component news

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Testing the 8086 microprocessor

The world of testing has become one step more complex with the invention of the microprocessor. Microprocessors may contain up to 70,000 transistors connected together to form a very complex device. The microprocessor differs from other logic devices because the function of the device is much more important than the DC characteristics. This means that a test must exercise a large portion of the internal logic to make sure that the device really works as it should. To do this fully is not possible in a reasonable length of time because this would entail trying all instructions in all combinations. Unlike other logic devices, the pattern needed to run even a simple test is not easily created.

Intel's 8086 microprocessor adds another level of complexity because it is actually two microprocessors in one — the ALU (arithmetic logic unit) and the bus execution unit. The bus execution unit tries to load up a queue so that when the ALU needs some more information it can get it from the queue rather than having to request it from the bus. The interaction of these two processors is not readily available because the user rarely cares how they do the job, as long as it gets done.

The tester, however, must know this relationship if a strict logic-to-pattern type test is to be performed. Intel has said that this relationship cannot be disclosed, as it would mean releasing the microcode for the 8086 (which they will not do).

The test method chosen was to write an assembler that would create an input code, and then learn what the device put out on its outputs. This requires one good or "gold" device which worked in the final product and could be used to create the patterns to which all other devices would be compared.

There are several problems associated with this method. First, what happens if the gold device is slightly faster or slower than the device under test? This may cause the test to reject devices that would work in the final product, due to some small timing difference.

Second, can an assembler be written to allow all possible instructions to be called out and executed? The 8086 is somewhat unique in this respect. Intel chose to write a very intelligent assembler for the 8086 and not give each opcode a unique name. An example might be the MOV instruction. There are 14 possible opcodes which the Intel assembler can assign for this mnemonic. The assembler chooses the most efficient type for the specific application.

The timing problem was solved by creating a program which acts as a logic analyzer and can plot any part of the pattern on the screen. It shows a cycle-by-cycle plot of the bus action and all of the other control lines. This allows a part

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which does not pass to be examined on a cycle-by-cycle basis. It then can be compared to a plot of a good device. If there is a timing problem it usually can be detected by an output transition near the compare window (see Figure 1).

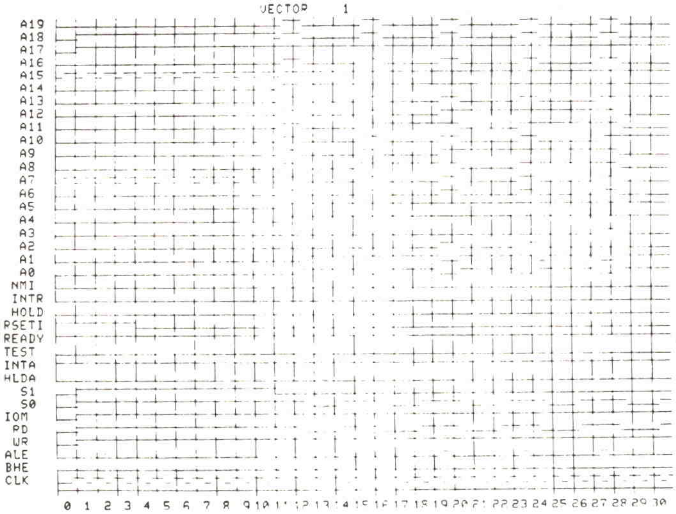
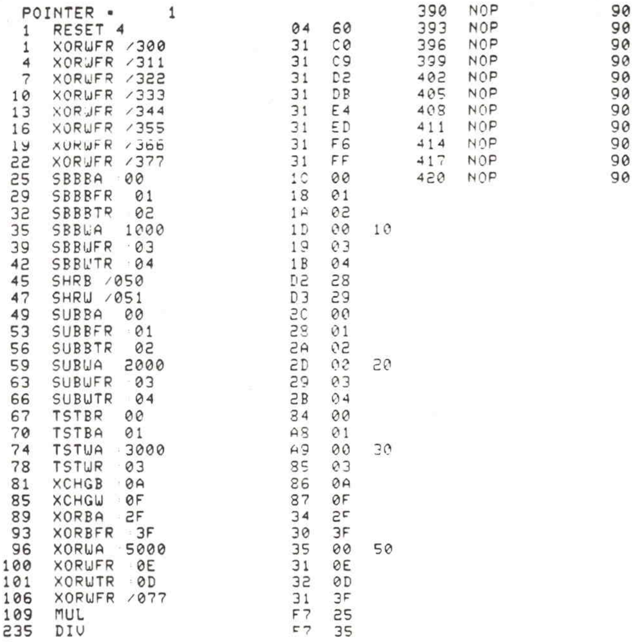


Figure 1 — Logic analyzer output

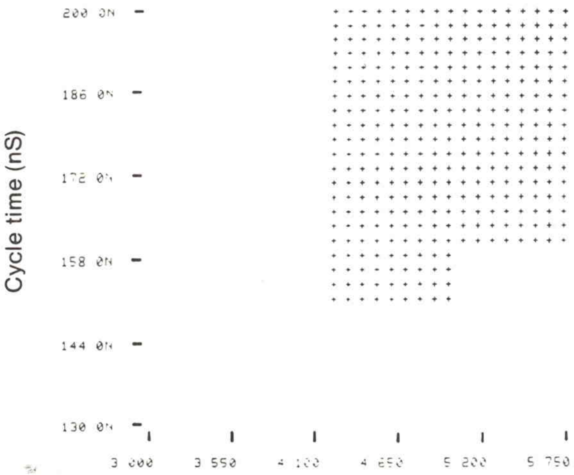
The assembler problem was somewhat harder to solve. In the past the assemblers created for other processors used the assembly code given by the manufacturer. This could not be done for the 8086, so a new set of mnemonics had to be created. This was done by trying to make the new mnemonics as close to the original as possible. However, a designer who has a problem with the 8086 may find the new instruction set a disadvantage when trying to create a pattern, because a new set of mnemonics will have to be learned. This situation will probably become more prevalent on the newer, larger microprocessors (see Figure 2).

This test has some other options which need to be explained. It was written as a characterization program, which allows the test results of one parameter to be plotted against another. For example, one of the more interesting comparisons that can be made is power supply voltage versus cycle time. An example of this plot is shown in Figure 3. As can be seen, the 8086 has a safe margin on the lower edge of its power supply spec. A common question that comes up is, "What happens with temperature?"



```
 POINTER •     1                                390  NOP              90
  1  RESET 4               04  60               393  NOP              90
  1  XORWFR /300           31  C0               396  NOP              90
  4  XORWFR /311           31  C9               399  NOP              90
  7  XORWFR /322           31  D2               402  NOP              90
 10  XORWFR /333           31  DB               405  NOP              90
 13  XORWFR /344           31  E4               408  NOP              90
 16  XORWFR /355           31  ED               411  NOP              90
 19  XORWFR /366           31  F6               414  NOP              90
 22  XORWFR /377           31  FF               417  NOP              90
 25  SBBBA  00             1C  00               420  NOP              90
 29  SBBBFR  01            18  01
 32  SBBBTR  02            1A  02
 35  SBBWA  1000           1D  00  10
 39  SBBWFR  03            19  03
 42  SBBWTR  04            1B  04
 45  SHRB /050             D2  28
 47  SHRW /051             D3  29
 49  SUBBA  00             2C  00
 53  SUBBFR  01            28  01
 56  SUBBTR  02            2A  02
 59  SUBWA  2000           2D  02  20
 63  SUBWFR  03            29  03
 66  SUBWTR  04            2B  04
 67  TSTBR  00             84  00
 70  TSTBA  01             A8  01
 74  TSTWA  3000           A9  00  30
 78  TSTWR  03             85  03
 81  XCHGB  0A             86  0A
 85  XCHGW  0F             87  0F
 89  XORBA  2F             34  2F
 93  XORBFR  3F            30  3F
 96  XORWA  5000           35  00  50
100  XORWFR  0E            31  0E
101  XORWTR  0D            32  0D
106  XORWFR /077           31  3F
109  MUL                   F7  25
235  DIV                   F7  35
```

Figure 2 — Example of mnemonic input to the assembler



Vcc at 25°C

Figure 3

The test system has a thermal stream which allows the parts to be tested from −60 to +160°C. This allows any of the test parameters to be measured over temperature, or allows comparison

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of two parameters over temperature. The possible parameters that can be measured or compared are:

Cycle time
Clock high time
Clock low time
Address and data valid time
Output compare time
Temperature
Input high voltage
Input low voltage
Output high voltage
Output low voltage
Clock high voltage
Clock low voltage
Power supply voltage

Two examples of these parameters are shown in Figures 4 and 5.

