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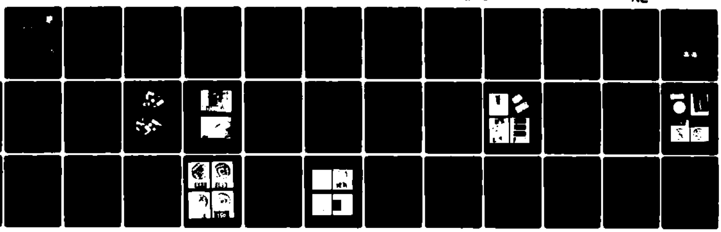

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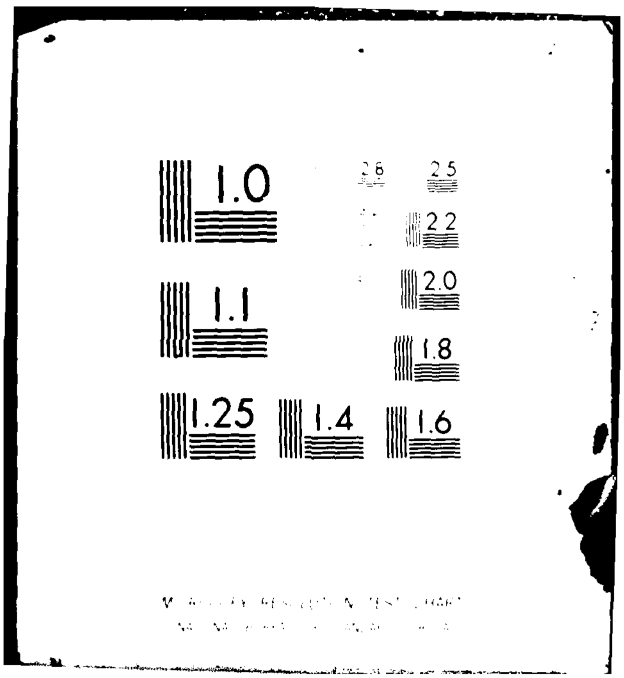
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RADC-TR-82-93
Final Technical Report
May 1982

GLASS-TO-METAL SEAL QUALITY

General Electric Company

L. Zakraysek and H. Lin

AD A117598

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, NY 13441

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Microelectronic packages with marginal glass-to-metal seals often escape detection at receiving inspection when they are tested by present methods for determining hermeticity. A more effective test method is desirable for fulfilling the requirement of effectively detecting marginal quality microelectronic package hermeticity. This final report describes the results of an extensive study of various dye penetrant materials and specially designed equipment in developing an optimum and effective liquid dye penetrant test

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) method for determining the hermetic quality of various types of microelectronic packages.

EVALUATION

This effort supports TPO 4F1, Solid State Device Reliability. The premise that elevated temperature fluorescent dye penetrant testing can be an effective alternative for determining microcircuit package hermeticity has been verified. However, the test is destructive, so it cannot be used to screen out leakers. Further in-house effort will be necessary to develop this technique into a test method suitable for inclusion into MIL-STD-883, Test Methods and Procedures for Microelectronics.

JOHN E. McCORMICK
Project Engineer

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The authors gratefully acknowledge the support and technical assistance provided by Dr. R. Thomas and Mr. J. McCormick. Valuable technical assistance was also provided by A. Hare and D. Kelsey from the Electronics Laboratory, General Electric Company.

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1 INTRODUCTION

No available test method now seems to fulfill the requirement of effectively detecting marginal quality of microelectronic package hermeticity, as is evident by the recurrence of hermeticity failure, on system components even following extensive testing by present means. Microelectronic packages with marginal glass-to-metal seals often escape detection at receiving inspection when they are tested by present methods for determining hermeticity. As a result, significant numbers of packages are found to be leakers after the application of processing stresses that are required for chip mounting, wire bonding, cover welding, soldering or thermal cycling. There is some evidence that dye penetrant testing[1,2] can be effective in improving test efficiency. We suggest that a modified test approach by the changing of temperature and pressure conditions during exposure to the liquid dye penetrant test can be developed. This final report describes the results of a study of various dye penetrant materials used and the test equipment designed for developing the optimum liquid penetrant testing for various microelectronic package hermeticity.

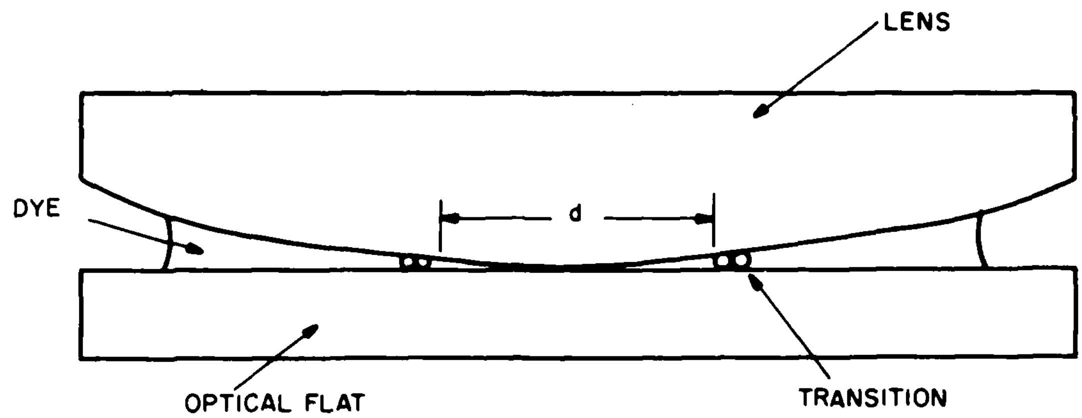
2 MATERIALS AND EQUIPMENT

2.1 DYE PENETRANT SELECTION AND EVALUATION

Based on the premise that liquid penetrants could be made effective if used at elevated temperatures and pressures, four candidate materials were selectd from among seven commercially available liquid penetrants. These were tested to temperatures as high as 200°C. Visible and fluorescent dye penetrants were evaluated for the effect of temperature and time by the Meniscus Method[3], where a lens contact spot diameter is used to measure penetrating effectiveness as well as to determine whether or not degradation of the penetrant occurs. Prior to any penetrant testing, the following penetrants from the noted source were subjected to the meniscus test method before and after elevated temperature aging:

a.	Crown Industrial Products	1. 1075
b.	Magnaflux Corp.	1. SKL-W 2. ZL-55
c.	Sherwin Inc.	1. HM-607 2. KO-17 3. RC-77
d.	Testing Systems Inc.	1. FL-50 2. DD60A
e.	Turco Products Inc.	1. Fluoro-Check-WW 2. Visi-Check-WW
f.	URESCO Inc.	1. P330F 2. P400 3. P403

The test method is illustrated in Figure 1, and the test results are shown in Table I and Figure 2. The results indicate that fluorescent dye penetrants are basically more sensitive than visible dye penetrants. For this program, a commercial visible dye penetrant and a commercial fluorescent dye penetrant were selected as being suitable for the testing of microelectronic package hermeticity to temperatures as high as 150°C. In addition, the specific dye selection was made on the basis of the ease of interpreting indications during the test. Water-wash removal of dye residuals was also considered to be a necessity.



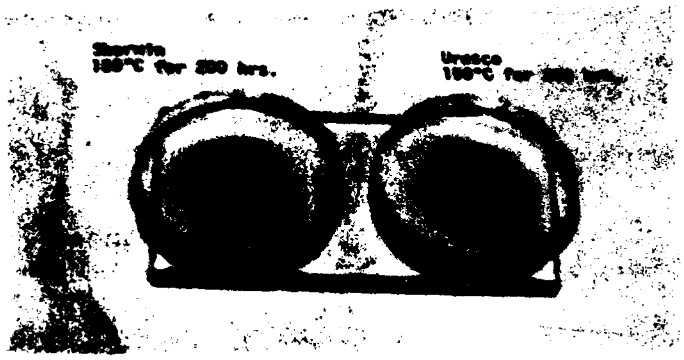


Figure 1. Meniscus Test Method

TABLE I.

