DEFENSE
AIRCRAFT

Munters

DRY AIR PROTECTION

Dry air protection is the most effective way of controlling a major threat to aircraft– moisture.

Moisture has a degrading effect on most materials and substances, causing metals to corrode, electronics to degrade and mold to form.

Studies have demonstrated that at a high relative humidity (RH) rates of corrosion are 100-2000 times greater than at lower humidity values.

The impact of moisture-induced failures and corrosion on aircraft performance and support costs is tremendous. It is estimated that $2-4 billion in corrosion damage occurs annually to U.S. military aircraft. The Royal Air Force (RAF) has also calculated that their fleet of 70 Phantom aircraft alone has suffered a penalty in excess of 50,000 manhours each year due to moisture induced electronic and engine failures.

Even loss of aircraft has been attributed to moisture induced electronic system failure.

Aircraft are at risk whether stored or operational, and the damaging effects can be both widespread and complex.

Munters Dry Air Method of protection eliminates the moisture needed to degrade materials, thereby virtually eliminating corrosion and moisture-induced electronic faults.

This is achieved by supplying a continual flow of dehumidified (dry) air to the aircraft, reducing the RH in and around vital aircraft systems to 30-45% – quite a reduction when you consider the average relative humidity in many parts of the world (see Fig. 1).

Fig. 1 Annual Mean Average Relative Humidity.

City	% RH
San Diego	71
Miami	73
Rio de Janeiro	78
Toronto	75
Vancouver	81
Tokyo	71
Juneau AK	80
Singapore	80
Rome	72
Munich	80
Amsterdam	83
Athens	63
Washington DC	67
St. Louis MO	67
London	81
Paris	78
Stockholm	82

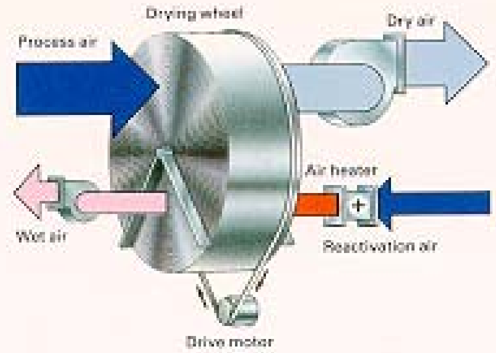
U.S. Marine Corps AV-8B Harrier dehumidified to increase reliability and availability.

BENEFITS

Since introducing Munters Dry Air Method, startling improvements have been achieved.

- Swedish Defence Ministry tests (see Fig. 2) resulted in a 300% increase in Mean Time Between Failures (MTBF), an overall improved reliability in excess of 26%, and in increased aircraft readiness of 5%, which amounts to one extra aircraft being permanently available to every squadron. All Swedish Air Force hangars are now equipped with Munters dehumidification, a one year investment amounting to $926,000 and returning a payback of just 2.4 months.

Fig. 3 Principle of Operation.



The dehumidifier is based on Munters unique Honeycombe® sorption* drying wheel:

- Process air passes through the drying wheel and leaves the dehumidifier as dry air.
- Heated reactivation air collects the moisture absorbed by the drying wheel and leaves the dehumidifier as wet air.

* Sorption = combined absorption and adsorption.

Fig. 2 Aircraft J-35 Draken. Evaluation of faults. Comparison MTBF, radar and cabin equipment.

1. 23 pcs aircraft without dry air connection, time period Jan. 1 - Dec. 31, 1981
2. 10 pcs dry air connected aircraft (rest), time period Jan. 1 - Dec. 31, 1981
3. 52 pcs dry air connected aircraft (stationary inst.), time period Jan. 1 - Dec. 31, 1985

MUNTERS DRY AIR METHOD

This is based on Honeycombe® Desiccant Wheel (DEW) dehumidification technology (see Fig. 3). The dry air is ducted either directly into the aircraft avionics, engines and airframe (see Fig. 4) or distributed within the aircraft enclosure.

- The RAF has conservatively estimated savings in excess of $2.1 million will be gained from dehumidification of their 70 operational Phantom aircraft with a payback of less than 5 months.
- In isolating engine corrosion as their principal problem, the Danish Air Force has dehumidified all their operational aircraft realizing a payback of 7.4 months from reduced maintenance of engines alone.
- In long term storage the French Air Force has increased the life of aircraft. Major overhauls have been extended from 9 years to 13 years.

