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A PERFORMANCE EVALUATION OF A HIGH DENSITY HERMETIC ASSEMBLY USING EPOXY DIE ATTACHMENT

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ABSTRACT

This report details the results of a typical performance evaluation of high reliability hermetic I.C. packaging. Described are the test procedures employed for evaluating the materials under a variety of environmental stress conditions. Items analyzed and discussed include gold and aluminum wire bond strengths, die attach epoxy mechanical and electrical integrity and the use of package atmosphere analysis in such evaluations. The report concludes that within the range of normally encountered environmental conditions and operating temperatures epoxy can be used reliably in such packaging, so long as extended operating temperatures do not exceed 125°C.

INTRODUCTION

The evaluations of I.C. assembly technologies for the production of high reliability hermetic I.C. packaging can be a complex and time consuming process. Consideration must be given to a variety of material performance characteristics in light of the ultimate use of the assembly and the required or specified reliability criteria being applied to the product. This report details a typical evaluation of a high density hermetic chip carrier assembly for use in implantable medical electronic applications. The test methodology however could be applied to a variety of other high reliability applications requiring simiilar packaging. Specific areas investigated include the mechanical strength of wire and I.C. die bonds, the electrical stability of conductive epoxies, and the influence of extended high temperatures, and other environmental stresses on the residual gases in the package.

EXPERIMENTAL PROCEDURE

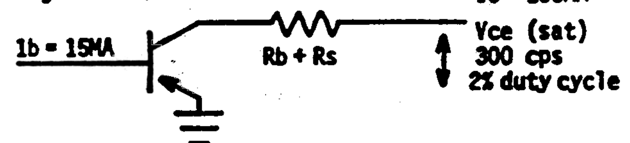
The particular assemblies chosen for evaluation were .400" square leadless hermetic chip carriers. Both gold thermosonic and aluminum ultrasonic wire bonding are typically used in this product. Die attach is by means of conductive epoxy and lid sealing is performed with gold tin solder using a parallel resistive seam welder in a dry nitrogen atmosphere. This sealing method restricts the peak package temperature during seal to less than 200°C which is a safe operating area for the epoxy die bonds.

For comparison sake, two conductive epoxies were evaluated in this study. The first was Epoxy Technology's H20E. The second was Amicon CT2523-1. Both of these materials are two component heat cured formulations which were mixed one to one by weight immediately before use. Infrared spectra run on these samples show that they are made of virtually identical base stock resins. A 150°C two hour cure schedule was used for both materials throughout this study.

The mechanical strength of the epoxy die bonds was measured as a function of their lateral shear strengths. In order to obtain meaningful real number results relatively small .020" square gold backed transistor die were used as the test vehicles. Four of these devices were epoxy die bonded onto the integrated circuit pad of a .400" square chip carrier. Sample size was chosen so that no fewer than 32 shear strength values were obtained at each test point shown in matrix one. Testing was performed using an Anzatek model 520D die shear tester in accordance with Mil Std 833D, section 2019.1. These chip carrier assemblies are ultimately intended for solder attachment to a hybrid substrate. Thus in addition to high temperature storage evaluations, Matrix One also contains procedures for evaluating the ability of the material to withstand repeated solder reflow cycles.

In addition to mechanically securing the device in the package, conductive epoxies are commonly used to provide an ohmic contact, either to the back of an I.C. or to the collector of a transistor die. In the transistor application a stable low impedance collector bond is generally essential for reliable device operation. In order to measure the electrical stability of the two epoxies in question, the following test vehicle was assembled. Four 2N2907 pnp transistors (the same transistors used for the mechanical tests) were die bonded to the common I.C. pad of the chip carrier. The backside of these devices provides the collector contact. The impedance of this interconnect was measured as a function of the Vce (sat) voltage of the transistor.

The Vce sat voltage was measured using the following basic test circuit:



High current (for this transistor) was used to avoid Vce (sat) voltage shifts due to beta shifts in the transistors. The total collector circuit resistance of this test configuration can be calculated as:

$$\frac{Vce(sat}{.150A} = Rb + Rs$$

Rb is the epoxy bond resistance and Rs is the bulk resistivity of the transistor plus the interconnect resistance. Rs was assumed to remain constant. All testing was performed on a Tektronic Model 177 Curve Tracer. Thirty readings were taken at each of the test points indicated in Matrix Two.

The mechanical strength of the wire bonds was

tested as outlined in Matrix Three. The test I.C. die used were internally manufactured. The I.C.'s were manually bonded using both 1 mil .999 fine gold wire (non Be doped) and 1 mil aluminum (1% silicon doped) wire. All wires were 100% non-destruct pull tested at three grams prior to lid sealing.

Residual Gas Analysis (R.G.A.) was performed at various points throughout the test matrixes. A R.G.A. measures the volumetric composition of the gases inside the package. Residual gas analysis techniques have improved dramatically in the past few years and now offer a reliable means of assessing material outgassing rates and composition in I.C. packages. There are several reliable laboratories currently offering this service to the industry. The R.G.A.'s presented in this report were prepared by Onieda Research Corporation. Appendixes A and B give explanations of the test methodology and results interpretation.

RESULTS AND DISCUSSIONS

An acceptance criteria of .40 kg net shear force was adopted for the.020 square transistors used in the Matrix One tests. This is equivalent to a 2200 pounds/square inch of adhesion strength. This strength value is slightly higher than the actual Mil Std 833B requirements in order to allow for the additional strength contributed by the epoxy fillet area and to take into account the lower detection limit of the Anzatek tester (approximately .1 kg).

The shear test results are summarized in graphs one and two. The initial bond failures were primarily cohesive with epoxy being left on both the substrate and the die. After prolonged high temperature storage, the failure modes became adhesive; generally failing at the substrate interface. The graphs reveal that both the Amicon CT2523-1 and the Epotek H20E materials exhibit very good initial shear strength values. At 150°C no significant strength degradation was observed out to 1000 hours. After 2000 hours at this temperature a small average strength loss was observed, however all measured values remained well above the minimum .40 kg level. At 175°C however, somewhat larger strength losses were observed at 2000 hours. Even at this temperature all values remained above .40 kg for both epoxies.

Illustration one shows a typical solder reflow profile measured at the die surface. This profile is used for solder attaching the chip carriers to hybrid substrates. As a means of guard banding this process, test samples were subjected to six repeated exposures to this soldering profile. Prior to this testing, all samples were also subjected to a full environmental processing and 150 hours at 150°C. Graph three shows the strength performance results of both epoxies out to six reflow cycles. This test revealed a significant difference between the two materials. The Amicon CT2523-1 epoxy suffered a significant adhesive strength loss after just one reflow cycle, and continued to lose strength out to the sixth cycle. After six cycles nearly 25% of the values fell below the .40 kg accept limit. Ten percent of the sample exhibited nearly zero shear strength. The Epotek H20E however, performed significantly better in this test. Essentially no mean shear strength loss was noted. After six reflows all measured values were above .60 kg with this material.

