TROPICAL TESTING OF ELECTRONIC EQUIPMENT

by

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Electronic equipments are rather prone to breakdowns and erratic behaviour in the tropics more than any other electrical equipment. This is because unlike others, high insulation resistance is essential for the proper functioning of electronic equipment. All components, terminal strips, tag strips, wires and such like have to be well protected against ingress or deposition of moisture if they are to function satisfactorily. Since surface moisture combined with high ambient temperature aids the growth of fungus in addition to reducing the insulation resistance, all components have to be suitably treated to prevent the wetting of the surface by condensed moisture. Condensation is quite heavy in the tropics due to the large variation in temperature between day and night and high humidity. The tests that are to be conducted to assess the efficacy of tropic proofing has to take into consideration all these factors and devise the tests in such a way that they show up incipient faults in the equipment.

The proper method of proving the reliability of components or equipment for operation in the tropics is by using such equipment in the field and observing its deterioration over a long period, which may extend to a number of years. This procedure, while being ideal, will take far too long to prove an equipment and hence attempts have been made to simulate such tropical conditions in the laboratory and evolve accelerated tests which will indicate the effectiveness of tropicalisation in a reasonably short period. The importance of proving the ability of equipment to stand tropical conditions was brought forth very forcibly during the Second World War when equipment failures were so considerable in the tropical theatre of war at the beginning of the hostilities, that the logistics of maintaining electronic equipment operating became a formidable task.

In the beginning when accelerated tests were first formulated, they were confined to exposing equipment to very severe conditions of high temperature and heavy condensation of moisture almost amounting to flooding of the equipment. Such tests revealed gross defects in sealing of the equipment but the water, apart from thoroughly wetting the wiring, components and such of those parts that absorb moisture, did not penetrate through any fine 'hairline' cracks. The result was that even when equipments were found to withstand repeated cyclings in a humidity chamber at 60°C and 95% to 100% humidity they continued to fail in service. On investigation it was found that if the sealing is not satisfactory due to the presence of fine cracks or pores, water as vapour used to get in by the 'breathing in' of moisture laden air at night and expulsion of dry air during the day as there is a large difference in the temperature between night and day under normal conditions in the tropics. A surprising amount of moisture can collect inside a 'hermatically sealed'

component in this way if the sealing is not perfect. The value of the insulation resistance is an indication of effectiveness of sealing.

In order to detect such defects, additional tests were prescribed which cycles the equipment through a 15°C variation in temperature from 35 ± 5°C to 20 ± 5°C, the maximum and minimum periods corresponding to the duration of the day and night temperature as closely as possible. Humidity was kept above 95%. The tests are conducted for nearly three months and the essential characteristics checked periodically.

All these tests can be carried out in well equipped laboratories but there is one factor which need very careful consideration in evaluating the results of tests in a laboratory in the tropics as compared to similar tests conducted elsewhere in temperate countries. Measurement of the insulation resistance of samples will differ greatly at different periods of the day and year if they are tested at the prevailing room temperatures. For e.g. the temperature in summer can be quite high and humidity low which will give excellent results, whereas the same equipment checked for insulation resistance during the monsoon can be quite low and may lead to a total rejection. Therefore, it is essential to prescribe suitable standard conditions and periods for recovery before testing components. Then only results of different laboratories can be comparable. In the tropics this would mean air-conditioning the laboratory where such tests are conducted if uniform temperature and humidity conditions are to be maintained.

This problem was not very serious when testing of equipment for tropical use was mostly confined to countries in temperate zones. When tests were conducted in India, the test results did not agree with those obtained in the temperate countries and generally showed the equipment to be poorer than claimed. What was more, test results obtained in different parts of India particularly those from the coastal areas, did not agree with those from dry regions in the middle or northern parts of India.

The importance of stipulating room conditions for testing is sometimes overlooked even in international documents. As an instance, in the original draft I.E.C. specification the mould growth test was prescribed to be conducted in a mould growth chamber whose temperature and humidity conditions were clearly defined for a specified period. Then the components are to be taken out and kept at room temperature for another month before any measurements are taken. The laboratory room conditions were not specified. In the tropics, room temperature and humidity conditions will itself further enhance the growth of the moulds and we will not get any comparable results. The original object was apparently to see if any chemical compounds that may be formed during mould growth will have any deleterious effects on the components. The test prescribes a definite period for mould growth under appropriate atmospheric conditions followed by a period when the mould does not multiply and yet it gives sufficient time for chemical action if any, to take place. It is necessary, therefore, to specify clearly the conditions in which samples, after exposure in the mould growth chamber, are to be kept for any evidence of chemical action. This lacuna has been rectified in the latest draft.

The necessity for specifying recovery conditions was stressed by India at the meeting of the International Electro-technical Commission and has led to a revision of some of the important clauses of the specifications. It has been recognized that it is essential to have a separate temperature for, testing in the tropics and precise recovery conditions have also been laid down to ensure correlation of results.