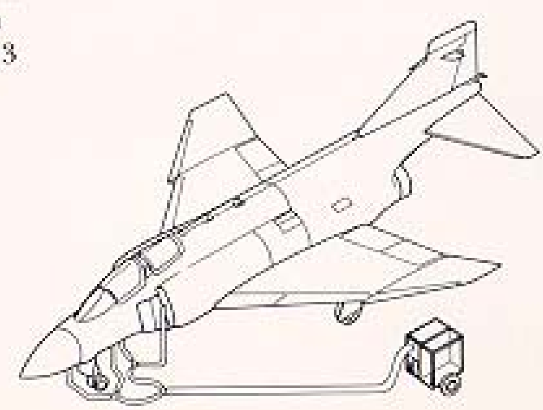


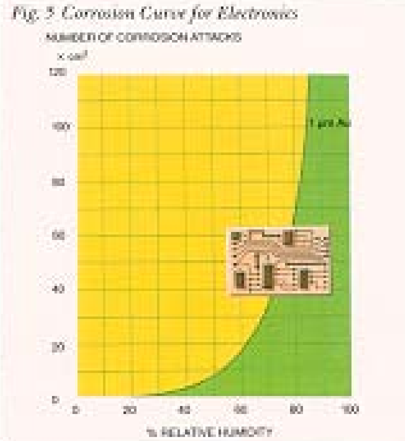
Fig. 4 Phantom 'hooked up.'

FIXED WING AIRCRAFT

Dry Air For Avionics and Electronic Sub-Systems

A closer look at the relationship between relative humidity and the performance of electronics shows why such large economies from dehumidification are immediately attainable. Fig. 5 shows how high humidity corrodes electronic contact material and Fig. 6 illustrates its degrading effect on cables and wiring harness.

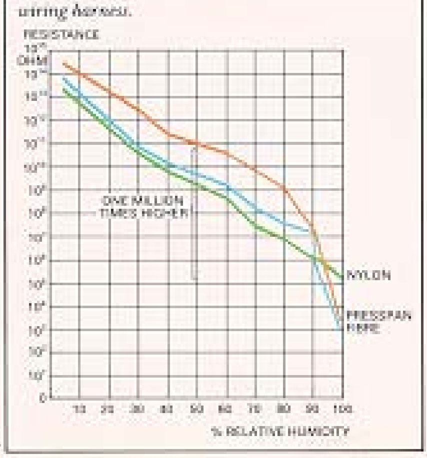
Fig. 5 Corrosion Curve for Electronics



The combined effect is to produce large leakage currents and surface discharge, sometimes called 'Wet Arc Tracking'.

These processes manifest themselves in the form of complete electronic system failures, leading to extensive rewiring and damage repair. In addition there are reduced MTBF's including a high rate of "No Fault Found' occurences leading to excessive maintenance manhours (see Fig. 7).

Fig. 6 Change of electrical resistance in cables and wiring harness.



Major benefits can be clearly seen from the introduction of Munters Dry Air method into the avionics of many aircraft both operational and in storage.

Fig. 7 RAF Aircraft 'no fault found analysis'.

	No Fault Found Electrical Manhours
Phantom FG1 and FGR2 and F4J	6131
Harrier GR3 T2/T4	625
Hercules C1 and C1K and C3	3670
Nimrod MR2	5549
Tornado GR1 and F2/F3	14943
TOTAL	30918 hrs

Top: Luftwaffe Tornado. Improved cockpit avionics and environmental control systems.

Below: RAF Phantom FGR2. Total manhour reduction for first line fault arisings 27%.

Above: French Air Force Mirage. Reduced maintenance manhours in storage

Dry Air for Composite Structures

In the production and repair of composites, temperature and humidity parameters are important considerations if faults are to be avoided. The wing sections of F111's with the Royal Australian Air Force are repaired under humidity controlled conditions, supplied by Munters dehumidifiers.

Dry Air for Furnishings

Above 70% RH, mold and mildew propagate. The effect is to degrade aircraft internal furnishings and sound proofing materials. The problem is aggravated by tobacco smoke and the on-board preparation of hot meals.

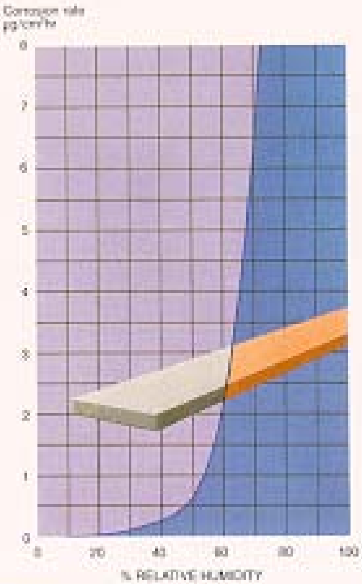
Below: Airbus aircraft are sometimes stored in dehumidified hangars to protect avionics, engines, airframe and furnishings.

Dry Air For Engines and Airframes

Generally the effects of metal corrosion take slightly longer to become apparent unless a particularly aggressive environment prevails. However the end result can prove more costly to repair and ultimately more dangerous. Fig. 8 illustrates how humidity corrodes metal. In engines the compressor is particularly vulnerable as moisture borne contaminants produce small deposits which considerably impair efficiency. Another problem is corrosion pitting which becomes a source of cracking and fissures leading to engine failure.

In airframes the 'normal' rate of corrosion is often accelerated by the proximity of Heat Insulation Material. As the insulation absorbs moisture it not only gains weight, reducing fuel economy, but also provides a constant source of moisture for airframe corrosion.

Fig. 8 Corrosion curve for iron.



Royal Danish Airforce. Savings of $4.8m in engine maintenance in first four years.

U.S. Navy P3C-Orion. Maritime role provides a highly corrosive environment.

Fokker B.V. Aircraft are cocooned and dehumidified to prevent corrosion during storage.

HELICOPTERS

Helicopters are subject to all the problems suffered by fixed-wing aircraft. However these problems are often worse as the aircraft are not pressurized and typically have a higher air leakage, thereby suffering greater moisture ingress. This is aggravated by the aggressive salt sea environments in which helicopters frequently operate. When left on deck or in a hangar after compressor washing, moisture condenses out and, combined with its salt content, attacks the helicopter internal components.

Above: Helicopter turbine blades operated under identical conditions, the top ones used Munters Dry Air Method.

U.S. Army. Dehumidification of AH-64 Apache for protection of electronic systems.

German Bundeswehr – BO105 short term dehumidified storage of 1st line helicopters.

Particularly at risk are the areas under the cabin floor, with the avionics bays, although engine compressor sections, external casing and flow dividers also degrade rapidly (see Fig 9).

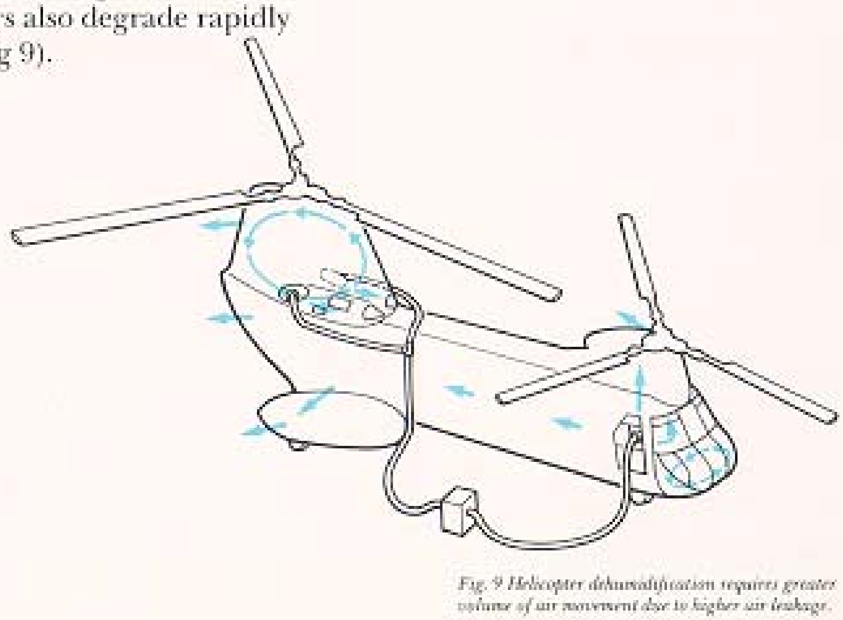


Fig. 9 Helicopter dehumidification requires greater volume of air movement due to higher air leakage.

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