RELIABILITY ISSUES AND FAILURE MECHANISMS-The "real world"

Factory conditions are deliberately as consistent as possible, not just to make it more comfortable for the workers, but also to enable the products produced to be tested under known conditions, and thus compared accurately against each other. It is unusual for any but the most rugged military products to be fully tested over the range of conditions that they will experience in the real world. The 'real world' consists of extreme temperatures and changes in temperature, a range of mechanical hazards, and contamination from the environment.

Taking these in turn:

External temperatures vary according to location and season, but generally are contained within the constricted range of −40°C to +40°C. Yes, there are colder and hotter places on the Earth's surface, but the density of electronic equipment in these places is low. However, this does not mean that electronic equipment only has to survive these temperatures. Chilled in the wind, or taken to high altitudes, equipment will get much colder; lying in full sun, or inside the engine compartment of a car, equipment will get much hotter. Forgetting the occasional piece of equipment that is put down an oil well, a fairly realistic estimate of the temperature extremes is −65°C to +150°C. You will already have realised that some of the structures on which we depend, such as solder joints are at the extreme of their temperature range in these conditions.

The real world does not just have a daily cycle between maximum and minimum temperature; real components and circuits are powered-up from cold, sometimes rapidly reaching a high temperature, and then generally left to cool in an uncontrolled fashion upon switch-off. Depending on the application, this thermal cycling may happen many times per day.

In the real world, products don't lie on the bench, but they are "shaken, rattled and rolled" with varying levels of acceleration, vibration, bump and shock applied. If steps are not taken to limit their effects, the energy imparted to the assembly can result in damage and malfunction.

Occasionally the environment is cold and dry, so that we only have to worry about electrostatic discharge; more frequently, it is humid, whether this is the cold wetness of a Northern winter or the hot and humid conditions of the jungle. We have seen already that humidity can have an impact on the life expectancy of components. Real life relative humidities are rarely less than 10–20%, but frequently reach 100%, often with additional 'condensing water', which needs to be guarded against. Also from the environment, depending greatly on temperature and humidity, are particles, both of dust and living organisms. A build-up of dust, of growth, or of mould, can result in short-circuit conditions as well as affecting any cooling by reducing the circulation of air and water.

Typically equipment that is work- or office-based has an 'easier life' than portable equipment, and both enjoy a relatively benign experience compared with military and automotive applications. Arguably the hardest life of all is that of a piece of equipment that exists in a car engine compartment – the so-called 'under-hood' electronics.

In Table 1, we have tried to compare the environmental conditions experienced by various types of equipment. Each is rated on an arbitrary 1–10 scale, representing a range of impacts from minimal to extreme.

Table 1: A comparative assessment of the environmental conditions to which different classes of equipment are exposed

environmental condition	mobile phone	personal computer	car engine management system	military aircraft radar
temperature extremes	3	1	10	8
thermal cycling	4	3	10	7
acceleration; vibration; bump; shock	5	2	9	10
humidity	4	2	10	8
dust; mould growth	4	3	9	10
electromagnetic environment	5	3	7	10
Classified on a scale of 1 = benign to 10 = severe				

Obviously the scale is relatively arbitrary, but it is worth noting that some level of hazard can be associated with most items of equipment.

In some cases, the conditions will depend on the user – you may always be careful not to drop your mobile phone, but there are others who do, and in consequence many failed phones! Also, although nothing more is said about this aspect during this module, one has to consider the electromagnetic environment. In other parts of this module, we have mostly considered the EMC aspect, but one of the reasons that a military aircraft radar has a more severe classification is that it needs to withstand the high electromagnetic pulse from a nuclear event!

It becomes very important to know the detail of the 'real world' in which your equipment will be operating, in order to make informed choices for technology and construction. Challenges in our real world also include:

Occasional supply over-voltage conditions, in addition to the more common low-voltage 'brown out'. This is a particular problem if you live on the end of a network with overhead power lines. Over-voltage may also occur by accident, as when a 12V appliance is connected to a 24V vehicle system.

Start-up conditions, for instance, drawing excess current for a limited period. In some cases it is necessary to stagger the application of power, in order to prevent system overload.

Differences between storage conditions and operation. Whilst a stored piece of equipment is not exposed to a high voltage or current, and does not reach high temperatures, neither will it remain dry in a cold damp environment, where the dissipation from operation would normally prevent the absorption of damaging moisture.

In the real world there are also differences between normal and abnormal operation. For example, with industrial computers and motor drives, it is not unusual for equipment to be specified to operate at a high dissipation for restricted periods.

Finally, in the real world, one needs to make provision for likely accidents. You may decide not to have a coffee-proof keyboard for your workstation, but an equivalent function in an industrial environment may need a different input mechanism, in order to guard against operators with gloves dripping unknown fluids!

Author: Martin Tarr

Source: http://www.ami.ac.uk/courses/topics/0194_trw/index.html