A major revision of the test procedures, particularly the damp heat cycle is being contemplated. For arriving at a proper and effective test schedule a working group on comparative Long Term Damp Heat tests on components was constituted at the Philadelphia meeting of the I.E.C. to study this question and report. The members of this group were Canada, France, Germany, Italy, Netherlands, United Kingdom and U.S.A. and these countries were to carry out tests on long term damp heat according to three prescribed procedures namely, I.E.C. (Test C Damp heat long term) Publication No. 68; MIL standards 202, test 103 (steady state humidity); and I.E.C. test C with the upper temperature at 40°C and lower at 30°C, relative humidity in all cases being 95 to 100%. The object is to see which one of these tests gives reproducible results.

It is significant that none of the countries are in the tropical belt, though it may be said a few have territories under their control in the tropical belt where tests on correlation can be carried out. India had volunteered to cooperate in these tests but the offer, unfortunately was not accepted.

At the conclusion of their tests the working group has recommended among other things, that the recovery procedure must be strictly defined.

In spite of many years of study and investigations a correlation between actual life of an equipment under tropical conditions and the number of cycles it withstands in the laboratory has not been clearly established. We in India are in a unique position as we are in the tropics and weather conditions range from extremely hot, very dry, and dusty to hot and humid conditions approaching that of the tropical jungles. It is possible to carry out accelerated tests as prescribed in the specifications of the different standards and simultaneously operate identical equipment under different tropical conditions to find out which of the tests specified more nearly correspond to the actual conditions. Such correlation is absolutely essential if we are to design equipment or choose the right raw materials for components and equipment. These investigations will necessarily have to be carried out for a number of years before such correlation can be established with certainty.

In most specifications a clause prescribes a storage test. But here again the actual conditions of storage, such as temperature, humidity ventilation etc., has not been specified; or, if specified, the tests are to be conducted under standard atmospheric conditions. Storage test, at best, is only required if we are not quite sure of the results of our accelerated and long term tests. Equipment and components will have to be stored under widely varying conditions in the tropics and the tests, to be effective, will have to be done under at least two broad categories of temperature and humidity to yield any worthwhile results. As surface moisture and dust plays such an important part it may be necessary to specify that all equipment must be suitably packaged for storing in tropics.

Apart from humidity and heat there are other factors which also are of importance. Chemical corrosion is usually accelerated by temperature and humidity. Dust in the presence of greasy or oily matter on terminal strips can cause flash overs in transformer terminal boards, tag strips etc. and so it is necessary to provide larger distances between tags and keep the insulating material on which the tags are mounted clean and free from grease or oil. In the industrial cities on the coast such as Bombay, Madras or Calcutta salt spray combined with Industrial gases cause rapid deterioration and breakdown of insulation. So tests such as the dust chamber test and exposure to salt atmosphere are essential even for civilian equipment. There is a tendency in International committees drawing up standards to think these tests are not necessary. That conclusion, is not quite correct.

Growth of fungus in electronic equipment over components and wiring has been successfully retarded by adding inhibitors in the chemicals used for covering the wire, moulding compositions of components and by antifungii spray. Recent investigations carried out in Switzerland[1] however, show that fungus, by itself, does not cause short or open circuits and neither is the insulation resistance adversely affected. However, the effect of badly pitted metal parts due to fungus and the deterioration in finish gives the impression that the equipment is defective.

NPL of India has started long term tests on this problem of correlation by exposing radio components to the vagaries of Delhi weather. The table below gives temperature and humidity conditions for each month of the year in Delhi. Components are kept in a desiccator which has a layer of water at the bottom and thus the atmosphere surrounding the components is saturated with water vapour. The desiccator is kept in a place where the maximum and minimum day and night temperatures are about 35°C and 20°C respectively. Identical sets of components are undergoing tests simultaneously in the laboratory rooms where it is air-conditioned, the temperature being maintained at 25°C$\pm$ 5°C.

Another desiccator loaded similarly with components, is kept in an air oven maintained at 40°C$\pm$1°C for six hours and is kept at room temperature for the rest of the period. Simultaneous experiments on exposing components according to MIL standard specifications continuously at 40°C without cycling in an air oven are also being conducted. The detailed results of the tests will be published when sufficient data has been gathered. In the desiccator test there is condensation of moisture on the surface of the components at night and this is what happens in actual storage in the tropics during rainy season.

As stated earlier the I.E.C. working group is primarily concerned with the repeatability of results as obtained in laboratories in different countries of Europe and the United States. But there is also an equally important consideration as to which of the tests, namely cycling through a fifteen degree variation in temperature or constant exposure with high humidity, more nearly corresponds to actual field conditions.

It is hoped that the long term correlation tests undertaken by National Physical Laboratory will help to provide data for specifying a proper method for accelerated tests on climatic durability.

NEW DELHI

	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Mean daily maximum	88·8	70·5	74·7	85·0	96·6	104·8	102·4	95·3	93·0	93·5	92·5	83·2	73·7
Mean daily minimum	64·5	45·3	49·2	57·1	67·7	78·8	82·5	80·1	78·4	75·5	64·3	51·8	45·0
Highest maximum ever recorded.	115	84	92	106	111	114	115	113	104	105	101	92	84
Lowest minimum ever recorded.	31	31	35	45	63	65	66	71	72	64	49	39	34
R. H. % at 0000 hrs. IST	61	68	71	55	40	39	56	77	80	74	58	53	67
R. H. at 1700 hrs. IST	33	38	35	18	13	16	37	55	61	44	28	25	31

* From data collected by Meteorological Department.

Reference

1. Ganz, E. and Baden, O, Wälchli, Saint-Gall, "Les moisissures dans les appareils électroniques, Associations suisse Des Electriciens, Tirageápart du Bulletin de l' Association Suisse des Electriciens, No. 6, April 1955.

Discussion

The Discussion was initiated by Col. Mehta who pointed out that K114 specifications were the basis for tropical testing in India. These specifications were of a general character and included various types of hazards to which equipment could be exposed for tropical testing. One could choose the conditions likely to be met in the country where a particular equipment was to be used and could test that accordingly.

In answer to a question regarding the fungus growth in the damp weather he suggested that hermetical sealing of equipment under a low pressure (cā 5 lbs) seemed to meet most of the requirements and prevented growth of fungus.

Wing Commander Srinivasan pointed out that electronic equipment in aircraft was faced with the problem of meeting large variations of temperature and pressure and that they were experiencing difficulties in finding equivalent spares, as those commercially available were too bulky and could not always be used as substitutes.

Brig. Kapur pointed out that reliability of electronic valves was one of the important problems and in the United States several groups were working to produce very reliable tubes for different applications.

Commander B.C. Chatterjee, I.N., pointed out that the Indian Navy did not have any establishment to carry out tests on tropicalisation of its own. In their experience a number of components failed because of the large variation between the ambient temperature to which the components were exposed although they might have passed simulated tests in the laboratory. He also drew attention to the importance of looking into the electrical ratings of the components and its tolerances. He suggested that K114 specifications were not very ideal for India and that specifications for service equipment should be devised to meet Indian conditions

Dr. Rao (TDE, Dehra Dun) pointed out that accelerated testing was a short-term procedure and was necessary for the manufacturers to be able to supply the equipment. He pointed out that there were large variations and changes in the tropical weather which were responsible for deterioration in components and it was difficult to simulate the meteorological conditions from hot, dry weather prevalent in Rajputana to extremely wet conditions at Cochin. Accelerated tests should be based on sound statistical weather data. Even then long term field testing would be necessary to revise or to confirm accelerated testing according to Indian specifications.

Professor Chandrashekhar Aiya (Engineering College, Ahmedabad) pointed out the effects of wide variations of temperature and humidity on electronic equipments and stressed that suitable tests should be framed after collecting the data from Meteorological Dept. He pointed out that correct logging of the failure of components or equipments was also necessary. He also suggested that factors which affected the life and variation of the actual values of components should also be looked into.

Major Mishra (Institute of Armament Studies) pointed out that they had developed composite resistors which maintained their values within three per cent.

Dr. B. N. Singh pointed out that the failure of electronic equipment due to valves mostly occurred during the first few hours of its life. Western countries were producing equipment which could be guaranteed hundred per cent reliable. The problem of reliability had to be attacked at the design stage itself and a certain amount of redundancy must be built into the equipment.

Dr. Amarjit Singh (CEERI, Pilani) pointed out that one should make a distinction between different uses of reliability, for example, there were valves which were required to operate in projectiles, in computers or in submarine repeaters, and these required different aspects of reliability. There was also need for studying deterioration inside the components such as valves during the operations.

Professor S. P. Chakravarti pointed out a case in which some components had exploded during use and the defect was attributed to gas accumulation in electrolytic capacitors.

Mr. Bose (Civil Aviation Dept.) pointed out that fungus proofing treatment given to equipment obtained from U.S.A. or U.K. did not withstand the weather conditions in Bombay . He also wanted to know if any work had been carried out at NPL on tropical testing of crystals. Crystals manufactured in India and obtained from abroad have been found on test to fail to provide the specified frequency tolerance under the varying range of weather conditions in India. The frequency tolerances of crystals had become more stringent and a good deal of work was necessary to study the problem of gas accumulation in Electrolytic capacitors. and sealing of crystals.

Dr. Srivastava (INPL, Cochin) pointed out that deposition of copper sulphate had been noted on wire-wound resistors and calibrated attenuators at Cochin. This was very probably due to the presence of certain amount of sulphur dioxide in the atmosphere, and hot and damp conditions at Cochin helped this deterioration. He also pointed out that reliability of components and equipments had been studied in defence science and that failure of air borne electronic equipment was mostly due to shocks and vibrations to which ordinary components were exposed in the early hours of flight.

In conclusion, Mr. Ramamurti stated that a certain amount of re-thinking was necessary on K114 specifications. Although the specification covered a wide range of weather conditions it was being realised that redrafting of specifications should be undertaken to meet most of the tropical requirements. He also suggested that fungus was not the common cause of electronic breakdown, although it spoiled the appearance of the equipment.