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|---|---|
| N66-17076 (ACCESSION NUMBER) | (THRU) |
| 79 (PAGES) | 1 (CODE) |
| CR 70303 (NASA CR OR TMX OR AD NUMBER) | 09 (CATEGORY) |

FACILITY FORM 602

GPO PRICE $ ______

CFSTI PRICE(S) $ ______

Hard copy (HC) 3.00

Microfiche (MF) .75

ff 653 July 65

RE-ORDER NO. 65-1027

# FINAL REPORT
# ON
# CAPACITOR SCREENING EVALUATION TEST PROGRAM
CONTRACT NUMBER 950864
MODIFICATION NO. 2

FOR

JET PROPULSION LABORATORY

17 NOVEMBER 1965


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"This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, pursuant to a subcontract issued under Prime Contract NAS7-100 between the California Institute of Technology and the United States of America represented by the National Aeronautics and Space Administration."

# ABSTRACT

## I. Purpose and Objective of Program

This Screening Evaluation Test Program was conducted to evaluate the effects of screening upon fixed ceramic dielectric low voltage capacitors by supplying failure data and parameter degradation data.

To accomplish this end, two groups (screened and unscreened) were subjected to a 10,000-hour life test with periodic measurements of critical capacitor parameters. Statistical comparisons between the groups were made based upon the periodic measurements to reveal differences in their parametric behavior. Since the groups were treated identically in the test program, the cause of these differences can validly be assumed to be due to differences in treatment prior to the life test, thus, to the screening process which one group experienced but the other did not.

## II. Identification of Test Samples

The total test sample lot of 400 capacitors, Type CK06CW103K, manufactured by Vitramon, was received from JPL with the lot divided equally into two (2) Groups designated P and C. The test samples were then numbered as follows:

| Group | Specimen Numbers |
|---|---|
| P | 1 - 200 |
| C | 201 - 400 |

## III. Tests Performed

The test samples were subjected to the following tests in the sequence indicated:

(1) Test Sample Grouping (Performed by JPL)

(2) Test Sample Identification

(3) Visual Inspection

(4) Initial Electrical Parameter Measurements

- (a) Capacitance
- (b) Dissipation Factor
- (c) Insulation Resistance

(5) Life Test - 10,000 Hours

(6) Electrical Parameter Measurements after 50, 168, 336, 504, 1008, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, and 10,000-hours of the Life Test.

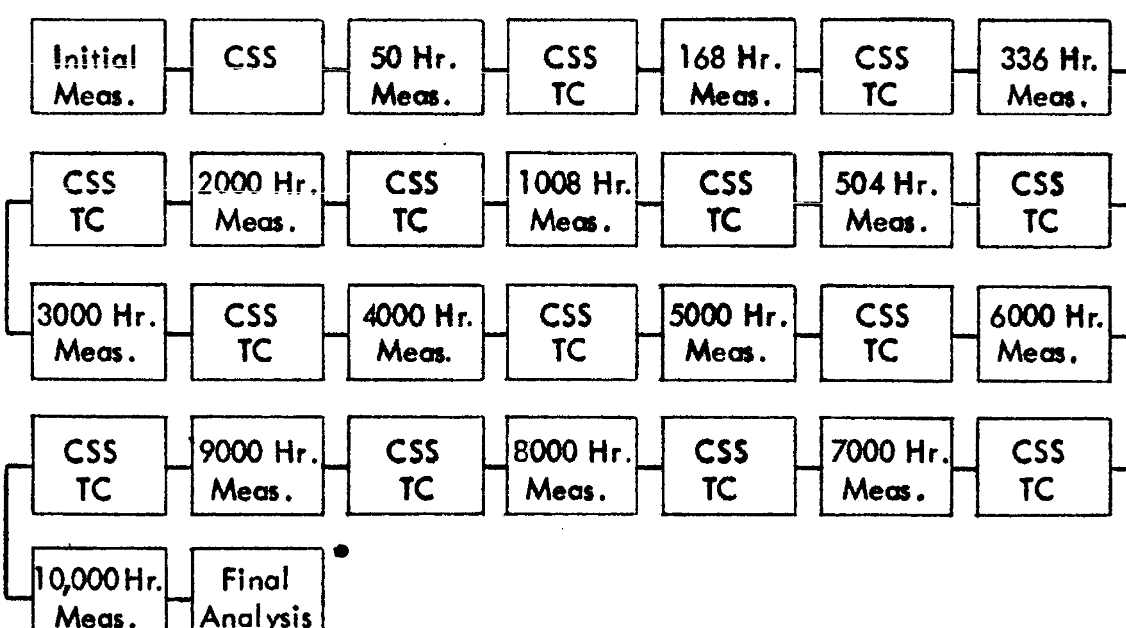
After each electrical parameter measurement, the test data was subjected to the required statistical analyses.

The life test was conducted on all samples at rated voltage and at a temperature of 100°C. Each sample was monitored with a series connected fuse leading directly to a battery DC voltage supply capable of supplying greater than four (4) amperes of current. Charging and discharging of test samples was conducted with current limiting resistors allowing less than 50 ma of current. Measurements during the life test were conducted by removing the test samples from the life test boards.

## IV. Statistical Analysis

The following figure details the steps of the test program and the corresponding types of data analysis submitted at each step.

DATA ANALYSIS FLOW DIAGRAM



Note: CSS - Computed Statistics Sheets
TC - t-Computations

*Final Analysis Data

(a) CSS
(b) TC
(c) $\bar{X}$ versus Time, Graphical Representation
(d) Life Test Computations based on $\bar{X}$'s
(e) Reliability Estimates and Comparisons

## V. Failure Definition

A. Catastrophic - A catastrophic failure is defined as a shorted or open capacitor. A capacitor is considered shorted when it blows two consecutive 1/16 amp fuses during the life test. A capacitor is considered open when during the electrical parameter measurements an extremely low or zero capacitance measurement is indicated.

B. Parametric - A parametric failure is defined as capacitance less than 9,000 pf or greater than 11,000 pf, dissipation factor greater than 2.5%, and insulation resistance less than 100K megohms.

## VI. Test Results and Conclusions

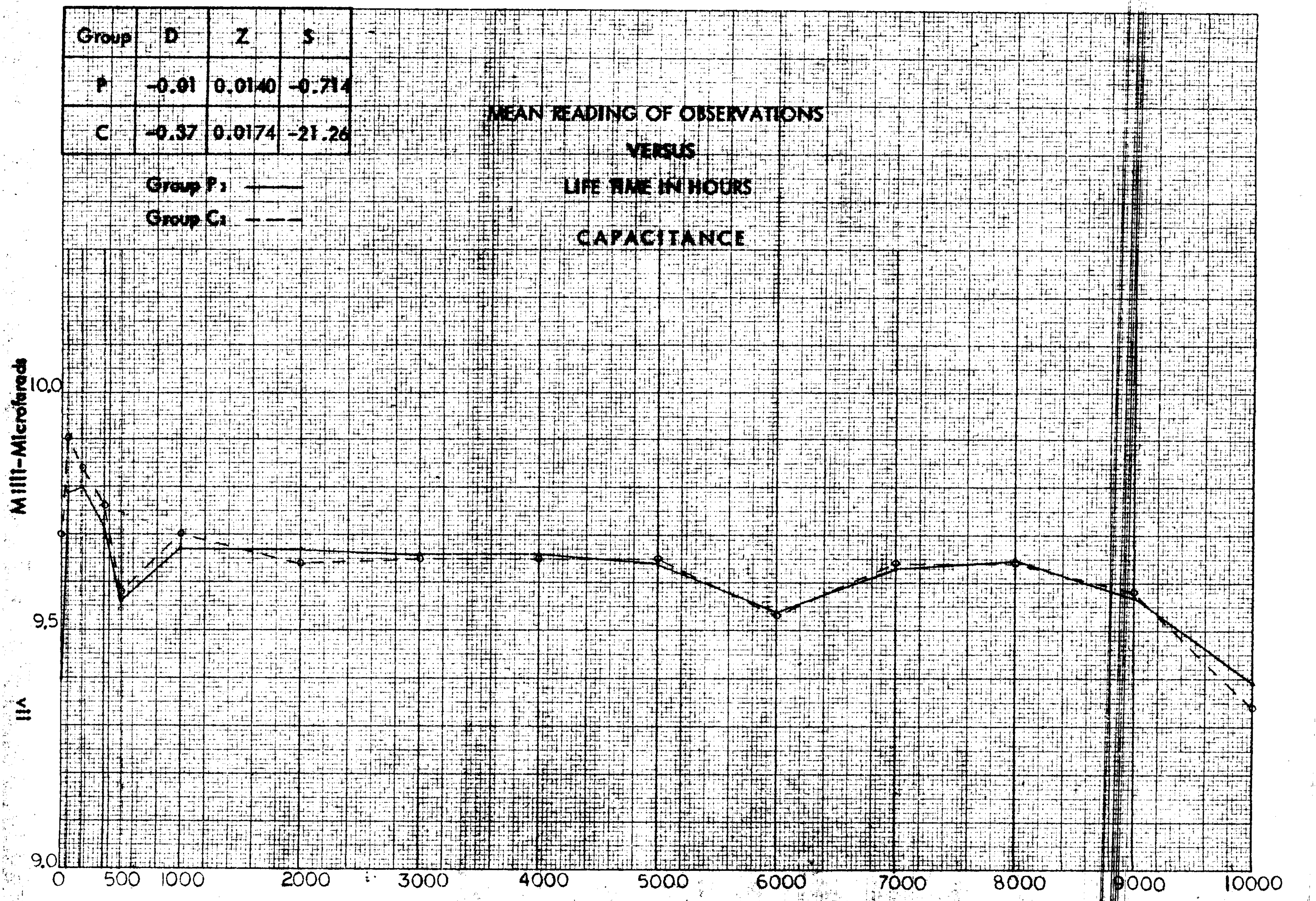
A. No catastrophic or parametric failures occurred during the 10,000-hour life test program.

B. There was a definite overall downward drift in all three parameters from initial to 10,000-hours with an accelerated decline in parametric value between 8000 and 10,000-hours.

C. Both groups reacted significantly to the first 50-hour temperature burst and again at the 500-hour point in the life test. For all parameters, stabilization did not seem to occur until the 1000-hour point had been reached. After this point, the parameter means for both groups tended to drift closer together and stabilize to the 5000-hour point.

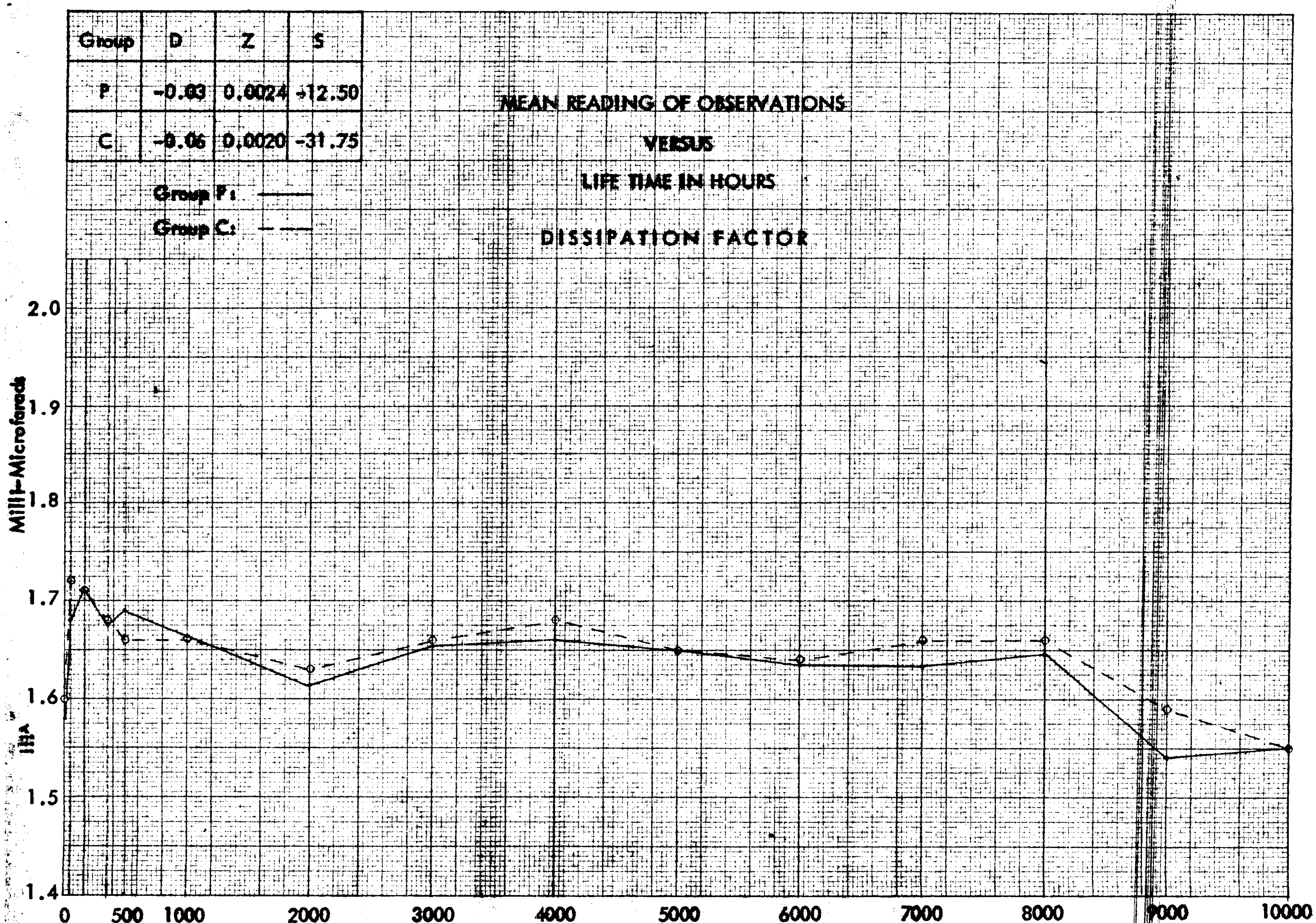
D. There is evidence to support the conclusion that the instability of the parts was caused by one or a combination of two factors: (1) Physical characteristics of the components; or, (2) the repeated removal of the components from temperature and allowing them to return to room temperature for measurement. In effect, the parts may have been temperature cycled over the short time period between initial and 500-hours due to this factor.

