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flatpack evaluations

UNITED STATES GOVERNMENT

Memorandum

TO : EG/Chief, Guidance and Control Division DATE: June 19, 1964

FROM : EG32/C. D. Brady

SUBJECT: Integrated Circuit packages for the AGC

REFERENCES: (a) Bellcomm memorandum from B.T.Howard and I.M.Ross to A.J.Hornbeck, subject "Integrated circuit packages for the AGC, dated May 28, 1964.
(b) Bellcomm notes from C.M.Klingman, subject "Integrated Circuit Package for Apollo Guidance Computer - Case 210, dated May 27, 1964.

Bellcomm presents several criticisms of the flat package proposed by MIT/IL and recommends use of the TO-47 or the TO-5 transistor can (enclosure a). The writer has been conducting a survey of both vendors and users of integrated circuits in an attempt to establish levels of confidence in the various packaging techniques. The purpose of this memorandum is to utilize the information obtained in the survey as a basis for commenting upon the Bellcomm analysis.

Information was obtained from the following sources:

Fairchild
Texas Instruments
Corning Glass
MIT/IL
Univac
Minneapolis-Honeywell, St. Petersburg
Autonetics
Sperry Gyro
Signetics

The Bellcomm criticism opens with the strong, general statement that "No satisfactory Flat-Pak design has yet been produced." This conclusion is based primarily on the problems involved with the sealing of the packages. One method mentioned involves high-temperature sealing using solder or low-melting glass frits. It is stated that the high temperatures introduce purple plague problems and the solder and glass introduce contaminants. Again this is a general statement and has little meaning unless taken in the context of the particular packages.

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One of the packages that looks promising for Apollo is the hard glass package produced by Corning. This package requires the higher temperature sealing, however, actual measurements have shown the chip temperature to be in the range of 340°C to 360°C and existing for only a very short time. Consequently, the package is free of purple plague problems.

Another package of interest is the Fairchild flat pack which also requires high-temperature sealing. This package, however, uses all aluminum wiring and is thus free of purple plague.

No one contacted had ever experienced any contaminant trouble due to the package. Corning stated that they had not detected contaminants nor had any customers complained of contamination. Univac which uses the hardglass Corning package, had some such initial problems but these were not caused by the package. Signetics could conceive no possible way for their glass frits to cause problems. They have performed radiations tests and detected no evidence of contamination. Furthermore, the flat-pack contained devices have exhibited no increase in failure rates over those incorporated in the TO-5 can. At one time Fairchild was experimenting with a solid-glass package (as opposed to the presently considered "Coffin type") which was plagued with contamination problems. This was the only source of complaint about contamination the writer could find, and it is not applicable in this case.

The only question raised about the TI package concerned whether a leak-free seal can be obtained. The suspected weak points were the stitch weld and the amount of glass around the leads. (Actually the depth of glass in the TI package is at least as great as that in the TO-47 can). Leaky packages, whatever the specific causes, should present no insurmountable reliability problem, for leaky seals can be screened out through good quality control and quality assurance. That this can be done successfully was testified to by Univac, Autonetics, Sperry, MIT/IL, and Minneapolis-Honeywell. Bellcomm pointed out that this is also required for TO-47 cans.

Bellcomm stated that for equal yield flat packs exhibit leak rates three orders of magnitude higher than those of "conventional Kovar - glass encapsulations". This statement has little meaning; it implies that one specifies yield and accept whatever leak rate results. The question should be asked whether a satisfactory yield can be obtained for a specified leak rate. A satisfactory yield is one which does not cause a great increase in cost. It would appear that the flat packs with the lower yield would have the higher price. However, this is not the case due to other factors involved. For example, Fairchild now quotes a price of $9.45 per gate in the flat pack versus $14.20 for the last supply of TO-47 cans purchased for Apollo. The same factors that increase the TO-47 prices would also effect the ten leaded TO-5 cost.

In an effort to compare yields of the flat packages with ten-leaded TO-5 can it was found that the industry wide leak rate specifications is 10^{-6} standard cc/sec. For this leak rate a ten leaded TO-5 yield of over 99%

is easily obtained; this has been demonstrated by Minneapolis-Honeywell. There appears to be little TO-5 can yield data for any other leak rates. However, it is also true that flat pack yields of greater than 99% are also easily obtainable for the 10^{-6} cc/sec leak rate.