As described in the experimental procedure section the electrical conductivity of the epoxies were measured as a function of the Vce (sat) voltage of a transistor. Graphs four and five show the percent change from the initial values ($\Delta v/v$) versus time at temperature. The observed impedance shifts for both materials were extremely small. The H20E showed the greatest change, a minus 4 to minus 5% impedance decrease after the initial environmental processing. This effect is most likely due to some residual curing and shrinkage in material. With extended high temperature aging a gradual impedance increase was detected. The Amicon epoxy shown in graph four behaved very similarly. The only substantial difference detected between the two materials was a lower initial average impedance for the Amicon epoxy. The initial calculated average bond resistance for the Epotek H20E was 1.5Ω versus 1.2Ω for the Amicon. This probably indicates that the bulk resistivity of the Amicon epoxy is lower than the Epotek.

As previously mentioned the performance of both gold and aluminum wire bonds were evaluated. Of the two bond types gold wires are the most sensitive to thermally accelerated failure modes.[10] Unequal intermetalic diffusion coefficients between gold and aluminum has been shown to produce bond failures due to the formation of "Kirkendahl" voids beneath the bond ball. This diffusion mechanism is assumed to be governed by simple first order reaction kinetics and has been shown to follow a well defined time to failure Arrhenius acceleration curve.[9,10] The onset of failure due to Kirkendahl voiding is characterized by a sudden large increase in bond resistance followed almost immediately by the appearance of ball lift failure modes. Previous studies at Micro-Rel produced the Arrhenius acceleration plot shown in Figure One. This curve was generated by plotting the time to the appearance of a bond failure at the ninety-ninth percentile level of the bond strength distribution. This plot predicts that the first bond failures should occur after 2000 hours at 150°C and at approximately 600 hours at 175°C. In fact the first ball lift was detected at the 1000 hour test point at 175°C and at 2000 hours three ball lifts occurred in the 150°C group and an additional two lifts in the 175°C group. On balance the gold wires tested in this study appeared to perform as predicted by the .82 ev acceleration curve generated by this previous study.

Graph seven summarizes the strength behavior of the aluminum wires. Aluminum wire bonds characteristically show a strength loss with thermal stressing due to temperature induced annealing effects.[10] This annealing mechanism is generally self limiting in nature resulting in stable bond strengths after some specific time at temperature. Typically a mean strength loss of 25 to 50% can be expected after such environmental conditioning as temperature cycling and burn-in.

The aluminum wire studied in this report exhibited just such a characteristic performance. The initial preseal wire pull values averaged 4.5 grams. Bond strength fell to 3.3 grams after lid sealing and environmental processing. Subsequent high temperature processing produced little further strength loss. The bonds exhibited the well documented asymptotic strength behavior induced by thermally induced grain boundary reorientation in the aluminum.[14,15,16,18] After 2000 hours at 150°C only one tenth of one percent of these wires fall below 1.5 grams.

Residual Gas Analysis of the internal atmospheric content of hermetically sealed packages is an analytical technique that is rapidly coming into its own. Until recently the complexity of the procedure, equipment limitations, and the lack of a standardized calibration methology, often resulted in large systematic and interpretative errors. Recent improvements in equipment and the instituting of a standardized cross calibration method under the auspices of the Mil Std has improved the test reliability.[22] It is now possible to obtain information not only regarding package moisture levels but also on a variety of other outgassing by products (see Appendix B).

Military Standard 883B Notice 3 published on February 1, 1981, has established a limit of 5000 ppmv limit for moisture in the delivered package. This is a package dew point of approximately zero degrees Celsius. Theoretically this should insure that no liquid water can exist in the package. However, the real world situation is much more complex. No conclusive studies have been successfully performed demonstrating a clear reliability relationship between indicated moisture levels, either higher or lower than this limit.[16,17,20,21] Limits or even recommended maximum levels for other package gas constituates, as discussed in Appendix B, have not even been considered.

At this point it would be best to digress slightly and discuss the role of the die attach material and the specific package geometry on the final R.G.A. results. Low moisture levels are much more difficult to obtain when using organic (epoxies, polyimides, etc.) die attach than when metallurgical eutectic bonding is employed. Epoxies and similar organic materials are highly hydroscopic. Studies have shown them to acquire substantial quantities of water after only short periods of room ambient exposure.[26,24] In addition organic materials tend to produce additional water and various other decomposition reaction by products upon thermal stressing. These factors become especially important when the free air space above the device is very small in relation to the amount of adhesive present such as in the high density packaging being evaluated here. Assuming that water (as an example) acts as an ideal gas the mass required to saturate (100% R.H. = 26,400 ppmv) the free air volume of the package ($40 mm^3$) is given by:[24]

$m = M P v / RT$

$M = 18$ g/mole

$P = 20.7$ Torr (water partial pressure 100% RH)

$v = 40\ mm^3$

R = ideal gas constant (.0835)

$T = 298°$ K

Solving this equation shows that only .780 micrograms of water are required to fully saturate the free volume of the package.[24] Consider that epoxy materials have been shown to absorb up to .5% by weight of water after only a few minutes of room air exposure and that there is typically 1.5 milligrams of epoxy in the average I.C. die bond, it can be seen that this typical bond could contain up to 7.5 micrograms of absorbed moisture alone.[24] This is enough to saturate the package volume ten times over if fully desorbed.

Hi reliability I.C. packages are normally subjected to a "vacuum bake" prior to final lid sealing. The purpose of this production step is to remove by desorption any moisture entrapped in the assembly. However typical vacuum baking schedules in the 4 to 16 hour at 150° range are generally not sufficient to remove more than the first incremental fraction of the total absorbed moisture. All the test samples in this experiment were subjected to a 4 hour 150°C vacuum bake prior to seal. This cycle yielded an average post seal moisture level of 1500 ppmv for these epoxy die bonded parts.

What we are ultimately interested in, in terms of the actual package reliability, is not what the R.G.A. values immediately after sealing are, but what the actual field performance of the assembly will be. To investigate this, Matrix Four was assembled to evaluate the effects of various environmental processing and long term high temperature storage upon the initial R.G.A. values. Graph 8 summarizes the matrix results for water vapor. At all of the test storage temperatures moisture levels are seen to increase. At both 150°C and 175°C moisture desorption appears to be accompanied by additional moisture generation due to anerobic decomposition of the epoxy die bonds. The rate of increase of other typical epoxy decomposition products such as CO_2, CO, hydrocarbons, various aldehydes and ketones, and ammonia tracked the increase in moisture.

