STANDARDS ASSOCIATION OF AUSTRALIA

Australian Standard
for
BASIC ENVIRONMENTAL TESTING PROCEDURES FOR ELECTROTECHNOLOGY

Part 3—BACKGROUND INFORMATION

SECTION 2—COMBINED TEMPERATURE/LOW AIR PRESSURE TESTS

This standard shall be read in conjunction with AS 1099.1, General; AS 1099.2A, Test A: Cold; AS 1099.2B, Test B: Dry Heat; and AS 1099.2M, Test M: Low Air Pressure.

2.1 SCOPE. A range of air pressures covering ground or aircraft applications is considered for the combined temperature/low air pressure tests referred to in this Section. Air pressures below 10 mb are outside the scope of these tests.

2.2 BACKGROUND INFORMATION. In the range of air densities considered, the mean free path of molecules is always a small fraction of a millimetre.

The thermal conductivity and the absolute viscosity of air are then practically independent of the pressure.

The air flux is in general of the viscous type or turbulent and therefore governed by the laws applicable to normal pressure.

The fundamental laws of heat transmission by free or forced air convection are, then, the same as for normal air pressures. As a consequence, all the considerations on convection given in AS 1099.3.1 can also be applied, at least in general, to testing at reduced air pressures.

The reduction of the air density, ρ, however, considerably affects the value of the convection coefficient, α_c, which is a function of ρ^n with n = 0.5 to 0.7 (for both free and forced convection).

In a test on heat-dissipating specimens, forced air circulation can considerably reduce the specimen surface temperature compared with the value in 'free air' conditions within the whole range of air pressures considered. This is illustrated in Fig. 2.1, which shows changes in the surface mean temperature of a homogeneous specimen with air velocity and pressure (constant power dissipation and air temperature).

As a consequence, the test method for a heat dissipating specimen specifies 'free air' conditions (with no forced air circulation) or an air velocity which is sufficiently low that the additional cooling effect is unimportant.

The α_c decrease, with decreasing air density, increases the importance of heat dissipation by radiation, especially at the lower pressures considered, although the heat transmission by convection cannot be disregarded.

The increased importance of radiation requires a careful control of the emissivity characteristics and of the temperature of the chamber walls, particularly at lower air pressures. Due to the importance of thermal radiation at low air pressures, the thermal interaction between different heat-dissipating specimens in the same test chamber may be large and affect the reproducibility of the test. To avoid this, the procedures for heat-dissipating specimens, based on air temperature monitoring, are limited to the testing of one specimen at a time.

The requirements on the dimensions of 'free air' chambers to be used for testing of heat-dissipating specimens have been based on the diagram used for testing at normal air pressures, because the molecular mean free path is still a very small fraction of the resulting dimensions.

2.3 ENVIRONMENTAL EFFECTS.

2.3.1 Combined Temperature and Low Air Pressure Effects. The following effects on a specimen are considered to be due to the combination of temperature and low air pressure:

(a) Increase of surface temperature and changes of temperature gradients of heat-dissipating specimens in comparison with the values achieved with Tests A or B are due to the decrease of the convection coefficient α_c, at low air pressure (low air density). Although the increase of surface temperatures can be achieved by using a higher test temperature at normal air pressure, this test temperature value cannot be properly established and the correct temperature gradients cannot be achieved without combining with low air pressure.

(b) Changes in functional or safety characteristics of specimens due to changes with pressure and temperature of dielectric properties of air (air density and ion mobility effects). At low pressures, particularly when combined with high temperature, there is a marked reduction of air dielectric strength with the consequent increased risk of arc, surface or corona discharges.