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# *Conference Report*

Conference on Reliability in Electronic and Electrical Components and Systems (Eurocon '82)
Held June 14 to 18, 1982, Copenhagen.

Continuous growth in the appreciation of the importance of reliability of electrical and electronic component systems has been recognised in the corresponding growth in the number of conferences devoted to this all important subject. The 5th Eurocon Conference held in Copenhagen June 1982 was one of these meetings. One hundred and seventy papers were presented in four parallel sessions, with the papers selected from a total of two hundred and eighty which were presented to the Technical Programme Committee. Six hundred participants were present.

Eurocon '82 was jointly sponsored by EUREL (The Convention of National Societies of Electrical Engineers of Western Europe) and by the IEEE (Institute of Electrical and Electronic Engineers), with additional support from the Danish Society of Chemical, Civil, Electrical and Mechanical Engineers, the Society of Engineers of Denmark, and the Danish Electro Technical Association.

Not all aspects of the conference were of direct relevance to the component and sub system engineer. Theoretical aspects of the study of reliability were well covered by papers on computational methods and reliability modelling as well as on the analysis of complex systems, field tree analysis, and studies of redundant systems. Practical aspects of reliability in electronic systems were presented with particular reference to telecommunications, and other types of systems were examined in the sessions devoted to detection and control, satellites, transportation, consumer products, power distribution and industrial networks, power generation, sub station equipment and dispersed generation sources. The Conference also recognised the importance of software reliability and data processing systems, with three sessions devoted to this area. The costs of achieving reliability were recognised by many authors in their papers, but two sessions were specifically devoted to this area covering life cycle costs, maintainability and availability. Finally, the human and legal aspects of reliability were considered in one session of three papers.

With regard to components themselves sessions were devoted to passive components and interconnections, discrete semiconductors and integrated circuits, connectors, memories, opto electronic devices and component testing.

The themes and aims of the Conference were well set by many of the invited papers given at the plenum sessions. The very first paper by Sir Herbert Durkin, President of the IEE in the United Kingdom on the "Technical and Economic Implications of Reliability", emphasised the most important point that reliability does not happen, it cannot be grafted on after design is complete, and most of all it is not something that requires attention only by one group of people responsible for a particular part of a project. It must be recognised at all times that quality and reliability must be related to application and that nowadays poor quality and reliability not only has the effect of increasing costs to the company due to customer returns but also in this age of fierce competition will lose the company future orders. It also needed to be emphasised these days that the concept of a bath-tub curve for representing the change of failure rates with time in which after an initially high failure rate, the failure rate is low and relatively constant in middle life, and then rises again gradually as the end of life approaches, is no longer valid unless one is considering systems which are mainly mechanical or which have well defined chemical wearing out processes. The evidence is becoming much less well established that there is a wear out mechanism in electronic components both passive and semiconductors, and for these the bathtub curve looks much more like an asymptotic fall to a very low or zero failure rate.

Kan L. Wong, the Manager of the Design Effectiveness Operations for Hughes Aircraft in the States gave a keynote paper on "New Directions for Electronic Reliability Engineering in the 80s". In summary Mr. Wong felt that now the time had come for all of us to direct our attention to the real failures which were usually called random failures. These failures came from interaction of stresses and flaws and it was necessary to eliminate them. He felt that reliability

engineers were now entering the era of interaction in which reliability engineering and basic engineering must work closely together to create an environment for achieving even higher reliability failure analysis.

Neither Sir Herbert Durkin, or Kan L. Wong, presented any definitive data to support their important conclusions. This was not however the case with the important invited paper given by Dr. Fred Reynolds of British Telecom on "Measuring and Modelling Integrated Circuit Failure Rates". This paper, while acknowledging the difficulty of obtaining field failure data, emphasised the importance to the reliability engineer of such an operation. Figures were presented for certain components which have been studied in field failure terms since 1967 and later. Very important summary charts were presented giving failure rates, together with other results, obtained from a wide number of sources. However, it needs to be recognised that most of the reports used for accumulating field failure data gave little help to the present day system designer who is now dealing with different types of devices than those incorporated into equipment manufactured in earlier years. The natural alternative of life test data acquisition was examined and the various data banks that exist around the world for collecting and processing such information were summarised.