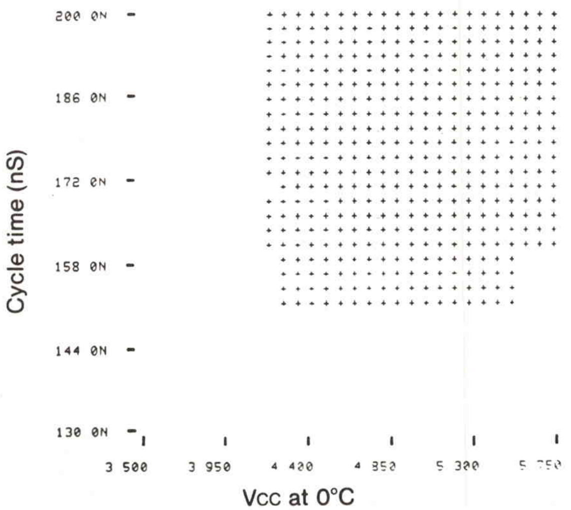

Figure 4

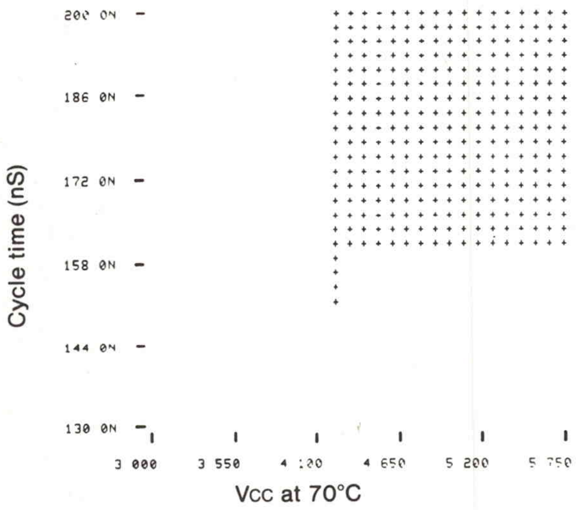

Figure 5

The 8086 differs from other microprocessors in the way it does its initialization. Hardware reset does not initialize all of its resistors and it is necessary to clear the registers before using them so that a known result will occur. In a user application this would happen automatically, but in the test system the input program does not have to do anything special except exercise a large portion of the internal parts of the microprocessor. The first part of Figure 2 shows XOR instructions clearing the internal registers of the 8086. The last mnemonics in this list are all NOPs. This is done to flush the queue of instructions so that all previous instructions are executed.

At this time there are no known bugs in the 8086. Its instruction set seems to work as specified. This seems rather remarkable after the problems encountered with the 8085. It may well be that the engineering effort that was missing on the early 8085 program has been used to make this product bug-free.

The 8086 is one of the hardest microprocessors to hand code. Intel realizes this fact. They plan for the user to purchase support from Intel in the form of development systems. This type of program makes small users suffer because, unlike Tek, they cannot afford to purchase a development system for each new microprocessor they purchase or evaluate.

If you'd like more information about our evaluation of the 8086 microprocessor, please contact me at 78-573, ext. DR-2572.

Wilton Hart
Digital Component Engineering

New Documentation Coordinator

Betty Carter has joined the Documentation Coordination group as a Documentation Coordinator. Betty has 25 years experience at Tek, much of this time spent in pilot, prototype support and cataloging. Please call Betty or Sue Krause with questions concerning your PPIFs. They can be reached on ext. DR-2586.

Accelerated life testing a Tek-made IC

The ICM Reliability Group has just completed an accelerated life test of a recent production sample of the 155-0078-10 (P84E). The demonstrated failure rate was well below the goal of 0.02%/1000 hours at a reference junction temperature of 75°C, thus providing assurance that ICM's highest volume part is also a very reliable one.

The P84E is a differential amplifier designed for the 485 vertical. The cascade outputs can provide gain adjust or invert functions by using the proper control voltage. All transistors have been designed to carry a maximum of 90mA while maintaining their f_T. The rise time is 355pS or less.

The dynamic high-temperature life test was run at a junction temperature of 151°C. Input signals were from a driver board designed to activate all junctions to simulate typical instrument conditions (except for the 151°C junction temperature).

Running a life test at higher than typical operating temperature in order to accelerate the test is valid as long as the failure mechanism that causes the failures is identical to that which would cause the failure at normal operating junction temperature.

An integrated circuit has three operating life time windows, as shown on the classic "bath tub" curve — (1) early or infant failures, (2) random/chance failures, and (3) wearout failures. An ideal burn-in program would remove all early failures from the population. The reliability prediction for the IC would therefore concern itself only with the chance/random failures and with wearout.

For this life test there were no early or infant failures. The test was run into the wearout mode until more than 50% of the parts had failed for the wearout mechanism. This wearout failure **mechanism** was intermetallics at the gold wire-aluminum bond pad interface. This condition is commonly referred to as "purple plague." It causes high resistance contact between the aluminum bonding pad and the gold wire, see Figure 1. For this part number, the contact resistance was in series with the IC gain setting resistor, so that the failure **mode** was low gain.

Random failures

Although no random/chance failures occurred during this test, a failure rate can be calculated statistically based on the number of parts on test and the times-to-failure, using the Exponential Reliability Distribution for chance failures. A lower confidence limit on the failure rate was calculated using the Chi-Square (X^2) Distribution for 2r + 2 degrees of freedom, where "r" is the number of failures.

Again because there were no random failures, no activation energy for a failure mechanism could be determined. The activation energy for most early failure mechanisms is 1.0ev/°K or greater. The activation energy used in the Arrhenius equation to calculate acceleration factors for 75°C and 100°C referenced to 151°C was 1.0ev/°K. This provides the most pessimistic estimate of the predicted failure rate.

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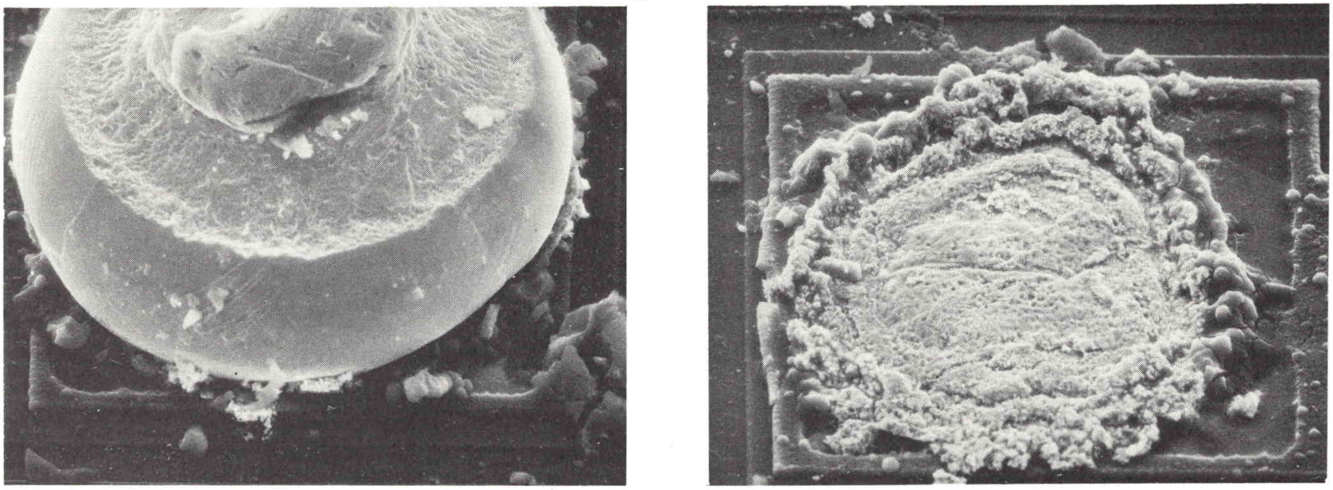
Figure 1



Gold wire bond on aluminum bonding pad

Intermetallic formation on pad causing bond failure ("purple plague")

The maximum failure rate at the 90% confidence level for random/chance failures was calculated to be:

Junction temperature	Failure rate (λ)
75°C*	λ≤0.0096%/1000 hrs.
100°C	λ≤0.09%/1000 hrs.
151°C	λ≤3.70%/1000 hrs.

