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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	N78-19395
4. TITLE (and Subtitle)	RELIABILITY EVALUATION OF HERMETIC DUAL IN-LINE AND FLAT MICROCIRCUIT PACKAGES
5. TYPE OF REPORT & PERIOD COVERED	FINAL TECHNICAL REPORT OCTOBER 1976 - DECEMBER 1977
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)	G. M. JOHNSON L. K. CONAWAY
8. CONTRACT OR GRANT NUMBER(s)	NAS8-31446
9. PERFORMING ORGANIZATION NAME AND ADDRESS	MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-ST. LOUIS
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
11. CONTROLLING OFFICE NAME AND ADDRESS	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GOERGE C. MARSHALL SPACE FLIGHT CENTER MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812
12. REPORT DATE	DECEMBER 1977
13. NUMBER OF PAGES	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	
15. SECURITY CLASS. (of this report)	UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	N/A

16. DISTRIBUTION STATEMENT (of this Report)

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

NASA MSFC CONTRACTING OFFICER'S REPRESENTATIVE
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AREA CODE 205-453-2864

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An extensive study was conducted to evaluate the relative strengths and weaknesses of commonly used hermetic flat and dual in-line packages. The study included: a) a literature and data search for package related failure modes, manufacturing problems and test related problems, b) physical analyses of 35 different package types, and c) a matrix of thermal shock, thermal cycling, high temperature bake and lead integrity tests of ten different package types. Results of the study were used to rank each of the 35 packages evaluated using

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a numerical weighting scheme for package attributes. The list of attributes included desirable features in five major areas: lead and lead seal, body construction, body materials, lid and lid seal, and marking.

The metal flat pack and multilayer integral ceramic flat pack and DIP received the highest rankings (most reliable package), and the soft glass Cerdip and Cerpak types received the lowest rankings. Loss of package hermeticity due to lead and lid seal problems was found to be the predominant failure mode from the literature/data search. However, environmental test results showed that lead and lid seal failures due to thermal stressing was only a problem with the hard glass (Ceramic) body DIP utilizing a metal lid and/or bottom. Insuffient failure data was generated for the other package types tested to correlate test results with the package ranking. However, the ranking procedure included numerous factors in addition to seal integrity, and lack of test data does not invalidate the ranking.

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PREFACE

The work described in this report was performed by the Parts Evaluation Laboratory section of the McDonnell Douglas Astronautics Company-St. Louis (MDAC-St. Louis) Engineering Reliability Department during the period between October 1976 and December 1977. The work was performed for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center under Contract Number NAS8-31446. Mr. F. Villella acted as the NASA Contracting Officer's representative. Thanks are due to Leon Hamiter of NASA for his technical suggestions, Gary Keller of MDAC-St. Louis for his physical analysis of package samples, and Fred Schmedeman of MDAC-St. Louis for performing the many package hermeticity tests required during the program.

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1.0 INTRODUCTION

Mircocircuit packages play a critical role in determining the overall reliability and cost of completed devices. However, little information is available for assessing the relative merits of the various microcircuit packages in use today. It is the intent of this study to evaluate the relative strengths and weaknesses of commonly used hermetic flat pack and dual in-line packages, and to formulate recommendations for package improvements. The resulting information can then be used as a guide for designing an improved package. It can also be used to making cost-reliability trade-offs for various packaging options.

2.0 PROGRAM DESCRIPTION

The Microcircuit Package Evaluation Program was accomplished in five phases as shown in Figure 1. Phase A involved the selection of specific flat pack and dual in-line packages (DIP) for physical analysis during Phase C. The selected packages were representative of a cross-section of hermetic packages used or planned for use in military and space applications. Phase B was conducted concurrently with Phases A and C. The objective of Phase B was to determine, through a review of current literature and a survey of selected microcircuit manufacturers, the predominant package failure modes, manufacturing problems and test related problems. Phase C involved a detailed physical analysis of the DIP and flat pack types selected during Phase A. The analysis included a determination of the package materials, dimensions, and construction techniques used during the package and microcircuit assembly processes. During Phase D, the data derived from Phase B and C activities was analyzed to determine the relative strengths and weaknesses of the specific package types included in the program. The packages were then ranked using a numerical weighting scheme for package attributes, and recommendations for package improvements were formulated from the results of the data analysis. During Phase E, selected packages included in data evaluation were subjected to a matrix of thermal shock, thermal cycling, high temperature bake and lead integrity tests.

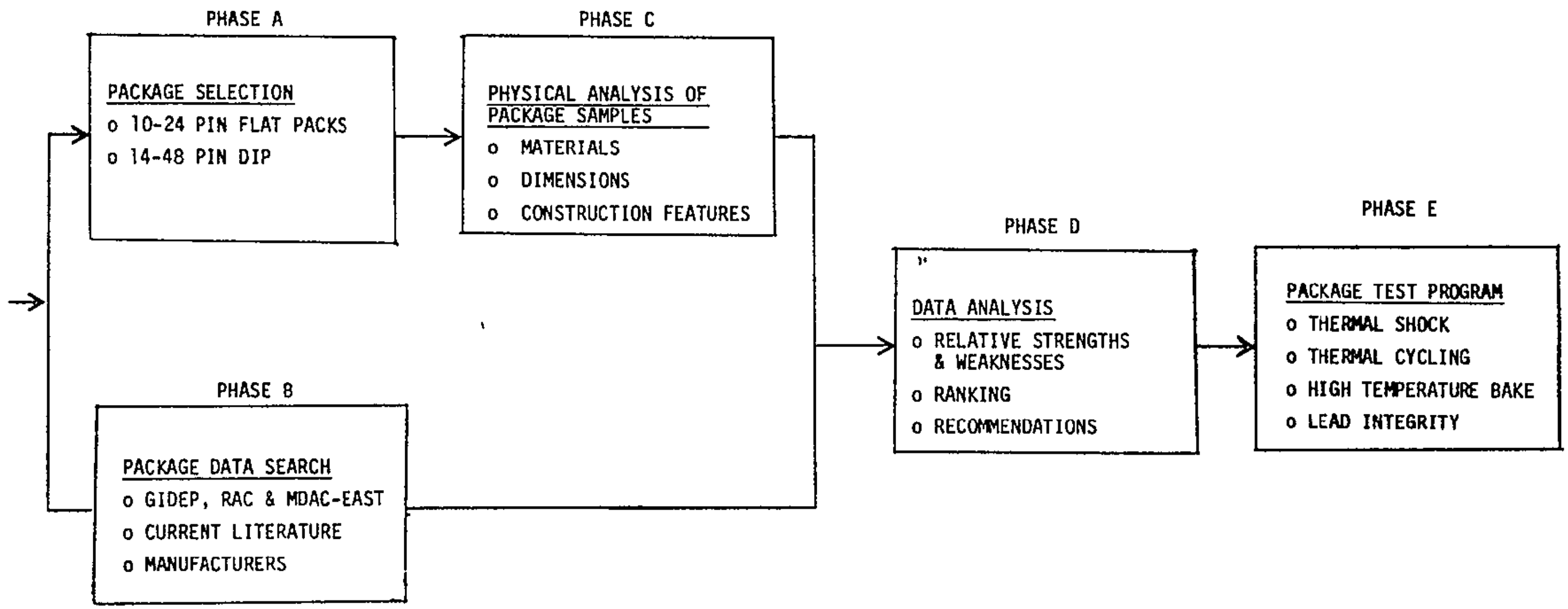

FIGURE 1. PACKAGE EVALUATION PROGRAM

3.0 PACKAGE SELECTION

The specific package configurations selected for physical analysis are shown in Tables 1 and 2. These thirty-five selections (12 Flat Packs and 23 DIPs) were based on considerations of known construction features, MIL-M-38510 qualification status and availability of samples. The flat pack configurations included: a) the soft glass body, ceramic top and bottom construction (Cerpak), b) hard glass body with metal top and/or bottom construction, c) the multilayer integral or cofired ceramic with brazed lead construction, and d) metal package. Package sizes ranged from 1/8 inch x 1/4 inch to 3/8 inch x 9/16 inch, and the number of leads per package ranged from 10 to 24 pins. Four of the twelve flat pack configurations are utilized with MIL-M-38510 qualified microcircuits, and two of the packages have been subjected to extensive life and temperature cycling tests at MDAC-St. Louis. In addition, the Diacon package is a special package designed to provide and maintain a low internal moisture content.

The DIP configurations included: a) the soft glass body with ceramic top and bottom construction (Cerdip), b) hard glass body with metal top and/or bottom construction, and c) cofired ceramic with brazed lead construction. Package sizes ranged from 1/4 inch x 3/4 inch to 1/2 inch x 2 13/24 inch, and the number of leads per package ranged from 14 to 48 pins. Four of the nine 14 and 16 pin DIPs selected are utilized with microcircuits qualified to MIL-M-38510. However, none of the thirteen packages selected with more than 16 pins (18 to 48 pins) are qualified to MIL-M-38510. In addition, the Intel 24 pin package is used exclusively for ultraviolet (UV) erasible programmable read only memories (PROM).

TABLE 1. FLAT PACK CONFIGURATIONS

PACKAGE TYPE	MANUFACTURER	NO. LEADS	REMARKS
CERPAK, BLACK	DIACON	14	SPECIAL DESIGN FOR LOW MOISTURE CONTENT
	MOTOROLA	14 & 16	M38510B QUALIFIED
CERPAK, WHITE	MOTOROLA	14	
	FAIRCHILD	16	M38510B QUALIFIED
	FAIRCHILD	24	BeO PACKAGE
METAL	TEXAS INST.	14	EXTENSIVE MDAC-ST. LOUIS TEST EXPERIENCE
WHITE CERAMIC, METAL TOP AND/OR BOTTOM	NATIONAL	10	M38510B QUALIFIED
	NATIONAL	14	M38510B QUALIFIED AND EXTENSIVE MDAC-ST. LOUIS TEST EXPERIENCE
	SILICONIX	14	
WHITE COFIRED CERAMIC, BOTTOM BRAZE LEADS	RCA	14	ROUND CAP
	NATIONAL	16	

TABLE 2. DUAL IN-LINE CONFIGURATIONS

PACKAGE TYPE	MANUFACTURER	NO. LEADS	REMARKS
CERDIP, BLACK	MOTOROLA	14 & 16	M38510B QUALIFIED
	FAIRCHILD	24	
WHITE CERAMIC, METAL TOP AND/OR BOTTOM	ELECTRONIC ARRAYS	14	
	NATIONAL	14	M38510B QUALIFIED
	RAYTHEON	14	
	SOLID STATE SCIENTIFIC	16	
	ITT	24	
	MOTOROLA	24	
WHITE COFIRED CERAMIC, BOTTOM BRAZED LEADS	RCA	16	ROUND CAP-M38510B QUALIFIED
	SOLITRON	28	
	KYOCERA	28 & 40	
WHITE COFIRED CERAMIC, SIDE BRAZED LEADS	SIGNETICS	14	M38510B QUALIFIED
	NATIONAL	16	
	INTEL	24	UV GLASS WINDOW
	KYOCERA	24 & 40	
WHITE COFIRED CERAMIC, TOP BRAZED LEADS	KYOCERA	48	
BLACK COFIRED CERAMIC, SIDE BRAZED LEADS	INTEL	18 & 32	
	KYOCERA	24 (Two types)	

4.0 PACKAGE DATA SEARCH

The search for microcircuit package data consisted of: a) a review of available test data to identify the predominant package failure modes, b) discussions with microcircuit and package manufacturers to identify package manufacturing problems, and c) a review of current literature for discussions of package failure mechanisms.

4.1 Test Data Review - Sources of failure mode data included the USAF Reliability Analysis Center (RAC), Alerts distributed by the Government-Industry Data Exchange Program (GIDEP), and MDAC-St. Louis life test results.

4.1.1 RAC Data - The RAC data provided the distribution of packaging system failure modes shown in Table 3, and includes several general configurations of DIPs and flat packs. Unfortunately, details of the exact package configurations are not specified, and it is unknown if the ceramic/metal packages are cofired ceramic or utilize a glass lead seal. This lack of specific nomenclature for package construction types was a problem throughout the study in attempting to relate failure modes and problems to specific packages. Additional nomenclature is required to clearly identify the package type being discussed or specified. However, the RAC data does show that the microcircuit package itself is responsible for most of the packaging system failures (package, wire and wirebond). Lack of hermeticity appears to be the major overall cause of package failures and is an important factor in the failure distribution for each individual package type. The ceramic DIP appears to be especially susceptible to hermeticity problems since 80% of the 129 reported failures were attributed to nonhermetic seals. The ceramic/metal DIP is apparently less susceptible to seal damage than the ceramic DIP with only 38% of the 133 reported failures attributed to nonhermetic seals. However, the ceramic/metal package is apparently more prone to die bond defects and external lead corrosion than the ceramic DIP. Without a detailed

TABLE 3. PACKAGING SYSTEM FAILURE MODES *

FAILURE CLASSIFICATION	DUAL-IN-LINE CERAMIC NO.	DUAL-IN-LINE CERAMIC %	DUAL-IN-LINE CERAMIC/METAL NO.	DUAL-IN-LINE CERAMIC/METAL %	FLAT PACK CERAMIC NO.	FLAT PACK CERAMIC %	FLAT PACK CERAMIC/METAL NO.	FLAT PACK CERAMIC/METAL %	FLAT PACK METAL NO.	FLAT PACK METAL %	FLAT PACK GLASS NO.	FLAT PACK GLASS %	TOTAL NO.	TOTAL %
WIREBOND RELATED	9	7	41	31	19	33	4	45	15	32	3	25	91	23.5
BROKEN BOND	4	3	35	26	7	12	4	45	2	4	1	8	53	13 7
INTERMETALLIC FORMATION	1	1											1	0.3
LIFTED BOND	2	1	5	4	8	14			1	2	2	17	18	4.6
MISPLACED BOND	1	1	1	1					4	9			6	1.5
MULTIPLE BONDS					1	2							1	0.3
OVERBONDED	1	1			3	5			8	17			12	3.1
WIRE RELATED	12	9	1	1	9	16	2	22	3	6	1	8	28	7.2
BROKEN WIRE	1	1	1	1	2	3	1	11	3	6	1	8	9	2.3
CORRODED WIRE							1	11					1	0.3
WIRE DRESS					7	12							7	1.8
SHORTED WIRES	2	1											2	0.5
WIRE TO DIE SHORT	9	7											9	2.3
PACKAGE RELATED	108	84	91	68	29	51	3	33	29	62	8	67	268	69.3
DIE BOND DEFECT			25	19	4	7			20	43			49	12.7
EXTERNAL LEAD, BROKEN					2	3	1	11					3	0.8
EXTERNAL LEAD, CORROSION			14	10	1	2							15	3.9
EXTERNAL LEAD FATIGUE	1	1					1	11					2	0.5
SEAL MATERIAL, EXCESSIVE	1	1	1	1	9	17							11	2.8
SEAL, NONHERMETIC	104	80	51	38	11	20	1	11	9	19	8	67	184	47.6
SOLDER REJECT	2	2			2	3							4	1.0
TOTAL	129	100%	133	100%	57	100%	9	100%	47	100%	12	100%	387	100%

* FROM RAC, CATALOG NO. MDR-4, 1976

knowledge of the exact package configurations included in the RAC data, reasons for the observed differences in failure mode percentages for the two DIP configurations cannot be postulated. In addition, the RAC data for flat packs is not sufficient to permit comparisons between the ceramic, ceramic/metal, metal and glass flat packs.

4.1.2 Alert System Data - A review of Alerts distributed by GIDEP provided some insight into the types of package problems experienced by microcircuit users. The results of this review are summarized in Table 4, and reflect problems reported during the 1968 to 1977 time period. The thirty-three instances of problems shown in Table 4 are either directly related, or could be related to hermetic DIPs and flat packs. With one exception, problems associated with plastic and metal can packages are not knowingly included in the summary. The one metal can problem included in the summary relates to a bonding surface texture problem that could be encountered with almost any type package, and was the only reported instance of this type problem. Categorization of the thirty-three Alerts by failure mode results in the following distribution of reported problems:

a) Lack of hermeticity and/or internal corrosion - 10 instances
b) Die bond related - 8 instances
c) Internal contamination or particles - 6 instances
d) Marking - 4 instances
e) Wire and wire bond related - 3 instances
f) External corrosion or contamination - 2 instances

Lack of hermeticity and/or internal corrosion due to contaminated internal package atmosphere was the most frequently reported problem. This tends to support the RAC data and indicates that hermetic seal problems are the major cause of package related microcircuit failures. Poor die bonds was the second most frequently reported cause of failures and is also in general agreement with the

TABLE 4. SUMMARY OF FLATPACK AND DIP RELATED ALERTS

PROBLEM CATEGORY	ALERT NO	PACKAGE TYPE MANUFACTURER	PROBLEM DESCRIPTION
HERMETICITY &/OR INTERNAL CORROSION	MSC-69-06	1/4 X 1/4 GLASS FLAT PACK - FAIRCHILD	LEAD WIRES CORRODED OPEN DUE TO MOISTURE ENTERING PACKAGE OR CONTAMINANTS IN SPLATTERED LID SEALING GLASS
	MSFC-72-15	FLAT PACK - TEXAS INSTRUMENTS	DENDRITE FORMATION DUE TO MOISTURE ENTERING PACKAGE
	AB-A-73-01	10 LEAD FLAT PACK - NATIONAL	INTERNAL CORROSION DUE TO LOSS OF HERMETICITY, POSSIBLY CAUSED BY LEAD FORMING OPERATION
	F3-72-08 & MSFC-A-72-12	CERAMIC DIP	CRACKED PACKAGES DUE TO CONFORMAL COATING/THERMAL CYCLING & BOARD FLEXING
	FL-A-73-02	DIP - AMD/KILBORN	INADEQUATE GLASS LEAD SEAL
	DD-A-75-01	CERAMIC DIP - NATIONAL	30% FINE LEAK TEST FAILURES, CAUSE NOT REPORTED
	K5-A-76-03	14 PIN CERAMIC DIP NATIONAL	LID SEPARATION & PACKAGE FRACTURE AT FRIT SEAL
	GD-A-76-02	UNKNOWN - ANALOG DEVICES	CORROSION OF THIN FILM RESISTORS DUE TO SEALING IN DRY AIR INSTEAD OF DRY NITROGEN
	Y1-A-74-02	CERAMIC DIP - SIGNETICS	CERAMIC LIDS & MOST LEADS CAME OFF DUE TO IMPROPER PACKAGING IN SHIPPING CONTAINER (PLASTIC TUBE)
EXTERNAL CORROSION OR CONTAMINATION	MSFC-68-08A	CERAMIC FLAT PACK FAIRCHILD, ITT	PIN TO PIN SHORTS DUE TO LEAD (Pb) PRECIPITATE ON SURFACE OF SOFT LEAD (Pb) GLASS SEALS
	GSFC-A-74-07 GH-A-75-07A	14 & 16 LEAD COFIRED CERAMIC, BOTTOM BRAZED LEAD FLAT PACK - RCA	LEAD CRACKS & BREAKAGE DUE TO STRESS-CORROSION-CRACKING. SOLDER-DIPPED LEADS APPEAR TO BE LESS SUSCEPTIBLE THAN GOLD OR NICKEL PLATED LEADS
INTERNAL CONTAMINATION	GSFC-69-06	14 LEAD FLAT PACK - FAIRCHILD	EXCESSIVE GLASS FRIT DIE BOND MATERIAL ON TOP OF DIE CAUSED EXCESSIVE LEAKAGE CURRENT
	WS-70-01A	UNKNOWN (KOVAR LID, SOLDER SEAL) - NATIONAL	PARTICLE CONTAMINATION FROM LID SEAL & POSSIBLY DIE BONDING MATERIAL
	SC-71-01	CERAMIC DIP - TEXAS INSTRUMENTS	LOOSE GOLD PARTICLE CONTAMINATION FROM DIE ATTACH PREFORM
	MSFC-71-02	UNKNOWN - SYLVANIA	LOOSE GOLD-TIN PARTICLE CONTAMINATION FROM GOLD EUTECTIC USED IN LID SEAL
	54-A-74-01	DIP (BRAZED KOVAR LID) - HARRIS SEMI.	PARTICLE CONTAMINATION DUE TO SPLATTERING OF LID SEALING METAL DURING THE BRAZING OPERATION
	GSFC-69-09	14 LEAD METAL FLAT PACK - UNISEM	PARTICLE CONTAMINATION DUE TO GOLD-TIN DIE ATTACH

TABLE 4. SUMMARY OF FLATPACK AND DIP RELATED ALERTS (CONT.)

PROBLEM CATEGORY	ALERT NO.	PACKAGE TYPE MANUFACTURER	PROBLEM DESCRIPTION
DIE BONDS	B8-68-01	UNKNOWN - TEXAS INSTRUMENTS	BROKEN LEAD WIRES DUE TO SEPARATION OF DIE FROM PACKAGE
	GSFC-68-09	FLAT PACK - TEXAS INSTRUMENTS	BROKEN LEAD WIRES DUE TO SEPARATION OF DIE FROM PACKAGE
	JS-70-02	DIP - FAIRCHILD	INADEQUATE DIE BONDING
	GSFC-70-06	14 LEAD FLAT PACK - TEXAS INSTRUMENTS	CRACKED DIE DUE TO THERMAL EXPANSION MISMATCH BETWEEN DIE & PYROCERAM BOND MATERIAL. PYROCERAM SHOULD NOT BE USED FOR DIE BONDING
	C6-72-01	FLAT PACK - FAIRCHILD	DEFICIENT DIE BONDS ALLOWED DIE TO SEPARATE FROM HEADER - PROBABLY OPERATOR ERROR
	X2-A-73-01	UNKNOWN (HYBRID) TRANSITRON	BROKEN LEAD WIRES DUE TO INADEQUATE EPOXY DIE BONDS THAT ALLOWED DIE TO SEPARATE FROM HEADER
	G4-A-74-05	1/4" X 1/8" METAL FLAT PACK - TEXAS INSTRUMENTS	DIE SHEAR STRENGTH LESS THAN 10 GRAMS DUE TO DELAMINATION AT THE HEADER GOLD NICKEL PLATING INTERFACE
	DD-A-76-04	14 LEAD DIP FAIRCHILD	LESS THAN 50% SILICON RETENTION NOTED DURING DIE SHEAR TESTS. GOLD SEPARATED FROM HEADER. SUSPECTED HEADER PLATING PROBLEM MANUF DISAGREES & CLAIMS AVERAGE DIE SHEAR STRENGTH GREATER THAN 7 LBS
WIRES & WIRE BONDS	E9-A-74-04	UNKNOWN - NATIONAL	WIRE SHORTING TO VARIOUS PLACES DUE TO POOR LEAD DRESS
	G2-A-73-02	UNKNOWN - RAYTHEON	MARGINAL BOND STRENGTH AT POST DUE TO CORROSION OF KOVAR WHICH STARTED AT SMALL AREAS WHERE GOLD DID NOT ADHERE USE OF NICKEL FLASH PRIOR TO GOLD PLATING RECOMMENDED
	G2-A-75-01	TO-5 - NATIONAL	DEFECTIVE WIRE BONDS AT POST DUE TO INAPPROPRIATE BONDER POWER SETTING AND ROUGH TEXTURE OF GOLD PLATING AT POST
MARKING	E9-68-03	14 LEAD FLAT PACK - ITT SEMI	ORIENTATION DOT MISAPPLIED RESULTING IN BURN OUT OF DEVICE DURING ELECTRICAL TEST
	G4-69-04	GLASS FLAT PACK - TELEDYNE	MARKING NOT SOLVENT RESISTANT DUE TO IMPROPER PACKAGE CLEANING PRIOR TO MARKING
	K9-A-74-C7	FLAT PACK - RAYTHEON	LIDS REVERSED RESULTING IN INCORRECT PIN IDENTIFICATION
	E2-A-75-01	14 LEAD DIP - NATIONAL	INCORRECT IDENTIFICATION OF PIN 1

RAC data. The third most frequently reported cause of failure was internal contamination, primarily from die bond or lid seal materials. Problems associated with marking, wires and wire bonds, and external corrosion were not frequently reported. However, the severity of the reported problems in each category emphasizes that careful attention to all aspects of package design, manufacture, shipping and ultimate use is essential for high microcircuit reliability.

4.1.3 MDAC-St. Louis Experience - Package related problems experienced at MDAC-St. Louis in the course of performing microcircuit reliability studies include: a) loss of hermeticity due to thermal cycling stress, shipping damage and misaligned lids, b) wire-to-die shorts due to marginal internal lead dress, and c) external lead corrosion. The major problem associated with loss of hermeticity was encountered with one manufacturer's glass lead seal, metal top and bottom DIP package during high temperature accelerated life testing. After approximately ten thermal shock cycles from 25°C to 200°C, these packages exhibited cracks in the glass seal area as shown in Figure 2. The loss of package hermeticity due to these cracks resulted in numerous failures due to moisture related leakage currents, open circuits due to moisture induced corrosion at the heel of the wire bonds, and charge migration failures. Although this manufacturer's DIP package was used with MIL-M-38510, Class B qualified microcircuits, the lead seal glass was apparently marginal.

The cofired ceramic DIP is less susceptible to thermal shock induced seal cracks as evidenced by the results of MDAC-St. Louis thermal shock tests with one manufacturer's cofired ceramic package. No seal leak test failures were observed after 200 liquid-to-liquid cycles from -55°C to 175°C. Flat packs with glass lead seals may also be less susceptible to thermal shock than glass body DIPs, as evidenced by the results of MDAC-St. Louis temperature cycling tests of a glass flat pack with metal top and bottom and a 1/2 inch x 1/8 inch metal flat pack. No seal leak failures were observed after 4,000 air-to-air cycles from -55°C to 150°C.

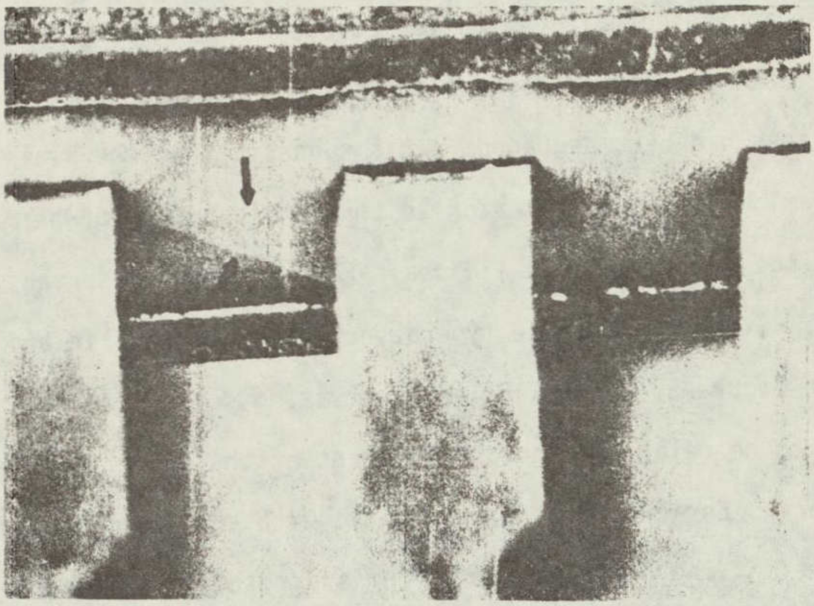

FIGURE 2. CRACKS IN GLASS SEAL DURING HIGH TEMPERATURE LIFE TESTING (ARROW)

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Lack of package hermeticity has also been observed during incoming inspection seal leak tests. These leak test failures may have been escapes from the manufacturer's testing or the packages may have been damaged during shipment. The use of plastic rails for shipment of DIPs can result in gross damage to Cerdips as shown in Figure 3. Cofired ceramic packages with brazed leads can also be damaged in shipping containers (rails) as shown in Figure 4. However, fine and gross leak tests of damaged devices indicated that the hermeticity of only the Cerdip packages had been degraded. This suggests that the seal integrity of the cofired ceramic package is superior to the Cerdip. Lack of hermeticity due to misaligned lids and inadequate lid seals has also been observed with DIPs utilizing a metal lid. Examples of these type defects (misaligned lid and solder dewetting) are shown in Figure 5. The example illustrating solder dewetting at the lid seal is believed to be related to gold enrichment of the gold-tin eutectic used as a solder preform. Enrichment of the eutectic with gold from the lid plating increases the melting point of the solder and results in inadequate wetting of the seal surface. Discussions of the gold enrichment problem are contained in References [19] and [20].

Wire-to-die shorts are the second most frequent package system type failure observed during MDAC-St. Louis reliability evaluations. A typical wire-to-die short is shown in Figure 6. This failure and thirty-two others were attributed to a combination of the following design factors and workmanship errors: a) bonding pads were located too close to the edge of the die, b) the use of ultrasonically bonded wires in a low profile cavity which resulted in wires departing the bonding pad at very shallow angles, c) bonds were misplaced toward the edge of the die such that the heel of the bond was almost situated in the scribe area, and d) smeared pad metal or entrapped debris beneath the wire that extended into the scribe area.

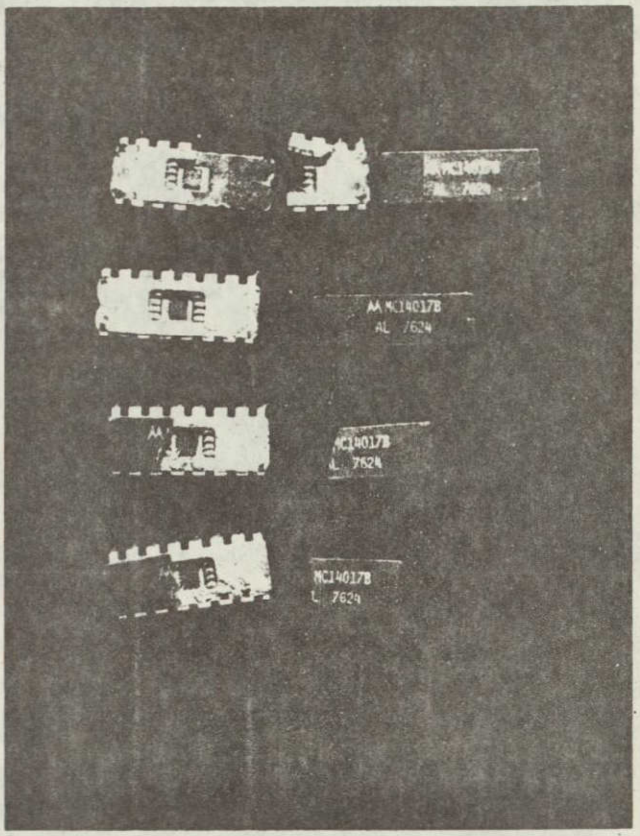

FIGURE 3. CERDIP PACKAGES AS RECEIVED IN PLASTIC RAILS.

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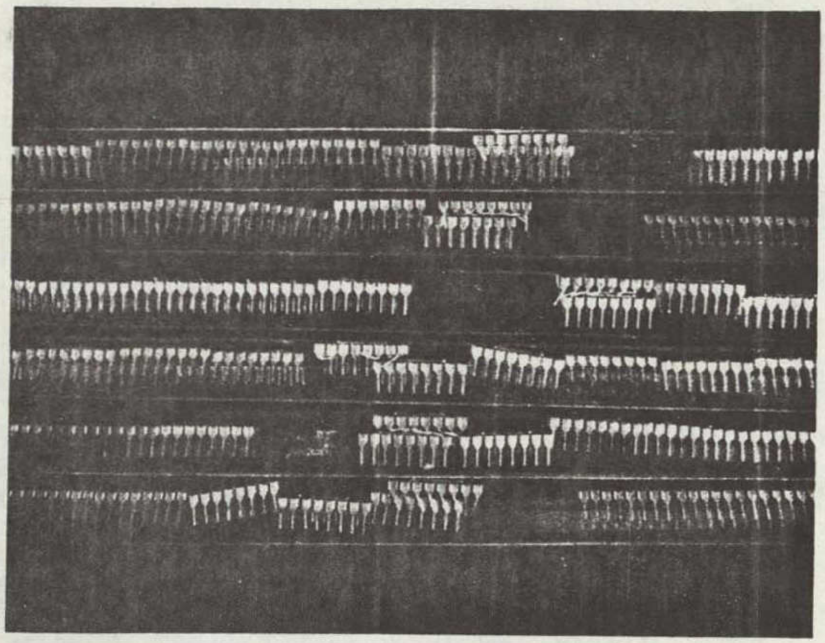
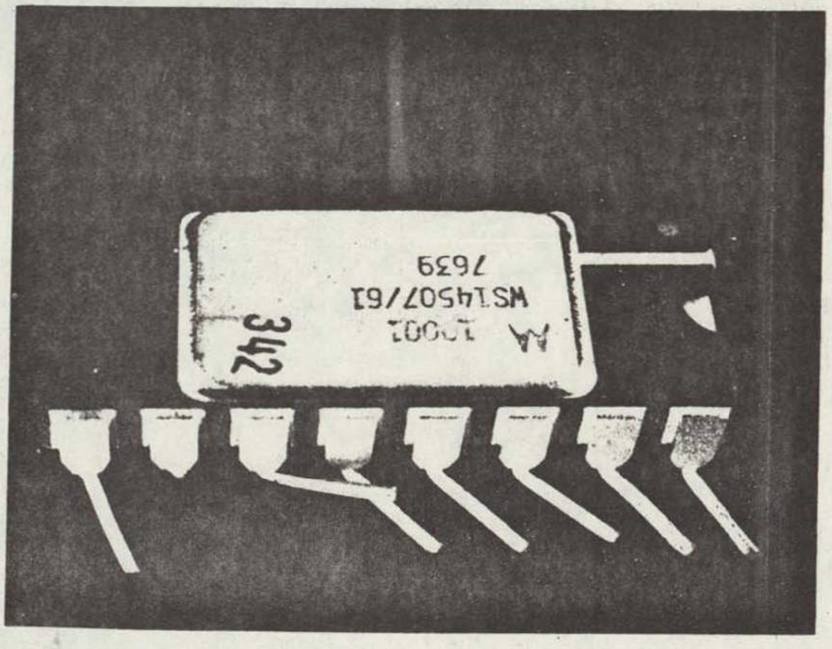
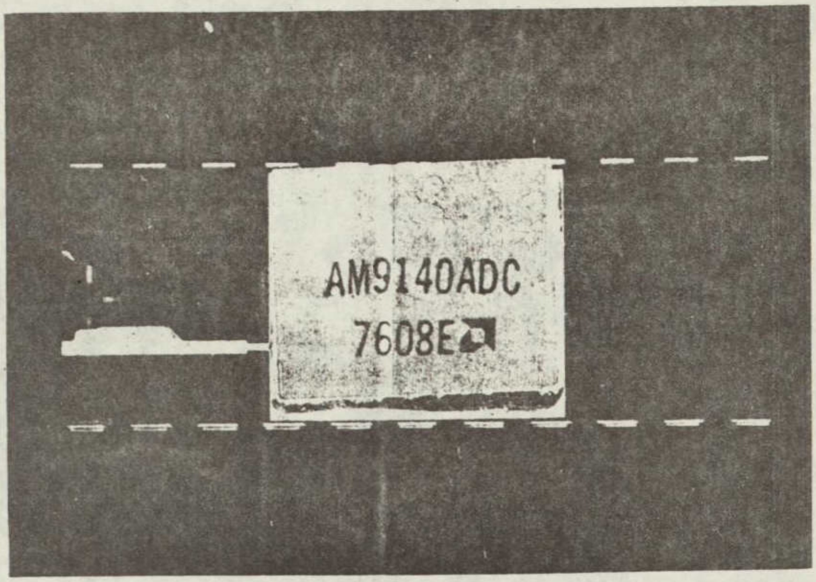


LOW PROFILE DEVICES DAMAGED IN HIGH PROFILE SHIPPING RAILS

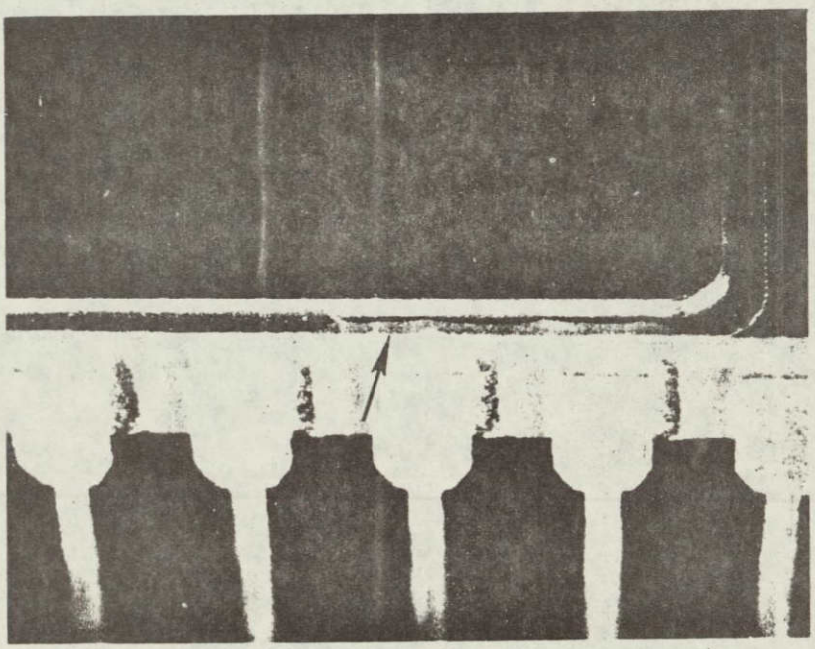


TYPICAL DAMAGED PACKAGE - NO LOSS OF HERMETICITY

FIGURE 4. DAMAGED COFIRED CERAMIC PACKAGES



MISALIGNED SOLDER SEAL LID



DEWETTING ON SOLDER SEAL LID (ARROW)

FIGURE 5. EXAMPLES OF LID SEAL PROBLEMS

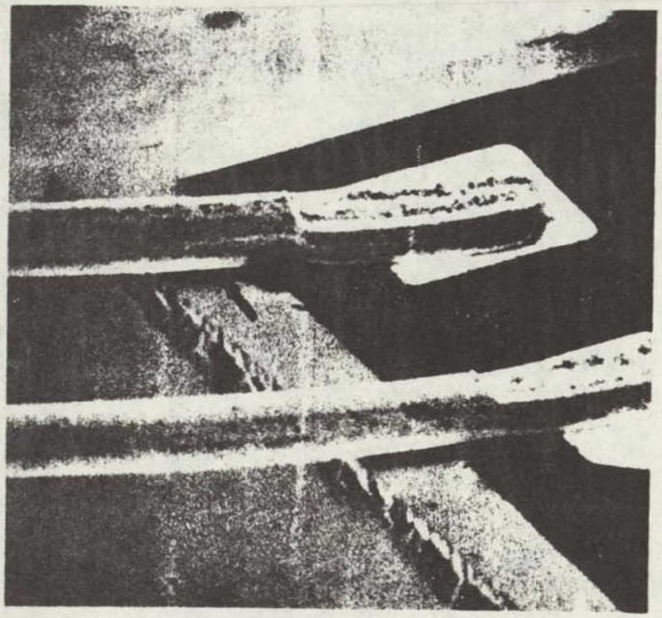


FIGURE 6. EXAMPLE OF TYPICAL WIRE TO DIE SHORT (ARROW)

TABLE 5. SUMMARY OF MANUFACTURER SURVEY

INFORMATION REQUESTED	MICROCIRCUIT MANUFACTURER'S RESPONSE						
	A	B	C	D	E	F	G & H
FLAT PACK PRODUCTION AS A PERCENT OF TOTAL HERMETIC FLAT PACK & DIP PRODUCTION	10-15	30-40	5-10	10-15	10-15	35-40	*
FLAT PACK (FP) VS DIP PREFERENCE - ASSUME SIMILAR CONSTRUCTION & APPLICATION	FP	FP	FP	FP	EQUAL	DIP	*
FLAT PACK TYPES USED & PREFERED TYPE OF CONSTRUCTION							*
- CERPACK	X	X	(X)			(X)	
- HARD GLASS, METAL TOP & BOTTOM	X	(X)	X	(X)			
- MULTILAYER COFIRED CERAMIC, BOTTOM BRAZE	(X)				(X)		
- BeO, SOFT GLASS SEAL			X				
DIP TYPES USED & PREFERED TYPE OF CONSTRUCTION							*
- CERDIP	X	X	(X)	X	X	(X)	
- HARD GLASS, METAL TOP & BOTTOM	X	X		X		X	
- MULTILAYER COFIRED CERAMIC, BRAZED LEAD	(X)	(X)		(X)	(X)		
MAJOR CONSIDERATION FOR PACKAGE PREFERENCE	REL.	REL.	COST	REL. + COST	REL.	COST	*
MAJOR PACKAGE MANUFACTURING PROBLEM	△	△	NONE	△	NONE	△	*

* INFORMATION NOT SUPPLIED

X MICROCIRCUITS SUPPLIED IN PACKAGE INDICATED

◯ PREFERED CONSTRUCTION

△ CRACKING OF LEAD SEAL IN HARD GLASS DIP was better due to its smaller size and mass, and the added care required in handling. Most flat packs are handled, tested and shipped in carriers that provide protection from handling abuse. The manufacturers also generally agreed that the multilayer cofired ceramic DIP is a more reliable package than either the soft glass Cerdip or hard glass body with metal top and/or bottom DIP varieties, but that the higher cost of the cofired ceramic DIP limited it's usage. Only Manufacturers C and F indicated a preference for the soft glass Cerdip. However, Manufacturer C also stated that strict process controls are required to achieve high yields with the Cerdip construction techniques. Without these controls, the more expensive cofired ceramic would be a better package selection.

With the exception of problems encountered with cracked lead seals in the hard glass, metal top and bottom DIPs, none of the manufacturers indicated any major package related problems. However, they did indicate that minor problems had been experienced from time-to-time with:

a) Cleanliness of seal surfaces and control of sealing temperature profiles,

b) Excess sealing glass over lead frame bonds in Cerpack/Cerdips,

c) Misaligned lids, leads, and bases,

d) Cracked lead seals and exposure of lead base metal due to lead forming/ flexing,

e) Blow holes in sealing glass,

f) Improper lead trim,

g) Inadequate window frame plating,

h) Bent/damaged leads due to handling, and

i) Damage to DIPs during shipment in plastic rail type shipping containers.

None of the manufacturers provided data to support their preferences for package construction techniques.

4.3 Literature Search - The literature search was conducted using the McDonnell Douglas DIALOG data retrieval system. DIALOG is a dial-up, direct assess retrieval system for literature searching from a computer terminal. The data base utilized for this search was the Inspec Science Abstract-Electrical and Computer. Logical combinations of the following descriptors were used in the search: Integrated Circuits, Microcircuits, Packaging, Packages, Dual In-Line, Flat Pack, Reliability, Screening, Failure, Hermeticity, Thermal Stress, and Thermal Cycling. This search produced abstracts of 83 articles pertaining to microcircuit packaging. A review of these abstracts and their references resulted in a review of over 200 articles. Of the 200 articles reviewed, 83 were considered pertinent to this study of micro circuit packages. These 83 articles are listed in the References (paragraph 8.0), and are categorized by subject matter in Table 6. The remainder of the articles generally pertained to plastic and hybrid packages and were not directly related to this study.

TABLE 6. RELATED MICROCIRCUIT PACKAGE LITERATURE

SUBJECT	RELATED REFERENCES
GENERAL CONSTRUCTION TECHNIQUES	3, 4, 5, 10, 11, 12, 14, 16, 17, 21, 25, 26, 28, 29, 30, 36, 45, 46, 47, 52, 53, 53, 55, 56, 65, 73, 82
BODY MATERIALS	3, 4, 5, 6, 7, 8, 10, 11, 16, 17, 21, 25 26, 27, 28, 29, 30, 32, 38, 39, 43, 50, 52, 54, 56, 58, 61, 63, 73, 74, 82
LID AND LID SEAL	3, 5, 9, 11, 12, 14, 19, 20, 21, 23, 24, 25, 26, 27, 30, 36, 42, 58, 61, 74, 82
LEADS AND LEAD SEAL	1, 3, 5, 9, 11, 12, 21, 23, 24, 25, 26, 27, 30, 36, 45, 61, 63, 74
DIE BONDS	3, 19, 21, 26, 27, 30, 37, 52, 53, 56, 59, 61, 68, 81
WIRE BONDS	3, 9, 11, 13, 14, 21, 30, 34, 37, 40, 48, 52, 56, 61, 64, 65, 66, 69, 70, 71, 75, 76, 77, 78, 79, 80, 84, 85
CORROSION	1, 3, 13, 15, 16, 17, 33, 34, 63, 67, 83
MOISTURE	1, 3, 4, 8, 10, 22, 26, 28, 33, 34, 44
THERMAL CHARACTERISTICS	3, 4, 5, 6, 7, 9, 23, 24, 27, 28, 29, 30, 33, 38, 39, 40, 41, 49, 50, 56, 57, 60, 64, 72
COMPARISON OF PACKAGE TYPES	1, 3, 5, 7, 9, 11, 21, 28, 31, 32, 35, 36, 40, 51, 61, 62
COST	3, 5, 11, 30, 39, 43, 52

5.0 PHYSICAL ANALYSIS OF PACKAGE SAMPLES

A physical analysis of the selected DIP and flat pack configurations was performed to evaluate the construction features used in these packages. The analysis included identification of package materials and dimensions, optical and x-ray examinations of the package interior, and examination of a cross-sectioned package. The results of these analyses are documented in Appendix A.

Classification of the packages shown in Appendix A according to the package categories defined in Reference [3] shows that six categories of packages were evaluated. These included four types of glass body packages, one ceramic body type (cofired) and one metal body type (T.I.'s 1/4" x 1/8" flat pack). The four glass body types were: a) soft glass (Cerpac and Cerdip), b) glass body with ceramic base and metal window frame for lid attach purposes, c) glass body with ceramic base and ceramic window frame, and d) glass body with metal base and metal window frame. Specific packages included in each of the six categories are referenced in Table 7 according to their respective Appendix A Figure Number.

A brief description of the general construction techniques used in each package category (condensed from Reference [3]) is provided in the following paragraphs:

Soft Body Glass - This type package, typically referred to as the Cerpac or Cerdip, consists of a ceramic top, ceramic bottom and metal lead frame held together with a soft glass frit. During package fabrication, a soft glass frit is attached to the bottom of the ceramic lid and around the edges of the top of the ceramic base. During microcircuit assembly, the ceramic base is heated to 400°C to 450°C to soften the glass frit, and the lead frame is pressed into position. After wire bonding to the die and lead frame, the ceramic lid and base are brought into contact and heated to approximately 500°C. The glass frit then softens, flows and devitrifies to seal the lead frame between the top and bottom pieces of ceramic.

TABLE 7. PACKAGE CATEGORIES EVALUATED

PACKAGE CATEGORY	STYLE	APPENDIX A FIGURE NO. REFERENCE	
		METAL LID SOLDER SEAL	CERAMIC LID GLASS SEAL
GLASS BODY			
SOFT GLASS (CERPACK/CERDIP)	FP DIP		A1, A2, A3, A5 & A6 A13, A14, & A15
GLASS BODY/CERAMIC BASE/ METAL WINDOW FRAME	FP DIP	A10 A20 & A21	
GLASS BODY/CERAMIC BASE/ CERAMIC WINDOW FRAME	FP DIP		A4
GLASS BODY/METAL BASE/ METAL WINDOW FRAME	FP DIP	A8 & A9 A16, A17, A18 & A19	
CERAMIC BODY			
MULTILAYER INTEGRAL (COFIRED)			
BOTTOM BRAZE	FP DIP	A11 & A12 A22, A23, A24, & A25	
TOP BRAZE	DIP	A31	
SIDE BRAZE	DIP	A26, A27, A28, A29, A30, A32, A33 & A34	A35
METAL BODY			
METAL BASE	FP	A7 (WELDED LID)	

This relatively high temperature for the final seal can produce intermetallic formations in Au/Al metallization systems.

Glass Body/Ceramic Base/Metal Window Frame - This type of package utilizes hard glass technology to form a package comprised of a ceramic bottom, glass body, and a metal window frame on top of the glass body. The use of a metal window frame permits soldering, brazing or welding of the lid to the package, and avoids the problem of intermetallic formation associated with the soft glass body package. The ceramic base provides good thermal conductivity and electrical isolation of the die. However, the added cavity depth resulting from the use of a window frame could present problems during wire bonding.

Glass Body/Ceramic Base/Ceramic Window Frame - This type package is similar to the glass body/ceramic base/metal window frame package previously described. The basic difference is the use of a ceramic window frame instead of a metal window frame. A glass frit is normally used to seal on a ceramic or metal lid. The resulting glass seal lacks the strength of a solder or weld seal.

Glass Body/Metal Base/Metal Window Frame - The difference between this package and the previously described glass body/ceramic base/metal window frame is the use of a metal base for good thermal conductivity. However, it lacks electrical isolation between the die and underlying conductors on printed circuit boards.

Ceramic Body - The only ceramic body type package examined was the multilayer integral or cofired ceramic. This type package is constructed with multilayer alumina ceramic fired into a single monolithic package. Instead of a metal lead frame, conductors are printed onto the ceramic material while it is still in the green state. The ceramic pieces are then assembled and fired to form a single monolithic structure. Exposed conductor materials are then nickel/gold plated to achieve the desired metallization properties for bonding and assembly. External leads are attached by brazing to metallization pads outside the seal area. Thus, flexing of the external leads does not stress the hermetic seal area of the package.

Metal Body - The only metal body package included in the evaluation was T.I.'s flat pack. Construction of this package is achieved by welding a thick metal base to a castellated metal window frame. Hard glass-to-metal seals are made with glass inserts around the leads as they project through the castellations of the window frame. Lid sealing is accomplished by welding.

A more detailed summary of physical features noted in each flat pack is contained in Table 8, and a similar summary of DIP characteristics is shown in Table 9.

The results of the physical analysis revealed numerous differences in package construction techniques. However, most of the differences were noted between the different package categories. No major differences in packages within the same category were noted that would clearly indicate a superior/inferior construction technique. However, the Diacon Cerpak (Appendix A1) was designed to provide an extremely dry internal package atmosphere for thin film Nichrome resistors.

Special features of the Diacon package include the use of a non-devitrifying/low H_2O content glass and a compression type final seal. The lead frame is also selectively preplated with gold to leave a small portion of bare Kovar in the seal area. The lid incorporates a coffer dam type interface with the lead frame and base to minimize the amount of sealing glass entering or exposed to the package cavity, thereby minimizing the risk of contaminants/moisture that may outgass from the sealing glass into the cavity. The lead frame and base are attached at approximately 450°C, and the final seal is accomplished in several seconds at 600°C using a heater block in a dry box. Diacon has indicated that studies of the internal package atmosphere showed negligible moisture content.