The problem of accelerated life tests is one that still requires urgent attention. For many industrial applications, the raising of the ambient temperature of the tested device to 125°C whilst continually operating it was often used as a suitable stress level. However, even this level requires large samples in order to generate a significant failure yield, and, furthermore, conditions of test used can expose modes of failure not actually seen in real service. The testing time used by most vendors is too short for any postulated lifetime distribution to be other than exponential so that long term failure rate trends cannot be predicted. Credible interpretation of failure behaviour can only be possible if the failure causes are known, so that individual activation energies can be associated with them and the effect of changes in testing temperature can then be assessed. In this assessment process mechanisms with low activation energy clearly give the greatest cause for concern.

It is impossible in the space available to summarise all the important points raised in Dr. Reynold's paper. However, his conclusions can be noted as follows:-

(a) Reliability models are attractive from a System Engineers point of view but they are essentially a bench fit to very scattered data so that any individual experience may be at variance with the model. However, when models are used for system evaluation purposes, statistical differences between predicted and observed failure rates will not be profoundly important. For ground based telecommunication equipment the CNET model is probably the best model presently used.

(b) The importance of identifying failure mechanisms in order to assess the applicability of accelerated life test is emphasised.

(c) The collection of field lifetime data is of vital importance as a source of predictive information.

Many of the subsequent contributed papers re-emphasised the themes discussed in the invited papers. Dr. Wayne (from Plessey Research, Caswell, England) discussed the "Thermal Fatigue Failure of Soldered Joints in Printed Circuit Board Assemblies". The failure mechanism associated with the soldered joints recrystallising on thermal cycling was recognised and many excellent electron micrographs were shown demonstrating the micro cracking that results. A best buy with regard to the use of tin cadmium solder joints, when the printed circuit boards had a bare copper or tinned finish, was suggested. Such a solder showed a fatigue resistance which was approximately four times better than that of the traditional tin-lead solder.

Changes in microstructure were recognised in a paper given by Hieber and Pape of the Philips Laboratories in Hamburg on "The Reliability of Thin Film Metallizations from Thermal Ageing Kinetics". Thin films of gold and aluminium were studied and changes of the microstructure with thermal treatment were analysed. It was recognised that these results were of interest for films prepared under relatively clean conditions and that the inclusion of impurities etc. in the films if they have been prepared by sputtering instead of evaporation could possibly lead to other failure mechanisms.

A most interesting Paper on "Failure Mechanisms in MOS Devices, both those in Integrated Circuits and Power Devices", was given on behalf of Dr. Edwards of the Siemens Corporation, Cherry Hill, U.S.A. The failure modes in integrated circuits were recognised as being due to oxide breakdown, electro migration, hot electron effects and finally soft errors due to alpha particle penetration. The alpha particles originated from the substrates being used and could have energies as high as 5.5 MeV. Both these last two errors were becoming increasingly important as the integrated circuits moved to smaller and smaller dimensions with channel lengths down to 2 microns. In the case of power devices which were being

designed to carry higher and higher currents and withstand higher and higher voltages, hot electron effects and alpha particle effects were not of any importance. These two failure mechanisms were replaced by the importance of guard structure defects and reverse bias leakage currents. In passing it was noted that p channel MOS devices were inherently better than n channel because ion migration would not be as important.

The influence of plastic encapsulation on failure modes in integrated circuits was discussed by Dr. Turconi from the Italian Telecommunications Society in Milano, Italy. The team there has investigated various aspects of plastic encapsulation, with particular reference to the use of integrated circuits in TLC equipments. The failure modes investigated included corrosion of metallization, connection breakage due to thermo mechanical stresses, and oxide contamination. The results of a wide variety of tests were presented that showed in conclusion that it was possible to use integrated circuits in plastic packages in TLC equipment, but the failure rate of plastic encapsulated devices was in fact higher than those of ceramic encapsulated ones. To define plastic useful life it is necessary among other things to establish the actual operating conditions of the component with particular reference to junction temperature and relative humidity.