A moisture level of 5000 ppmv was reached with the H20E epoxy after 300 hours at 150°C and after only 15 hours at 175°C. After 1000 hours the 175°C samples were completely saturated (+26,000 ppmv) and the 150°C samples were approaching 10,000 ppmv. At 125°C the rate of moisture evolution was sharply reduced with a level of only 3500 ppmv reached at 1000 hours. Additionally only small amounts of epoxy decomposition products were detected. The Amicon CT2523-1 epoxy bonded samples exhibited generally higher outgassing rates. Also relatively high levels of ammonia were detected at the 150°C and 175° test temperatures.

CONCLUSION

The objective of this paper was to demonstrate some of the analytical methods used to characterize the performance of a particular high reliability package configuration. For the packages and materials under evaluation we can generally conclude the following.

1. The gold and aluminum wire bonds can easily withstand 125°C for extended periods and even 175°C for shorter durations. Also no evident

interaction between the epoxy materials and the wires were noted.

2. Both of the epoxy materials showed little degradation of mechanical or electrical performance up to 175°C. The Amicon CT2523-1 however performed poorly when heated rapidly to 220°C during solder reflow. It is clearly not suitable for this application.
3. The R.G.A. results clearly demonstrate the effect of package geometry and the relative outgassing rates of materials at various temperatures. At 125°C the devices should operate well in excess of 1000 hours before exceeding the adopted 5000 ppmv moisture limits. At 150°C outgassing rates were considerably accelerated and also accompanied by what appears to be anerobic oxidation in the epoxies. Continuous exposure to this temperature should be avoided. Operation at 175°C should be severely limited.

It is hoped that the results and discussions set forth in this paper will assist the industry in planning and testing future packaging programs. Additional studies into a number of the areas discussed would be welcomed. Of particular interest would be an investigation of the effects of various preseal vacuum bake schedules on the long term moisture levels.

ACKNOWLEDGEMENTS

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REFERENCES

1. Berg, Howard and Curtis Mitchell, "Use of Conductive Epoxy for Die Attach", Motorola S.P.D., Published by Epoxy Technology Corporation.

2. David, Dr. R. F., "Advances in Epoxy Die Attach", Teledyne Microcircuits Division, Solid State Technology, September, 1975.

3. Shenfield, David M., "Materials and Curing Characteristics of Conductive Epoxide Adhesives" Standard Telecommunication Laboratories, The Proceedings of the International Society for Hybrid Microelectronics, 1979.

4. Kulesza, Frank, and Thomas Sanders, "The Significance of the Glass Transition Temperature on Conductive Epoxy", Standard Telecommunication Laboratories, The Proceedings of the International Society for Hybrid Microelectronics, 1979.

5. Redemski, R. T., "Multilayer Substrate Technology and Epoxy Component Attach for Hybrid Fabrication", Teledyne Microelectronics, 1976.

6. Bagnall, R. T. and Stanislow G. Shreter, "Selection and Control of Polymers Used in the Manufacture of Hybrid Circuits", The Raytheon Company, 1978.

7. Redemski, R. T., "Use of Epoxy in Hybrid Microcircuits", Teledyne Microelectronics, N.B.S. Bulletin.

8. Zimmerman, D. D., "Evaluation Study of Epoxy Materials for Use in Hybrid Assembly Processes", John Hopkins University, The International Hybrid Microelectronics Symposium, 1972.

9. E. Philofsky, Intermetallic Formation in Gold-Aluminum Systems, Solid-State Electronics, Vol.13, 1970, pp.1391-1399.

10. G. H. Ebel, Failure Analysis Techniques Applied in Resolving Hybrid Microcircuit Reliability Problems, 15th Annual Proceedings Reliability Physics, 1977, pp.70-81.

11. Harmon, George G., "Metallurgical Failure Mode of Wire Bonds", Institute for Applied Technology, N.B.S.

12. Fitch, William T., "The Degradation of Bonding Wires", Motorola S.P.D., R.A.D.C., Rome, New York.

13. Harman, George G., "A Metallurgical Failure Mode of Wire Bond Pull Test", Electronics Technology Division of N.B.S., 1979.

14. Somerville, D. T., "The Role of Hybrid Construction Techniques on Sealed Moisture Levels", Rockwell International, Reliability Physics, 1977.

15. Haack, Ray, and Alex Shumka, "Moisture and Other Contaminants in Hybrid Packages", J.P.L., The Proceedings of the International Hybrid Microelectronics Society, 1978.

16. Thomas, R. W., "Moisture Myths and Microcircuits", The Proceedings of the 1976 Electronic Components Conference, April, 1976.

17. Messenger, Charles G., "Moisture Syndromes in Microcircuit Packaging", R.A.D.C., The Proceedings of the International Hybrid Microelectronics Society, 1978.

18. Ebel, G.H., "Failure Analysis Techniques Applied in Resolving Hybrid Microcircuit Reliability Problems", Reliability Physics, 1977.

19. Fancher, Douglas, and Richard Horner, "Hybrid Package Hermeticity and Moisture Level Monitoring", I.S.H.M., 1978.

20. Messenger, Charles, "Moisture Effects on Hybrids Containing CMOS Circuits", Rome Air Development Center, I.S.H.M., 1979.

21. "Moisture Measurement Technique Certified", Reported in Electronic Packaging and Production, January, 1981.

22. Military Standard 883-B.

23. Willard, Hobart H., Instrumental Methods of Analysis, Fourth Edition, Van Nostrand Company Inc., 1965.

24. Czanderna, A. W., "Mass Changes of Adhesives During Curing, Exposure to Water Vapor, Evacuation and Outgassing", Clarkson College, The Proceedings of the International Hybrid Microelectronics Society, 1977.

APPENDIX A

Residual Gas Analysis (R.G.A.) Test Procedure

Illustration Two shows the construction of a typical mass spectrometer. Following the procedures of MIL-STD-882B, Method 1018, the part to be tested is heated to 100°C under a high vacuum in the mass spectrometer sample chamber. The lid of the part is then pierced, allowing the specimens internal gas contents to escape into the sample chamber of the spectrometer. As the sample gases enter the spectrometer, they pass an ionization source as shown in Illustration Two. The ion source imparts an electrical charge to the chemical species in the gas. The charged gas species then pass a set of charged acceleration plates whose voltage can be varied (analogous to the operation of a television picture tube). The charged gas ions have a definite mass (m) determined by their chemical composition (their molecular weight). As the charged gas particles of mass m and charge e pass the accelerator plates, they obtain a velocity v dependent upon the voltage present on the plates.[23]

$$v = 2\,e(V/m)^{1/2}$$

These accelerated ions then enter a constant intensity magnetic field H which is applied at right angles to their direction of motion. The magnetic field diverts the ions into a circular trajectory having a ratio proportional to the applied accelerator voltage (V) and their mass to charge ration m/e.

$$r = \left(\frac{2V}{H^2} \cdot \frac{m}{e}\right)^{2}$$

At the end of the analyzer tube is an ion detector having a very narrow entrance slit. The accelerator voltage is varied causing ions of different mass (m) to charge (e) ratios to be scanned across the detector slit (or window). The quantity of each constituent of the sample is proportional to the detected intensity.[24] Relative concentration levels of each chemical specie are determined by the peak intensity and are expressed on a PPM volume/volume basis relative to the total package gas volume.

APPENDIX B

Residual Gas Analysis R.G.A.) Interpretation

Nitrogen (N_2) - Molecular Weight 28

Parts are sealed in an inert gas atmosphere of 99.9 percent nitrogen. N_2 should always represent the balance of the package gas content. A decrease in the N_2 percent indicates that outgassing is occurring after the package has been sealed.

Oxygen (O_2) - Molecular Weight 32

Oxygen should be present in the package only if the sealing process was performed in an oxidizing atmosphere such as in ceramic sealing applications. Occasionally a gross leaker may exhibit an essentially atmospheric analysis of 79% N_2, 20% O_2, and 1% Argon.

Argon (Ar) - Molecular Weight 39.948

Argon comprises one percent of normal ambient air. Argon is normally not detected in package analysis except in the case where a gross leaker is encountered. Due to argons high molecular weight, it may be confused with satellite peaks of certain hydrocarbons.

Carbon Dioxide (CO_2) - Molecular Weight 44

Carbon dioxide is a by-product of respiration and the oxidative decomposition of hydrocarbons and other organic materials. CO_2 may be encountered as a decomposition and/or outgassing product of organic die bond materials.

Helium (He) - Molecular Weight 4

Trace amounts of He can sometimes be detected in packages subjected to He bomb fine leak detection methods.

Hydrogen (H_2) - Molecular Weight 2

Hydrogen getters strongly onto metals and ceramic surfaces. Certain package sealing techniques use hydrogen as a forming gas in addition to N_2 to aid solder wetting. This may result in H_2 levels in the one to two percent range. High H_2 levels also accompany decomposition and outgassing of organic die bond materials. Indicated levels will generally track CO_2 and hydrocarbon levels.

Moisture (H_2O) - Molecular Weight 18

Moisture is the only constituent for which defined acceptable limits have been established. The military specification limits moisture levels to 5,000 PPM in the delivered product. Excessive moisture levels can produce serious reliability problems, though considerable debate exists over what level is considered to be a problem. Correlation of test information, between various analytical labs, has also proven to be a problem. In general, the lower the moisture level obtainable in the package the better.

Methane (CH_4) - Molecular Weight 16

Methane is the elemental building block of hydrocarbons. Its presence may also be accompanied by the presence of hydrocarbons.

Freon (Fluorocarbons) - Molecular Weight Varies

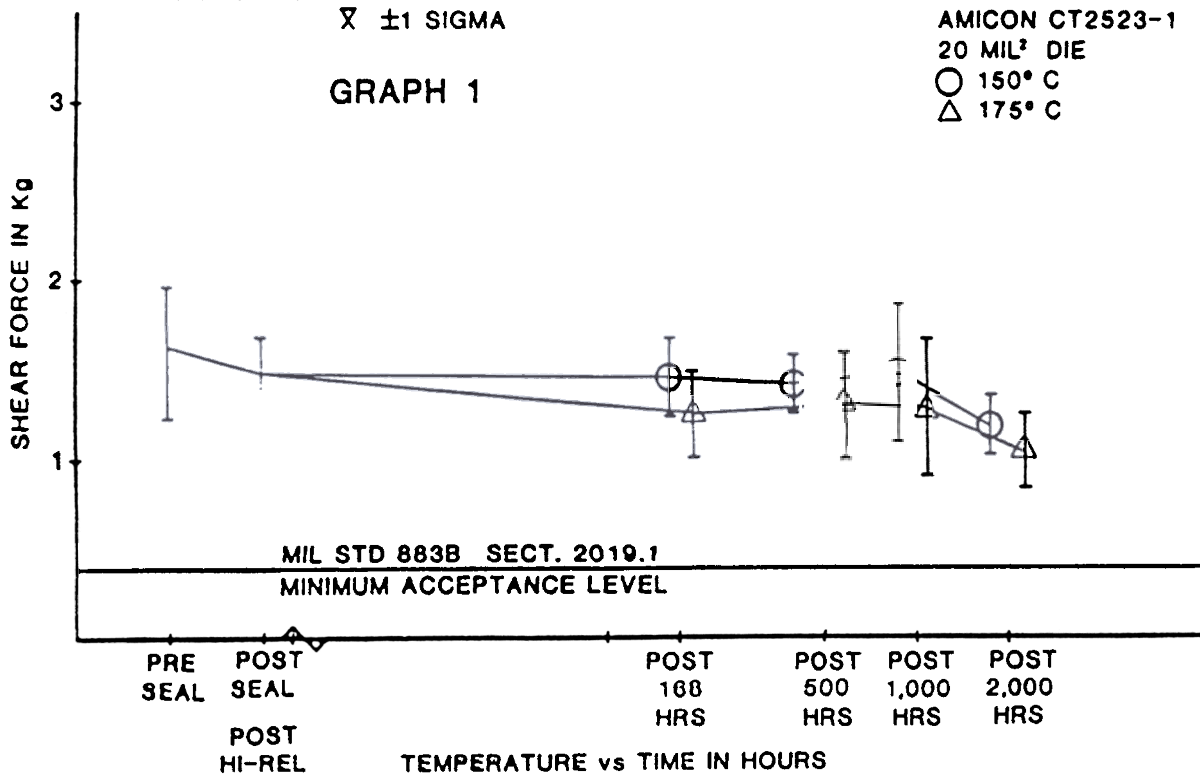
Freons are used in the fine and gross leak testing. The presence of Freon is a positive indicator of a non-hermetic part, generally a fine leaker.

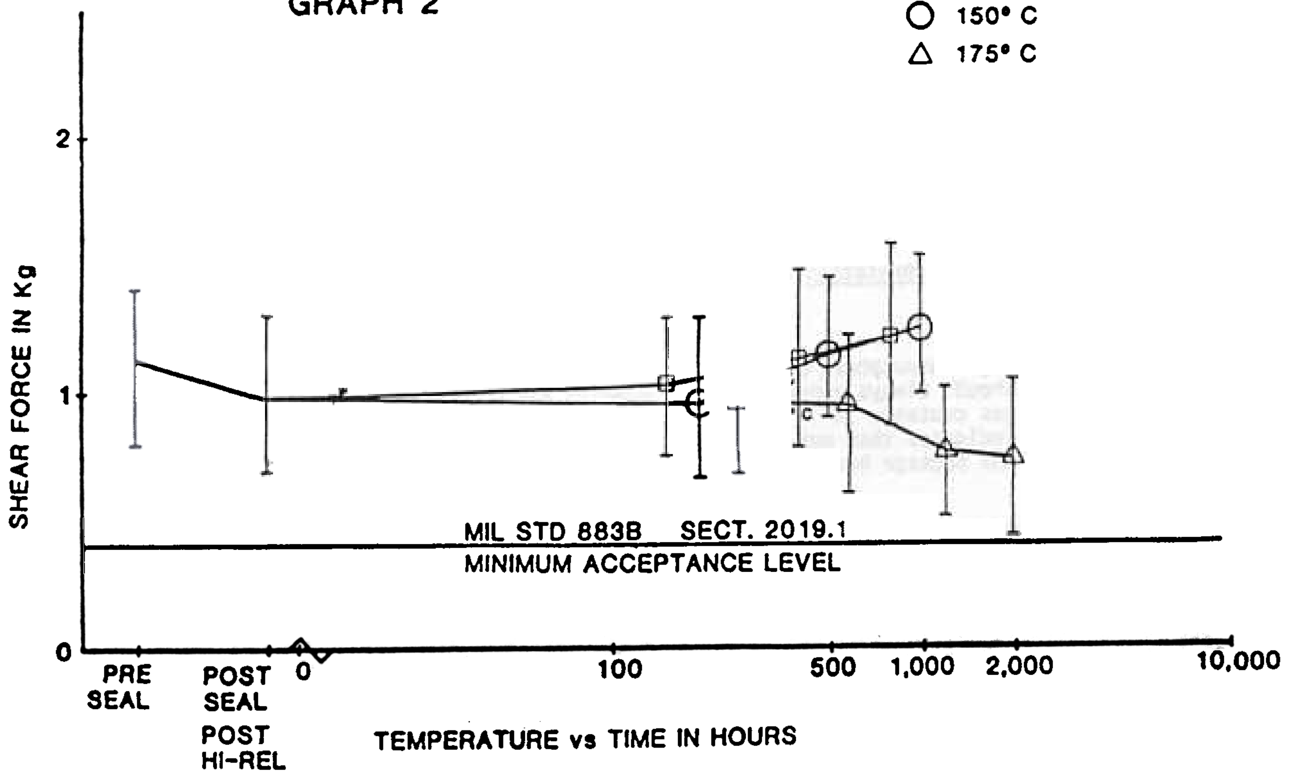
Hydrocarbons (H.C.) - Molecular Weight Varies

Hydrocarbons will only be detected when epoxy die bonding has been employed. The hydrocarbon reading is a lump sum value of a variety of molecular weight fragments; generally, butanes, propanes, and pentanes. Hydrocarbons result from epoxy outgassing due to curing by-products or thermally induced decomposition.

Ammonia (NH_3) - Molecular Weight 17

Ammonia is generally encountered as a residual cure product of amine cured epoxy resins. In sufficient quantities, and especially in the presence of moisture ammonia, can be very corrosive to aluminum metallizations.