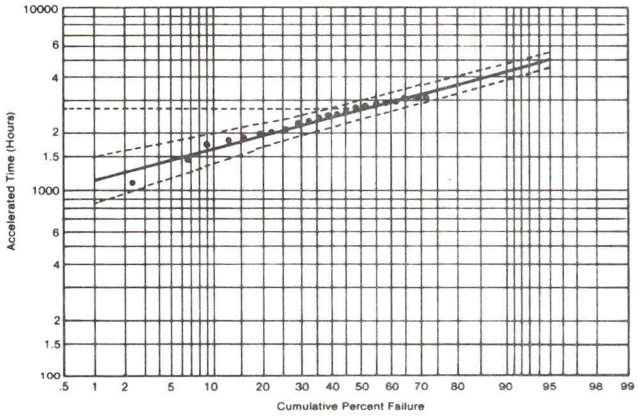
*ICM reference temperature established so all ICM reliability predictions can be compared at the same junction temperature.

The probability of random/chance failures exists throughout the life of the part — from the beginning infant failures to eventual wearout failures. Therefore the failure rate calculated for random/chance failures must be added to the failure rate determined for any other reliability distribution for that life test.

Wearout mode

For the wearout mode, the Log-Normal Reliability Distribution applies. Log-normal distribution can be recognized in all sufficiently large and sufficiently accelerated tests of semiconductors. Log-normal behavior occurs as a result of rate-dependent processes. Rate-dependency can be caused by processes such as chemical reactions, thermosetting, etching and/or diffusion.

Failure data for this life test were plotted as a log-normal distribution, and is shown in Figure 2. From Figure 2 the standard deviation and the cumulative percent failures at various operating times can be determined. The standard deviation and 50% cumulative percent failure (median-time-to-failure) are used to plot the failure rate curves.



Run No.: M003
Junction Temp.: 151° C
Activation Energy = 1.0 ev

Sample Size: 30
Failures: 22

Accelerated Median Life: 2712 Hours
Standard Deviation: .36

Figure 2 — 155-0078-10 failure data

Only one curve was plotted in Figure 2 — the data from the life test at 151°C (dashed lines are the confidence limits). Curves for 75°C and 100°C can be plotted by multiplying each data point by the acceleration factor for each temperature (as referenced to 151°C). The Arrhenius equation is used to calculate the acceleration factors. Because the activation energy for intermetallics is 1.00 to 1.05, acceleration factors were calculated using 1.0ev/°K.

The failure rate curves for the wearout mode (at 151°C, 100°C, and 75°C) are shown in Figure 3. The curves for 100°C and 75°C were plotted using median-time-to-failure for 151°C multiplied by the appropriate acceleration factors. As before, dashed lines represent confidence limits.

The failure rate of the 155-0078-10 at an operating time is therefore determined by adding the random failure rate (a constant) at the specified temperature, to the wearout failure rate (from Figure 3) at the specified time and the same temperature.

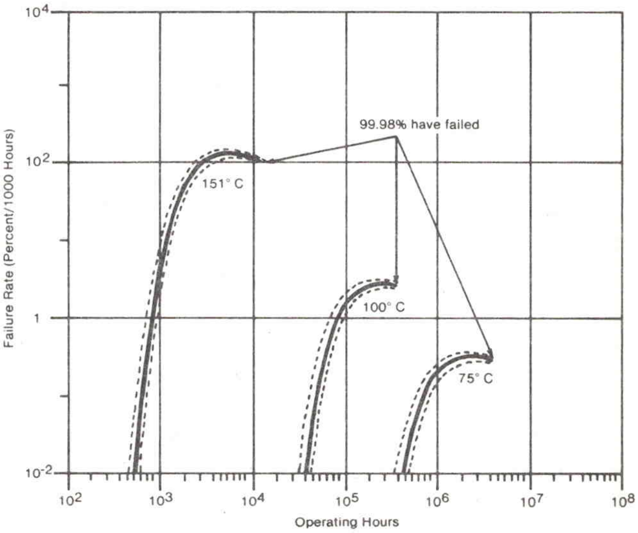


Figure 3 — 155-0078-10 failure rate curves for wearout mode

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Life test results

Figure 3 shows the failure rate to be an increasing function during most of the life of the part. From Figures 2 and 3 it can be determined that, at the maximum failure rate, 95% of the parts have failed. Figure 3 shows that at 151°C the maximum failure rate is at 5500 hours, and at 5500 hours on Figure 2, 95% of the parts have failed.

At 100°C (a typical operating junction temperature) — (1) the median life is 113,800 hours, (2) the maximum failure rate is 3.09%/1000 hours, and (3) the maximum failure rate occurs at 280,000 hours.

At 10,000 hours (the estimated useful life of an instrument) and 100°C — the maximum failure rate is the random failure rate of 0.09%/1000 hours. The wearout failure rate is so small that it doesn't contribute to the total failure rate. Also, at 10,000 hours at the ICM reference temperature of 75°C, the maximum failure rate is 0.0096%/1000 hours.

What does this all tell us? Simply that, for this device and innumerable other similar parts, significant increases in reliability can be attained by running the IC as cool as possible. Also, this report shows that at typical operating temperatures, the 155-0078-10 is a high reliability device.

If you have questions about the 155-0078-10 life test procedures and results, please contact me at 48-162, ext. B-7966.

Ken Davenport
Integrated Circuits Manufacturing
Reliability manager

Material change for mini-harmonica connectors

Due to a shortage in the supply of good, fire-retardant polypropylene, the material used to produce mini-harmonica connectors will be changed to Lexan 940 ® polycarbonate. A mod is now in progress.

The new polycarbonate material has a UL94V-0 rating in all colors, even when molded in the finished part. The mini-harmonica housing also passes UL1244 requirements, and it is a UL Recognized component. The material is noncorrosive to the connectors and restores the bright, uniform, easily distinguished colors that were characteristic of the harmonicas of yesteryear. The material will provide better yields during molding operations and, because the compound has pre-mixed colors, will reduce material scrap during color changes in the molding machine. The material is stiffer and stronger and will reduce the incidence of terminals falling out of the housings.

Also, a difference in solvent resistance exists between the two materials — chlorinated hydrocarbons vigorously attack the polycarbonate. Cleaning solvents containing methylene chlorides, "So-Cal", or "Green River" should not be used on polycarbonate. Most new instruments make extensive use of polycarbonate in instrument cabinets and composite front panels, therefore these solvents should be used with care.

The stiffer polycarbonate housings are also less tolerant of past misapplications. Large wire diameters and large coaxes are difficult to install even in the old polyproylene housings, and we've had constant problems with inadequate retention. For all new designs, the mini-harmonicas should be used with insulation diameters less than 0.060". For larger wires and heavy coaxes, the "maxi" series of harmonicas and terminals should be used.

Recommended hand installation and removal procedure

The entire row of connectors should be inserted with the receptacle box facing the hinge of the housing. The hinge can then be folded over and the contacts pressed one by one in place. A blunt, flat, plastic-tipped tool (such as a tuning adjustment tool) may be used to assist in latching the contact in place. **Note:** Do not use sharp metal pointed tools such as scribes or screwdrivers for this purpose. Minimal flexing of the hinge is recommended because the polycarbonate will crack along the hinge with multiple flexing.