Meniscus Method
(Temperature and Time Effect)
Visible Dye Penetrant Sensitivity Test Results

Condition	Sherwin, KO-17 Spot Diameter (mm)	Uresco, P330F Spot Diameter (mm)
As received	2.6	2.1
150°C for 5 hrs	2.8	3.0
10	2.6	3.0
20	3.0	3.4
30	3.0	3.7
40	3.0	4.0
60	3.0	4.0
80	3.2	4.2
100	3.1	4.1
150	3.6	4.5
200	7.4	4.6
200°C for 30 min	4.3	3.8

Fluorescent Penetrant Sensitivity Test Results

Condition	Sherwin RC-77 Spot Diameter (mm)	Sherwin HM-607 Spot Diameter (mm)
As received	1.4	1.2
150°C for 5 hrs	1.4	1.1
10	1.5	1.5
17	1.5	1.5
25	1.6	1.5
32	1.6	1.6
55	2.7 (color changed)	1.7
80	-	2.0
100		1.9
125		2.0

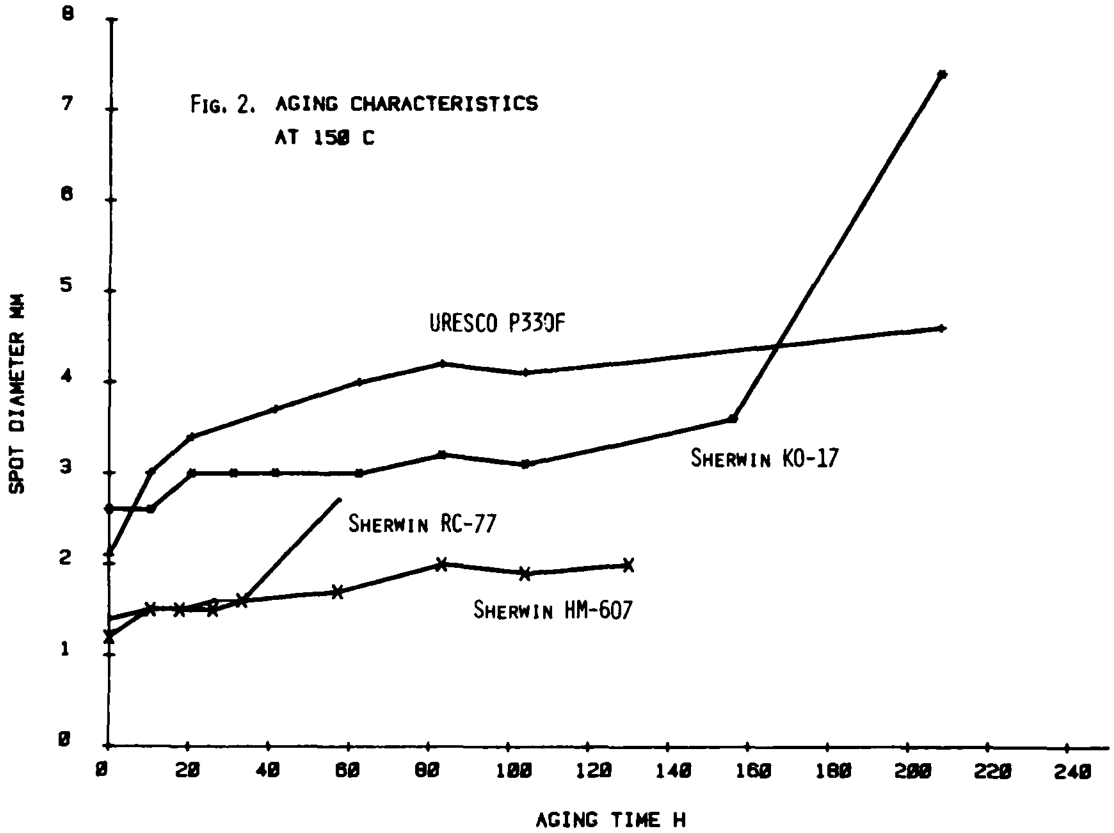


Figure 2. Aging Characteristics of Liquid Penetrant at 150°C

2.2 MICROELECTRONIC PACKAGES AND THEIR QUALITY

More than 1000 metal-can and cerdip types of packages were procured from various sources for testing during this program. They are tabulated in Table II and shown in Figure 3. All open and sealed packages were tested for hermeticity using the standard tracer gas helium fine leak test, MIL-STD-883B, Method 1014.4, Seal, Conditions A_1 and A_4 respectively as a control and base line before dye penetrant test. A leak rate of 5×10^{-8} atm.cc./sec. was set as the acceptance limit for hermetic quality. Throughout the program, only one of the as-received open packages failed the helium fine leak test. For as-received sealed packages, approximately 7% of them failed helium fine leak test. This indicates the possibility of package degradation due to assembly.

Metallographic evaluation for glass-to-metal seal quality[4] was also performed on representative packages in terms of interface bonding, oxide thickness, glass meniscus, gas porosity and finishing qualities. The results showed a rather high density of gas porosity in glass phase, a non-uniform oxide thickness, and uneven plating thickness. In general, the metallographic qualities of procured package can be classified as marginal to good package quality. This may account for the degradation of package hermeticity from the 10^{-9} level to 10^{-8} after assembly and/or delidding.

2.3 EQUIPMENT

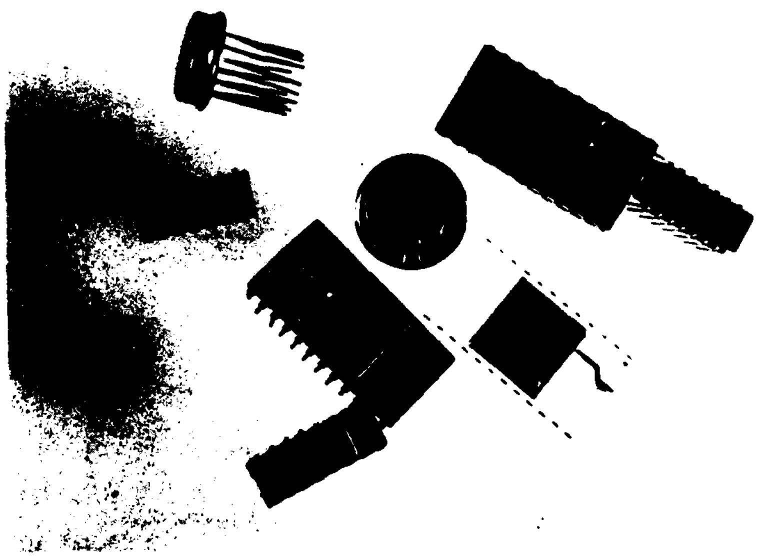
A modified pressure-bomb test chamber was designed and constructed for the testing of sealed microelectronic packages. A thermocouple is attached for temperature measurement and the chamber is insulated to minimize temperature fluctuation. The temperature can be controlled within ±2°C and the pressure can be varied up to 120 psig.

An exploratory test fixture was specially designed and fabricated for testing open TO-8 packages. The sample attachment techniques, temporary gasket used and test conditions are all taken into consideration. The pressure-bomb test chamber for testing sealed package and exploratory test fixture for testing open package are shown in Figure 4.

TABLE II. MICROELECTRONIC PACKAGE TYPES, SOURCES AND QUALITY

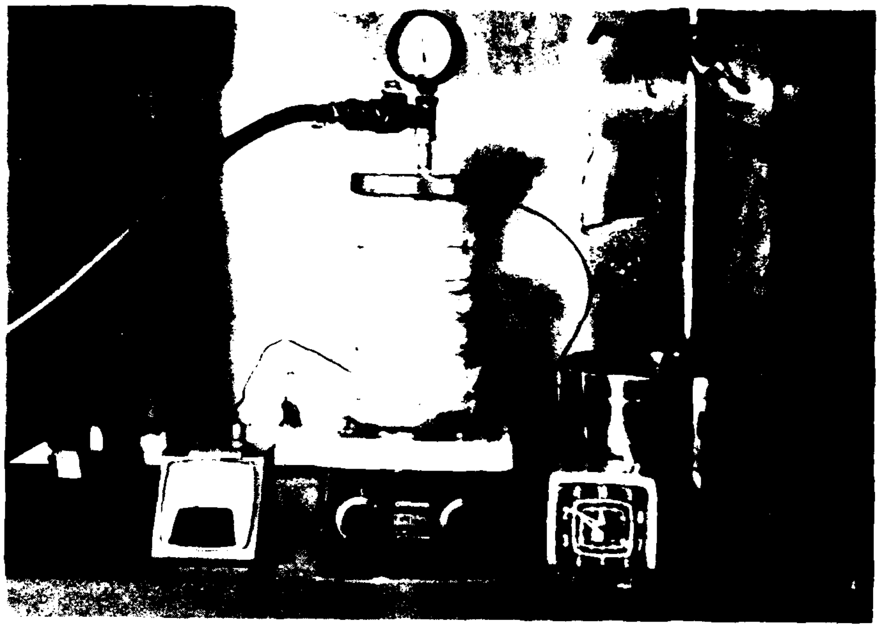
Type	Open Package			Sealed Package		
	Number	Suppliers	Number Failed Helium Test	Number	Suppliers	Number Failed Helium Test
TO-8	300	Hermetite Glasseal	1	230	GE-Syracuse GE-Korea GE-Philippines	7
Cerdip (Side-Braze)	300	Kyocera Met Ceram American Lava	None	150	GE-Syracuse	11
Unibody	125	Hermetite	3	-	-	-
Cerdip (Lead Frame)	250	Kyocera	None	8	RADC	3