TABLE 8. FLAT PACK PACKAGES

	NO PINS	BODY SIZE				BODY TYPE ⚠1				BODY MAT. ⚠2		BODY SEAL				LID TYPE					LID SEAL					BOTTOM TYPE					LEAD EGRESS			IC OR PACKAGE MFG.
CONSTRUCTION ANALYSIS REF NO		1/8 X 1/4	1/4 X 1/4	1/4 X 3/8	3/8 X 9/16	2 PIECE	3 PIECE	5 PIECE	6 PIECE	CER, WHITE	METAL	FIRED CER	GLASS, BLACK	GLASS, GRAY	GLASS, AMBER	METAL	CER, WHITE	CER, BLACK	METAL, ROUND	BEO	SOLDER	GLASS, WHITE	GLASS, BLACK	GLASS, GRAY	METAL WELD	METAL	CER, BLACK	CER, WHITE	BEO	CER, WHITE (PLUS PC BOARD)	SIDES ONLY	SIDES & ENDS	BOTTOM BRAZE	
A8	10		X				X			-				X		X					X					X					X			NATIONAL
A1	14		X			X				-			X					X					X				X					X		DIACON ⚠3
A2	14		X			X				-				X				X						X			X					X		MOTOROLA
A4	14		X				X			-				X			X					X						X				X		MOTOROLA
A9	14		X				X			-				X		X					X					X						X		NATIONAL
A10	14		X				X			-			X			X					X							X				X		SILICONIX
A7	14	X					X				X				X	X									X	X						X		TI
A11	14			X					X	X		X							X						X					X			X	RCA
A12	16			X				X		X		X				X					X							X					X	NATIONAL
A3	16			X		X				-				X				X						X			X				X			MOTOROLA
A5	16			X		X				-				X			X							X				X			X			NATIONAL
A6	24			X		X				-				X						X				X					X		X			FSC

⚠1 LEAD FRAME & BODY SEAL NOT INCLUDED

⚠2 - = BODY MATERIAL & BODY SEAL SAME

⚠3 PACKAGE MFR

TABLE 9. DUAL IN-LINE PACKAGES

CONSTRUCTION ANALYSIS REF. NO.	NO. PINS	LEAD ROW SPACING			BODY TYPE					BODY MAT △1		BODY SEAL △2		LID TYPE									LID SEAL			BOTTOM TYPE				LEAD EGRESS					IC OR PACKAGE MFR.
		.300"	.400"	.600"	2 PIECE	3 PIECE	4 PIECE	5 PIECE	6 PIECE	CER., WHITE	CER., BLACK	FIRED CER	GLASS, GRAY	1/4 METAL	1/3 METAL	1/3 METAL (GLASS WINDOW)	1/3 CER., BLACK	1/2 METAL	3/4 METAL	FULL METAL	FULL CER., BLACK	ROUND	SOLDER	GLASS, GRAY	WELD	METAL	METAL RECESSED CAVITY	CER , WHITE	CER., BLACK	SIDE FRAME	SIDE + END FRAME	SIDE BRAZE	BOTTOM BRAZE	TOP BRAZE	
A16	14	X				X				X		X								X			X				X			X					EA
A17	14	X				X				X		X								X			X			X				X					NATIONAL
A26	14	X						X		X		X							X				X					X				X			SIGNETICS
A13	14	X			X					-			X								X			X					X	X					MOTOROLA
A18	14	X				X				X		X							X				X				X			X					RAYTHEON
A22	16	X						X		X		X										X			X			X					X		RCA
A14	16	X			X					-			X								X			X					X	X					MOTOROLA
A27	16	X						X		X		X							X				X					X				X			NATIONSL
A19	16	X				X				X		X								X			X			X					X				SSS
A32	18	X						X			X	X						X					X						X			X			INTEL
A33	22		X				X				X	X			X								X						X			X			INTEL
A20	24			X		X				X		X						X					X					X		X					ITT
A15	24			X	X					-			X								X			X					X	X					FSC
A28	24			X					X	X		X				X							X					X				X			INTEL
A21	24			X			X			X		X			X								X					X		X					MOTOROLA
A35	24			X				X			X	X					X							X					X			X			KYOCERA △3
A34	34			X				X			X	X			X								X						X			X			KYOCERA
A29	24			X				X		X		X			X								X					X				X			KYOCERA
A23	28			X				X		X		X			X								X					X					X		SOLITRON
A30	40			X				X		X		X		X									X					X				X			KYOCERA
A24	28			X				X		X		X			X								X					X					X		KYOCERA
A25	40			X			X			X		X		X									X					X					X		KYOCERA
A31	48			X			X			X		X		X									X					X						X	KYOCERA

△1 LEAD FRAME & BODY SEAL NOT INCLUDED

△2 - = BODY MATERIAL & BODY SEAL SAME

△3 PACKAGE MFR

Two other packages contained features unique to their category. The Fairchild 24 lead white Cerpak (Appendix A6) utilizes a BeO lid and base for improved thermal conductivity, and the Intel 24 lead cofired ceramic DIP incorporates a glass window in the lid to permit erasure of UV PROMs.

General construction features of all the package types are evaluated in the Data Analysis portion of this report.

6.0 DATA ANALYSIS

An analysis of all the data and information gathered during the data search and physical analysis phases of the program was performed to: a) evaluate the relative strengths and weaknesses of the different package categories, b) establish a list of ideal package attributes, c) rank all of the packages examined during the program relative to the ideal package, and d) formulate recommendations for package improvements.

6.1 Strengths and Weaknesses of Package Categories - The major strengths and weaknesses of the six package categories included in the evaluation are summarized in Table 10. Generally, it appears that the soft glass package has low cost as its major advantage, but the most potential reliability problems. The multilayer integral ceramic package offers the best solution to hermeticity problems, but is the highest cost package. The hard glass and metal body package types rank between the soft glass and cofired ceramic types. Beyond these general observations of major advantages and disadvantages of package categories, no conclusions should be drawn as to the reliability of a specific manufacturer's package. Many seemingly minor construction features, such as stress relieved leads, plating, die attach, and position of the die surface relative to the lead frame, can influence the overall package reliability. In fact, instances of problems with packages in all categories have been reported. Thus, considerably more detailed evaluations are required prior to selecting the ideal package.

6.2 Ideal Package Attributes - An ideal microcircuit package might be considered as a minimum cost, size and weight structure that provides uninterrupted electrical connection to the die, maximum heat transfer away from the die, and maximum protection of the die from external environments. Other factors such as ease of identification with respect to both part number and pin orientation, ease of handling during test and equipment assembly, and ease of testing after installation

TABLE 10. STRENGTHS AND WEAKNESSES OF PACKAGE CATEGORIES

PACKAGE TYPE	MAJOR STRENGTHS	MAJOR WEAKNESSES
SOFT GLASS BODY	o LOW COST	o HIGH LID SEAL TEMPERATURE CAN CAUSE INTERMETALLICS IN DUAL METAL SYSTEM o Pb PRECIPITATES FROM GLASS CAN CAUSE SHORTS o OUTGASSING OF MOISTURE AND CONTAMINANTS FROM SEAL GLASS
HARD GLASS BODY		
CERAMIC BASE/METAL WINDOW FRAME	o HARD GLASS LEAD SEAL o LOW TEMPERATURE LID SEAL	o LEAD SEALS SUSCEPTIBLE TO CRACKING
CERAMIC BASE/CERAMIC WINDOW FRAME	o HARD GLASS LEAD SEAL o LOW TEMPERATURE LID SEAL	o LEAD SEALS SUSCEPTIBLE TO CRACKING o SOFT GLASS FRIT LID ATTACH
METAL BASE/METAL WINDOW FRAME	o HARD GLASS LEAD SEAL o LOW TEMPERATURE LEAD SEAL o GOOD THERMAL CONDUCTIVITY	o LEAD SEALS SUSCEPTIBLE TO CRACKING o NO ELECTRICAL ISOLATION OF DIE
MULTILAYER INTEGRAL CERAMIC	o EXCELLENT HERMETIC SEAL INTEGRITY o LOW TEMPERATURE LID SEAL	o SUSCEPTIBLE TO STRESS CORROSION CRACKING o HIGH COST
METAL BODY	o HARD GLASS LEAD SEAL o LOW TEMPERATURE, HIGH STRENGTH WELDED LID SEAL	o NO ELECTRICAL ISOLATION OF DIE o HIGH COST

into equipment, are also considerations for an ideal package. In an attempt to further define an ideal package that could be used as a standard for evaluating existing packages, the list of package attributes shown in Table 11 was formulated. Since the attributes relate to a nonexistent ideal package, coexistence of two or more attributes in a single package may not be physically realizable. This only indicates that trade-offs have to be made when designing a new package and does not negate the usefulness of the list for comparison purposes. Also, all of the attributes listed in Table 11 are not considered equally important. Thus, with the exception of cost, a numerical importance rating between "0" and "1" was assigned to each attribute. Attributes weighted "1" are considered most important. The attributes with the higher importance ratings (0.8 to 1.0) are generally related to the integrity of hermetic seals, since, as previously indicated, this is the major cause of package failures. The lowest rated attributes (0.3) are generally related to ease of test and ease of handling or equipment assembly. The remaining, and majority of the attributes, are ranked somewhat arbitrarily between 0.4 and 0.7. These attributes are considered highly desirable, but are not as critical as those related to hermeticity. The "low cost" attribute was not weighted because its importance varies so widely with the ultimate package application, i.e., from high volume commercial equipment to critical spaceflight equipment.

As an aid in understanding the weight given to each attribute, a brief discussion of attribute importance is provided in the following paragraphs:

6.2.1 Leads and Lead Seal Attributes

a) Minimum Seal Stress During Lead Flexure - (Importance 1.0) - Stresses imposed on glass lead seals due to lead flexure can result in seal damage and loss of hermeticity. Lead flexing can occur as a result of device insertion into a printed circuit board or socket. The resulting damage may go undetected and result in microcircuit failure at a later time. Thus, minimum seal stress during lead

TABLE 11. IDEAL PACKAGE ATTRIBUTES

ATTRIBUTE	RELATIVE IMPORTANCE
LEADS AND LEAD SEAL	
A) MINIMUM SEAL STRESS DURING LEAD FLEXURE	1.0
B) LEADS WITH STRAIN RELIEF	0.8
C) LEADS DO NOT REQUIRE POST PLATING	0.8
D) MONOMETALLIC LEAD FRAME/FLYWIRES	0.8
E) LEAD SEAL & LID SEAL SEPARATE	0.8
F) HIGH TEMP. MATERIALS	0.7
G) CORROSION RESISTANT	0.7
H) NO LEAD BENDING REQUIRED	0.6
I) SOLDERABLE & WELDABLE	0.6
J) TOP OR SIDE EXPOSED LEADS	0.3
BODY CONSTRUCTION	
A) STRESS RELIEVED CONSTRUCTION	1.0
B) DIMENSIONALLY STABLE	0.8
C) LEAD FRAME HIGHER THAN DIE	0.7
D) LOW LENGTH TO WIDTH RATIO	0.6
E) SMOOTH LEAD FRAME BONDING AREA	0.6
F) MINIMUM PROCESS STEPS	0.6
G) MINIMUM PIECE PARTS	0.6
H) OPTIMUM CAVITY SIZE	0.5
I) PIN ONE MECHANICALLY IDENTIFIED	0.3
J) LOW PROFILE	0.3
BODY MATERIAL	
A) NON ORGANIC	0.6
B) LOW IONIC CONTENT	0.6
C) CORROSION & SOLVENT RESISTANT	0.6
D) MAXIMUM THERMAL CONDUCTIVITY	0.5
E) MINIMUM OF DIFFERENT MATERIALS	0.5
F) LIGHT TIGHT	0.5
G) HIGH TEMP. MATERIAL	0.4
H) NONCONDUCTIVE BASE	0.3
I) LOW SURFACE POROSITY	0.3
LID AND LID SEAL	
A) SMALL LID SEAL PERIPHERY	1.0
B) LID SEAL AWAY FROM PACKAGE EDGE	1.0
C) SELF CENTERING LID	0.6
D) LOW TEMP. LID SEAL CAPABILITY	0.6
E) SOLDERABLE/WELDABLE	0 4
PACKAGE MARKING	
A) PERMANENT MARKING	1.0
B) FLAT SURFACE FOR MARKING	0 7
C) HIGH TEMP. MARKING	0.6
LOW COST	---

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flexure is considered an important attribute. Multilayer ceramic packages with brazed leads possesses this attribute.

b) Leads with Strain Relief - (Importance 0.8) - Some type of strain relief in the external leads, such as a notch or neckdown, is important to limit the stress applied to the lead seal during lead bending or flexure. It will also minimize lead breakage. Leads will bend at the notch or neckdown before excessive stresses are induced in the lead seal or package.

c) Leads Do Not Require Post Plating - (Importance 0.8) - Leads that do not require plating after accomplishing the final package seal minimize the potential loss of good dice due to plating yield losses. There is also no risk of plating solutions attacking soft glass seals or other package materials. Typically the soft glass body packages (Cerpak and Cerdip) require lead plating after final seal, since exposed Kovar lead material is required for a good glass to metal seal. However, the Diacon Cerpak (Appendix A1) avoids this problem by selectively preplating the lead frame with gold to leave a small portion of Kovar exposed in the seal area.

d) Monometallic Lead Frame/Flywires - (Importance 0.8) - To minimize the growth of intermetallics at the package lead frame or lead frame metallization, the lead frame, or the subsequent plating, should be of the same metallic material as the flywires. Lead frames with aluminum plating on the bonding area are available for the Cerdip and Cerpak packages. This allows the use of aluminum flywires without the risk of intermetallic formulation during package seal or subsequent high temperature processing or testing. The multilayer ceramic package has no provisions for aluminum plating internally, and is one of the main weaknesses of this type package.

e) Lead Seal and Lid Seal Separate - (Importance 0.8) - With the lead seal and the lid seal operations performed separately, the lead seal can be accomplished at much higher temperatures than the lid seal, thereby avoiding the problems of intermetallic growth, or thermally induced die related problems. The lead seal can be accomplished by the package manufacturer and any process yield loss will not create undue waste of good dice should the lead seal be accomplished incorrectly. This potential loss of good dice due to sealing losses is inherent in the Cerpak and Cerdip where the lead seal and final lid seal are the same.

Care must also be used in handling the unsealed Cerdip and Cerpak as the lead frame is only attached to the bottom ceramic piece with one half the sealing glass. The other half is formed when the lid is attached. Also, the leads must remain shorted via the lead frame shorting bus strip until after the final seal and subsequent plating. Thus, preseal visual inspections cannot be accomplished on these devices without the risk of package damage, and preseal electrical measurements can not be performed.

f) High Temperature Materials - (Importance 0.7) - The use of lead materials capable of withstanding prolonged exposure to ambient temperatures up to 300°C is desirable if high temperature accelerated life or burn-in tests are to be performed on the completed microcircuit. Gold and possibly nickel boron are acceptable high temperature lead plating materials.

g) Corrosion Resistant - (Importance 0.7) - Corrosion resistant lead materials capable of being readily bonded to other materials are desired for high reliability electrical connections of the microcircuit to external circuitry. Most commonly used platings are acceptable, although gold has superior corrosion resistant properties. Care must be taken, however, when gold is used as a lead plating since other problems such as tin/lead solders leaching gold from the lead surface and stress corrosion cracking of brazed leads (Alert No. GH-A-75-07A) may result. The subject of stress corrosion cracking is discussed extensively by Wirick in Reference [16]. He also presents a plating process to prevent stress corrosion cracking of Kovar leads in Reference [17].

h) No Lead Bending Required - (Importance 0.6) - Lead forming or bending requires added controls/inspections in the manufacturing process, and may even damage the lead plating or lead seals. Thus, a package that does not require a final lead forming operation is desirable. The side brazed DIP is one package that does not require lead bending and hence possesses this attribute.

i) Solderable and Weldable Leads - (Importance 0.6) - Since most avionic and spacecraft applications require soldering of microcircuits to printed circuit boards, a solderable lead is desired. Some applications, primarily for flat packs, require welding, and to promote standardization, a lead that is both solderable and weldable is desired.

j) Top or Side Exposed Leads - (Importance 0.3) - Top or side exposed leads are desirable to facilitate device probing and inspection during troubleshooting and checkout of completed assemblies. All of the packages evaluated exhibited this attribute to some degree.

6.2.2 Body Construction Attributes

a) Stress Relieved Construction - (Importance 1.0) - Construction techniques that minimize the residual stresses left in the package are highly desirable. Packages with no residual stresses will better withstand additional stresses imposed as a result of environmental factors such as thermal shock or temperature cycling. In general the multilayer integral ceramic packages possesses this attribute, while packages with glass seals only partially satisfy the requirement.

b) Dimensionally Stable - (Importance 0.8) - This attribute is related to the ability of the package components to be assembled properly and not exhibit dimensional shifts or misalignments that exceed design values. All the package types evaluated suffer to some extent from lack of this attribute. Cerpaks and Cerdips have been received at MDAC-St. Louis with the bottom, top and leads grossly misaligned. Others have been received with final sealing glass over the lead frame bonding area, and Stanley at MIT Lincoln Laboratory [12] reports receiving Cerpaks with the entire cavity filled with sealing glass. Lead misalignment on the side, top and bottom braze type packages, as illustrated in Figure 7, is a frequently observed problem at MDAC-St. Louis.

c) Lead Frame Higher Than Die - (Importance 0.7) - A lead frame bonding surface that is higher than the die surface is desired to promote a high vertical angle of the internal lead wire with respect to the die surface. A large angle between the flywire and microcircuit die is desired to minimize the probability of a subsequent wire-to-die short, a problem experienced at MDAC-St. Louis [10] and reported in Alerts (see Table 4).

d) Low Length to Width Ratio - (Importance 0.6) - A package with a low length to width ratio is desired since it is less likely to suffer damage when subjected to bending stresses experienced during handling and flexure of printed circuit boards. All other factors being equal, a square package exhibits maximum strength. The long 40 and 48 pin DIPs are marginal with respect to this attribute.

e) Smooth Lead Frame Bonding Area - (Importance 0.6) - A smooth lead frame bonding area is desired to promote good metal combination between the wire and lead frame. Rough porous surfaces associated with thick film inks, as illustrated in Figure 8, may cause spotty bonding and a non-uniform intermetallic growth. This condition also increases the risk of voiding and cracking of the bond due to increased stress at the interface [13].

f) Minimum Process Steps - (Importance 0.6) - The fewer steps involved in a manufacturing process, the less risk there is for an error. There are also fewer inspections and controls required in the process, and the cost is generally lower.

g) Minimum Piece Parts - (Importance 0.6) - Minimum piece parts are desirable for the same reasons outlined for minimum process steps.

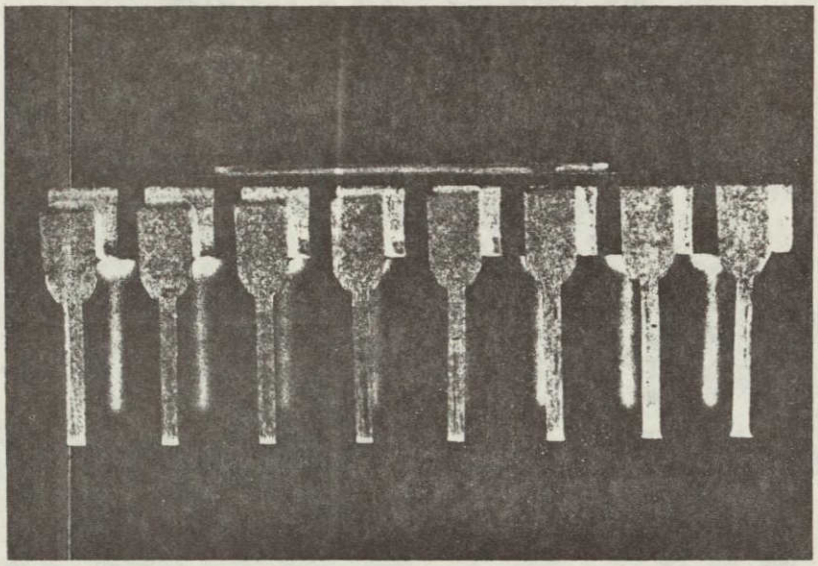

FIGURE 7. MISALIGNED LEADS AND IMPROPER LEAD TRIM

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OF POOR QUALITY

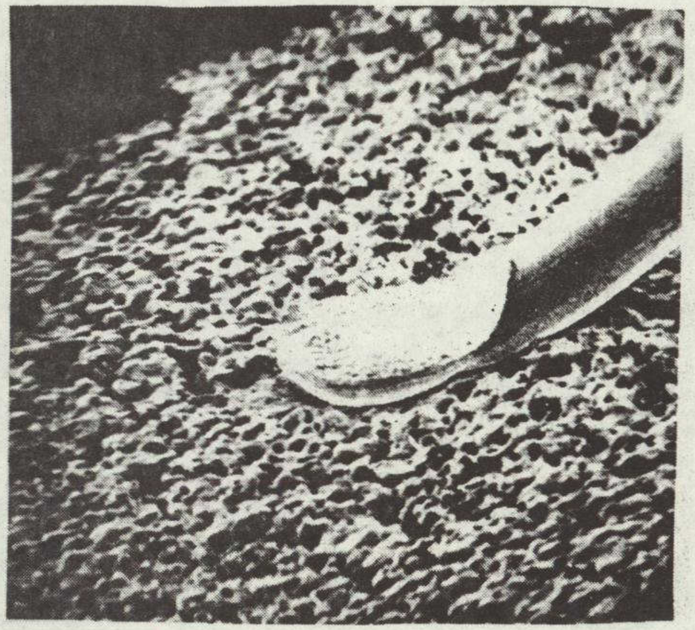


FIGURE 8. ROUGH METALLIZATION (BONDING SURFACE)

Al_2O_3 and BeO with minimum concentractions of ionic impurities such as Na, Li, K and multivalence cations of Fe, Ti, Ni, etc. [4].

c) Corrosion and Solvent Resistant - (Importance 0.6) - Body materials, as well as leads and lid materials, should be resistant to corrosion and solvents if package integrity is to be maintained.

d) Maximum Thermal Conductivity - (Importance 0.5) - Good thermal conductivity is required to conduct heat away from the microcircuit die. Most of the heat in a microcircuit is conducted to the outside ambient via the base and the leads. Thus, these materials should be selected to provide adequate thermal conductivity. Kovar, Ni and Alumina Ceramic (Al_2O_3) have thermal conductivities in the range of 0.05 to 0.15 cal/sec/cm^2/°C. Beryllia Ceramic (BeO) provides a 0.55 cal/sec/cm^2/°C thermal conductivity and is used as a package material whem maximum heat transfer is required.

e) Minimum of Different Materials - (Importance 0.5) - A minimum number of different materials is desired for the reasons of processing simplicity and low cost previously discussed. A minimum number of different materials also minimizes the risk of damage at material interfaces due to differing coefficients of thermal expansion.

f) Light Tight - (Importance 0.5) - A light tight enclosure for the semiconductor die is desirable to minimize electrical characteristic changes due to light striking semiconductor junctions. However, it is not always essential, as evidenced by the use of a transparent glass window in the lid of the UV PROM. In applications requiring maximum light absorption, the black ceramic clearly has an advantage over the white ceramic.

g) High Temperature Material - (Importance 0.4) - This attribute, as previously discussed under lead materials, is desired when accelerated life testing is to be performed at ambient temperatures above 200°C. In that case, the use of low temperature die attach and lid sealing materials (glass frits and solder) should be avoided.

h) Nonconductive Base - (Importance 0.3) - The use of a nonconductive base eliminates the need for an extra insulator between the microcircuit and printed circuit board conductors that may be under the package.

i) Low Surface Porosity - (Importance 0.3) - Materials with low surface porosity are desired to minimize the risk of moisture or other contaminants being trapped in surface pores prior to final package seal. Subsequent outgassing of the trapped moisture/contaminants may eventually contaminate the die surface. Helium or Krypton trapped in external surface pores during fine leak testing will result in false leak rate measurements. In addition, the surface characteristics of Alumina are especially important when a conductive film is to be deposited [8].

6.2.4 Lid and Lid Seal Attributes

a) Small Lid Seal Periphery - (Importance 1.0) - A small lid seal periphery is desirable on the premise that, the smaller the cavity perimeter to be sealed, the less chance of a defect or hole in the seal between the cavity and outside ambient. Other factors, such as seal width and type of seal (glass frit, solder or weld) are also considerations. However, it is felt that seal perimeter is the primary factor for comparison purposes.

b) Lid Seal Away From Package Edge - (Importance 1.0) - A lid seal away from the package edge will not be susceptible to damage during shipping and handling. Lids sealed with soft glass or solder are especially susceptible to this type damage. The lids of Cerdips constitute the package edge, and, as previously described, have suffered severe damage from shipping in plastic rails.

c) Self Centering Lid - (Importance 0.6) - A self centering lid such as the RCA round cap (Appendices A11 and A22) is desired to minimize the probability of lid misalignment during lid seal.

d) Low Temperature Lid Seal Capability - (Importance 0.6) - Performance of the lid sealing operation at temperatures between 180°C and 365°C is desired to minimize the risk of damage to the die and the formation of intermetallics at Au/Al wire bonds. This desire may conflict with the need for high temperature materials when accelerated life tests are to be performed. However, good control over die processing and the use of monometallic metallization systems (usually implemented in Cerdips and Cerpaks where seal temperatures are 400°C to 500°C) would minimize the importance of this low temperature lid sealing attribute.

e) Solderable/Weldable - (Importance 0.4) - As was the case for solderable and weldable lead materials, it is also desirable for standardization purposes to have metal lids that can be both soldered and welded to the package.

6.2.5 Package Marking Attributes -

a) Permanent Marking - (Importance 1.0) - Microcircuits that can not be identified as to type are useless to equipment manufacturers and frustrating to maintenance personnel trying to effect a replacement. Thus, the requirement for permanent marking is essential.

b) Flat Surface for Marking - (Importance 0.7) - A flat marking surface is desirable for maximum legibility.

c) High Temperature Marking - (Importance 0.6) - This attribute is only desirable if high temperature life or burn-in tests are to be performed. In that event, the marking should remain legible after exposure to temperatures up to 300°C.

6.3 Relative Ranking of Packages Evaluated

A comparison of the packages subjected to physical analyses (Appendix A) with the attributes described for an ideal package resulted in the relative rankings shown in Tables 12 and 13. These tables show how closely each package achieved the objectives described by each of the ideal package attributes. Since in most cases the packages examined neither completely lacked the attribute, nor completely

TABLE 12. RELATIVE RANKING OF DUAL-IN-LINE PACKAGES

Package	Source	Construction Analysis Ref No (Appendix A)	BODY MATERIAL: Non Organic	Low Ionic Content	Corrosion & Solvent Resistant	Maximum Thermal Conductivity	Minimum of Different Materials	Light Tight	High Temp Material	Nonconductive Base	Low Surface Porosity	BODY CONSTRUCTION: Stress Relieved Construction	Dimensionally Stable	Lead Frame Higher Than Die	Low Length to Width Ratio	Smooth Lead Frame Bonding Area	Minimum Process Step	Minimum Piece Parts	Optimum Cavity Size	Pin One Mechanically Identified	Low Profile
			6	6	6	5	5	5	4	3	3	10	8	7	6	6	6	6	5	3	3
BLACK CERDIP	MOTO - 14 PIN	A13	6	6	6	8	10	10	8	10	7	4	3	7	8	9	10	10	8	10	8
	MOTO - 16 PIN	A14	6	6	6	8	10	10	8	10	7	4	3	7	8	9	10	10	8	10	8
	FSC - 24 PIN	A15	6	6	6	8	10	10	8	10	7	4	3	7	8	9	10	10	6	10	8
WHITE CERAMIC METAL TOP AND/OR BOTTOM	EA - 14 PIN	A16	8	7	7	8	8	9	8	0	9	4	6	7	8	9	7	8	7	0	8
	NSC - 14 PIN	A17	8	7	7	8	8	9	8	0	9	4	6	7	8	9	7	8	7	0	8
	RAY - 14 PIN	A18	8	7	7	8	8	9	8	0	9	4	7	9	8	9	7	8	7	0	8
	SSS - 16 PIN	A19	8	7	7	8	8	9	8	0	9	4	6	7	8	9	7	8	7	0	8
	ITT - 24 PIN	A20	8	7	7	7	7	9	8	0	9	5	6	7	8	9	7	8	7	0	9
	MOTO - 24 PIN	A21	8	7	7	7	7	9	8	0	9	4	6	7	8	9	7	8	6	10	8
WHITE CERAMIC BOTTOM BRAZE	RCA - 16 PIN	A22	9	9	4	8	5	7	9	5	8	10	8	7	8	8	4	6	9	10	9
	SOL - 28 PIN	A23	9	9	4	8	7	7	9	5	8	10	7	7	7	8	6	7	6	10	9
	KYO - 28 PIN	A24	9	9	4	8	6	7	9	5	8	10	8	7	7	8	3	7	6	10	9
	KYO - 40 PIN	A25	9	9	4	8	6	7	9	5	8	10	8	7	5	8	3	7	6	10	9
WHITE CERAMIC SIDE BRAZE	SIG - 14 PIN	A26	9	9	4	8	5	7	9	7	8	10	8	7	8	8	4	6	5	10	9
	NSC - 16 PIN	A27	9	9	4	8	5	7	9	7	8	10	8	7	8	8	4	6	8	10	9
	INT - 24 PIN	A28	9	9	4	8	4	7	9	7	8	9	8	7	8	8	4	5	6	10	8
	KYO - 24 PIN	A29	9	9	4	8	5	7	9	7	8	10	8	7	8	8	4	6	6	10	9
	KYO - 40 PIN	A30	9	9	4	8	5	7	9	7	8	10	8	7	5	8	4	6	6	10	9
WHITE CERAMIC TOP BRAZE	KYO - 48 PIN	A31	9	9	4	8	6	7	9	10	8	10	8	7	3	8	3	7	7	10	9
BLACK CERAMIC SIDE BRAZE	INT - 18 PIN	A32	9	9	4	8	5	10	9	7	8	10	8	7	7	8	4	6	6	10	9
	INT - 22 PIN	A33	9	9	4	8	5	10	9	7	8	10	8	7	6	8	4	6	6	0	9
	KYO - 24 PIN	A34	9	9	4	8	5	10	9	7	8	10	8	7	8	8	4	6	6	10	9
	KYO - 24 PIN	A35	6	6	4	8	5	10	8	7	8	10	8	7	8	8	4	6	6	10	9

Construction Analysis Ref No	LEAD AND LEAD SEAL: No Seal Stress During Lead Flexure	Leads With Strain Relief	Does Not Require Post Plating	Nonmetallic Lead Frame/Flywire*	Lead Seal & Lid Seal Separate	High Temp Material*	Corrosion Resistant*	No Lead Bending Required	Solderable/Weldable*	Top or Side Exposed Leads	LID SEAL: Small Lid Seal Periphery	Lid Seal Away From Package Edge	Self Centering Lid	Low Temp Lid Seal Capability	Solderable/Weldable	MARKING: Permanent Marking*	Flat Surface for Marking	High Temp Marking*	Total Merit Value	Relative Ranking
	10	8	8	8	8	7	7	6	6	3	10	10	6	6	4	10	7	6		
A13	0	0	0	10	0	-	-	3	-	10	4	2	3	3	0	-	10	-	97.4	19
A14	0	0	0	10	0	-	-	3	-	10	4	2	3	3	0	-	10	-	97.4	19
A15	0	0	0	10	0	-	-	3	-	10	2	2	3	3	0	-	10	-	94.4	20
A16	6	0	10	0	10	-	-	3	-	9	4	2	3	10	5	-	10	-	119.7	18
A17	6	0	10	0	10	-	-	3	-	9	4	2	3	10	5	-	10	-	119.7	18
A18	6	0	10	0	10	-	-	3	-	9	6	3	5	10	4	-	10	-	125.7	17
A19	6	0	10	0	10	-	-	3	-	9	4	2	3	10	5	-	10	-	119.7	18
A20	6	10	10	0	10	-	-	3	-	9	7	6	4	10	7	-	10	-	136.4	16
A21	6	10	10	0	10	-	-	3	-	9	7	7	4	10	8	-	10	-	139.8	13
A22	8	0	10	0	10	-	-	3	-	10	10	9	8	8	5	-	2	-	138.6	14
A23	6	7	10	0	10	-	-	3	-	9	8	7	4	10	7	-	10	-	143.0	11
A24	9	6	10		10	-	-	3	-	10	8	7	4	10	7	-	10	-	144.0	8
A25	9	6	10		10	-	-	3	-	10	8	7	4	10	7	-	10	-	143.8	9
A26	10	3	10	0	10	-	-	10	-	9	7	6	4	10	7	-	10	-	144.7	7
A27	10	3	10	0	10	-	-	10	-	9	7	6	4	10	7	-	10	-	146.2	4
A28	10	3	10	0	10	-	-	10	-	10	8	7	4	10	7	-	10	-	145.1	6
A29	10	3	10		10	-	-	10	-	10	8	7	4	10	7	-	10	-	147.5	2
A30	10	3	10		10	-	-	10	-	10	8	7	4	10	7	-	10	-	145.7	5
A31	9	6	10		10	-	-	3	-	10	8	7	4	10	7	-	10	-	143.6	10
A32	10	3	10	10	10	-	-	10	-	10	7	6	4	10	7	-	10	-	146.4	3
A33	10	3	10	10	10	-	-	10	-	10	7	6	4	10	7	-	10	-	142.8	12
A34	10	3	10		10	-	-	10	-	10	8	6	4	10	7	-	10	-	148.9	1
A35	10	3	10		10	-	-	10	-	10	8	6	4	3	0	-	10	-	137.4	15

* Not used in computation of Total Merit Value/Relative Ranking

TABLE 13. RELATIVE RANKING OF FLAT PACK PACKAGES

Package	Vendor / Pins	Construction Analysis Ref $\emptyset\emptyset$ (Appendix A)	Body Materials: Non Organic (.6)	Low Ionic Content (.6)	Corrosion & Solvent Resistant (.6)	Maximum Thermal Conductivity (.5)	Minimum of Different Materials (.5)	Light Tight (.5)	High Temp. Material (.4)	Nonconductive Base (.3)	Low Surface Porosity (.3)	Body Construction: Stress Relieved Construction (1.0)	Dimensionally Stable (.8)	Lead Frame Higher Than Die (.7)	Low Length to Width Ratio (.6)	Smooth Lead Frame Bonding Area (.6)	Minimum Process Steps (.6)	Minimum Piece Parts (.6)	Optimum Cavity Size (.5)	Pin One Mechanically Identified (.3)	Low Profile (.3)
Black Cerpak	DIA - 14 PIN	A1	4	7	6	4	10	10	4	10	7	4	4	7	10	9	10	10	9	10	9
	MOTO - 14 PIN	A2	6	6	6	8	10	10	8	10	7	4	4	7	10	9	10	10	9	10	9
	MOTO - 16 PIN	A3	6	6	6	8	10	10	8	10	7	4	4	7	9	9	10	10	9	0	9
White Cerpak	MOTO - 14 PIN	A4	6	6	6	8	9	3	8	10	7	4	5	7	10	9	9	6	9	10	10
	FSC - 16 PIN	A5	6	6	6	8	10	3	8	10	7	4	4	7	9	9	10	10	9	0	10
BeO Cerpak	FSC - 24 PIN	A6	6	6	6	10	10	3	8	10	7	4	4	7	8	9	10	10	8	0	10
Metal 1/4 x 1/8	TI - 14 PIN	A7	8	8	8	8	10	10	9	0	10	8	5	8	9	7	8	9	10	10	10
White Ceramic Metal Top and/or Bottom	NSC - 10 PIN	A8	8	7	7	7	8	9	8	0	9	4	5	7	10	9	7	8	8	0	10
	NSC - 14 PIN	A9	8	7	7	7	8	9	8	0	9	4	5	7	10	9	7	8	8	10	10
	SIL - 14 PIN	A10	8	7	7	8	8	6	8	10	9	4	5	7	10	9	8	8	8	10	10
White Ceramic Bottom Braze	RCA - 14 PIN	A11	2	6	3	5	4	7	4	0	3	10	8	7	9	8	4	7	9	0	9
	NSC - 16 PIN	A12	9	9	7	8	6	6	9	0	8	9	8	7	9	8	6	6	5	0	9

Package	Vendor / Pins	Ref	Lead and Lead Seal: No Seal Stress During Lead Flexure (1.0)	Leads with Strain Relief (.8)	Does Not Require Post Plating (.8)	Nonmetallic Lead Frame/Flywire* (.8)	Lead Seal & Lid Seal Separate (.8)	High Temp Material* (.7)	Corrosion Resistant* (.7)	No Lead Bending Required (.6)	Solderable/Weldable* (.6)	Top or Side Exposed Leads (.3)	Lid & Lid Seal: Small Lid Seal Periphery (1.0)	Lid Seal Away from Package Edge (.8)	Self Centering Lid (.6)	Low Temp Lid Seal Capability (.6)	Solderable/Weldable (.4)	Marking: Permanent Marking* (.8)	Flat Surface for Marking (.7)	High Temp Marking* (.6)	Total Merit Value	Relative Ranking
Black Cerpak	DIA - 14 PIN	A1	4	8	7	10	0	-	-	6	-	10	9	2	3	5	8	-	9	-	119.3	8
	MOTO - 14 PIN	A2	4	8	8	10	0	-	-	6	-	10	9	2	3	3	0	-	9	-	116.7	9
	MOTO - 16 PIN	A3	4	8	0	10	0	-	-	6	-	10	8	2	3	3	8	-	10	-	112.8	10
White Cerpak	MOTO - 14 PIN	A4	4	8	10		10	-	-	6	-	10	9	2	3	3	0	-	9	-	126.8	7
	FSC - 16 PIN	A5	4	8	8	10	0	-	-	6	-	10	8	2	3	3	0	-	10	-	109.4	11
BeO Cerpak	FSC - 24 PIN	A6	4	8	0	10	8	-	-	6	-	10	7	2	3	3	0	-	10	-	108.5	12
Metal 1/4 x 1/8	TI - 14 PIN	A7	6	8	10		10	-	-	7	-	9	10	3	7	6	8	-	8	-	148.3	1
White Ceramic Metal Top and/or Bottom	NSC - 10 PIN	A8	5	8	10	0	10	-	-	6	-	9	9	4	3	10	7	-	9	-	135.0	5
	NSC - 14 PIN	A9	5	8	10	0	10	-	-	6	-	9	9	4	4	10	7	-	9	-	138.6	4
	SIL - 14 PIN	A10	5	8	10	10	10	-	-	6	-	9	9	3	4	8	7	-	9	-	139.0	3
White Ceramic Bottom Braze	RCA - 14 PIN	A11	9	8	10	0	10	-	-	7	-	10	10	9	9	8	5	-	2	-	133.6	6
	NSC - 16 PIN	A12	9	8	10	0	10	-	-	7	-	9	8	5	4	10	7	-	9	-	142.7	2

* Not used in computation of Merit Value/Relative Ranking

achieved the objectives of the attribute, merit values between "0" and "10" were assigned. A "0" was used to represent complete lack of the attribute being studied, and a "10" was used to represent complete compliance with the objective of the ideal package attribute. An overall package merit value was obtained using the relationship,

$$Mp = \sum_{k=1}^{n} m_k I_k$$

where:

Mp = overall merit value for a particular package

m = merit value for the kth attribute - a number from 0 to 10

I = importance value of the kth attribute - a number between 0.3 and 1.0

Using this relationship, the ideal package would receive an overall merit value of 233. However, several attributes could not be included in the actual package ranking process. Those attributes excluded from the ranking were: permanent marking, high temperature marking, solderable/weldable leads, corrosion resistant leads and lead seal, high temperature lead finish, and monometallic lead frame/flywire. With the exception of the monometallic lead frame/flywire attribute, the degree of compliance with these attributes could only be determined by tests beyond the scope of this study. The monometallic lead frame/flywire attribute was excluded because some of the packages did not contain a die, and the type of flywire that would be used could not be determined. Thus, for comparison purposes, the ideal package merit value excluding these attributes is 193.

The overall merit value for the packages examined in Appendix A ranged from a low of 94.4 for a soft glass Cerdip (A15) to a high of 148.3 for the metal flat pack (A7). A graphic representation of the overall merit values calculated for each package is shown in Figure 9, and illustrates the range of values calculated for each major type of package. The highest ranking package types were the metal flat pack and the cofired ceramic with the side brazed leads. Since only one

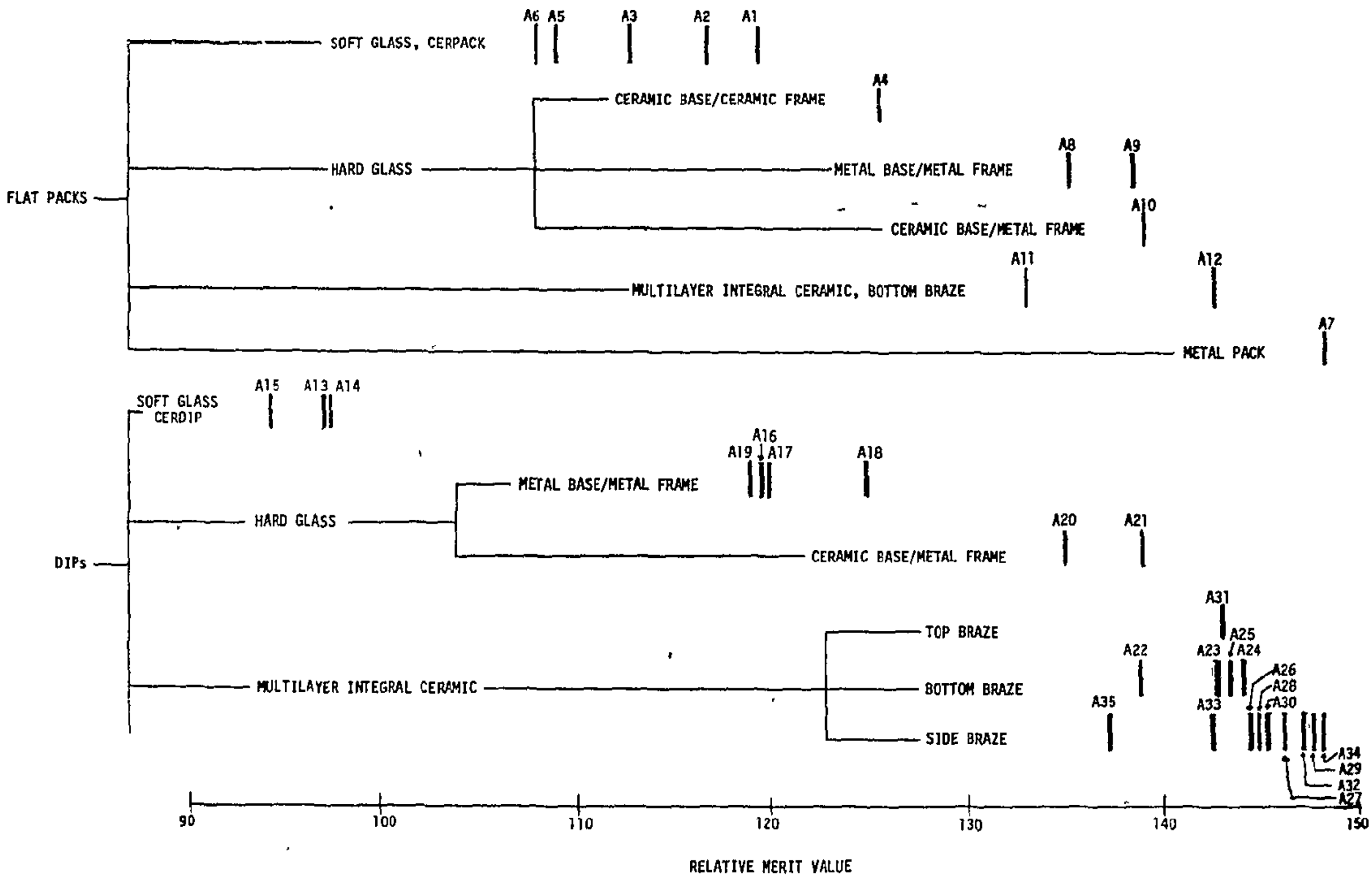


FIGURE 9. RELATIVE RANKING OF PACKAGE TYPES

metal package was examined, it can not be stated whether the ranking of the T.I. metal flat pack is typical of all metal flat packs. The range of merit values for the side brazed ceramic packages is quite large, and the observed spread may be attributed to factors such as lid sealing method (glass frit (A35) vs solder (A34), lack of a mechanical identifier for pin "1" (A33), and the fact that white ceramic is more transparent than black ceramic. The top braze cofired ceramic DIP (A31) ranked in the lower range of the cofired ceramic category, primarily due to the low length to width ratio of this 48 pin package and the fact that the top brazed leads must be formed (bent) prior to use. The bottom braze leads also require forming, and suffer from having exposed leads on the bottom of the package. Both of the bottom brazed flat packs incorporate features to avoid the exposed braze area on the bottom of the package. The RCA package (A11) utilizes a fiber insulator attached to the base with epoxy. This adds piece parts and process steps. The National package (A12) incorporates a recessed area in the ceramic base for the leads, but this is not considered adequate protection for the exposed braze areas.

Hard glass body package types generally ranked lower than the multilayer integral ceramic types and exhibited the widest range of merit values (119 to 139). Although the ceramic base/metal window frame package type exhibited the higher merit values in the hard glass seal category, the use of a ceramic base and metal window frame were generally not the reasons for the higher ranking. The lower ranking metal base/metal window frame DIP packages were deficient in the areas of lead strain relief, size of lid seal periphery, and proximity of the lid seal to the package edge.

The soft glass Cerdips and Cerpaks scored the lowest due to the reasons previously discussed, i.e., high lid seal temperature, possibility of lead (Pb) precipitates from the soft glass, difficulties of alignment during assembly, etc. Cerdips scored lower than Cerpacs due to inferior performance of Cerdips in the areas of lead strain relief, seal stresses induced with lead forming and flexure, and, size of the lid seal periphery.

6.4 Package Improvements - As an aid in formulating recommendations for package improvements, the major strengths and weaknesses of the highest and lowest ranking flat pack and DIP were examined. These strengths and weaknesses are summarized in Tables 14 and 15. Elimination of the major weaknesses in the highest ranking packages is a good starting point for obtaining a better package. However, not all of the weaknesses can be eliminated, since some are inherent to the basic construction technique. Seal stresses induced during flexure of the leads in the highest ranking flat pack (T.I.'s metal flat pack) are inherent with glass seal packages. The two other weaknesses noted in the T.I. metal pack (lead frame bonding area that is not flat and a conductive base) could possibly be eliminated. A lead frame with a flat bonding area could easily be fabricated, and a nonconductive finish on the base of the package could also be employed. However, care should be taken when attempting to incorporate an insulating finish on the base to ensure that the manufacturing process does not become unduly complex, as was the case with the fiber insulator added to the base of the RCA bottom brazed ceramic flat pack.

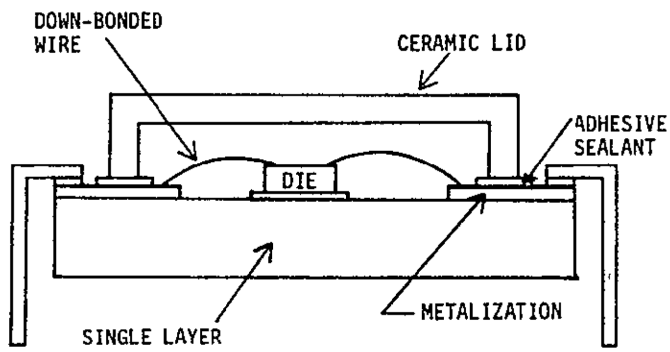
The highest ranking DIP (multilayer integral side brazed ceramic, A34) also suffers from inherent weaknesses such as the number of piece parts and process steps involved in its manufacture. A low cost single layer ceramic package was discussed by Barrett [11] that would eliminate the many piece parts and process steps in multilayer integral ceramic packages. This design is shown in Figure 10 with a 3 layer ceramic package for comparison purposes. Disadvantages of this low cost single layer design are the use of "down bonding" of the lead wires and epoxy lid sealing. Since the die surface is higher than the lead metallization in the single layer package, the lead wires must extend from the die surface down

TABLE 14. COMPARISON OF HIGHEST AND LOWEST RANKING FLAT PACK

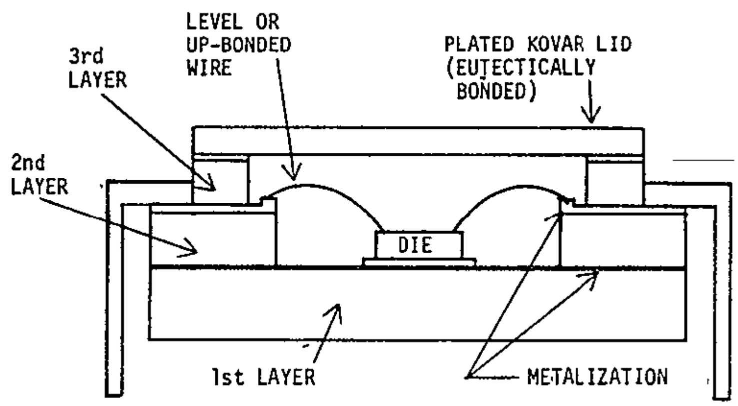
	MAJOR PACKAGE STRENGTHS	MAJOR PACKAGE WEAKNESSES
TI - 14 LEAD METAL 1/4 X 1/8 FP PACKAGE	SMALL SIZE NON ORGANIC LOW IONIC CONTENT CORROSION & SOLVENT RESISTANT ADEQUATE THERMAL CONDUCTIVITY MINIMUM OF DIFFERENT MATERIALS LIGHT TIGHT HIGH TEMP. MATERIALS MINIMUM PROCESS STEPS MINIMUM PIECE PARTS OPTIMUM CAVITY SIZE WELDED LID DOES NOT REQUIRE POST PLATING	CONDUCTIVE BASE SEAL STRESS DURING LEAD FLEXURE LEAD FRAME BONDING AREA NOT FLAT
FSC - 24 LEAD BeO FP PACKAGE	MAXIMUM THERMAL CONDUCTIVITY MINIMUM OF DIFFERENT MATERIALS HIGH TEMP. MATERIALS NON CONDUCTIVE BASE LOW SURFACE POROSITY MINIMUM PIECE PARTS MINIMUM PROCESS STEPS	LIGHT SENSITIVE SEAL STRESS DURING LEAD FLEXURE DIMENSIONALLY UNSTABLE REQUIRES POST PLATING LID SEAL AND LEAD SEAL-TOGETHER LARGE LID SEAL PERIPHERY LID SEAL ON PACKAGE EDGE LOW STRENGTH LID SEAL

TABLE 15. COMPARISON OF HIGHEST AND LOWEST RANKING DUAL-IN-LINE PACKAGE

	MAJOR PACKAGE STRENGTHS	MAJOR PACKAGE WEAKNESSES
KYOCERA - 24 LEAD, SIDE BRAZE LEAD DIP PACKAGE	STRESS RELIEVED CONSTRUCTION DIMENSIONALLY STABLE LOW SEAL STRESS DURING LEAD FLEXURE SEPARATE LEAD & LID SEAL NO LID SEAL ON PACKAGE EDGE ADEQUATE THERMAL CONDUCTIVITY ADEQUATE CAVITY SIZE VARIETY OF LID SEAL LOW PROFILE LEAD SEAL MADE AT VERY HIGH TEMP. NO BASE METAL EXPOSED DURING NORMAL LEAD FLEXURE DOES NOT REQUIRE POST PLATING NO POSITIVE LEAD BEND	MANY PROCESS STEPS MANY PIECE PARTS LID AND LEAD MISALIGNMENT MORE SUSCEPTIBLE TO STRESS CORROSION CRACKING GOLD METALLIZATION/ALUMINUM FLYWIRES EXTERNAL PACKAGE SHORTS
FSC - 24 LEAD, CERDIP PACKAGE	MINIMUM PROCESS STEPS MINIMUM PIECE PARTS ADEQUATE THERMAL CONDUCTIVITY NONCONDUCTIVE BASE CAN BE SELECTIVELY PLATED	FINAL SEAL ON PACKAGE PERIPHERY DIMENSIONALLY UNSTABLE LEAD & LID SEAL NOT SEPARATE REQUIRES POST PLATING SEAL STRESS DURING LEAD FLEXURE LEAD BENDING EXPOSES BASE LEAD METAL SIDE CENTER SEAL AREA TOO SMALL LEADS CAN SHIFT DURING FINAL SEAL REQUIRES LEAD BENDING BOTTOM SEALING GLASS MUST BE REFLOWED GLASS SEAL SUSCEPTABLE TO CHEMICAL ATTACK GLASS OUTGASSING PRODUCES BLOW HOLES FINAL SEAL GLASS CAN FLOW OVER FLYWIRE BOND SOFT GLASS SEAL HAS LOWER BOND STRENGTH



SINGLE LAYER CERAMIC PACKAGE



THREE LAYER CERAMIC PACKAGE

FIGURE 10. SINGLE AND THREE LAYER CERAMIC PACKAGES (FROM [11])

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OF POOR QUALITY

to the lead metallization (down bonding). Although tests performed by Barrett [11] resulted in no failures, wire-to-die shorts in down bonded packages have been observed in accelerated life tests at MDAC-St. Louis. Thus, wire-to-die shorts are possible, and it is still believed that the probability of a wire-to-die short is greater with down bonding than with conventional bonding. The use of an epoxy lid seal is also believed to present a reliability risk since moisture can penetrate the seal area. A solder seal could be used with the single layer package, but at the expense of increased cost [11].