Removing contacts from the new housing without damaging the contacts or the housing is difficult. The recommended procedure is to destroy

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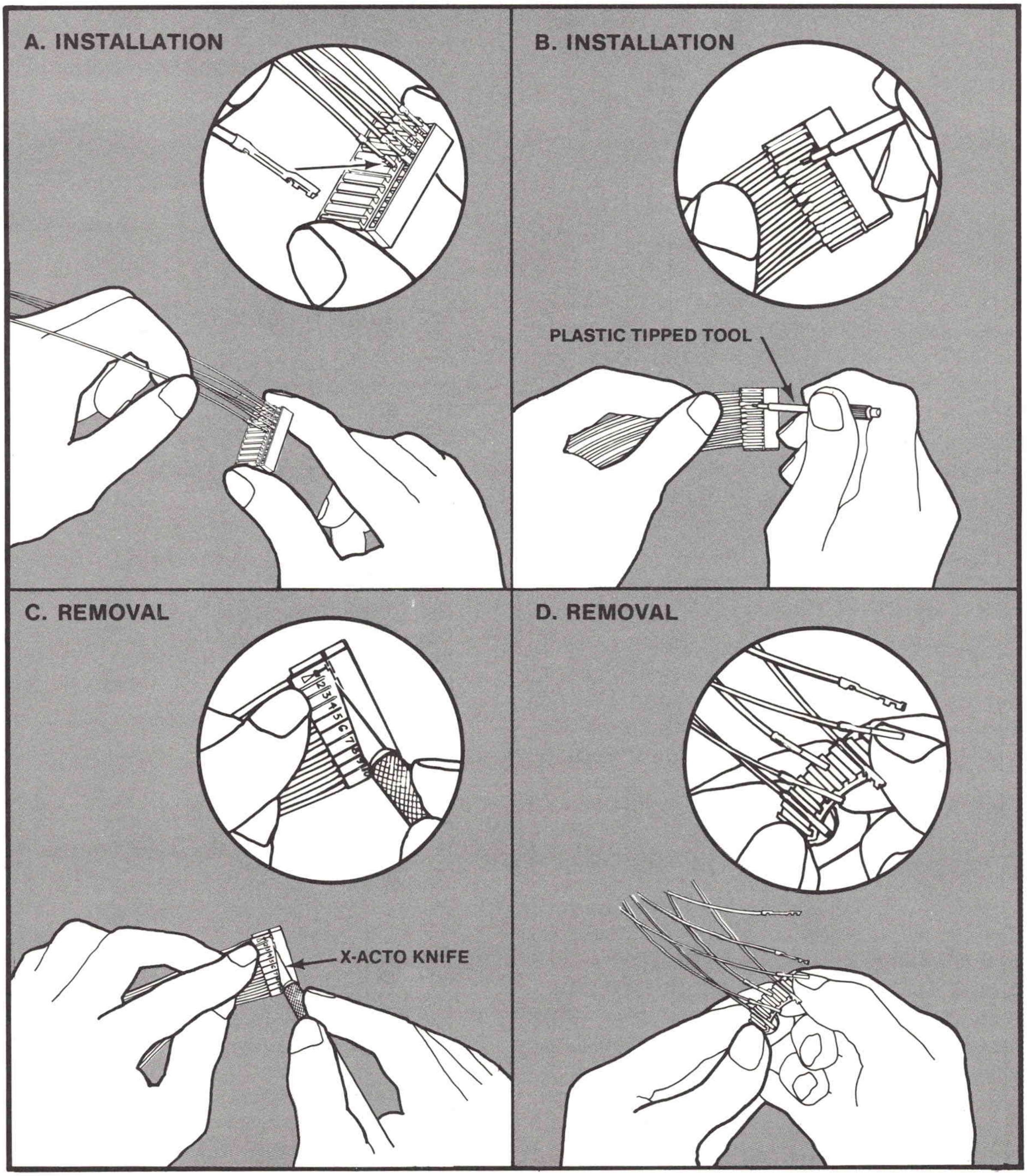
the old housing and use a new one. Cut the hinge with an Exacto or utility knife, taking care not to damage the contacts. The box section of the housing can then be removed. The remaining "clasping" section of the holder will easily release the contacts if bent in a backward radius.

New test adapter

Because individual contacts are difficult to remove, this has posed a problem where contacts were removed from housings to break a circuit for testing. A new Test Adapter Ket (P/N 006-3621-00) has been set up to solve this problem. The contact is crimped to a square post which may be installed into any housing to suit the particular demand or application. The contact required to be broken is simply left out of the housing. The adapter can then be inserted between the board and the cable, and the circuit tested as required.

If you'd like more information about this material change contact **Bert Hippe, ext. V-7296.** If you have questions about environmental/UL testing contact **Jim Smiley, ext. B-7886**, or **Wally House, ext. B-7374.** Direct questions about new applications to **Peter Butler, ext. DR-2474.**



A. INSTALLATION

B. INSTALLATION

C. REMOVAL

D. REMOVAL

Telephone grade cap prevents electrolyte leakage

Many applications at Tek require an aluminum electrolytic capacitor with a large CV product (capacitance times working voltage), high ripple current and the ability to be conveniently mounted on a printed circuit board. This ecological niche is usually filled by the Sprague 68D, Mepco Electra 3187, or Mallory PFP caps that are called out in our green RC catalog as "type D" capacitors (see Figure 1). The 68D capacitor is very popular at Tek, with most instruments using several of these parts. Our annual usage is in the vicinity of 700,000 units.

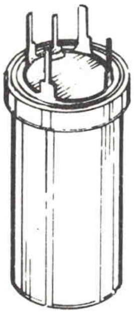


Figure 1 — "Type D" PC mount Aluminum electrolytic capacitor

The advantages of the 68D are high CV product, good ripple current capability, wide range of voltages and can sizes (¾", 1" and 1⅜" diameters), the ability to be soldered directly onto the PC board, and a low price. Its disadvantages are a short life and an unreliable header or end seal that occasionally leaks highly conductive electrolyte all over the printed circuit board. The 68D header is a three layer laminated rubber design that unfortunately is very sensitive to variations in its material or in its assembly process.

If the electrolyte leak is a major one, in about 50% of these cases the board is damaged beyond repair by the arcing and fire that results. Repair costs range from $125 to more than $600 per failure. For estimation purposes, many people assume $125 for an in-plant failure and $350 for a field failure.

Stress test weeds out some "leakers"

We have developed a seal stress test, called out in Tek Standard 062-4032-00, that will catch some of the leaking capacitors. The cap is heated at 85°C for 24 to 48 hours in a base down configuration, and then is inspected closely for any physical signs of electrolyte leakage. This test will catch the capacitors with no seal or with a very poor seal, but it does not develop enough internal pressure to reveal all of the poor seals. Plans are proceding to test all 68D type caps on a sample basis, but they are not yet in effect.

From March 1978, to December 1978, this test was used to screen lots of caps that had known problems. From January 1979, the process has been used to sample test some incoming lots. By late spring of 1981, we should be able to sample test (to 1% LTPD) all incoming 68D type capacitors. Table 1 is a list of the parts tested (different part numbers) between March 1978 and September 1979, and the percent of leakers in each lot. The average lot size was 2000 parts. It can be seen that this is a persistent problem. The parts from GE were so bad that we removed GE's parts from all 140 part numbers in the middle of 1978. Currently we are investigating a problem where several batches of the 290-0521-00 caps with suspected bad seals went into some of our large screen TV monitors.

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Table 1
Aluminum Electrolytic Failure History*

Date	Manufacturer	Date Code	% Defective
Mar 1978	GE	7729	15.0
Mar 1978	GE	7742	5.9
Mar 1978	GE	7720	5.7
Mar 1978	GE	7726	20.0
Mar 1978	GE	7738	10.0
Mar 1978	GE	7738	10.0
May 1978	GE	7739	8.7
Nov 1978	Mallory	7839	46.0
Nov 1978	Mallory	7842	5.6
Nov 1978	Mallory	7835	7.4
Nov 1978	Mallory	7828	2.5
Nov 1978	Mallory	7839	47.5
Nov 1978	Mallory	7842	5.6
Jan 1979	Sprague	7840	66.7
Jan 1979	Sprague	7841	44.6
Mar 1979	Mallory	7906	5.6
Mar 1979	Sprague	7913	0
Mar 1979	Sprague	7834	8
Mar 1979	Sprague	7848	1.7
Mar 1979	Sprague	7847	0
Apr 1979	Sprague	7905	5.7
Apr 1979	Sprague	7902	0
Apr 1979	Sprague	7905	13.5
Apr 1979	Sprague	7913	?
June 1979	Mallory	7847/7848	0
July 1979	Sprague	7926	1.9
Aug 1979	Sprague	7920	0
Aug 1979	Mallory	7839	11.2
Aug 1979	Mallory	7920	0
Sep 1979	Sprague	7939	?