Not all the papers were able to identify failure mechanisms as such, but were able to identify the conditions under which one would get the highest reliability. One such paper was that presented by Mr. Villien from the Danish Centre of Applied Electronics at Horsholm, Denmark. He considered the comparative quality testing of IC sockets with reference to the contact type, the contact material, and the contact plating. After extensive testing, the results of which were summarised in the paper, the conclusion has been reached that the "best buy" consists of a single sided contact with the contact springs made of phosphor bronze, and that generally the socket plating does not influence the probability of failure to a marked degree, though there is evidence that gold plated socket contacts mated with silver or gold plated IC pins are the most reliable combination.

It is impossible in the space available to summarise the data presented on all the components and sub systems discussed. Other interesting papers were given on the following components, "Impregnated Capacitors for DC Use, Impregnated with both PCB and Synthetic Nonchlorinated Oils", "Large Energy Filter Capacitors made using a Paper-Polyester Mixed Dielectric Impregnated with a Non toxic Oil", "Single Bipolar Transistors", "Emitter coupled logic devices", "64K MOS dynamic rams", "Solder Connections for Solder Bump Integrated Circuits", "Type HE9 Connectors (France)", "Tin-Tin Connectors for Dry Circuit and Microcomputer Circuits", "Proms and Eproms", "CCD Video Line Store Integrated Circuits", "Magnetic Disc Memories", "Gallium Arsenide – Silicon LEDs", "Protective Relays", "Testing of Printed Circuit Boards" (with regard to automatic visual inspection and also quality control of multi layer systems), "The Design and Manufacture of High Reliability Hybrid Circuits", "Testing Problems Associated with Test Pattern Generation for Devices with LSI and VLSI Circuits", and "Characterisation of Test Methods for Microprocessors".

Finally, mention must be made of the paper by Herr Blasberg of the Institute of Microwave Techniques and Electronics at the University of Karlsruhe, Germany. He gave a paper on "Results of Long Real Time Field Testing of TV Receivers". This paper illustrated perfectly the importance of obtained field data as emphasised by Dr. Reynolds and also illustrated the importance of component quality on the design and performance of systems. Both European and Japanese sets have been tested over a period of more than 2000 days (more than 5½ years) in the field. The results showed that the percentage of failures in early life of the European sets was much greater than that of the Japanese sets. (9% compared with 2%). However, after 450 days and up to 1350 days (3½ years) the groups had nearly the same percentage of failures (5%). For long times (greater than 5½ years) the reliability of European sets appeared better than that of the Japanese ones. The results of the work showed that there were two main reasons for high failure in colour television sets. The use of poor components was responsible for failures in early life of the sets, but design faults were normally responsible for failures in the latter period of the life of the sets. The relatively high failure rates of European sets in the first 50 days could be attributed directly to the sets being designed with poor components and the reliability would be much improved if the producers of the sets did not use such components. It was emphasised that good components cannot be obtained by testing and selection, they must be produced from reliable batches in the first case. The producer of the sets should prove the specifications of the components that he purchases by using well known statistical methods and if the quality of the component is not sufficient he must control their quality by discussions with the producer of the components. Wear out failures of

television sets which began to occur in both groups after 1000 days cannot be prevented entirely by using components of good quality. The most important condition here is to avoid design failures so that the components are not stressed too much in use. To improve on design it is important that all the information about failures which happen during production, failures which are repaired by the producers own service organisation and long field test data, must be recorded. In this way design failures can be found and eliminated.

The above paper by Herr Blasberg brought us full circle in our thinking about the reliability of components and systems. The points emphasised at the beginning of this report as given us by the keynote speakers were seen in application.

The Proceedings of the Conference will be published by North Holland Publishing Company in the near future. The present preprints run to over 1100 pages and it is expected that the final published version will be at least as long as this, produced almost certainly in two volumes.

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