ACCELERATED TEMPERATURE EVALUATION
DIE SHEAR STRENGTHS IN KILOGRAMS - 010119 DIE
X̄ ±1 SIGMA
AMICON CT2523-1
20 MIL² DIE
150° C
175° C
GRAPH 1
SHEAR FORCE IN Kg
3
2
1
MIL STD 883B SECT. 2019.1
MINIMUM ACCEPTANCE LEVEL
PRE SEAL
POST SEAL
POST HI-REL
POST 168 HRS
POST 500 HRS
POST 1,000 HRS
POST 2,000 HRS
TEMPERATURE vs TIME IN HOURS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GRAPH 2
SHEAR FORCE IN Kg
2
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MIL STD 883B SECT. 2019.1
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PRE SEAL
POST SEAL
POST HI-REL
0
100
500
1,000
2,000
10,000
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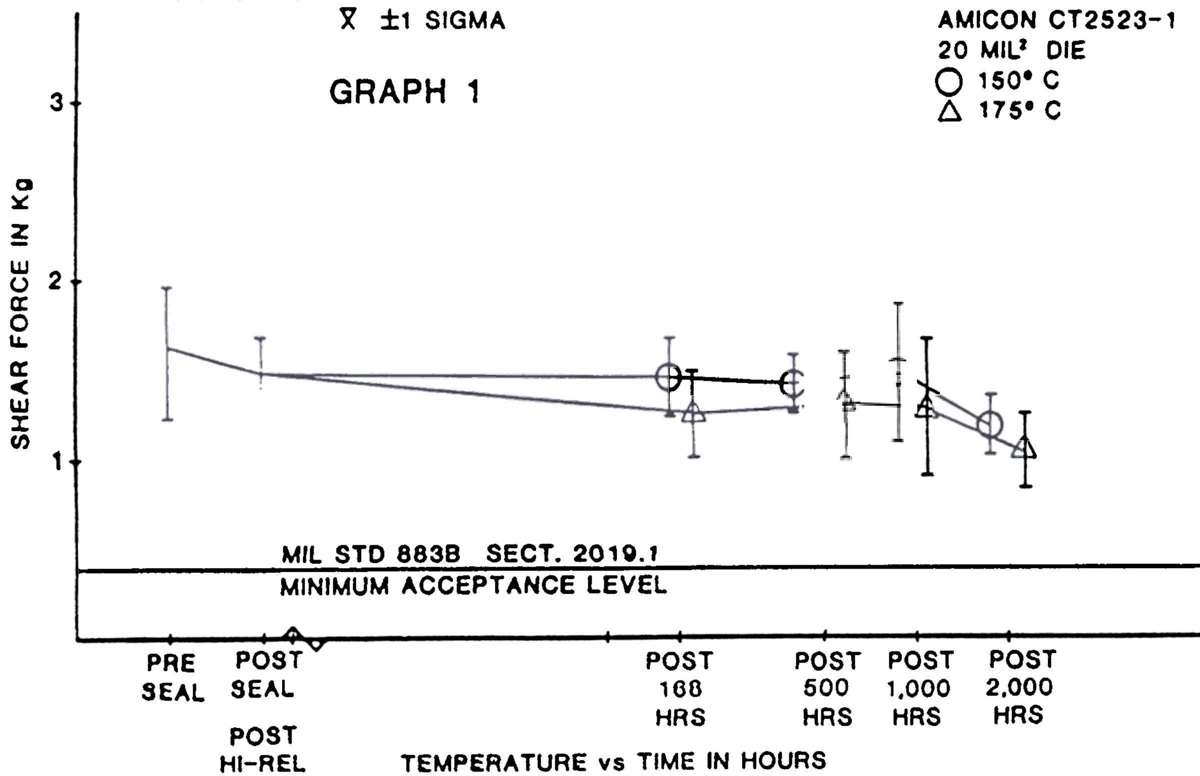
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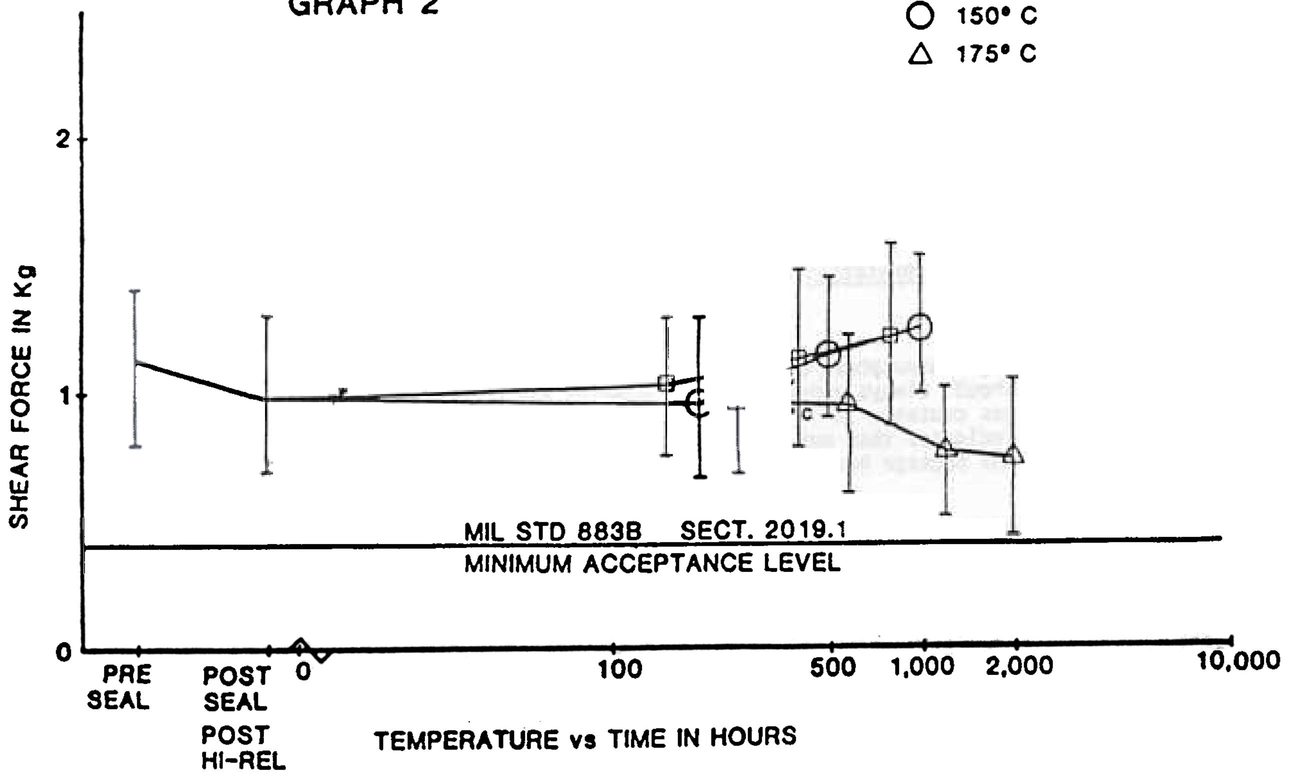
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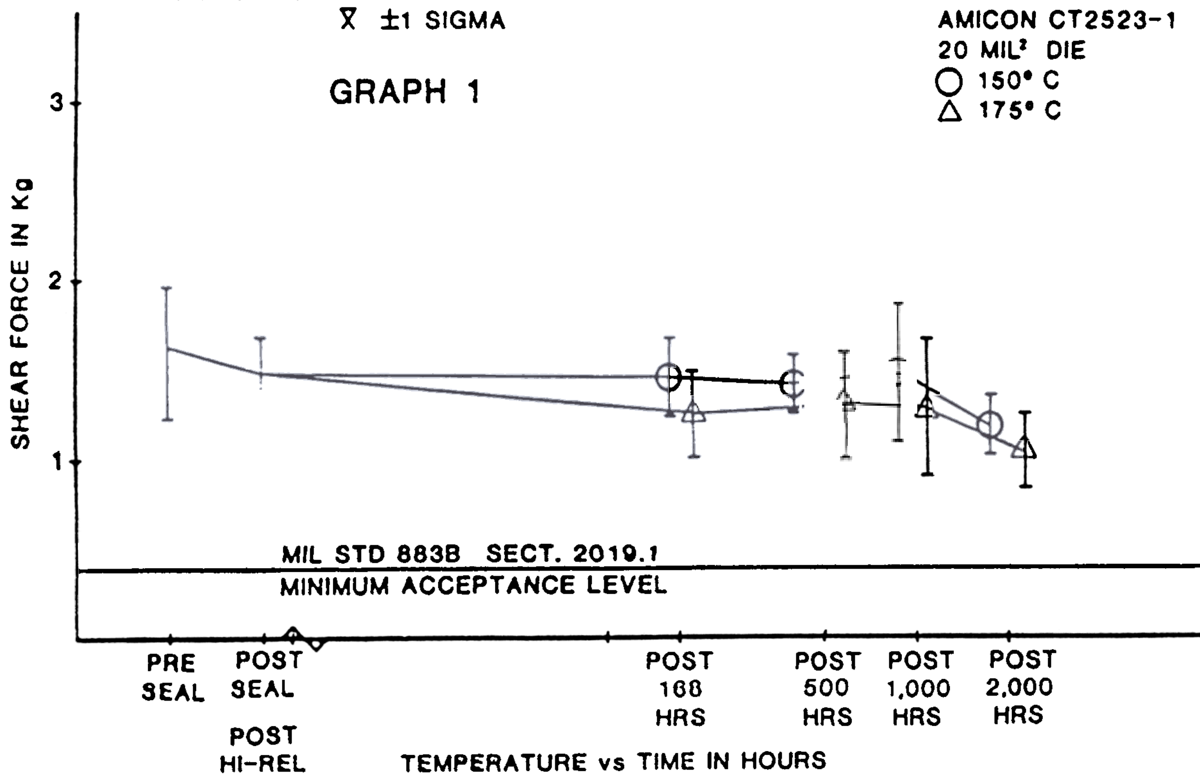