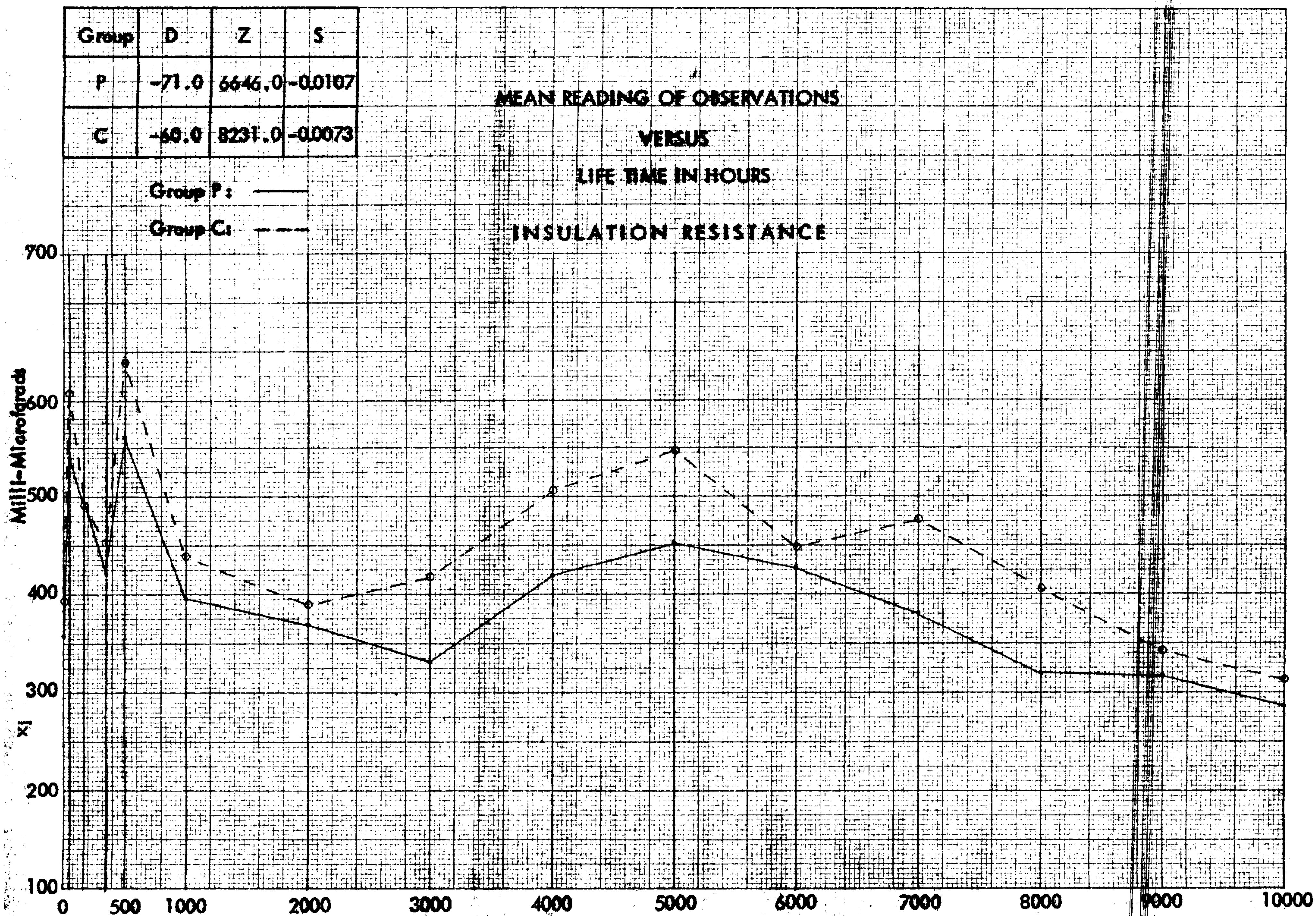
E. There was a definite significant difference between Group P and Group C for Capacitance and DF, between initial and 10,000-hour measurements. While both groups drifted together in the same direction during life test, Group P returned to its initial value, while Group C ended significantly lower. This fact was due to the higher initial reading of Group C, indicating that post-screening measurements may be more indicative of parameter readings at 10,000-hours than pre-screening or non-screened initial measurements.



| Group | D | Z | S |
|---|---|---|---|
| P | -0.01 | 0.0140 | -0.714 |
| C | -0.37 | 0.0174 | -21.26 |

Group $P_1$ ———
Group $C_1$ – – –
MEAN READING OF OBSERVATIONS
VERSUS
LIFE TIME IN HOURS
CAPACITANCE
Milli-Microfarads
10.0
9.5
9.0
0
500
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000


Group D Z S
P -0.03 0.0024 +12.50
C -0.06 0.0020 -31.75
Group P: ———
Group C: — —
MEAN READING OF OBSERVATIONS
VERSUS
LIFE TIME IN HOURS
DISSIPATION FACTOR
Milli-Microfarads
2.0
1.9
1.8
1.7
1.6
1.5
1.4
0
500
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000



Group | D | Z | S
P | -71.0 | 6646.0 | -0.0107
C | -60.0 | 8231.0 | -0.0073
Group P :
Group C:
MEAN READING OF OBSERVATIONS
VERSUS
LIFE TIME IN HOURS
INSULATION RESISTANCE
Milli-Microfarads
700
600
500
400
300
200
100
0
500
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

## GROUP COMPARISONS

### CAPACITANCE: NOMINAL VALUE 10.00 MILLIPICOFARADS

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| Initial | 9.40 | 9.71 | .164 | .186 | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 9.79 | 9.91 | .188 | .196 | 1.32 | 1.10 | .384 | .200 | .073 | .078 | +4.08 | +2.06 | +74.1 | +36.2 | + 24.3 | +.393 |
| 168 | 9.80 | 9.84 | .177 | .191 | .88 | .96 | .008 | -.069 | .074 | .069 | + .08 | + .70 | + 1.5 | -14.2 | + 10.8 | +.077 |
| 336 | 9.72 | 9.76 | .176 | .191 | .99 | .99 | - .079 | -.082 | .030 | .030 | - .80 | - .83 | -37.8 | -39.2 | + 1.01 | +.003 |
| 504 | 9.56 | 9.57 | .163 | .186 | .86 | .95 | - .154 | -.187 | .042 | .042 | -1.58 | -1.92 | -51.8 | -63.1 | + 8.12 | +.034 |
| 1008 | 9.68 | 9.71 | .178 | .192 | 1.19 | 1.07 | .119 | .139 | .041 | .041 | +1.24 | +1.45 | +40.9 | +47.4 | - 4.82 | -.020 |
| 2000 | 9.67 | 9.64 | .176 | .201 | .98 | 1.10 | - .015 | -.064 | .032 | .052 | - .15 | - .66 | - 6.6 | -17.3 | + 11.4 | +.049 |
| 3000 | 9.66 | 9.65 | .172 | .191 | .95 | .90 | - .006 | .007 | .026 | .049 | - .06 | + .07 | - 3.2 | + 1.9 | - 31.6 | -.013 |
| 4000 | 9.66 | 9.65 | .176 | .186 | 1.05 | .94 | .001 | .000 | .033 | .030 | + .01 | + .00 | + .4 | + .00 | + .32 | +.001 |
| 5000 | 9.64 | 9.65 | .179 | .197 | 1.03 | 1.12 | - .018 | .005 | .020 | .034 | - .19 | + .05 | -13.2 | + 2.01 | - 8.30 | -.023 |
| 5000 to Initial | - | - | - | - | 1.19 | 1.12 | 2.41 | -.052 | .046 | .053 | +2.56 | - .55 | +73.86 | -13.8 | +158.45 | +.393 |

F: Significant at 0.005 level above 1.44, or below 0.694.

t: Significant at 0.005 level above 2.807.

## GROUP COMPARISONS

### CAPACITANCE: NOMINAL VALUE 10.00 MILLIPICOFARADS

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| 6000 | 9.54 | 9.53 | .171 | .184 | .91 | .87 | -.107 | -.118 | .030 | .028 | -1.11 | -1.22 | -50.5 | -60.2 | +3.91 | +.011 |
| 7000 | 9.63 | 9.63 | .177 | .189 | 1.07 | 1.06 | +.082 | +.104 | .028 | .044 | +.86 | +1.09 | +44.7 | +33.5 | -18.2 | -.021 |
| 8000 | 9.65 | 9.64 | .172 | .201 | .94 | 1.13 | +.020 | +.006 | .024 | .041 | +.21 | +.06 | +11.8 | +2.1 | +4.13 | +.014 |
| 9000 | 9.57 | 9.58 | .173 | .192 | 1.02 | .913 | -.073 | -.062 | .022 | .022 | -.75 | -.65 | -46.7 | -40.7 | -4.66 | -.010 |
| 10000 | 9.39 | 9.34 | .141 | .181 | .94 | .89 | -.180 | -.238 | .045 | .076 | -1.89 | -2.49 | -56.5 | -44.5 | +9.38 | +.059 |
| 10000 to Initial | - | - | - | - | 1.052 | .94 | -.011 | -.362 | .068 | .092 | -.11 | -3.74 | -2.2 | -55.9 | +43.6 | .352 |

F: Significant at 0.005 level above 1.44, or below 0.694.

t: Significant at 0.005 level above 2.807.

## GROUP COMPARISONS

### DISSIPATION FACTOR: NOMINAL VALUE - N/A - PERCENT

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| Initial | 15.8 | 16.1 | .484 | .645 | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 16.8 | 17.2 | .538 | .726 | 1.24 | 1.27 | 1.04 | +1.16 | .509 | .593 | +6.59 | +7.23 | +28.9 | +27.7 | -2.12 | -.012 |
| 168 | 17.1 | 17.1 | .580 | .658 | 1.16 | .82 | .24 | - .08 | .572 | .642 | +1.43 | - .46 | + 5.93 | - 1.76 | +5.26 | +.032 |
| 336 | 16.8 | 16.8 | .520 | .666 | .80 | 1.02 | - .31 | - .36 | .518 | .546 | -1.82 | -2.10 | - 8.57 | - 9.37 | + .94 | +.005 |
| 504 | 16.9 | 16.6 | .492 | .585 | .90 | .77 | .13 | - .21 | .497 | .549 | + .78 | -1.25 | + 3.86 | - 5.38 | +6.69 | +.035 |
| 1008 | 16.6 | 16.6 | .453 | .558 | .85 | .91 | - .24 | - .00 | .487 | .478 | -1.43 | - .05 | - 7.03 | - .24 | -4.85 | -.331 |
| 2000 | 16.1 | 16.3 | .489 | .620 | 1.16 | 1.23 | - .53 | - .25 | .448 | .517 | -3.18 | -1.51 | -16.7 | - 6.84 | -5.77 | -.028 |
| 3000 | 16.5 | 16.6 | .490 | .527 | 1.01 | .72 | .40 | + .31 | .447 | .454 | +2.47 | +1.91 | +12.6 | + 9.68 | +1.95 | +.009 |
| 4000 | 16.6 | 16.8 | .524 | .536 | 1.14 | 1.03 | .06 | + .20 | .400 | .374 | + .37 | +1.19 | + 2.15 | + 7.45 | -3.52 | -.014 |
| 5000 | 16.5 | 16.5 | .484 | .563 | .85 | 1.10 | .11 | - .28 | .376 | .435 | - .66 | -1.64 | - 4.11 | - 8.94 | +4.07 | +.017 |
| 5000 to Initial | - | - | - | - | 1.00 | .761 | .07 | + .49 | .430 | .473 | +4.50 | +3.06 | +23.3 | +14.7 | +4.82 | +.022 |

F: Significant at 0.005 level above 1.44 or below 0.694 .

t: Significant at 0.005 level above 2.807 .