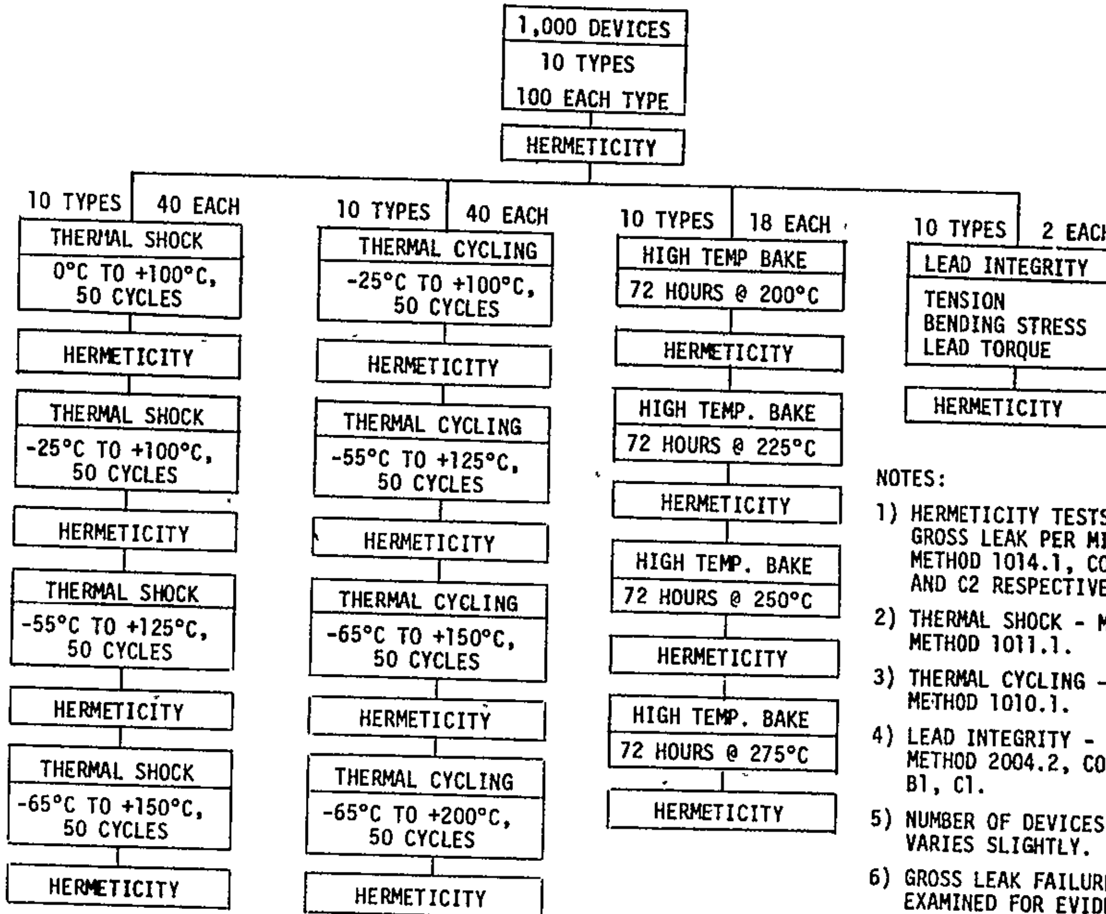
Other weaknesses noted with brazed lead multilayer integral ceramic packages could be eliminated, or their effects greatly minimized. The susceptibility of brazed leads to stress corrosion cracking is minimized with the side brazed construction since lead forming is not required and no stresses are induced. The use of a nickel plating under the final lead finish will further minimize the occurrence of stress corrosion cracking. The stress corrosion cracking phenomenom and a seven step lead plating/brazing process to prevent stress corrosion cracking is described by Weirch in References [16] and [17].

A self aligning lid, similar to the round cap used in the RCA bottom brazed DIP (A22), could be used to eliminate lid seal problems caused by lid misalignment. Lead alignment problems with the side braze package could also be minimized by incorporating recessed areas in the ceramic for lead alignment. Having the leads recessed into the ceramic would also minimize the possibility of shorting adjacent leads with a probe or test lead. However, the cost of this package may be prohibitive.

7.0 PACKAGE TEST PROGRAM

Selected package types, representative of all the package categories previously evaluated, were subjected to a matrix of thermal shock, thermal cycling, high temperature bake and lead integrity tests. These tests were designed to evaluate the integrity of package seals and leads. A total of ten package types (six DIP and 4 flat packs) were subjected to the test matrix shown in Figure 11. The thermal shock, thermal cycling and high temperature bake tests are step-stress type tests with package hermeticity tests performed after each step. Each step of the thermal shock and thermal cycling tests consisted of fifty cycles of either liquid-to-liquid thermal shock or air-to-air thermal cycling, with transfer times of approximately ten seconds. Devices passing the gross leak test at the completion of fifty cycles were subjected to an additional fifty cycles between progressively more severe temperature extremes. The high temperature bake sequence was conducted in a similar manner with each step of the sequence consisting of 72 hours of storage at a specified ambient temperature between 200°C and 275°C. Devices failing the gross leak test were removed from the test sequence and subjected to an analysis to determine the most probable location of the leak. Devices failing the fine leak test (leak rate in excess of 5×10^{-8} atm cc/s) were returned to the test sequence.

The package types included in the test matrix were representative of the cofired ceramic DIP and flat pack, hard glass metal top and bottom DIP, soft glass Cerdip and Cerpak, and metal flat pack. The relative rankings previously assigned to the packages included in the test matrix ranged between 2 and 19 for the DIPs, and 1 and 9 for the flat packs. The specific packages included in the matrix, their relative ranking, and a summary of test results are shown in Table 16. With the exception of the Solid State Scientific 14 lead ceramic DIP with metal top and bottom, less than ten percent total failures were observed for each package type.



NOTES:

1) HERMETICITY TESTS - FINE & GROSS LEAK PER MIL-STD-883, METHOD 1014.1, CONDITION A1 AND C2 RESPECTIVELY.

2) THERMAL SHOCK - MIL-STD-883, METHOD 1011.1.

3) THERMAL CYCLING - MIL-STD-883, METHOD 1010.1.

4) LEAD INTEGRITY - MIL-STD-883, METHOD 2004.2, CONDITIONS A, B1, C1.

5) NUMBER OF DEVICES PER TYPE VARIES SLIGHTLY.

6) GROSS LEAK FAILURES SHALL BE EXAMINED FOR EVIDENCE OF CRACKS, CHIPS, ETC. TO DETERMINE THE MOST PROBABLE LOCATION OF LEAK.

FIGURE 11. PACKAGE TEST PROGRAM

TABLE 16. SUMMARY OF TEST RESULTS /1

PACKAGE TYPE	MANUF.	APPENDIX A REFERENCE	RELATIVE RANKING	INITIAL		THERMAL SHOCK		THERMAL CYCLING		HIGH TEMP. BAKE		LEAD INTEGRITY		TOTAL NO. FAILS
				NO. TESTED	NO. FAILS	NO. TESTED	NO. FAILS	NO. TESTED	NO. FAILS	NO. TESTED	NO. FAILS	NO. TESTED	NO. FAILS	
DUAL IN-LINE														
24 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A29	2	100	0	40	0	40	0	18	0	2	0	0
40 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A30	5	94	0	37	2	37	1	18	0	2	0	3
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	RCA	A22	14	100	0	40	3	40	0	18	1	2	0	4
14 LEAD WHITE CERAMIC, METAL TOP AND BOTTOM	SOLID STATE SCIENTIFIC	A19	18	100	9	36	9	37	4	16	2	2	1	25
14 LEAD CERDIP, BLACK	MOTOROLA	A13	19	100	0	40	4 /2	40	0	18	0	2	0	4
14 LEAD CERDIP, BLACK	ITT	SIMILAR TO A13	19	100	3 /3	40	4	38	0	17	2	2	0	9
FLAT PACKAGES														
14 LEAD 1/4" X 1/8" METAL	TEXAS INST	A7	1	107	7	40	0	40	1	18	0	2	0	8
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	NATIONAL	A12	3	100	0	40	1	40	1	18	0	2	0	2
14 LEAD CERPAK, BLACK	DIACON	A1	8	100	0	40	0	40	1	18	0	2	0	1
14 LEAD CERPAK, BLACK	FAIRCHILD	SIMILAR TO A2	9	96	1	37	0	38	0	18	0	2	0	1
TOTALS				997	20	390	23	390	8	177	5	18	1	57

NOTES:

/1 UNLESS OTHERWISE INDICATED, ALL FAILURES ARE GROSS LEAK TEST FAILURES.

/2 TWO (2) PARTS FAILED FINE LEAK TEST ONLY.

/3 ONE (1) PART FAILED FINE LEAK TEST ONLY.

This small percentage of failures prevents making any comparisons of failure percentages with the previously established relative ranking. In addition, no conclusions should be drawn from the initial test results, since it is unknown if the package suppliers performed hermeticity tests prior to providing the package samples to MDAC-St. Louis. The high percentage (25%) of Solid State Scientific package failures indicates that the ceramic DIP with metal top and/or bottom is more susceptible to thermal stress induced seal damage than the other package types evaluated.

Summaries of the thermal shock, thermal cycling, high temperature bake, and lead integrity test results are shown in Tables 17, 18, 19 and 20. Examination of this data shows that thermal shock testing produced the highest percentage of failures, although the temperature extremes were generally lower at each step of the test sequence than the thermal cycling or high temperature bake. Thus, liquid-to-liquid thermal shock is probably a better test of package seal integrity than air-to-air thermal cycling.

Analysis of the 54 gross leak test failures revealed that many of the failures could not be confirmed by repeating the gross leak test. However, visual examinations of these devices revealed package seal anomolies similar to those observed in confirmed failures. A summary of the analysis findings is shown in Table 21, and indicates that of the 31 confirmed package failures, 18 leaked at solder or weld lid/base seals, 12 leaked at glass lead seals, and one leaked at a ceramic layer interface. Typical examples of anomalies observed in confirmed failures of each package type are provided in Figures 12 through 21. No attempt was made to determine if the observed anomolies extended into the package cavity.

The results of fine leak tests performed during the test program are summarized in Tables 22, 23 and 24. These tables provide values of the mean and standard deviation of the test sample leak rates. Histogram presentations of the fine leak data are provided in Appendix B. Examinations of the fine leak rate data generally did not show any change in leak rates that could be attributed to the environmental stress levels. Variations in the values of both the mean and standard deviation were observed, but these are believed to be due to variations in the helium bomb pressure time and variations in elapsed time between removal of pressure and measurement of the helium leak rate. Leak rate measurements of ten control sample parts were performed 129 times during the program, and mean values of the ten control sample leak rates ranged between 5.7 and 12.6 atm cc/s. The standard deviations of the control sample measurements ranged between 3.1 and 11.5 atm cc/s. These results suggest that the repeatability of leak rate measurements performed in accordance with MIL-STD-883, Method 1014.1, Condition A, is probably no better than ±50%. The revisions to this method continued in the recently issued MIL-STD-883B should improve the repeatability of fine leak test measurements.

TABLE 17. THERMAL SHOCK TEST SUMMARY

PACKAGE TYPE	MANUF.	APPENDIX A REFERENCE	RELATIVE RANKING	NO. INTO TEST	CUMULATIVE NO. OF FAILURES /1 - THERMAL SHOCK SEQUENCE			
					0°C TO 100°C 50 CYCLES	-25°C TO 100°C 50 CYCLES	-55°C TO 125°C 50 CYCLES	-65°C TO 150°C 50 CYCLES
DUAL IN-LINE								
24 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A29	2	40	0	0	0	0
40 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A30	5	37	1	2	2	2
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	RCA	A22	14	40	3	3	3	3
14 LEAD WHITE CERAMIC, METAL TOP AND BOTTOM	SOLID STATE SCIENTIFIC	A19	18	36	1	1	7	9
14 LEAD CERDIP, BLACK	MOTOROLA	A13	19	40	1	1	2	4 /2
14 LEAD CERDIP, BLACK	ITT	SIMILAR TO A13	19	40	1	2	3	4
FLAT PACKAGES								
14 LEAD 1/4" X 1/8" METAL	TEXAS INST.	A7	1	40	0	0	0	0
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	NATIONAL	A12	3	40	1	1	1	1
14 LEAD CERPAK, BLACK	DIACON	A1	8	40	0	0	0	0
14 LEAD CERPAK, BLACK	FAIRCHILD	SIMILAR TO A2	9	37	0	0	0	0
TOTAL				390	8	10	18	23

NOTES:

/1 ALL FAILURES ARE GROSS LEAK TEST FAILURES UNLESS OTHERWISE INDICATED.

/2 TWO (2) PARTS FAILED FINE LEAK TEST ONLY.

TABLE 18. THERMAL CYCLING TEST SUMMARY

PACKAGE TYPE	MANUF.	APPENDIX A REFERENCE	RELATIVE RANKING	NO. INTO TEST	CUMULATIVE NO. OF FAILURES /1 - THERMAL CYCLING			
					-25°C TO +100°C 50 CYCLES	-55°C TO 125°C 50 CYCLES	-65°C TO +150°C 50 CYCLES	-65°C TO 200°C 50 CYCLES
DUAL IN-LINE								
24 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A29	2	40	0	0	0	0
40 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A30	5	37	1	1	1	1
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	RCA	A22	14	40	0	0	0	0
14 LEAD WHITE CERAMIC, METAL TOP AND BOTTOM	SOLID STATE SCIENTIFIC	A19	18	37	2	3	3	4
14 LEAD CERDIP, BLACK	MOTOROLA	A13	19	40	0	0	0	0
14 LEAD CERDIP, BLACK	ITT	SIMILAR TO A13	19	38	0	0	0	0
FLAT PACKAGES								
14 LEAD 1/4" X 1/8" METAL	TEXAS INST.	A7	1	40	0	1	1	1
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	NATIONAL	A12	3	40	0	1	1	1
14 LEAD CERPAK, BLACK	DIACON	A1	8	40	0	1	1	1
14 LEAD CERPAK, BLACK	FAIRCHILD	SIMILAR TO A2	9	38	0	0	0	0
TOTAL				390	3	7	7	8

NOTES:

/1 ALL FAILURES ARE GROSS LEAK TEST FAILURES.

TABLE 19. HIGH-TEMPERATURE BAKE SUMMARY

PACKAGE TYPE	MANUF.	APPENDIX A REFERENCE	RELATIVE RANKING	NO. INTO TEST	CUMULATIVE NO. OF FAILURES /1 - BAKE SEQUENCE			
					72 HR @ 200°C	72 HR @ 225°C	72 HR @ 250°C	72 HR @ 275°C
DUAL IN-LINE								
24 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A29	2	18	0	0	0	0
40 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A30	5	18	0	0	0	0
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	RCA	A22	14	18	0	0	1	1
14 LEAD WHITE CERAMIC, METAL TOP AND BOTTOM	SOLID STATE SCIENTIFIC	A19	18	16	0	0	2	2
14 LEAD CERDIP, BLACK	MOTOROLA	A13	19	18	0	0	0	0
14 LEAD CERDIP, BLACK	ITT	SIMILAR TO A13	19	17	2	2	2	2
FLAT PACKAGES								
14 LEAD 1/4" X 1/8" METAL	TEXAS INST.	A7	1	18	0	0	0	0
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	NATIONAL	A12	3	18	0	0	0	0
14 LEAD CERPAK, BLACK	DIACON	A1	8	18	0	0	0	0
14 LEAD CERPAK, BLACK	FAIRCHILD	SIMILAR TO A2	9	18	0	0	0	0
TOTAL				177	2	2	5	5

NOTES.

/1 ALL FAILURES ARE GROSS LEAK TEST FAILURES

TABLE 20. LEAD INTEGRITY TEST SUMMARY

PACKAGE TYPE	MANUF.	APPENDIX A REFERENCE	RELATIVE RANKING	TENSION		TORQUE /1		BENDING	
				NO. TESTED	NO FAILED	NO. TESTED	NO. FAILED	NO. TESTED	NO. FAILED
DUAL IN-LINE									
24 LEAD WHITE CERAMIC SIDE BRAZE LEADS	KYOCERA	A29	2	1	0	1	0	1	0
40 LEAD WHITE CERAMIC SIDE BRAZE LEADS	KYOCERA	A30	5	1	0	1	0	1	0
16 LEAD WHITE CERAMIC BOTTOM BRAZE LEADS	RCA	A22	14	1	0	1	0	1	0
14 LEAD WHITE CERAMIC METAL TOP AND BOTTOM	SOLID STATE SCIENTIFIC	A19	18	1	1 /2	1	0	1	0
14 LEAD CERDIP, BLACK	MOTOROLA	A13	19	1	0	1	0	1	0
14 LEAD CERDIP, BLACK	ITT	---	19	1	0	1	0	1	0
FLAT PACKAGES									
14 LEAD 1/4" X 1/8" METAL	TEXAS INST.	A7	1	1	0	1	0	1	0
16 LEAD WHITE CERAMIC BOTTOM BRAZE LEADS	NATIONAL	A12	3	1	0	1	0	1	0
14 LEAD CERPAK, BLACK	DIACON	A1	8	1	0	1	0	1	0
14 LEAD CERPAK, BLACK	FAIRCHILD	SIMILAR TO A2	9	1	0	1	0	1	0

NOTES:

/1 THE SAME PACKAGE WAS USED FOR TENSION TESTING AS WAS USED FOR TORQUE TESTING UNLESS THE PACKAGE FAILED THE TENSION TEST.

/2 GROSS LEAK TEST FAILURE ONLY.

TABLE 21. GROSS LEAK TEST FAILURE ANALYSIS SUMMARY

PACKAGE TYPE	MANUF.	APPENDIX A REFERENCE	RELATIVE RANKING	TOTAL NO. GROSS LEAK FAILS	NO. FAILURES CONFIRMED BY RETEST	PROBABLE LOCATION OF LEAK
DUAL IN-LINE						
24 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A29	2	0	-	---
40 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A30	5	3	1	CERAMIC LAYER INTERFACE
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	RCA	A22	14	4	0	---
14 LEAD WHITE CERAMIC, METAL TOP AND BOTTOM	SOLID STATE SCIENTIFIC	A19	18	25	17	LID SOLDER SEAL - 12 FAILURES GLASS LEAD SEAL - 5 FAILURES
14 LEAD CERDIP, BLACK	MOTOROLA	A13	19	2	0	---
14 LEAD CERDIP, BLACK	ITT	SIMILAR TO A13	19	8	3	GLASS LEAD SEAL
FLAT PACKAGES						
14 LEAD 1/4" X 1/8" METAL	TEXAS INST.	A7	1	8	7	TOP/BOTTOM WELD SEAL - 4 FAILURES GLASS LEAD SEAL - 3 FAILURES
16 LEAD WHITE CERAMIC BOTTOM BRAZE LEAD	NATIONAL	A12	3	2	2	LID SOLDER SEAL
14 LEAD CERPAK, BLACK	DIACON	A1	8	1	0	---
14 LEAD CERPAK, BLACK	FAIRCHILD	SIMILAR TO A2	9	1	1	GLASS LEAD SEAL
TOTAL				54	31	

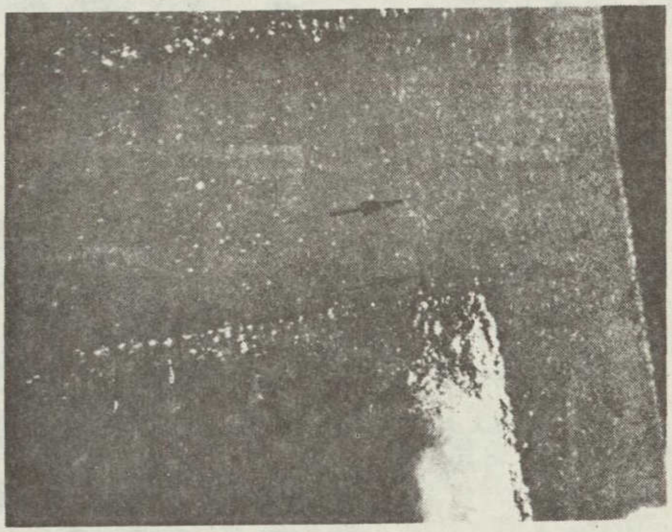


FIGURE 12. KYOCERA 40 LEAD CERAMIC DIP - LEAK AT CERAMIC LAYER INTERFACE AFTER -25°C/100°C THERMAL SHOCK SEQUENCE.

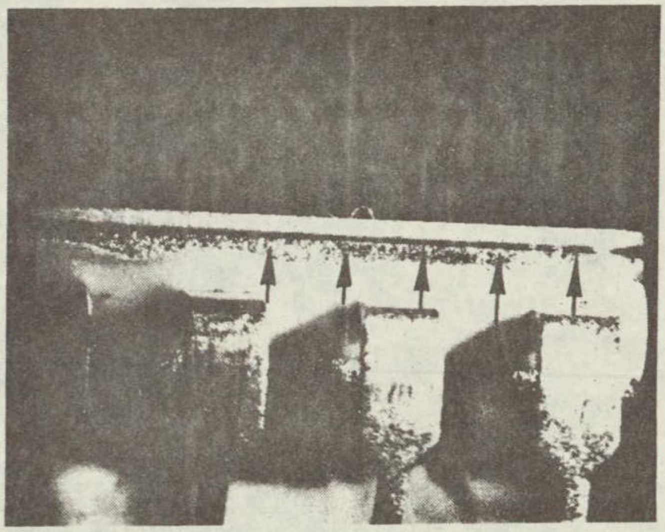


FIGURE 13. SOLID STATE SCIENTIFIC 14 LEAD CERAMIC DIP - LEAK AT SOLDER LID SEAL AFTER -25°C/100°C THERMAL CYCLE SEQUENCE.

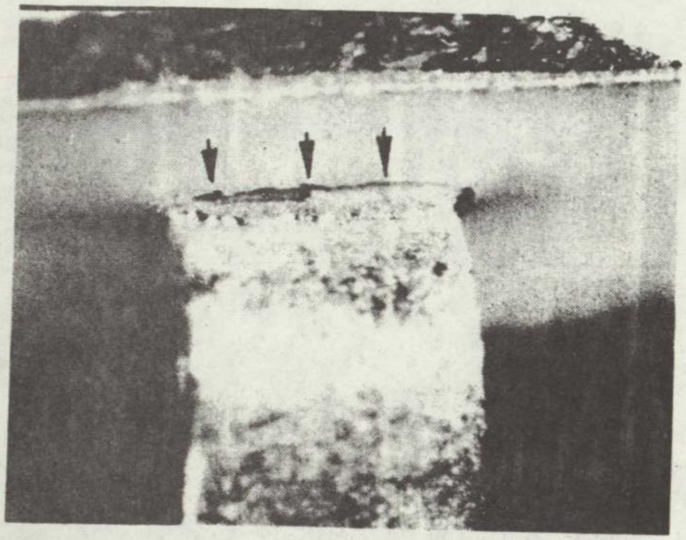


FIGURE 14. SOLID STATE SCIENTIFIC 14 LEAD CERAMIC DIP - LEAK DUE TO CRACK IN LEAD SEAL AFTER 0°C/100°C THERMAL SHOCK SEQUENCE.

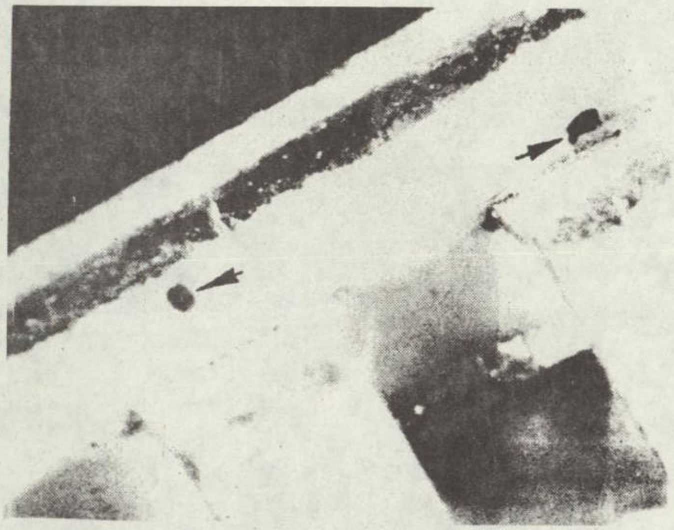


FIGURE 15. SOLID STATE SCIENTIFIC 14 LEAD CERAMIC DIP - LEAK DUE TO BLOW HOLE IN LEAD SEAL AFTER -55°C/125°C THERMAL SHOCK SEQUENCE.

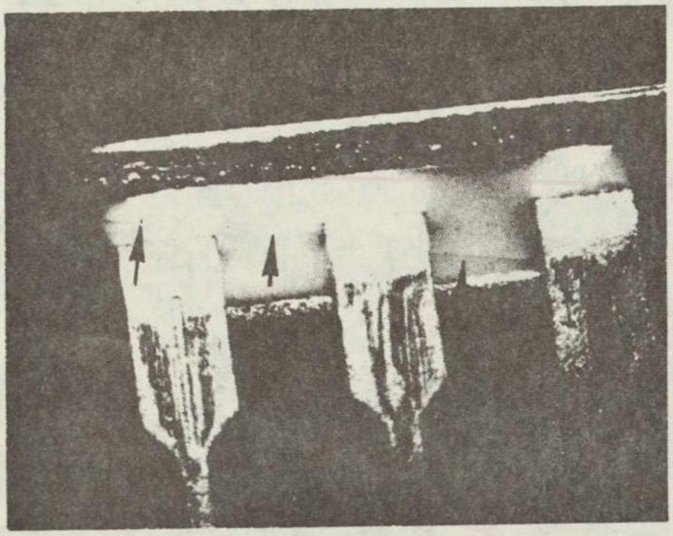


FIGURE 16. SOLID STATE SCIENTIFIC 14 LEAD CERAMIC DIP - LEAK DUE TO CRACK IN LEAD SEAL AFTER LEAD TENSION TEST.

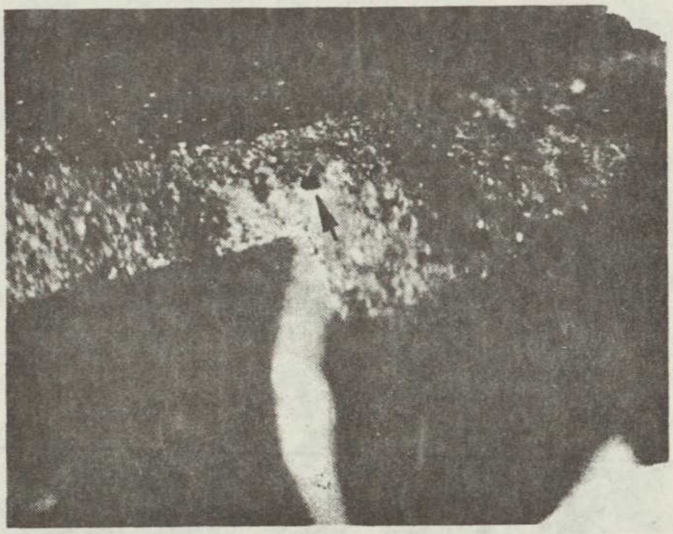


FIGURE 17. ITT 14 LEAD CERDIP - LEAK AT GLASS LEAD SEAL AFTER 0°C/100°C THERMAL SHOCK SEQUENCE.

FIGURE 18. TEXAS INSTRUMENTS 1/4 X 1/8 METAL PACK - LEAK AT LID WELD SEAL, INITIAL TEST FAILURE.

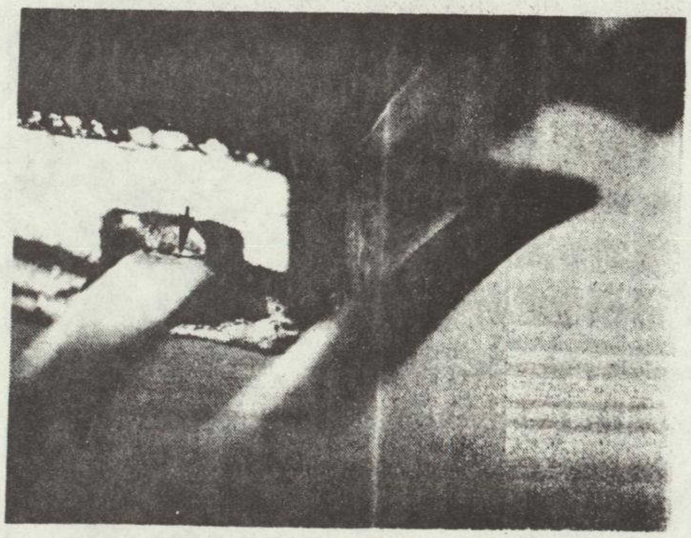


FIGURE 19. TEXAS INSTRUMENTS 1/4 X 1/8 METAL PACK - LEAK AT GLASS LEAD SEAL, INITIAL TEST FAILURE.

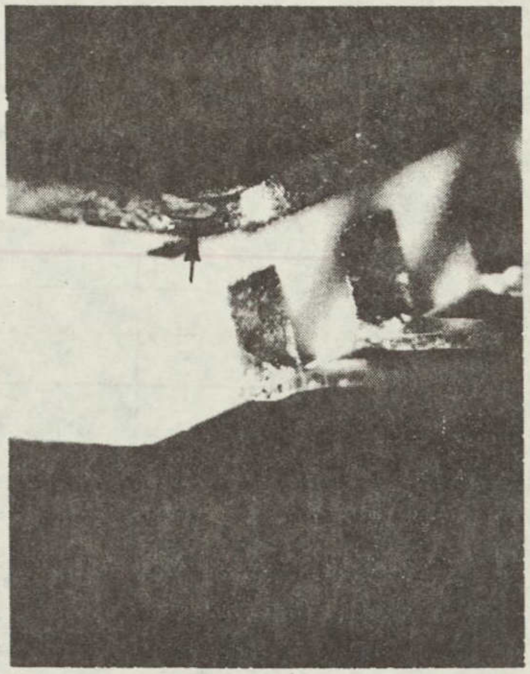


FIGURE 20. NATIONAL 16 LEAD CERAMIC FLAT PACK - LEAK AT LID SOLDER SEAL AFTER -55°C/ 125°C THERMAL CYCLE SEQUENCE.

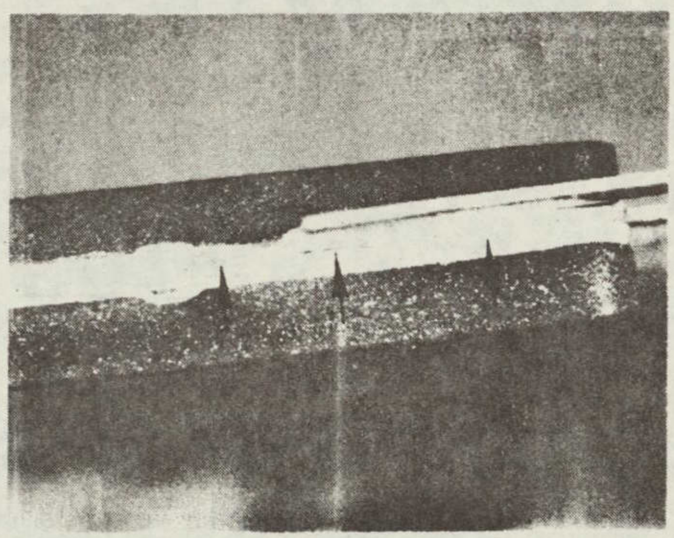


FIGURE 21. FAIRCHILD 14 LEAD CERPAK - LEAK AT GLASS LEAD SEAL, INITIAL TEST FAILURE.

TABLE 22. FINE LEAK RATES - THERMAL SHOCK TEST

PACKAGE TYPE	MANUF.	APPENDIX A REFERENCE	RELATIVE RANKING	NO. INTO TEST	FINE LEAK RATES - AVERAGE ($\overline{X}$) & STD. DEV. (σ) (10^{-9} ATM CC/S)									
					INITIAL DATA		0°C TO 100°C 50 CYCLES		-25°C TO 100°C 50 CYCLES		-55°C TO 125°C 50 CYCLES		-65°C TO 150°C 50 CYCLES	
					$\overline{X}$	σ	$\overline{X}$	σ	$\overline{X}$	σ	$\overline{X}$	σ	$\overline{X}$	σ
DUAL IN-LINE														
24 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A29	2	40	5.6	1.6	7.1	3.9	7.3	4.3	5.8	3.8	5.9	3.6
40 LEAD WHITE CERAMIC, SIDE BRAZE LEADS	KYOCERA	A30	5	37	6.9	4.7	10.5	6.1	8.1	2.8	8.3	4.0	8.5	3.2
16 LEAD WHITE CERAMIC, BOTTOM BRAZE LEADS	RCA	A22	14	40	5.0	2.3	9.2	3.1	17.3	6.9	13.2	5.6	13.7	6.7
14 LEAD WHITE CERAMIC, METAL TOP AND BOTTOM	SOLID STATE SCIENTIFIC	A19	18	36	16.4	8.0	8.2	3.3	20.7	10.6	16.9	9.7	13.7	6.1
14 LEAD CERDIP, BLACK	MOTOROLA	A13	19	40	18.8	7.6	17.4	4.2	25.4	7.4	26.8	6.7	37.8	8.1
14 LEAD CERDIP, BLACK	ITT	SIMILAR TO A13	19	40	22.2	6.9	17.1	10.7	9.1	4.5	8.6	4.0	7.8	2.7
FLAT PACKAGES														
14 LEAD 1/4" X 1/8" METAL	TEXAS INST.	A7	1	40	7.4	2.2	6.3	1.7	7.5	2.7	6.4	2.0	8.6	3.5
16 LEAD WHITE CERAMIC BOTTOM BRAZE LEADS	NATIONAL	A12	3	40	4.0	1.2	2.2	0.6	8.5	4.1	4.2	1.1	8.6	2.9
14 LEAD CERPAK, BLACK	DIACON	A1	8	40	5.6	2.1	6.4	3.0	3.8	0.8	8.3	2.7	4.7	1.5
14 LEAD CERPAK, BLACK	FAIRCHILD	SIMILAR TO A2	9	37	18.4	10.1	4.4	1.1	5.2	1.4	4.8	2.7	4.8	1.1

TABLE 24. FINE LEAK RATES - HIGH TEMPERATURE BAKE

PACKAGE TYPE	MANUF.	APPENDIX A REFERENCE	RELATIVE RANKING	NO. INTO TEST	FINE LEAK RATES - AVERAGE ($\bar{X}$) & STD. DEV. (σ) (10^{-9} ATM CC/S)									
					INITIAL DATA		200°C 72 HOURS		225°C 72 HOURS		250°C 72 HOURS		275°C 72 HOURS	
					$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
DUAL IN-LINE														
24 LEAD WHITE CERAMIC SIDE BRAZE LEADS	KYOCERA	A29	2	18	3.5	0.5	2.9	0 6	2.8	0 5	2 9	0.5	3.6	1.0
40 LEAD WHITE CERAMIC SIDE BRAZE LEADS	KYOCERA	A30	5	18	4.1	0.5	7.7	2.5	7.9	2.9	10.6	2.9	8.9	1.3
16 LEAD WHITE CERAMIC BOTTOM BRAZE LEADS	RCA	A22	14	18	4.7	2.3	9.4	2.1	18.1	4.7	17.6	5.8	14.2	6.1
14 LEAD WHITE CERAMIC METAL TOP AND BOTTOM	SOLID STATE SCIENTIFIC	A19	18	16	7.7	1.7	11.6	3.9	13.3	2.6	9.5	2.6	9.4	2.6
14 LEAD CERDIP BLACK	MOTOROLA	A13	19	18	17.9	3.3	13.6	2.0	24 9	8.2	24.3	4.8	18.3	3.1
14 LEAD CERDIP, BLACK	ITT	SIMILAR TO A13	19	17	20.9	6.3	6.8	1.7	14.3	1.6	11.3	1.7	6.6	1.0
FLAT PACKAGES														
14 LEAD 1/4 X 1/8 METAL	TEXAS INST.	A7	1	18	6.0	1.4	4.6	1.1	6 9	0.7	4.1	0.5	3.3	0.8
16 LEAD WHITE CERAMIC BOTTOM BRAZE LEADS	NATIONAL	A12	3	18	2.8	1.1	4.8	1.2	7.1	1.1	3.0	0.7	2.5	0.4
14 LEAD CERPAK, BLACK	DIACON	A1	8	18	8.8	1.5	3.7	0.8	5.0	0.7	2.7	0.5	2.6	0.4
14 LEAD CERPAK, BLACK	FAIRCHILD	SIMILAR TO A2	9	18	4.9	1.0	3.5	0.6	3.7	0.7	3.6	0.6	3.9	0.6

8.0 CONCLUSIONS

A wide range of hermetic DIP and flat pack configurations are available and used in today's electronic equipment. Configurations range from the lowest ranked (least reliable) soft glass body Cerdip/Cerpak to the highest ranked (most reliable) metal flat pack and cofired ceramic side brazed DIP. None of the thirty five (35) packages examined constituted an ideal package, and improvements could be made in even the highest ranked package. Cerdips and Cerpaks were ranked lowest for a multiplicity of reasons, including: a) high lid sealing temperature, b) lid seal not separate from lead seal, c) the possibility of lead (Pb) precipitates from the soft glass seal, d) difficulty of piece part alignment during assembly, and e) susceptibility to seal damage and exposure of lead base material due to lead forming and flexure. The highest ranking flat pack (metal package with hard glass lead seal) does not exhibit most of the deficiencies noted with the Cerpak. Its major weaknesses were the conductive base, susceptability of the glass lead seals to damage during lead flexure, and a non flat lead frame bonding area. A metal package with a non conductive finish on the base and the use of a lead frame with a flat bonding area is recommended. However, the susceptibility of the lead seals to damage from lead flexure is inherent with glass lead seals, and no recommendations can be made in this area for the metal package. The multilayer cofired side brazed ceramic package, which is the highest ranked DIP, eliminates the problem of damaged glass lead seals. However, its major weaknesses are: a) requires many individual piece parts and process steps to manufacture, b) leads are susceptible to stress corrosion cracking unless the proper plating processes are employed, c) lids and leads are frequently misaligned, and d) lead frame bonding areas are gold plated, and the use of aluminum flywires can result in intermetallic formation. A single layer package utilizing fewer piece parts is recommended, but available single layer ceramic packages suffer from weaknesses (use of down-bonding and epoxy seals) that outweigh the advantage of simpler construction. Construction features to minimize the probability of misaligned lids and leads are also recommended for the ceramic DIP.

Although the literature search indicated seal integrity was a major package problem, and the ranking process suggested a wide variation in seal integrity, environmental tests of package seal integrity failed to reveal, with one exception, any important difference in package types. The Solid State Scientific ceramic DIP with metal top and bottom was clearly more susceptible to thermal stress induced lead and lid seal damage than the other packages evaluated. Use of this type package in a temperature shock/cycling environment should be avoided. The lack of sufficient failure data for the remaining package types precluded correlations with package ranking. However, this does not invalidate the rankings. It only indicates that the susceptibility to thermal induced seal damage is similar for most of the packages evaluated. The relative ranking assigned to each package was based on numerous factors in addition to seal integrity.

Although cost data was not collected, the relative cost appeared to be directly related to the ranking. Higher ranking packages cost more, and the type of package to use in a given application must be based on a cost-reliability trade-off. Critical applications in severe environments where replacement of failed devices is not practical will require the highest ranked, most expensive package. Less critical applications will probably use the lower ranked, less expensive packages. However, it is important to understand the relative package strengths and weaknesses prior to selecting a package type, and this study has provided much of the required information for hermetic DIPs and flat packs.

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APPENDIX A

MICROCIRCUIT PACKAGE CONSTRUCTION ANALYSIS

TABLE OF CONTENTS

CONSTRUCTION ANALYSIS DATA -A1

Diacon 14 Lead Cerpak

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Diacon

   B. TYPE PACKAGE 14 Lead Flat Pack

   C. PART NUMBER N/A

   D. DATE CODE N/A

   E. DEVICE FUNCTION N/A

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510-F1

2. MATERIAL IDENTIFICATION

   A. BODY Special "Low Moisture, Low Temp Glass"

   B. BASE Ceramic - Black

   C. LID Ceramic - Black

   D. LEAD FRAME INTERNAL Kovar (type)

   E. LEAD FRAME PLATING INTERNAL Aluminum

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Special "Low Moisture, Low Temp Glass"

   J. LID PLATING N/A

   K. LID SEAL Special "Low Moisture, Low Temp Glass"

3. DIE ATTACH MATERIAL Special Glass

4. INTERNAL FLY WIRE TYPE N/A

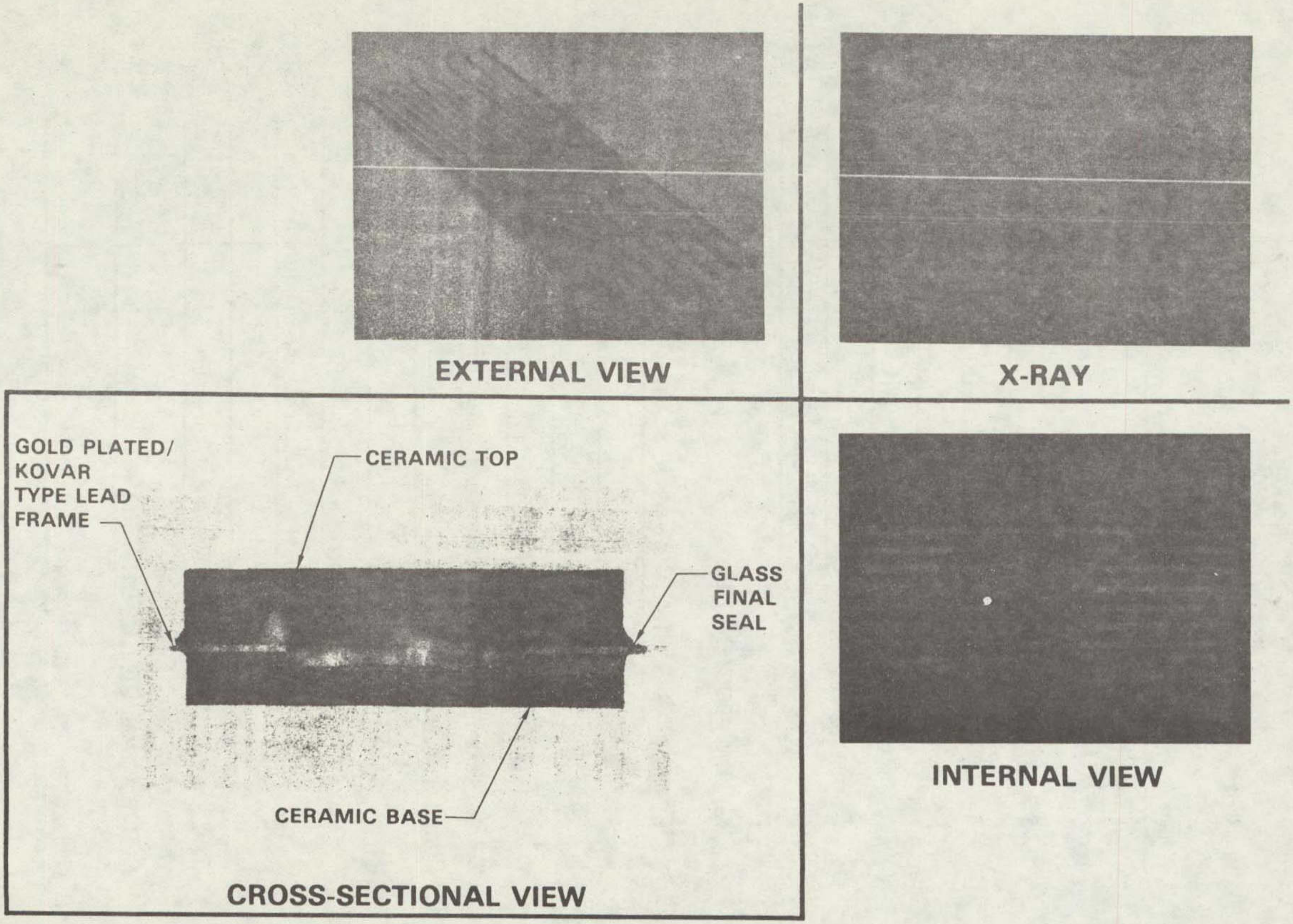

Figure A1 Construction Details – Diacon 14 Lead CERPAK

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA -A2

Motorola 14 Lead Black Cerpak

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Motorola

   B. TYPE PACKAGE 14 Lead Flat Pack

   C. PART NUMBER JM38510/00202BAB

   D. DATE CODE 7626

   E. DEVICE FUNCTION Dual J-K flip flop

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510-F1

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE Ceramic - Black

   C. LID Ceramic - Black

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Aluminum

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Tin

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Gray Glass

   J. LID PLATING N/A

   K. LID SEAL Gray Glass

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

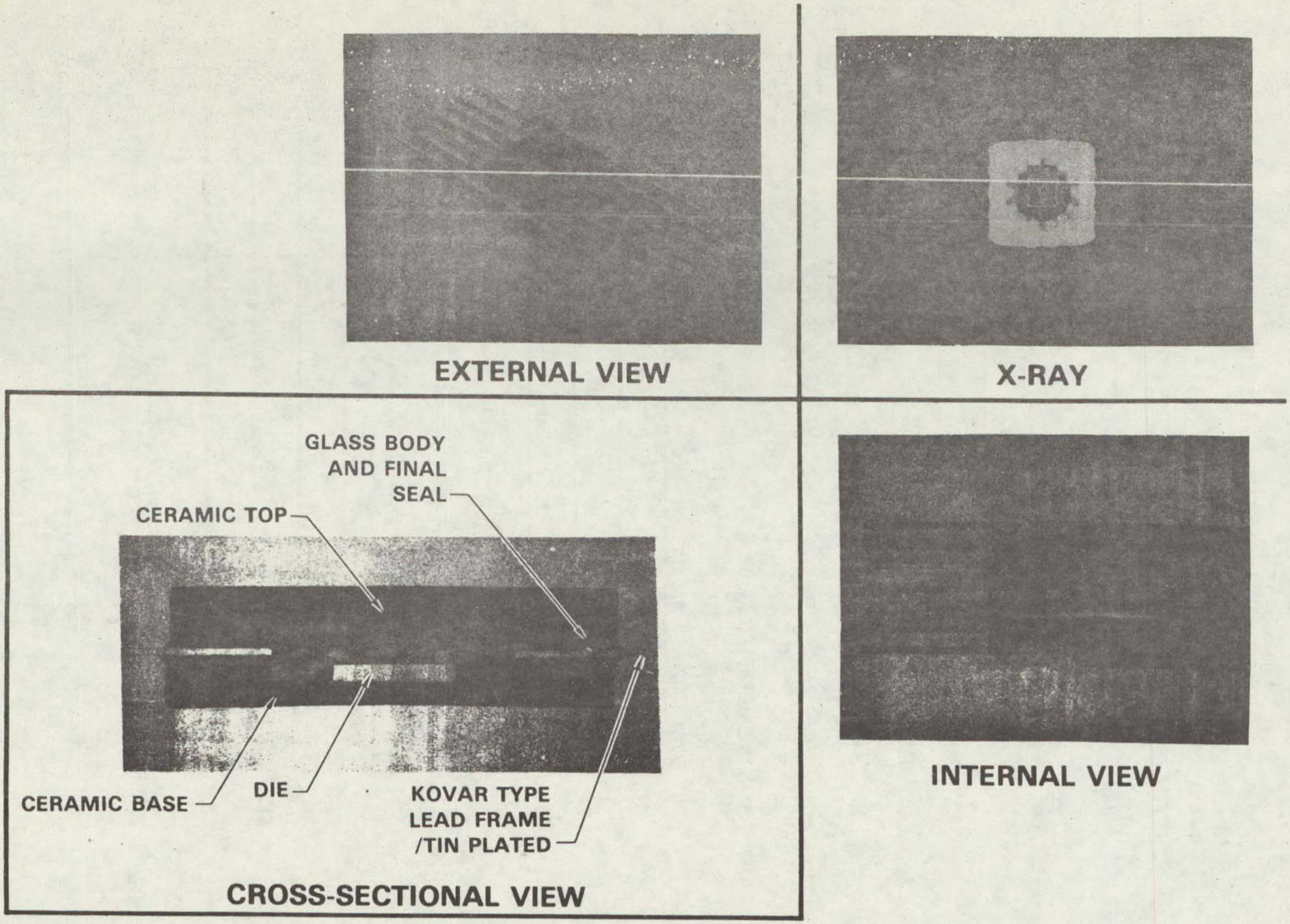

Figure A2 Construction Details – Motorola 14 Lead Black CERPAK

MCDONNELL DOUGLAS CORPORATION

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CONSTRUCTION ANALYSIS DATA -A3