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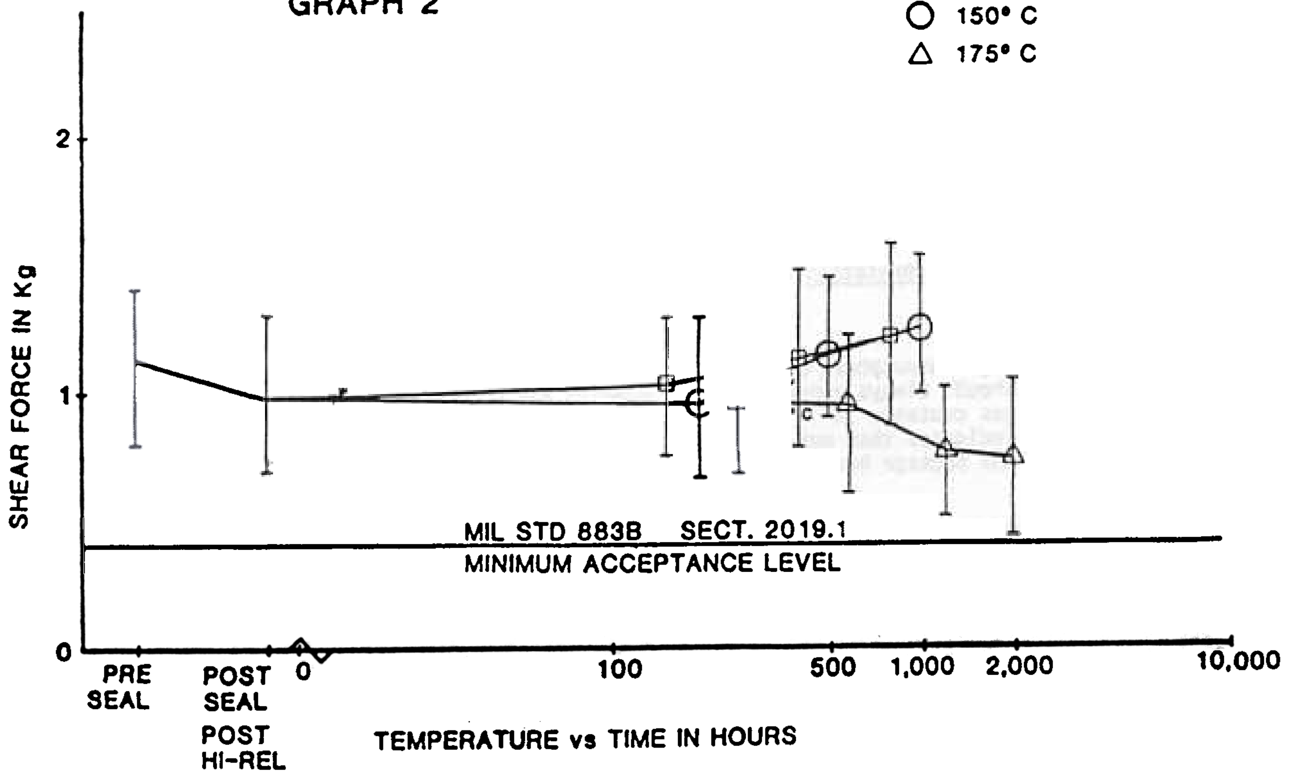
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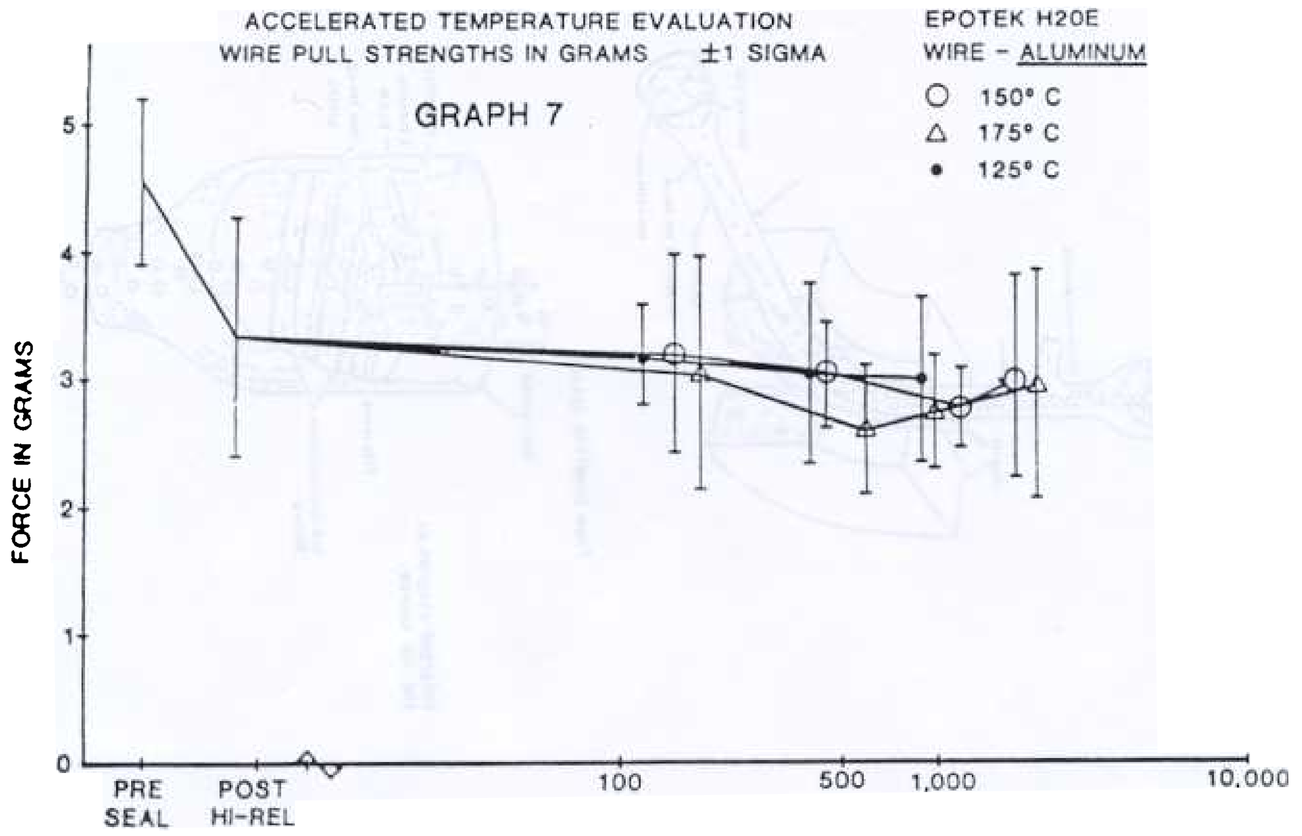
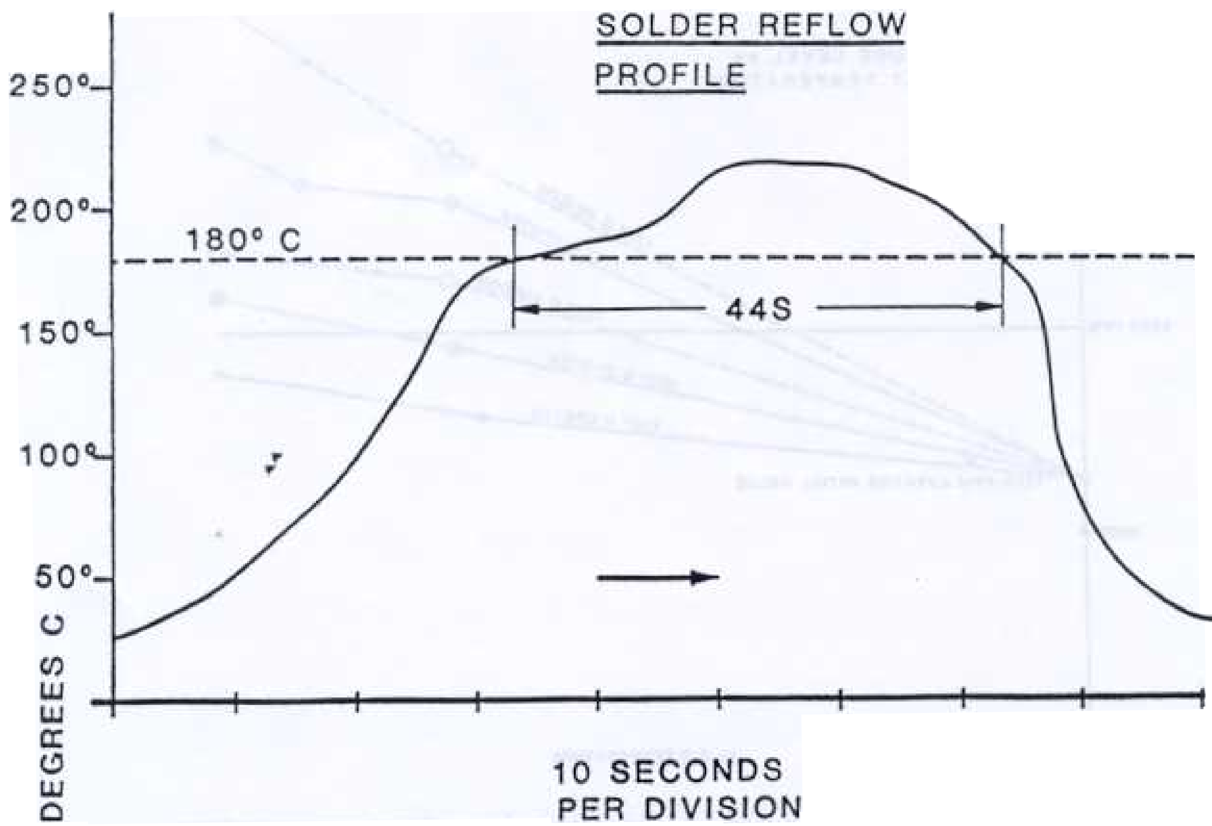
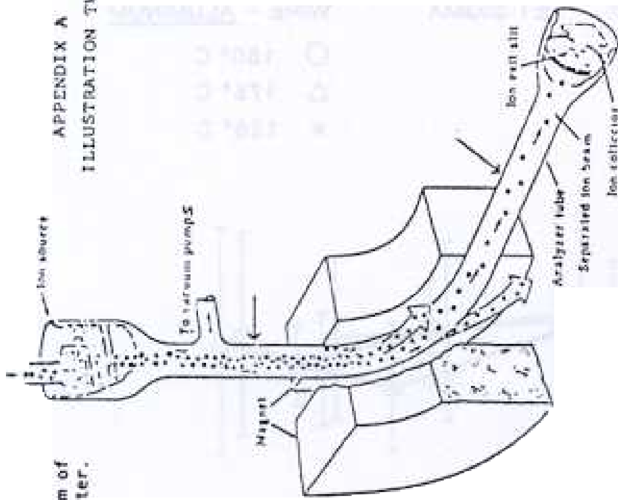


TEMPERATURE vs TIME IN HOURS

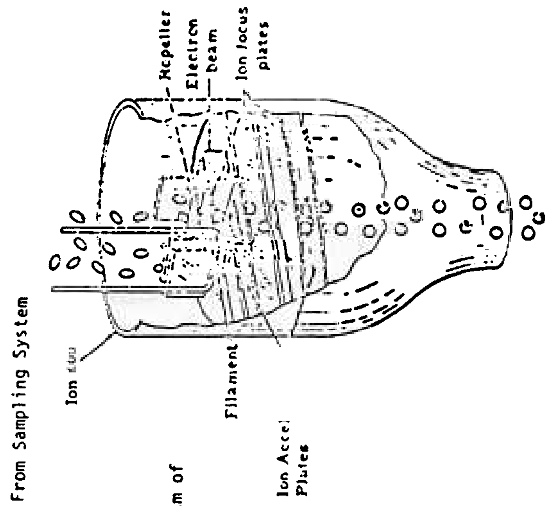
ILLUSTRATION ONE



APPENDIX A
ILLUSTRATION TWO



Schematic diagram of a mass spectrometer.



Enlarged diagram of the ion source.