*Data obtained from Reliability Engineering studies and Incoming Inspection shelf stock inspection results.

This header design is very sensitive to process or material variations, and history shows that the manufacturers' quality control is not adequate to detect and correct all these variations. The sample lot testing that will be initiated should detect lots with 1% or greater leakers, but it will not catch all the bad parts, or the parts that will leak at a higher internal pressure than this test generates.

It should be noted that Sprague and Mallory parts have safety vents in the middle of the header. If the cap is overstressed by the circuit, or it develops an internal problem that creates overpressure, the vent will blow open and electrolyte vapor (and perhaps liquid electrolyte) will impinge on the PC board. The end result is the same as leakage, but this is usually the result of a circuit failure or component misapplication, not a capacitor failure.

Why do these caps leak?

Capacitors can be classified as having either a "standard" or a "premium quality" section (the capacitor element itself), and either a "commercial" or a "premium quality" package (can, header and leads). The 68D has a standard quality section and a commercial package (at best).

The 68D type capacitor header is composed of two layers of bakelite for strength and support of the leads, with a soft, partially-cured rubber sandwiched between them. When the aluminum can is crimped over the outer bakelite layer, it compresses the soft rubber between the two bakelite pieces and then the rubber flows out and seals against the can and the leads going through the header (see Figure 2). If the crimping of the can does not provide the right pressure, or if the composition of the rubber is not correct, the seal will leak at a lower pressure than it should. Internal pressures can exceed 100psi, and are due to two sources: (1) hydrogen gas formed by electrolyte disassociation, and (2) electrolyte vapor pressure caused by ambient and ripple current heating. Very bad seals will fail initially, poor seals will fail later in life. A good seal should remain leak-tight up to the pressure at which the capacitor vent blows.

The life of an aluminum electrolytic cap is determined by the loss of electrolyte. When 50% of the electrolyte is lost, the change in capacitor electrical parameters is so great that the cap is declared dead. Electrolyte is lost by disassociation due to DC leakage through the capacitor and by electrolyte vapor permeation through the capacitor enclosure. The seal of the 68D type capacitor has a high rate of vapor permeation compared to the computer grade seal, and this is one of the major factors contributing to the short life of this capacitor.

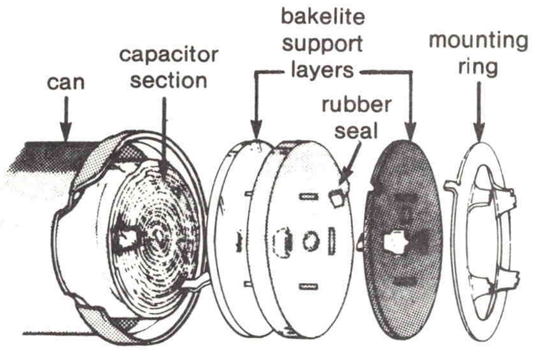

Figure 2 — Exploded view of 68D capacitor

Computer grade cap reduces leakage

One of the two alternatives to the 68D type capacitor is to use a computer grade cap. This cap uses a molded phenolic header, an external rubber O-ring seal (premium quality package), a premium quality section that provides moderate CV product (due to more built-in derating), good ripple current, low ESR, low DCL and a very long life. This header is a very reliable, proven design that is at least one to two orders of magnitude less likely to leak electrolyte. It also provides a large part of the long operating life of the cap.

The computer grade header has either two electrical terminals (Type A) or two electrical terminals and two mounting inserts (Type B), see Figure 3. It comes in diameters of 1⅜", 1¾", 2", 2½" and 3", and lengths from 1⅜" to 8". It is not a direct replacement for the 68D because it is larger and has a different mounting arrangement, but it is highly recommended for new designs and instrument modifications.

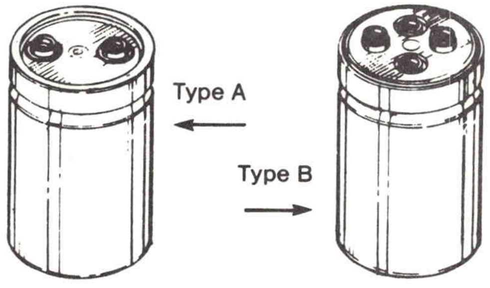

Figure 3 — Computer grade capacitors

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Telephone grade cap direct retrofit

The second alternative to the 68D capacitor is a slight modification to the "telephone grade" cap designed for and used by Western Electric. This modification uses the same capacitor section, can and mounting ring as the 68D. It uses the telephone grade header, which is a molded header with wire leads and an internal rubber O-ring seal that is very similar to the computer grade seal (see Figure 4). It differs from the 68D mounting arrangement in that it has both anodes and cathode leads brought out as wires from the header, whereas the 68D has the cathode lead connected to the mounting ring. So, if one additional hole in the PC board and a short run can be provided, you have a part that is exactly the same electrically as the 68D, is the same size, mounts almost the same, but will not leak electrolyte and will have a slightly increased life expectancy. The additional cost of the high quality molded header is about $0.50 at the present time. The 68D cap ranges between $0.60 and $2.00 each, depending on voltage and can size.

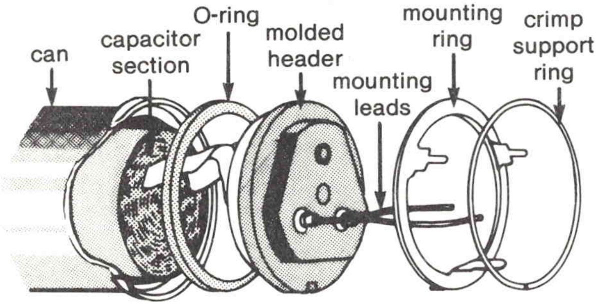


Figure 4 — Exploded view of telephone grade capacitor

The telephone grade header part with two leads can be supplied by two manufacturers. We are currently negotiating with the manufacturers to make a part that has the cathode lead connected to the mounting ring, which would make a part that is a direct replacement for the 68D type. We have received samples of this part from two manufacturers, but only one has the capability to make them in production quantities at this time.

The 68D type header was developed over 30 years ago for radios and TV sets where any electrolyte drippage would fall out the open bottom of the set and onto its wood cabinet. We no longer have this design freedom. So, to avoid the bad press that results from having smoke pour out of your instrument, I recommend that you switch to computer grade capacitors if you have the design freedom, or to a telephone grade header if you need an almost direct (or perhaps direct) replacement part.

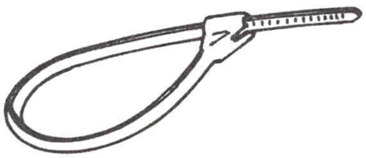
If you have any further questions about these capacitors, please contact me at 78-552, ext. DR-2545.

Don Anderson
Optoelectronic & Passive Comp. Eng.

Cable ties replace vinyl plastic Tye Kord

For a long time, vinyl plastic Tye Kord has served us well as a lacing for cable harness. But, it has limitations — it burns and melts easily, it is not UL Listed, and untrained people have a hard time retying it.

We have begun replacing the Tye Kord with cable ties. Cable ties provide many advantages — they don't melt or burn easily, several sources of supply are available, they are UL Listed, and anybody can fasten a cable tie.



Another benefit is labor savings. We have already realized a one-week labor savings of $2000 (potentially $104,000/year) on one harness assembly. The change to cable ties has also helped department efficiency achieve a new high of 110%.

These savings are significant enough to warrant a broad investigation on the use of cable ties in other areas. Mods will follow and all mods will be entered from the Cable Harness Department.

For additional information contact: **Larry Berry, ext. B-5177; Georgia Brune, ext. V-7268; or Betty Randolf, ext. V-7320.**

Valox connector housing found to warp

Recently, during temperature cycling, instrument failures were traced to intermittent contacts at the edgecard connectors. We discovered that the connector housings were so severely warped that very slight movements could cause a loss of continuity at the center contacts (see Figure 1). In addition, polarization keys would not be sufficiently retained if the warpage exceeded 0.010".