## GROUP COMPARISONS

### DISSIPATION FACTOR: NOMINAL VALUE - N/A - PERCENT

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| 6000 | 16.3 | 16.4 | .478 | .521 | .98 | .86 | -.14 | -.14 | .358 | .390 | -.88 | -.86 | -5.72 | -5.15 | +.080 | -.000 |
| 7000 | 16.3 | 16.6 | .483 | .508 | 1.02 | .95 | +.01 | +.23 | .406 | .381 | +.05 | +1.43 | +.26 | +8.75 | -5.78 | -.023 |
| 8000 | 16.5 | 16.6 | .449 | .567 | .87 | 1.24 | +.12 | -.07 | .365 | .379 | +.76 | -.43 | +4.80 | -2.69 | +5.27 | +.020 |
| 9000 | 15.4 | 15.9 | .462 | .546 | 1.06 | .93 | -1.07 | -.07 | .343 | .379 | -6.52 | -.42 | -44.29 | -2.61 | -27.8 | -.100 |
| 10000 | 15.5 | 15.5 | .502 | .548 | 1.18 | 1.01 | +.11 | -.39 | .412 | .454 | +.688 | -2.46 | +3.64 | -12.15 | +11.4 | +.050 |
| 10000 to Initial | - | - | - | - | 1.07 | .72 | -.28 | -.58 | .491 | .574 | -1.787 | -3.63 | -8.12 | -14.34 | +5.63 | +.030 |

F: Significant at 0.005 level above 1.44 or below 0.694 .

t: Significant at 0.005 level above 2.807 .

# GROUP COMPARISONS

## INSULATION RESISTANCE: NOMINAL VALUE - N/A, LOWER LIMIT 100 K MEGOHMS

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| Initial | 357 | 393 | 91 | 97 | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 539 | 608 | 194 | 216 | 4.54 | 4.93 | +182 | +215 | 213 | 241 | +51 | +54 | +12.1 | +12.6 | -1.44 | -32.8 |
| 168 | 495 | 491 | 119 | 136 | .38 | .40 | - 44 | -117 | 230 | 245 | - 8 | -19 | - 2.72 | - 6.76 | +3.08 | +73.1 |
| 336 | 422 | 452 | 128 | 128 | 1.16 | .88 | - 73 | - 38 | 170 | 183 | -15 | - 8 | - 6.08 | - 2.95 | -1.96 | -34.7 |
| 504 | 562 | 639 | 243 | 248 | 3.60 | 3.77 | +140 | +186 | 256 | 284 | +33 | +41 | + 7.75 | + 9.27 | -5.41 | -46.2 |
| 1008 | 396 | 438 | 86 | 130 | .13 | .27 | -166 | -200 | 306 | 344 | -30 | -31 | - 7.67 | - 8.24 | +1.06 | +34.5 |
| 2000 | 369 | 388 | 109 | 100 | 1.59 | .60 | - 29 | - 50 | 136 | 159 | - 7 | -11 | - 3.05 | - 4.39 | +1.36 | +20.2 |
| 3000 | 331 | 417 | 94 | 116 | .74 | 1.34 | - 38 | + 27 | 139 | 145 | -10 | + 7 | - 3.89 | + 2.59 | -4.56 | -64.8 |
| 4000 | 420 | 506 | 142 | 153 | 2.31 | 1.72 | + 88 | + 90 | 162 | 182 | +27 | +22 | + 7.71 | + 6.98 | + .078 | - 1.35 |
| 5000 | 453 | 547 | 135 | 159 | .90 | 1.09 | + 37 | + 41 | 182 | 216 | + 9 | + 8 | + 2.85 | + 2.69 | - .225 | - 4.50 |
| 5000 to Initial | - | - | - | - | 2.20 | 2.70 | + 96 | +154 | 155 | 174 | +27 | +39 | + 8.73 | +12.53 | +3.57 | -58.8 |

F: Significant at 0.005 level above 1.44 or below 0.694 .

t: Significant at 0.005 level above 2.807 .

# GROUP COMPARISONS

## INSULATION RESISTANCE: NOMINAL VALUE - N/A, LOWER LIMIT 100 K MEGOHMS

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| 6000 | 427 | 448 | 148 | 131 | 1.20 | .67 | -25 | -99 | 202 | 207 | -6 | -18 | -1.78 | -6.79 | +3.61 | +74.0 |
| 7000 | 381 | 477 | 115 | 178 | .60 | 1.86 | -45 | +31 | 189 | 206 | -11 | +7 | -3.38 | +2.11 | -3.84 | -76.0 |
| 8000 | 320 | 406 | 76 | 109 | .43 | .37 | -59 | -72 | 154 | 215 | -16 | -15 | -5.45 | -4.76 | +.693 | +12.9 |
| 9000 | 316 | 343 | 77 | 90 | 1.03 | .68 | -3 | -60 | 135 | 149 | -1 | -15 | -0.30 | -5.70 | +4.01 | +56.9 |
| 10000 | 286 | 313 | 77 | 78 | 1.01 | .76 | -32 | -30 | 107 | 121 | -10 | -9 | -4.27 | -3.57 | -.171 | -1.95 |
| 10000 to Initial | - | - | - | - | .71 | .65 | -72 | -80 | 114 | 121 | -20 | -20 | -8.90 | -9.34 | +.832 | +8.25 |

F: Significant at 0.005 level above 1.44 or below 0.694 .

t: Significant at 0.005 level above 2.807 .

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**TEST REPORT**

805 EAST CERRITOS AVENUE • ANAHEIM, CALIFORNIA

## INTRODUCTION

### I. PURPOSE

This Screening Evaluation Test Program was conducted to evaluate the effects of screening upon fixed ceramic dielectric low voltage capacitors by applying failure data and parameter degradation data and statistically analyzing the results.

### II. START DATE

29 June 1964

### III. COMPLETION DATE

5 November 1965

### IV. TESTING FACILITY

Preston Scientific Incorporated
Test Laboratory Division
Anaheim, California

### V. DISPOSITION OF TEST SAMPLES

Returned to JPL at conclusion of all testing.

## VI. DRAWING, SPECIFICATION OR EXHIBIT

(a) JPL Specification No. 152-20-01/3, approved Test Program Plan, pages 1-13, and as amended by Modification No. 2, JPL Contract 950864.

(b) JPL Specification No. 152-20-01/3, Statistical Analysis, as amended by Modification No. 2, JPL Contract 950864.

(c) JPL Specification No. 152-20-01/1, Capacitor Screening Evaluation Test Program, Detail Specification, dated 22 January 1964.

(d) JPL Specification No. 152-20-01, Capacitor Screening Evaluation Test Program, General Specification, dated 23 January 1964.

(e) JPL Specification No. ZPP-2040-GEN A, General Specification, Computation and Submittal of Component Test Statistics, 19 July 1963.

(f) JPL Specification No. ZPP-2098-GEN, General Specification, Preparation and Submittal of Final Test Report on Component Part Test Programs, 8 January 1964.

(g) Massey, F.J., "The Kalmogorov-Smirnov Test for Goodness of Fit", American Statistical Association Journal, March 1951, pages 68-78.

## DESCRIPTION OF TEST ITEMS

### MANUFACTURER

Vitramon, Incorporated

### TYPE/MODEL NUMBER

Fixed Ceramic Dielectric Capacitor
Type CK 06CW103K

### RATINGS

(1) Capacitance: 10,000pf ± 10%

(2) Dissipation Factor: 2.5% maximum

(3) Insulation Resistance: 100K megohms

(4) Working Volts DC: 200V

(5) Environmental: minus 55°C to plus 150°C

(6) Case Style: molded, radial leads

(7) Case Dimensions:

| | | |
|---|---|---|
| Lead Length | - | 1-1/4 inches minimum |
| Height | - | .300 inches maximum |
| Width | - | .300 inches maximum |
| Depth | - | .100 inches maximum |

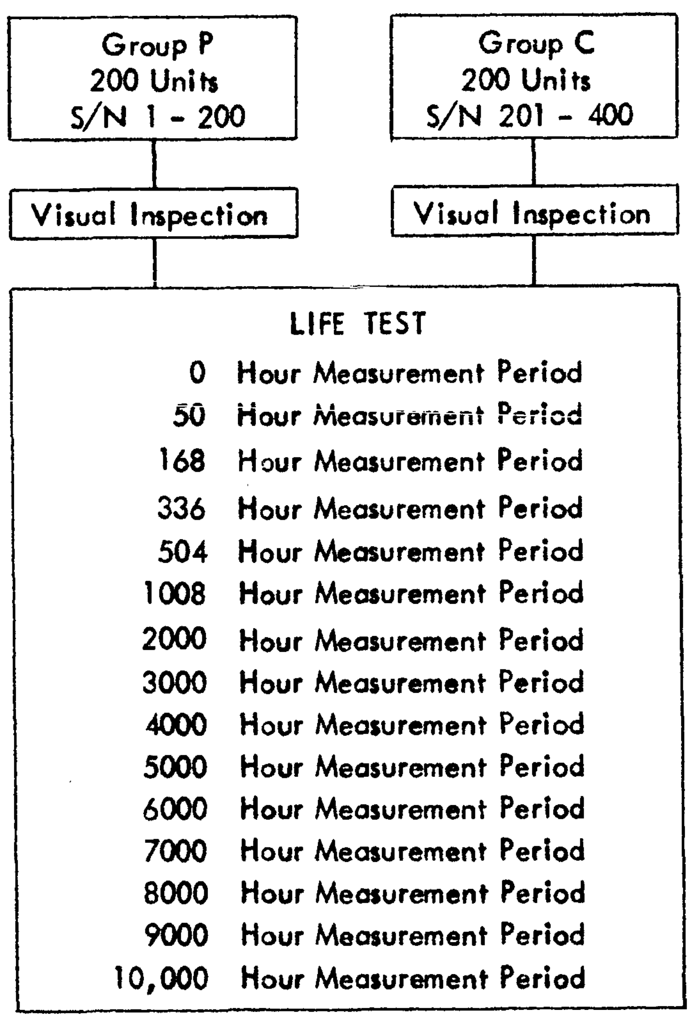
## DESCRIPTION OF TEST PROGRAM

### 1.0 TEST DESIGN

A total of 400 test samples were received from JPL with the lot divided equally into two (2) Groups designated P and C. The test samples were then identified with specially printed high-temperature wire markers (Brady Type B-400 Micro Marker) applied to the body of each test sample. These markers remained legible throughout the test program.

The Flow Diagram of Figure 1 below indicates the tests that were conducted and the sequence in which they were performed.

FIGURE 1: FLOW DIAGRAM



The life test was conducted for a period of 10,000-hours at a temperature of 100°C with 200 VDC applied. The applied voltage was that specified in the published ratings. The life test temperature, however, was under the manufacturer's rating of 150°C.

The three electrical parameters, measured at each measurement period, are indicated below.

(a) Capacitance
(b) Dissipation Factor
(c) Insulation Resistance

## 2.0 MEASUREMENT PROCEDURES

2.1 Visual Inspection - All test samples were subjected to a visual inspection under an illuminated magnifying glass. Each sample was examined for evidences of poor workmanship, dented cases, broken or corroded leads, and any other visual defects. The defects, if any, were recorded and the data submitted to JPL for disposition.

2.2 Electrical Parameter Measurement - All electrical parameter measurements were made in an air-conditioned and dust free area maintained at 25°C ± 1°C. The steps of the measurement process were as follows:

(a) Measurement of capacitance and dissipation factors on a General Radio Model 716-C Capacitance Bridge. The operator hand recorded the data on JPL Form No. 1494.

(b) A second measurement of capacitance and dissipation factor on a second measurement set up as described above was made.

(c) Measurement of insulation resistance on an Industrial Instruments Model L-7 Megohmeter. The operator hand recorded the data.

(d) A second measurement of insulation resistance on a second measurement set up as described above was made.

2.3 Capacitance Measurement - Each sample, in turn, was connected directly to the capacitance bridge terminals, see Appendix II. Short metal clips were used at the bridge terminals to facilitate lead attachment. The bridge was excited with an AC voltage not exceeding 2 volts rms at 1000 cps. The voltage was maintained within ±0.25 volts during measurements throughout the test program. Capacitance was measured and recorded to at least four (4) significant figures.

2.4 Dissipation Factor Measurement - During the capacitance measurement and under the same conditions, the dissipation factor was measured and recorded to three (3) significant figures.

2.5 Insulation Resistance Measurements - Each sample, in turn, was connected to an insulation resistance setup as shown in Appendix II. The test setup was energized with 200 vdc. Each capacitor was charged through a current limiting resistor for the electrification time of two (2) minutes. Insulation resistance was measured and recorded to at least four (4) significant figures within the limitations of the range of the megohm bridge. The upper range of the megohm bridge is 5000 K megohms.

2.6 Test Equipment - The test equipment was of sufficient accuracy, quality, and quantity to permit performance of tests and measurements within the tolerances specified. The test equipment used in this test program is listed in Appendix II. All test equipment was calibrated prior to the initial tests by the Preston Scientific Calibration Laboratory. During the test program the parameter measuring instruments were checked against standards on a normal recalibration schedule and also prior to each measurement period. During recalibration the instruments were not adjusted to change measuring tolerances without the prior approval of JPL. The same instruments were used to measure the same test samples throughout the test program.

2.7 Measurement Accuracy

| | | |
|---|---|---|
| Capacitance | - | ±0.2% |
| Dissipation Factor | - | ±2% for a DF of .025 or greater and .0005 for a DF smaller than .025. |

## 3.0 LIFE TEST PROCEDURE

The total of 400 parts were subjected to the 10,000-hour life test. This total test sample lot consisted of 200 parts in Group P and 200 parts in Group C. Both groups were installed in one test chamber to insure equal test conditions. Each part was lead mounted by means of specially designed spring clips which did not deform the leads. These spring clips were insulated from anodized aluminum terminal boards by teflon inserts. Two rows of 51 positions, each position uniquely identified, comprised a rack. These racks were installed into the temperature chamber. All of the internal wiring from the terminals on the board to AN connectors on the front door panels were teflon insulated. Power to the parts was applied through the AN connectors.

The method of power application is indicated in Appendix II. The voltage source was a series bank of high capacity batteries. Batteries were used to eliminate the possibility of voltage transients and surges. The batteries were recharged during the electrical parameter measurement periods of the life test or a slow trickle charge was applied as required. The fuses used during the life test were fast-acting type fuses rated at 1/16 amperes. A high-resistance potentiometer to limit the initial charge current to 50 ma or less was connected in series with the battery supply line. After voltage application, the potentiometer resistance was slowly decreased to zero in a period not less than 15 seconds. With the potentiometer at zero, the voltage source supplied a short circuit current limited only by the wiring resistance. Source and wiring resistance was less than 0.3 ohms per volt. With minimum resistance in the circuit, when a capacitor shorts and blows the series fuse, the effect on adjacent capacitors was minimized. After the capacitors were installed in the chamber as previously specified, 200 VDC was slowly applied. All fuses were then checked. The chamber temperature was increased to 100°C in a period of 2 ± 1/2 hours. All fuses were again checked. The above conditions were maintained for 10,000-hours except during the electrical parameter measurement periods when the chamber temperature was slowly decreased to room ambient temperature in 2 hours ± 1/2 hour and the parts removed for measurement. Measurements were taken after the parts were stabilized at room ambient temperature for at least six hours. After measurement, the parts were restored to their original positions in the chamber and the test resumed. The electrical parameter measurement tests were conducted after an elapsed time of 50, 168, 336, 504, 1008, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, and 10,000-hours of the life test.

During the life test, the voltage applied to the capacitors was measured and recorded a minimum of once each day. During this same period, each fuse was examined for evidence of shorted capacitors.

## 4.0 RECORDING OF DATA

The three electrical parameters were measured and recorded on hand-written data sheets at every measurement step. Data sheets were supplied by JPL(Form No. 1494) using the 80 column method of recording data.

The format for the recording of data was as follows:

| Columns | Usage |
|---|---|
| 1 - 2 | JPL Test Code (19) supplied by JPL |
| 3 - 5 | Component Code (001) supplied by JPL |
| 6 | Type of Test Code (3) |
| 7 - 8 | Group Code (01-P, 02-C) |
| 9 - 10 | Temperature Code (Blank) |
| 11 - 12 | Group Measurement Number (01 - 15) |
| 13 | Number of Parameters (3) |
| 14 | Number of Last Field (5) |
| 15 | Number of Cards (Blank) |
| 16 | Number of this card (Blank) |
| 17 | Data Form Code (1) |
| 18 - 20 | Item Number (001 - 200 or 201 - 400) |
| 21 - 25 | 1st Data Field (Capacitance in milli-microfarads) |
| 26 - 30 | 2nd Data Field (Blank) |
| 31 - 35 | 3rd Data Field (Dissipation Factor in percent) |
| 36 - 40 | 4th Data Field (Blank) |
| 41 - 45 | 5th Data Field (Insulation Resistance in K megohms) |
| 46 - 70 | Additional Fields (Blank) |
| 71 | Failure Code (0 - 2) |
| 72 - 80 | Blank |

## 5.0 DATA VERIFICATION

The following steps were used in the measurement of each test sample:

(1) The sample was measured on all parameters and the readings recorded in decimal form in the format specified above.

(2) A second independent reading was made by a second technician on a duplicate set of test equipment for all parameters. These readings were recorded in the same format as specified in step (1).

(3) The two sets of readings were compared by an engineer to check for agreement within the accuracy of the test equipment. If agreement existed, the value made in step (1) was considered verified and correct. If agreement did not exist, the sample was resubmitted to steps (1), (2), and (3) until agreement was obtained. The recorded readings were also checked for any illegible or questionable numbers which could lead to errors.

## 6.0 FAILURE VERIFICATION

6.1 Catastrophic - A catastrophic failure is defined as a shorted or open capacitor. A capacitor was considered shorted if it blew two consecutive 1/16 ampere fuses during the life test. A capacitor was considered open when during electrical parameter measurements an extremely low or zero reading was indicated. The catastrophic failures were to be removed from the test only during the electrical parameter measurements' tests which were conducted under room ambient conditions.

6.2 Parametric - A parametric failure is defined as a capacitance less than 9000pf or greater than 11,000pf, dissipation factor greater than 2.5%, and insulation resistance less than 100K megohms. Parametric failures were to be removed from the test only if so directed by JPL.

# 7.0 DATA ANALYSIS PROCEDURES

7.1 Data Analysis Flow Diagram - Figure 2 details the steps of the test program and the corresponding types of data analysis submitted at each step. The items on the Figure and the sections in which they are discussed are as follows:

(a) Computed Statistics Sheets (CSS) - 7.3.1
(b) t-Computations (TC) - 7.3.2
(c) Final Life Test Analysis - 7.4

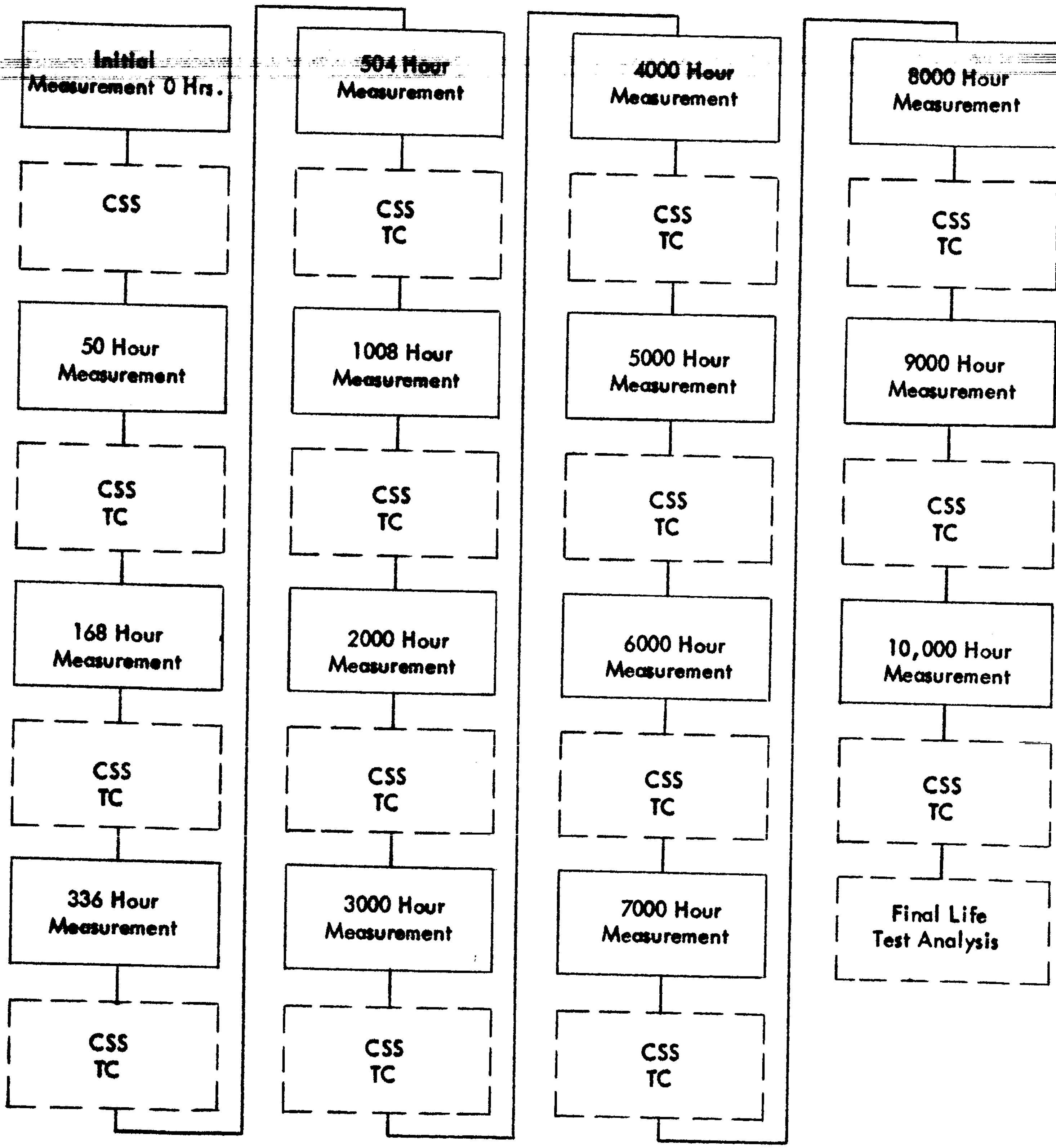
7.2 Data Submission Schedule - Computed statistic sheets and t-computations were submitted within one (1) week after completion of the test data accumulation for a specific measurement period. Parametric failure analysis sheets were to be submitted only in the final analysis.

## 7.3 Detailed Data Analysis Procedure

7.3.1 Computed Statistics Sheet (CSS) - The computed statistics sheet is a means of providing descriptive measures of the nature of a body of data both as to its present characteristics and also to the degree and significance of any changes which may have taken place in its characteristics since some earlier point in time (usually taken as the preceding measurement point). The computed statistics sheets were prepared in strict accordance with Reference (e). The sheet itself is a 8-1/2" x 11" size sheet presented in the exact format of Reference (e), Table II. A sample sheet was made available to JPL prior to the first measurement period for JPL approval.

7.3.1.1 Bodies of Data for which CSS Applies - A CSS was prepared for each Group (P and C) and parameter at each time so indicated on Figure 2 (shown on the following page). There were fifteen (15) such times in the program. CSS sheets were prepared each time making 90 sheets submitted to JPL during the course of the program.

## FIGURE 2: DATA ANALYSIS FLOW DIAGRAM



7.3.1.2 Cumulative Nature of the Sheet - Each CSS for an individual group was cumulative in nature, i.e., each time a CSS sheet was submitted it contained on it all previous CSS calculations made upon prior steps as well as those made upon the most recent step. In this way a picture of trends and developments within the group from initiation of the test to any given step were readily available.

7.3.1.3 Data Used - The data used in the preparation of a CSS was the parameter values of the noncatastrophic devices in the group, also the totality of parameter values which were made upon the devices which were noncatastrophic in the immediately preceding measurement step.

7.3.1.4 Statistics Computed - The following notation was utilized:

| | |
|---|---|
| $X_i$, $i = 1, n$ | the last parameter measurement made upon the ith device in the group of original size n |
| $X_{i0}$, $i = 1, n$ | the parameter value of the ith device made in the step immediately preceding the step in which $X_i$ was made |
| $Y_i$, $i = 1, n$ | the difference between $X_i$ and $X_{i0}$, i.e., $Y_i = X_i - X_{i0}$ |
| U | the upper specification limit of the parameter for devices in the group |
| L | the lower limit of the parameter for devices in the group |
| $n_1$ | the number of noncatastrophic devices in the group during the most recent measurement step |
| $n_{15}$ | the number of noncatastrophic devices in the group during the immediately preceding measurement step |

The fifteen (15) quantities of TABLE 1, Column 1, were computed and tabulated upon the CSS at each step. The respective notation used for each is given in TABLE 1, Column 2. Summations include only noncatastrophic devices.

TABLE 1: CSS STATISTICS

| Column 1<br>Statistic Computed | Column 2<br>Denoted By |
|---|---|
| 1. Minimum $X_i$ | Minimum |
| 2. Mean of $X_i$, $i = 1, n$: $\bar{X} = \sum_{i=1}^{n} \frac{X_i}{n_1}$ | Mean |
| 3. Maximum $X_i$ | Maximum |
| 4. Standard Deviation of $\bar{X}$: $S_{\bar{X}} = \sqrt{\sum_{i=1}^{n} \frac{(X_i - \bar{X})^2}{n_1 (n_1 - 1)}}$ | Standard |
| 5. F ratio for Comparing Variances: $F = \dfrac{\dfrac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{(n_1 - 1)}}{\dfrac{\sum_{i=1}^{n} (X_{io} - \bar{X}_o)^2}{(n_{15} - 1)}}$ | F |
| 6. Minimum $Y_i$ | Minimum D |
| 7. Mean of $Y_i$, $i = 1, n$: $\bar{Y} = \sum_{i=1}^{n} \frac{Y_i}{n_1}$ | Mean D |
| 8. Maximum $Y_i$ | Maximum D |
| 9. Standard Deviation of $\bar{Y}$: $S_{\bar{Y}} = \sqrt{\sum_{i=1}^{n} \frac{(Y_i - \bar{Y})^2}{n_1 (n_1 - 1)}}$ | Standard D |

TABLE 1: CSS STATISTICS (Continued)

| Column 1<br>Statistic Computed | Column 2<br>Denoted By |
|---|---|
| 10. "Percent" Change: | PC |
| $P.C. = \frac{\bar{Y}\,(100)}{\bar{X}}$ | |
| 11. t Value for Testing Hypothesis Mean D = 0: | t |
| $t = \frac{\bar{Y}}{s_{\bar{Y}}}$ | |
| 12. Number of Parts Being Measured in Present Step | $N_o$ |
| 13. Number of $X_i$'s $> U$ | $N_u$ |
| 14. Number of $X_i$'s $< L$ | $N_l$ |
| 15. Number of Catastrophic Failures | $N_c$ |

7.3.1.5 Presentation of Statistics - The statistics were presented in the format of Table 2. This Table is identical to Reference (e), Table II. At the top of the page are found the JPL test number, vendor name, part number, the parameter being measured, the unit used in the measurement, and finally, the nominal value and upper and lower limits. In order to obtain the necessary number of significant digits, a power of ten multiplier was used to shift the decimal point. The value of this multiplier was given as shown in Table 2 on the following page. The column headings in Table 2 are those defined in Table 1. The step numbers were 1 through 15, corresponding to the fifteen (15) measurement periods of the test, Step No. 16 being the final analysis line.

7.3.1.6 Significant Values - Statistics 1, 2, 3, 6, 7, and 8 were four significant digits where possible with a sign and a decimal. The position of the decimal is flexible. Statistics 4 and 9 were five significant digits with a decimal. Statistics 5, 10, 11, 12, 13, 14, and 15 were as given in Table 2. If statistic 5 or 11 exceeded 1000.000 in absolute magnitude, the value was recorded as +999.999 or as -999.999 as appropriate.

7.3.1.7 Submittal of Computed Statistics Sheets - After all statistics had been computed, a separate CSS was submitted to JPL (within the one week requirement) for each group and parameter making a total of 90 CSS's. Each CSS contained the statistics on all measurements made up to the time of submittal. Four (4) copies of the CSS's were submitted each time.

7.3.1.8 Initial Measurement Differences - For initial measurements, $Y_i$ does not exist since there have been no preceding measurements. Thus, F, Min D, Mean D, Max D, Std D, P.C., and t were set equal to zero for initial measurements.

7.3.2 t-Computations (TC) - t-Computations were made to test for differences in parametric stability between Groups P and C. A computation was made on successive changes in parametric value at fourteen (14) periods during the program as shown in Figure 2. The t-computation was made and submitted in strict accordance with Reference D, section 7.3.

## TABLE 2: COMPUTED STATISTIC SHEET

JPL Test No. (XXXX) Vendor (XXXX) Part Number (XXXX) Group (XX)

Multiplier (XXX) Unit (XXXX) Nominal Value (XXXX) Lower Limit (XXXX) Upper Limit (XXXX)

| Minimum | Mean | Maximum | Standard | F | Minimum D | Mean D | Maximum D | Standard D | P.C. | t | No. | $N_U$ | $N_L$ | $N_C$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Step 1 - Initial Measurements | | | | | | | | | |
| ±XX.XX | ±XX.XX | ±XX.XX | ±XX.XX | ±000.000 | ±00.00 | ±00.00 | ±00.000 | ±00.000 | ±00.00 | ±000.000 | XXX | XXX | XXX | XXX |
| | | | | | Step 2 - Life Test 50 Hours | | | | | | | | | |
| ±XX.XX | ±XX.XX | ±XX.XX | ±XX.XX | ±XXX.XXX | ±XX.XX | ±XX.XX | ±XX.XX | ±XX.XXX | ±XX.XX | ±XXX.XXX | XXX | XXX | XXX | XXX |
| -- | | | | | -- | | | | | -- | | | | |
| -- | | | | | -- | | | | | -- | | | | |
| -- | | | | | -- | | | | | -- | | | | |
| -- | | | | | -- | | | | | -- | | | | |
| | | | | | Step 16 - Final Analysis Line | | | | | | | | | |

7.3.2.1 Formulae - The formulae for quantities calculated are as follows:

$$t_{PC} = \frac{\Delta PC}{\sqrt{(\text{Std } D_p)^2 + (\text{Std } D_c)^2}}$$

where PC = Mean $D_p$ - Mean $D_c$

and where the quantities Mean D and Std D are defined in TABLE 1 of this document, quantities 7 and 9.

7.3.2.2 Presentation of $\Delta$ Values and t Values - The $\Delta$ values and t values were presented as shown in TABLE 3 with each value having three digits to the right of the decimal point.

Mfg. Vitramon Type No. CK06CW103K

______ Hours of Life Test

| Parameter | $\Delta$ | t |
|---|---|---|
| Capacitance | | |
| Dissipation Factor | | |
| Insulation Resistance | | |

TABLE 3: t-COMPUTATION TABLE

Such a table was submitted at each measurement step in the life test along with the CSS's.

7.4 Final Life Test Analysis - At the completion of the test program and in accordance with the schedule, a final analysis is presented, which includes the following statistical data:

(a) Final analysis line of computed statistic sheets
(b) Final t-computations
(c) Graphical representation: $\bar{X}$ versus Time
(d) Life test computations based on $\bar{X}$'s

7.4.1 Final Analysis Line of Computed Statistics Sheets - At the completion of the life test, the fifteen (15) statistics of the CSS were computed again. The readings used were those taken immediately preceding the life test (Step 1), and the readings taken after removal of the parts from life test at 10,000-hours (Step 15). This final row of data on the computed statistics sheets is entitled "Final Analysis".

7.4.2 Final t-Computation - A final t-computation is submitted utilizing the statistics calculated on the computed statistics sheets (CSS), for the last row entitled Final Analysis.

7.4.3 Graphical Representation: $\bar{X}$ Versus Time - Using the means of the readings from the CSS at each measurement interval, a graph was made plotting the means for each Group P and C on the same piece of graph paper using time as the abscissa. The means of Group P are connected with a solid line, those of Group C with a dash line. A graph was made for each of the three measured parameters.

7.4.4 Life Test Computations Based on the $\bar{X}$'s - Define the following quantities. Let $\bar{X}_1$, $\bar{X}_2, \ldots\ldots, \bar{X}_{15}$ be the life test means.

$$Z = \frac{15\sum_{i=1}^{15}\bar{X}_i^2 - \left(\sum_{i=1}^{15}\bar{X}_i\right)^2}{210}$$

$$D = \bar{X}_1 - \bar{X}_{15}$$

$$S = \frac{D}{Z}$$

These quantities were computed for each graph and group, making six sets in all. They are placed in the upper left corner of the graph from which they are derived.

## TEST RESULTS

Visual inspection conducted prior to any testing revealed no visual defects on any sample of the total test sample lot.

### 1.0 CATASTROPHIC FAILURES

No catastrophic failures occurred during the test program.

### 2.0 PARAMETRIC FAILURES

No parametric failures occurred during the test program.

### 3.0 DESCRIPTION OF PARAMETRIC DRIFTS DURING LIFE TEST

3.1 Group P - For all parameters of Group P, significant changes occurred throughout the test. In general, a large significant change occurred from initial measurement through 50-hours of life test. The parameter per cent change significant statistics decreased substantially at the 168-hour measurement point and again increased greatly through the 336-hour, and 504-hour measurement point. From the 1008-hour measurement to the 5000-hour, the test specimens seemed to stabilize, as indicated by the decreasing significance of the t statistic, Std D, and mean difference values on the CSS sheets to that point. However, from the 5000 to 10,000-hour point, all parameters tended to drift downward significantly, while still remaining within specified tolerance limits.

3.2 Group C - As in Group P, Group C experienced significant changes in parameter values throughout the test. From initial through the 50-hour measurement, a large and significant increase in all parameter values occurred. Again, in general, a significant decrease occurred from the 50 to 168-hour measurement point, with a build-up in significant change through the 500-hour point. From the 500-hour life test point to 5000-hours, the parameter changes seemed to decline in significance as noted by the decreasing values of the t, Std D, and Mean D statistics. Again, all parameters drifted downward significantly from 5000 to 10,000-hours. However, there were no parametric failures.

3.3 Group P versus Group C - Appendix III reveals the t statistics and $\Delta$ values for comparison of changes between Group P and C throughout the test. For capacitance and DF, significant changes between groups appeared between initial and 50-hours of life test. The change between groups seemed to decrease until the 500-hour point, and then jump to higher significant values. From 5000 to 10,000-hours, the difference between groups was significant for all three parameters. However, the significance varied from plus (+) to minus (-), indicating that neither group was continuously different than the other from point to point during this period. Insulation resistance indicated the smallest significant difference throughout the life test of all three parameters measured.

## 4.0 DISCUSSION OF TEST RESULTS

4.1 Engineering versus Statistical Significance - The following discussion of the test results will be based on the CSS Sheets and t-Comparison Sheets between groups. While statistically significant changes occurred through the program for all parameters in both groups, it must be remembered that in no case did any test item fail catastrophically, or any parameter degrade to the point where out-of-tolerance measurements occurred. In this context, the engineering significance of the test results is questionable, and would tend to indicate that additional testing is required to insure that any conclusions reached from an engineering standpoint, (i.e. - that all units can survive the designed life test without failing or going out-of-tolerance) are valid ones.

The interpretation of the statistical data must necessarily be a positive one, and while the following discussion may appear to draw certain conclusions from statistical data, the engineering significance may tend to detract from the statements that will be made in the following paragraphs.

### 4.2 Group P and Group C Parameters

4.2.1 Capacitance - In all cases, the first burst of 50-hours life test caused a large increase in capacitance. The capacitance decreased until 500-hours and then increased significantly. After the 1000-hour exposure, the parameter values changed very little, tending, however, to stabilize and decrease slightly in value to the 5000-hour point.

This result is highly significant in that it happened for both the screened and unscreened Groups, P and C. In effect, the 168-hours of prior screening did not seem to stabilize the parts. The 1000-hour exposure point seems to be the place at which stabilization starts to take effect. This interpretation would tend to indicate that the parts were not burned-in a sufficiently long enough time to cause parameter stabilization. A case can be made for the conclusion that between 168 and 1000-hours, something happens to the physical structure of the capacitors to cause instability, and that the screening burn-in time of 168-hours was not sufficient to cause permanent stability.

Another cause of apparent instability at the initial exposure points (i.e. - 0, 50, 168, 336, and 504-hours) may be the short time the components are in the oven compared with actual measurement time. In other words, taking the components in and out of the oven over short periods of life test time, may, in effect be similar to an actual temperature cycling of the parts, since they are allowed to return to room temperature prior to measuring. Over a long life test measurement cycle (i.e., 1000-hours), this effect is negligible since the parts are essentially stabilized, or becoming more stabilized after 1000-hours.

After 5000-hours, the capacitance parameter drifted downward significantly to 10,000-hours. A highly significant dip in capacitance occurred at 6000-hours, as shown on the $\overline{X}$ Charts. At first glance, this point would appear erroneous in view of the return to previous capacitance values at 7000-hours. However, test set ups, chart recordings, temperatures and voltages, and recorded data were checked thoroughly and no inconsistancies or errors were found in the data. These laboratories can find no logical explanation for this occurrence, other than a possible physical change in the characteristics of the material occurring at this point, and perhaps signifying a future rapid decline in capacitance.

It is interesting to note that for Group P, the 10,000-hour reading returned to almost the exact reading taken during initial measurements, while the Group C reading at 10,000-hours was significantly lower than initial.

4.2.2 Dissipation Factor - Again, the first initial burst in temperature (i.e. - 50-hours) is significant, and parameter values vary greatly for both screened and unscreened parts (Groups P and C). However, the balance of the statistics and parameter changes appear to be fairly random in nature for both groups, and no significant statistical conclusions can be reached regarding part behavior up to 8000-hours. However, if dissipation factor should be considered a governing parameter in the analysis of results, the high significant values (i.e., t and Mean D) at 500-hours should be considered as stated in the previous paragraph. Also, it appears from the data that dissipation factor stabilizes somewhat faster than capacitance. However, at 8000-hours, the parameter values fall off sharply as shown on the $\overline{X}$ Charts and tend to level off somewhat at 10,000-hours.

4.2.3 Insulation Resistance - The first burst of 50-hours was also very significant for the insulation resistance parameter. Again, the 500-hour point was very critical, with high degrees of significance occurring for both Groups (P and C). After this point, however, the values drift down in value to the 3000-hour point, and then tend to increase again to 5000-hours and decrease significantly to 10,000-hours. However, it has been the experience of these laboratories that random measuring errors are often the cause of significant variances in insulation resistance readings, mainly due to instrument accuracy and the nature of the parts themselves. Therefore, no definite conclusions can be reached from considerations of IR variances alone, other than a general trend of decreasing IR values throughout the life test.

4.3 Group P Compared with Group C - Interpretation of the $\overline{X}$ Charts reveals slightly higher parameter readings for Group C than for Group P throughout the 10,000-hour life test period.

Capacitance parameter t-comparison statistics reveal a high significant difference between Group P and Group C, both 10,000-hours to initial and 5000-hours to initial. As stated previously, Group P tended to return to the initial measurement point readings at 10,000-hours, while Group C drifted downward continuously from initial to 5000 hours to 10,000-hours.

The statistical results, comparing the 10,000-hour point to initial measurements, indicate that Group C changed significantly downward, while Group P changed very little. However, this conclusion must be weighted by the fact that the initial measurement of P was significantly lower than C. Actually, the $\overline{X}$ Charts show both groups reacting about the same once stabilization is reached at about 1000-hours of life test.

An interpretation of the above analysis that has statistical validity, is that post screening measurements may be more indicative of the measurement values at 10,000 than pre-screening, or non-screened part measurements.

The same analysis and conclusions can be reached concerning Dissipation Factor. The mean value of P initially was 15.8 and 15.5 at 10,000-hours. The mean value of C was 16.1 initially and 15.5 at 10,000-hours.

Insulation Resistance drifted downward about the same for both groups, however. The Z statistic on the $\bar{X}$ Charts indicates an extreme variance in the data means at each measurement point, indicating random measuring errors or other causes explained in paragraph 4.2.3.

## 5.0 CONCLUSIONS

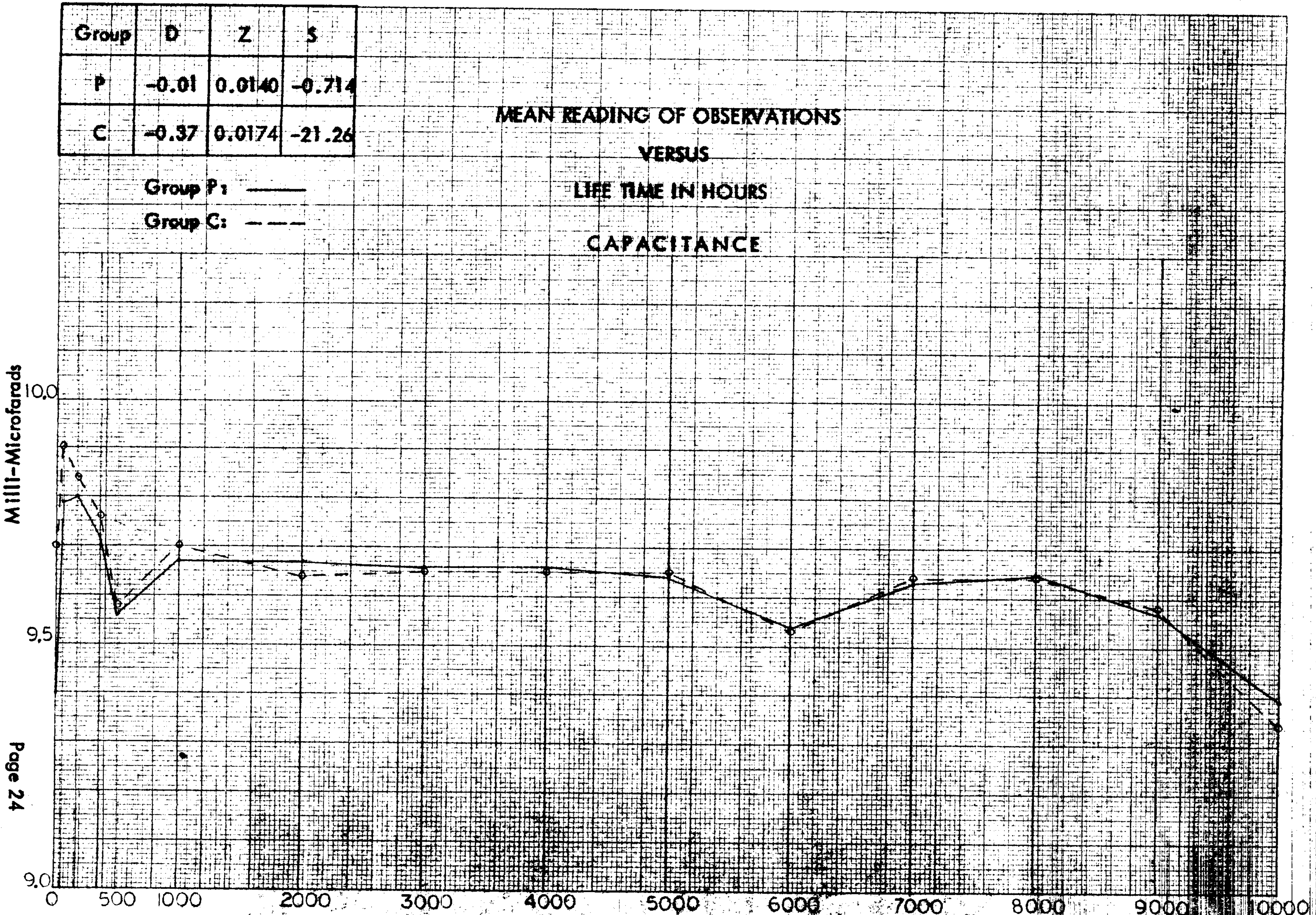
A. No catastrophic or parametric failures occurred during the 10,000-hour life test program.

B. There was a definite overall downward drift in all three parameters from initial to 10,000-hours with an accelerated decline in parametric value between 8000 and 10,000-hours.

C. Both groups reacted significantly to the first 50-hour temperature burst and again at the 500-hour point in the life test. For all parameters, stabilization did not seem to occur until the 1000-hour point had been reached. After this point, the parameter means for both groups tended to drift closer together and stabilize to the 5000-hour point.

D. There is evidence to support the conclusion that the instability of the parts was caused by one or a combination of two factors: (1) Physical characteristics of the components; or, (2) the repeated removal of the components from temperature and allowing them to return to room temperature for measurement. In effect, the parts may have been temperature cycled over the short time period between initial and 500-hours due to this factor.

E. There was a definite significant difference between Group P and Group C for Capacitance and DF, between initial and 10,000-hour measurements. While both groups drifted together in the same direction during life test, Group P returned to its initial value, while Group C ended significantly lower. This fact was due to the higher initial reading of Group C, indicating that post-screening measurements may be more indicative of parameter readings at 10,000-hours than pre-screening or non-screened initial measurements.




| Group | D | Z | S |
|---|---|---|---|
| P | −0.01 | 0.0140 | −0.714 |
| C | −0.37 | 0.0174 | −21.26 |

| Group | D | Z | S |
|---|---|---|---|
| P | -0.03 | 0.0024 | +12.50 |
| C | -0.06 | 0.0020 | -31.75 |

MEAN READING OF OBSERVATIONS

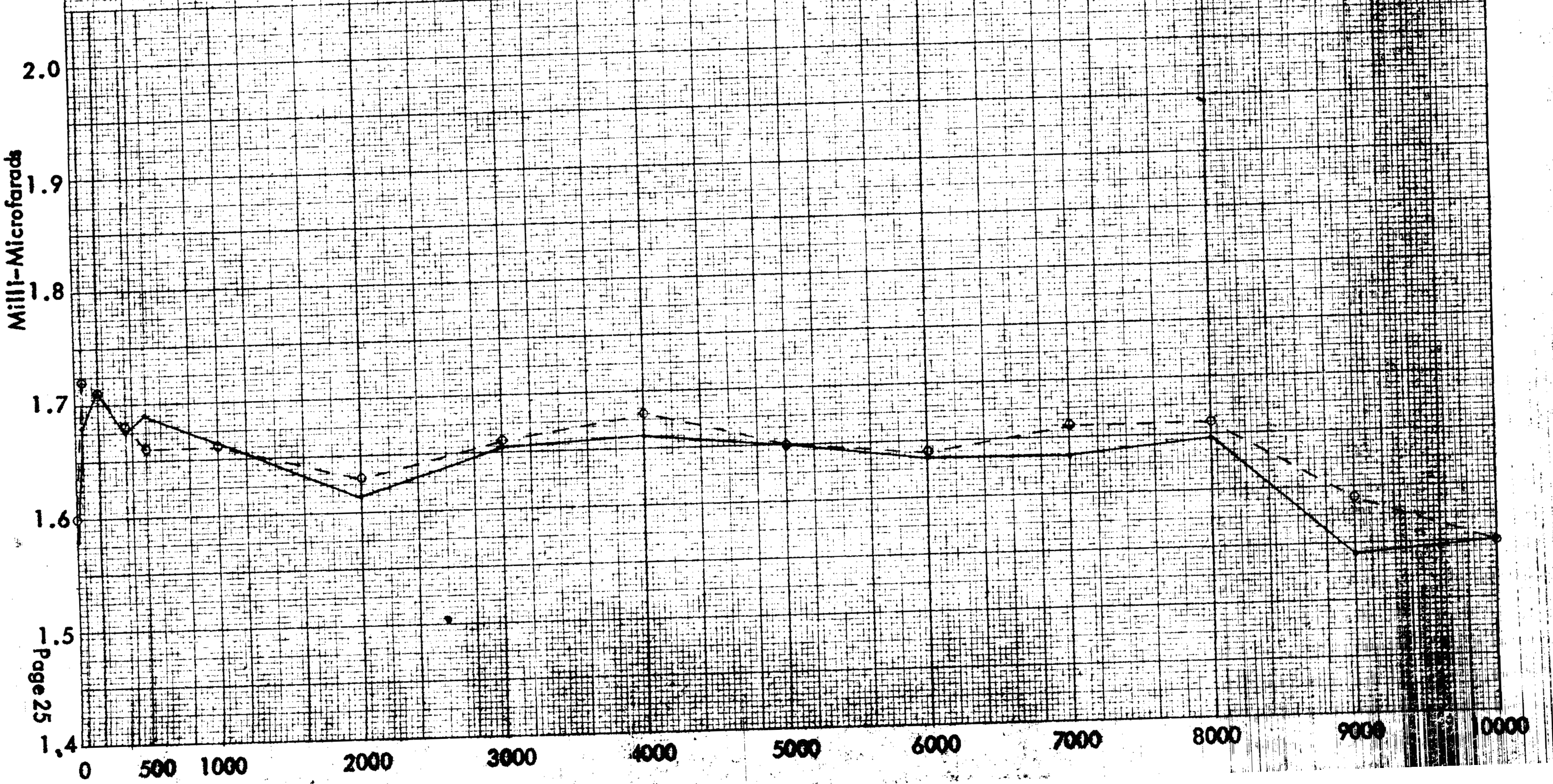
VERSUS

LIFE TIME IN HOURS

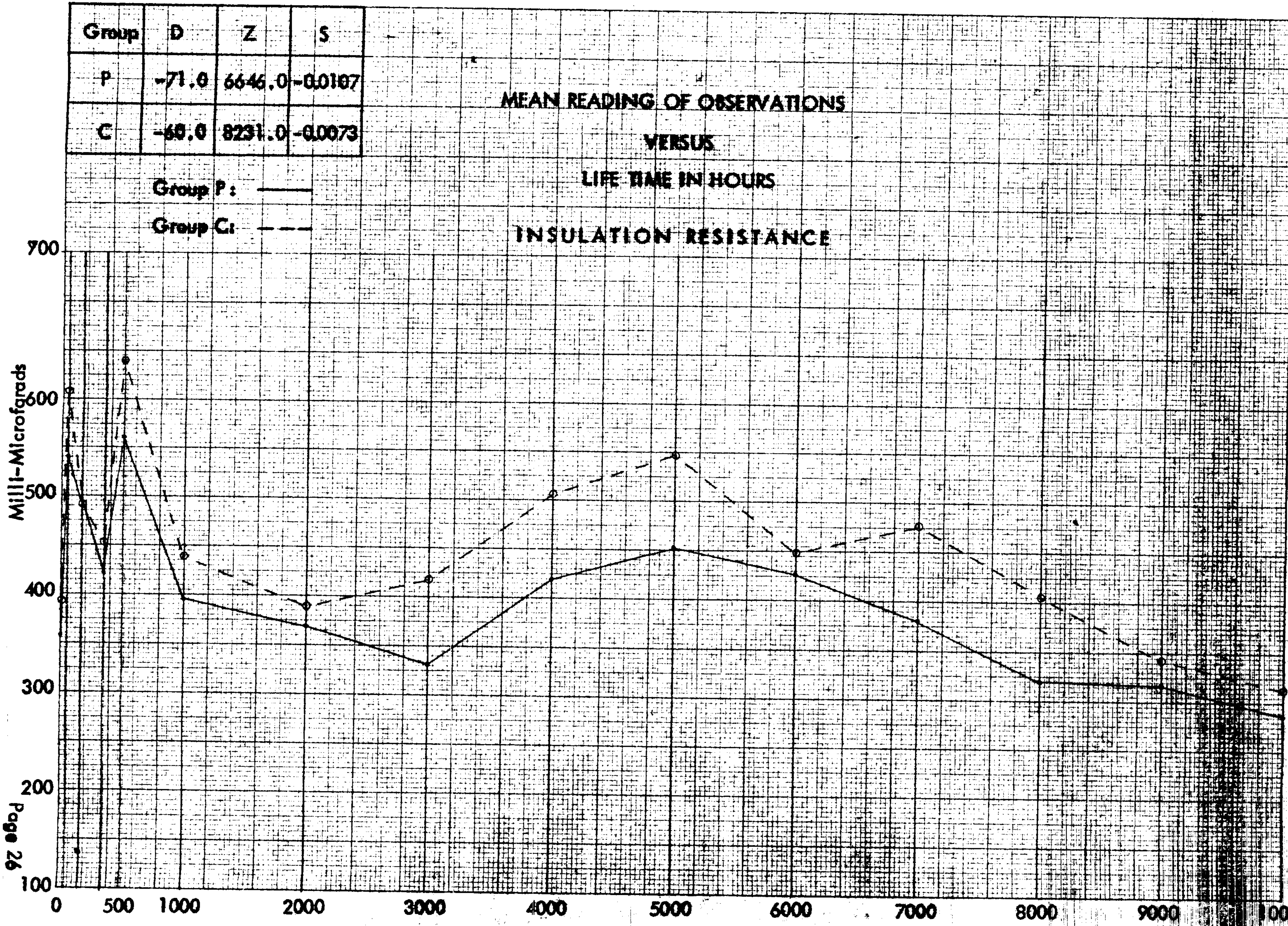
DISSIPATION FACTOR

Group P: ———

Group C: – – –



| Group | D | Z | S |
| --- | --- | --- | --- |
| P | -71.0 | 6646.0 | -0.0107 |
| C | -60.0 | 8231.0 | -0.0073 |



## GROUP COMPARISONS

### CAPACITANCE: NOMINAL VALUE 10.00 MILLIPICOFARADS

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| Initial | 9.40 | 9.71 | .164 | .186 | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 9.79 | 9.91 | .188 | .196 | 1.32 | 1.10 | .384 | .200 | .073 | .078 | +4.08 | +2.06 | +74.1 | +36.2 | + 24.3 | +.393 |
| 168 | 9.80 | 9.84 | .177 | .191 | .88 | .96 | .008 | -.069 | .074 | .069 | + .08 | + .70 | + 1.5 | -14.2 | + 10.8 | +.077 |
| 336 | 9.72 | 9.76 | .176 | .191 | .99 | .99 | - .079 | -.082 | .030 | .030 | - .80 | - .83 | -37.8 | -39.2 | + 1.01 | +.003 |
| 504 | 9.56 | 9.57 | .163 | .186 | .86 | .95 | - .154 | -.187 | .042 | .042 | -1.58 | -1.92 | -51.8 | -63.1 | + 8.12 | +.034 |
| 1008 | 9.68 | 9.71 | .178 | .192 | 1.19 | 1.07 | .119 | .139 | .041 | .041 | +1.24 | +1.45 | +40.9 | +47.4 | - 4.82 | -.020 |
| 2000 | 9.67 | 9.64 | .176 | .201 | .98 | 1.10 | - .015 | -.064 | .032 | .052 | - .15 | - .66 | - 6.6 | -17.3 | + 11.4 | +.049 |
| 3000 | 9.66 | 9.65 | .172 | .191 | .95 | .90 | - .006 | .007 | .026 | .049 | - .06 | + .07 | - 3.2 | ± 1.9 | - 31.6 | -.013 |
| 4000 | 9.66 | 9.65 | .176 | .186 | 1.05 | .94 | .001 | .000 | .033 | .030 | + .01 | + .00 | + .4 | + .00 | + .32 | +.001 |
| 5000 | 9.64 | 9.65 | .179 | .197 | 1.03 | 1.12 | - .018 | .005 | .020 | .034 | - .19 | + .05 | -13.2 | + 2.01 | - 8.30 | -.023 |
| 5000 to Initial | - | - | - | - | 1.19 | 1.12 | 2.41 | -.052 | .046 | .053 | +2.56 | - .55 | +73.86 | -13.8 | +158.45 | +.393 |

F: Significant at 0.005 level above 1.44, or below 0.694.

t: Significant at 0.005 level above 2.807.

## GROUP COMPARISONS

### CAPACITANCE: NOMINAL VALUE 10.00 MILLIPICOFARADS

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| 6000 | 9.54 | 9.53 | .171 | .184 | .91 | .87 | -.107 | -.118 | .030 | .028 | -1.11 | -1.22 | -50.5 | -60.2 | +3.91 | +.011 |
| 7000 | 9.63 | 9.63 | .177 | .189 | 1.07 | 1.06 | +.082 | +.104 | .028 | .044 | +.86 | +1.09 | +44.7 | +33.5 | -18.2 | -.021 |
| 8000 | 9.65 | 9.64 | .172 | .201 | .94 | 1.13 | +.020 | +.006 | .024 | .041 | +.21 | +.06 | +11.8 | +2.1 | +4.13 | +.014 |
| 9000 | 9.57 | 9.58 | .173 | .192 | 1.02 | .913 | -.073 | -.062 | .022 | .022 | -.75 | -.65 | -46.7 | -40.7 | -4.66 | -.010 |
| 10000 | 9.39 | 9.34 | .141 | .181 | .94 | .89 | -.180 | -.238 | .045 | .076 | -1.89 | -2.49 | -56.5 | -44.5 | +9.38 | +.059 |
| 10000 to Initial | - | - | - | - | 1.052 | .94 | -.011 | -.362 | .068 | .092 | -.11 | -3.74 | -2.2 | -55.9 | +43.6 | .352 |

F: Significant at 0.005 level above 1.44, or below 0.694.

t: Significant at 0.005 level above 2.807.

## GROUP COMPARISONS

### DISSIPATION FACTOR: NOMINAL VALUE - N/A - PERCENT

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| Initial | 15.8 | 16.1 | .484 | .645 | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 16.8 | 17.2 | .538 | .726 | 1.24 | 1.27 | 1.04 | +1.16 | .509 | .593 | +6.59 | +7.23 | +28.9 | +27.7 | -2.12 | -.012 |
| 168 | 17.1 | 17.1 | .580 | .658 | 1.16 | .82 | .24 | - .08 | .572 | .642 | +1.43 | - .46 | + 5.93 | - 1.76 | +5.26 | +.032 |
| 336 | 16.8 | 16.8 | .520 | .666 | .80 | 1.02 | - .31 | - .36 | .518 | .546 | -1.82 | -2.10 | - 8.57 | - 9.37 | + .94 | +.005 |
| 504 | 16.9 | 16.6 | .492 | .585 | .90 | .77 | .13 | - .21 | .497 | .549 | + .78 | -1.25 | + 3.86 | - 5.38 | +6.69 | +.035 |
| 1008 | 16.6 | 16.6 | .453 | .558 | .85 | .91 | - .24 | - .00 | .487 | .478 | -1.43 | - .05 | - 7.03 | - .24 | -4.85 | -.331 |
| 2000 | 16.1 | 16.3 | .489 | .620 | 1.16 | 1.23 | - .53 | - .25 | .448 | .517 | -3.18 | -1.51 | -16.7 | - 6.84 | -5.77 | -.028 |
| 3000 | 16.5 | 16.6 | .490 | .527 | 1.01 | .72 | .40 | + .31 | .447 | .454 | +2.47 | +1.91 | +12.6 | + 9.68 | +1.95 | +.009 |
| 4000 | 16.6 | 16.8 | .524 | .536 | 1.14 | 1.03 | .06 | + .20 | .400 | .374 | + .37 | +1.19 | + 2.15 | + 7.45 | -3.52 | -.014 |
| 5000 | 16.5 | 16.5 | .484 | .563 | .85 | 1.10 | .11 | - .28 | .376 | .435 | - .66 | -1.64 | - 4.11 | - 8.94 | +4.07 | +.017 |
| 5000 to Initial | - | - | - | - | 1.00 | .761 | .07 | + .49 | .430 | .473 | +4.50 | +3.06 | +23.3 | +14.7 | +4.82 | +.022 |

F: Significant at 0.005 level above 1.44 or below 0.694.

t: Significant at 0.005 level above 2.807.

## GROUP COMPARISONS

### DISSIPATION FACTOR: NOMINAL VALUE - N/A - PERCENT

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| 6000 | 16.3 | 16.4 | .478 | .521 | .98 | .86 | -.14 | -.14 | .358 | .390 | -.88 | -.86 | -5.72 | -5.15 | +.080 | -.000 |
| 7000 | 16.3 | 16.6 | .483 | .508 | 1.02 | .95 | +.01 | +.23 | .406 | .381 | +.05 | +1.43 | +.26 | +8.75 | -5.78 | -.023 |
| 8000 | 16.5 | 16.6 | .449 | .567 | .87 | 1.24 | +.12 | -.07 | .365 | .379 | +.76 | -.43 | +4.80 | -2.69 | +5.27 | +.020 |
| 9000 | 15.4 | 15.9 | .462 | .546 | 1.06 | .93 | -1.07 | -.07 | .343 | .379 | -6.52 | -.42 | -44.29 | -2.61 | -27.8 | -.100 |
| 10000 | 15.5 | 15.5 | .502 | .548 | 1.18 | 1.01 | +.11 | -.39 | .412 | .454 | +.688 | -2.46 | +3.64 | -12.15 | +11.4 | +.050 |
| 10000 to Initial | - | - | - | - | 1.07 | .72 | -.28 | -.58 | .491 | .574 | -1.787 | -3.63 | -8.12 | -14.34 | +5.63 | +.030 |

F: Significant at 0.005 level above 1.44 or below 0.694 .

t: Significant at 0.005 level above 2.807 .

## GROUP COMPARISONS

### INSULATION RESISTANCE: NOMINAL VALUE - N/A, LOWER LIMIT 100 K MEGOHMS

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| Initial | 357 | 393 | 91 | 97 | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 539 | 608 | 194 | 216 | 4.54 | 4.93 | +182 | +215 | 213 | 241 | +51 | +54 | +12.1 | +12.6 | -1.44 | -32.8 |
| 168 | 495 | 491 | 119 | 136 | .38 | .40 | - 44 | -117 | 230 | 245 | - 8 | -19 | - 2.72 | - 6.76 | +3.08 | +73.1 |
| 336 | 422 | 452 | 128 | 128 | 1.16 | .88 | - 73 | - 38 | 170 | 183 | -15 | - 8 | - 6.08 | - 2.95 | -1.96 | -34.7 |
| 504 | 562 | 639 | 243 | 248 | 3.60 | 3.77 | +140 | +186 | 256 | 284 | +33 | +41 | + 7.75 | + 9.27 | -5.41 | -46.2 |
| 1008 | 396 | 438 | 86 | 130 | .13 | .27 | -166 | -200 | 306 | 344 | -30 | -31 | - 7.67 | - 8.24 | +1.06 | +34.5 |
| 2000 | 369 | 388 | 109 | 100 | 1.59 | .60 | - 29 | - 50 | 136 | 159 | - 7 | -11 | - 3.05 | - 4.39 | +1.36 | +20.2 |
| 3000 | 331 | 417 | 94 | 116 | .74 | 1.34 | - 38 | + 27 | 139 | 145 | -10 | + 7 | - 3.89 | + 2.59 | -4.56 | -64.8 |
| 4000 | 420 | 506 | 142 | 153 | 2.31 | 1.72 | + 88 | + 90 | 162 | 182 | +27 | +22 | + 7.71 | + 6.98 | + .078 | - 1.35 |
| 5000 | 453 | 547 | 135 | 159 | .90 | 1.09 | + 37 | + 41 | 182 | 216 | + 9 | + 8 | + 2.85 | + 2.69 | - .225 | - 4.50 |
| 5000 to Initial | - | - | - | - | 2.20 | 2.70 | + 96 | +154 | 155 | 174 | +27 | +39 | + 8.73 | +12.53 | +3.57 | -58.8 |

F: Significant at 0.005 level above 1.44 or below 0.694 .

t: Significant at 0.005 level above 2.807 .

# GROUP COMPARISONS

## INSULATION RESISTANCE: NOMINAL VALUE - N/A, LOWER LIMIT 100 K MEGOHMS

| | Mean | | Std | | F | | Mean D | | Std D | | PC | | t | | $t_{PC}$ | $\Delta_{PC}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | C | P | C | P | C | P | C | P | C | P | C | P | C | | |
| 6000 | 427 | 448 | 148 | 131 | 1.20 | .67 | -25 | -99 | 202 | 207 | -6 | -18 | -1.78 | -6.79 | +3.61 | +74.0 |
| 7000 | 381 | 477 | 115 | 178 | .60 | 1.86 | -45 | +31 | 189 | 206 | -11 | +7 | -3.38 | +2.11 | -3.84 | -76.0 |
| 8000 | 320 | 406 | 76 | 109 | .43 | .37 | -59 | -72 | 154 | 215 | -16 | -15 | -5.45 | -4.76 | +.698 | +12.9 |
| 9000 | 316 | 343 | 77 | 90 | 1.03 | .68 | -3 | -60 | 135 | 149 | -1 | -15 | -0.30 | -5.70 | +4.01 | +56.9 |
| 10000 | 286 | 313 | 77 | 78 | 1.01 | .76 | -32 | -30 | 107 | 121 | -10 | -9 | -4.27 | -3.57 | -.171 | -1.95 |
| 10000 to Initial | - | - | - | - | .71 | .65 | -72 | -80 | 114 | 121 | -20 | -20 | -8.90 | -9.34 | +.832 | +8.25 |

F: Significant at 0.005 level above 1.44 or below 0.694 .

t: Significant at 0.005 level above 2.807 .

# APPENDIX I

## COMPUTED STATISTICS AND t-COMPARISON SHEETS

t-Comparison Table

Manufacturer: Vitramon Type Number: CK06CW103K

10,000 Hours of Life Test

| Parameter | Δ | t |
|---|---|---|
| Capacitance | .0585 | 9.385*** |
| Dissipation Factor | .0496 | 11.423*** |
| Insulation Resistance | -1.95 | -0.1706 |

*** indicates significance at .005 level

** indicates significance at .01 level

* indicates significance at .05 level

t–Comparison Table

Manufacturer: Vitramon                                        Type Number: CK06CW103K

**10,000 to 0 Hour Life Test**

| Parameter | Δ | t |
|---|---|---|
| Capacitance | .3518 | 43.60*** |
| Dissipation Factor | .0300 | 5.627*** |
| Insulation Resistance | 8.25 | .8316 |

*** indicates significance at .005 level
** indicates significance at .01 level
* indicates significance at .05 level

LIFE TEST COMPUTED STATISTIC SHEETS

Page 1 of 12
JPL T [illegible]
Uni milli-microfarads

Test Code: 2
Vendor: Vitramon
Nominal Value 10

Component Code 001
Part No. CK06CW103K
Lower Limit 9

Parameter 1 Group P
Parameter CAP
Upper Limit 11

| Min | Mean | Max | Std | F | MinD | MeanD | MaxD | StdD | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Initial Measurement | | | | | | | | | | |
| 9.135 | 9.404 | 9.900 | .16403 | 00.00 | 00.00 | 00.00 | 00.00 | 00.000 | 000.00 | 00.00 | 200 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | 50 Hour Life | | | | | | | | | | |
| 9.344 | 9.788 | 10.40 | .18847 | 1.320 | .170 | .384 | .551 | .07332 | +4.08 | 74.07 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 168 Hour Life | | | | | | | | | | |
| 9.516 | 9.796 | 10.33 | .17700 | .882 | -.092 | .008 | .236 | .07398 | + .08 | 1.53 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 336 Hour Life | | | | | | | | | | |
| 9.412 | 9.718 | 10.29 | .17604 | .989 | -.248 | -.079 | .005 | .02957 | - .80 | -37.78 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 504 Hour Life | | | | | | | | | | |
| 9.306 | 9.564 | 10.13 | .16306 | .858 | -.236 | -.154 | .096 | .04185 | -1.58 | -51.82 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 1003 Hour Life | | | | | | | | | | |
| 9.392 | 9.683 | 10.23 | .17779 | 1.189 | -.077 | .119 | .312 | .04110 | 1.24 | 40.87 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 2000 Hour Life | | | | | | | | | | |
| 9.382 | 9.667 | 10.19 | .17587 | .979 | -.205 | -.015 | .142 | .03190 | -.15 | -6.63 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 3000 Hour Life | | | | | | | | | | |
| 9.370 | 9.661 | 10.19 | .17176 | .954 | -.064 | -.006 | .142 | .02624 | -.06 | -3.23 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 4000 Hour Life | | | | | | | | | | |
| 9.340 | 9.662 | 10.21 | .17650 | 1.056 | -.228 | .001 | .082 | .03316 | +.01 | .42 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 5000 Hour Life | | | | | | | | | | |
| 9.331 | 9.644 | 10.19 | .17919 | 1.031 | -.067 | -.018 | .065 | .01991 | -.192 | -13.15 | 200 | 200 | 0 | 0 | 0 | 0 |

# LIFE TEST COMPUTED STATISTIC SHEETS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Page | 2 of 12 | Test Code | 2 | Component Code | 001 | Parameter | 1 Group P |
| JPL Test No. | 019 | Vendor | Vitramon | Part No. | CK06CW103K | Parameter | CAP |
| Unit | milli-microfarads | Nominal Value | 10 | Lower Limit | 9 | Upper Limit | 11 |

| Min | Mean | Max | Std | F | Min D | Mean D | Max D | Std D | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 5000 to Initial | | | | | | | | | | |
| - | - | - | - | 1.193 | .135 | .241 | .577 | .0461 | +2.56 | 73.86 | - | - | - | - | - | - |
| | | | | | | 6000 Hour Life | | | | | | | | | | |
| 9.272 | 9.536 | 10.11 | .17105 | .911 | -.177 | -.107 | .123 | .02996 | -1.11 | -50.46 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 7000 Hour Life | | | | | | | | | | |
| 9.320 | 9.627 | 10.15 | .17700 | 1.071 | -.131 | .082 | .162 | .02839 | .86 | 44.75 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 8000 Hour Life | | | | | | | | | | |
| 9.351 | 9.646 | 10.17 | .17167 | .941 | -.085 | .020 | .152 | .02391 | .21 | 11.77 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 9000 Hour Life | | | | | | | | | | |
| 9.273 | 9.573 | 10.09 | .17343 | 1.021 | -.118 | -.073 | .048 | .02198 | -.75 | -46.71 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 10,000 Hour Life | | | | | | | | | | |
| 9.084 | 9.393 | 9.938 | .14150 | .941 | -.288 | -.180 | -.081 | .04500 | -1.89 | -56.50 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | Final Line - 10,000 to Initial | | | | | | | | | | |
| - | - | - | - | 1.052 | -.109 | -.011 | .385 | .06800 | -.11 | -2.24 | - | - | - | - | - | - |

## LIFE TEST COMPUTED STATISTIC SHEETS


JPL Test No. 019
Unit Percent

Test Code: 2
Vendor: Vitramon
Nominal Value N/A

Component Code 001
Part No. CK06CW103K
Lower Limit N/A

Parameter 2 Group P
Parameter DF
Upper Limit 2.5

| Min | Mean | Max | Std | F | MinD | MeanD | MaxD | StdD | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Initial Measurement (x.1) | | | | | | | | | | |
| 14.50 | 15.78 | 17.00 | .48455 | 00.00 | 00.00 | 00.00 | 00.00 | 00.000 | 000.00 | 00.00 | 200 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | 50 Hour Life (x.1) | | | | | | | | | | |
| 15.00 | 16.82 | 18.60 | .53848 | 1.235 | -.40 | 1.04 | 2.80 | .50881 | +6.59 | 28.91 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 168 Hour Life (x.1) | | | | | | | | | | |
| 15.60 | 17.06 | 18.70 | .58026 | 1.161 | -1.40 | .24 | 1.80 | .57205 | +1.43 | 5.93 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 336 Hour Life (x.1) | | | | | | | | | | |
| 15.20 | 16.75 | 18.50 | .52003 | .803 | -1.90 | -.31 | 1.30 | .51760 | -1.82 | -8.57 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 504 Hour Life (x.1) | | | | | | | | | | |
| 15.80 | 16.88 | 18.90 | .49239 | .897 | -1.20 | .13 | 1.40 | .49661 | .78 | 3.86 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 1008 Hour Life (x.1) | | | | | | | | | | |
| 15.30 | 16.64 | 18.30 | .45311 | .847 | -2.70 | -.24 | 1.10 | .48664 | -1.43 | -7.03 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 2000 Hour Life (x.1) | | | | | | | | | | |
| 14.80 | 16.14 | 17.60 | .48881 | 1.164 | -1.60 | -.53 | .70 | .44818 | -3.18 | -16.69 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 3000 Hour Life (x.1) | | | | | | | | | | |
| 15.00 | 16.54 | 18.00 | .49053 | 1.007 | -.80 | .40 | 1.70 | .44676 | +2.47 | 12.63 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 4000 Hour Life (x.1) | | | | | | | | | | |
| 15.00 | 16.60 | 18.20 | .52390 | 1.141 | -1.10 | .06 | .90 | .39985 | +.37 | +2.15 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 5000 Hour Life (x.1) | | | | | | | | | | |
| 15.00 | 16.49 | 18.20 | .48374 | 0.853 | -1.10 | .11 | 1.10 | .37639 | -.66 | -4.11 | 200 | 200 | 0 | 0 | 0 | 0 |

LIFE TEST COMPUTED STATISTIC SHEETS

Page 4 of 12 | Test Code 2 | Component Code 001 | Parameter 2 Group P
JPL Test No. 019 | Vendor Vitramon | Part No. CK06CW103K | Parameter DF
Unit Percent | Nominal Value N/A | Lower Limit N/A | Upper Limit 2.5

| Min | Mean | Max | Std | F | Min D | Mean D | Max D | Std D | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5000 to Initial | | | | | | | | | | | | | | | | |
| - | - | - | - | 0.997 | -.04 | .07 | .20 | .4302 | 4.50 | 23.3 | - | - | - | - | - | - |
| 6000 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.00 | 16.35 | 18.30 | .47784 | 0.976 | -1.10 | -.14 | 0.80 | .3583 | -.88 | -5.72 | 200 | 200 | 0 | 0 | 0 | 0 |
| 7000 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.00 | 16.34 | 18.00 | .48269 | 1.020 | -1.20 | .01 | 1.00 | .4059 | .05 | .26 | 200 | 200 | 0 | 0 | 0 | 0 |
| 8000 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.20 | 16.46 | 18.00 | .44910 | .866 | -1.00 | .12 | 1.10 | .3650 | .76 | 4.80 | 200 | 200 | 0 | 0 | 0 | 0 |
| 9000 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 14.10 | 15.40 | 16.90 | .46220 | 1.059 | -2.00 | -1.07 | 0.00 | .3429 | -6.52 | -44.29 | 200 | 200 | 0 | 0 | 0 | 0 |
| 10,000 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 14.30 | 15.51 | 17.20 | .50200 | 1.180 | -1.00 | .11 | 1.10 | .4120 | .688 | 3.64 | 200 | 200 | 0 | 0 | 0 | 0 |
| Final Line - 10,000 to Initial | | | | | | | | | | | | | | | | |
| - | - | - | - | 1.071 | -1.70 | -.28 | 1.00 | .4910 | -1.787 | -8.12 | - | - | - | - | - | - |

LIFE TEST COMPUTED STATISTIC SHEETS


JPL Test No. 019
Unit K Megohms

Test Code: 2
Vendor: Vitramon
Nominal Value N/A

Component Code 001
Part No. CK06CW103K
Lower Limit 100

Parameter 3 Group P
Parameter IR
Upper Limit N/A

| Min | Mean | Max | Std | F | MinD | MeanD | MaxD | StdD | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Initial Measurement | | | | | | | | | | |
| 200.0 | 357.5 | 600.0 | 91.024 | 00.00 | 00.00 | 00.00 | 00.00 | 00.000 | 000.00 | 00.00 | 200 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | 50 Hour Life | | | | | | | | | | |
| 200.0 | 539.4 | 1000. | 193.99 | 4.542 | -300. | 181.9 | 800.0 | 213.27 | +50.88 | 12.06 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 168 Hour Life | | | | | | | | | | |
| 250.0 | 495.3 | 900.0 | 118.79 | .375 | -700. | -44.1 | 500.0 | 229.55 | -8.18 | -2.72 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 336 Hour Life | | | | | | | | | | |
| 200.0 | 422.3 | 1000. | 128.06 | 1.162 | -550. | -73.0 | 550.0 | 169.82 | -14.74 | -6.08 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 504 Hour Life | | | | | | | | | | |
| 200.0 | 562.3 | 1000. | 242.91 | 3.598 | -400.0 | 140.0 | 800.0 | 255.54 | 33.15 | 7.75 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 1008 Hour Life | | | | | | | | | | |
| 200.0 | 396.3 | 800. | 86.38 | .126 | -800.0 | -166.0 | 500.0 | 306.09 | -29.52 | -7.67 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 2000 Hour Life | | | | | | | | | | |
| 180.0 | 369.4 | 800. | 109.04 | 1.594 | -400.0 | -29.4 | 400.0 | 136.26 | -7.41 | -3.05 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 3000 Hour Life | | | | | | | | | | |
| 200.0 | 331.3 | 600. | 93.567 | .736 | -500.0 | -38.2 | 300.0 | 138.85 | -10.33 | -3.89 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 4000 Hour Life | | | | | | | | | | |
| 200.0 | 419.5 | 1000. | 142.11 | 2.307 | -300.0 | 88.3 | 700.0 | 161.96 | +26.64 | +7.71 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 5000 Hour Life | | | | | | | | | | |
| 250.0 | 452.8 | 1000. | 135.17 | .905 | -500.0 | 36.8 | 600.0 | 182.08 | +8.76 | +2.85 | 200 | 200 | 0 | 0 | 0 | 0 |

LIFE TEST COMPUTED STATISTIC SHEETS

| | | | |
|---|---|---|---|
| Page 6 of 12 | Test Code 2 | Component Code 001 | Parameter 3 Group P |
| JPL Test No. 019 | Vendor Vitramon | Part No. CK06CW103K | Parameter IR |
| Unit K Megohms | Nominal Value N/A | Lower Limit 100 | Upper Limit N/A |

| Min | Mean | Max | Std | F | Min D | Mean D | Max D | