


FIGURE 4 – AVIONICS COOLING WITH AIR CYCLE REGRIGERATION (WITHOUT REHEAT)- SI

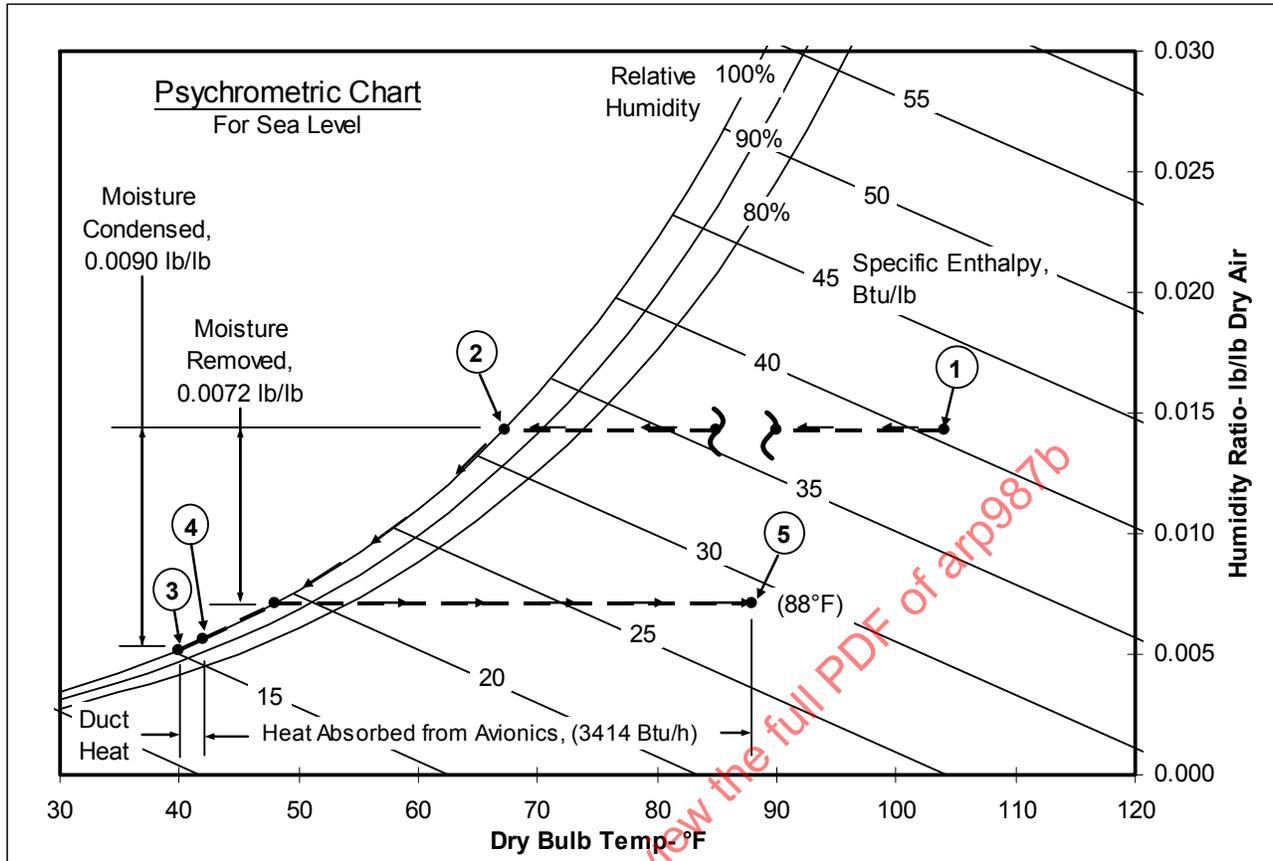


FIGURE 5 – AVIONICS COOLING WITH AIR CYCLE REGRIGERATION (WITHOUT REHEAT)- USCS

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Some avionics cooling systems utilize exhaust air from the aircraft cabin where a moderate temperature and relative humidity is normally maintained for the occupants. In these installations air cycle or vapor cycle systems may deliver humid air to the cabin; but after being heated by the thermal loads in the cabin, the air is delivered in a relatively low relative humidity condition to the avionics bay. Moisture production due to night and day temperature cycles in aircraft parked out-of-doors remains a problem in these systems if the equipment is not adequately isolated or insulated from the exterior surfaces of the aircraft. The cabin exhaust air also creates a more severe dirt and dust problem than would exist in a directly cooled system. This is a result of the presence of aerosols from smoking and of dust and lint from clothing and carpets.

5. ENVIRONMENT CONTROL IN "OPEN" EQUIPMENT

Moisture resistant coatings and reduction of the relative humidity of the cooling air will eliminate malfunctions of the avionics equipment due to exposure to moisture. For the former, non-flammable sprays that penetrate and seal out moisture are available. In addition, encapsulants can also be used that embed electronic circuits to isolate circuits from the harmful effects of moisture and other contaminants and also from thermal and mechanical stresses. Encapsulants are typically applied in thick layers exceeding 3.2 mm (125 mils).

To reduce the relative humidity and presence of free moisture in the cooling air, systems can be designed or corrected by applying the techniques noted in the following paragraphs:

5.1 Improving Existing Systems

The recommendations made in this section are intended as "minimum change" modifications to control humidity in existing systems for improved avionics life and reliability. See 5.2 for new design.

5.1.1 Air Cycle Refrigeration Systems

5.1.1.1 Adding Reheat to System with a Low Pressure Water Separator

A reheat system can be installed in an existing air cycle system to maintain the air at a temperature above the maximum dew point specified for the application. This temperature can range from 1.4 °C to 32 °C (35 °F to 90 °F), depending on where the aircraft is to be operated, the type of avionics and degree of moisture protection, whether or not a water separator is installed, and aircraft system limitations. To conserve engine bleed air, a variable temperature control system which takes advantage of the low humidity at altitude is commonly used. This would employ a high supply temperature setting for low altitude where humidity is high, and a low temperature setting at high altitudes where the ambient air is very dry. The F/A-18C/D, for example, supplies cooling air at 4.4 °C (40 °F) from sea level to 7620 m (25,000 ft), varies it linearly from 4.4 °C (40 °F) to -18 °C (0 °F) between 7620 m (25,000 ft) and 12 950 m (42,500 ft), and remains constant at -18 °C (0 °F) above 12 950 m (42,500 ft). Commercial electronics are qualified to short term cold supply air temperatures of -40 °C (-40 °F) and steady state cold supply air of -15 °C (+5 °F). But throughout their lifetimes, exposure to extreme cold temperatures is usually limited, hence enabling high reliability. Use of consistently cold supply air temperatures, per military equipment cooling schemes, would result in abbreviated life expectancies due to thermal fatigue, as well as potential humidity issues.

Reheat may be furnished by a controlled bypass of engine bleed air (see Figure 6). The increase in total delivered airflow, which may be required to offset the increase in cooling air supply temperature, can be provided by the bypass air itself if its temperature isn't too high. The selection of the point in the system from which to tap the bypass air (e.g., upstream or downstream of a heat exchanger), can be made after determining the flow increase required to satisfy avionics cooling with warmer air. It should also be noted that the greater the quantity of bypass used, the higher will be the absolute humidity of the mixture delivered to the avionics, since the bypass usually has not been subjected to moisture removal.

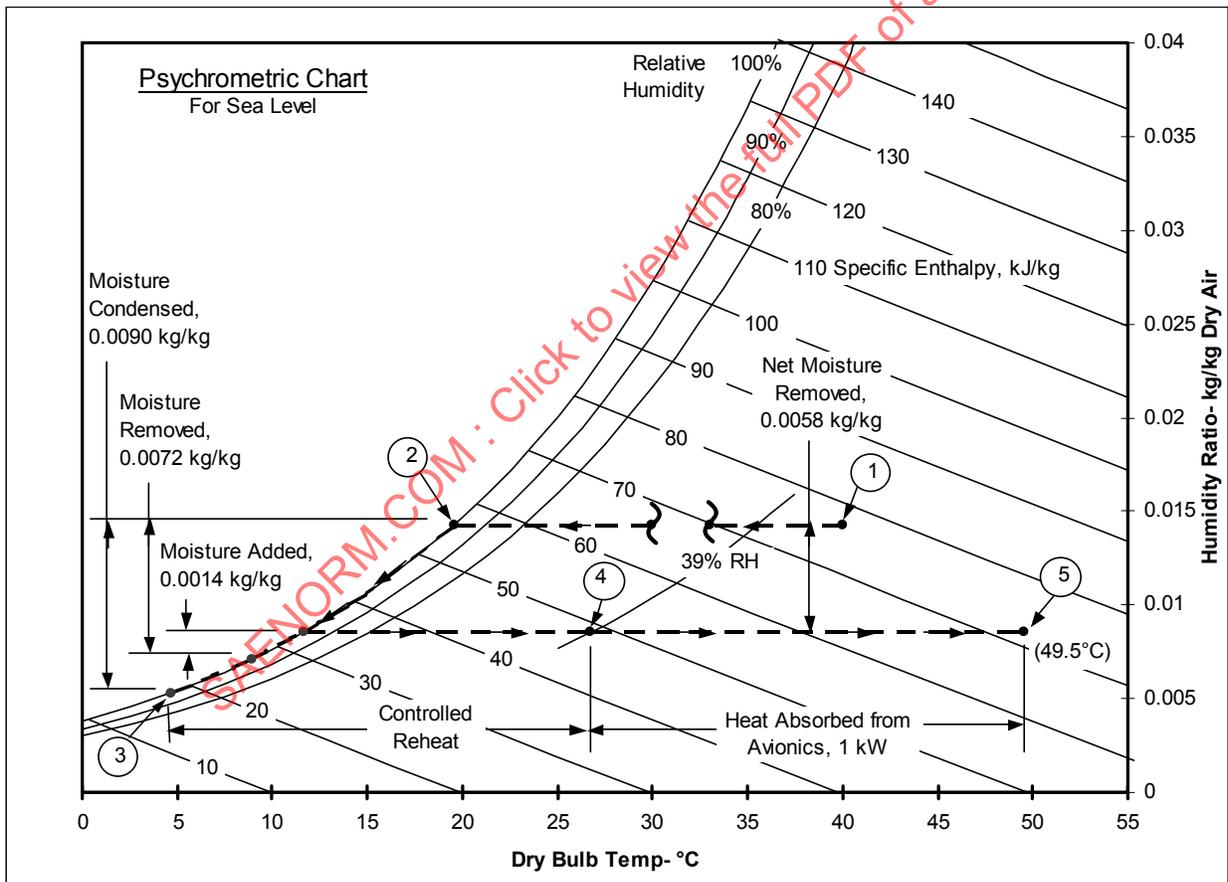
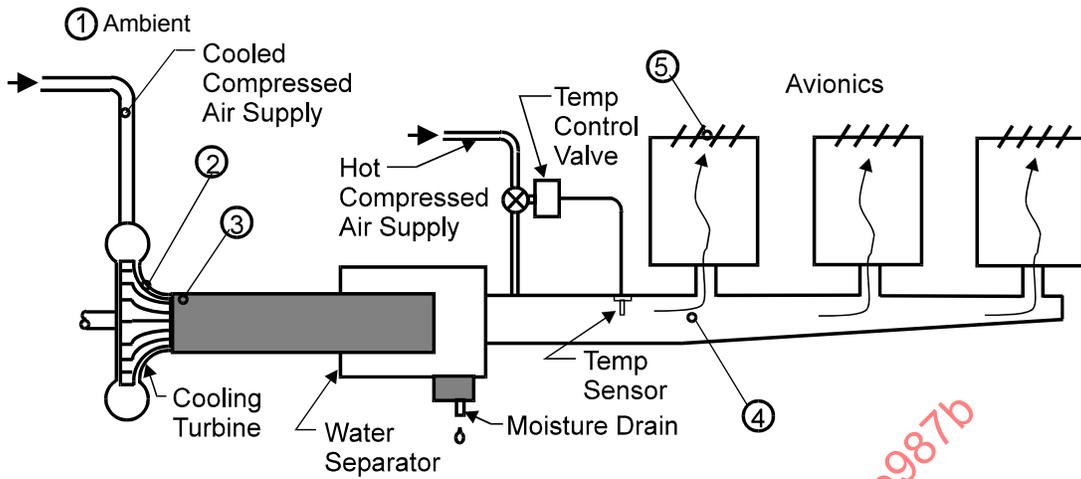


FIGURE 6 – AVIONICS COOLING WITH AIR CYCLE REFRIGERATION (WITH REHEAT)- SI

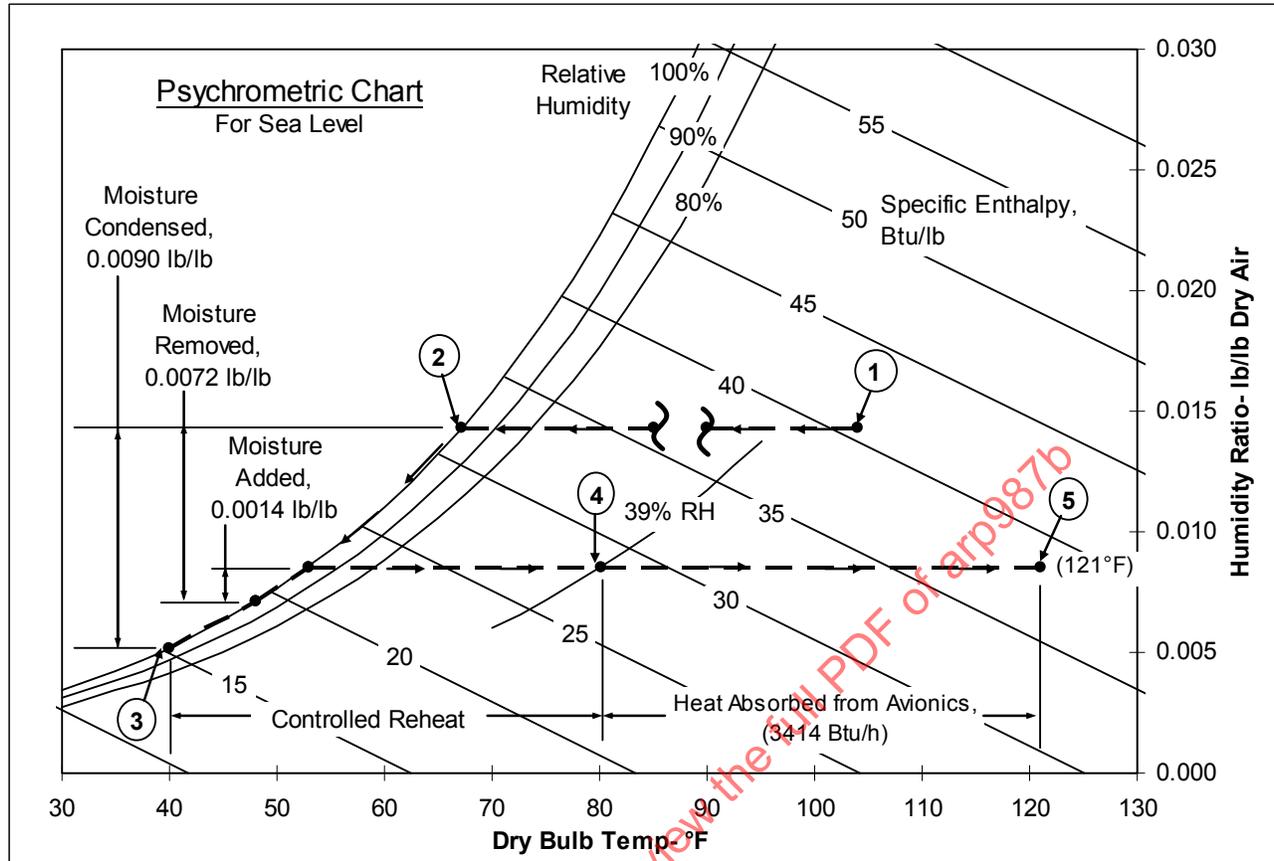


FIGURE 7 – AVIONICS COOLING WITH AIR CYCLE REFRIGERATION (WITH REHEAT)- USCS

In the example shown in Figure 6 and Figure 7, 2.07 kg/min (4.56 lb/min) of air is cooled (as in the example of 4.3), to 4.7 °C (40 °F) which produces 9.0 g/kg (0.009 lb/lb) of entrained moisture (fog), and the water separator removes 80% or 7.2 g/kg (0.0072 lb/lb) of the fog. Controlled reheat with air at 132 °C (270 °F) raises the cooling air temperature to 27 °C (80 °F) and increases the moisture content by 1.43 g/kg (0.00143 lb/lb), as shown at point (4), and increases the delivered air flow 22%. The relative humidity of the delivered air is 39% at point (4), and the temperature rise required to absorb 1 kW (3414 Btu/h) from the avionics is less than the example of 4.3 as a result of the increased airflow.

5.1.1.2 High Pressure Water Separation

The high-pressure water separator (HPWS) system has replaced the low-pressure system for most air cycle environmental control systems designed since the 1980's. HPWS advantages of elimination of periodic maintenance and improved water removal efficiency more than offset the disadvantages of higher initial cost and weight. A HPWS can deliver dry air at, near, or below freezing temperatures since the water condensation occurs at high pressure upstream of the turbine.

The HPWS typically consists of reheater and condenser heat exchangers, a water extractor, water spray nozzle and a temperature control system as shown in Figure 8 with example state points. The warm side of the reheater further cools the high-pressure air from the secondary heat exchanger. Water vapor in the air from the reheater is condensed on the cold metal walls of the warm side of the condenser. The liquid water is in the form of droplets larger than those that occur with a low-pressure water separator since the liquid condenses on a solid object. Furthermore, since the condensation occurs at temperatures above freezing, the water extractor can be located further downstream, allowing droplets to coalesce in the connecting duct. The water extractor uses inertial or centrifugal separation to remove 90 to 95% of the liquid water in the air stream. The air and any remaining liquid water are warmed in the reheater to increase cycle efficiency and evaporate the remaining liquid water prior to the turbine inlet. The cold air from the turbine exit cools the condenser prior to delivery to the cabin or avionics. Temperature or delta P sensors are used to detect icing in the condenser and control condenser cold side inlet temperature by varying the addition of warm air to the turbine outlet air.

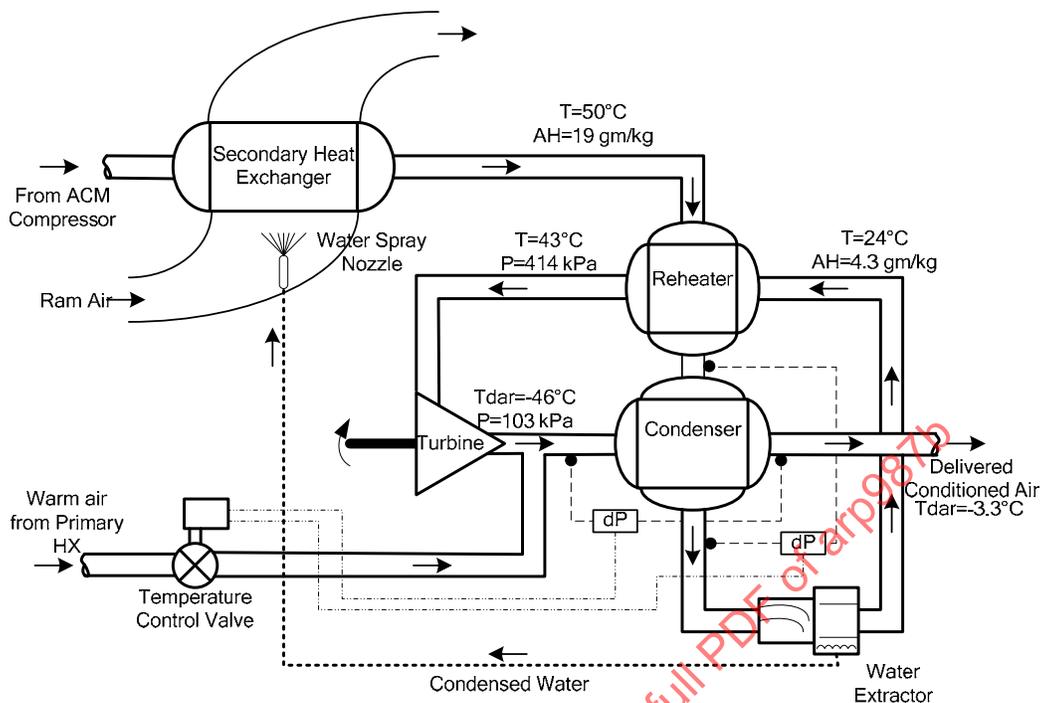


FIGURE 8 – AVIONICS COOLING WITH AIR CYCLE REFRIGERATION & REHEAT WITH HIGH PRESSURE WATER SEPARATION

5.1.1.3 Adding Reheat to System without a Water Separator

If the cooling system does not have a water separator and if there is not sufficient space in the aircraft to install one, a significant improvement is obtainable by installing reheat provisions alone. The liquid moisture can be eliminated during most operations, even though the relative humidity will remain high in hot-humid climates. This modification requires more bypass air because no water is removed and because all of the water droplets must be re-evaporated. For example, if the bypass air temperature is 132 °C (270 °F) and if the cold flow from the turbine in Figure 4 example remains unchanged, an airflow increase of 38% is necessary to evaporate the entrained moisture. Thus the temperature rise to remove the 1 kW (3414 Btu/h) of avionics heat is less than the previous examples. However, the avionics equipment must be capable of tolerating the higher cooling air temperature and resultant higher operating temperature.

Forced air cooled electronics equipment on most commercial airplanes are qualified to operate steady state with air supplied between -15 °C (+5 °F) and 55 °C (131 °F). Predicted reliability, however, is based upon nominal supply air temperatures between 30 °C (86 °F) and 40 °C (104 °F). Hence, to provide this reliability, the supply air temperature should be regulated to between 30 °C (86 °F) and 40 °C (104 °F).

5.1.1.4 Desiccant Wheel

Desiccants have not been widely used for moisture removal in aircraft, except for very select applications. One drawback is the requirement to restore the bed after it reaches saturation. Desiccant wheels have solved that issue by alternately passing air being dehumidified and air used to dry out (regenerate) the bed (Figure 9). This results in a constant regeneration of the bed and eliminates the need for a maintainer to restore the bed. Desiccant wheels are typically applied to drying cabin air but could be considered for drying avionics cooling air. The desiccant not only removes moisture, but it also heats the air due to the activation energy released. This increase in temperature will further raise the cooling air temperature above the dew point, providing additional protection against potential moisture issues. Since this temperature increase will reduce the cooling effect on the equipment, it must be taken into account. As shown in Figure 9, a small regenerative flow is required to restore the desiccant. Since the regenerative flow must be warm, the exhaust from the avionics could potentially be used. If the avionics exhaust is insufficient or impractical to recover, a separate heated air source will be required. The vendors of the desiccant wheel should be consulted for the regenerative flow requirement, since it will vary with the configuration and the type of desiccant used.

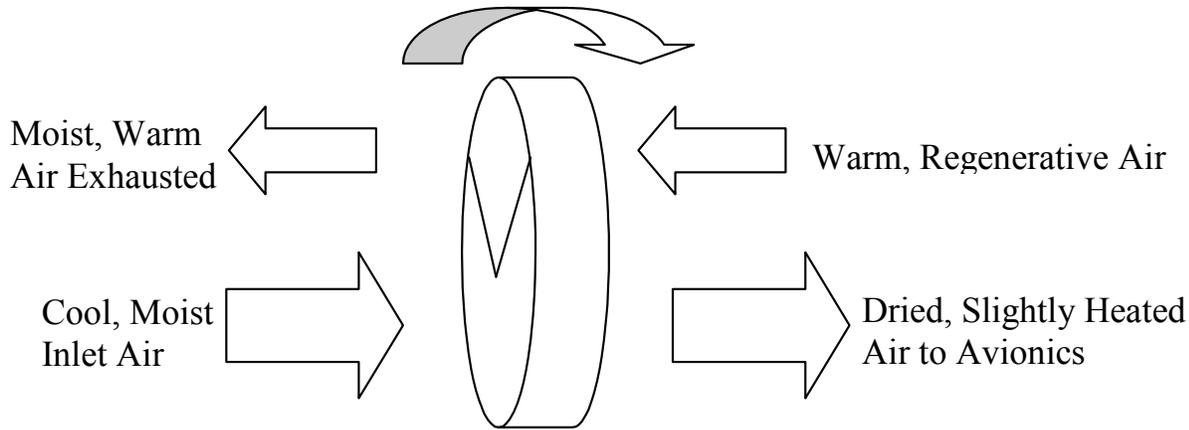


FIGURE 9 – DESICCANT WHEEL

The reliability requirement for a system on a commercial airplane is determined both by the direct operating cost goals and by the effects on safety of its failure. 14 CFR/CS 25.1309 and associated advisory material provide the procedures to determine safety related cooling system and component reliability requirements. If an electronics equipment cooling system is an essential system, then the failure rate should be on the order of $1E-7$ per flight hour. If the failure effect of a desiccant wheel results in loss of effective cooling, then its frequency of occurrence must be less than the $1E-7$ per flight hour. To meet the required reliability, a bypass might be required. Installation issues with additional fans, valve, and ducting would need to be considered.

5.1.1.5 Vapor Cycle Refrigeration Systems

Reheating the cooling air to a temperature above the ambient dew point temperature should be considered for existing systems with low delivery temperatures. This can be accomplished by increasing the airflow through the evaporator or by adding recirculated compartment air. Vapor cycle systems are commonly used in ground refrigeration units for avionic cooling. Ground units with controllable discharge air temperatures should be posted with clearly written operating instructions to insure the use of the proper air temperature for each aircraft which it is intended to service. If the ground unit cannot readily be modified for air temperature control, then instructions to operate with "blower only" for a period of 5 to 10 minutes after refrigerated air operation and before ground unit shutdown are advisable to evaporate any condensation on the avionic equipment after a ground run. During the period of operation with uncooled blower air, the avionics should be shut down to guard against overheating.

Another consideration is the scenario where ground carts are used for cooling airplanes down from hot storage. Maintenance manuals typically specify ducts from ground carts be placed in the flight deck as well as electronics equipment bays. $70\text{ }^{\circ}\text{C}$ ($158\text{ }^{\circ}\text{F}$) is the max short term operating temperature of electronic equipment bay & flight deck installed equipment. To ensure that air supplied from the ground cart is moisture free, it would be advisable to operate the ground cart in blower only mode for a period of 5 to 10 minutes prior to activating the vapor cycle unit, as well as after refrigerated air operation to ensure removal of any condensed moisture.

5.1.1.6 Parked Aircraft

When an aircraft is stored for several days out-of-doors in moist climates, it is beneficial to "dry out" the electronics periodically by forcing warm air through them. This can be accomplished either by using the "blower only" of a ground unit, or the aircraft system may be used if it can be regulated to deliver warm air. It may be advantageous to remove particularly sensitive avionic equipment from the aircraft and store it indoors if outdoor storage of the aircraft for extended periods of time is required. However, the possibility of damage to the avionic equipment during handling, storage and replacement must be taken into account.