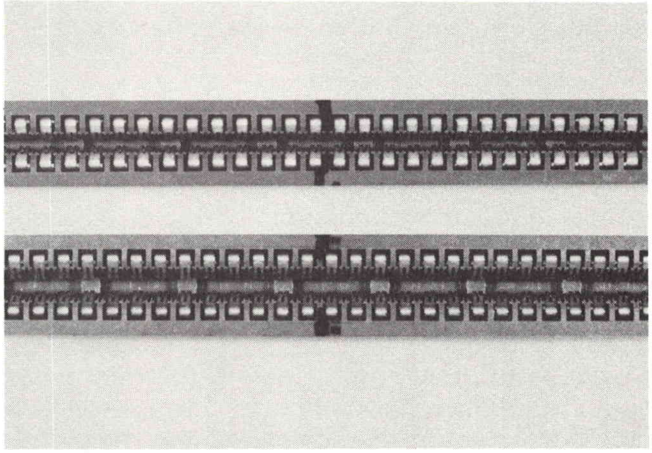


Figure 1

Component Engineering performed tests on samples molded from Phenolic, DAP, polyphenylene sulfide and polyester (GE Valox) representing about seven different manufacturers. Connectors were held at elevated temperatures for predetermined amounts of time. After cooling to room temperature, their warpage at the center of the housing was determined.

Test results

We found that warpage occurred only in the Valox housing of the AMP, Inc. "low profile" connector, and then only when mated to a PC board. All other samples, including the AMP "standard edge" connector and polyester connectors from other manufacturers, showed acceptable levels of warpage (less than 0.010"). Further, it seemed that the older the manufacturing date code of the "low profile" connector, the more severe the warpage (see Figure 2.)

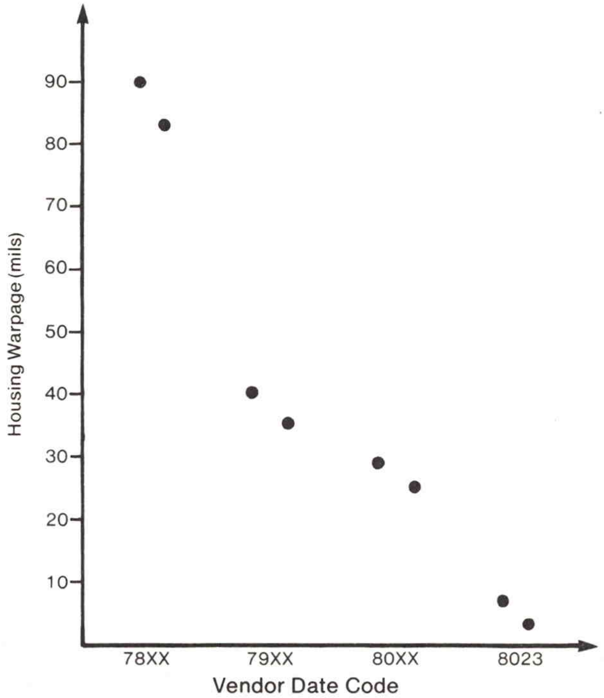


Figure 2 — Housing warpage vs. vendor date code

Time-temperature studies gave the results shown in Figures 3 and 4. Note that the onset of warpage is rather sharp at 50 - 60°C and that housings manufactured in 1978 are almost fully warped after only five minutes at 80°C. Other results indicated that heat treating a connector in the unmated configuration prevented any subsequent warpage from occurring regardless of the test conditions.

continued on page 12

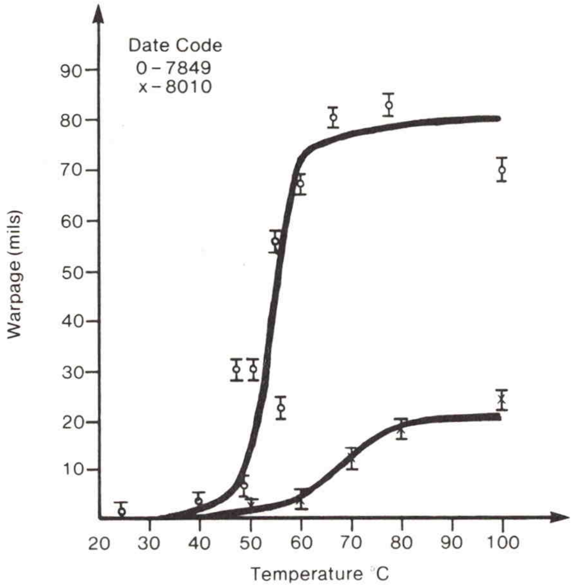


Figure 3 — Housing warpage as a function of temperature. Exposure time was held constant at 35 minutes

After the vendor was notified, AMP representatives met with CE to discuss the problem and its solution. AMP claimed that this problem was novel to them, and was attributable to internal stresses remaining in the housing after molding.

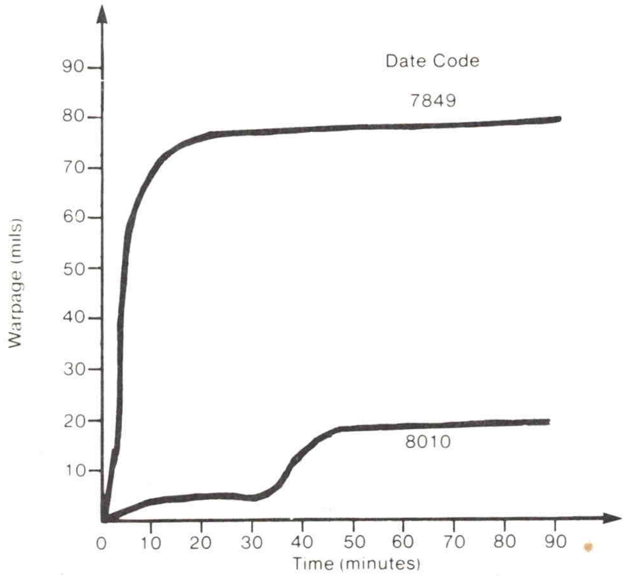


Figure 4 — Housing warpage as a function of time. Ambient temperature was 80°C

The glass transition temperature for crystalline plastics like polyester is the temperature above which the constituent polymers are free to move and below which they are immobilized into some regular crystalline lattice. If an injection molded plastic is cooled too rapidly through the glass transition temperature, then the frozen state is not in the lowest energy configuration and the material does not exhibit highly ordered crystallinity.

This state of frozen amorphism characterizes the AMP housings as we received them at Tek. When the AMP housing is heated above 50°C (the glass transition temperature for Valox) the material begins an annealing process in which the polymers move into their lowest energy crystalline state. It is during this period of stress relief that the Valox is weakened, and when externally stressed, yields plastically. When the connector is mated, the contact spring force exerted on the housing provides sufficient external stress to cause the material to yield at these elevated temperatures. Once the connector has been fully annealed, yielding ceases and the deformation becomes permanent. The trend indicated in Figure 2 was attributed to changes made in the molding process and not to an aging phenomenon.

This particular problem illustrates one of the inherent difficulties with polyester. A part improperly molded from polyester may not show any external indications of the degraded state of the finished product. On the other hand, the preferred housing materials (Phenolic, diallyl phthalate and polyphenylene sulfide) will crack, blister, etc. in vivid demonstration of internal stresses residing within an improperly molded part.

Recommendations

Until AMP can demonstrate that their low profile edgecard connector is stable, it is not recommended that they be used in new design. All Tek parts representing the AMP low profile edgecard connector will be returned to the vendor unless such action would result in line shutdown. In the latter case, heat treating the connector should prevent warpage from occurring. AMP low profile connectors already part numbered by Tek and no longer recommended for new design are shown in Figure 5.

Tek Part Number	AMP Part Number
131-2056-00	2-530662-5
131-2282-00	2-530662-5
131-2059-00	3-530683-0
131-2059-01	3-530671-0
131-2282-01	2-530671-5
131-2279-00	3-530662-0

Figure 5 — Edgecard connectors no longer recommended for new design.

For more information, contact **Joe Reshey (78-552), ext. DR-2313.**

Get one...they're free!

The Parts Catalog group has numerous copies of the 1980 AMI MOS Products Catalog. If you're interested in getting one, stop by 78-567, or call ext. DR-2585.

Selecting the proper solder and flux

Soldering involves bonding two metal surfaces by the use of a third metal filler at temperatures below 800°F (427°C). This definition is an over-simplification for our needs, however; we currently use 15 different solders, and each has unique properties and applications.