Motorola 16 Lead Black Cerpak

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Motorola

   B. TYPE PACKAGE 16 Lead Flat Pack

   C. PART NUMBER JM38510/01306BFB

   D. DATE CODE 7541

   E. DEVICE FUNCTION Synchronous 4-Bit Binary Counter

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-F5

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE Ceramic - Black

   C. LID Ceramic - Black

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Aluminum

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Tin

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Gray Glass

   J. LID PLATING N/A

   K. LID SEAL Gray Glass

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

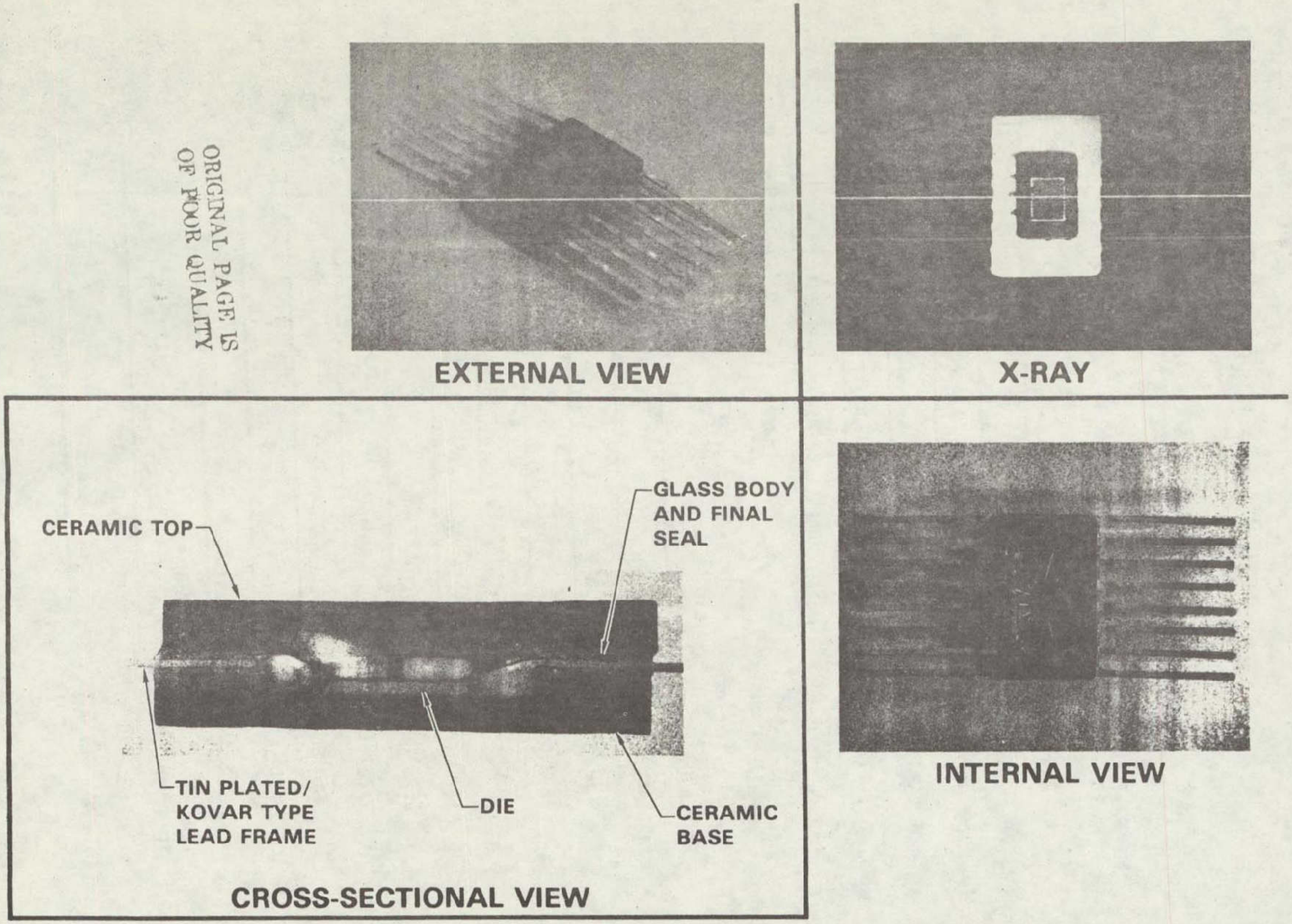


Figure A3 Construction Details – Motorola 16 Lead Black CERPAK

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA -A4

Motorola 14 Lead White Cerpak

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Motorola

   B. TYPE PACKAGE 14 Lead Flat Pack

   C. PART NUMBER 11400173

   D. DATE CODE 7210

   E. DEVICE FUNCTION

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510-F1

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE Ceramic - Black

   C. LID Ceramic - Black

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Gray Glass

   J. LID PLATING N/A

   K. LID SEAL Gray Glass

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

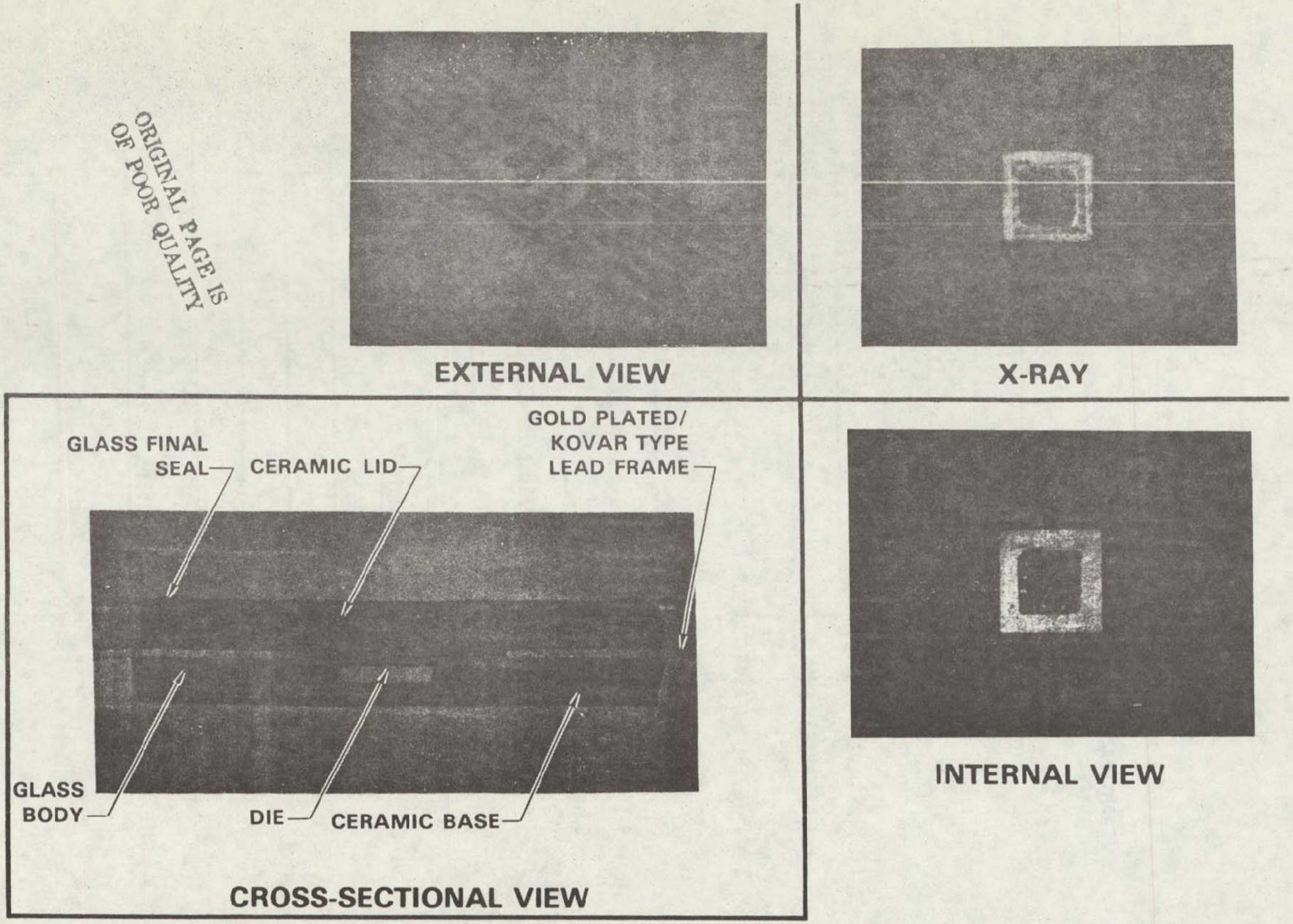


Figure A4 Construction Details – Motorola 14 Lead White CERPAK

CONSTRUCTION ANALYSIS DATA - A5

Fairchild 16 Lead White Cerpak

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Fairchild

   B. TYPE PACKAGE 16 Lead Flat Pack

   C. PART NUMBER N/A

   D. DATE CODE N/A

   E. DEVICE FUNCTION N/A

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510-F5

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE Ceramic - White

   C. LID Ceramic - White

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Aluminum

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Tin

   H. EXTERNAL LEAD ATTACH N/A

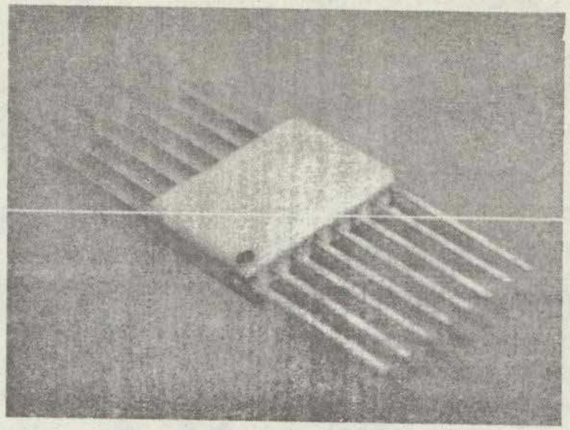
   I. LEAD SEAL Gray Glass

   J. LID PLATING N/A

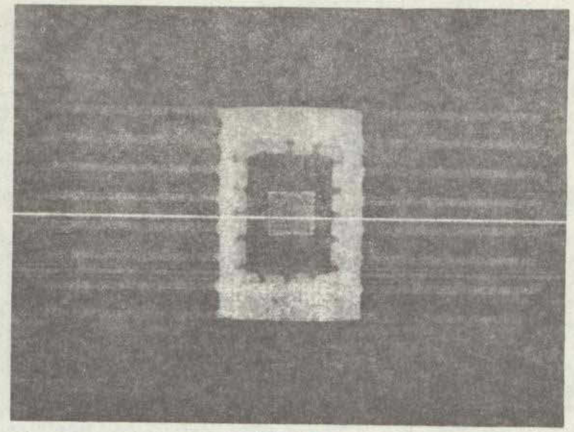
   K. LID SEAL Gray Glass

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

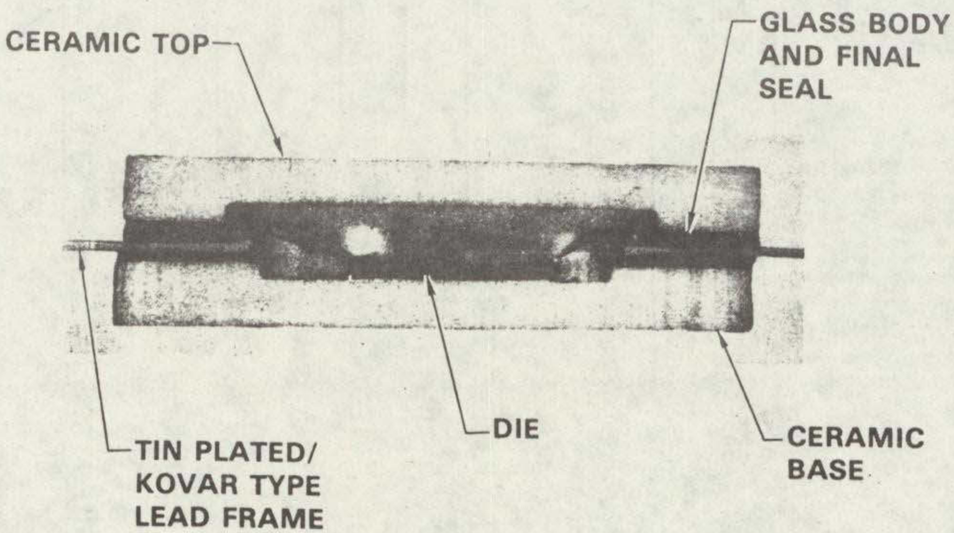
4. INTERNAL FLY WIRE TYPE Aluminum



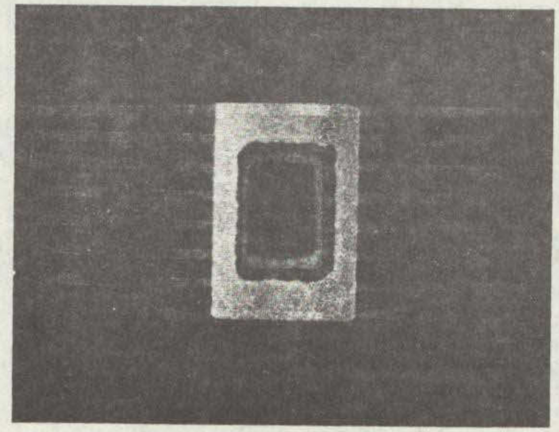
EXTERNAL VIEW



X-RAY



CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A5 Construction Details — Fairchild 16 Lead White CERPAK

CONSTRUCTION ANALYSIS DATA -A6

Fairchild 24 Lead White Cerpak

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Fairchild

   B. TYPE PACKAGE 24 Lead Flat Pack

   C. PART NUMBER 11400172

   D. DATE CODE 7207

   E. DEVICE FUNCTION 1 of 16 Decoder

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510-F6

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE BeO

   C. LID BeO

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Aluminum

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Gray Glass

   J. LID PLATING N/A

   K. LID SEAL Gray Glass

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

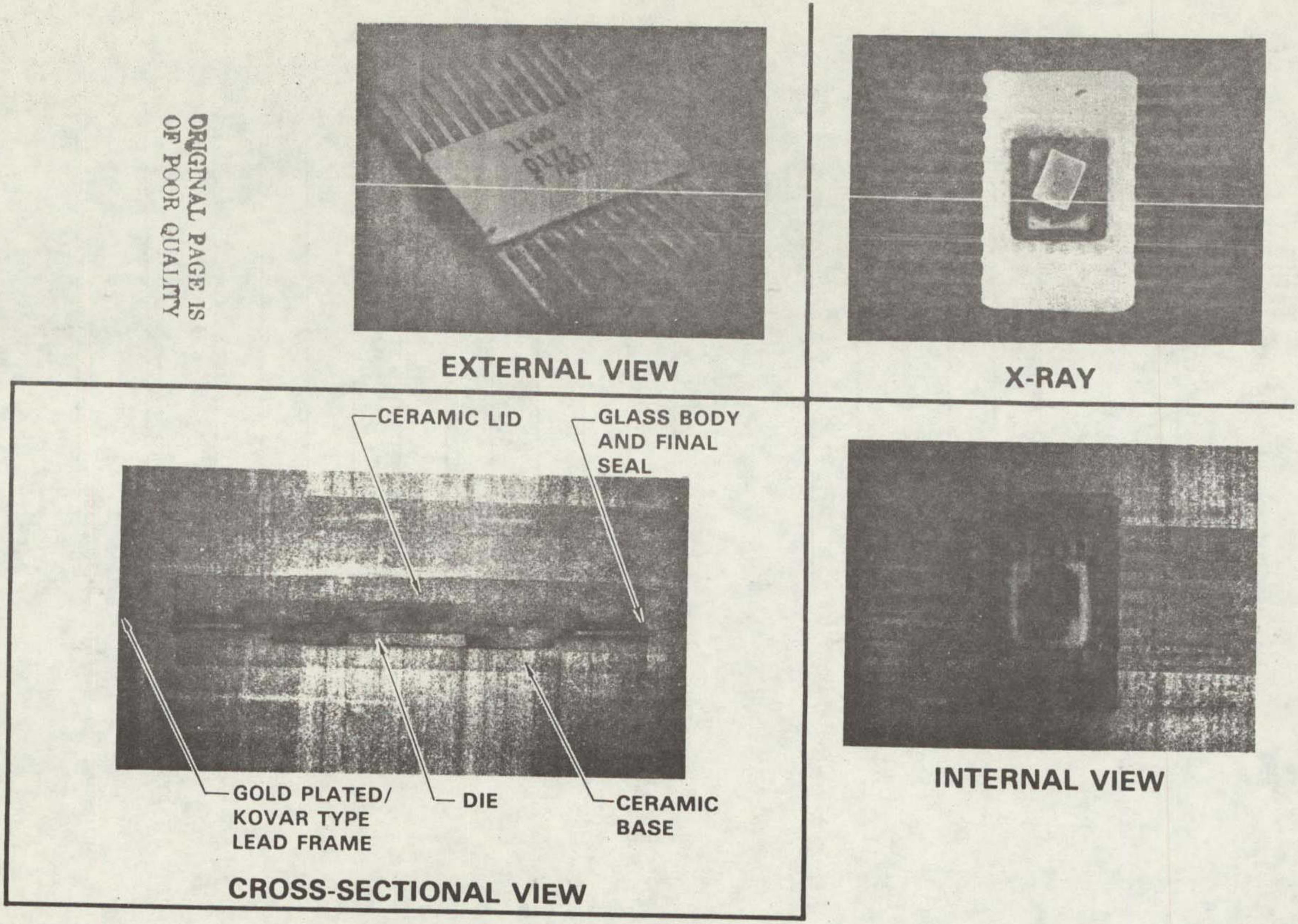


Figure A6 Construction Details – Fairchild 24 Lead White CERPAK (BEO)

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA-A7

Texas Instrument 14 Lead Metal Flat Pack

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Texas Instrument

   B. TYPE PACKAGE 14 Lead Flat Pack

   C. PART NUMBER 54L10

   D. DATE CODE 7323A

   E. DEVICE FUNCTION Triple 3-input Positive NAND

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-F3

2. MATERIAL IDENTIFICATION

   A. BODY Metal Gold Plated

   B. BASE Metal Gold Plated

   C. LID Metal Gold Plated

   D. LEAD FRAME INTERNAL F15 Type

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL F15 Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Amber Glass

   J. LID PLATING Gold

   K. LID SEAL Welded

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Gold

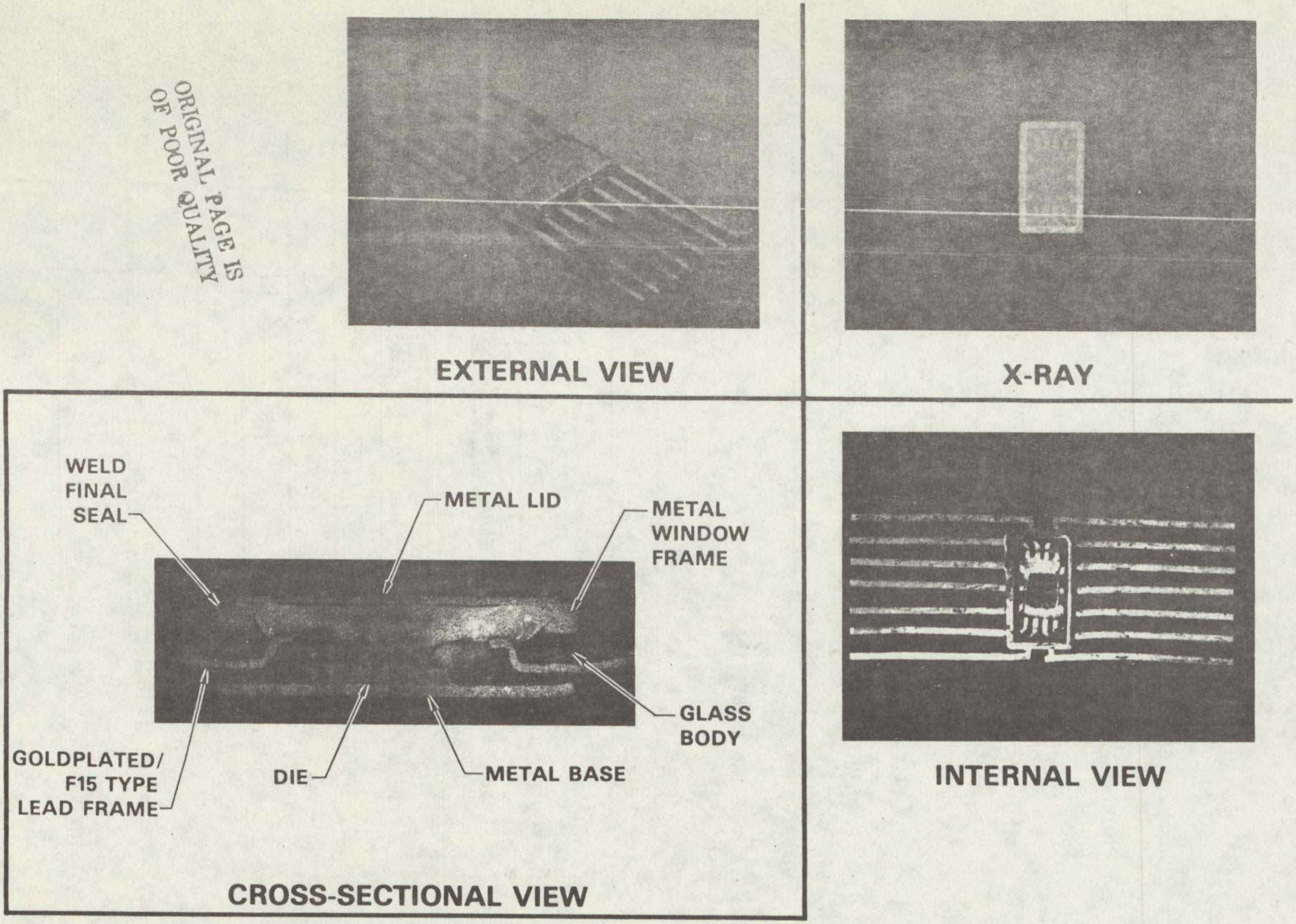


Figure A7 Construction Details — Texas Instrument 14 Lead Metal

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA -A8

National 10 Lead White Ceramic/Metal Top and Bottom

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER National Semiconductor Co.

   B. TYPE PACKAGE 10 Lead Flat Pack

   C. PART NUMBER LM108A

   D. DATE CODE 7217

   E. DEVICE FUNCTION Operational Amplifier

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510-F4

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE Metal

   C. LID Metal

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Gray Glass

   J. LID PLATING Gold

   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

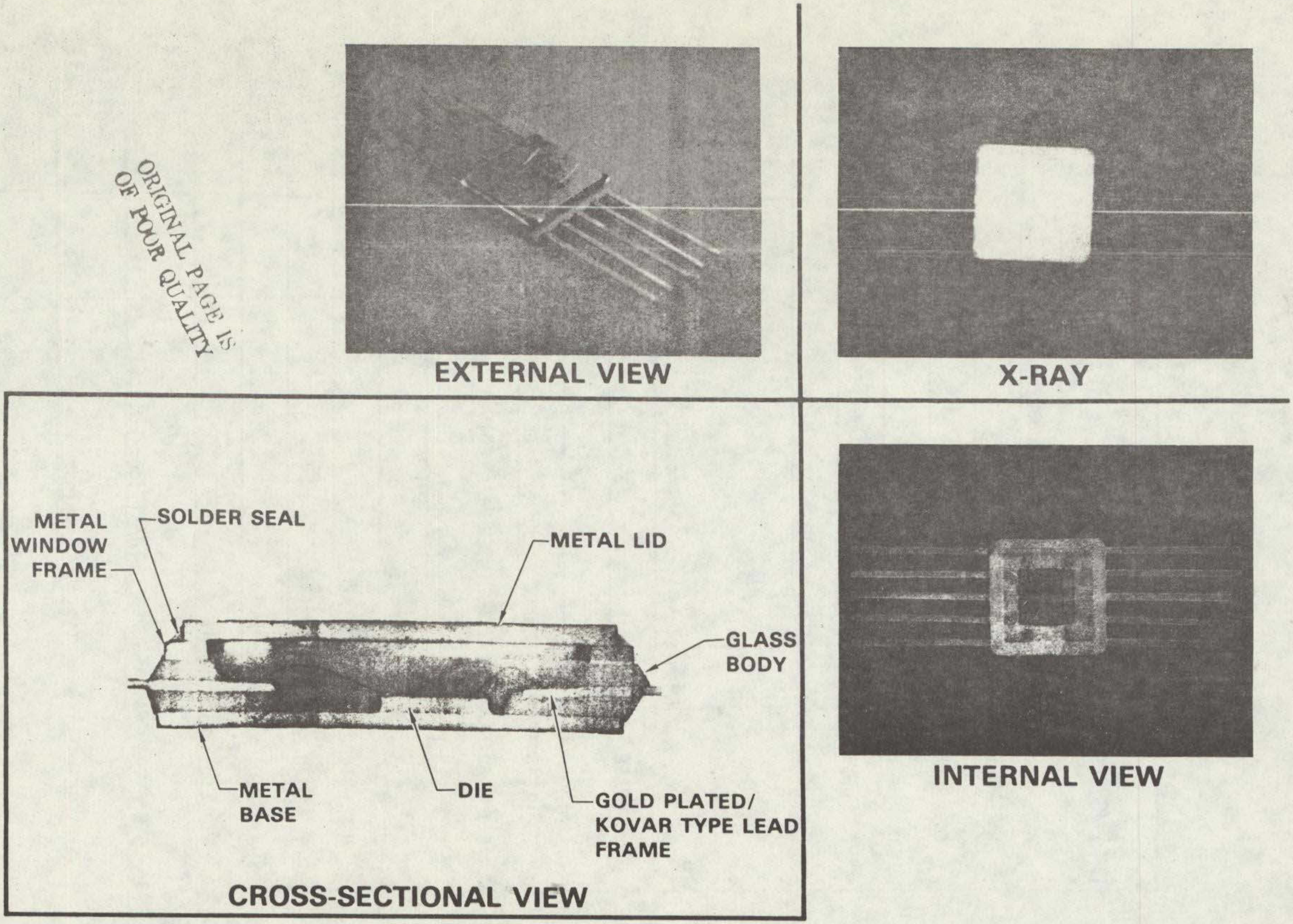


Figure A8 Construction Details – National 10 Lead White Ceramic/Metal Top and Bottom

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA -A9

National 14 Lead White Ceramic/Metal Top and Bottom

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER National Semiconductor

   B. TYPE PACKAGE 14 Lead Flat Pack

   C. PART NUMBER M38510/002058AA

   D. DATE CODE 7137

   E. DEVICE FUNCTION Dual D-Type Flip Flop

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510-F1

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE Metal

   C. LID Metal

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold Plated - Solder Dipped

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Gray Glass

   J. LID PLATING Gold

   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

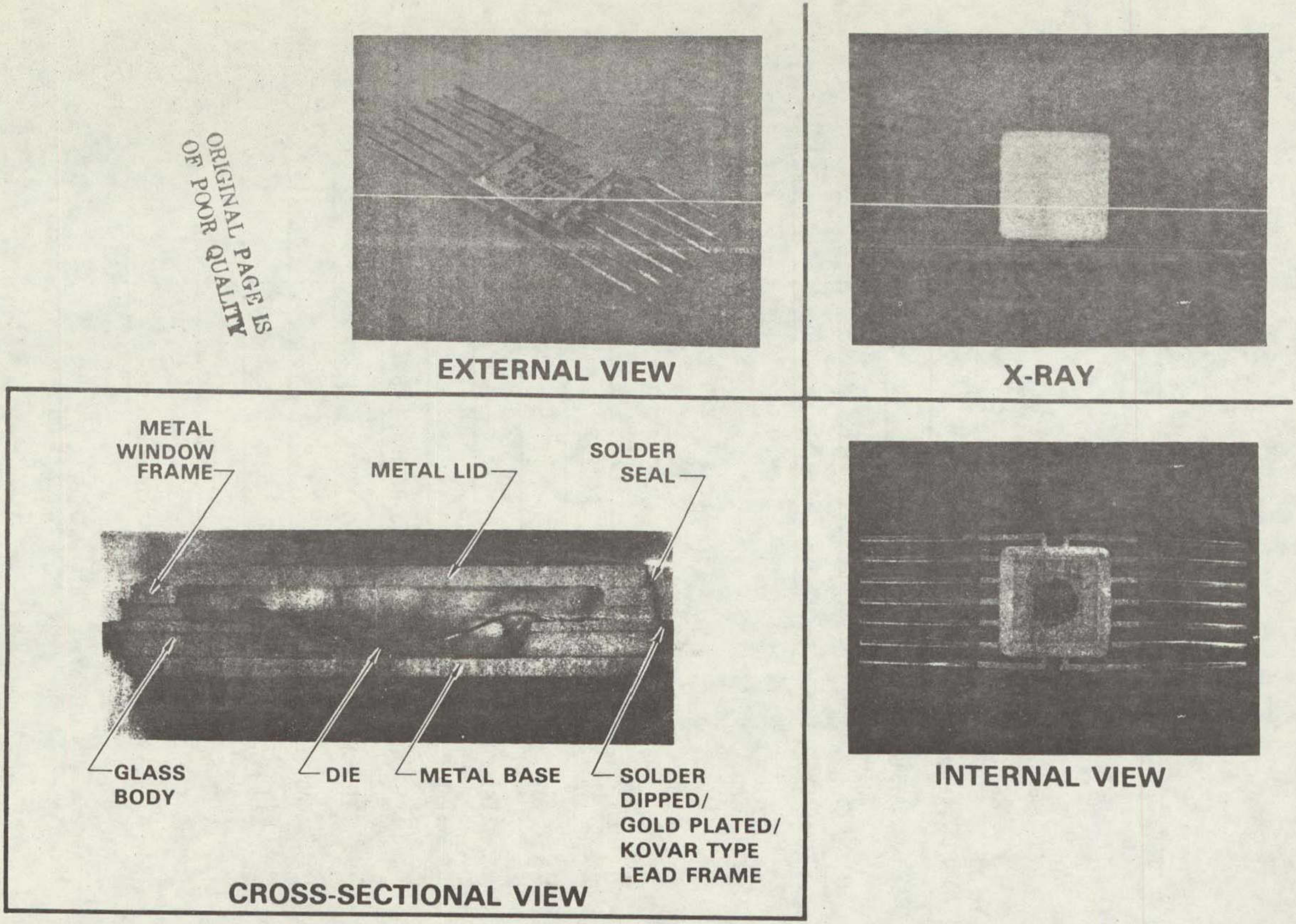


Figure A9 Construction Details – National 14 Lead White Ceramic/Metal Top and Bottom

CONSTRUCTION ANALYSIS DATA -A10

Siliconix 14 Lead White Ceramic/Metal Top

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Siliconix

   B. TYPE PACKAGE 14 Lead Flat Pack

   C. PART NUMBER DG1296

   D. DATE CODE 6938

   E. DEVICE FUNCTION Analog Switch

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-F1

2. MATERIAL IDENTIFICATION

   A. BODY Black Glass with Metal Window Frame

   B. BASE Ceramic - White

   C. LID Metal

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Black Glass

   J. LID PLATING Gold

   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Gold

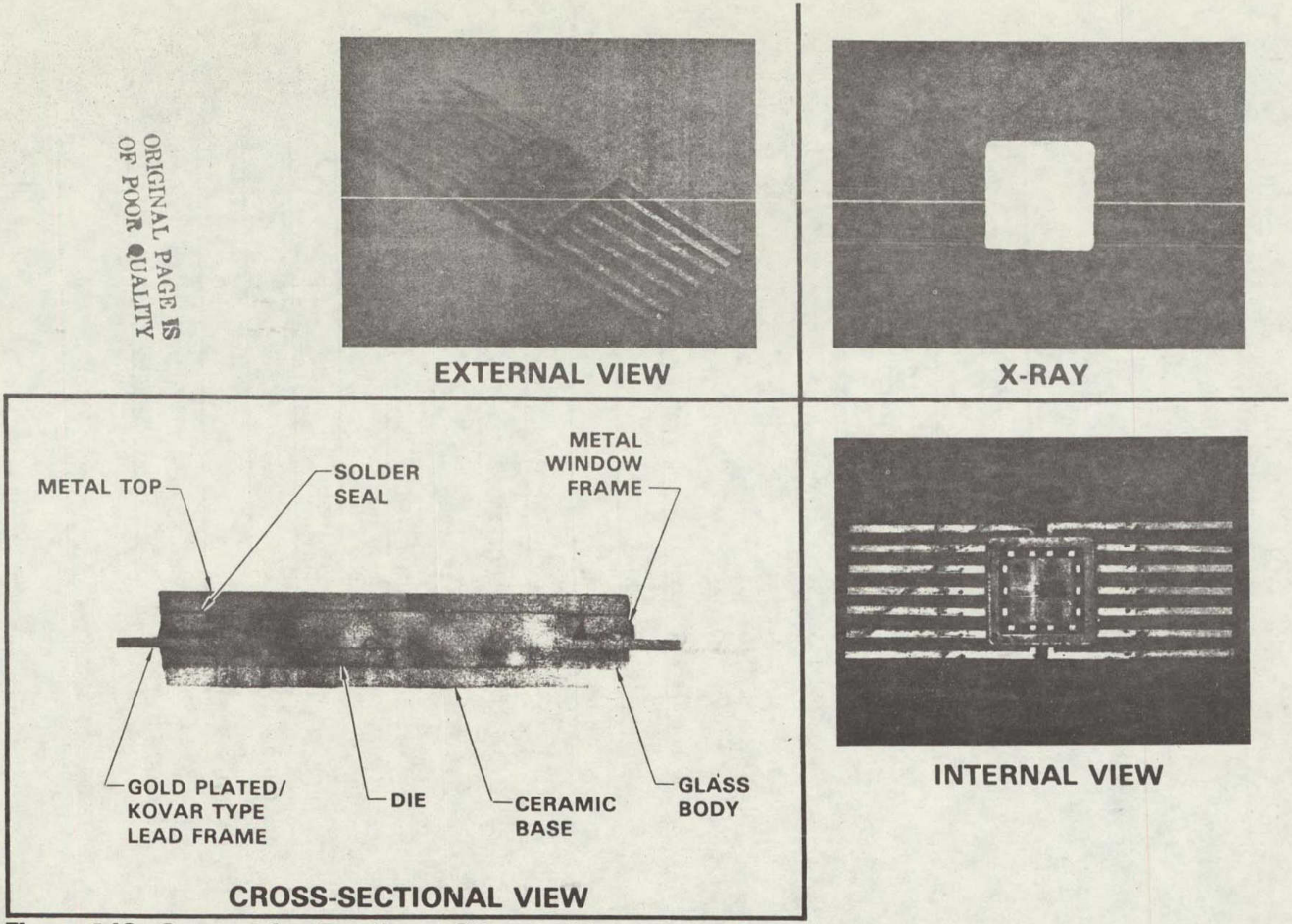


Figure A10 Construction Details – Siliconix 14 Lead White Ceramic/Metal Top

CONSTRUCTION ANALYSIS DATA -A11

RCA 14 Lead White Ceramic/Bottom Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER RCA

   B. TYPE PACKAGE 14 Lead Flat Pack

   C. PART NUMBER 230022

   D. DATE CODE N/A

   E. DEVICE FUNCTION N/A

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-F2

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic

   B. BASE Cofired Ceramic & Epoxy & Fiber Board

   C. LID Metal

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel

   E. LEAD FRAME PLATING INTERNAL Nickel/Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING Nickel

   K. LID SEAL Welded

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

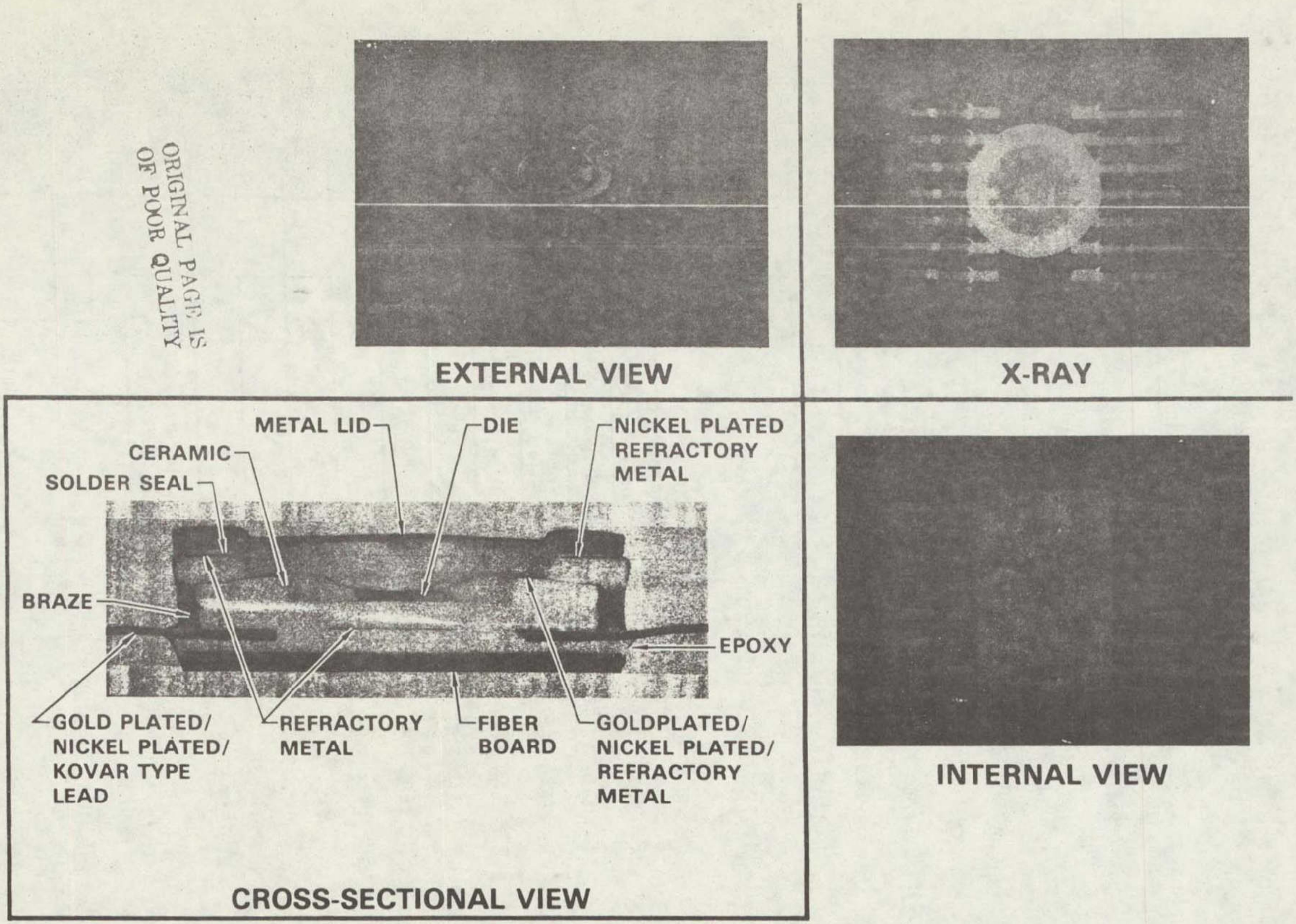


Figure A11 Construction Details – RCA 14 Lead White Ceramic/Bottom Braze Leads

CONSTRUCTION ANALYSIS DATA -A12

National 16 Lead White Ceramic/Bottom Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER National Semiconductor

   B. TYPE PACKAGE 16 Lead Flat Pack

   C. PART NUMBER (7845 on Die)

   D. DATE CODE N/A

   E. DEVICE FUNCTION N/A

   F. PACKAGE DIMENSIONS Similar to 38510C-F5

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic

   B. BASE Cofired Ceramic

   C. LID Metal (Kovar Type)

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING Gold

   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

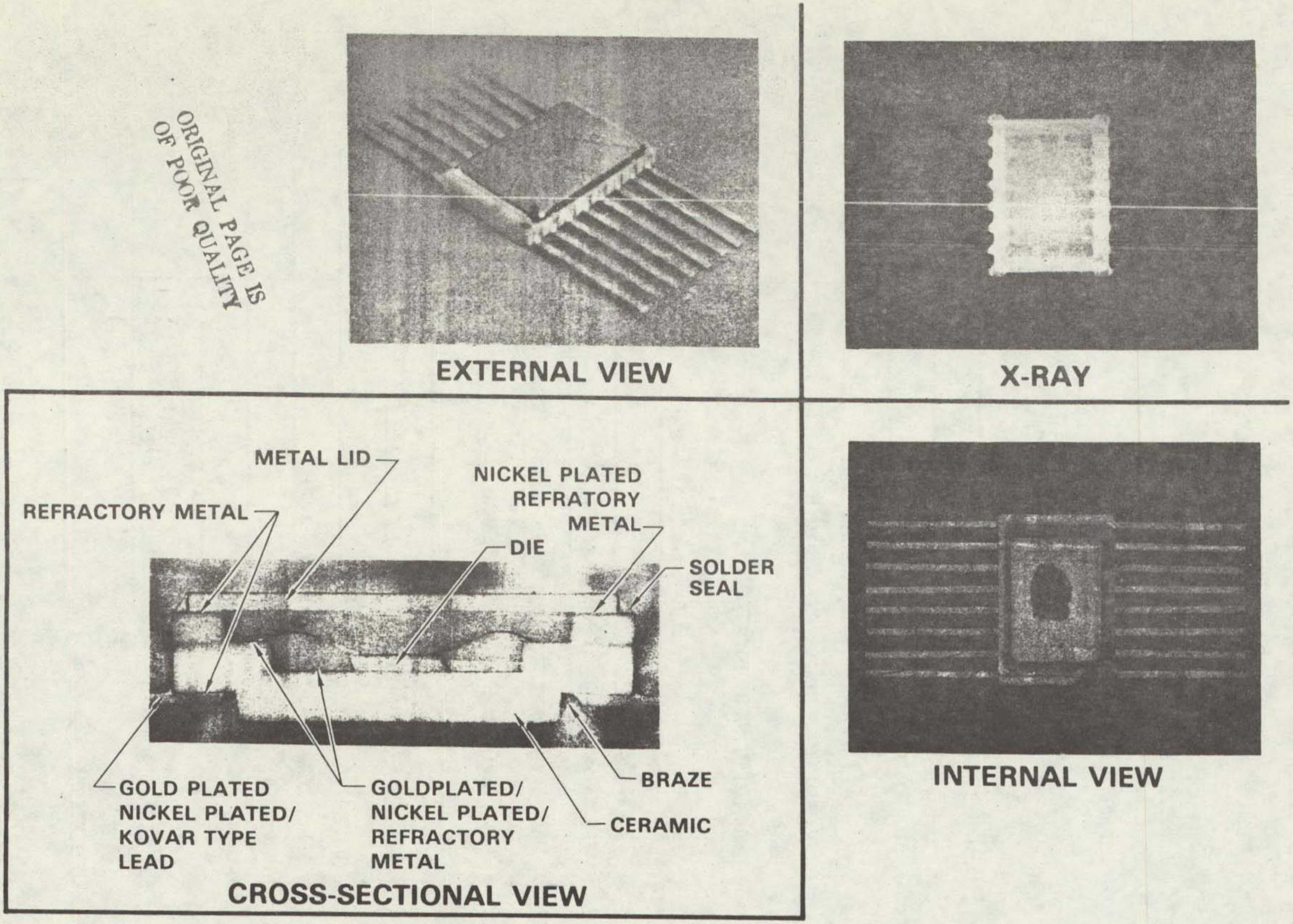


Figure A12 Construction Details – National 16 Lead White Ceramic/Bottom Braze Leads

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA -A13

Motorola 14 Pin Black Cerdip

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Motorola

   B. TYPE PACKAGE 14 Lead Dual in Line

   C. PART NUMBER MC5405L

   D. DATE CODE 7043

   E. DEVICE FUNCTION Hex Inverter

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-C1

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE Ceramic Black

   C. LID Ceramic Black

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Aluminum

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Tin

   H. EXTERNAL LEAD ATTACH N/A

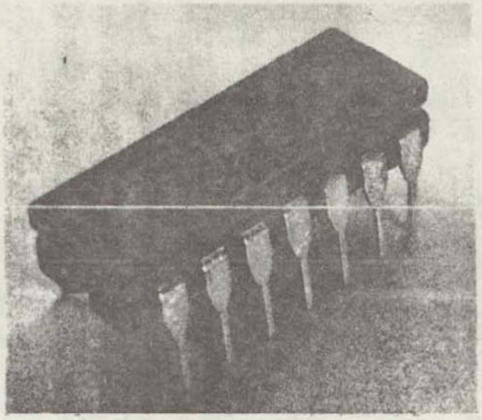
   I. LEAD SEAL Gray Glass

   J. LID PLATING N/A

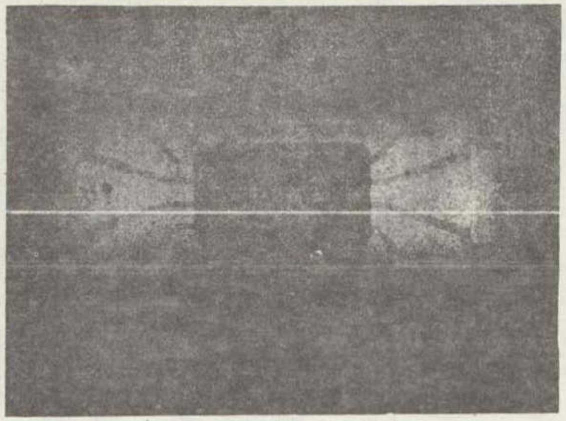
   K. LID SEAL Gray Glass

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

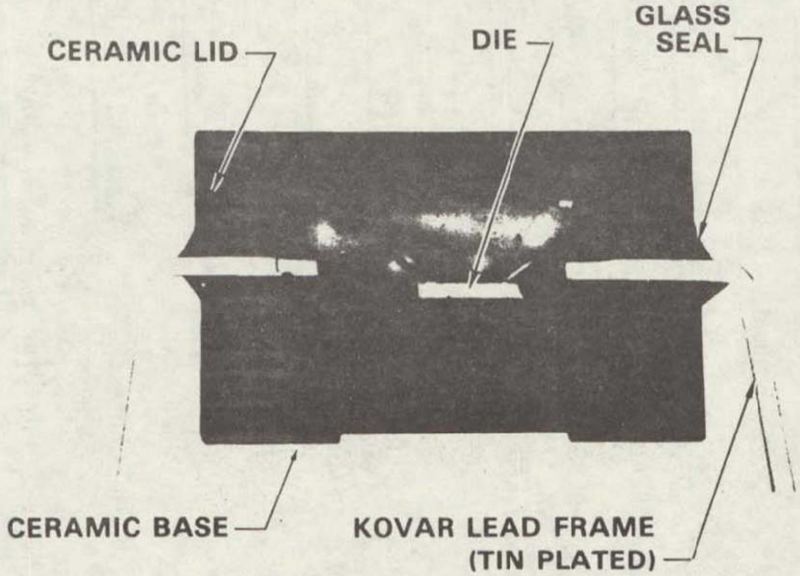
4. INTERNAL FLY WIRE TYPE Aluminum



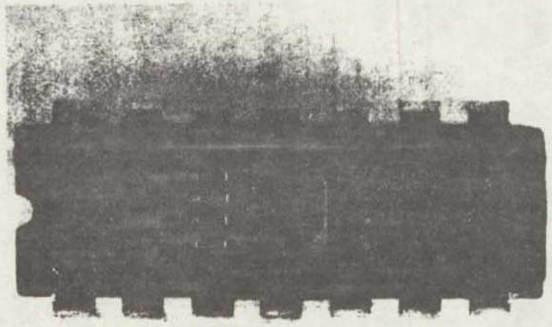
EXTERNAL VIEW



X-RAY



CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A13 Construction Details – Motorola 14 Pin Black CERDIP

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA-A14

Motorola 16 Lead Black Cerdip

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Motorola

   B. TYPE PACKAGE 16 Lead Dual in Line

   C. PART NUMBER MC14501CL

   D. DATE CODE 7230

   E. DEVICE FUNCTION Triple Gate

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D2

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE Ceramic - Black

   C. LID Ceramic - Black

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Aluminum

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Tin

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Gray Glass

   J. LID PLATING N/A

   K. LID SEAL Gray Glass

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

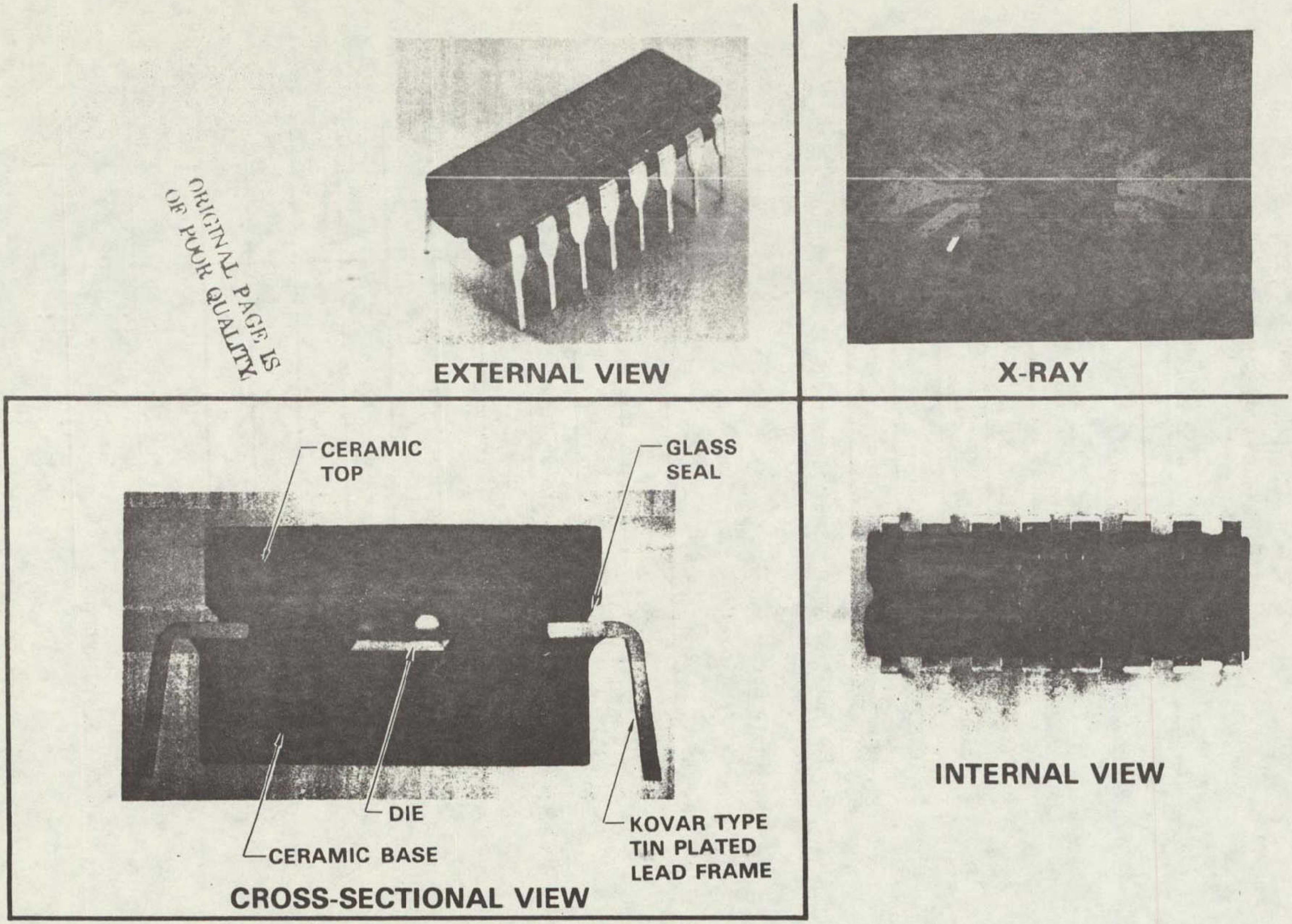


Figure A14 Construction Details – Motorola 16 Lead Black CERDIP

CONSTRUCTION ANALYSIS DATA -A15

Fairchild 24 Lead Black Cerdip

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Fairchild

   B. TYPE PACKAGE 24 Lead Dual In Line

   C. PART NUMBER 11400102 (9311)

   D. DATE CODE 037A

   E. DEVICE FUNCTION 1 of 16 Decoder

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D3

2. MATERIAL IDENTIFICATION

   A. BODY Gray Glass

   B. BASE Ceramic - Black

   C. LID Ceramic - Black

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Aluminum

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH N/A

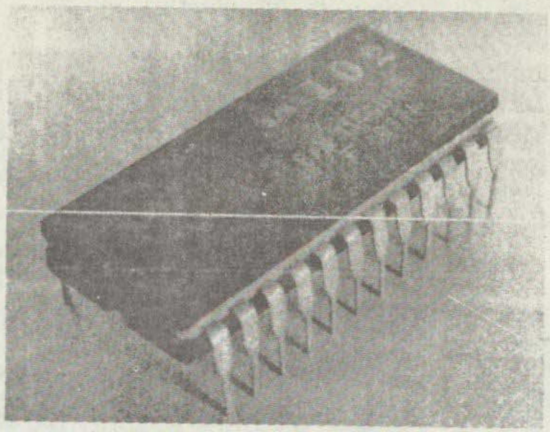
   I. LEAD SEAL Gray Glass

   J. LID PLATING N/A

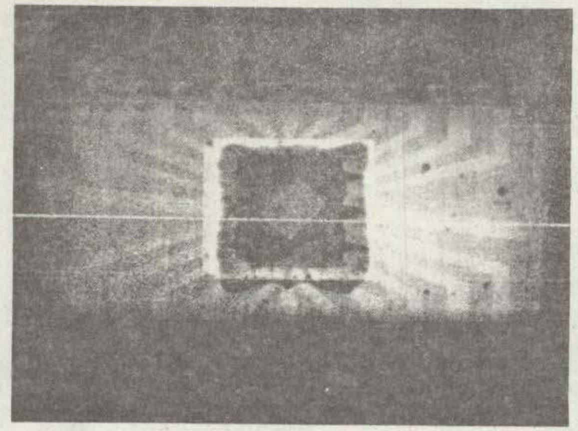
   K. LID SEAL Gray Glass

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum



EXTERNAL VIEW



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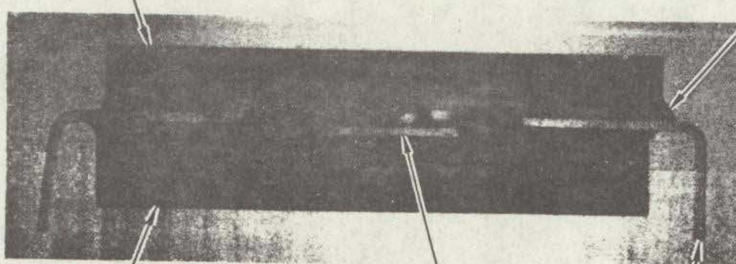
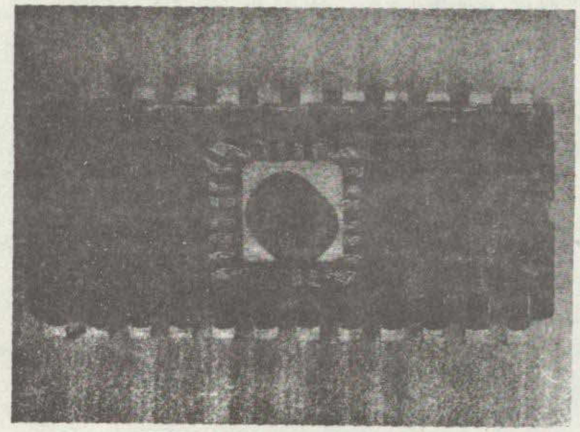


CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A15 Construction Details – Fairchild 24 Lead Black CERDIP

CONSTRUCTION ANALYSIS DATA -A16

Electronic Array White Ceramic/Metal Top and Bottom

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Electronic Array

   B. TYPE PACKAGE 14 Lead Dual In Line

   C. PART NUMBER EA 1205D

   D. DATE CODE 7113

   E. DEVICE FUNCTION Dynamic Shift Register

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D1

2. MATERIAL IDENTIFICATION

   A. BODY Fired Ceramic

   B. BASE Metal

   C. LID Metal

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

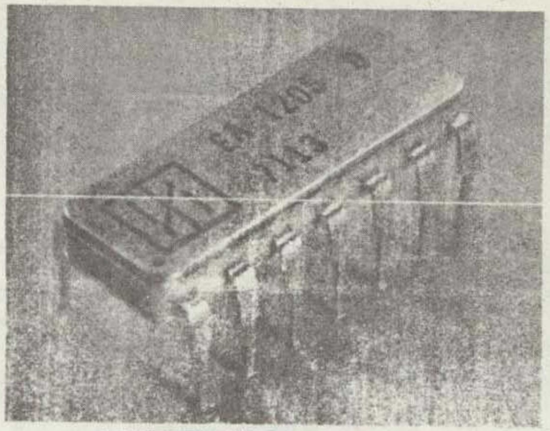
   I. LEAD SEAL Fired Ceramic

   J. LID PLATING Gold

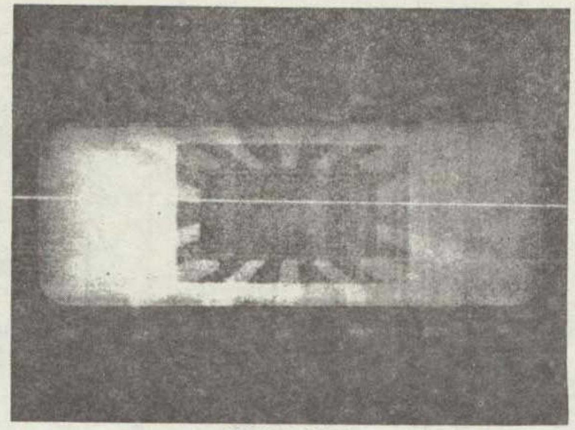
   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum



EXTERNAL VIEW



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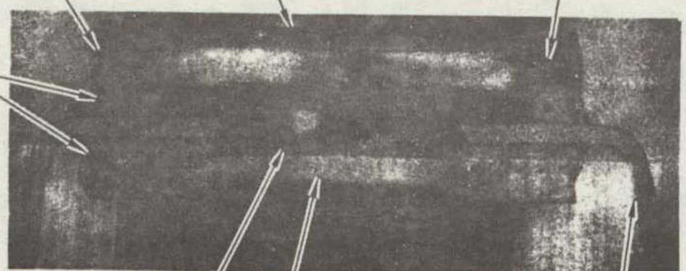
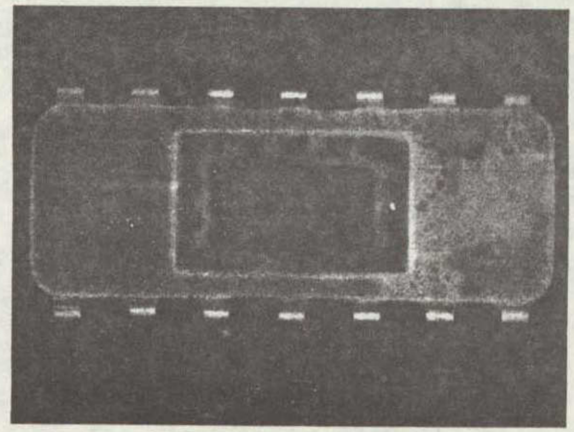


CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A16 Construction Details – Electronic Array White Ceramic/Metal Top and Bottom

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA-A17

National 14 Lead White Ceramic/Metal Top and Bottom

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER National Semiconductor

   B. TYPE PACKAGE 14 Lead Dual In Line

   C. PART NUMBER DM/SN5405J

   D. DATE CODE 7121

   E. DEVICE FUNCTION Hex Inverter

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D1

2. MATERIAL IDENTIFICATION

   A. BODY Ceramic White & Metal Window Frame

   B. BASE Metal

   C. LID Metal

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovary Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

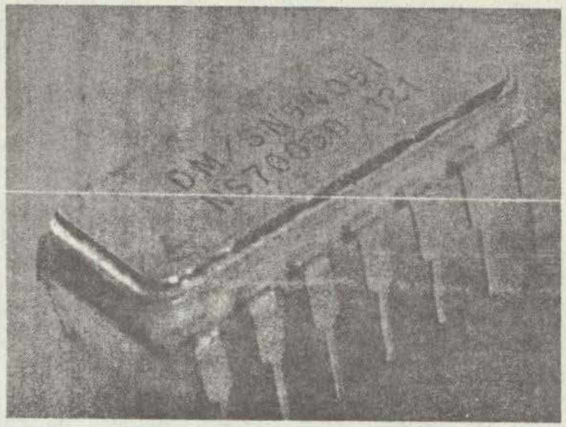
   I. LEAD SEAL Ceramic - White

   J. LID PLATING Gold

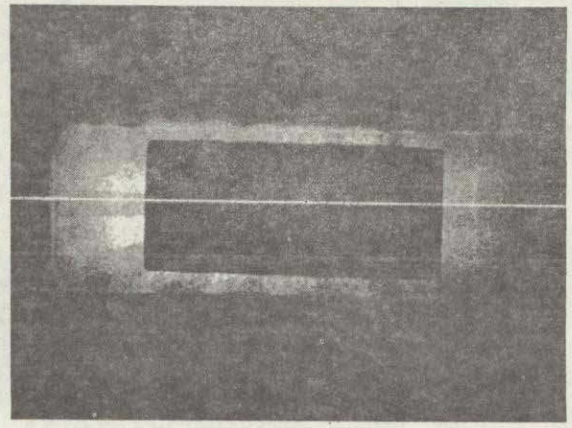
   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum



EXTERNAL VIEW



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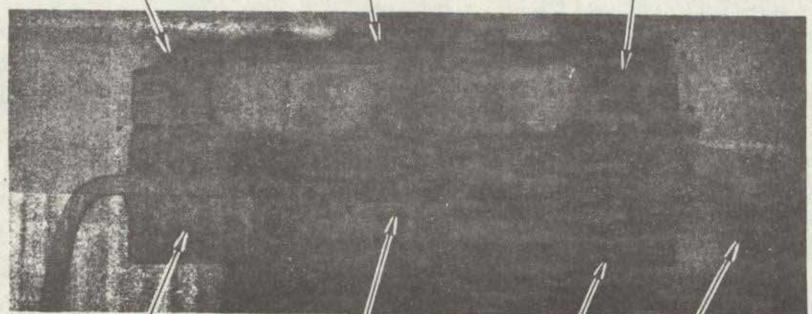
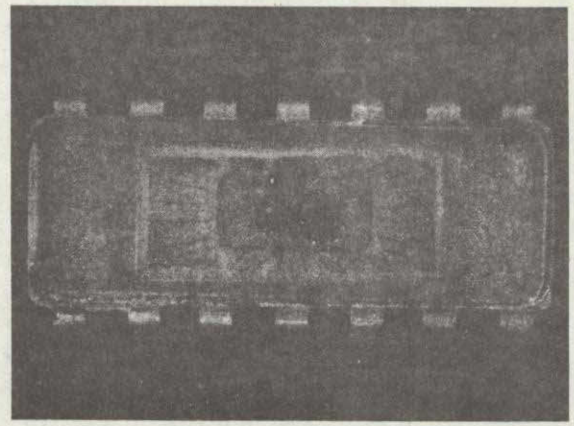


CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A17 Construction Details – National 14 Lead White Ceramic/Metal Top and Bottom

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA -A18

Raytheon 14 Lead White Ceramic/Metal Top and Bottom

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Raytheon Semiconductor

   B. TYPE PACKAGE 14 Lead Dual In Line

   C. PART NUMBER RM963D

   D. DATE CODE 7110

   E. DEVICE FUNCTION DTL

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D1

2. MATERIAL IDENTIFICATION

   A. BODY Ceramic - White & Metal Frame

   B. BASE Metal

   C. LID Metal

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

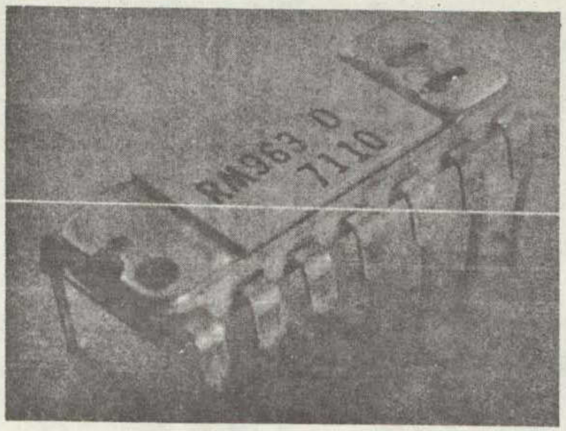
   I. LEAD SEAL Ceramic -White

   J. LID PLATING Gold

   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum



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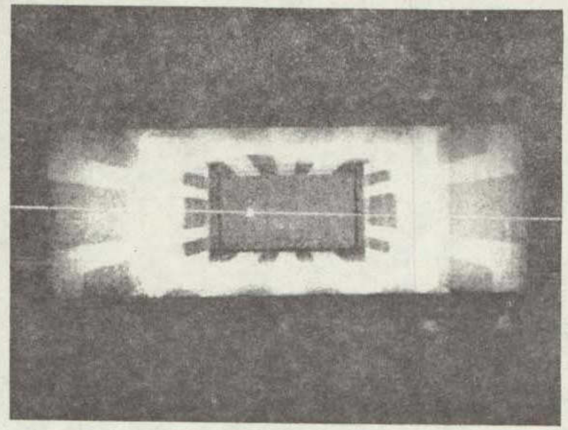

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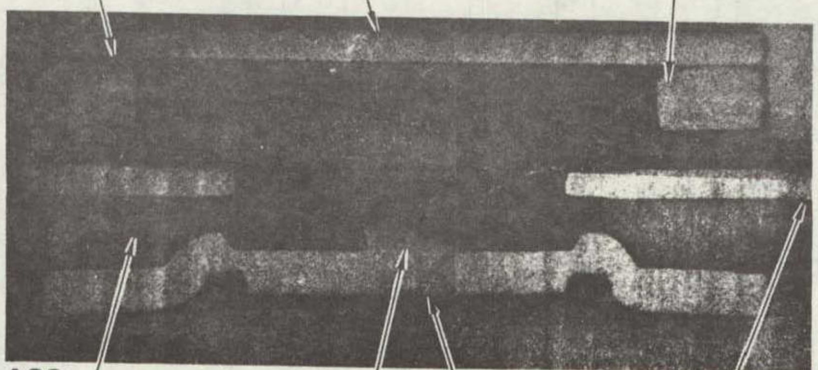
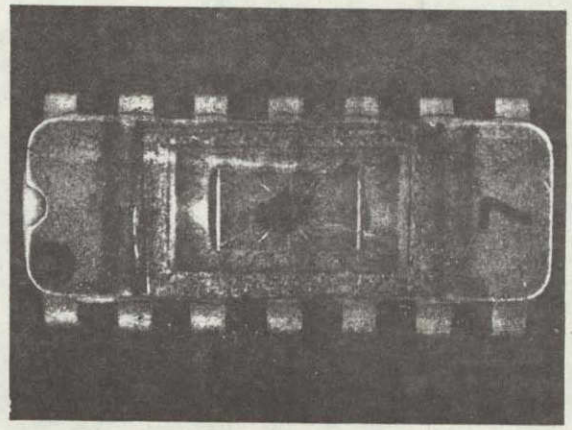


CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A18 Construction Details – Raytheon 14 Lead White Ceramic/Metal Top and Bottom

CONSTRUCTION ANALYSIS DATA - A19

Solid State Scientific 16 Lead White Ceramic/Metal Top and Bottom

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Solid State Scientific

   B. TYPE PACKAGE 16 Lead Dual In Line

   C. PART NUMBER SCL5510

   D. DATE CODE N/A

   E. DEVICE FUNCTION N/A

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D2

2. MATERIAL IDENTIFICATION

   A. BODY Ceramic White & Metal Window Frame

   B. BASE Metal

   C. LID Metal

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Ceramic White

   J. LID PLATING Gold

   K. LID SEAL Solder

3. DIE ATTACH MATERIAL

4. INTERNAL FLY WIRE TYPE Aluminum

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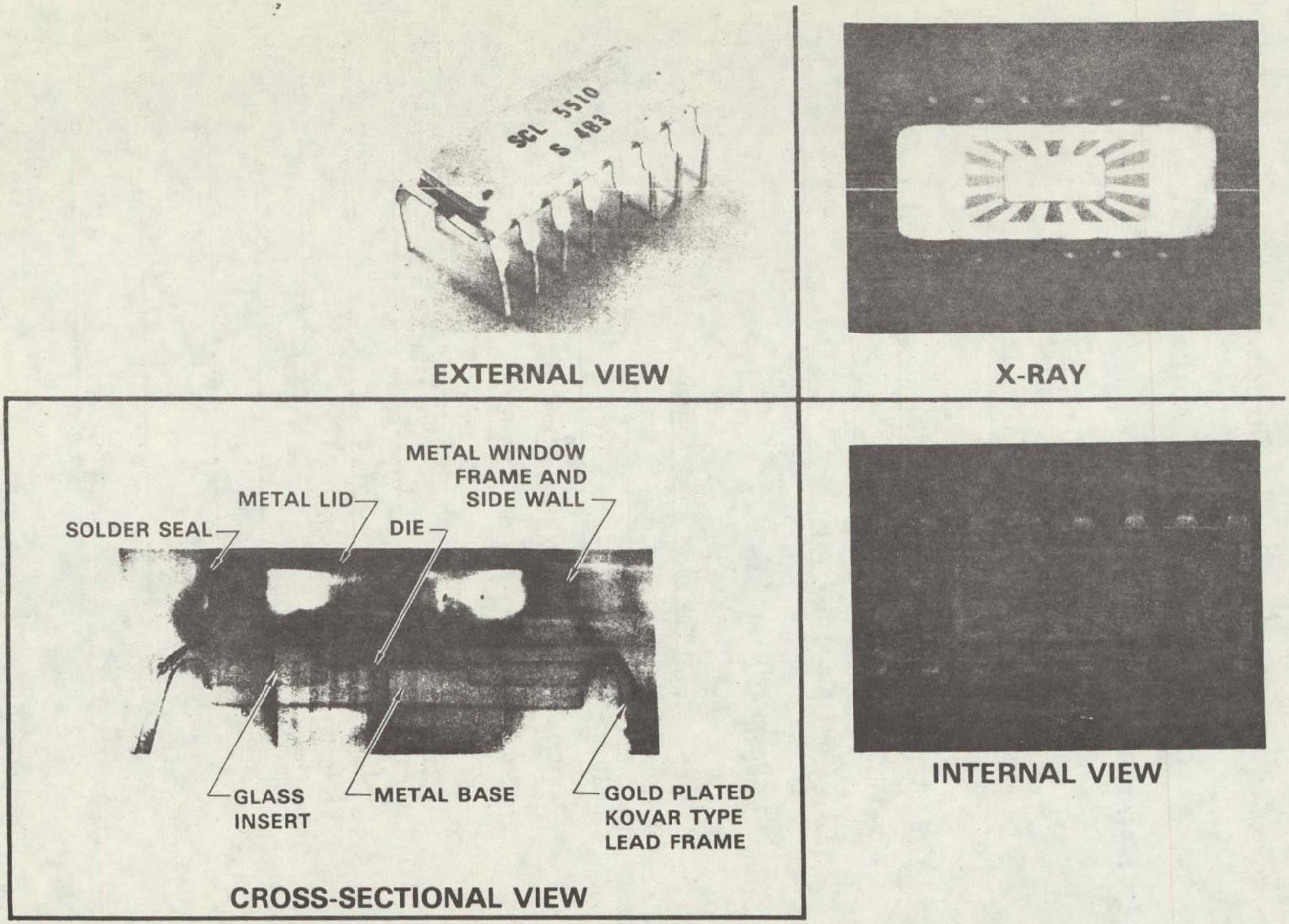


Figure A19 Construction Details — Solid State Scientific 16 Lead White Ceramic/Metal Top and Bottom

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA -A20

ITT 24 Lead White Ceramic/Metal Lid

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER ITT Semiconductor

   B. TYPE PACKAGE 24 Lead Dual In Line

   C. PART NUMBER ITT9311

   D. DATE CODE None

   E. DEVICE FUNCTION 1 of 16 Decoder

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D3

2. MATERIAL IDENTIFICATION

   A. BODY Ceramic White & Metal Window Frame

   B. BASE Ceramic White

   C. LID Metal

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

   I. LEAD SEAL Ceramic White

   J. LID PLATING Gold

   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

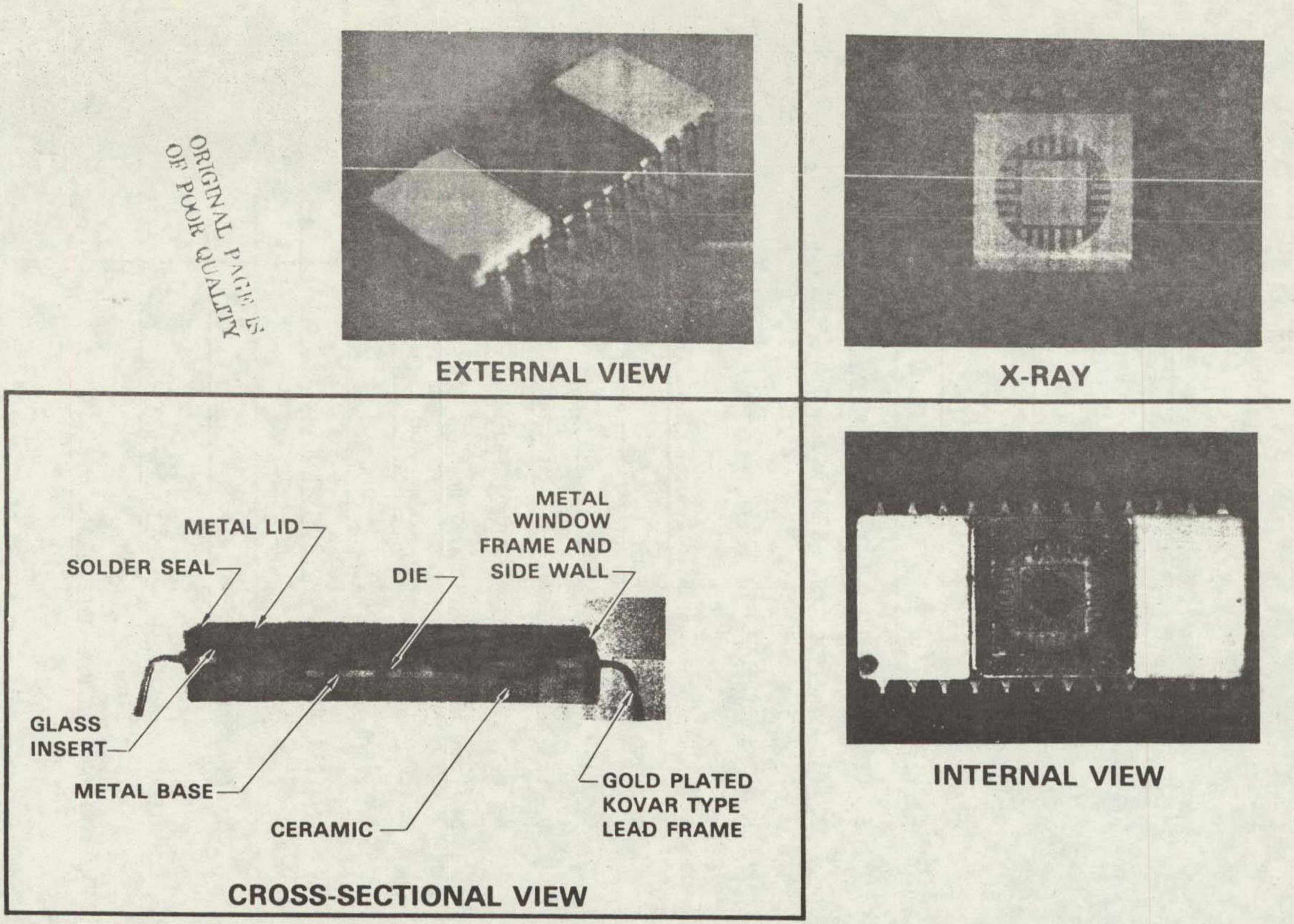


Figure A20 Construction Details – ITT 24 Lead White Ceramic/Metal Lid

CONSTRUCTION ANALYSIS DATA -A21

Motorola 24 Lead White Ceramic/Metal Top

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Motorola

   B. TYPE PACKAGE 24 Lead Dual In-Line

   C. PART NUMBER MC14508CL

   D. DATE CODE 7234

   E. DEVICE FUNCTION

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D3

2. MATERIAL IDENTIFICATION

   A. BODY Ceramic - White & Metal Window Frame

   B. BASE Ceramic

   C. LID Metal

   D. LEAD FRAME INTERNAL Kovar Type

   E. LEAD FRAME PLATING INTERNAL Gold

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold

   H. EXTERNAL LEAD ATTACH N/A

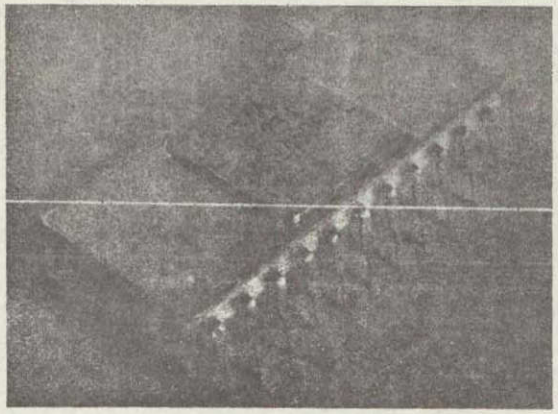
   I. LEAD SEAL Ceramic White

   J. LID PLATING Gold

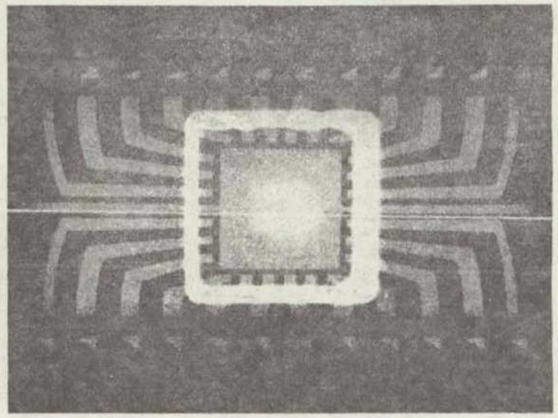
   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

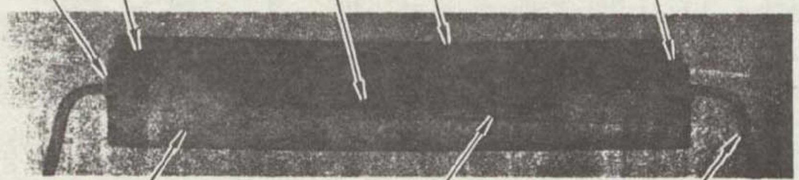
4. INTERNAL FLY WIRE TYPE Aluminum



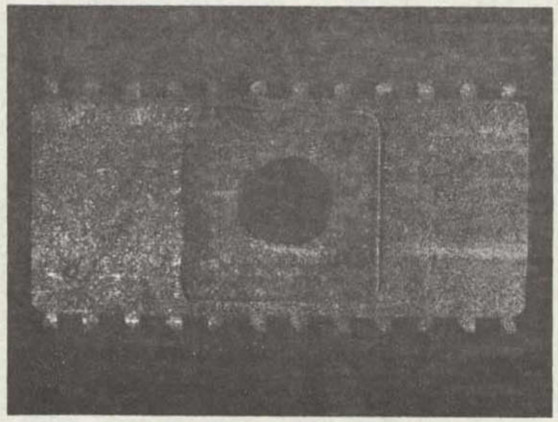
EXTERNAL VIEW



X-RAY



CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A21 Construction Details – Motorola 24 Lead White Ceramic/Metal Top

CONSTRUCTION ANALYSIS DATA -A22

RCA 16 Lead Dual-In-Line

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER RCA

   B. TYPE PACKAGE 16 Lead Dual In-Line

   C. PART NUMBER TA5873

   D. DATE CODE 7104

   E. DEVICE FUNCTION

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D2

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic White

   B. BASE Cofired Ceramic White

   C. LID Metal Round

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Braze

   H. EXTERNAL LEAD ATTACH Cofired Ceramic

   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING Nickel

   K. LID SEAL Welded

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

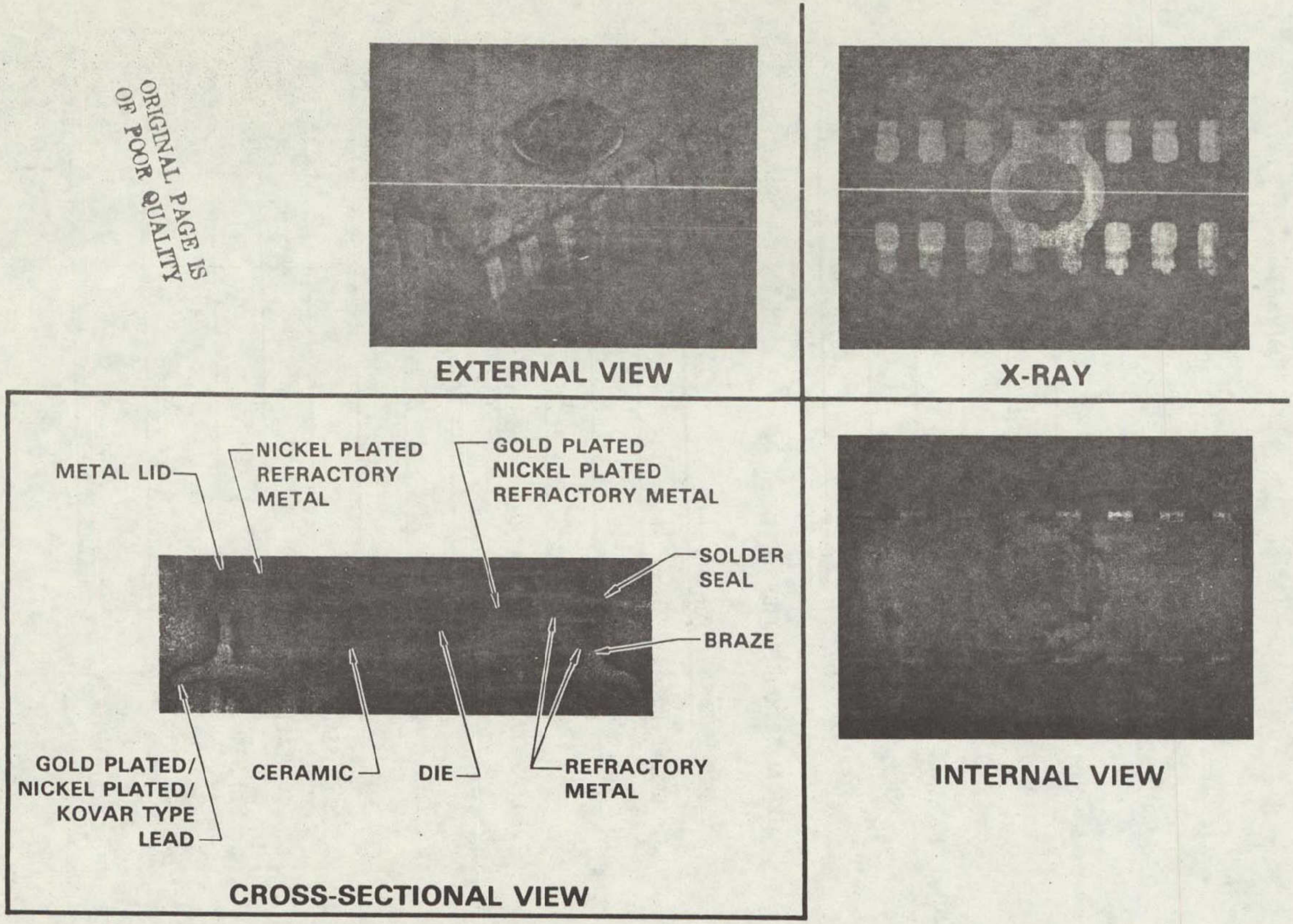


Figure A22 Construction Details – RCA 16 Lead White Ceramic/Bottom Braze Leads

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA - A23

Solitron 28 Lead White Ceramic/Bottom Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Solitron
   B. TYPE PACKAGE 28 Lead Dual In-Line
   C. PART NUMBER UC7550D
   D. DATE CODE 7109
   E. DEVICE FUNCTION Random Access Memory
   F. PACKAGE DIMENSIONS Figure A37

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic White
   B. BASE Cofired Ceramic White
   C. LID Metal
   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated
   E. LEAD FRAME PLATING INTERNAL Gold over Nickel
   F. LEAD EXTERNAL Braze
   G. LEAD PLATING EXTERNAL Cofired Ceramic
   H. EXTERNAL LEAD ATTACH Braze
   I. LEAD SEAL Cofired Ceramic
   J. LID PLATING Gold
   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

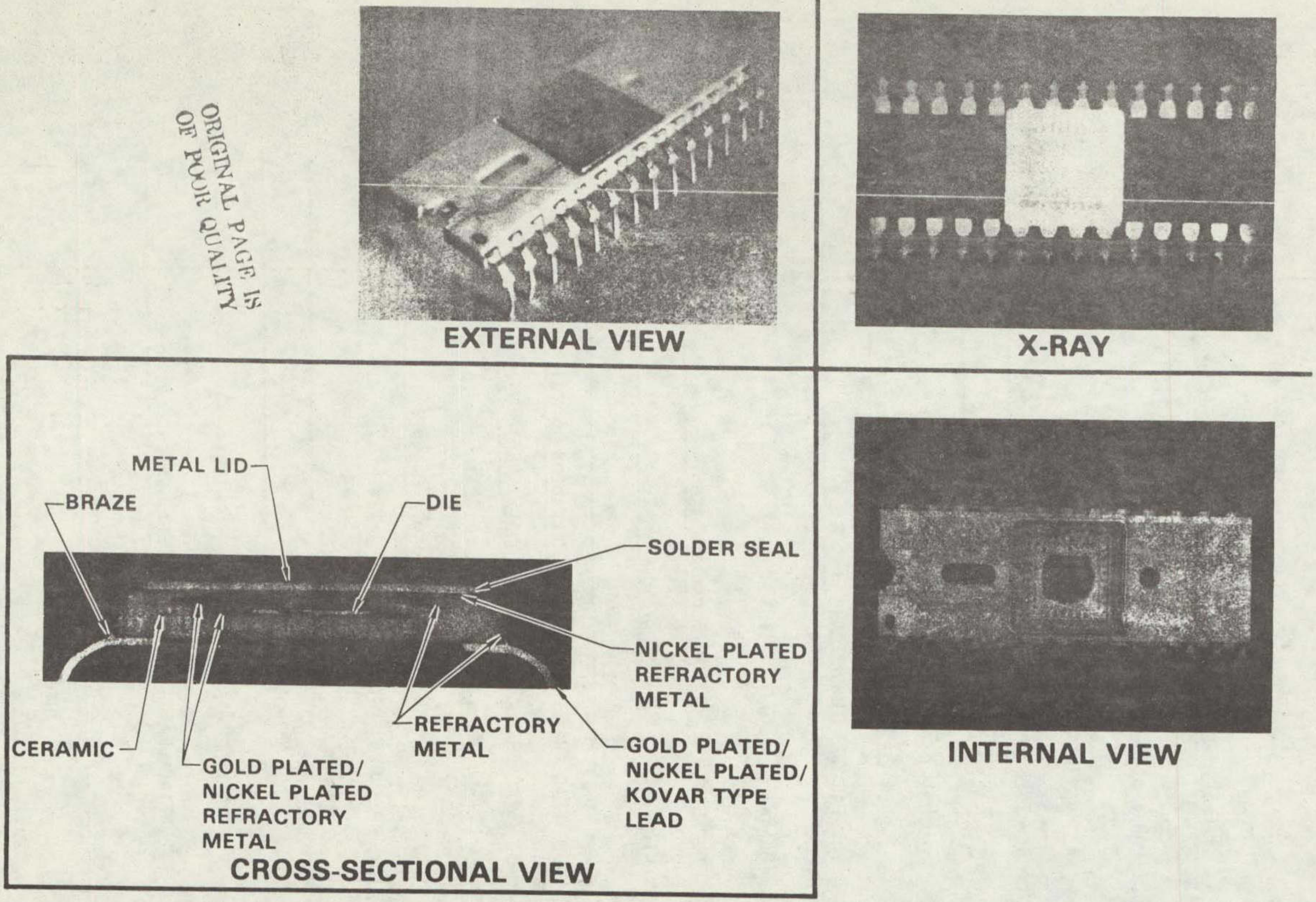


Figure A23 Construction Details — Solitron 28 Lead White Ceramic/Bottom Braze Leads

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA -A24

Kyocera 28 Lead White Ceramic/Bottom Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Kyocera

   B. TYPE PACKAGE 28 Lead Dual In-Line

   C. PART NUMBER ---

   D. DATE CODE ---

   E. DEVICE FUNCTION ---

   F. PACKAGE DIMENSIONS Kyoto Ceramic KD-71201-A

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic White

   B. BASE Cofired Ceramic White

   C. LID Metal (Not Supplied)

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

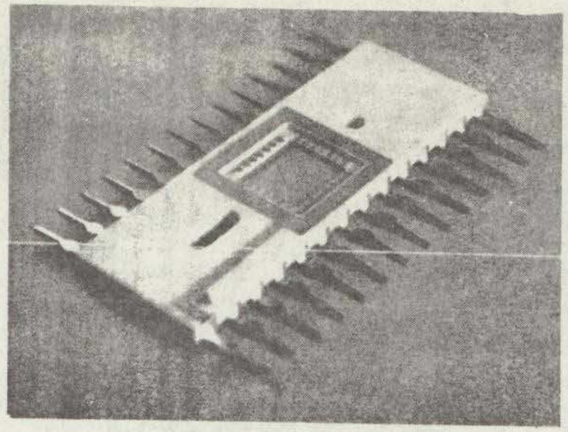
   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING (Not Supplied)

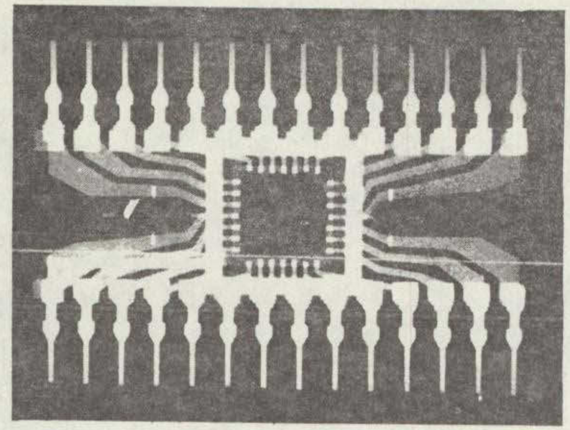
   K. LID SEAL (Made for Solder Seal)

3. DIE ATTACH MATERIAL Silk Screened Gold (No Die)

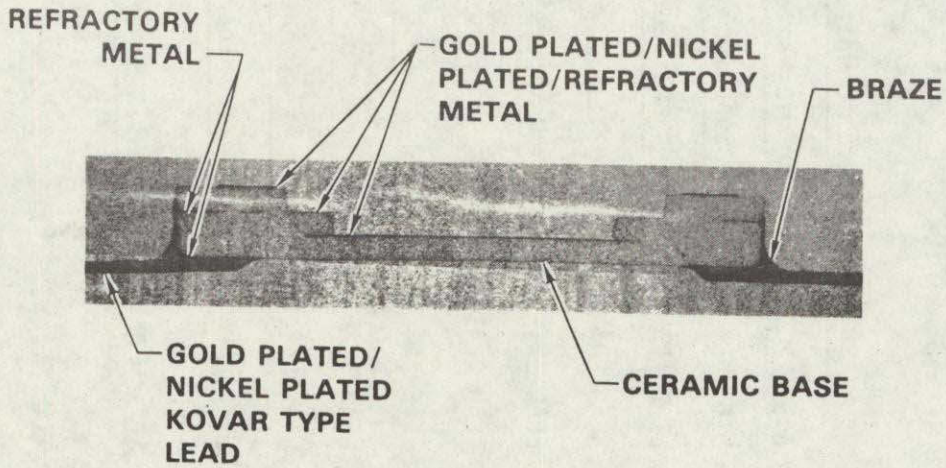
4. INTERNAL FLY WIRE TYPE N/A



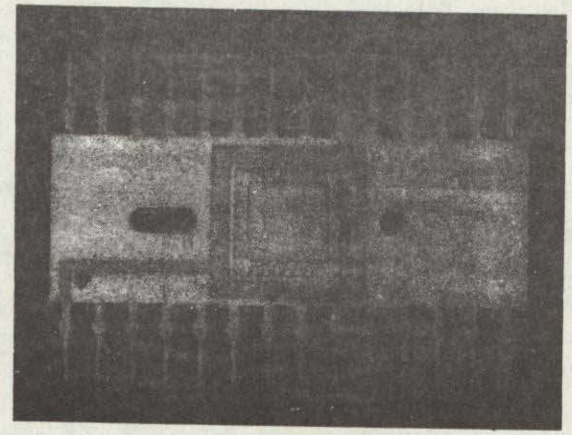
EXTERNAL VIEW



X-RAY



CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A24 Construction Details – Kyocera 28 Lead White Ceramic/Bottom Braze Leads

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA - A25

Kyocera 40 Lead White Ceramic/Bottom Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Kyocera

   B. TYPE PACKAGE 40 Lead Dual In-Line

   C. PART NUMBER ---

   D. DATE CODE ---

   E. DEVICE FUNCTION ---

   F. PACKAGE DIMENSIONS Kyoto Ceramic KD-71288-B

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic White

   B. BASE Cofired Ceramic White

   C. LID Metal (Not Supplied)

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING (Not Supplied)

   K. LID SEAL (Made for Solder Seal)

3. DIE ATTACH MATERIAL Silk Screened Gold (No Die)

4. INTERNAL FLY WIRE TYPE N/A

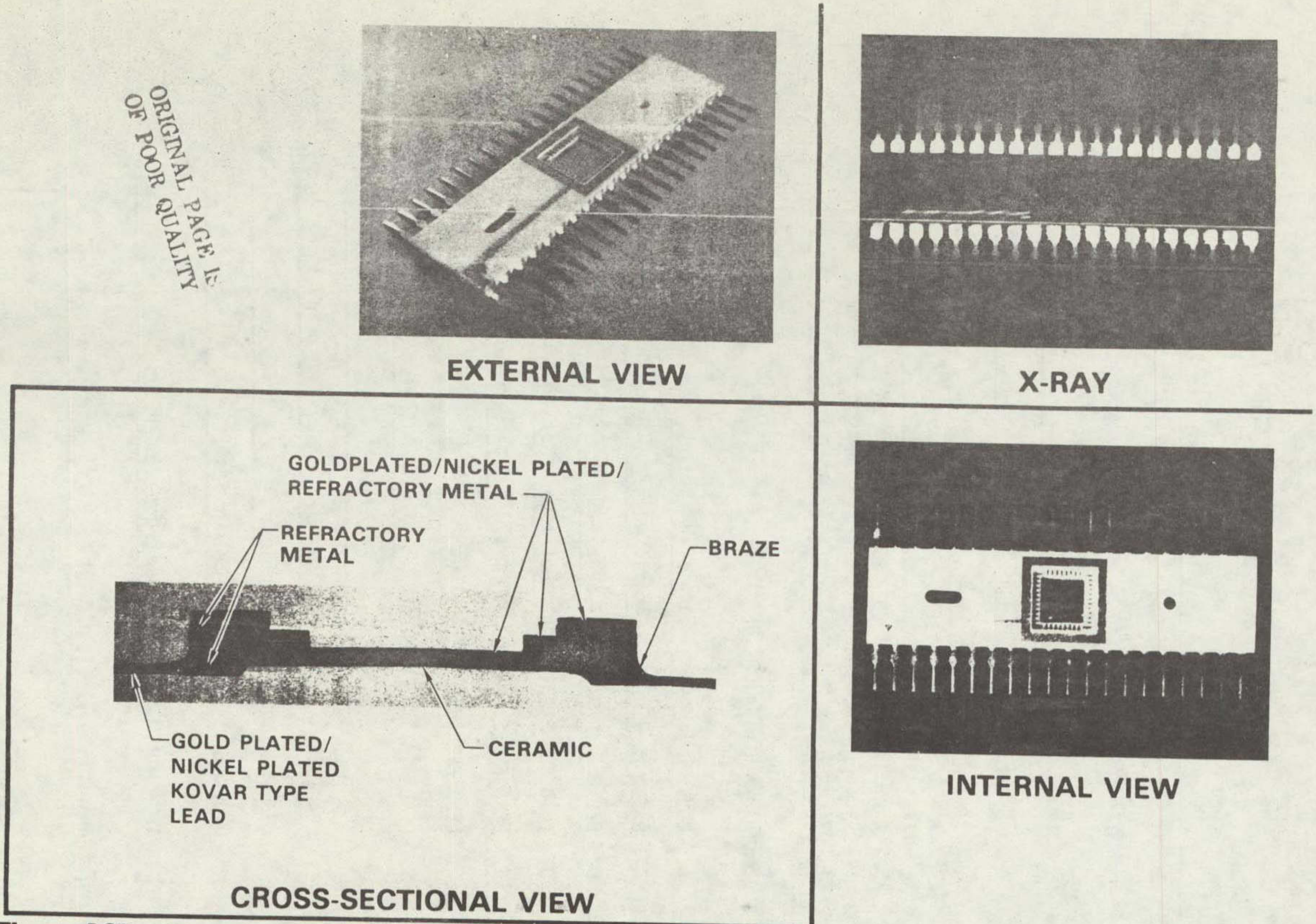


Figure A25 Construction Details – Kyocera 40 Lead White Ceramic/Bottom Braze Leads

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA - A26

Signetics 14 Lead Dual In Line

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Signetics
   B. TYPE PACKAGE 14 Lead Dual In-Line
   C. PART NUMBER RC51001
   D. DATE CODE 7219
   E. DEVICE FUNCTION Quad Two-Input NAND G te
   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D1

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic White
   B. BASE Cofired Ceramic White
   C. LID Metal
   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated
   E. LEAD FRAME PLATING INTERNAL Gold over Nickel
   F. LEAD EXTERNAL Kovar Type
   G. LEAD PLATING EXTERNAL Gold over Nickel
   H. EXTERNAL LEAD ATTACH Braze
   I. LEAD SEAL Cofired Ceramic
   J. LID PLATING Gold
   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum

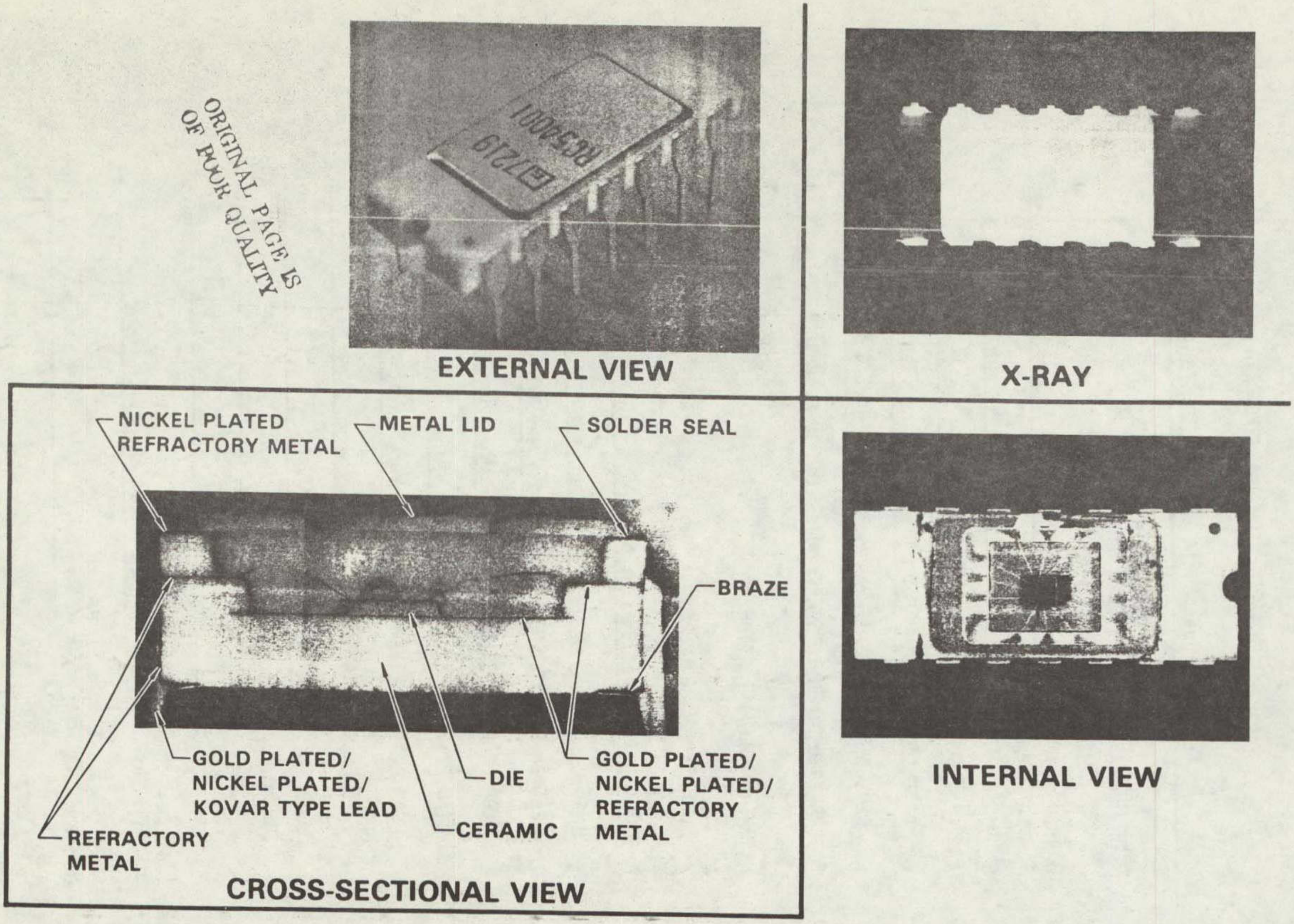


Figure A26 Construction Details – Signetics 14 Lead White Ceramic/Side Braze Leads

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA - A27

National 16 Lead Dual In Line

1. PART/PACKAGE DESCRIPTION

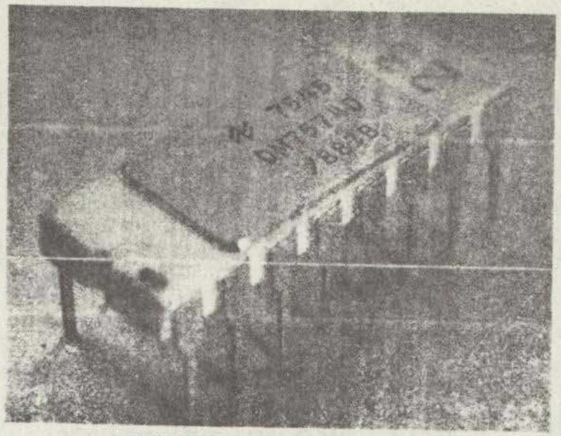
   A. MANUFACTURER National Semiconductor
   B. TYPE PACKAGE 16 Lead Dual In-Line
   C. PART NUMBER DM7574D
   D. DATE CODE 7545
   E. DEVICE FUNCTION Read Only Memory
   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D2

2. MATERIAL IDENTIFICATION

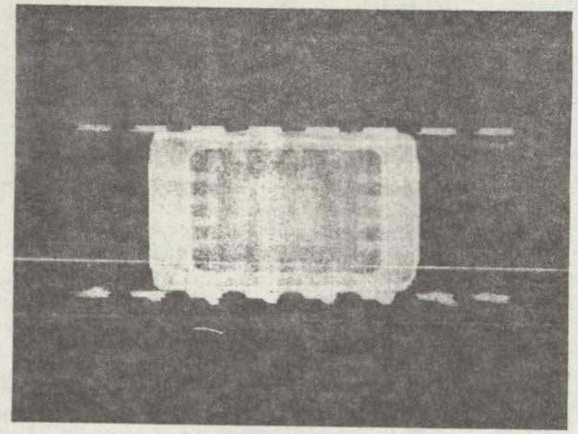
   A. BODY Cofired Ceramic White
   B. BASE Cofired Ceramic White
   C. LID Metal
   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated
   E. LEAD FRAME PLATING INTERNAL Gold over Nickel
   F. LEAD EXTERNAL Kovar Type
   G. LEAD PLATING EXTERNAL Gold over Nickel
   H. EXTERNAL LEAD ATTACH Braze
   I. LEAD SEAL Cofired Ceramic
   J. LID PLATING Gold
   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

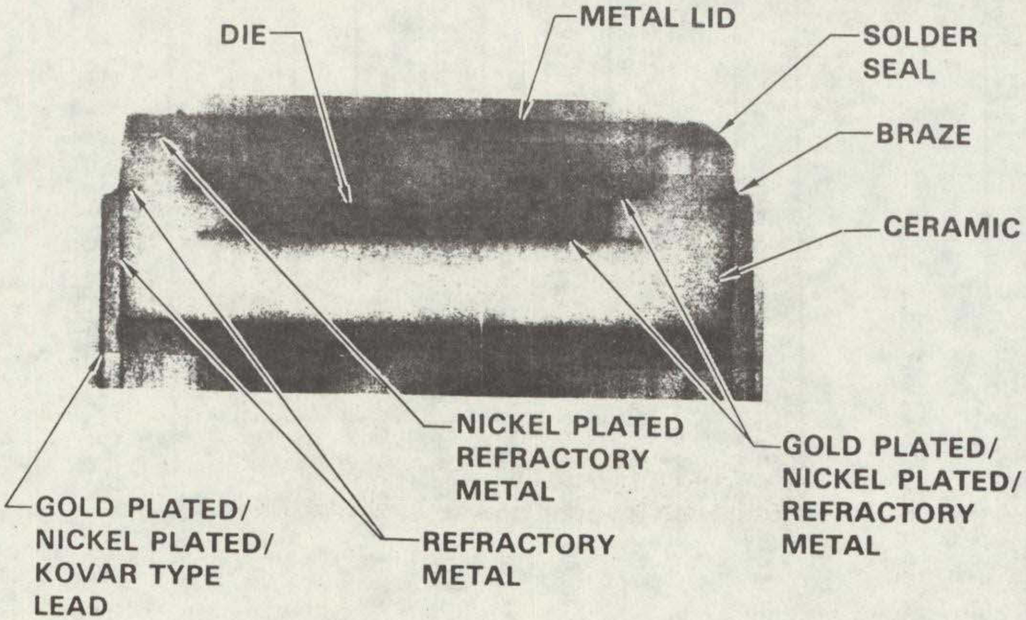
4. INTERNAL FLY WIRE TYPE Aluminum



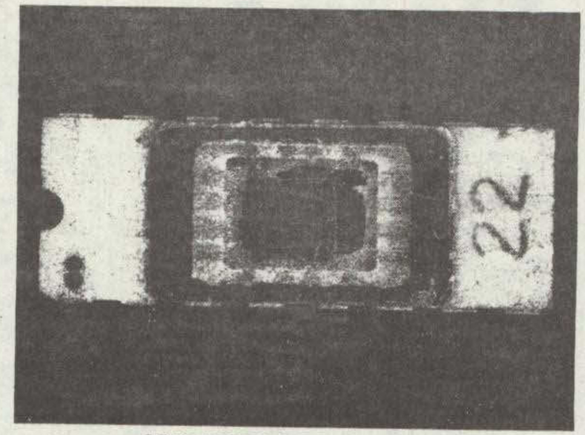
EXTERNAL VIEW



X-RAY



CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A27 Construction Details – National 16 Lead White Ceramic/Side Braze Leads

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA - A28

Intel 24 Lead White Ceramic/Side Braze/Glass Window

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Intel

   B. TYPE PACKAGE 24 Lead Dual In-Line

   C. PART NUMBER C2708

   D. DATE CODE None

   E. DEVICE FUNCTION 1024 X 8 NMOS Erasable PROM

   F. PACKAGE DIMENSIONS Similar to JEDEC outline MO-015AA

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic White

   B. BASE Cofired Ceramic White

   C. LID Metal with Special Glass Window

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

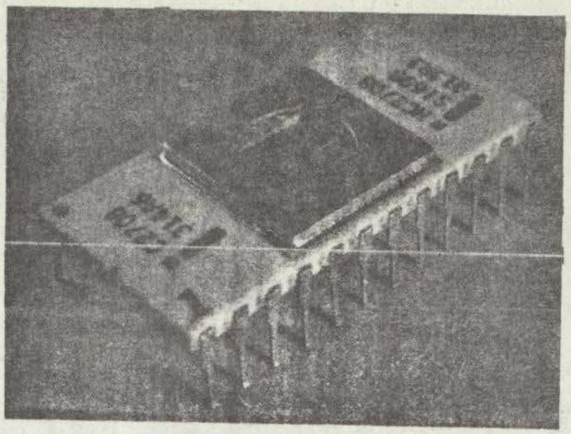
   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING Gold

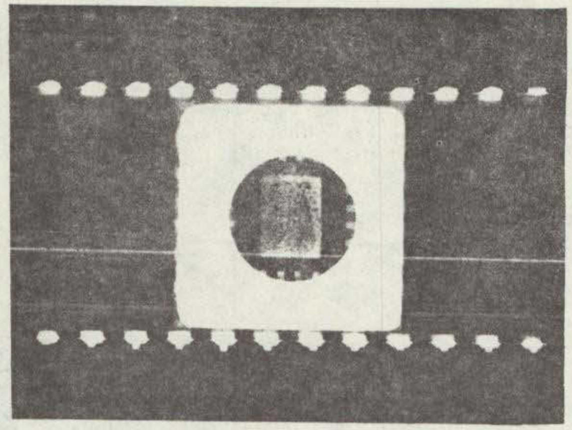
   K. LID SEAL Solder & Compression

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Aluminum



EXTERNAL VIEW



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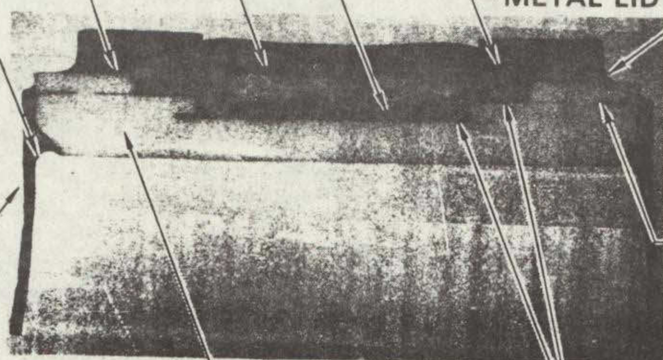
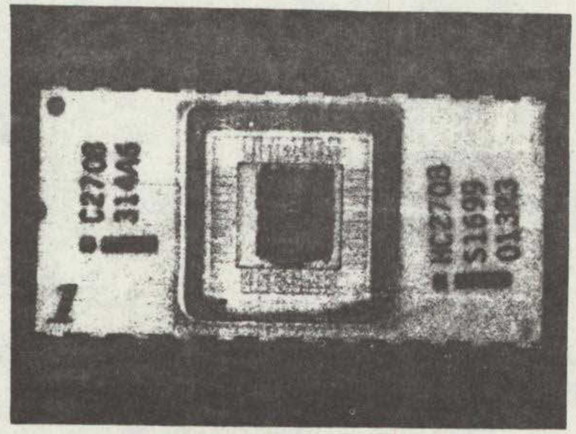