Open Package

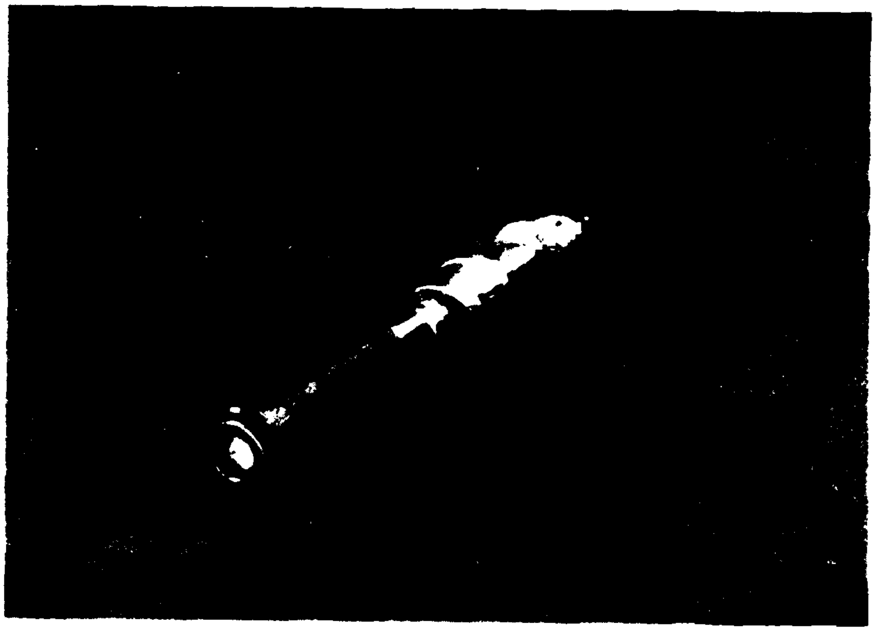


Sealed Package

Figure 3. Microelectronic Package - Open and Sealed Packages



a. For Testing Sealed Package



b. For Testing Open TO-8 Package

Figure 4. The Pressure-Bomb Test Chamber and Exploratory Test Fixture

3 DYE PENETRANT TESTING

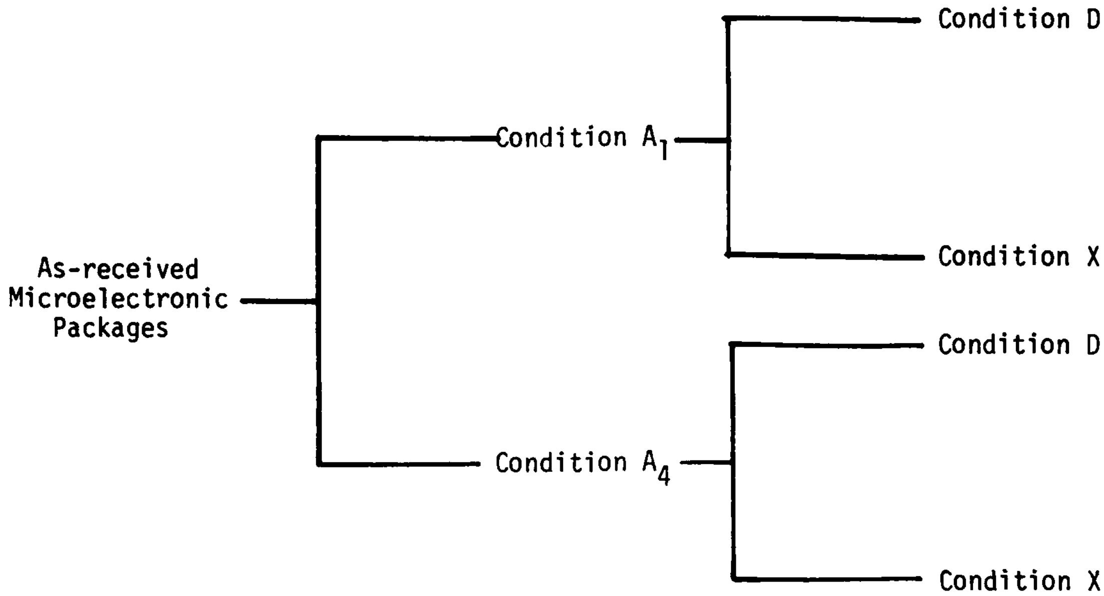
One visible dye penetrant and one fluorescent dye penetrant were used throughout this period of study. Test plans as shown in Figure 5 were used for all evaluations. The parameters under studies here included temperature, pressure and dwell time effects. Test conditions and procedures follow MIL-STD-883B, Method 1014.4, Seal, Test Condition D but varied the temperature, pressure and dwell time. In this manner, test procedures and temperature profiles were determined for sealed and for open packages. These profiles are shown in Figure 6. Visual inspection and deliddding were used as standard procedures for interpreting the test results.

3.1 VISIBLE DYE PENETRANT TEST-SEALED PACKAGES

Ten different test runs were performed in order that the optimum test condition in terms of temperature, pressure and dwell time could be derived. The packages used include TO-8 metal can packages, side braze cerdip with 14, 16 and 24 leads packages. Test temperature varied from room temperature to 150°C, the pressure changes from 0 to 120 psig and the dwell time was maintained from 1 min. to 3 hours. The specially selected developer was applied on each individual package after the testing cycle was completed and the indication of leakage and interpretation of the test results were made under low magnification before and after delidding. The test results are summarized in Table III. The essential findings of this phase of the study is that a certain escape rate (vs Helium) was obtained for all test conditions. In addition, that the packages which failed the visible dye penetrant test were all cover leak, either partially dye infiltrated or dye penetration into the package cavity. No glass-to-metal leakage was observed in this portion of the study. From these results the test condition of 150°C under 90 psig pressure for 3 min. is suggested as an optimum test condition which is derived from visible dye penetrant test data with 7.5% highest escape rate. Some typical test results are shown photographically in Figure 7.

3.2 FLUORESCENT DYE PENETRANT TEST-SEALED PACKAGES

A similar number (10) of test runs were conducted by using fluorescent dye penetrant. The parameters under study were temperature, pressure, dwell time and rinsing time. The purpose of introducing a rinse time study is an attempt to obtain a reasonable correlation between visual inspection before dilidding and after delidding, the rinse time was varied from 1 min to 10 min and in some cases was assisted



NOTE: MIL-STD-883B, Method 1014.4 "SEAL"

Condition A_1 - Fixed Method, Tracer Gas Helium Fine Leak.

Condition A_4 - Unsealed Package Method, Tracer Gas Helium Fine Leak.

Condition D - Penetrant Dye Gross Leak

Condition X_1 - Proposed Test Method, High Temperature Dye Penetrant Test.