A pure metal always melts at a single temperature. Some solder alloys and fusible alloys also have just one melting point, which we call the "eutectic" temperature. Table 1 gives the plastic ranges of the solders we are now using at Tek.

Table 1
Solders Used At Tek

Nominal Composition %	Melting Ranges °C/°F (Approx. Only) Solidus*	Liquidus†	Density gms/cm^3
63 Sn/37 Pb	183/361	183/361	8.42
60 Sn/40 Pb	183/361	188/374	8.65
50 Sn/50 Pb	183/361	212/413	8.85
95 Pb/5 Sn	310/590	314/598	11.30
97.5 Pb/2.5 Ag	303/579	303/579	11.35
97.5 Pb/1.5 Ag/1 Sn	309/588	309/588	11.28
59 Sn/37 Pb/4 Ag	190/374	262/503	8.6
60 Sn/37 Pb/3 Ag	183/361	252/485	8.5
97.5 Pb/2.5 Sn	32/90	316/600	11.33
95 Sn/5 Sb	233/452	240/464	7.25
89 Sn/7.5 Sb/3.5 Cu	241/466	354/669	7.39
61.5 Ag/24 Cu/14.5 In	630/1166	705/1301	9.48
50 Sn/50 In	118/244	125/257	7.30
50 Sn/40 Pb/10 Bi	120/248	167/332	8.77
88 Au/12 Ge	356/673	356/673	14.67

* Temperature at which solder begins to melt
† Temperature at which the solder is completely molten

Tin-lead (Sn-Pb) alloys are the most widely used of all solders because of their low melting points. Specifically, the 60/40 or 63/37 ratio of tin-to-lead are the most preferred in the electronics industry because of their rapid wetting characteristics and strength. Most of our applications call for the use of about 361°F, however some work also calls for higher temperatures, thus the need for special solders with higher temperature capabilities.

Alloying elements are often added to solders to improve solderability, strength, corrosion resistance, melting point, etc. Some of the most common and useful alloying elements are:

Antimony (Sb) — It is said to enhance galvanic corrosion, however it is added to improve creep and fatigue resistance; it is said to help stop "tin-pest". Sn-Sb solders are ideal for joining stainless steel.

Indium (In) — This is a non-ferrous, semi-precious metal which helps make other metals harder, stronger, more ductile, fatigue resistant, and provides better wetting and melting characteristics. When used to replace tin-based alloys, problems associated with leaching and scavenging of gold surfaces are minimized. This material is primarily used for soldering at low temperatures, especially in areas where there is a thermal mismatch.

Silver (Ag) — This alloy is used for high temperature soldering. Ag-Pb alloys are not readily workable and require adequate heat and an active flux. Silver alloys are particularly useful for soldering silver-coated ceramic or porcelain materials, because it prevents scavenging of the silver.

Bismuth (Bi) — Bismuth alloys are used where working temperatures are below 361°F. Cadmium is also used to create low melting point solder alloys. However, it is not advisable to use cadmium because it's very flammable and gives off toxic fumes when heated. Also, corrosion resistance in industrial atmospheres is poor.

Choosing the right flux

In the soldering process, the reactions between solder, host metals and flux occur in the absence of air. When exposed to the atmosphere, especially at high temperatures, most metals react to form oxides, nitrides and carbides on their surface. The rate of formation and tenacity of these formations vary with each base metal, and they are what determine the ease with which a metal can be soldered.

Fluxes clean the base metal surfaces of oxides and consequently provide a blanket-like protection over the material's surface to prevent reoxidation during the soldering process. (Adequate pre-cleaning of the parts to be soldered is very important also, because many fluxes are not designed primarily to remove oxides.)

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Most residual oxides are removed by using the proper flux. But, oxides of chromium, aluminum, titanium, silicon, magnesium, manganese and beryllium are difficult to remove and require special fluxes. Because aluminum is so widely used at Tek (and because it's so difficult to solder), we've prepared a listing of possible solders for aluminum, see Table 2.

Fluxes can be divided into three general classifications — inorganic (chlorides or acid fluxes), organic or "water soluble", and rosin fluxes. The inorganic type fluxes are the most active and can be used on all common metals except aluminum and magnesium. But remember, this is the most corrosive and conductive flux too, so it is not recommended for soldering fine electrical assembly units.

Organic and rosin fluxes are more suited for circuit assemblies and most other electronic applications. Most of the fluxes we use at Tek are rosin-based. It is the mildest type, and its residues are completely non-corrosive and electrically non-conductive. There are three classes of rosin fluxes:

1. The non-activated rosin (R types) which contain no activating agents.
2. The mildly-activated rosin (RMA types) where mild activating agents have been added.
3. The activated rosin (RA types) where small amounts of strong activating agents have been added.

Residues of an RA or RMA rosin flux may or may not be soluble in water or an organic solvent. Thus removing these residues depends on the specific reaction between the metals being soldered and the flux being used.

Water soluble fluxes are formulated with the same basic ingredients used for the rosin fluxes — alcohols, organic acids and halogenated salts. You should note, however, that these organic type fluxes are more acidic, more corrosive, more conductive and contain stronger activating agents than the activated rosin types. They are designed for difficult-to-solder metals which are heavily oxidized. Unlike rosin fluxes, all flux residues are water soluble — as long as these residues are removed within minutes of the soldering process. If not removed quickly, the acidic nature of these residues will etch the solder fillets and may become insoluble.

In summary, here are a few suggestions to keep in mind when using or selecting solders and fluxes:

1. Choose the right solder alloy for the job. The solder should have a lower melting point than the host metals.
2. Use the correct flux. The selection of flux is determined by the soldering application, its wetting characteristics, ease of cleaning and the degree of solderability of the parts to be soldered. Where

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Table 2
Suggested Solders for Aluminum

Composition %	Melting Range °C/°F (Approx. Only) Solidus	Liquidus	Density gms/cm^3	Wetting Ability On Aluminum	Relative Corrosion Resistance
100 Zn (high purity)	419/787	419/787	7.20	Good	Very Good
95 Zn/5 Al	399/720	399/720	6.64	Good	Very Good
91 Sn/9 Zn	199/390	199/390	7.20	Fair	Fair
70 Sn/30 Zn	199/390	311/592	7.20	Fair	Fair
60 Sn/40 Zn	199/390	341/645	7.20	Good	Good
70 Zn/30 Sn	199/390	376/708	7.20	Good	Good
90 Zn/10 Cd	265/509	399/750	7.20	Good	Fair
60 Zn/40 Cd	265/509	335/635	7.75	Very Good	Fair
80.1 Pb/18 Sn/1.9 Ag*	178/350	270/518	10.10	Very Good	Good

*ALU-SOL 45D MULTICORE SOLDER. Suggested soldering temperature is 300 – 350°C.

more than one flux is effective for a given metal, it is good practice to use the mildest flux.

3. Pick the right temperature range for good solder flow. A common rule of thumb is to use a range of 60°F to 160°F *above* the melting point of the solder alloy to ensure a good flow and wetting.
4. Poor cleaning can cause non-wetting or de-wetting. Sufficient pre-cleaning of the surfaces to be joined is a must.
5. Always clean off any flux residues thoroughly.
6. Keep critical touch-up time and temperature to a minimum.
7. The effective temperature range of a flux must conform to the soldering temperature. If soldering calls for a wide plastic range (as in step soldering), or if operating temperature is kept for several minutes, a less active and longer-lived flux is desirable. A quick-heating range needs a more active flux, and long life isn't as critical.

Finally, refer to Table 3, below, for more information on solderability and flux selection. If you have any other questions, please contact me at 78-552, ext. DR-2315.

Bella Geotina
Electromechanical Comp. Eng.