The MIT/IL specification is presently 10^{-6} cc/sec on the TO-47 can and on transistors as well. There is little doubt that this specification can be easily satisfied by flat packs for the AGC application. Even if it were necessary to tighten the specification, (MIT is investigating this question at present), data from Univac, MIT/IL, and TI indicate that satisfactory yields can be obtained for leak rates less than two orders of magnitude lower.

Bellcomm charges that no satisfactory reliability data has been obtained for integrated circuits in flat packs. This is a great overstatement. Previously one could state that there had not been sufficient data, but there is strong evidence that this is no longer true. Certainly there have been developmental problems with the flat package. However, the problems and failure modes have now been well defined and the necessary process changes and quality controls have been introduced. The success of such steps has been demonstrated by several companies.

The following comments concerning package experience are pertinent:

a. Univac: Univac stated that a year ago they were concerned about the package. They now accept the package as a proven item; they are concerned now primarily with the chip and its contents. They now have 10^6 operational device hours. The Univac specification is 10^{-8} cc/sec, and it is being easily satisfied. As a result there is some thought toward tightening the specification.

b. Fairchild: Fairchild felt that reliability would be no problem. They were only concerned about the effect of cost on yield; their price list as noted above obviates their cost argument.

c. Sperry Gyro: Sperry has accepted the flat package and has ordered 100K units with prospects of using 500K in their Loran C and other equipment. They are now approaching 10^6 operational hours with no failures and no indication of package weaknesses.

d. Minneapolis-Honeywell: Honeywell is presently using the ten leaded TO-5 can in a classified airborne computer. The engineer responsible for this decision, which was made a year ago, stated that at that time the TO-5 can represented less risk than the flat package. He has been quite satisfied with the results. He now feels, however, that the flat pack is proven and is recommending that Honeywell go to this package.

e. Texas Instruments: Although one should view vendor claims with caution, conversations with TI representatives and review of test data indicate that the new package is very satisfactory. This view point is substantiated by the experience of Univac, Autonetics, and MIT/IL. TI has accumulated 9×10^6 test hours and 6×10^6 operational field hours in the period from January, 1963, through March, 1964. This experience has served to define the failure modes and to point the way to corrective steps.

That the TI package is a success is manifested by its continued use in such programs as OGO, EGO, POGO, TIROS, ADSO, IMP, Mariner C, TFX, Sergeant, LORAN C, ASW21, AN/ASN27 data processing computer, ASN/44 navigation platform, Gemini, Saturn V, Apollo (CM central timer), Minuteman, and others. It is significant that the writer was unable to find anyone who regretted using flat packs.

Autonetics: Autonetics has accumulated 6×10^6 hours on the Minuteman program and has worked very closely with TI in the effort to isolate and correct package problems. At this time Autonetics feels that with proper handling and screening leak free reliable packages can be obtained.

Signetics: Signetics uses both the ten leaded TO-5 cans and the Corning flat package. It is Signetics' opinion that the flat package is just as reliable as the TO-5 can if handled properly. They felt that it is not difficult to institute proper handling procedures. Cracking is the only result of mishandling, and it is easily detected.

The flat package and the ten leaded TO-5 are both tested to 25×10^{-8} standard cc/sec. A yield of 90 - 100% is obtained with flat pack and 95 - 100% with the TO-5 can.

Bellcomm's statement that reliable flat packages will be available in 18 - 24 months was probably correct two years ago.

Bellcomm recommended either continue with the TO-47 can or use a twelve leaded TO-5 can. As for the TO-47 can, the MIT/IL opinion as interpreted in enclosure (b) is felt by the writer to be correct and sufficient to rule out the use of this can. As for the ten leaded TO-5 approach (twelve leads are neither necessary nor possible), it has no advantages. It will result in no size or weight savings, it is not "..... a proven reliable design with which there has been considerable flight and ground experience....." to any greater degree than the flat package. This package has the disadvantages of inferior heat dissipation properties, near obsolescence, and requires a new computer packaging approach. This last item is very important for it would prohibit or make difficult the use of the weld-free matrix and would require that MIT/IL redesign and again lay out the logic sticks. This approach would not benefit either from the Block I TO-47 experience or

from the great amount of effort expended by MIT/IL on the Block II flat pack design. It is doubtful that this third approach could be implemented within the schedules.

The writer concludes that the flat package approach represents no greater risk than any other, and the advantages justify its use.

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Enclosures (2)

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