ENVIRONMENTAL STRESS TESTING FOR RELIABILITY IMPROVEMENT

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Abstract

Environmental Testing is a powerful tool for detecting and resolving reliability problem early in the development phase. This paper describes the production system environmental stress testing conducted on the new developed products of Telecommunication Labs in Taiwan R.O.C.. These environmental stress testing processes are performed to identify and correct failures and anomalies resulting from manufacturing defects, workmanship errors, and "infant mortality" of components prior to customer shipment.

The environmental stress testing consists of environmental stress processes and a system electrical performance test.

The test data show that thermal stress is significantly more effective than vibration at detecting component type defects, conversely vibration is significantly more effective at detecting workmanship type defects.

Environmental Stress Testing

In TL the developed product has to be subjected to the environmental stress testing. The environmental stress testing consists of four environmental stress processes and a System Electrical Performance Test (S.E.P.T). The sequence is shown in Figure 1.

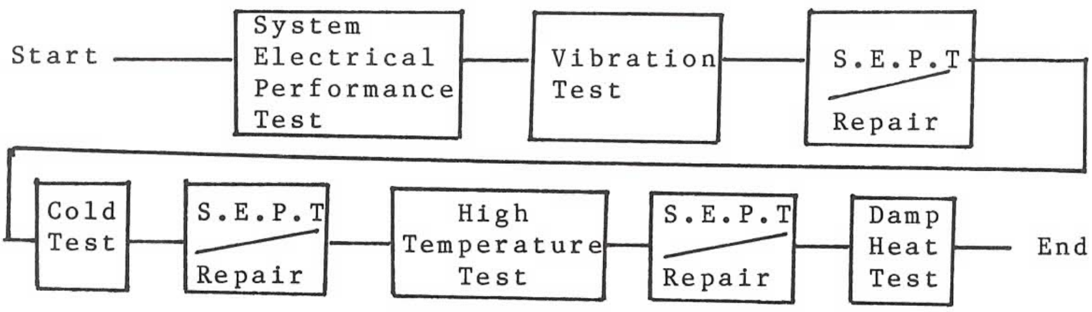

Figure 1: Environmental Stress Testing Flow

A description of each process is shown as below:

A) System Electrical Performance Test (S.E.P.T) System operation is verified through the S.E.P.T conducted prior to and after each environmental stress process.

B) Environmental stress processes include:

1. Vibration test is conducted at $25^{o}C$ with sinusoidal (10-55-10Hz) sweeps, for a duration of 2 hours. The system is vibrated in the vertical plan only.
2. Cold test conducted at $0^{o}C$ with a duration of 24 hours, system power applied.
3. High temperature test conducted at $+50^{o}C$ with a duration of 72 hours, system power applied.
4. Humidity test conducted at $40^{o}C$, 90-95% R.H. with a duration of 96 hours, system power applied.

When a hard failure occurs (unit requires technician trouble-shooting) the failure unit is sent for analysis along with documentation describing the symptom and environmental condition at the time of failure. Every effort is made to determine the fundamental cause of each failure whether it is design, process or material related. Solutions are then implemented and verified by further testing. The process is repeated until the test is failure free to provide assurance that the majority of the problem have been eliminated.

Test Results

The data obtained from 8 data concentrators (8X16CH), 20 RAX Trunk Testers and 120 CH Touch Tone Adaptor were analyzed. Table 1 summarizes the failure data.

Table 1

Failure Mode / Stress	Material Failure	Process Failure	Unknown
High Temperature	31	1	0
Vibration	3	15	0
Cold	1	0	0
Damp Heat	1	0	2
Total	36	16	2

As can be seen, the failures could be catagorized into three failure modes. The data shows that these failures were predominately material latent defects. The data also shows that thermal stress is significantly more effective than vibration at detecting infant mortality type material failures conversely vibration is significantly more effective at detecting process related defects. Among the four stresses used in environmental testing, high temperature test and vibration test seems to be most appropriate to screen out the latent defect.

Table 2

Failure Mode	Number of Failures			
	8 Data Concentrators		20 RAX Testers	
	During E.T	Field Use*	During E.T	Field Use*
Material Failure	19	3	0	1
Process Failure	3	---	12	---

* the first 6 months field operation

After environmental test, 8 data concentrators and 20 RAX Trunk testers were subjected to field use. The failure data gathered from field use as shown in Table 2 indicates that 3 latent defects in 8 data concentrators did escape the environmental test and fail during the early phase of field operation, though 19 defects were caught in this catagory during environmental test. It is noted that this environmental test still is not sufficiently thorough to eliminate "infant mortality" of components. Since the thermal stress is effective at detecting infant mortality type material failures, it was hypothesized that longer high temperature test duration might provide a better thermal screen. Therefore 500CH of Touch Tone Adaptors were subjected to high temperature test with a duration of six days, and the failure distribution was observed. Figure 2 shows the distribution of the failure and indicates the failure rate decreased as a function of the test time. The failure rate decreased rapidly after 3 test days and approached near to constant. Another 9 lots of 500CH Touch Tone Adaptors were subjected to the same test. The same result was obtained. The implication is clear. The stress screen does improve the reliability of the production population. The percent contribution of various components and workmanship is presented in Figure 3. It is noted that the majority (approximately 60%) of the failures were due to ICs. The detection of defective ICs is the primary factor in the reliability improvement during stress