Table 3
Solderability Chart & Flux Selector Guide

Metals	Solderability	Rosin Fluxes			Organic Fluxes Water Soluble	Inorganic Fluxes Water Soluble	Special Flux And/Or Solder
		Non-Activated	Mildly Activated	Activated			
Platinum Gold Copper Silver Cadmium Plate Tin (Hot Dipped) Tin Plate Solder Plate	Easy to Solder	✓	✓	✓	✓	Not recommended for electrical soldering	
Lead Nickel Plate Brass Bronze Rhodium Beryllium Copper	Less Easy to Solder	Not Suitable		✓	✓	✓	
Galvanized Iron Tin-Nickel Nickel-Iron Mild Steel	Difficult to Solder	Not Suitable			✓	✓	
Chromium Nickel-Chromium Nickel-Copper Stainless Steel	Very Difficult to Solder	Not Suitable			Not Suitable	✓	
Aluminum Aluminum-Bronze	Most Difficult to Solder	Not Suitable			Not Suitable		✓
Beryllium Titanium	Not Solderable						

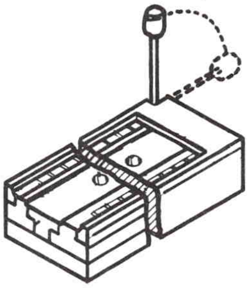
ZIF sockets discontinued

Textool has informed us that they are discontinuing their ZIP DIP I series of zero insertion force (ZIF) sockets. The part numbers affected are listed below. The ZIP DIP II series of sockets will be replacing the obsolete parts.

Obsolete Part Number	Number Of Contacts	Status	New Part Number	Comments
136-0533-00	14	CR		
136-0534-00	16	CR		
136-0688-00	16	CS		Bent handle
136-0535-00	18	CR		
136-0686-00	18	CS		Bent handle
136-0557-00	20	CR		
136-0553-00	22	PP		
136-0587-00	22	CS		Bent handle
136-0536-00	24	CR	136-0536-01	
136-0554-00	28	PP		
136-0537-00	40	CR	136-0537-01	

The major difference in the sockets are the solder tails, which now fit on a nominal 0.100" grid and will fit in vector boards. Other differences include dimensional changes in the body, a shorter actuating lever, a change in the screw mounting holes and centering of the contacts in the body.

Two of the ZIP DIP II sockets are already Tek part numbered and in stock. Mods have been initiated to change over to the new sockets. There are several bent handle sockets that are on Customer Service (CS) status and will no longer be available.



Purchasing will be allowed a last-time buy until March 1, 1981. Contact **Karel Strand (ext. DR-2743)** for more details. For technical information or questions regarding new designs, contact **Peter Butler (ext. DR-2474).**

COMPONENT CHECKLIST

The "Component Checklist" is intended to draw attention to problems or changes that affect circuit design. This listing includes: catalog and spec changes or discrepancies; availability and price changes; production problems; design recommendations; and notification of when and how problems were solved. For those problems of a continuing nature, periodic reminders with additional details will be included as needed.

Tek P/N	Vendor	Description of part	Who to contact, ext.
156-1328-00	**Signetics**	**4-bit shift register**	**Dale Coleman, DR-2573**

This device was single-sourced to Signetics. As a result of a product line evaluation, Signetics decided to discontinue manufacturing this device, leaving Tek with no source. To make matters worse, no replacement part is forthcoming.

Any persons or groups currently using or planning to use this component should contact Component Engineering for a suitable substitute.

TECHNICAL STANDARDS

The function of Technical Standards is to identify, describe, and document standard processes, procedures, and practices within the Tektronix complex, and to ensure these standards are consistent with established national and international standards. Technical Standards also provides a central repository for standards and specifications required at Tektronix.

Chuck Sullivan, manager (41-260)

New standards available

MIL-HDBK-979	Data Sheets for NASA STANDARD PARTS
MIL-T-4734C	**Transit Cases,** Combination Cases and Spare Parts for Ground Electronic Equipment
MIL-E-17362D	**Electronic Repair Parts Requirements,** Procedures for Provisioning Technical Documentation and Stock Numbering.
MIL-S-83734C	**Sockets,** Plug-in Electronic Components; General Specification for
MIL-STD-794D	Parts and Equipment Procedures for **Packaging and Packing**
MIL-C-13924C	**Coating,** Oxide, Black, for Ferrous Metals
MIL-E-13080C	Electrodes, Welding, Covered: Austenitic Steel (19-9 Modified) for Armor Applications
MIL-C-81562A	**Coatings,** Cadmium, Tin-Cadmium and Zinc (Mechanically Deposited)
MIL-W-81044B	Wire, Electric, Crosslinked Polyaldene, Crosslinked Alkane-Imide Polymer, or Polarylene Insulated, Copper or Copper Alloy
ANSI X3.77	Representation of Pocket Select Characters in Information Interchange
ANSI X3.73	For Single-Sided Unformatted **Flexible Disk Cartridge** (for 6631-BPR use)
MIL-C-7905E	**Cylinders,** Compressed Gas, Non-Shatterable
MIL-STD-2110	Registration, Overhaul, and Repair of Electronic Equipment
MIL-STD-2111	Technical Repair Standards — Electronic (4G Repairables), Preparation of
IEEE STD 389—1979	Recommended Practice for Testing Electronic Transformers and Inductors
IEEE STD 748—1979	Standard for **Spectrum Analyzers**
ANSI/AWS A3.0-80	Welding Terms and Definitions; Includes Brazing, Soldering, Thermal Spraying, and Thermal Cutting
MIL-C-28901	**Connectors,** Electrical, Plugs, TIP (Test Point Plug, Banana Plug)
MIL-I-85352	Inflator Assembly and Gauge Elements, Pneumatic Pressure, Remote Control, Direct Reading
MIL-S-85377	**Switch,** Stepping, Direct Current, Aircraft Dispenser

Finish Quality Standard (062-1718-00)

Cosmetic "finish" is intended to define the QUALITY or appearance of a metal part after all processes to produce it have been completed. It does not prescribe any finishing operations. It does not define how smooth, shiny, glossy, or dull a finish must be; it is concerned only with the degree of acceptability of imperfections.

The Standard prescribes four grades of acceptability; one or more must be identified on each part drawing by a note referring to 062-1718-00.

The grade must be maintained through final assembly, because careless handling subsequent to manufacture can result in damage to the finish and make the part unacceptable for assembly into a Tek Instrument. The criticality of a cosmetic finish influences the precision and care with regard to manufacturing and handling, but does not supersede the need for whatever mechanical or additive finish the part requires.

Tektronix Standard 062-1733-00, Rackmount Standards Warning

— Mounting Rail Dimensional Requirements Change. Reference: ANSI/EIA-RS-310-C, Page 4, Paragraph 4, Notes 1, By January 1, 1981, equipment shall be designed to fit 17.720 (450mm) Minimum clearance between rails.

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New reliability/quality requirements for digital SSI/MSI devices

The topic of purchased digital SSI/MSI IC reliability and quality has been studied at Tektronix. The conclusion is that incremental costs expended on improving the reliability/quality of these parts are at least offset by savings in Tek operations.

In accordance with a corporate decision made by Larry Mayhew in February 1980, all digital SSI/MSI devices will be purchased to a reliability level of 0.006%/1000 hours at 50°C and a quality level equivalent to 0.1% AQL for functional defects. Following is a list of characteristics describing parts affected, as set down by the SSI/MSI Project Task Force:

1. Digital inputs and outputs
2. Twenty-four pins or fewer
3. CMOS, TTL, LSTTL, LTTL, STTL, HTTL
4. Exclusions: PROMs
    Masked ROMs
    Memory greater than 64 bits
    Microprocessors

Instrument designers are advised that Purchased Part Initiation Forms (PPIFs) for new parts with the above listed characteristics should bear the reliability-screening stipulation to expedite processing. Mods involving already-existing Tek part numbers will be initiated where necessary by Digital CE.

Inquiries regarding the suitability of a device for screening under this program can be directed to Bruce Brown, ext. DR-2571, for TTL, or Wilton Hart, ext. DR-2572, for CMOS. Technical details on the screening process and documentation of the corporate decision are available from Ron Schwartz, Component Reliability Engineering, ext. WR-1991.

Yvonne Brinck
Digital Component Engineering

Stainless steel selection guide available

A stainless steel selection guide has recently been published by Kwaku Mensah, Corporate Metallurgist. The guide includes a descriptive classification of stainless steels, a generalized discussion of mechanical properties of metals (definitions and the significance of terminology), and the principles of corrosion as it applies to all metals.

In addition, the paper includes tables depicting typical mechanical and physical properties of some of the more common stainless steels. Designers should find this paper particularly useful.

To obtain a copy, call the Metallurgical Lab (ext. B-7833) and ask for the paper on stainless steel.