Figure 5. Test Plan Flow Chart A

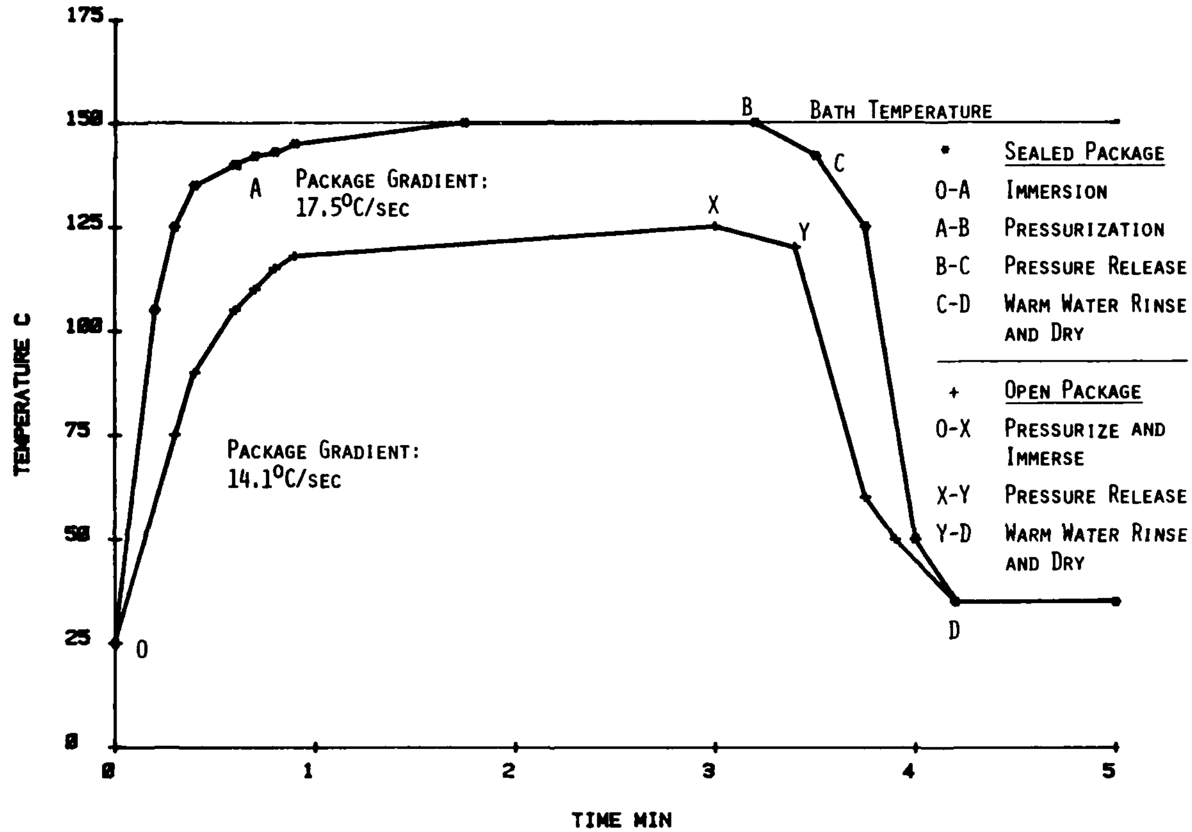


Figure 6. Temperature Profile Sealed and Open Packages

TABLE III.

VISIBLE DYE PENETRANT TEST RESULTS
SEALED MICROELECTRONIC PACKAGE

Test Condition (T,P,t)*	Sample Type	Sample Size	Number Failed Helium Test	Number Failed Penetrant Test	Escape Rate (%)
D (25,90,3H**)	Various	40	1	2	2.5
D_1(80,90,3H)	Various	40	0	2	5.0
D_2(150,0,3H)	Various	40	0	2	5.0
D_3(150,90,3H)	Various	40	1	0	-2.5
D_4(150,120,3H)	Various	42	6	6	0
D_5(150,90,3M***)	Various	40	2	5	7.5
MIL-STD-883B, Method 1014.4, Condition D	Various	40	1	2	2.5
Condition X	Various	202	9	15	3.0
Suggested Optimum Condition X*	Various	40	2	5	7.5

*: Temperature, pressure, time

**: Time is in hours

***: Time is in minutes

X*: 150°C, 90 psig, 3 min.

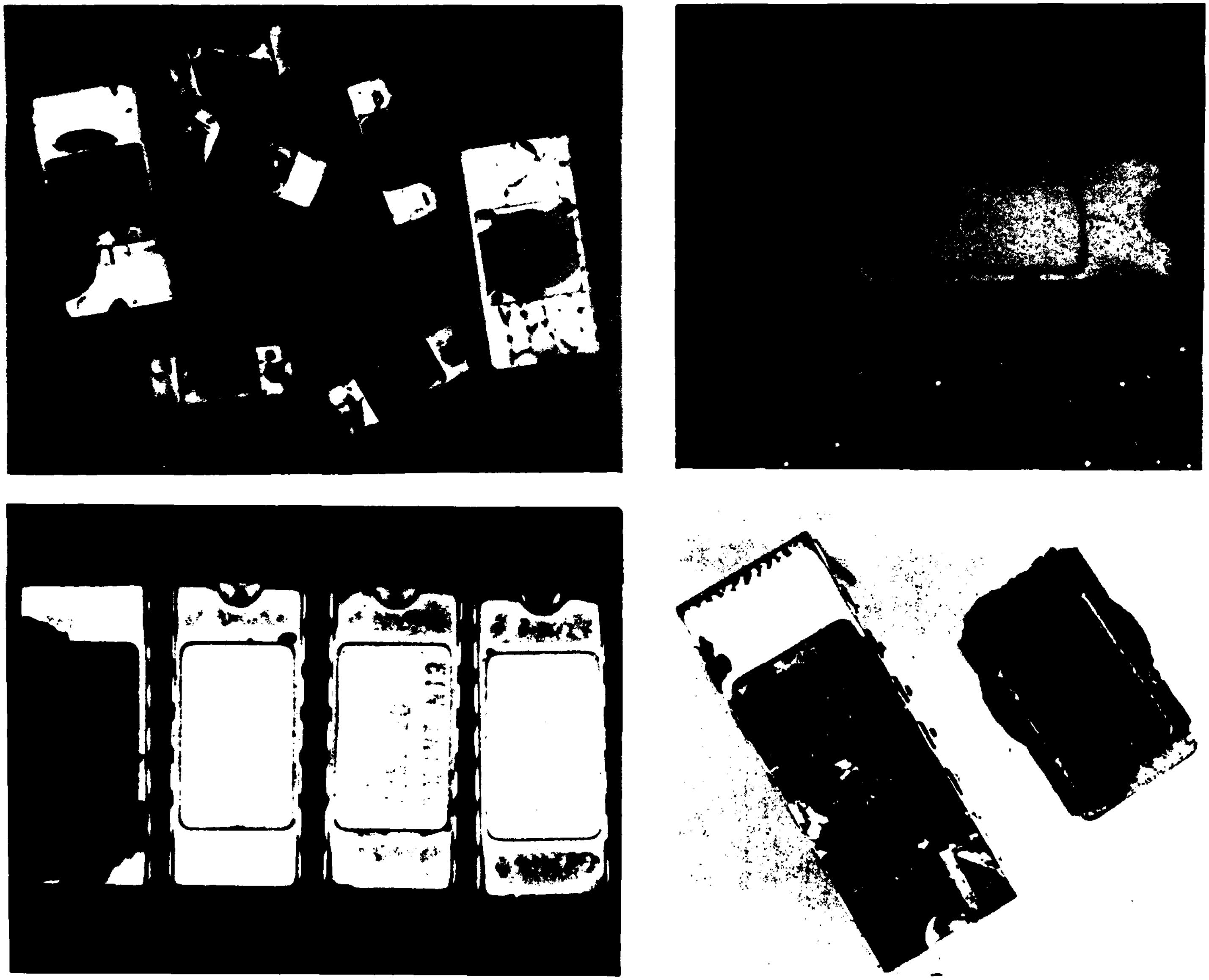


Figure 7. Typical Visible Dye Penetrant Test Results

with ultrasonic cleaning. Additional test runs were designed for testing open packages. One very important feature of using fluorescent dye penetrant is that it does not require developer after the test cycle to enhance the fluorescent intensity or sensitivity. The interpretation of test results relies on both visual inspection before and after delidding. The results indicate that:

1. Fluorescent dye penetrant is more effective in determining microelectronic package hermeticity than visible dye penetrant with higher escape rate obtained.

2. Most of TO-8 packages that failed fluorescent dye penetrant test are glass-to-metal seal leakage.

3. Interpretation of the test results, according to visual inspection, is more difficult than visible dye penetrant test due to its high sensitivity of fluorescent dye and existing sub-surface defects of the package.

4. The correlation between visual inspection and delidding is fair, approximately 75%.

5. An optimized and effective test condition was confirmed in this study as 150°C under 90 psig pressure for 3 minutes. An escape rate of 28.3% was obtained.

The test results are summarized in Table IV.

The photo evidence of typical leak through glass-to-metal seal in TO-8 package was shown in Figure 8 before and after delidding along with the evidence of microsection of the TO-8 package longitudinally and transversely. It vividly demonstrates the leakage and leak path clearly.

Analysis of test data on effect of temperature and pressure versus escape rate was shown in Figure 9.

3.3 FLUORESCENT DYE PENETRANT TEST - OPEN PACKAGES

The testing of open packages is desirable since the cost is relatively low at this stage of IC procurement. The primary problem with the fluorescent dye penetrant testing of open packages is the isolation of seals undergoing test. To overcome this difficulty, the following test plans were investigated. They are:

1. Pressure Bomb Test Chamber and follow the test plan flow chart A. Three test runs and a total of forty-five various packages were tested.

TABLE IV.

FLUORESCENT DYE PENETRANT TEST RESULTS
SEALED MICROELECTRONIC PACKAGE

Test Condition (T,P,t)	Sample Type	Sample Size	Number Failed Helium Test	Number Failed Penetrant Test	Escape Rate (%)
F_1(25,90,3H)	Various	17	1	6	29.4
F_2(150,0,5M)	Various	11	0	5	45.5
F_3(150,90,3H)	Various	30	0	1	3.3
F_4(150,90,3H)	Various	20	0	2	10.0
F_5(150,90,5M)	Various	25	0	6	24.0
F_6(25,0,5M)	TO-8	10	0	0	0
F_7(25,90,5M)	TO-8	10	0	0	0
F_8(150,0,1M)	TO-8	10	0	0	0
F_9(150,90,1M)	TO-8	10	0	2	20.0
F_{10}(150,0,5M)	TO-8	10	0	0	0
BS1(150,90,3M)	TO-8	25	5	14	36.0
BS2(25,90,3M)	TO-8	13	0	0	0
BS3(25,90,3H)	TO-8	13	2	1	-7.7
MIL-STD-883B, Method 1014.4, Condition D	Various	30	3	7	13.3
Condition X	Various	174	5	30	14.4
Suggested Optimum Condition X*	Various	60	5	22	28.3
T.S. - X*	TO-8	10	0	3	30.0

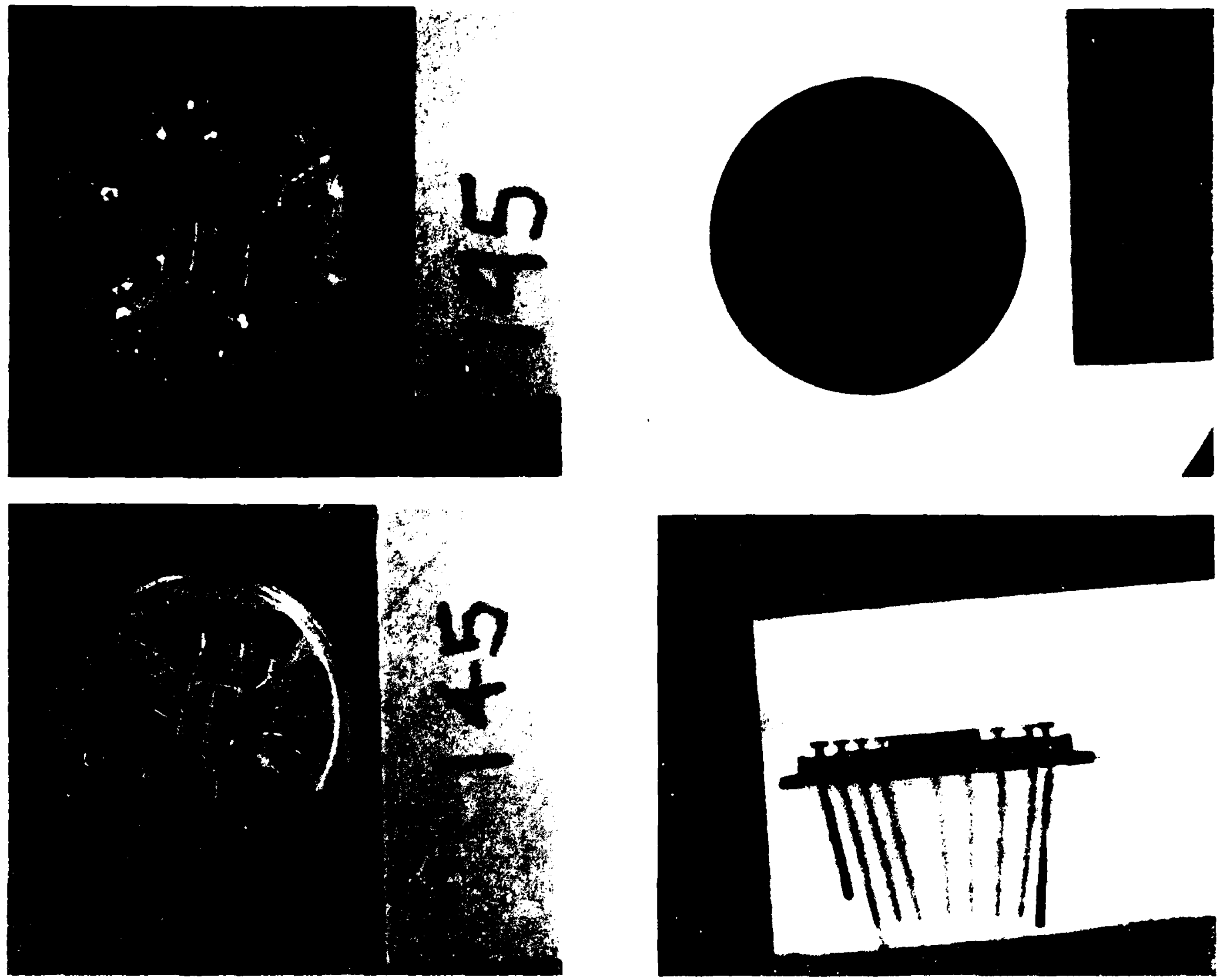


Figure 8. Typical Photo Evidence of Glass-To-Metal Seal Leak in TO-8 Package After Fluorescent Dye Penetrant Test

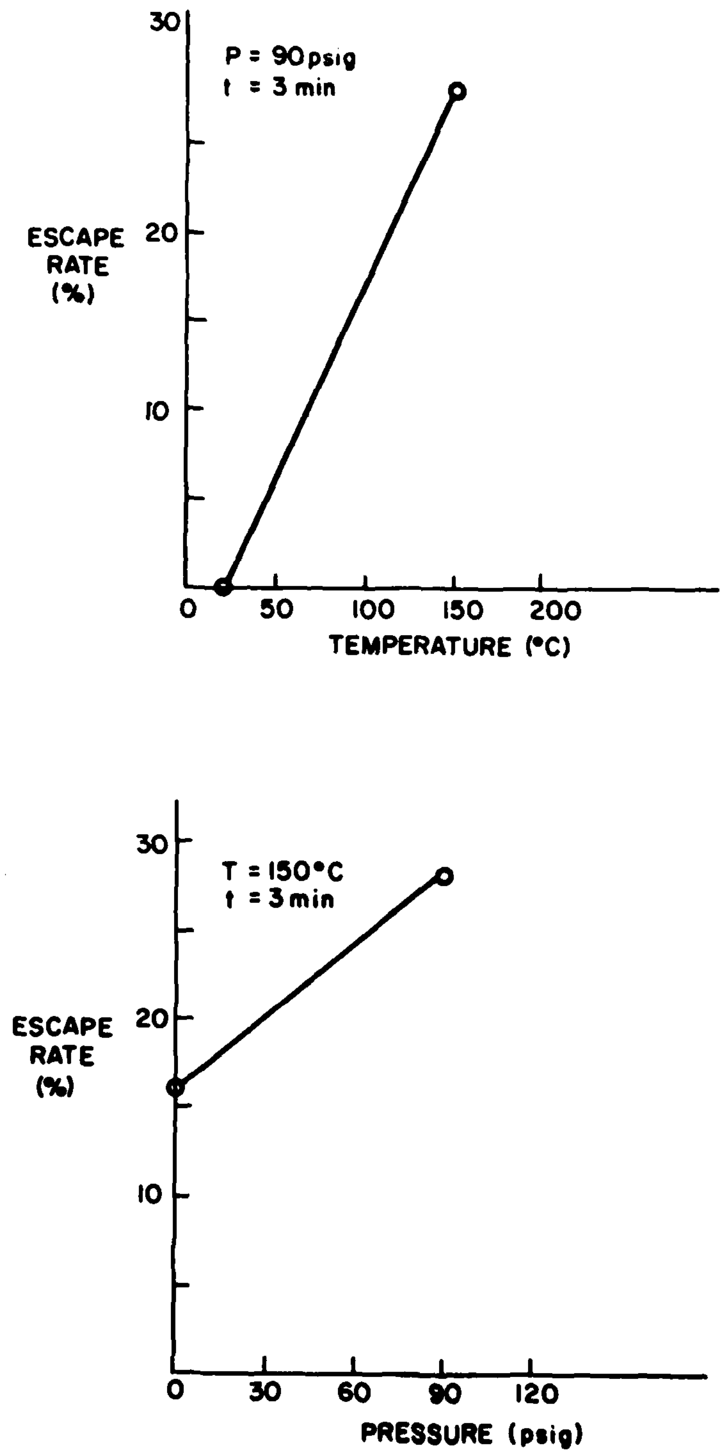


Figure 9. Effect of Temperature And Pressure on Fluorescent Penetrant Test Effectiveness

2. Pressure Bomb Test Chamber and follow the same test plan flow chart A with temporary seals, such as strippable vinyl coating, epoxy coating, high-temperature tape and silicone rubber sealant. -Total of forty-eight various packages were tested.

3. Exploratory fixture shown in Figure 4b for testing open package - and follow the test plan flow chart A - Five test runs and total of fifty TO-8 packages were tested.

The test results indicate that

1. Pressure Bomb Test Chamber -Since both sides are exposed to dye penetrant during the test, it is very difficult to interpret the test results.

2. Pressure Bomb Test Chamber and Temporary Seals.-Most of coating materials are not temperature stable at 150°C and dye is also partially penetrated into some of the coating materials. For the high temperature tape that the isolation of the seal was not accomplished at all.

3. Exploratory Test Fixture - It is felt that the sudden inducement of a steep thermal gradient as well as pressure application during the testing of sealed packages are the two key parameters in detecting the marginal quality package which escape from helium fine leak test. The fixture was finally insulated, as shown in Figure 4b, and two Viton O-rings were used to obtain a good temporary seal for fluorescent dye penetrant tests. The initial thermal gradient achieved by using this test fixture and following the suggested optimum test condition was measured at 14.1°C/sec versus 17.5°C/sec. measured under sealed package suggested optimum test conditions.

The sample attachment and temporary seal were successfully accomplished for testing open TO-8 packages by using Exploratory Fixture yet the test results on open TO-8 package, total of fifty packages tested, indicate that none of the tested open TO-8 packages were leaking. The following test plans were thus designed specifically for fluorescent dye penetrant test for TO-8 open packages, that is Test Plan Flow Chart B in Figure 10.

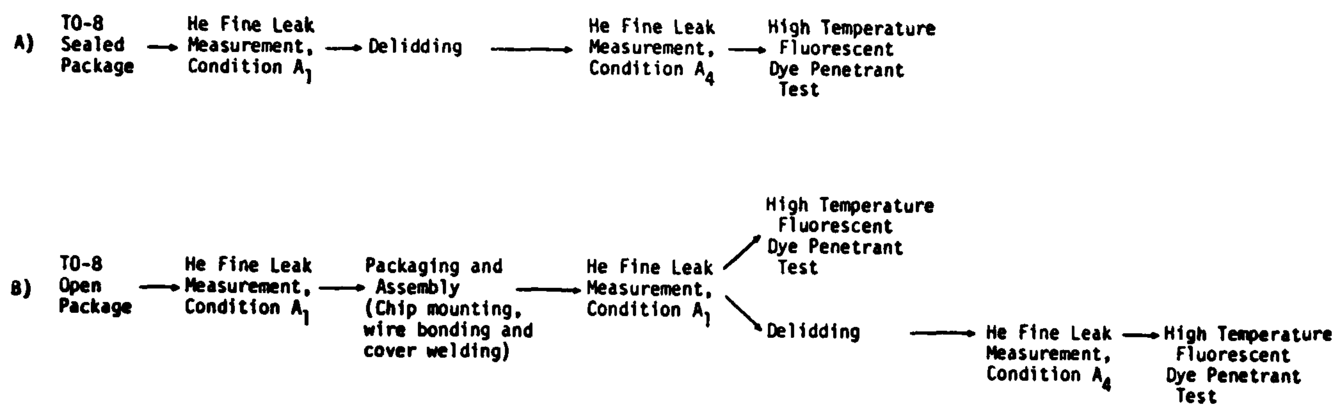


Figure 10. Test Plan Flow Chart B

Test results from sealed packages revealed that fluorescent dye penetrant test is an effective means of detecting hermetic quality of microelectronic packages with marginal quality of $>1 \times 10^{-8}$ atm/cc/sec. On the other hand TO-8 packages measured (by helium) at leak rates of 1×10^{-9} atm/cc/sec or better are believed beyond capability of detection by penetrants.

Test Plan Flow Chart B was designed and proposed in order that the effect of process stresses-die attachment, wire bonding and cover welding, as well as effect of re-work stress can be investigated and the degree of deterioration of the external stresses imposed on microelectronic package, particularly the TO-8 package, during the handling, assembling and delidding can be determined. The test results are summarized in Table V and shown photographically in Figure 11.

3.4 FLUORESCENT DYE PENETRANT TEST-DEMONSTRATION RUN

This specific test run was performed to verify and demonstrate the effectiveness of developed test method on sealed packages regardless of the type of package tested.

Eight pieces of 14-lead frame cerdip were provided by RADC, the program sponsor. As shown in Table VI, the base line data were established by two of the independent laboratories by using MIL-STD-883B, Method 1014.4, Seal, Conditions A and C, respectively. The packages then were tested under suggested optimum test condition in fluorescent dye penetrant. Visual inspection seems to indicate that these groups of lead frame cerdip packages were all leakers except one package, i.e. number 4 package, is a non-leaker.

It was decided that delidding and metallographic cross-section techniques were to be used in verifying the package quality. Five packages were delidded and three were metallographically cross-sectioned, either transversely or longitudinally. The results are summarized and tabulated in Table VI. Typical results of leak package was illustrated photographically in Figure 12.

It is concluded that

1. Five packages are identified as leaker out of eight packages tested.

2. Demonstrate the effectiveness of the elevated temperature fluorescent dye penetrant test on package hermeticity regardless of the type of sealed packages used

3. Delidding the package is a more effective means of identifying and interpreting the test results.

TABLE V. FLUORESCENT DYE PENETRANT TEST RESULTS

OPEN MICROELECTRONIC PACKAGE

	Test Condition (T,P,t)	Sample Type	Sample Size	Number Failed Helium Test	Number Failed Penetrant Test	Escape Rate (%)
Pressure Bomb, as Received	F01(150,90,5M)	Various	30		0	0
	F02(25,90,3H)	Various	30		0	0
	F03(150,0,5M)	Various	30		0	0
Test Fixture, As Received	F101(150,90,1M)	TO-8	10	$<10^{-8}$	0	0
	F102(150,90,5M)	TO-8	20		0	0
	F103(150,90,5M)	TO-8	10		0	0
	F104(150,0,5M)	TO-8	10		0	0
	F105(150,90,3H)	TO-8	4		0	0
	TO1(194,90,3M)	TO-8	16		0	0
	TO2(194,0,3M)	TO-8	8		0	0
	TO3(194,90,3M)	TO-8	10		0	0
Test Fixture, Assembly and Re-Work	AO1(150,0,3M)	TO-8	10	10	10	0
	AO2(25,90,3M)	TO-8	10	10	10	0
	AO3(150,90,3M)	TO-8	10	10	10	0
	BO1(150,90,3M)	TO-8	25	13	17	16
	BO1(25,90,3H)	TO-8	25	13	17	16
	X*(150,90,3M)	TO-8	50	$<10^{-8}$	0	0
	X*(150,90,3M)	TO-8	12	10^{-8}	4	33.3
	X*(150,90,3M)	TO-8	23	$>10^{-8}$	23	0

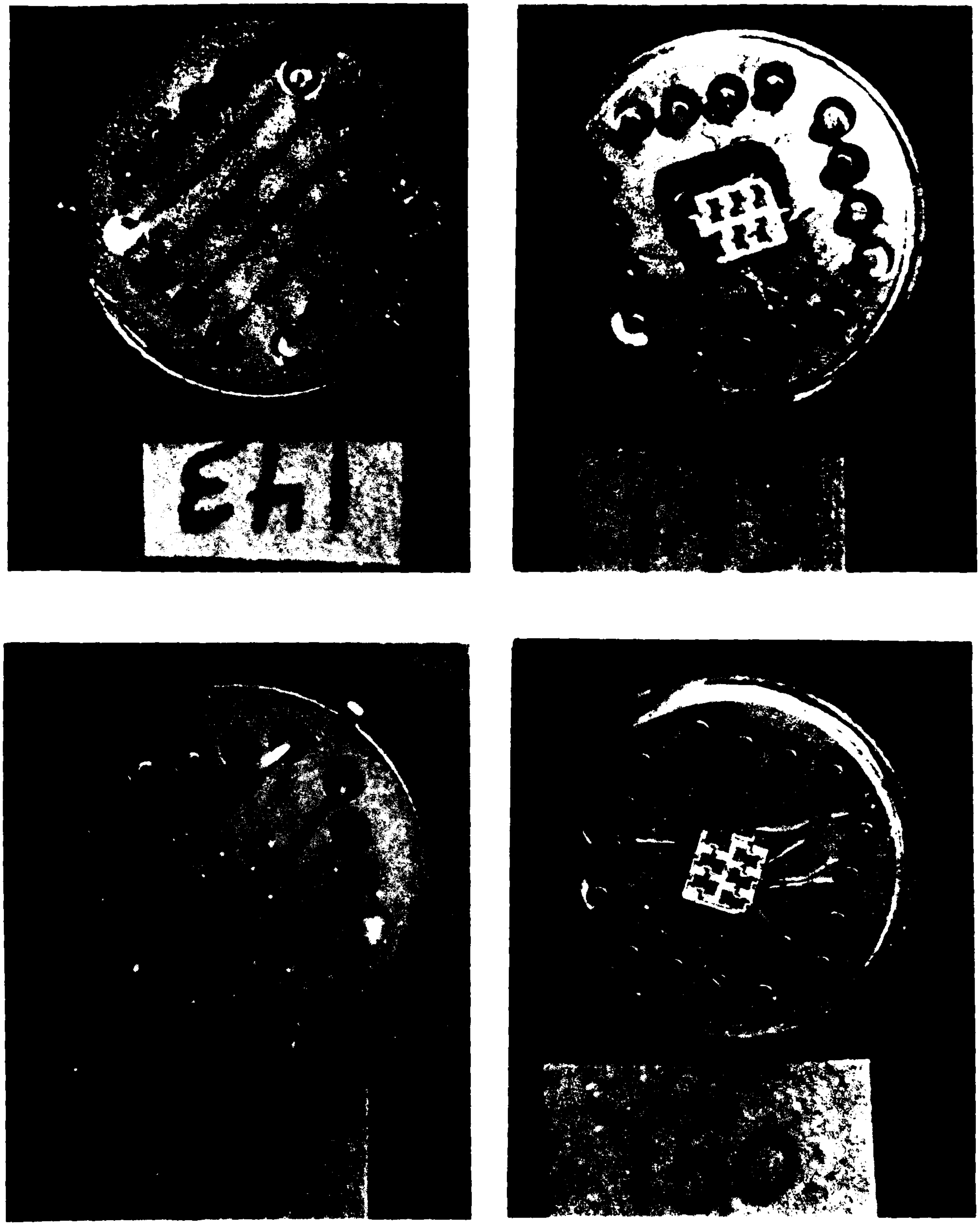


Figure 11. Typical Test Results of Open TO-8 Package

TABLE VI. HIGH TEMPERATURE FLUORESCENT DYE PENETRANT TEST

DEMONSTRATION RUN - 14 LEADS, LEAD FRAME CERDIP PACKAGE

Sample I.D.		RADC Results	E-Lab Results	Dye Penetrant Test: Visual Inspection	Dye Penetrant Test: Verification
JM38510/ 05101BCA7929 27014 U.S.A.	2	Failed F, G	Gross Leak	Leaker	Cross-sectioned - Leaker
	5	Failed F	Gross Leak	Leaker	Cross-sectioned - Leaker
	12	Failed F	Gross Leak	Leaker	Delidding - Leaker
			(atm cc/sec)		
JM38510/ 05202BCA7928 27014 U.S.A.	3	Passed F, G	7.3×10^{-8}	Non-leaker	Delidding - Non-leaker
	5	Passed F, G	6.3×10^{-8}	Leaker	Delidding - Leaker
	8	Passed F, G	7.9×10^{-8}	Leaker	Delidding - Leaker
	10	Passed F, G	6.3×10^{-8}	Leaker	Cross-sectioned - Non-leaker
	13	Passed F, G	6.8×10^{-8}	Leaker	Delidding - Non-leaker

F - Fine Leak Test

G - Gross Leak Test

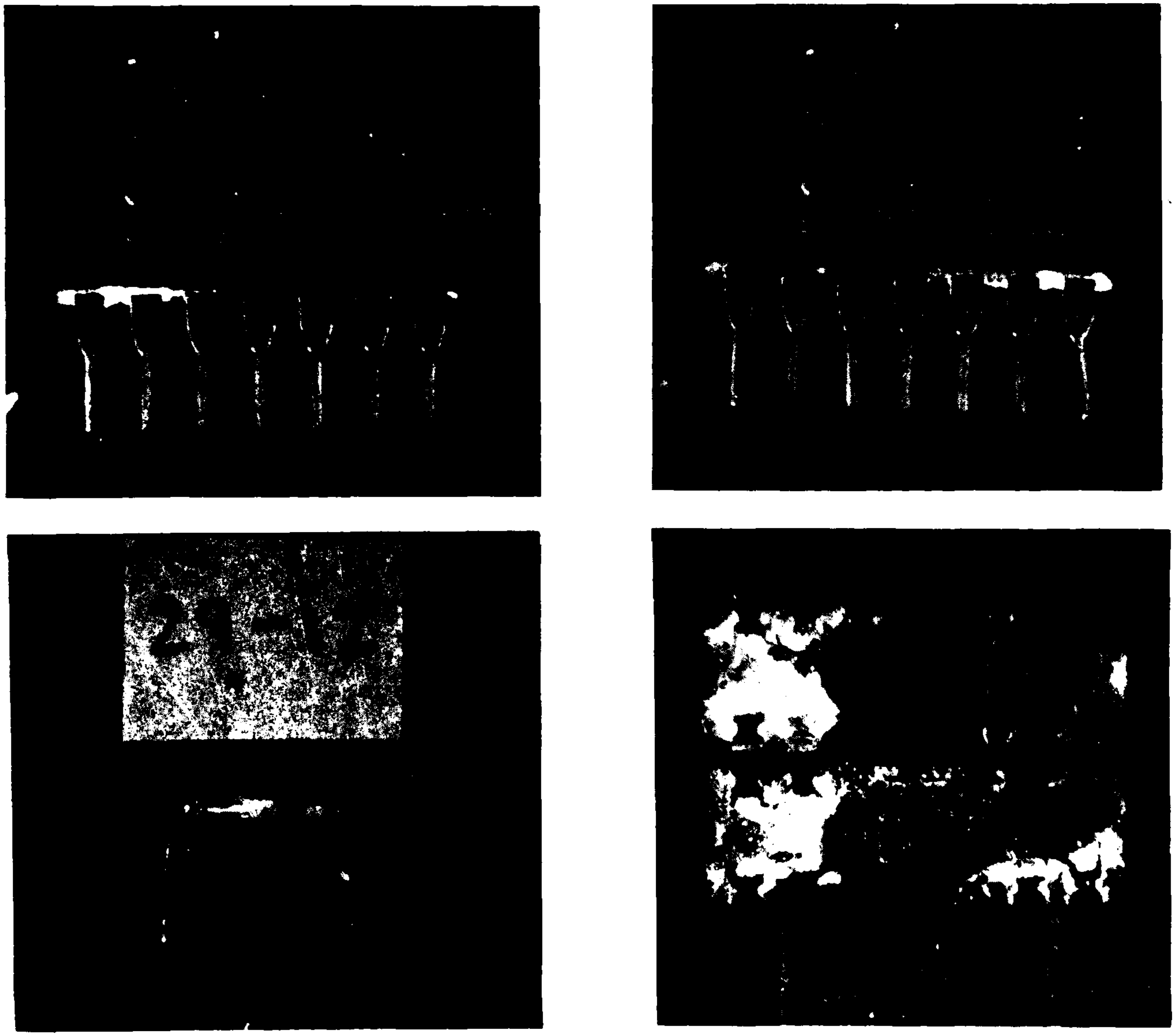


Figure 12. Demonstration Run Test Results - Lead Frame Cerdip

4 DISCUSSIONS AND CONCLUSIONS

Numerous liquid dye penetrants are available in the industry. Four candidate materials were tested according to the Meniscus Test Method, which is widely used in liquid dye penetrant industry on evaluating penetrant sensitivity. Two penetrants were selected for study. Both are temperature stable up to 150°C for at least 125 hours continuously. The spot diameter sensitivity indicator shows changes from 2.1 mm to 4.6 mm (visible) and 1.2 mm to 2.0 mm (fluorescent) respectively at the end of aging test at 150°C. This indicates that fluorescent dye penetrant is far more sensitive than visible dye penetrant. In addition, the water removal characteristic of selected penetrants simplify and expedite the dye penetrant test procedure.

Procurement of test specimens, microelectronic packages, was done to cover different types from different suppliers or sources. A total of 975 pieces of open packages and 380 pieces of sealed packages were obtained, and they include metal-can TO-8, unibody plug-in, and dual-in-line side braze and lead frame cerdip packages. According to MIL-STD-883B, Method 1014.4, Seal, Tracer Gas Helium Fine Leak Measurement, the package hermeticities are distributed as shown in Figure 13. It indicates that the procured open package hermeticity quality is better than 1×10^{-8} atm.cc/sec, and hermeticity quality of sealed packages are in the range of 10^{-9} to 10^{-7} atm.cc/sec ranges. In other words that the sealed packages are in the marginal quality with some packages are below than the marginal.

Two fixtures were designed and fabricated for testing sealed and open packages at elevated temperature and pressure by using liquid dye penetrants. The results of this work reveals that testing sealed packages is readily accomplished at real time savings with great effectiveness. However, the fixture for testing open packages is somewhat tedious, slow and only applicable on testing TO-8 packages one at a time. It is recommended that more elaborate and sophisticated equipment is needed for testing different types of open packages.

4.1 VISIBLE DYE PENETRANT

Optimization of the test variables, specifically temperature, pressure and dwell time, was conducted using a sample size of 242 sealed packages. The test results indicate that elevated temperature visible dye penetrant test can be an effective means of detecting package hermeticity with escape rate of 7.5% under suggested optimum test conditions of 150°C under 90 psig pressure for 3 min. with 17.5°c/sec thermal

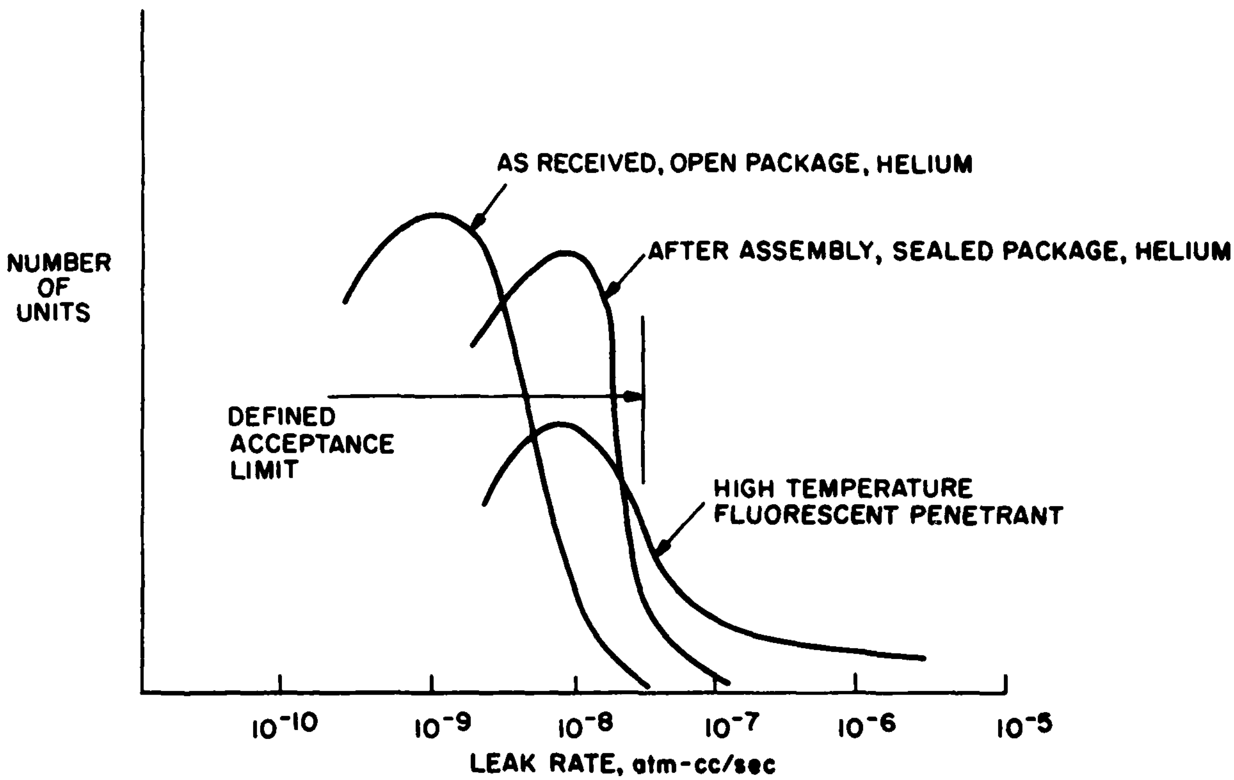


Figure 13. Quality Distribution of Package Hermeticity

gradient. It is interesting to note that test results, according to visual inspection and delidding, indicate that only cover leak type of defect was detected. The glass-to-metal seal type leakage was not identified on these samples by using visible dye penetrant. In addition, lower penetrant sensitivity is exhibited compared to fluorescent dye penetrant. Visible penetrants also require proper developer for dye indications.

4.2 FLUORESCENT DYE PENETRANT

Similar study was performed by using fluorescent dye penetrant on sealed microelectronic packages. In addition, the degradation of the process stresses on open packages and thermal stresses on sealed packages were also investigated. The advantages of using fluorescent dye penetrant are its high sensitivity, water solubility and inspectability without developer.

A total of 204 various package types were tested, of which the majority were TO-8 packages. The test results indicate that elevated temperature fluorescent dye penetrant test is a powerful and very effective test method for testing microelectronic package hermeticity, achieving as high as 28.3% escape rate under suggested optimum test condition. The optimum test conditions of 150°C, 90 psig for 3 min. is also verified. In addition, the indications and interpretation of test results on delidding of the package is vivid and clear under ultraviolet light. More important, the glass-to-metal seal type defects are found and the leak paths are also clearly identified by using micro-section technique. These results also indicate that process stresses degrade the package hermeticity quality from 10^{-9} down to as low as 10^{-7} atm-cc/sec region. Though the sample size is rather small, it is interesting to note that thermal stresses appear to degrade the package severely according to fluorescent dye penetrant test results on thermal shock tested packages.

A total of 179 pieces of TO-8 open packages were tested. The packages include open packages as received from suppliers, delidded packages from procured sealed packages and delidded packages from in-house assembly packages. As shown in Table IV, open TO-8 package quality, as received, is better than 10^{-8} atm-cc/sec, in which the fluorescent dye penetrant test did not pick up any leaker among the fifty pieces tested. But, if the open package quality (assembly and delidded) is in 10^{-8} atm-cc/sec, then 33.3% escape rate was obtained. In the case of open package quality is below 10^{-8} atm-cc/sec, fluorescent dye penetrant test detected all of the packages which were tested bad by helium leak measurement.

Eight pieces of 14-leads lead frame Cerdip was provided by RADC for demonstration and verification purposes. Routine suggested optimum test condition was performed. The results indicate that five leakers were found according to the proposed test method versus three leakers detected according to conventional helium leak test. It thus verifies and substantiates that elevated temperature fluorescent dye penetrant test approach is an effective means of determining microelectronic sealed package hermeticity in general.

4.3 CONCLUSIONS

1. Elevated temperature fluorescent dye penetrant inspection is more effective than conventional tracer gas helium fine leak test at leak rates of 10^{-8} atm-cc/sec or greater.

2. Optimum fluorescent dye penetrant test conditions are: 150°C, 90 psig, 3 min. with 17.5°C/sec thermal gradient.

3. Penetrant inspection is applicable to open packages and to sealed packages on an LTPD sampling basis. The test is destructive in nature.

4. Interpretation of penetrant indications is complex and may result in the sacrifice of hermetic packages.

5. Microelecronic packages are hermetically degraded by assembly or re-work stresses.

5 REFERENCES

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