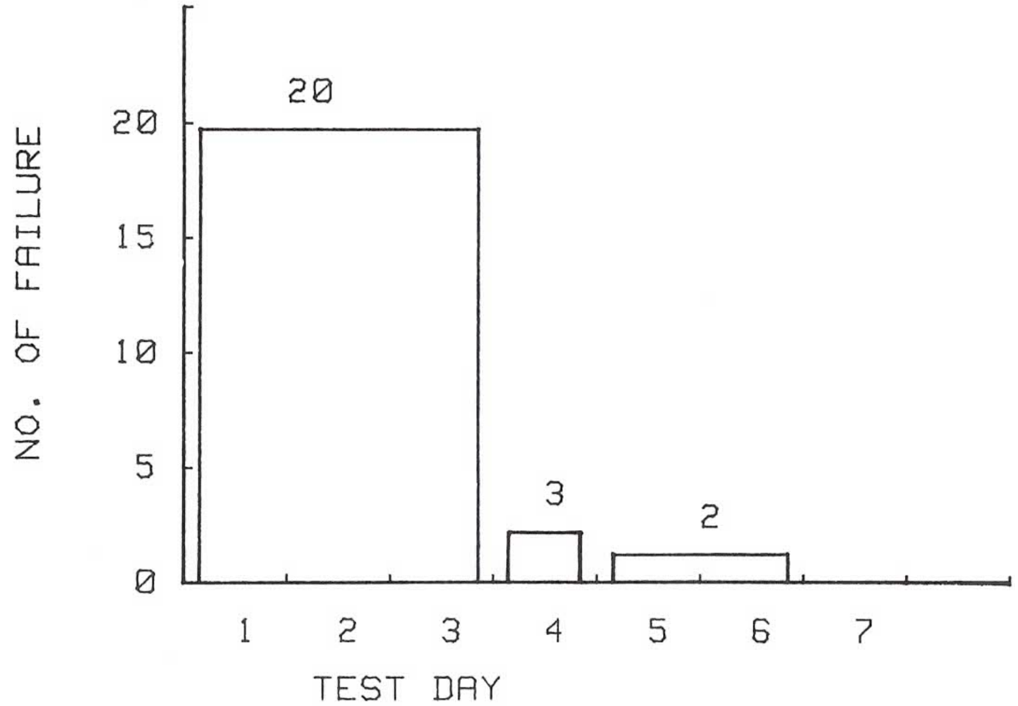

FIGURE 2: FAILURE DISTRIBUTION WITH RESPECT TO THERMAL TEST TIME

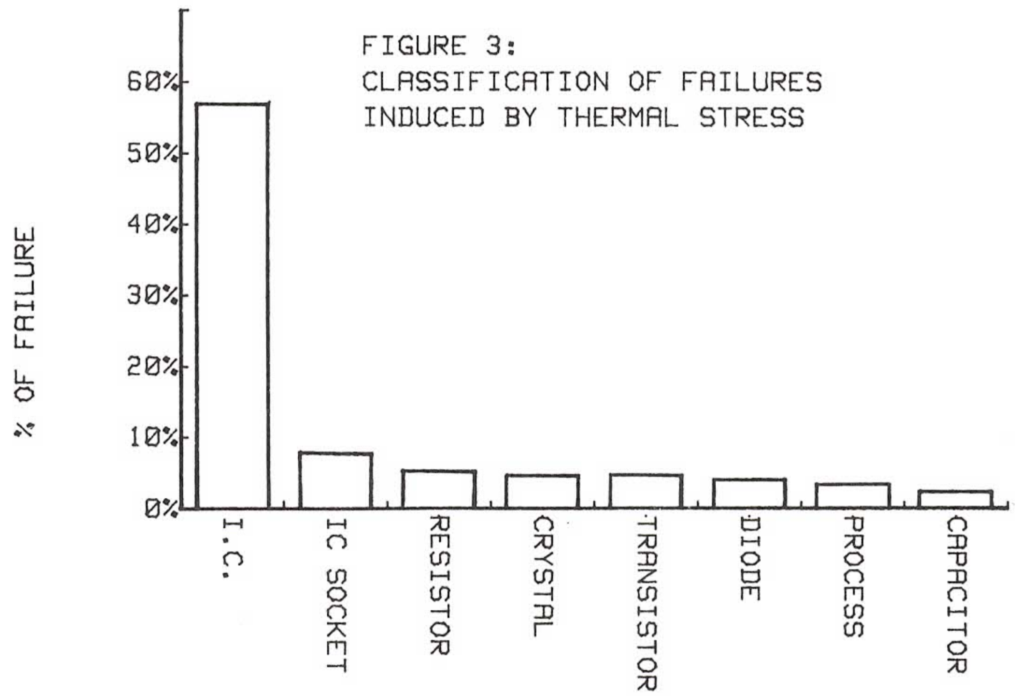

FIGURE 3:
CLASSIFICATION OF FAILURES
INDUCED BY THERMAL STRESS

screening.

Conclusion

Results of this investigation indicate that environmental screening is a powerful tool for detection of latent defects which are not detectable by other inspection or test methods.

For thermal stress test, the data shows that increasing test duration from 3 days to 6 days didn't significantly change the screened fraction defective. But a consecutive day failure-free requirement is necessary if the full benefit of the screening process is to be realized.

The failure data reveals that failures were predominatly material latent defects. It is recommended for reliability improvement and cost effectiveness to conduct stress screen in component level.