CROSS-SECTIONAL VIEW



INTERNAL VIEW

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Figure A28 Construction Details – Intel 24 Lead White Ceramic/Side Braze/Quartz Window

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA - A29

Kyocera 24 Lead White Ceramic/Side Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Kyocera International

   B. TYPE PACKAGE ---

   C. PART NUMBER ---

   D. DATE CODE ---

   E. DEVICE FUNCTION ---

   F. PACKAGE DIMENSIONS Similar to JEDEC Outline MO-015AA

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic White

   B. BASE Cofired Ceramic White

   C. LID Metal (Not Supplied)

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING (Not Supplied)

   K. LID SEAL (Made for Solder Seal)

3. DIE ATTACH MATERIAL Silk Screened Gold (No Die)

4. INTERNAL FLY WIRE TYPE N/A

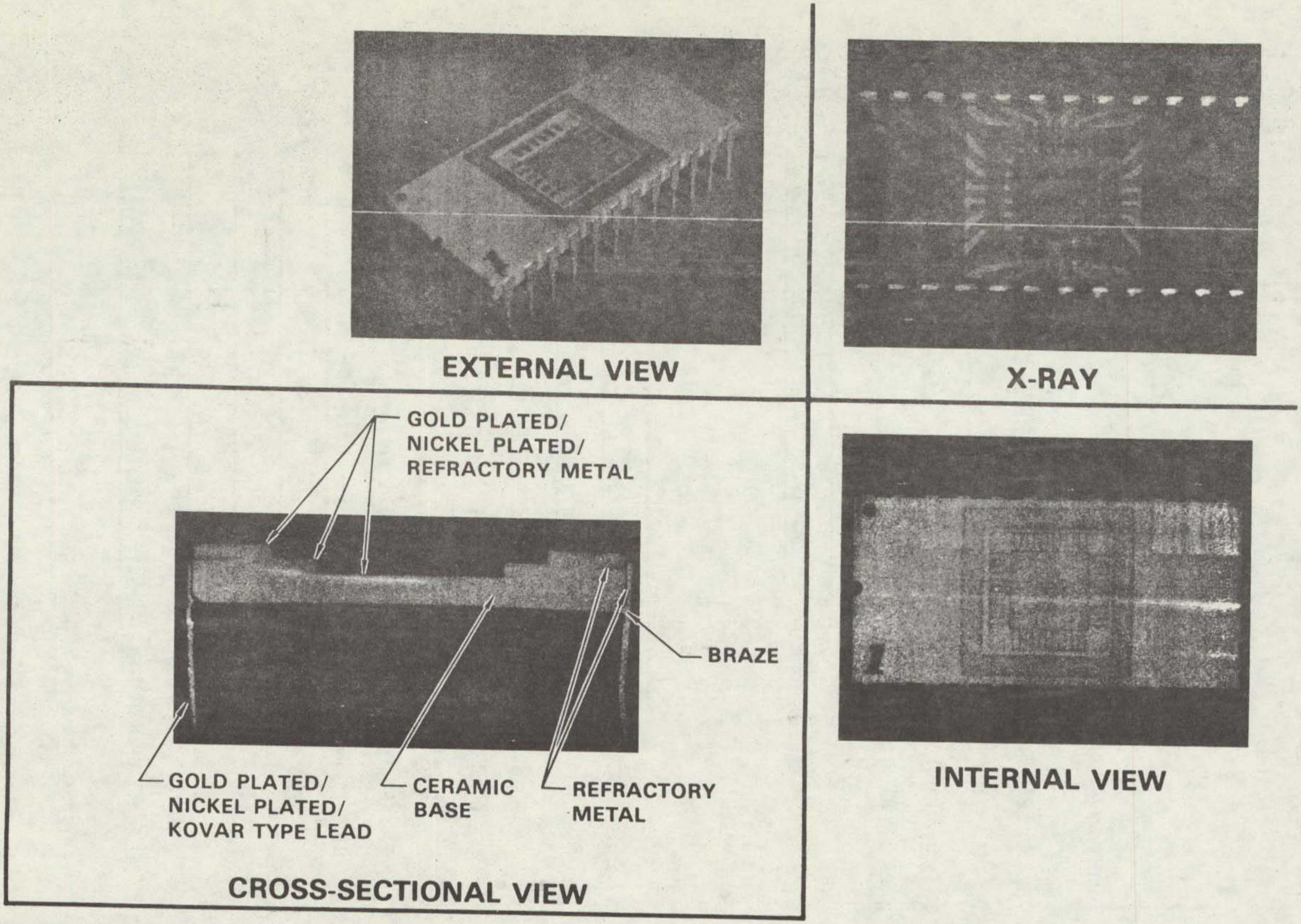


Figure A29 Construction Details — Kyocera 24 Lead White Ceramic/Side Braze Leads

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA - A30

Kyocera 40 Lead White Ceramic/Side Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Kyocera International

   B. TYPE PACKAGE 40 Lead Dual In-Line

   C. PART NUMBER ---

   D. DATE CODE ---

   E. DEVICE FUNCTION ---

   F. PACKAGE DIMENSIONS Kyoto Ceramic KD-72056-B

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic White

   B. BASE Cofired Ceramic White

   C. LID Metal (Not Supplied)

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

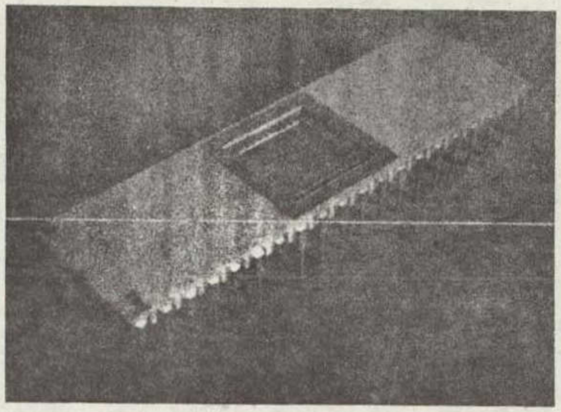
   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING (Not Supplied)

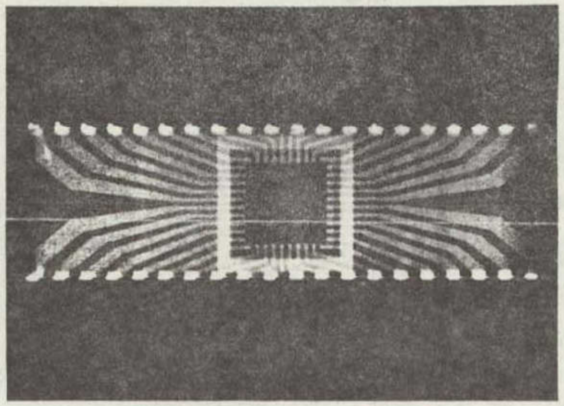
   K. LID SEAL (Made for Solder Seal)

3. DIE ATTACH MATERIAL Silk Screened Gold (No Die)

4. INTERNAL FLY WIRE TYPE N/A



EXTERNAL VIEW



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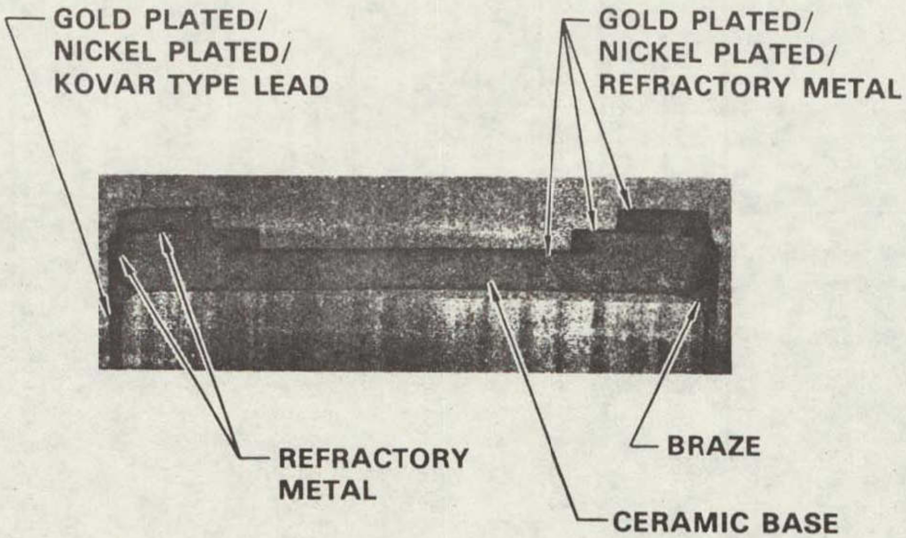
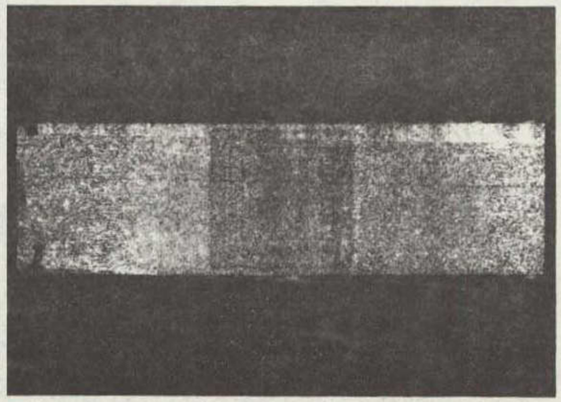


CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A30 Construction Details – Kyocera 40 Lead White Ceramic/Side Braze Leads

CONSTRUCTION ANALYSIS DATA - A31

Kyocera 48 Lead White Ceramic/Top Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Kyocera International

   B. TYPE PACKAGE 48 Lead Dual In-Line

   C. PART NUMBER ---

   D. DATE CODE ---

   E. DEVICE FUNCTION ---

   F. PACKAGE DIMENSIONS Kyoto Ceramic KD-73111 1/2

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic White

   B. BASE Cofired Ceramic White

   C. LID Metal (Not Supplied)

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

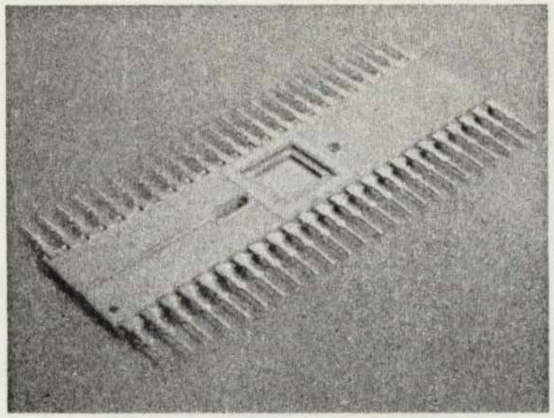
   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING Not Supplied

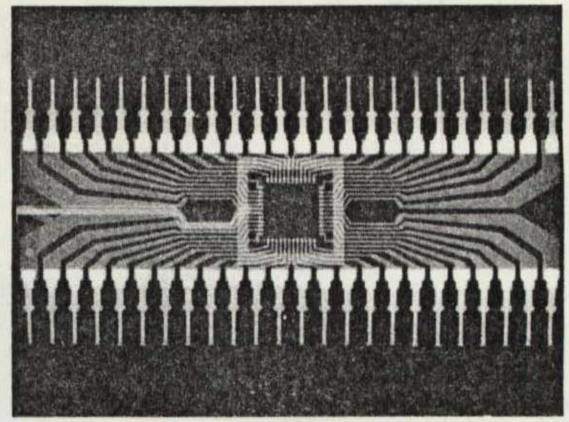
   K. LID SEAL (Made for Solder Seal)

3. DIE ATTACH MATERIAL Silk Screened Gold (No Die)

4. INTERNAL FLY WIRE TYPE N/A



EXTERNAL VIEW



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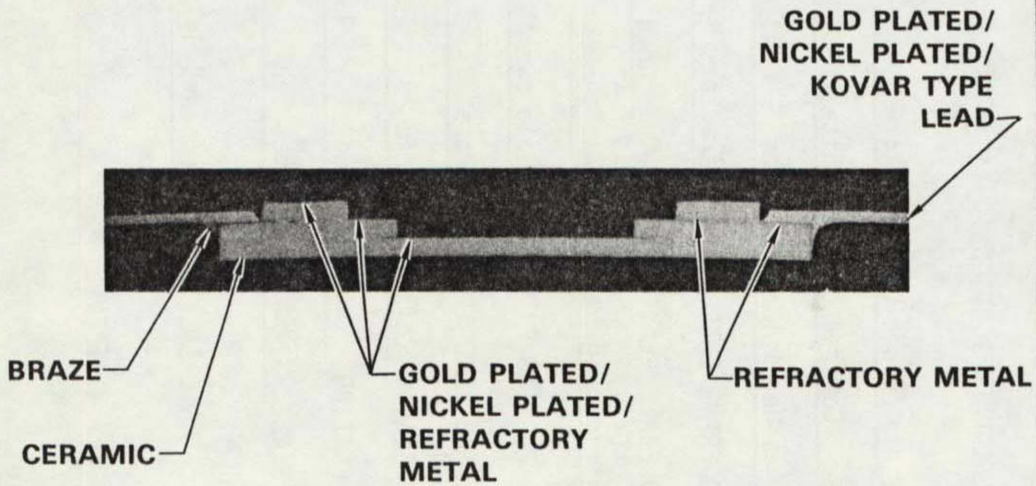
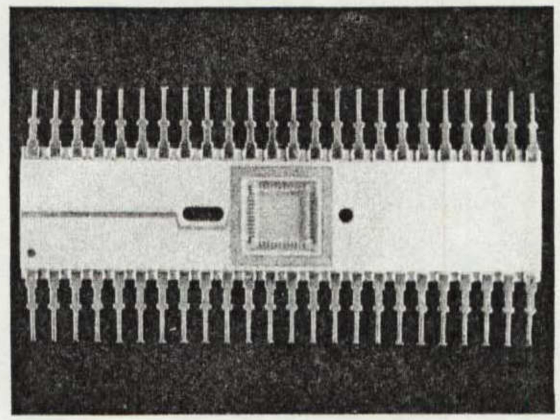


CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A31 Construction Details – Kyocera 48 Lead White Ceramic/Top Braze Leads

CONSTRUCTION ANALYSIS DATA - A32

Intel 18 Lead Black Ceramic/Side Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Intel

   B. TYPE PACKAGE 18 Lead Dual In-Line

   C. PART NUMBER C1103

   D. DATE CODE None

   E. DEVICE FUNCTION 1024 X 1 Dynamic PMOS RAM

   F. PACKAGE DIMENSIONS Figure A38

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic Black

   B. BASE Cofired Ceramic Black

   C. LID Metal

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING Gold

   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

4. INTERNAL FLY WIRE TYPE Gold

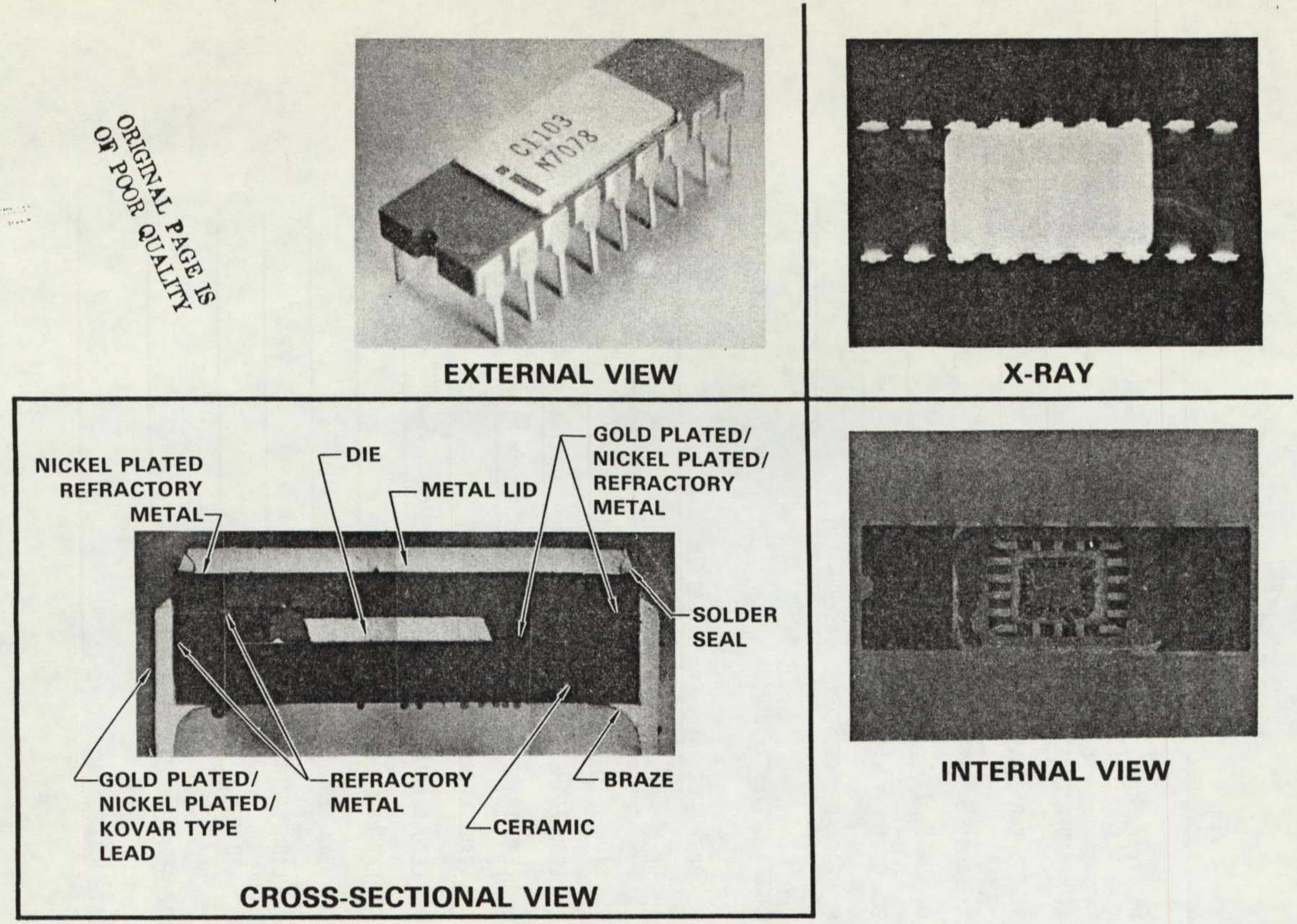


Figure A32 Construction Details – Intel 18 Lead Black Ceramic/Side Braze Leads

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA - A33

Intel 22 Lead Ceramic Black/Side Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Intel

   B. TYPE PACKAGE 22 Lead Dual In-Line

   C. PART NUMBER C2107A-8

   D. DATE CODE None

   E. DEVICE FUNCTION 4096 X 1 Dynamic MOS RAM

   F. PACKAGE DIMENSIONS Similar to JEDEC Outline MO-026AA

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic Black

   B. BASE Cofired Ceramic Black

   C. LID Metal

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

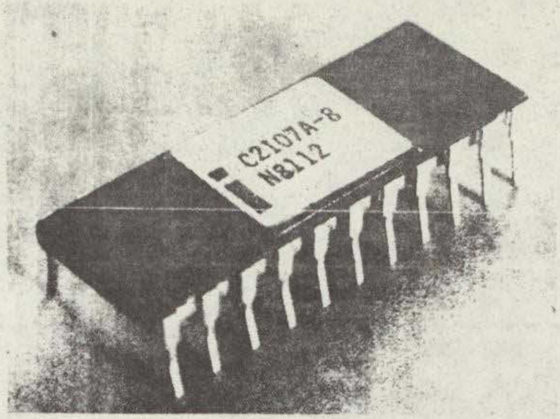
   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING Gold

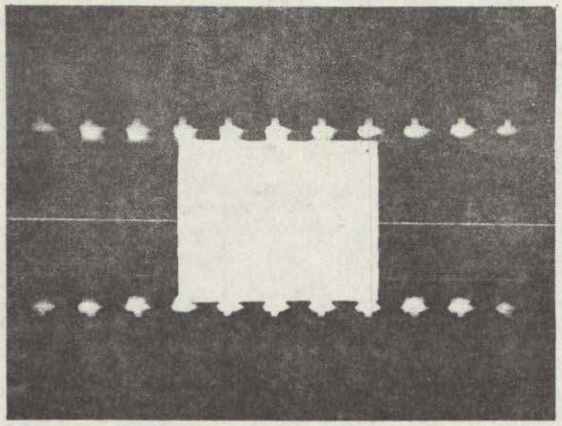
   K. LID SEAL Solder

3. DIE ATTACH MATERIAL Gold/Silicon Eutectic

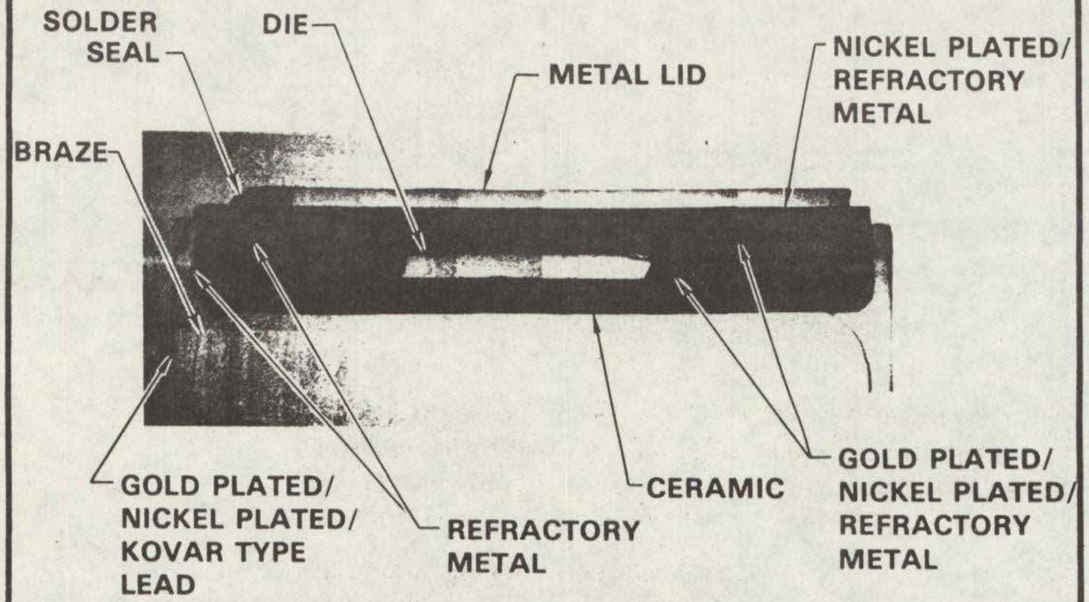
4. INTERNAL FLY WIRE TYPE Gold



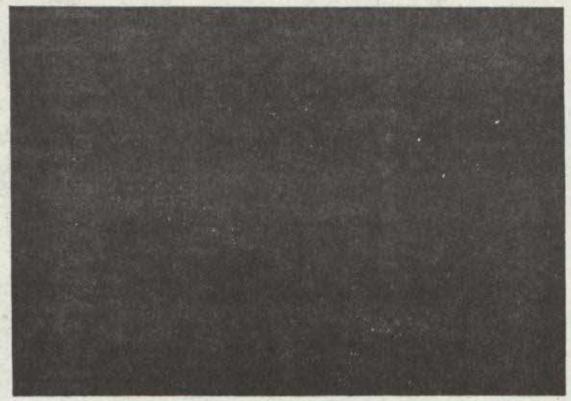
EXTERNAL VIEW



X-RAY



CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A33 Construction Details – Intel 22 Lead Black Ceramic/Side Braze Leads

MCDONNELL DOUGLAS
CORPORATION

CONSTRUCTION ANALYSIS DATA - A34

Kyocera 24 Lead Black Ceramic/Side Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Kyocera International

   B. TYPE PACKAGE 24 Lead Dual In-Line

   C. PART NUMBER ---

   D. DATE CODE ---

   E. DEVICE FUNCTION ---

   F. PACKAGE DIMENSIONS Similar to JEDEC Outline MO-015AA

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic Black

   B. BASE Cofired Ceramic Black

   C. LID Metal (Not Supplied)

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

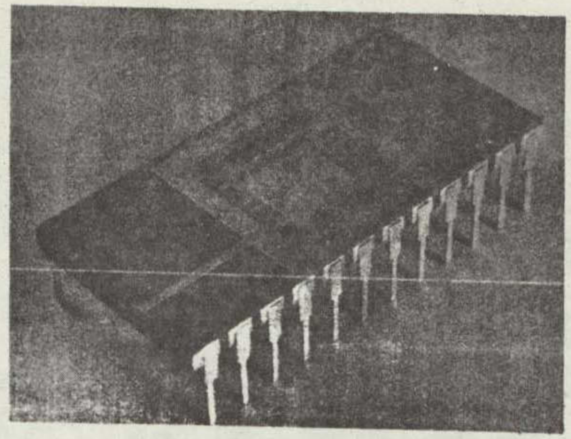
   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING (Not Supplied)

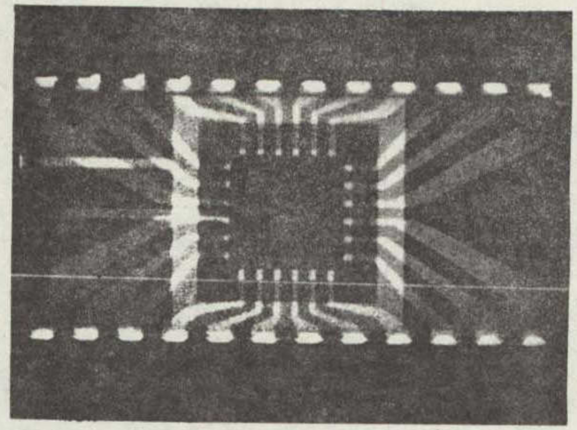
   K. LID SEAL (Made for Solder Seal)

3. DIE ATTACH MATERIAL Silk Screened Gold (No Die)

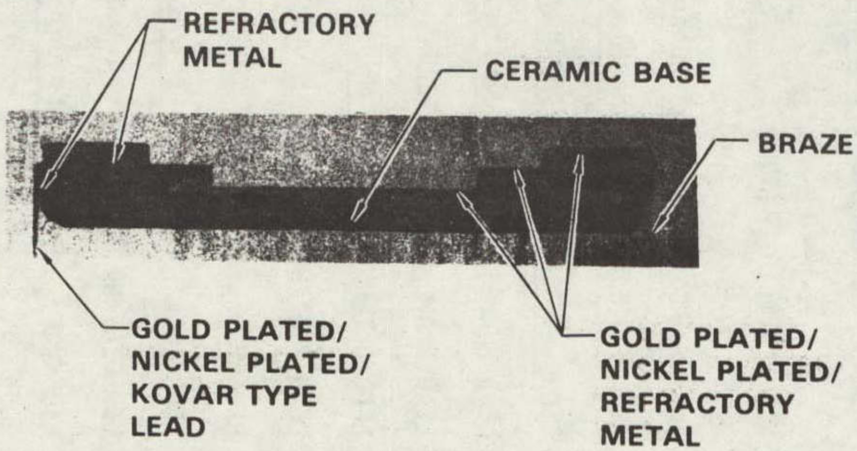
4. INTERNAL FLY WIRE TYPE N/A



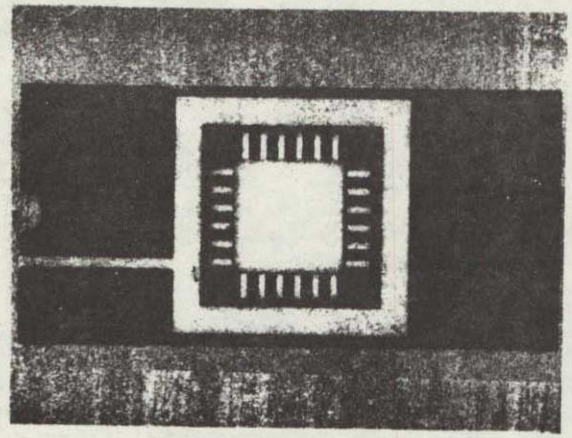
EXTERNAL VIEW



X-RAY



CROSS-SECTIONAL VIEW



INTERNAL VIEW

Figure A34 Construction Details – Kyocera 24 Lead Black Ceramic/Side Braze Leads

MCDONNELL DOUGLAS CORPORATION

CONSTRUCTION ANALYSIS DATA -A35

Kyocera 24 Lead Black Ceramic/Side Braze

1. PART/PACKAGE DESCRIPTION

   A. MANUFACTURER Kyocera International

   B. TYPE PACKAGE 24 Lead Dual In-Line

   C. PART NUMBER N/A

   D. DATE CODE N/A

   E. DEVICE FUNCTION N/A

   F. PACKAGE DIMENSIONS Similar to MIL-M-38510C-D3

2. MATERIAL IDENTIFICATION

   A. BODY Cofired Ceramic Black

   B. BASE Cofired Ceramic Black

   C. LID Metal or Ceramic (not supplied)

   D. LEAD FRAME INTERNAL Refractory Metal/Nickel Plated

   E. LEAD FRAME PLATING INTERNAL Gold over Nickel

   F. LEAD EXTERNAL Kovar Type

   G. LEAD PLATING EXTERNAL Gold over Nickel

   H. EXTERNAL LEAD ATTACH Braze

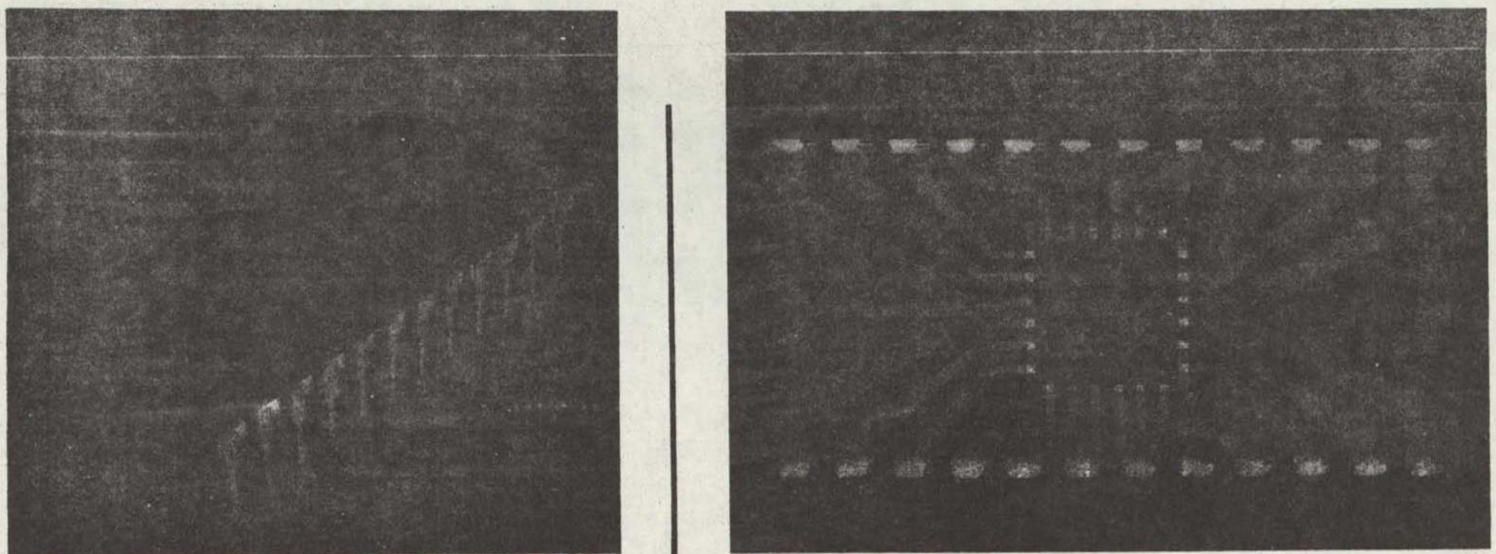
   I. LEAD SEAL Cofired Ceramic

   J. LID PLATING (not supplied)

   K. LID SEAL (made for glass seal)

3. DIE ATTACH MATERIAL Silk Screened Gold (no die)

4. INTERNAL FLY WIRE TYPE N/A



EXTERNAL VIEW | X-RAY

Figure A35 Construction Details – Kyocera 24 Lead Black Ceramic/Side Braze Leads

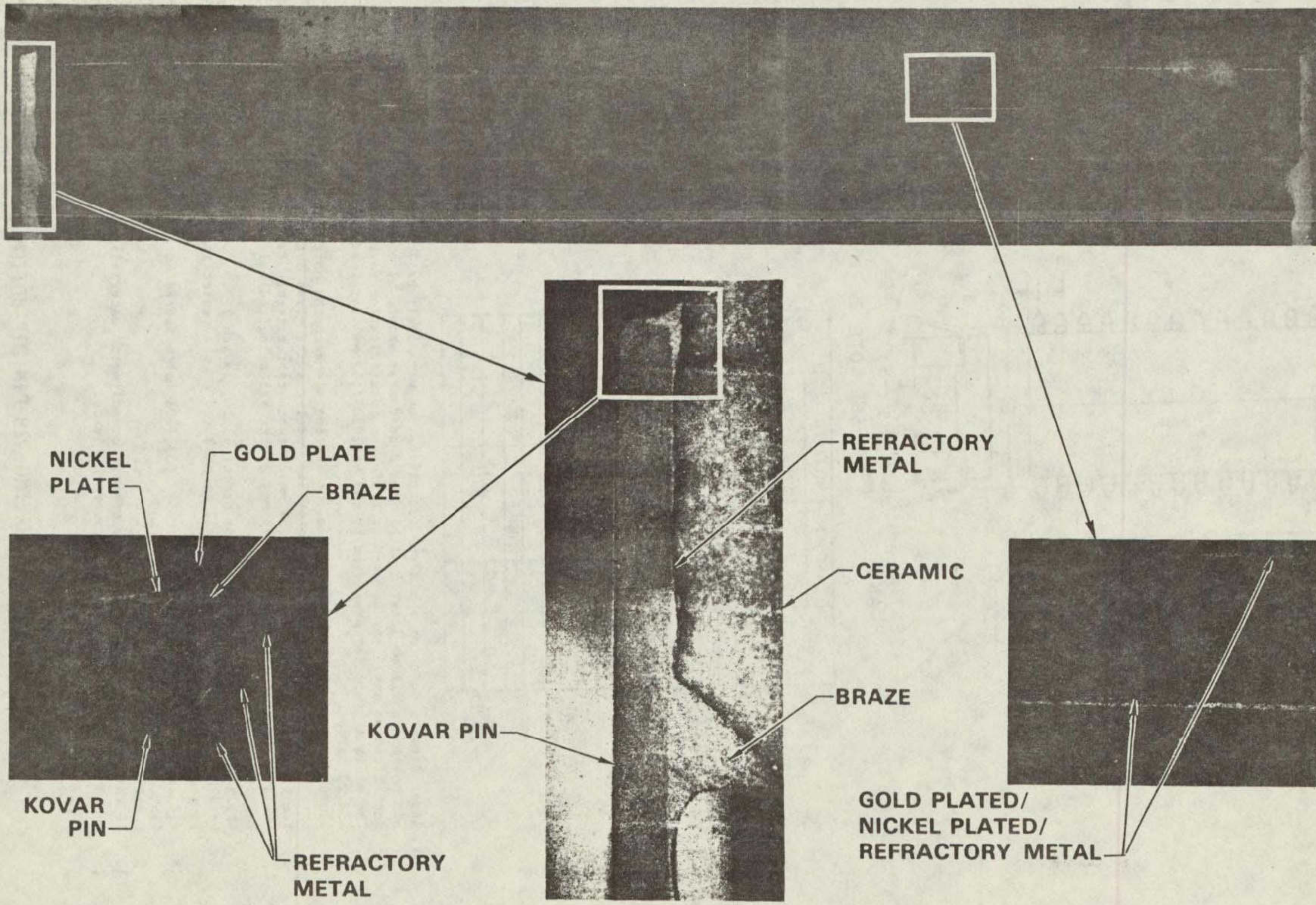
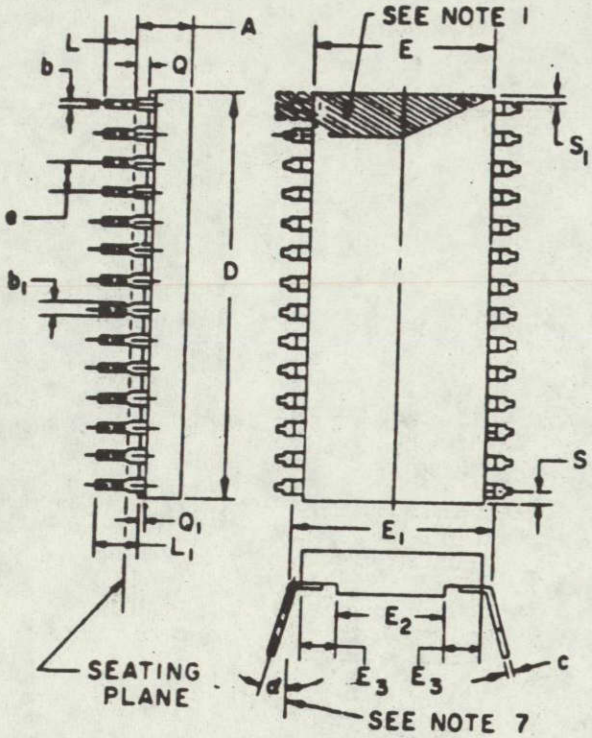


Figure A36 Construction Details – Kyocera 24 Lead Black Ceramic/Side Braze Leads

MCDONNELL DOUGLAS CORPORATION



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A		.225		5.72	
b	.014	.023	.36	.56	8
b_1	.030	.070	.76	1.78	2, 8
c	.008	.015	.20	.38	8
D		1.370		34.80	4
E	.500	.610	12.70	15.49	4
E_1	.590	.620	14.99	15.75	7
E_2	.270		6.86		
E_3	.050		1.27		
e	.100 BSC		2.54 BSC		5, 9
L	.120	.200	3.05	5.08	
L_1	.150		3.81		
Q	.015	.075	.38	1.91	3
Q_1	.020		.51		
S		.098		2.49	6
S_1	.005		.13		6
S_2	.005		.13		8
α	0°	15°	0°	15°	

NOTES:

1. Index area; a notch or a pin one identification mark shall be located adjacent to pin one and shall be located within the shaded area shown. The manufacturer's identification shall not be used as a pin one identification mark.
2. The minimum limit for dimension b_1 may be .020 (.51 mm) for leads number 1, 14, 15 and 28 only.
3. Dimension Q shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54 mm) between centerlines. Each pin centerline shall be located within ±.010 (.25 mm) of its exact logitudinal position relative to pins 1 and 28.
6. Applies to all four corners (leads number 1, 14, 15 and 28).
7. Lead center when α is 0 . E_1 shall be measured at the centerline of the leads (see 40.4 of this appendix).
8. All leads - Increase maximum limit by .003 (.08 mm) measured at the center of the flat, when lead finish A is applied.
9. Twenty-six spaces.
10. If this configuration is used, no organic or polymeric materials shall be molded to the bottom of the package to cover the leads.

FIGURE A37. OUTLINE DRAWING, 28 PIN DIP-BOTTOM BRAZE

APPENDIX B

HISTOGRAMS OF FINE LEAK RATE DATA

HISTOGRAM FORMAT & DEFINITION OF SYMBOLS

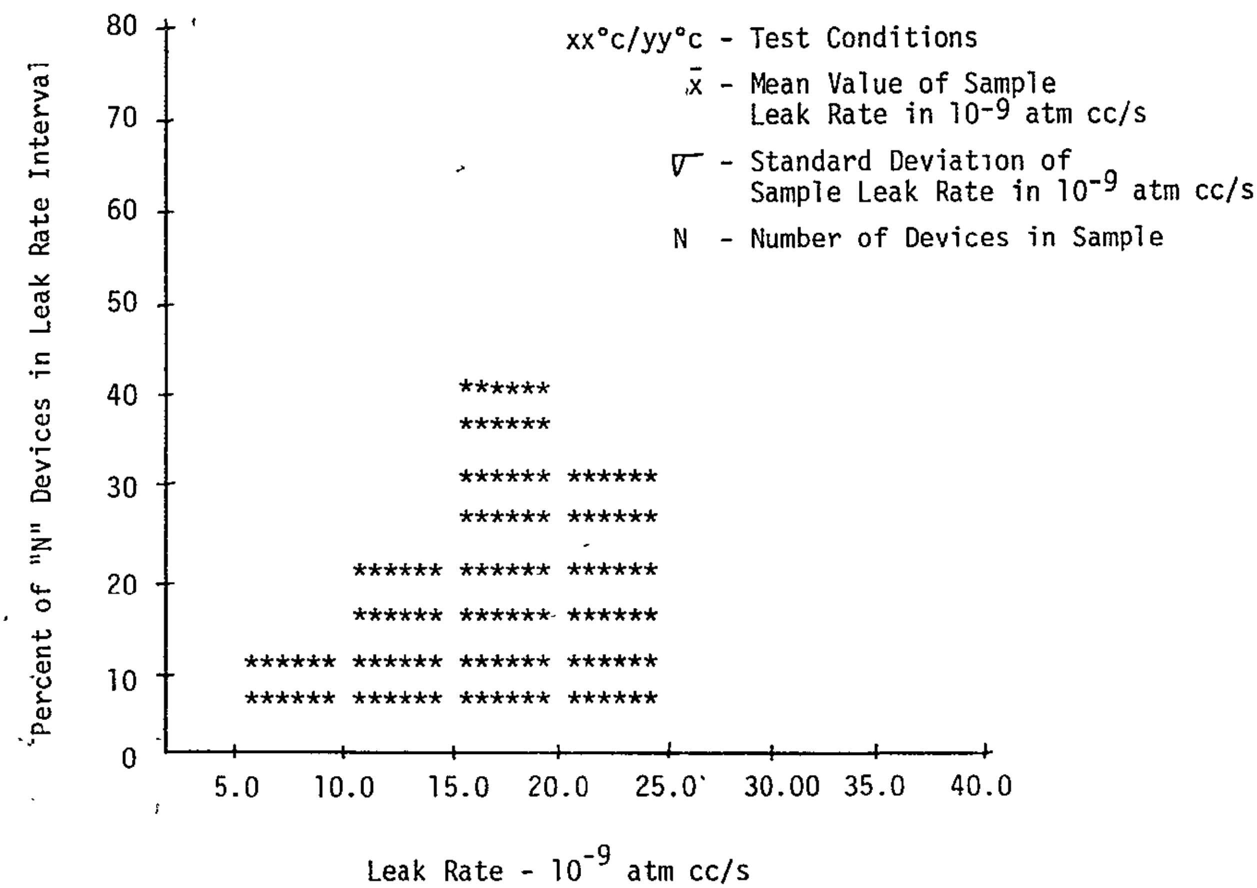


TABLE OF CONTENTS

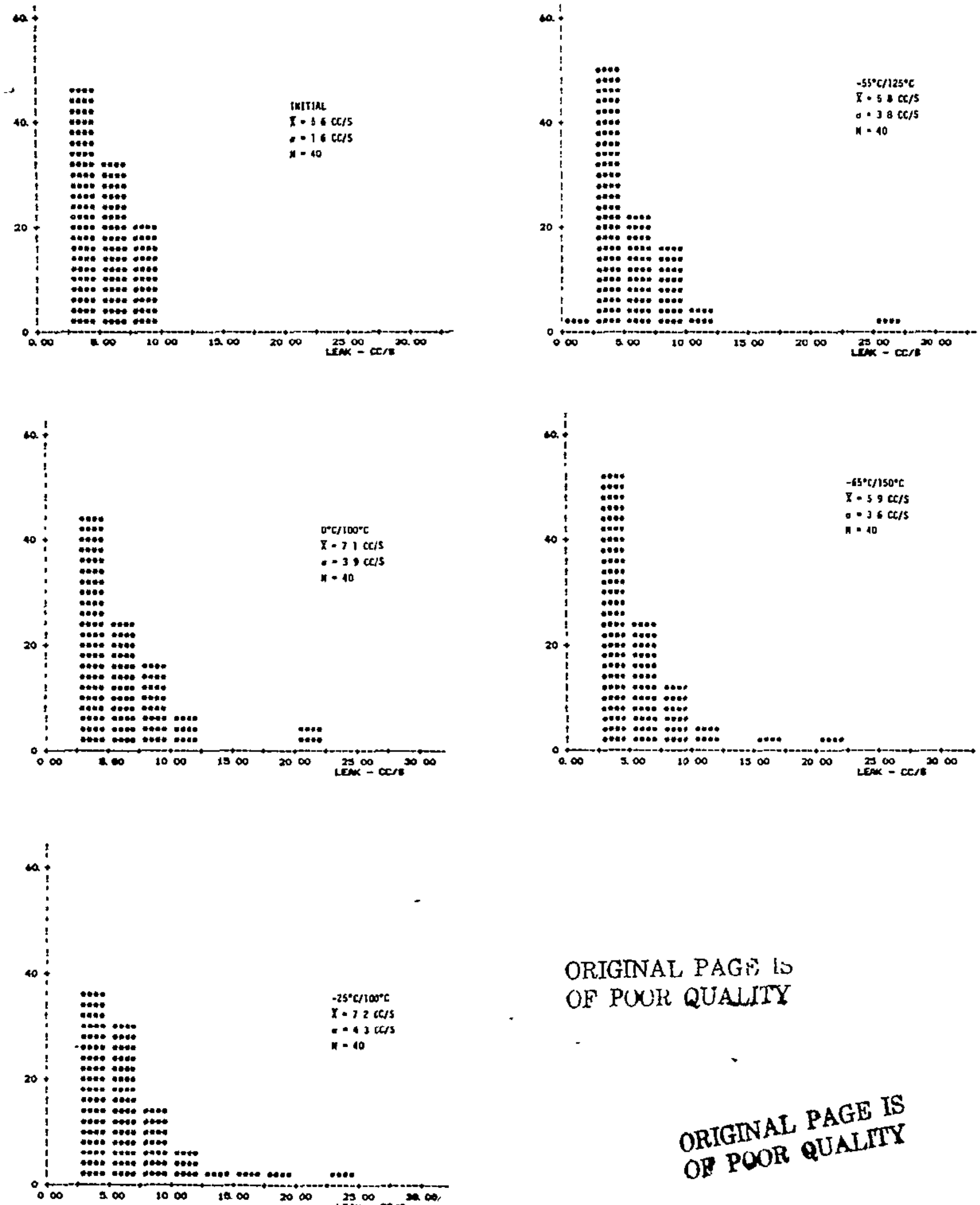


FIGURE B1-1. 50 CYCLES THERMAL SHOCK, KYOCERA 24 LEAD WHITE CERAMIC DIP

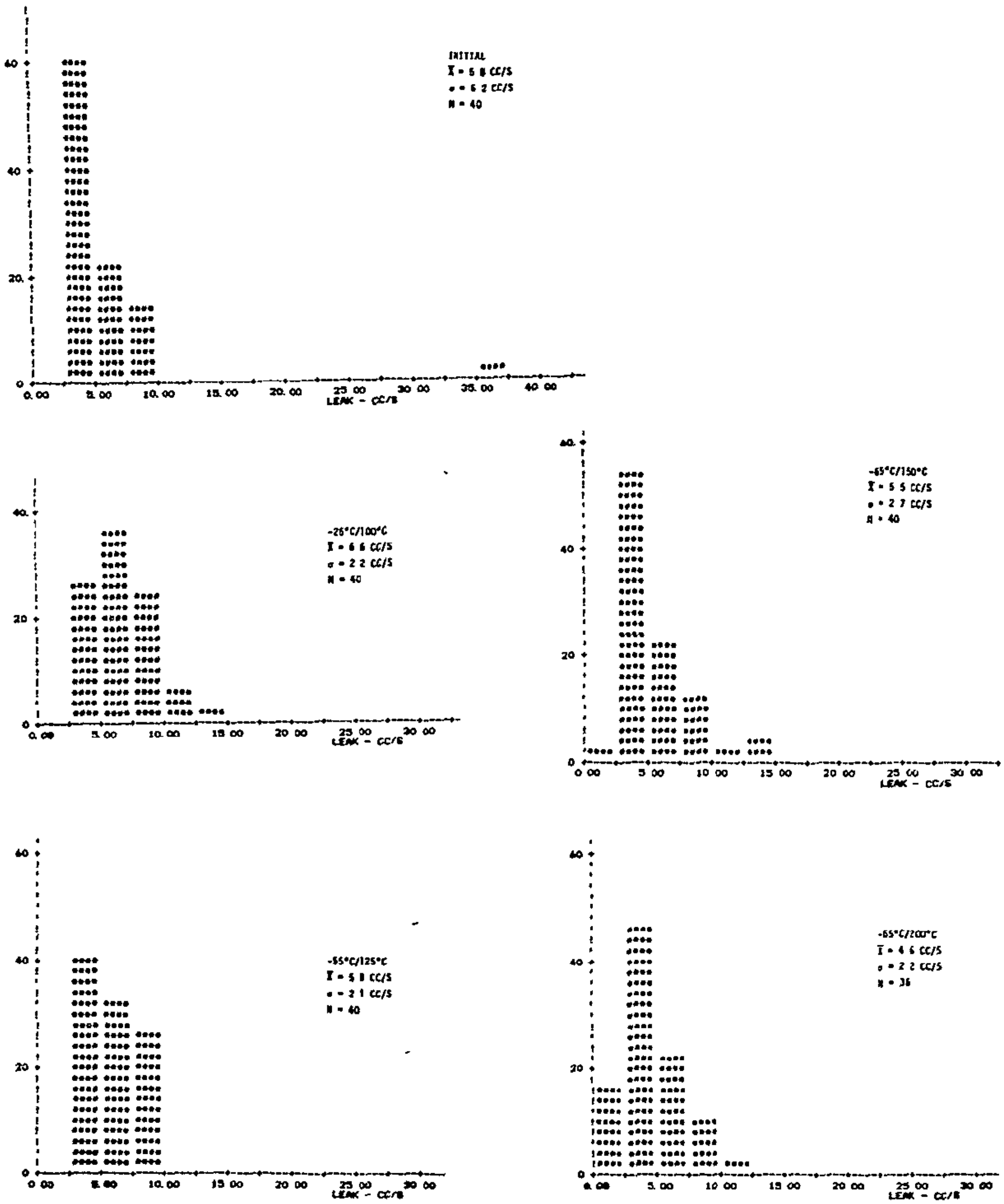


FIGURE B1-2. 50 CYCLES THERMAL CYCLING, KYOCERA 24 LEAD WHITE CERAMIC DIP

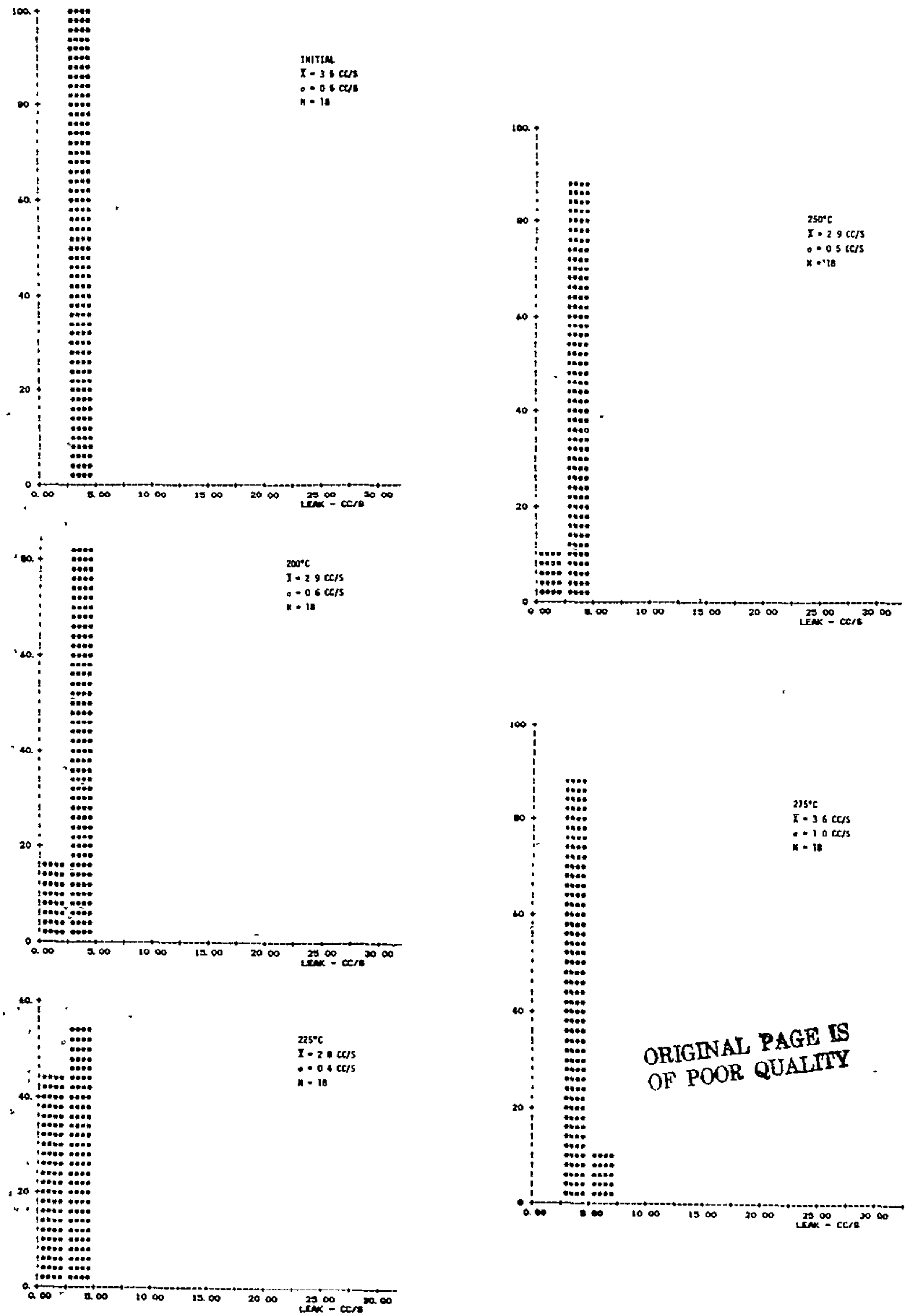


FIGURE B1-3. 72 HOURS HIGH TEMPERATURE BAKE, KYOCERA 24 LEAD WHITE CERAMIC DIP

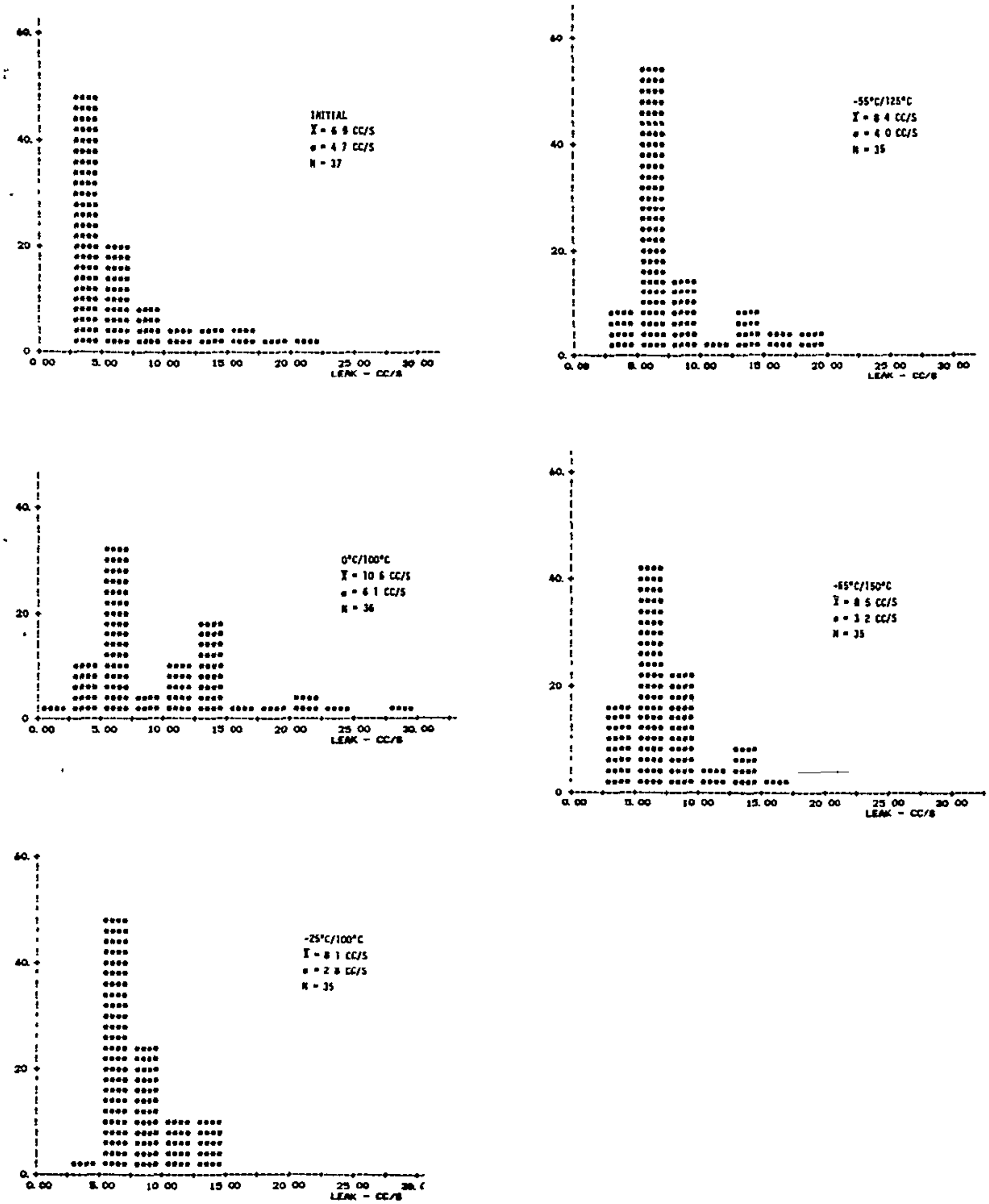


FIGURE B2-1. 50 CYCLES THERMAL SHOCK, KYOCERA 40 LEAD WHITE CERAMIC DIP

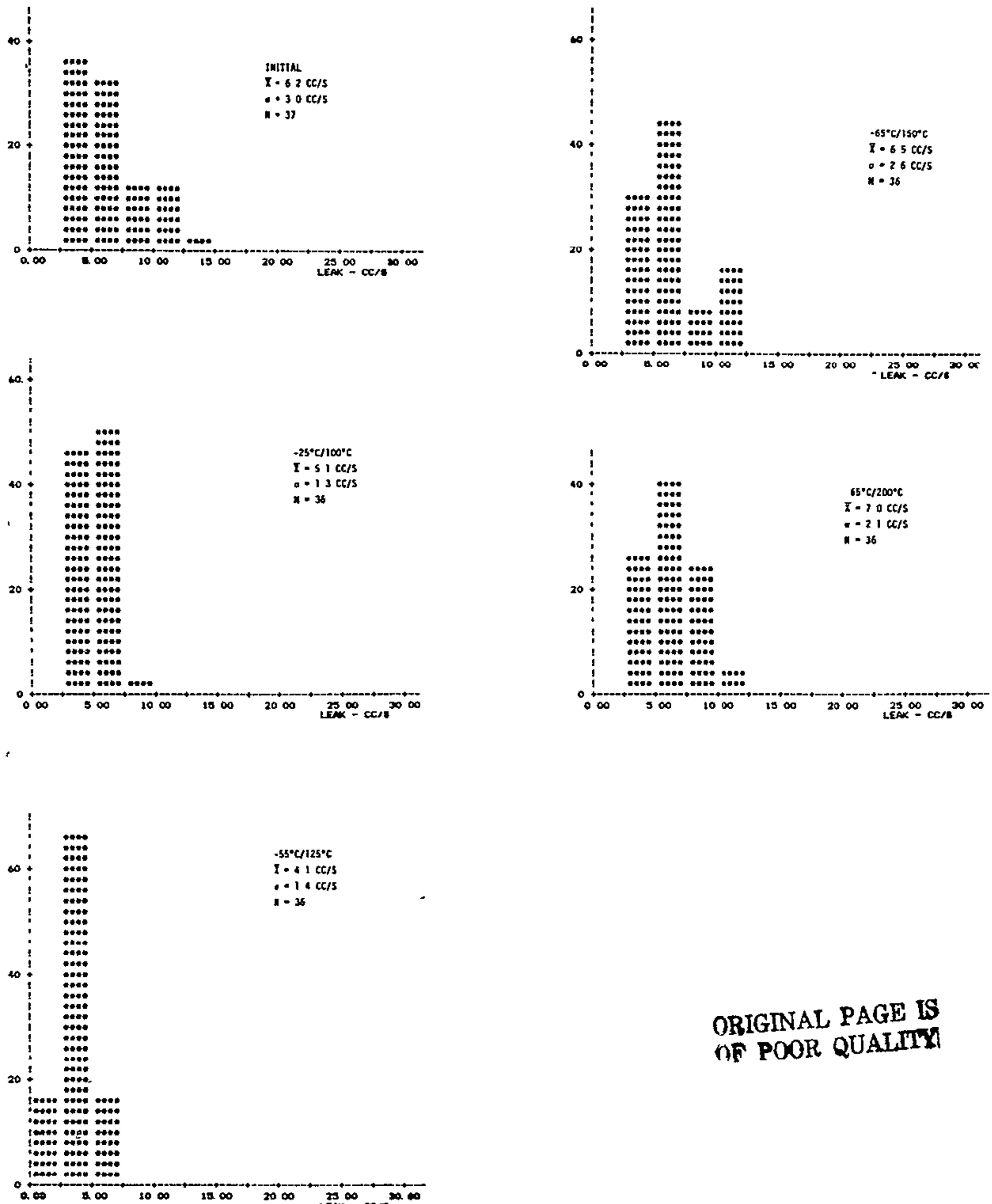


FIGURE B2-2. 50 CYCLES THERMAL CYCLING, KYOCERA 40 LEAD WHITE CERAMIC DIP

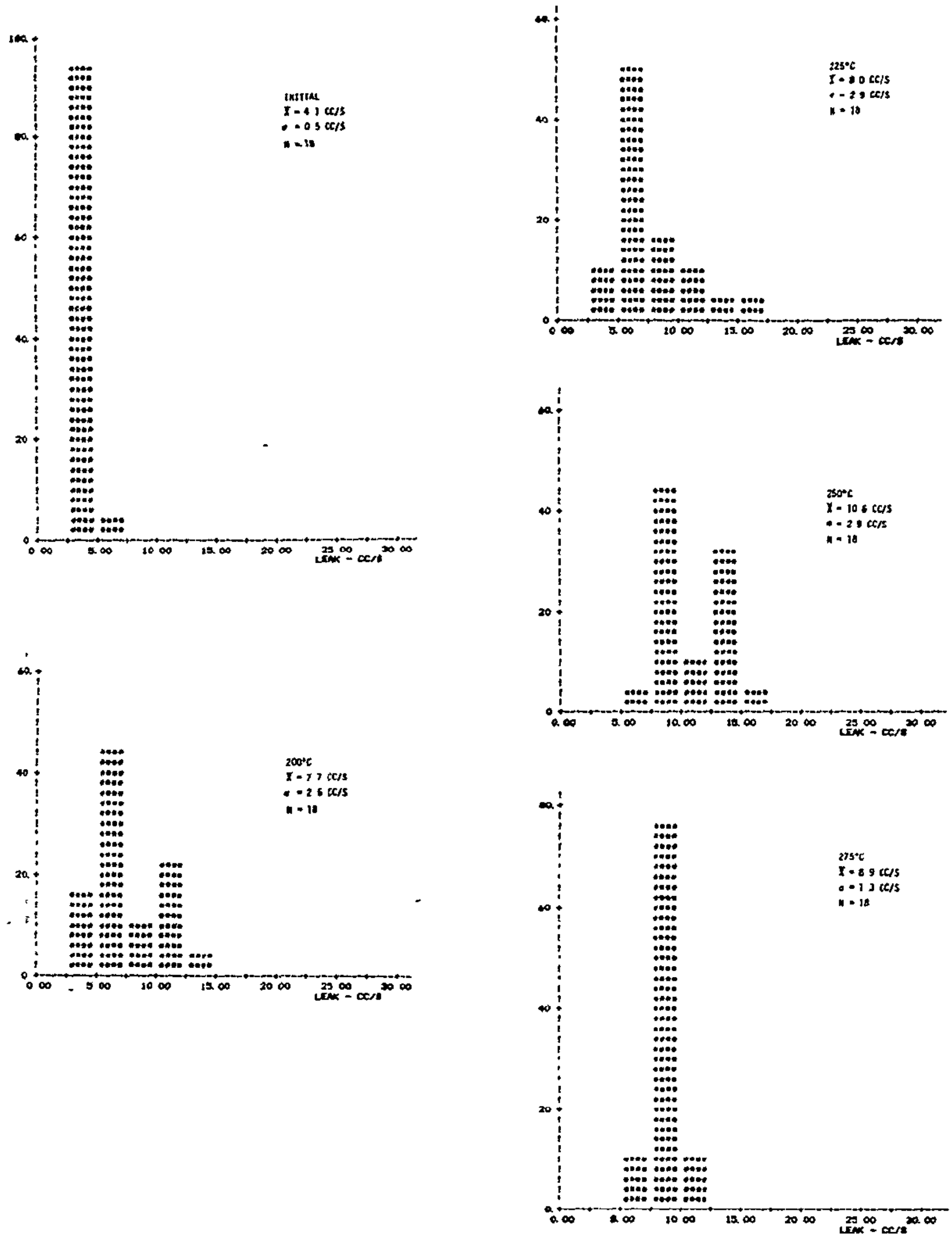


FIGURE B2-3. 72 HOURS HIGH TEMPERATURE BAKE, KYOCERA 40 LEAD WHITE CERAMIC DIP

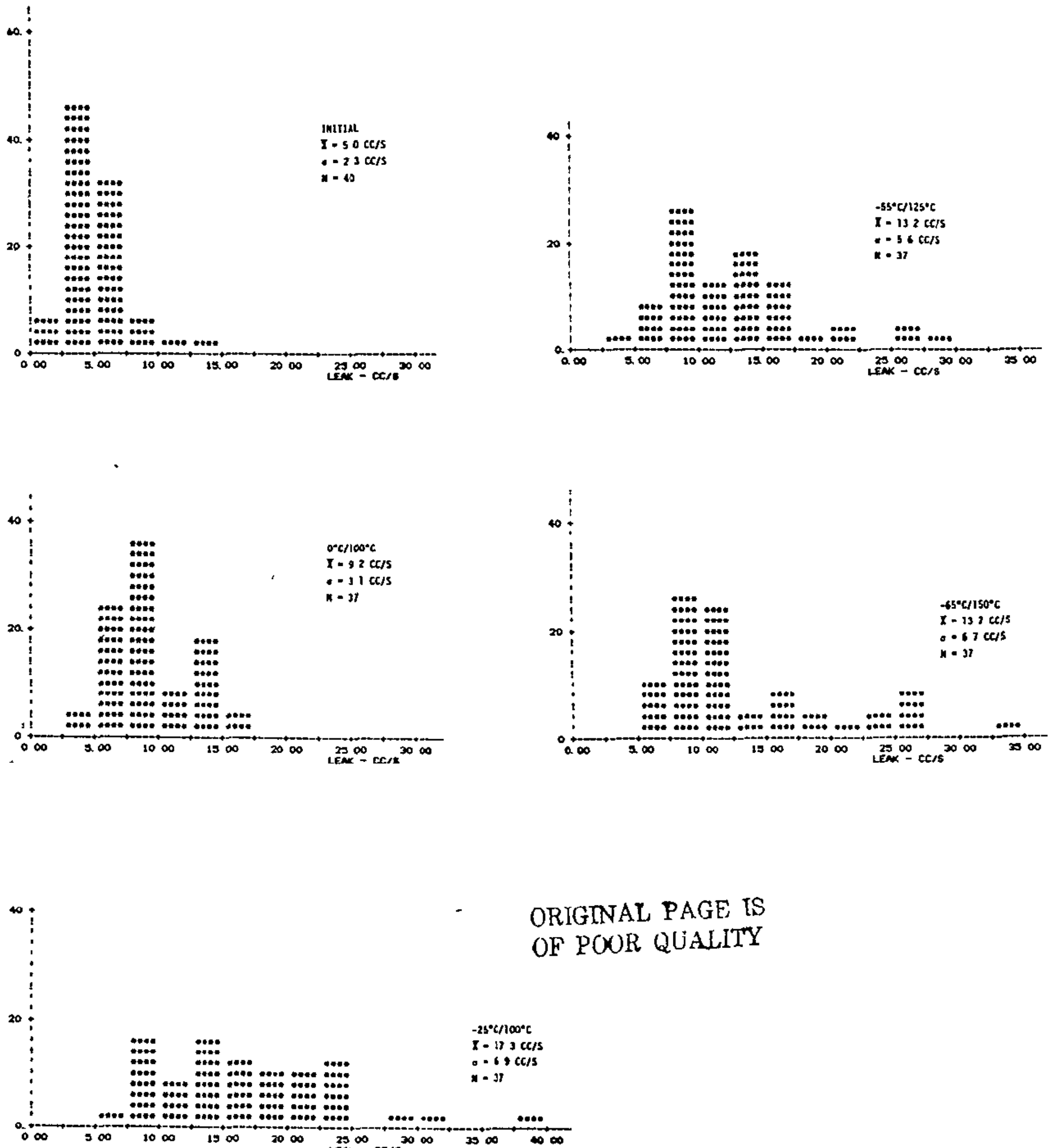


FIGURE B3-1. 50 CYCLES THERMAL SHOCK, RCA 16 LEAD WHITE CERAMIC DIP

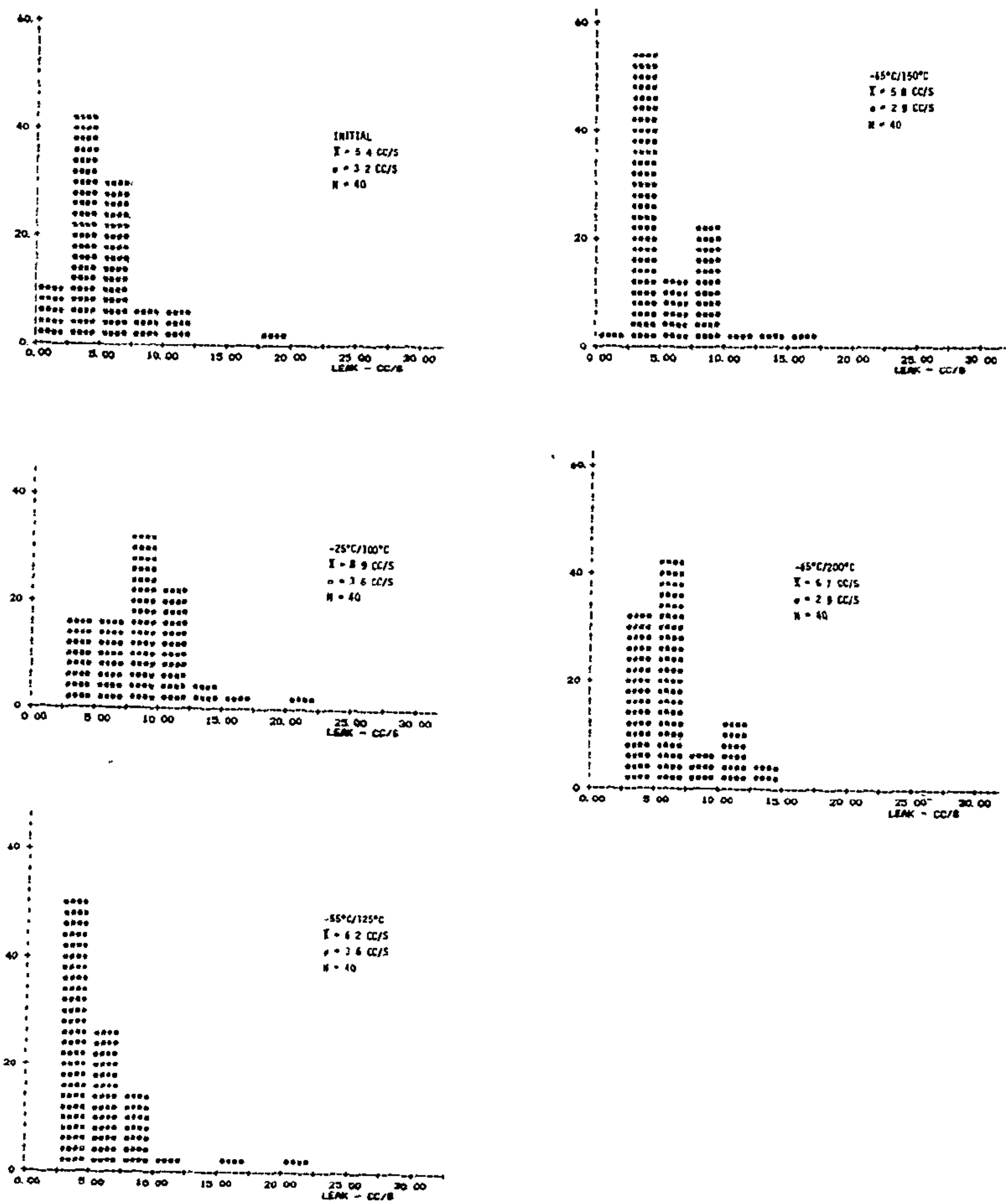
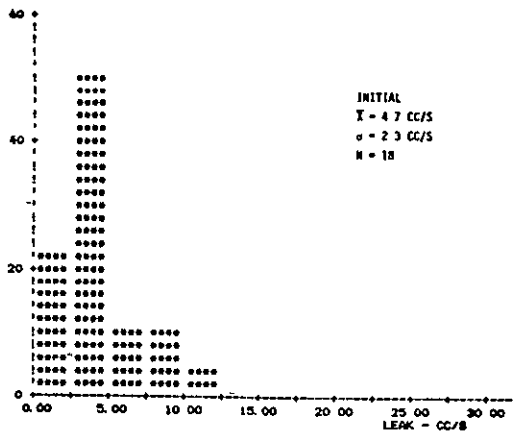
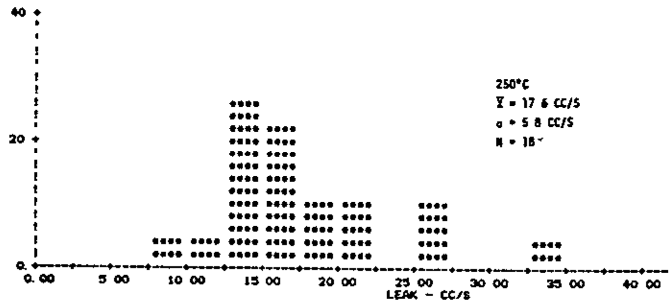
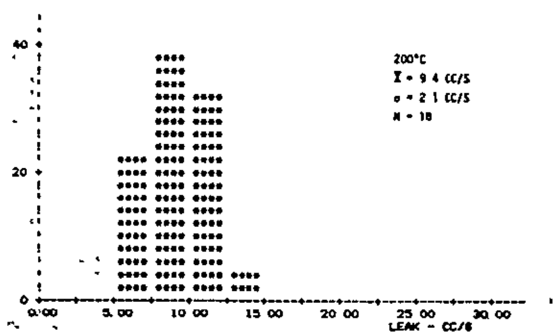
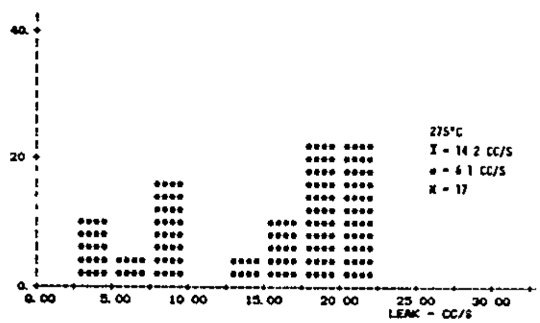


FIGURE B3-2. 50 CYCLES THERMAL CYCLING, RCA 16 LEAD WHITE CERAMIC DIP









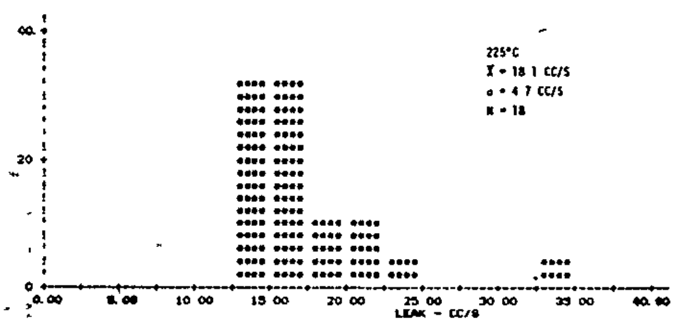


FIGURE B3-3. 72 HOURS HIGH TEMPERATURE BAKE, RCA 16 LEAD WHITE CERAMIC DIP

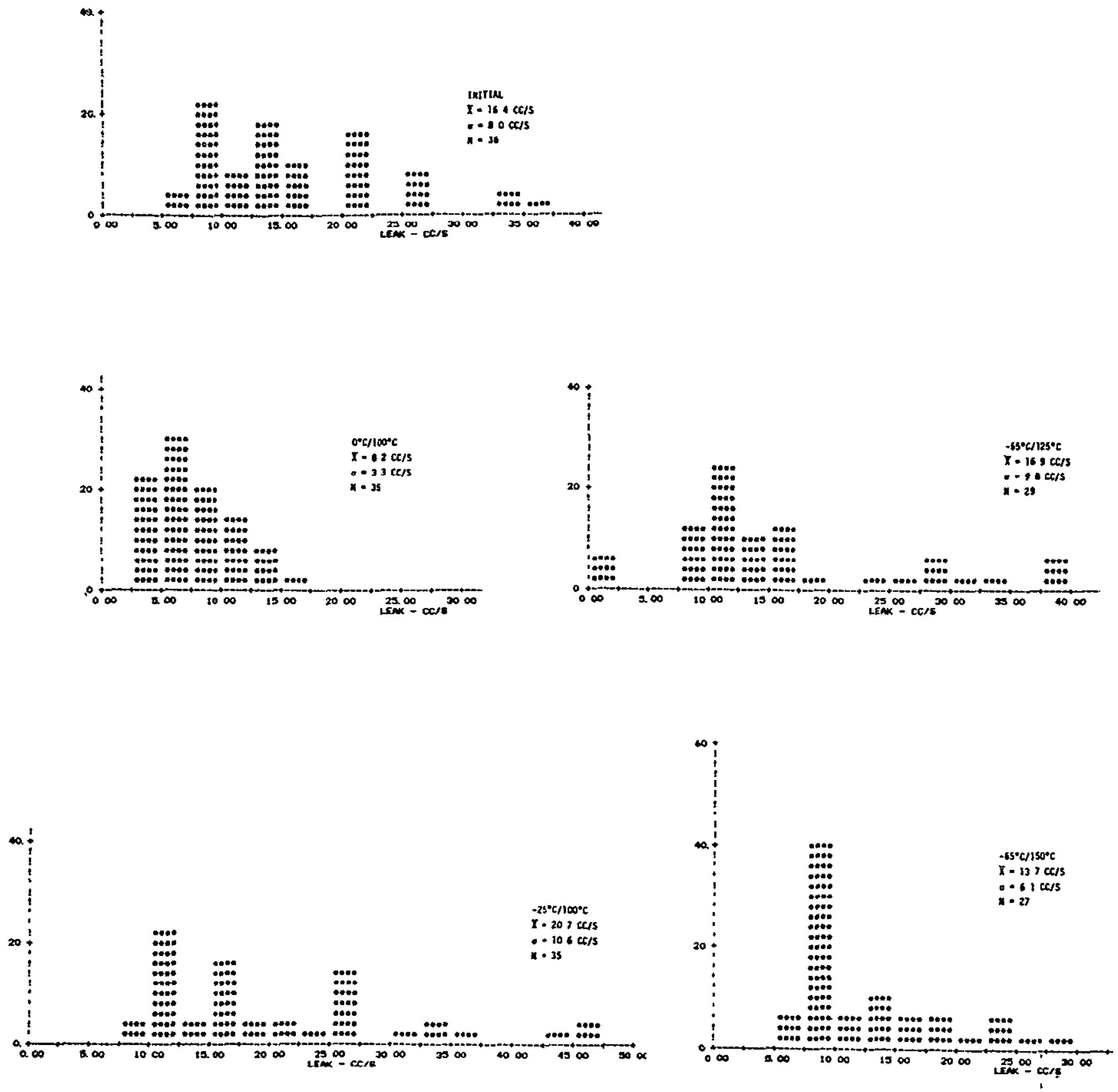
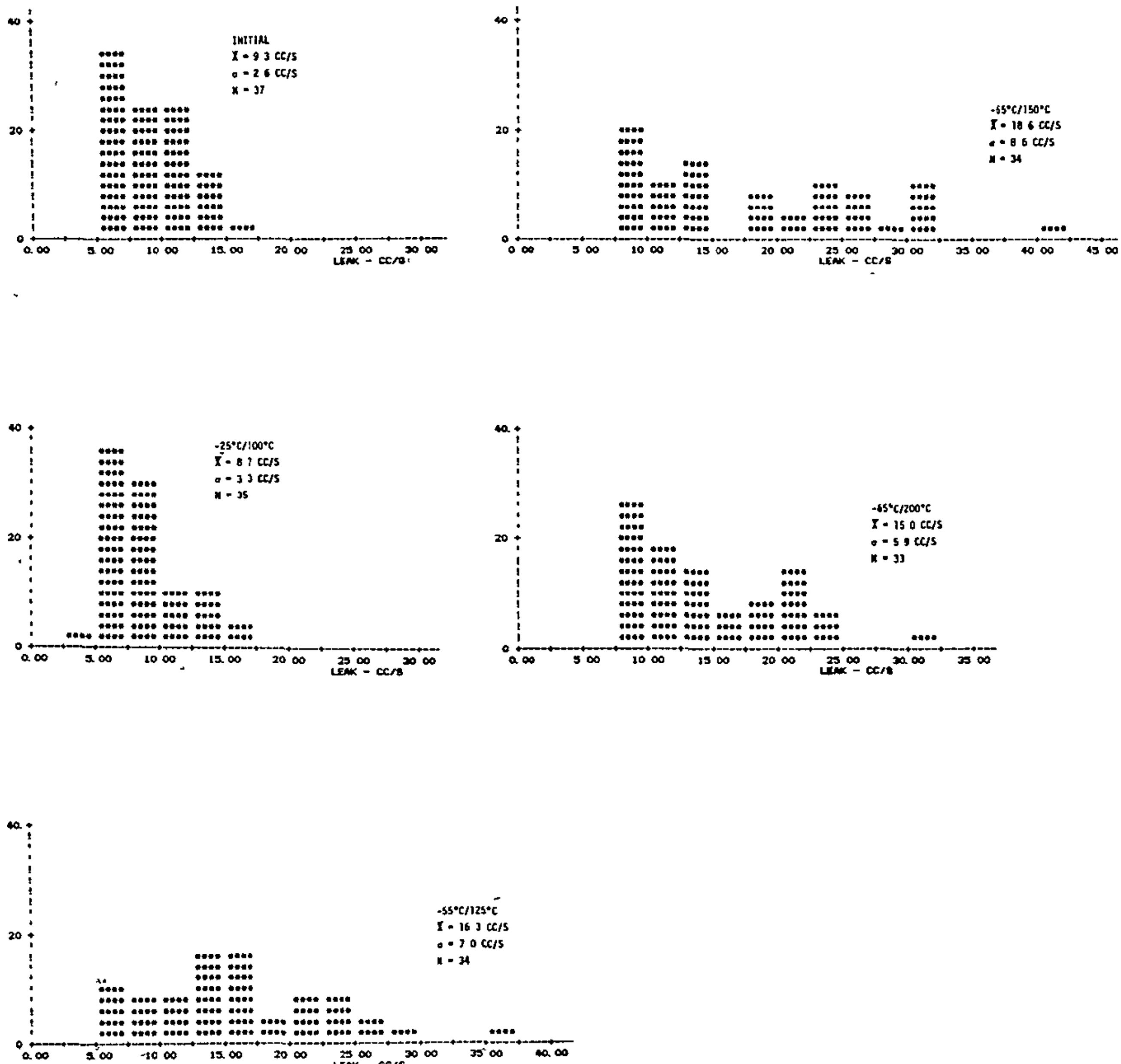


FIGURE B4-1. 50 CYCLES THERMAL SHOCK, SOLID STATE SCIENTIFIC 16 LEAD WHITE CERAMIC DIP



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OF POOR QUALITY

FIGURE B4-2. 50 CYCLES THERMAL CYCLING, SOLID STATE SCIENTIFIC 16 LEAD WHITE CERAMIC DIP

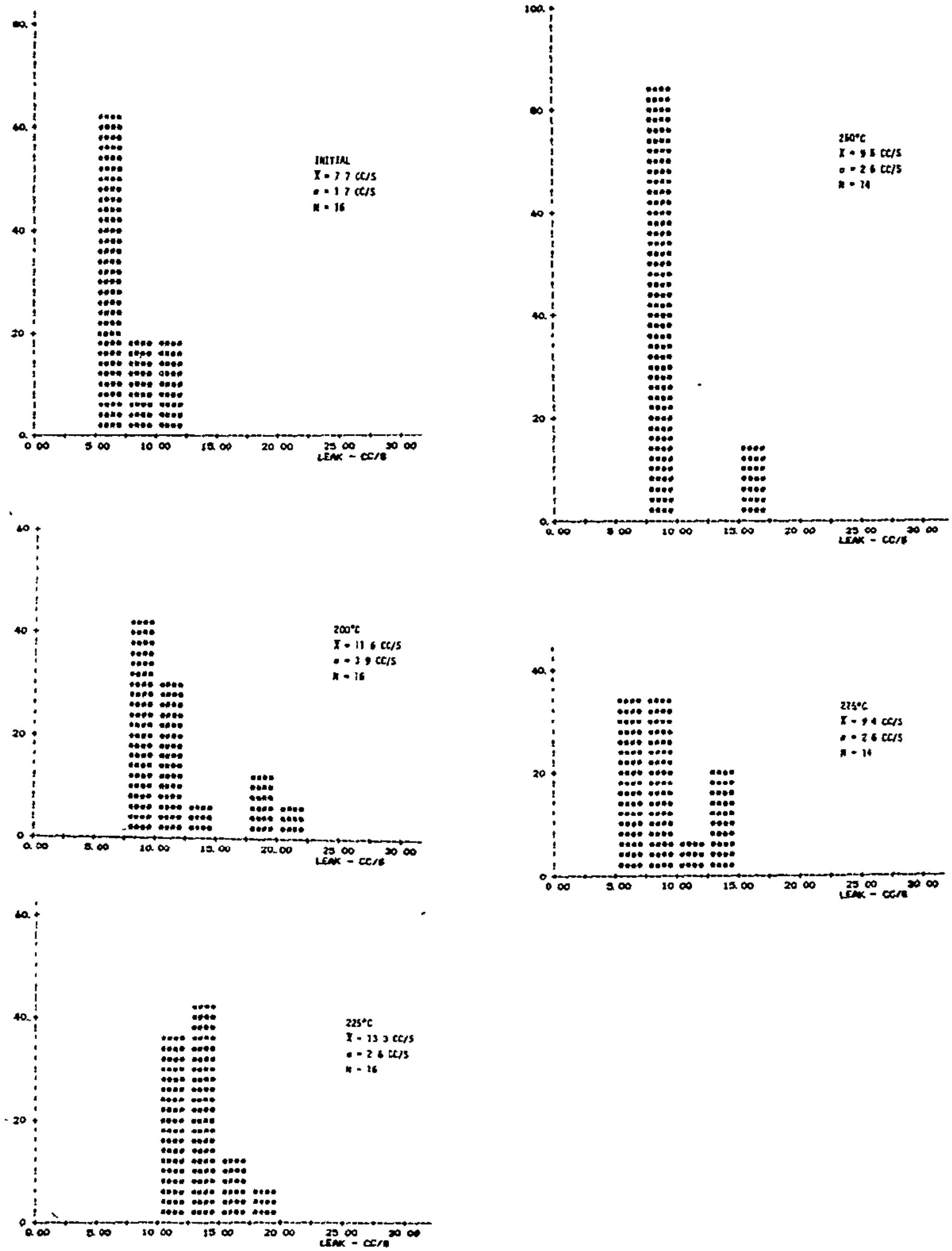
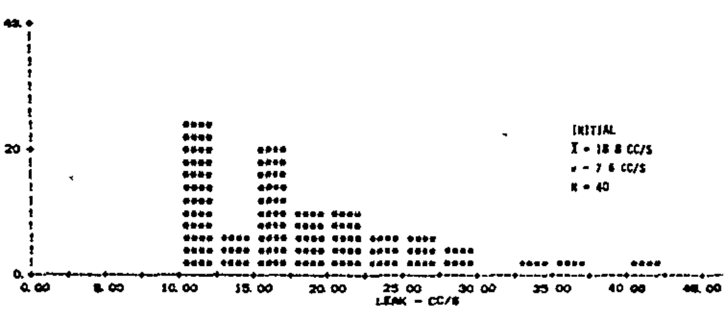
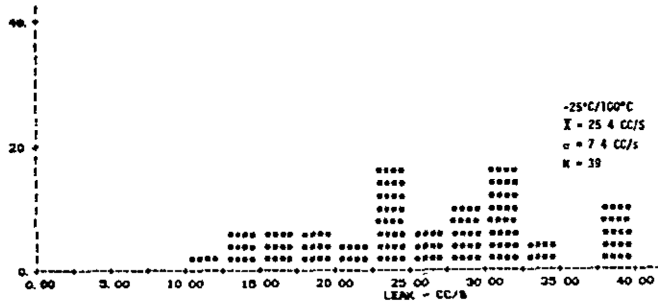
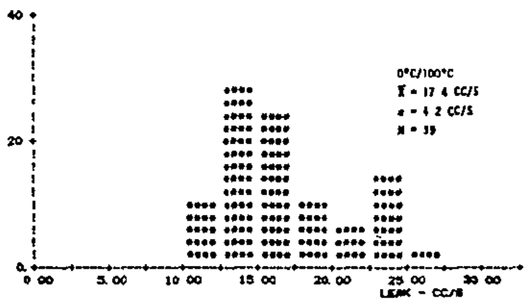
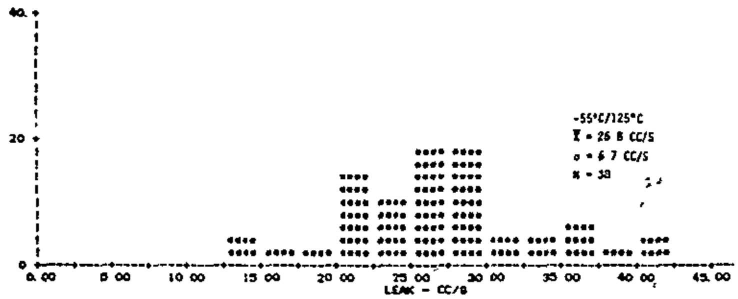


FIGURE B4-3. 72 HOURS HIGH TEMPERATURE BAKE, SOLID STATE SCIENTIFIC 16 LEAD WHITE CERAMIC DIP









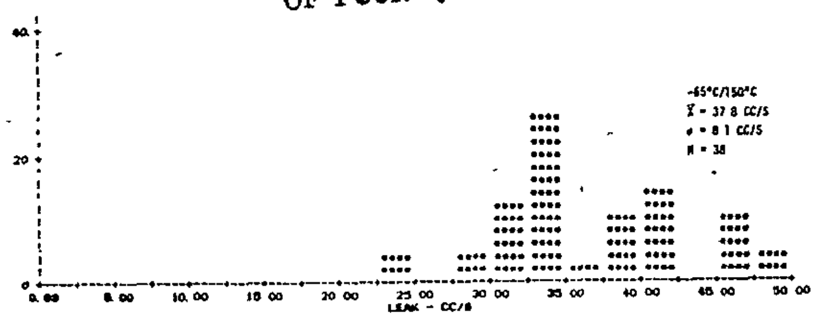


FIGURE B5-1. 50 CYCLES THERMAL SHOCK, MOTOROLA 14 LEAD CERDIP

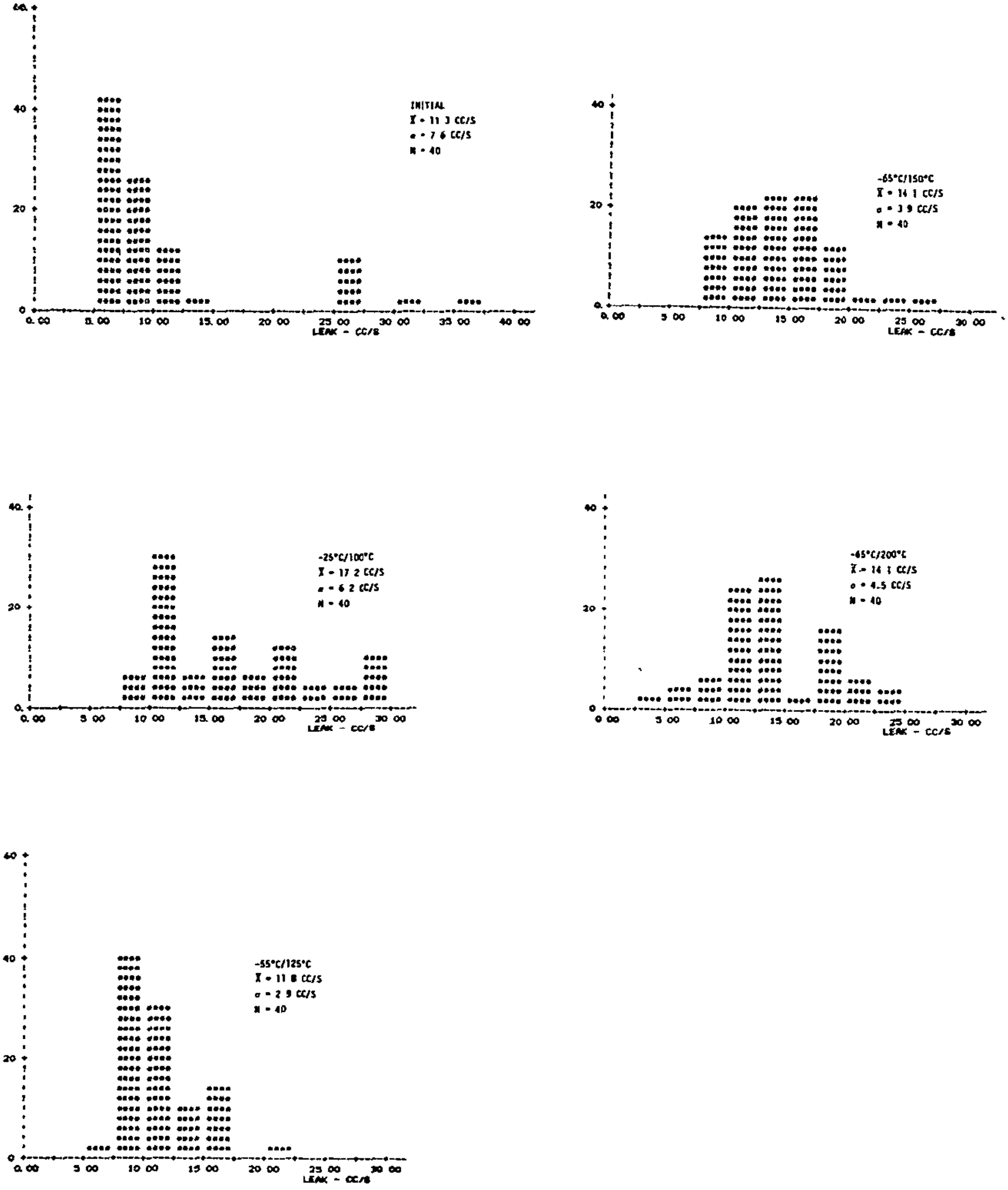


FIGURE B5-2. 50 CYCLES THERMAL CYCLING, MOTOROLA 14 LEAD CERDIP

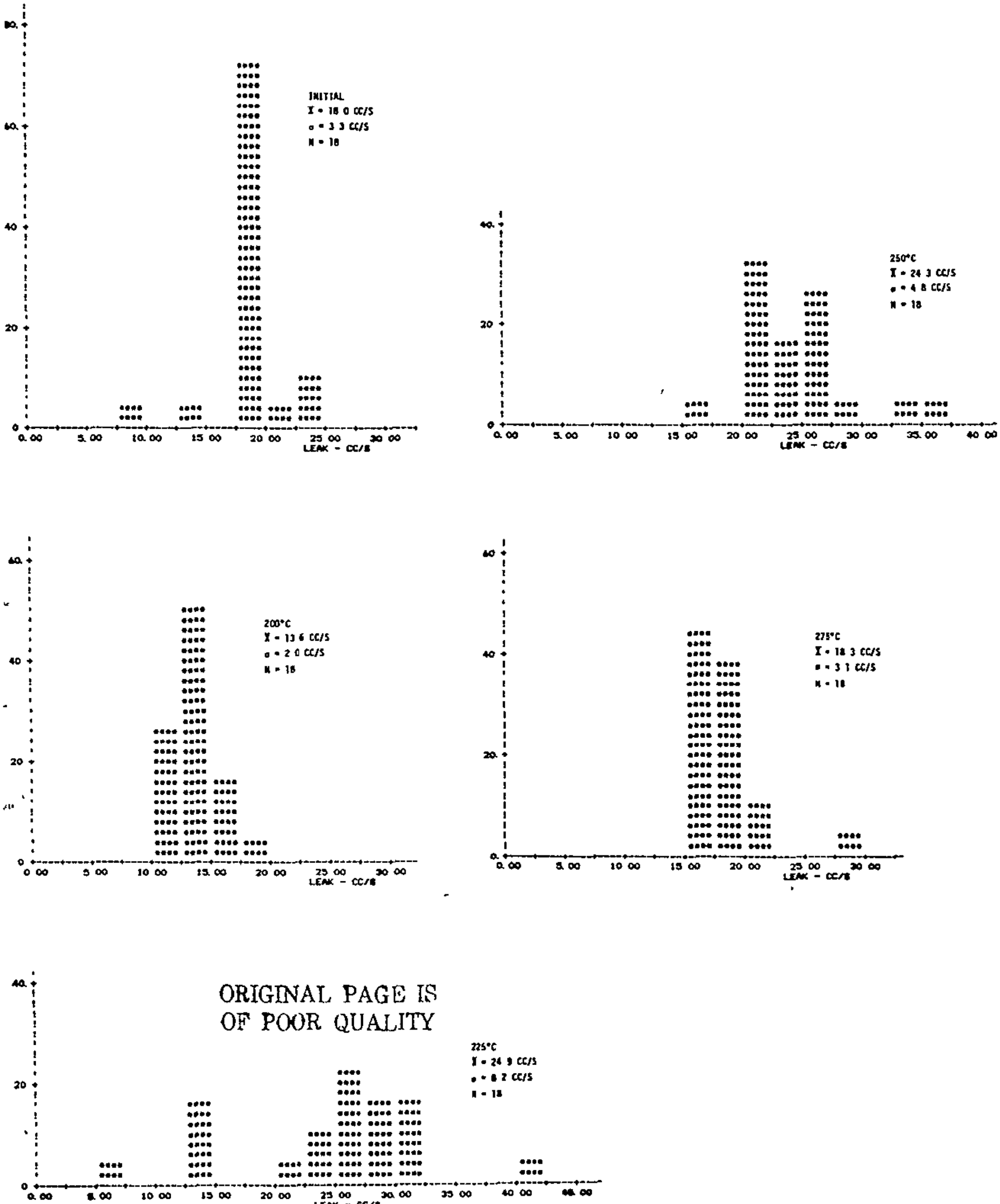


FIGURE B5-3. 72 HOURS HIGH TEMPERATURE BAKE, MOTOROLA 14 LEAD CERDIP

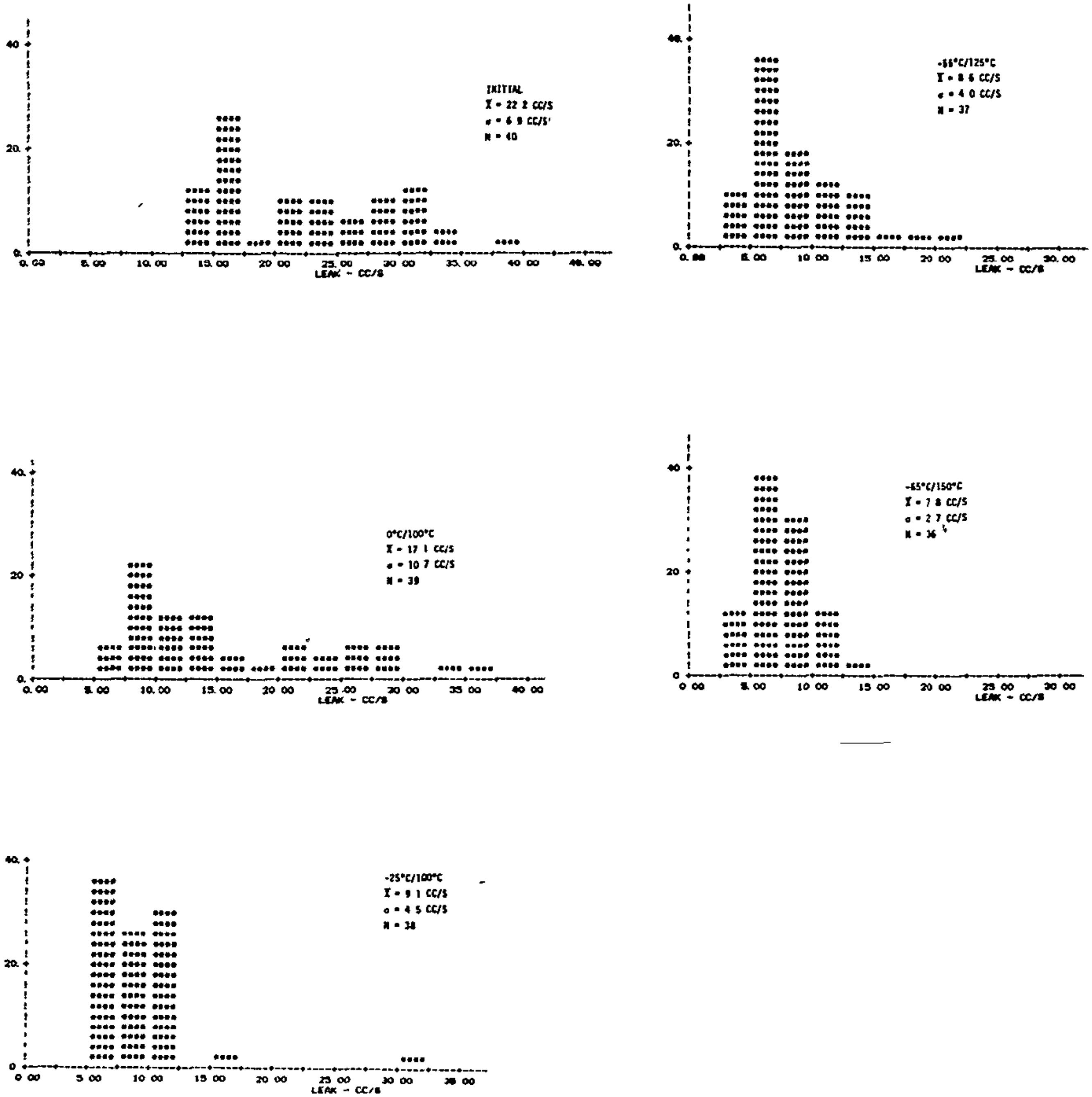


FIGURE B6-1. 50 CYCLES THERMAL SHOCK, ITT 14 LEAD CERDIP

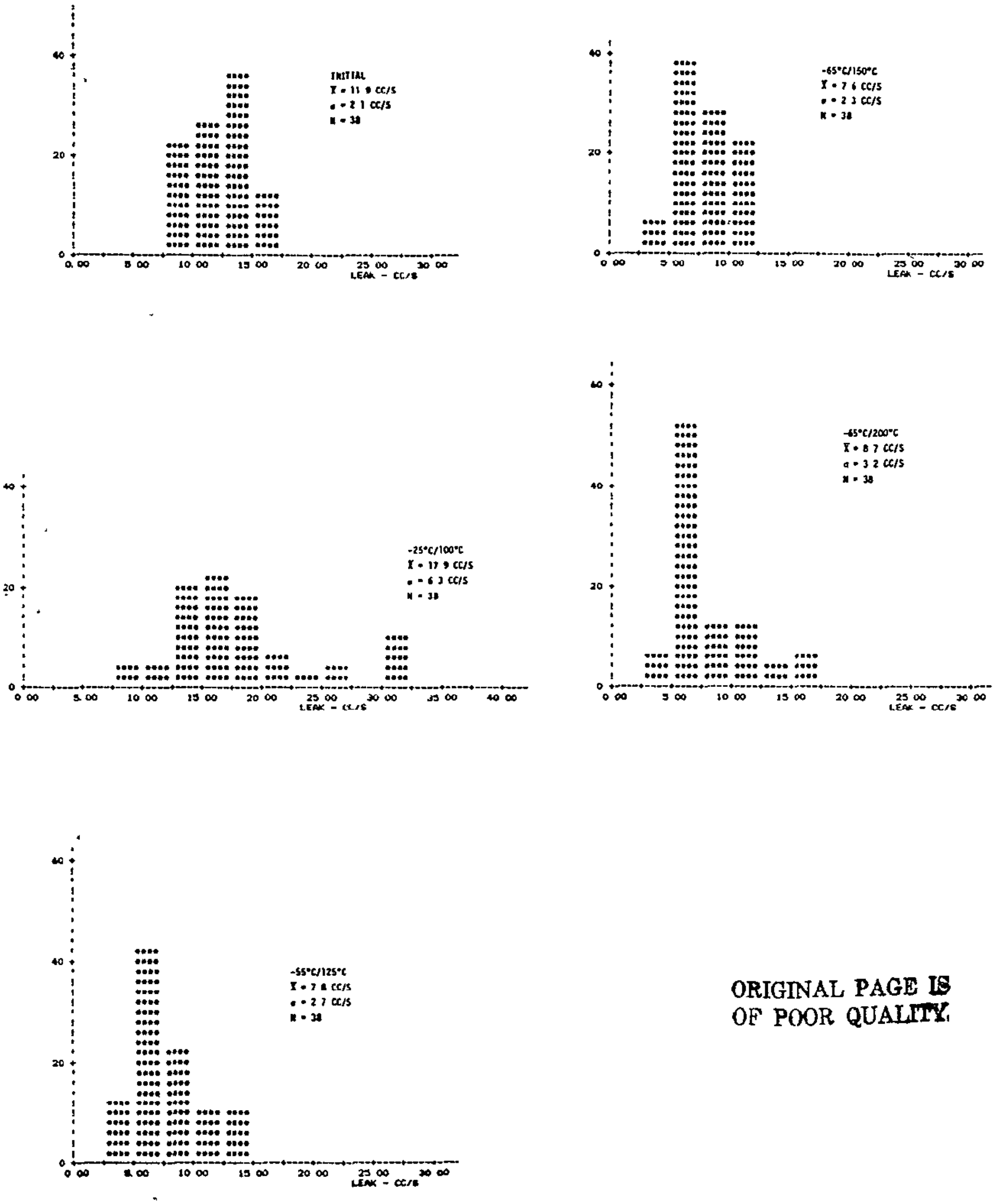


FIGURE B6-2. 50 CYCLES THERMAL CYCLING, ITT 14 LEAD CERDIP

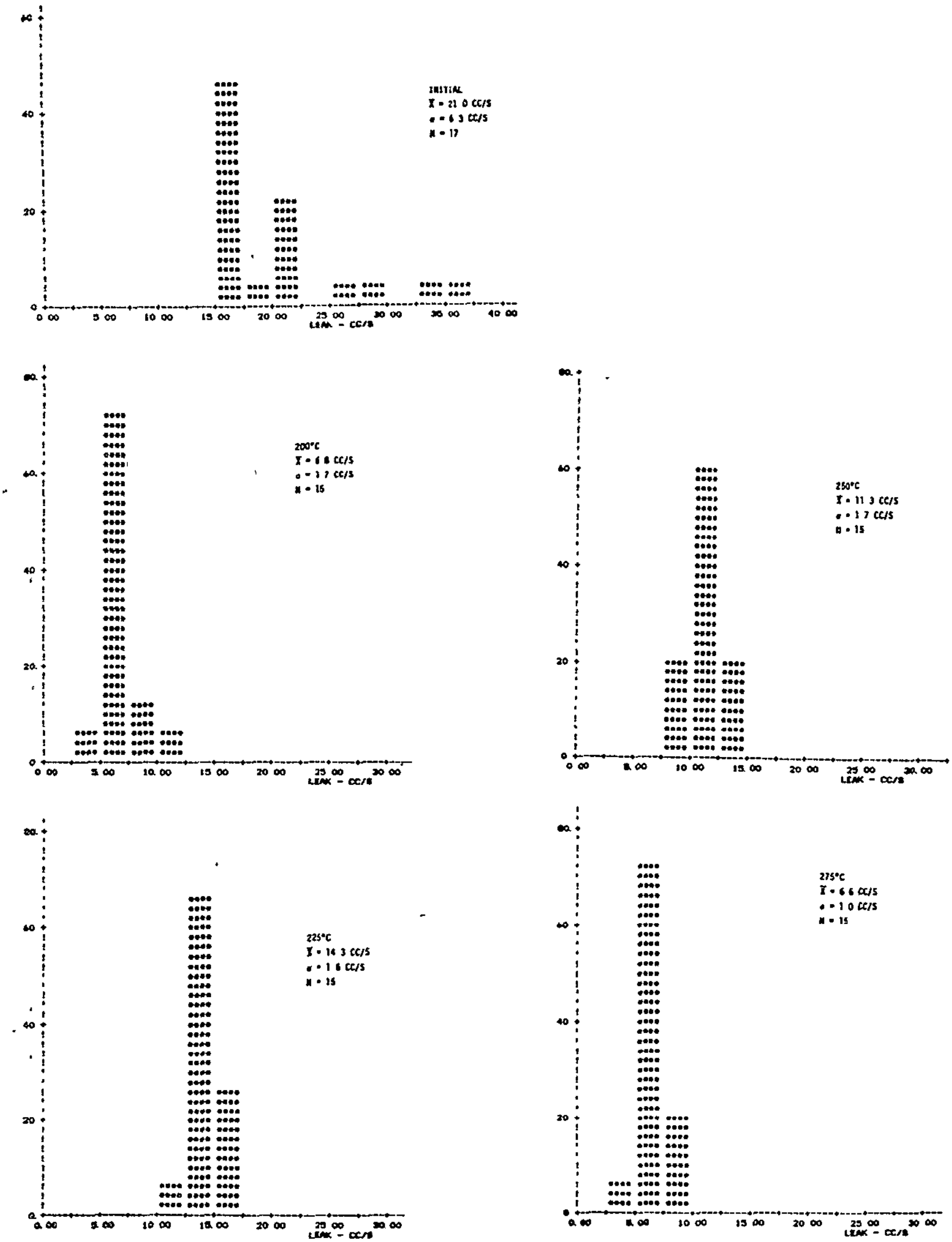


FIGURE B6-3. 72 HOURS HIGH TEMPERATURE BAKE, ITT 14 LEAD CERDIP

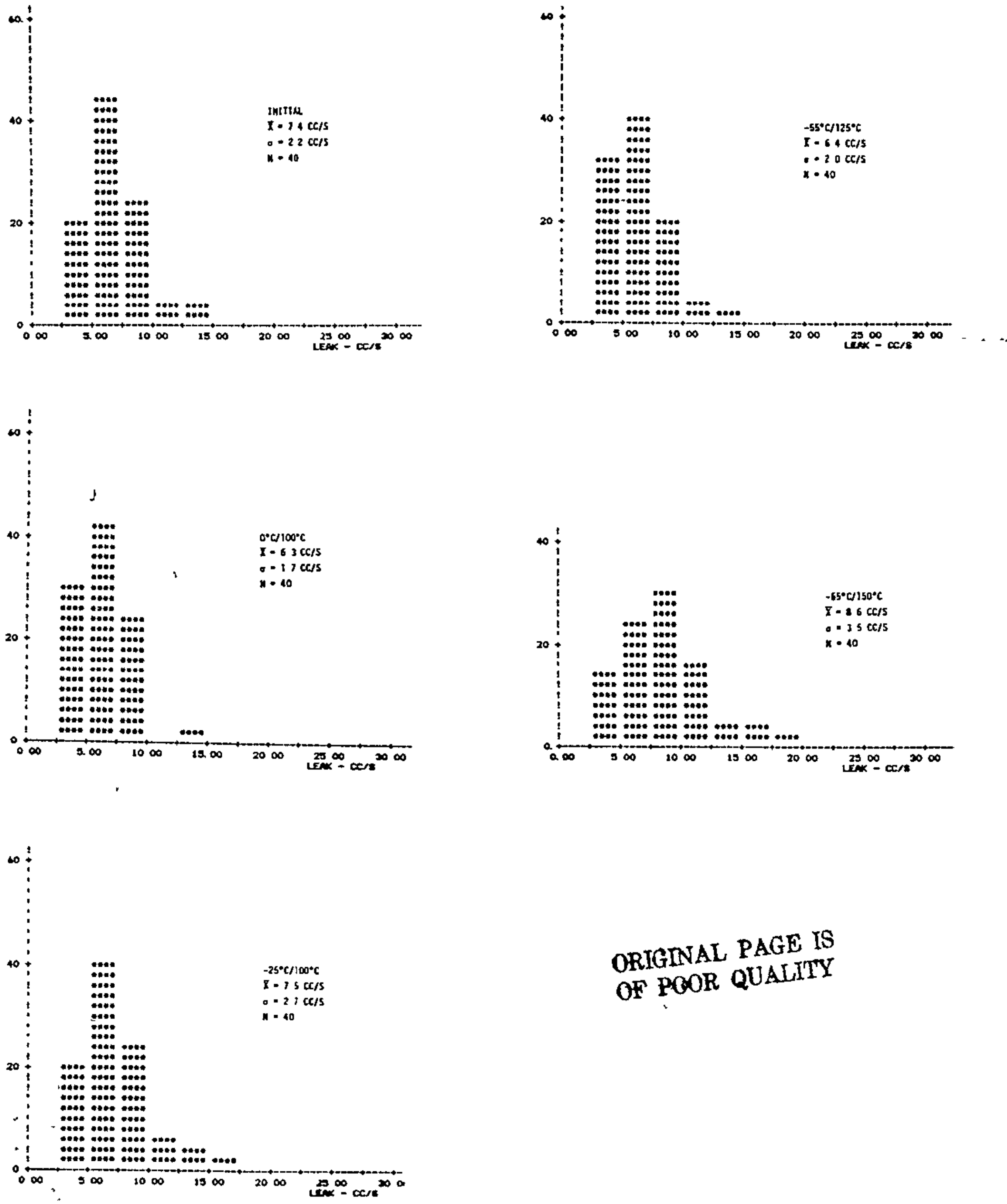


FIGURE B7-1. 50 CYCLES THERMAL SHOCK, TEXAS INSTRUMENTS 14 LEAD 1/4" X 1/8" METAL PACK

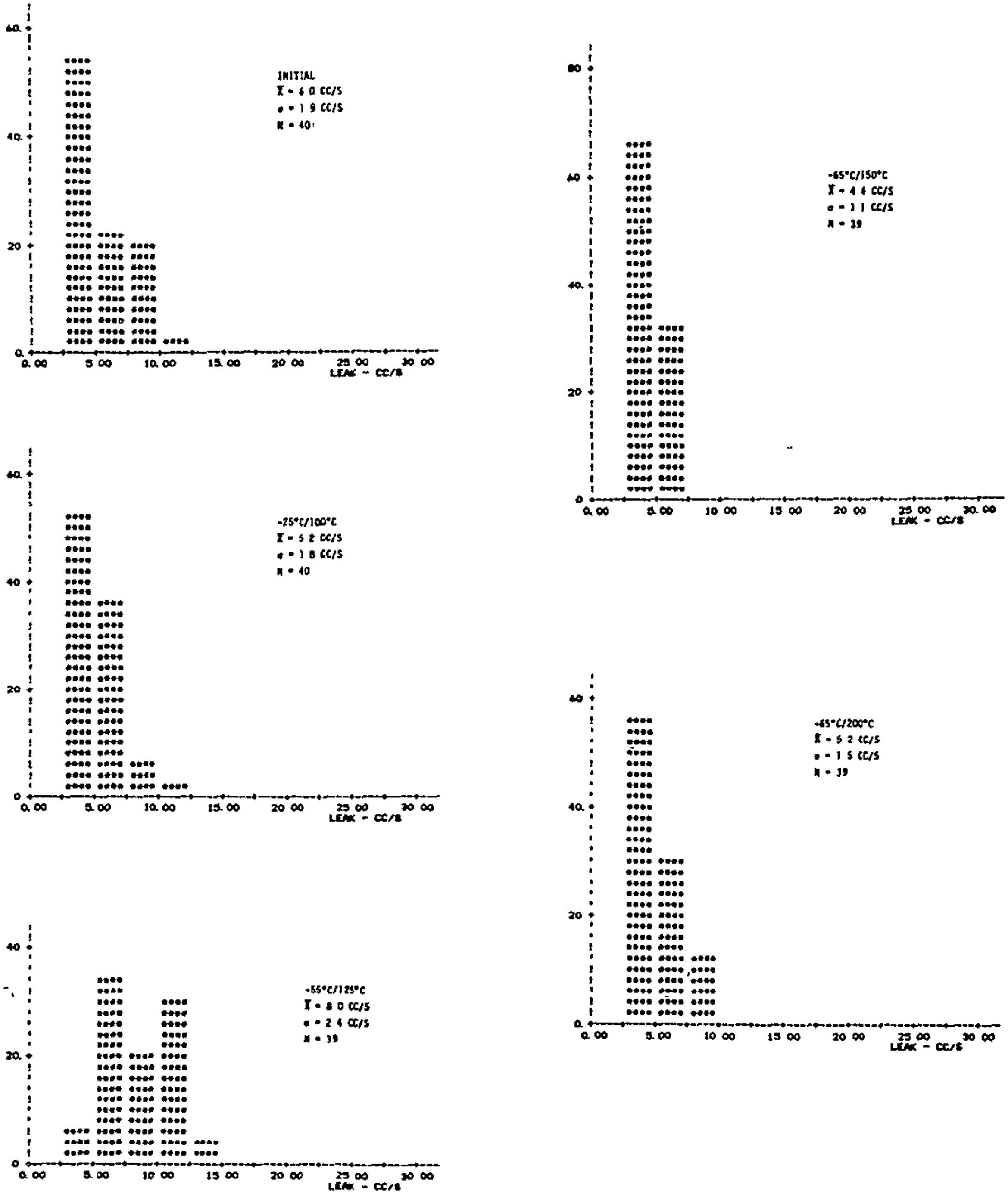


FIGURE B7-2. 50 CYCLES THERMAL CYCLING, TEXAS INSTRUMENTS 14 LEAD 1/4" X 1/8" METAL PACK

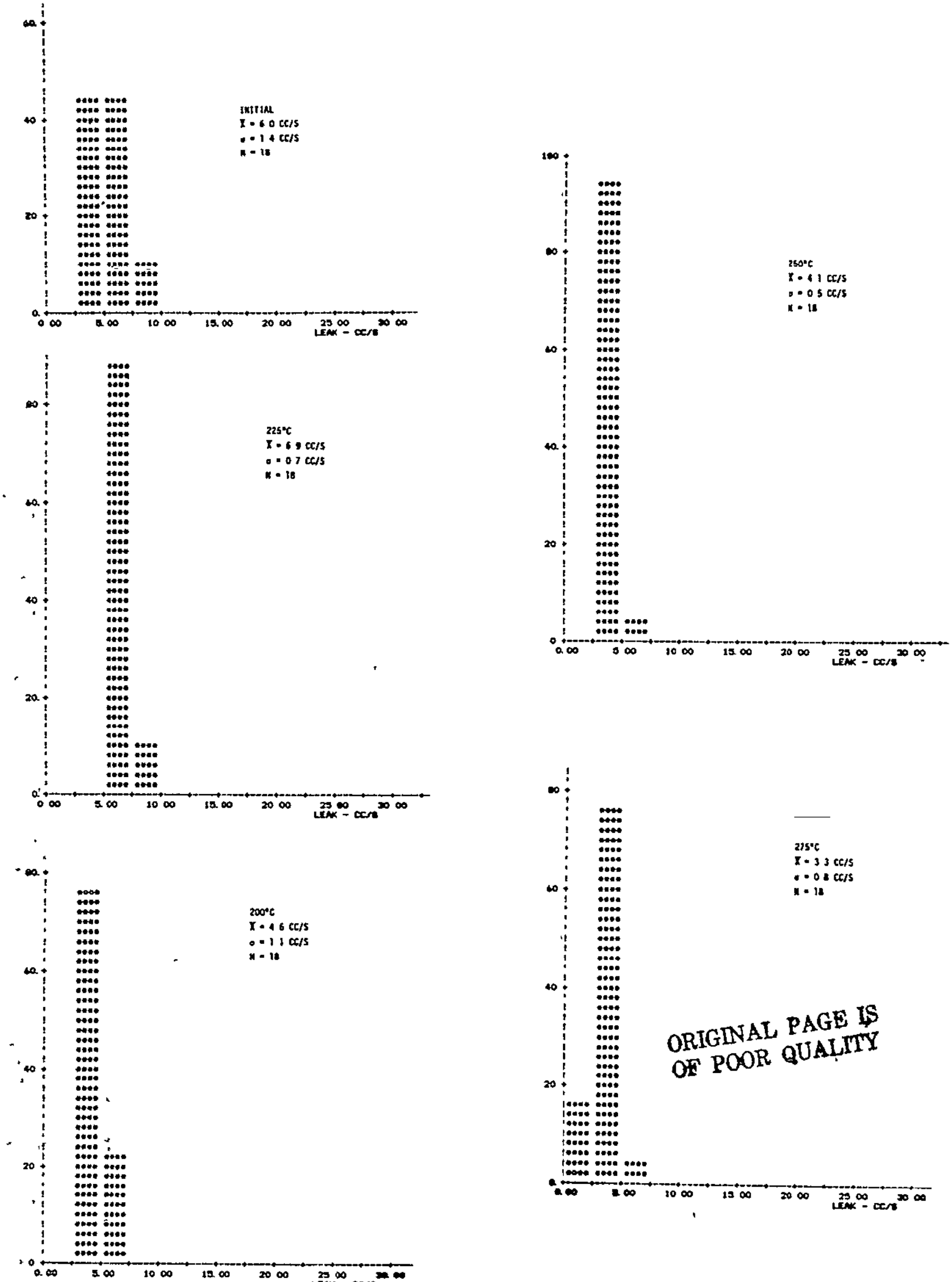


FIGURE B7-3. 72 HOURS HIGH TEMPERATURE BAKE, TEXAS INSTRUMENTS 14 LEAD 1/4" X 1/8" METAL PACK

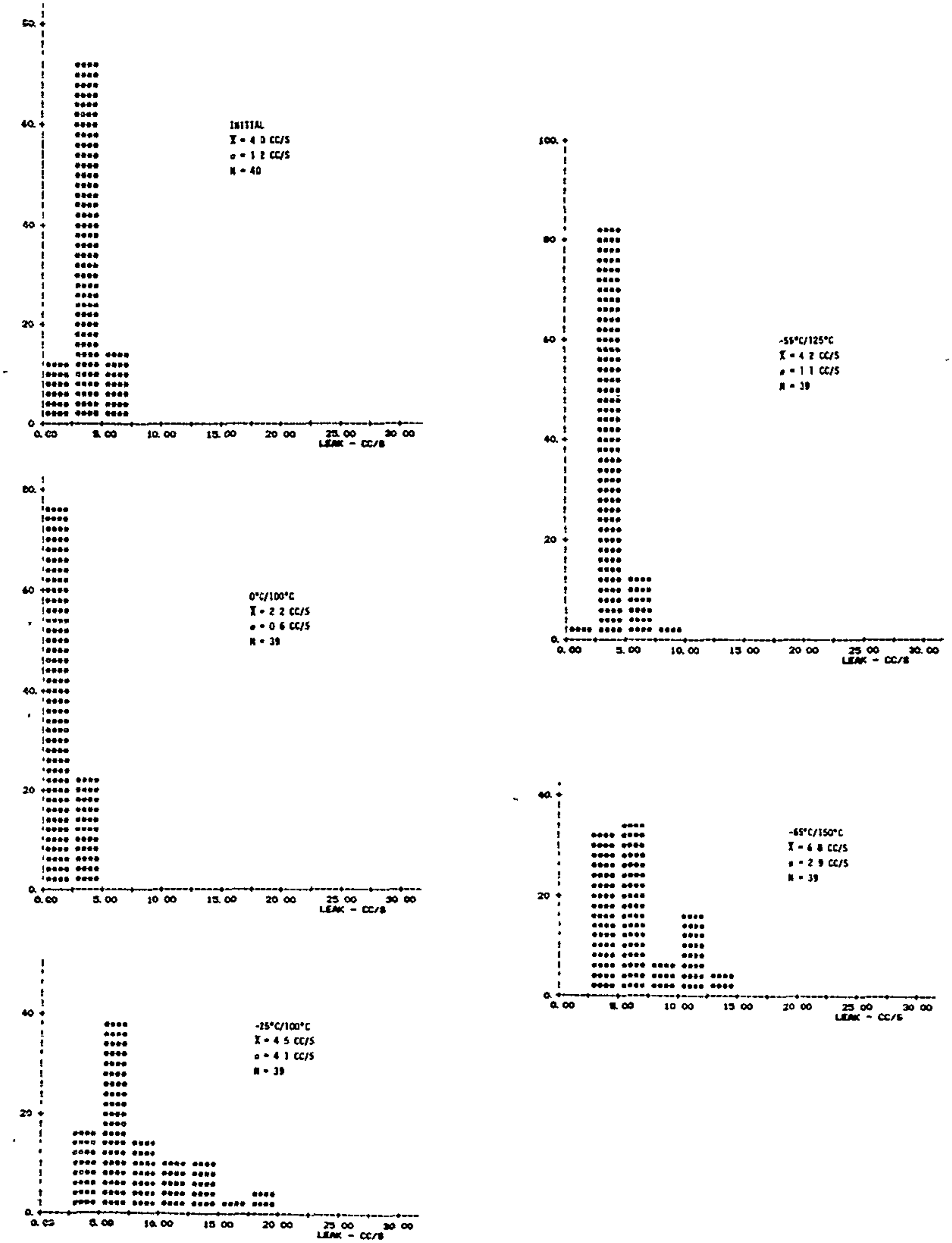


FIGURE B8-1. 50 CYCLES THERMAL SHOCK, NATIONAL 16 LEAD WHITE CERAMIC FLAT PACK

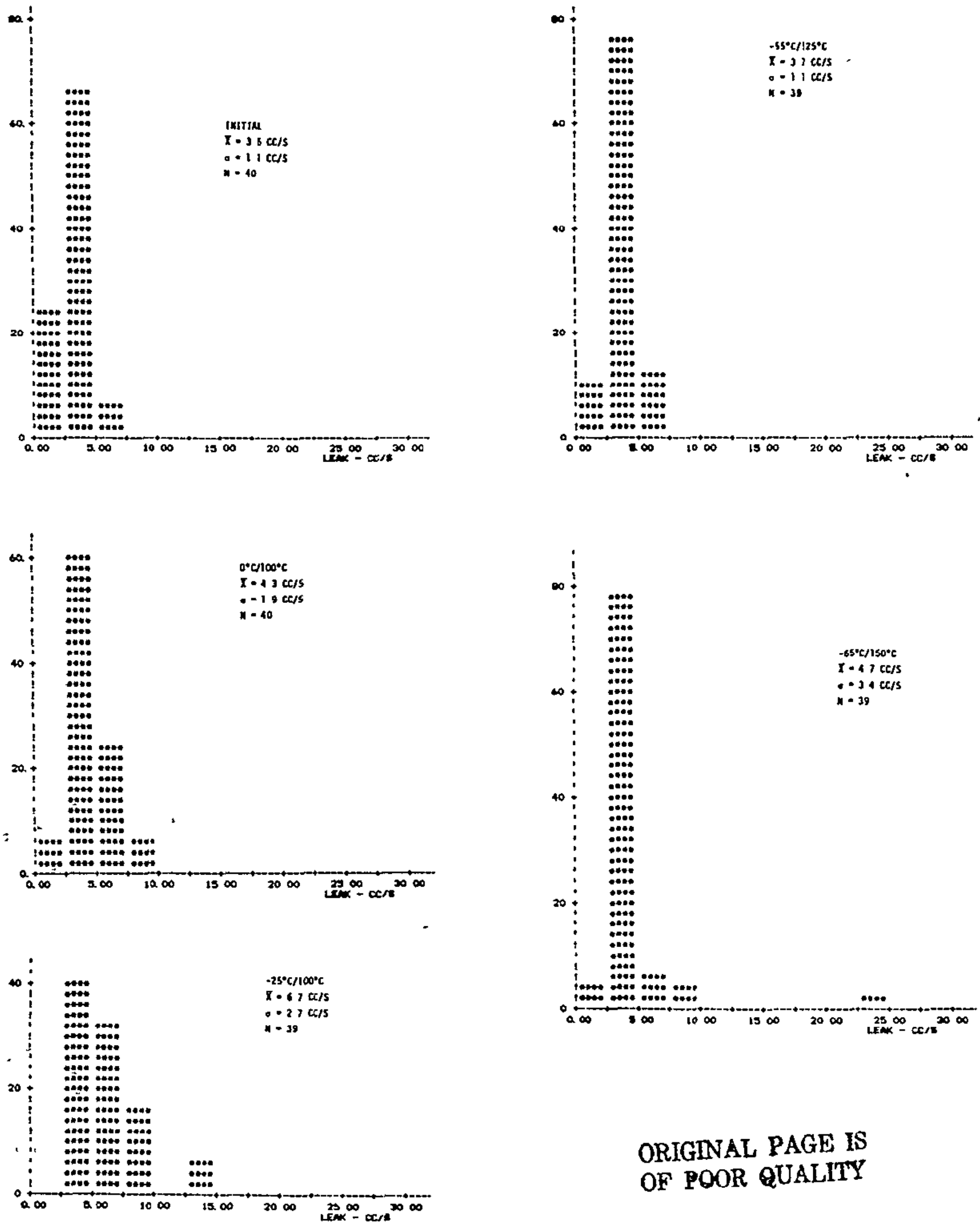


FIGURE B8-2. 50 CYCLES THERMAL CYCLING, NATIONAL 16 LEAD WHITE CERAMIC FLAT PACK

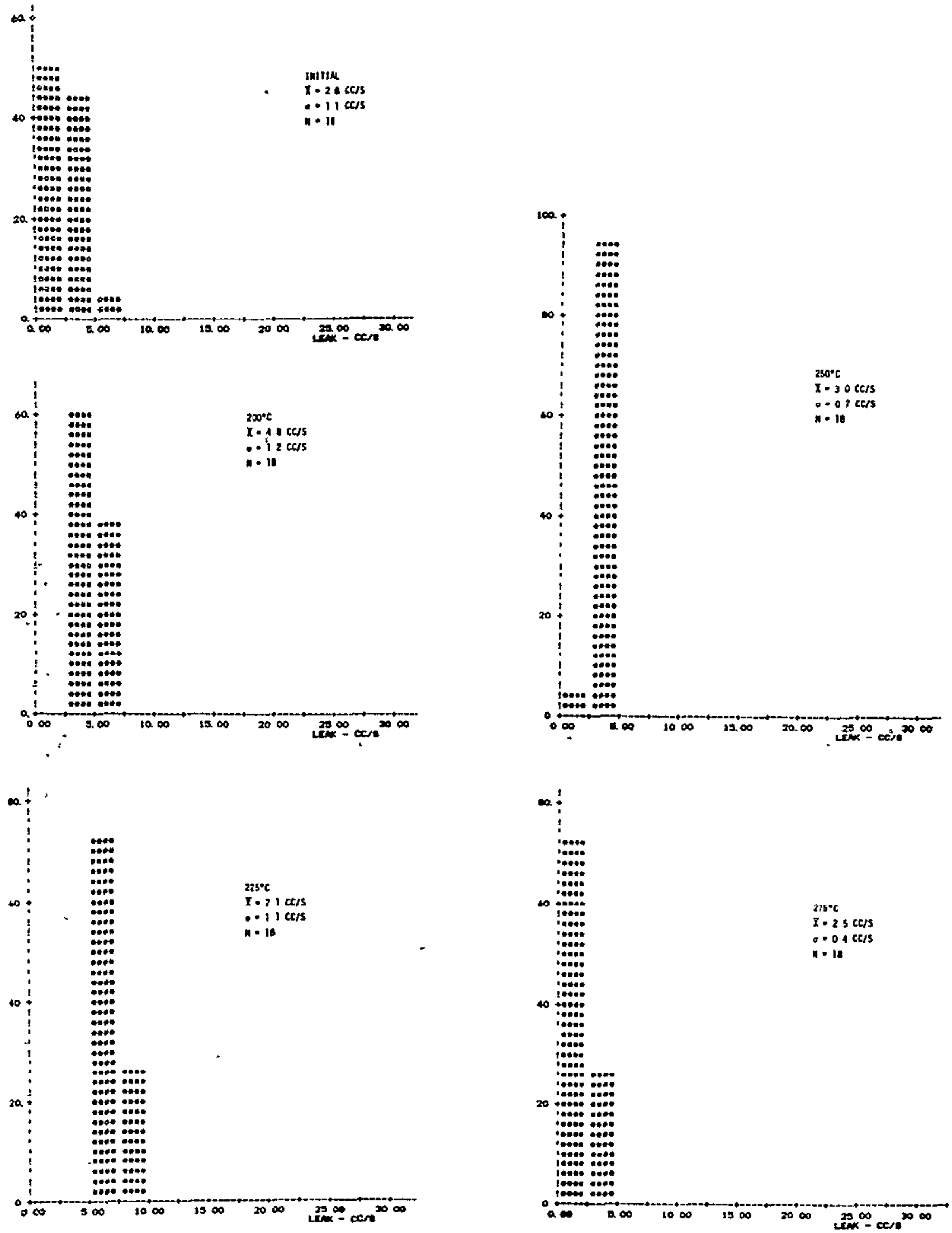


FIGURE B8-3. 72 HOURS HIGH TEMPERATURE BAKE, NATIONAL 16 LEAD WHITE CERAMIC FLAT PACK

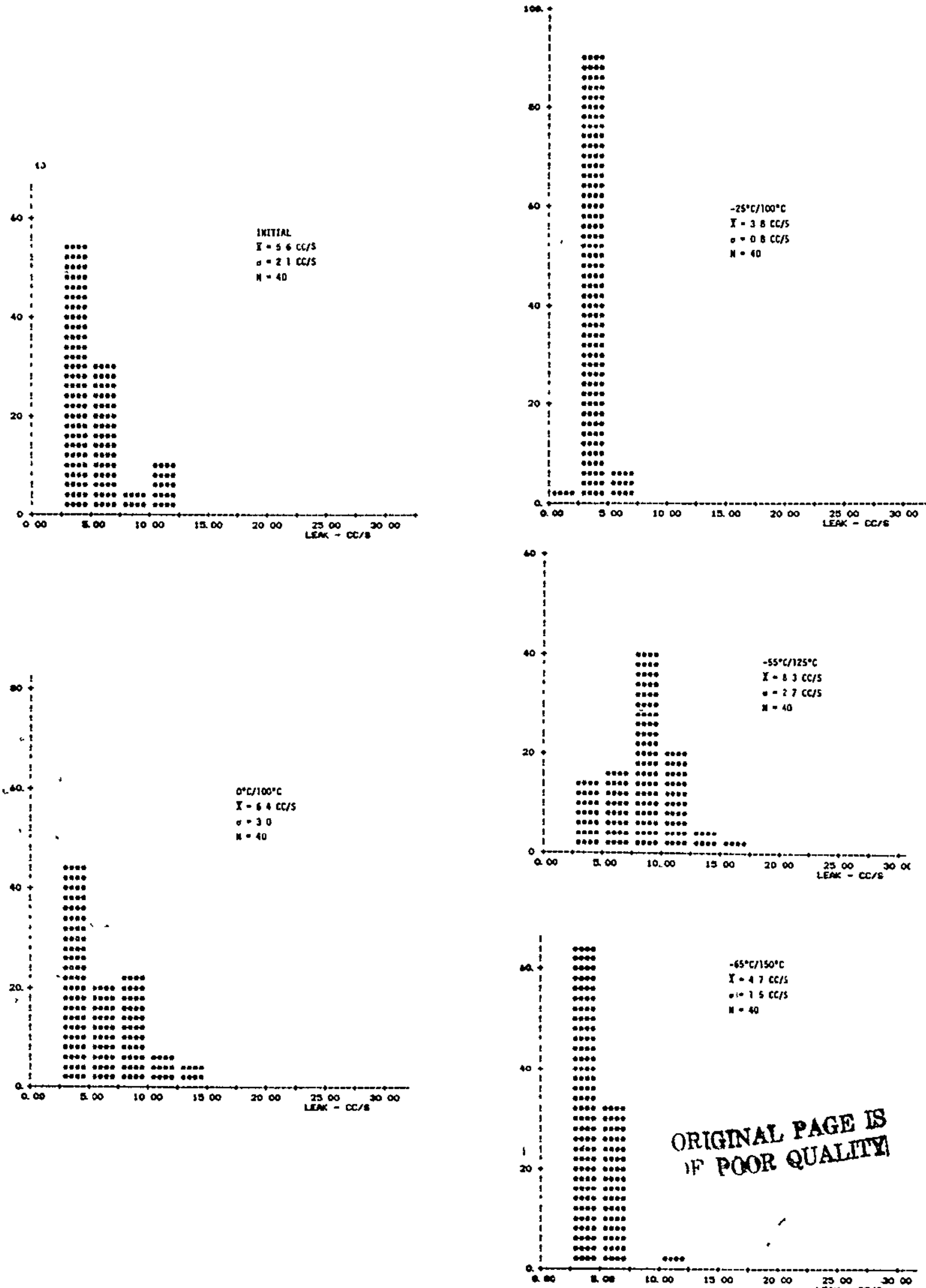


FIGURE B9-1. 50 CYCLES THERMAL SHOCK, DIACON 14 LEAD CERPAK

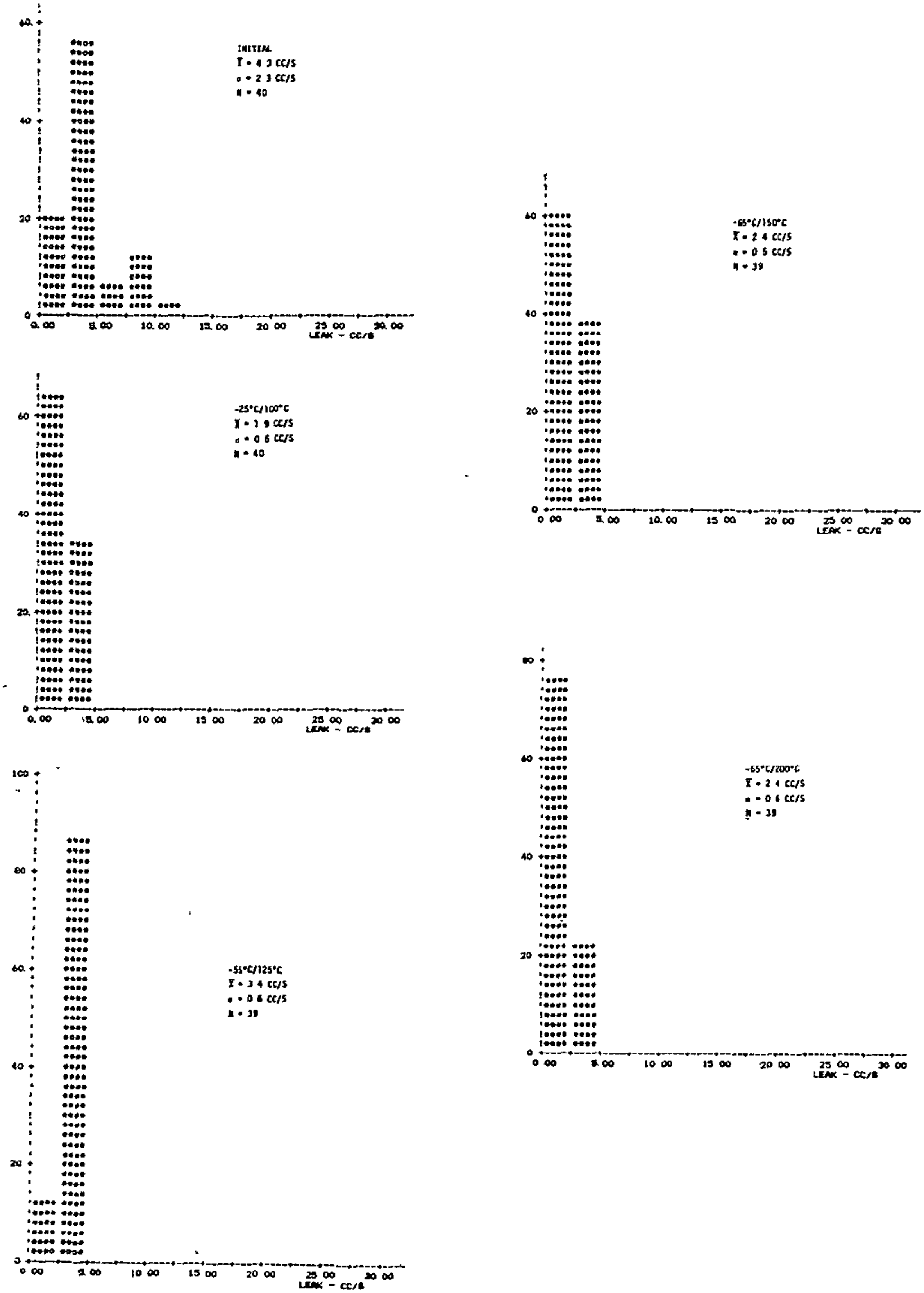


FIGURE B9-2. 50 CYCLES THERMAL CYCLING, DIACON 14 LEAD CERPAK

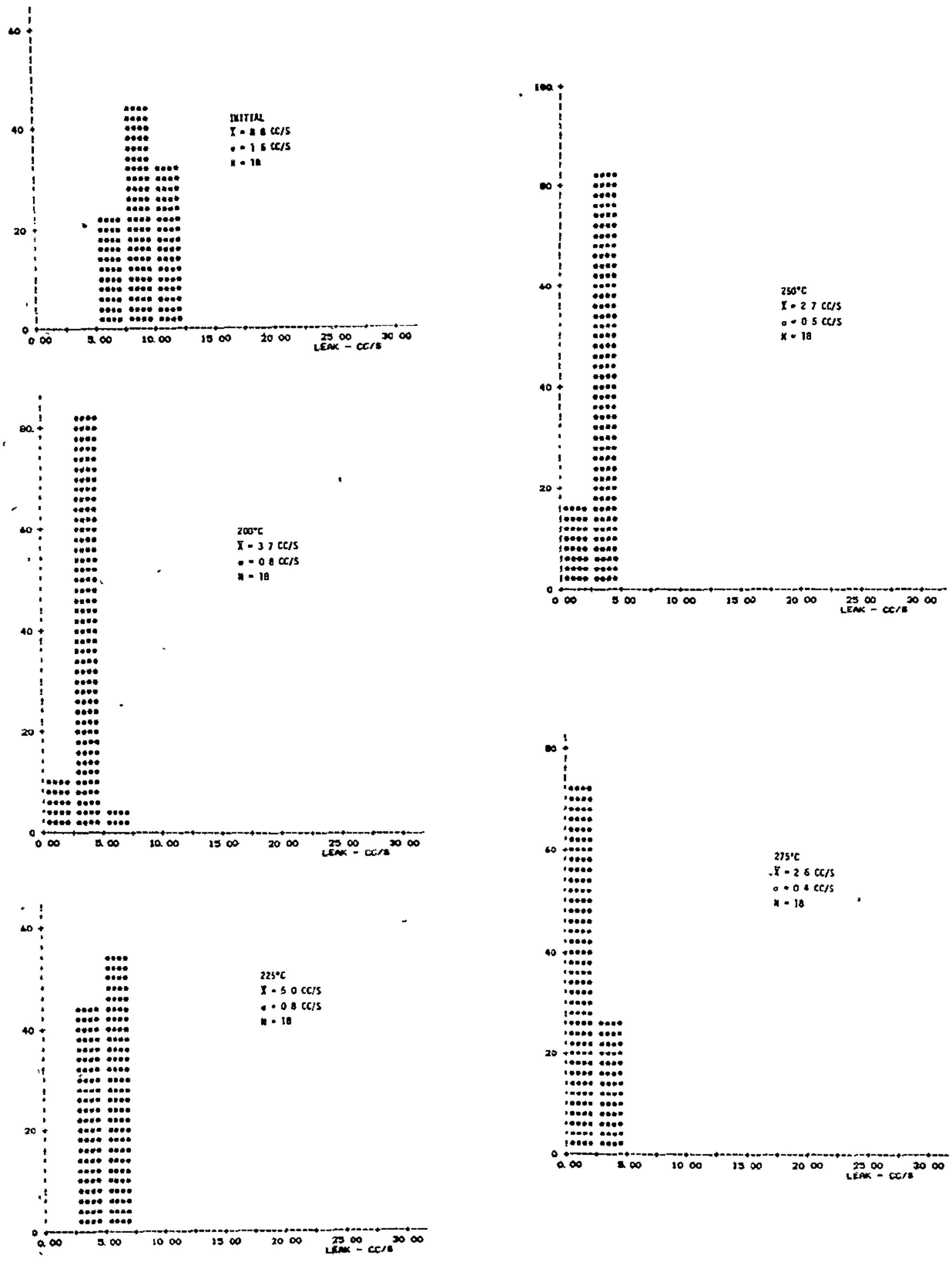


FIGURE B9-3. 72 HOURS HIGH TEMPERATURE BAKE, DIACON 14 LEAD CERPAK

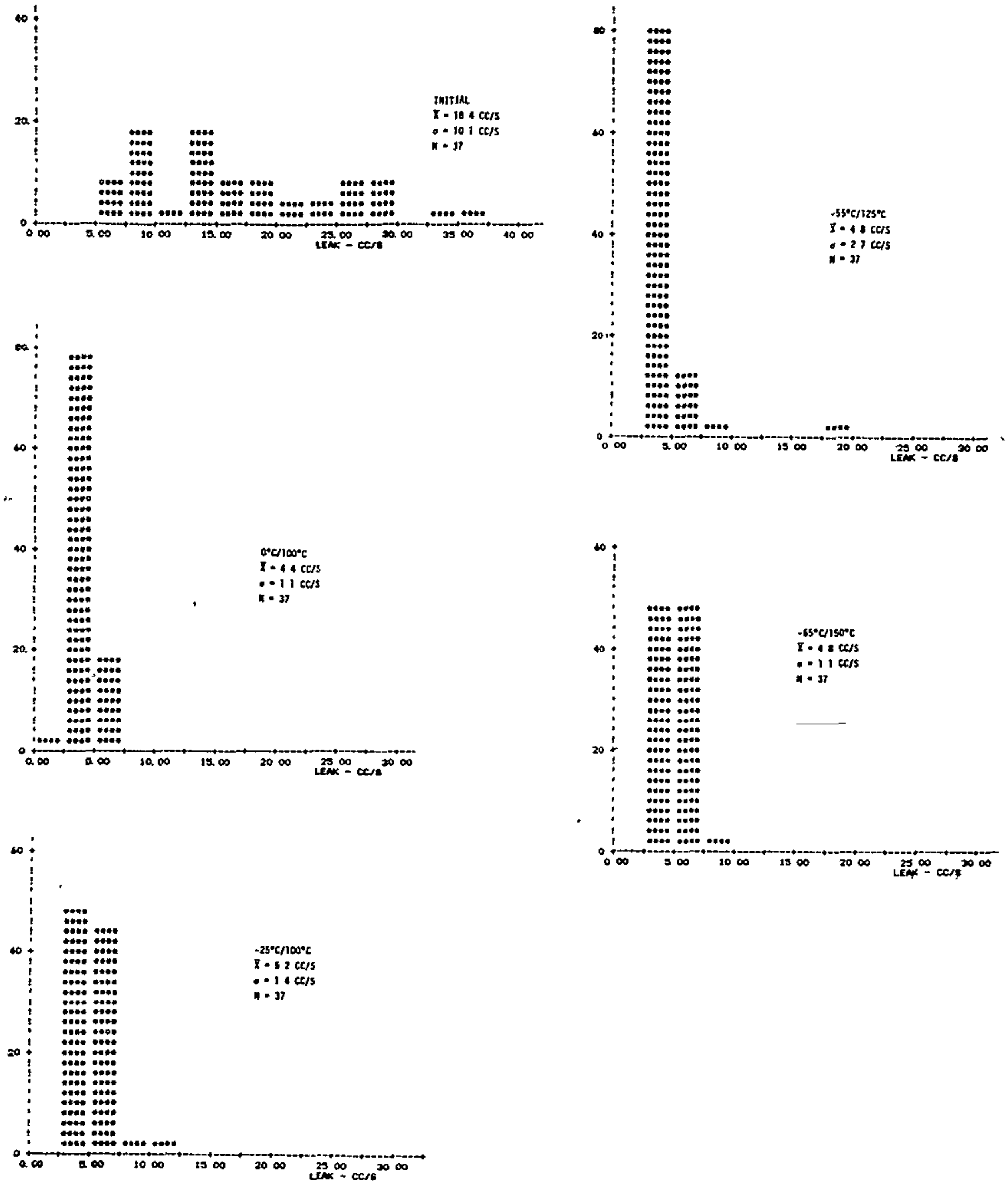


FIGURE B10-1. 50 CYCLES THERMAL SHOCK, FAIRCHILD 14 LEAD CERPAK

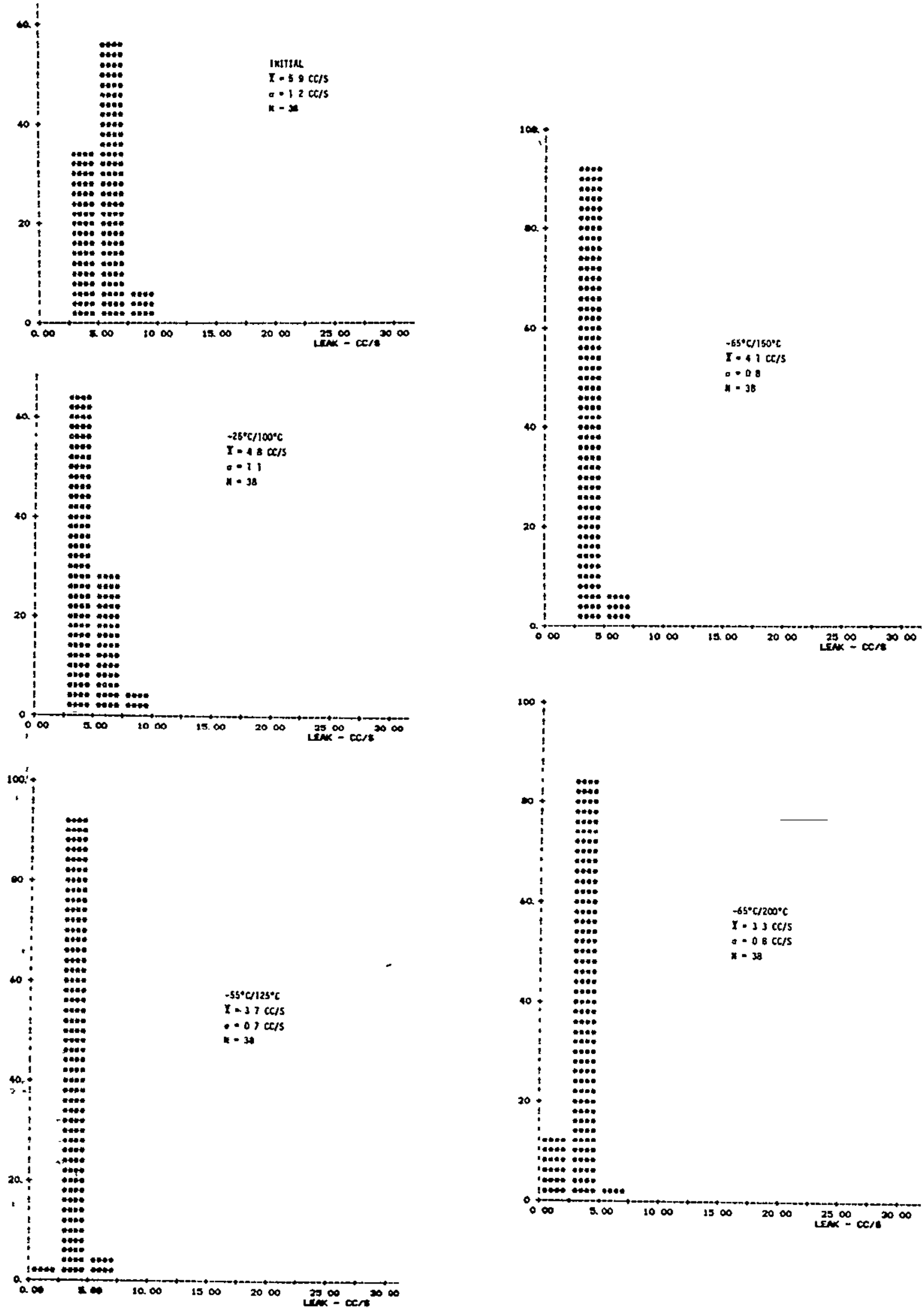


FIGURE B10-2. 50 CYCLES THERMAL CYCLING, FAIRCHILD 14 LEAD CERPAK

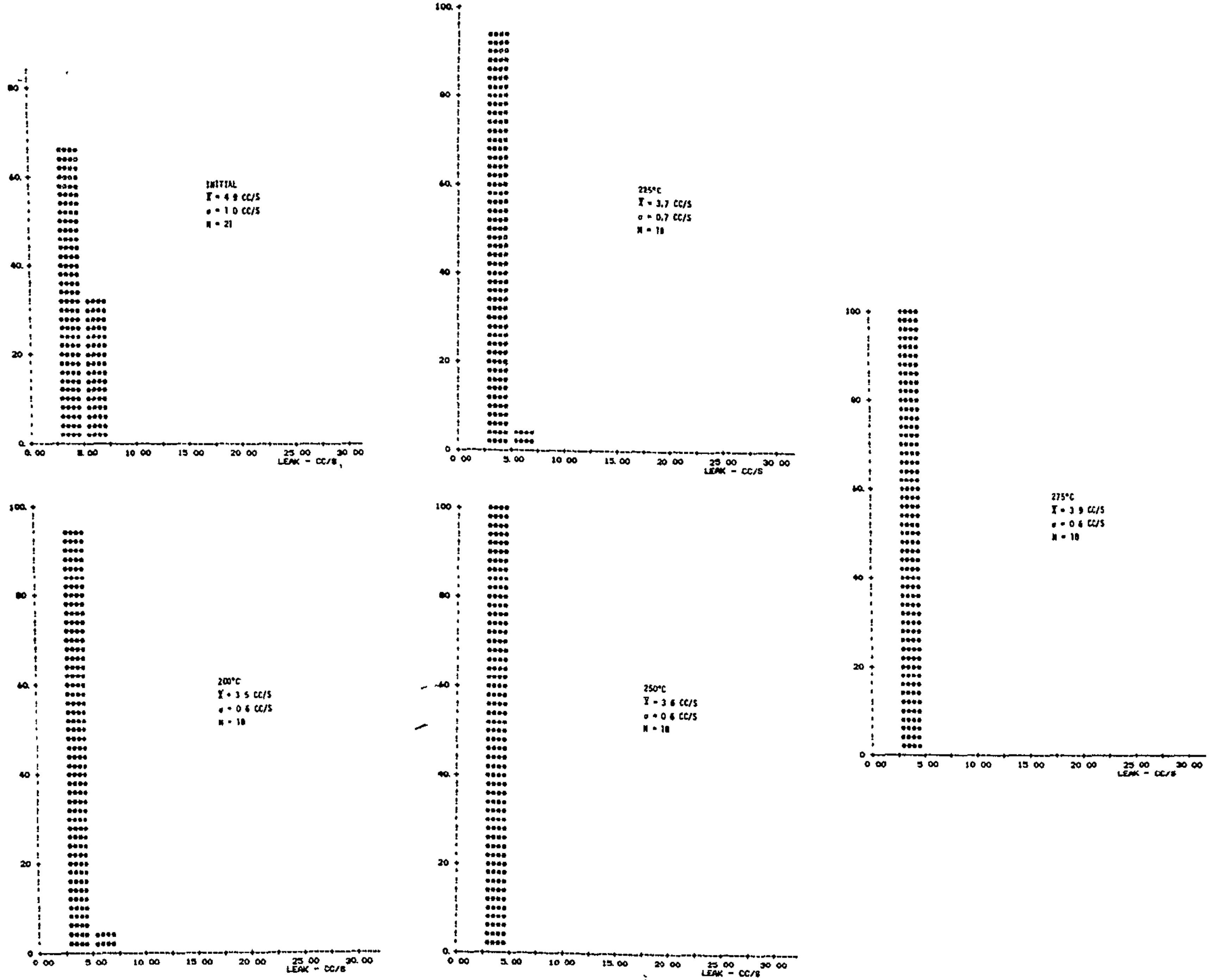


FIGURE B10-3. 72 HOURS HIGH TEMPERATURE BAKE, FAIRCHILD 14 LEAD CERPAK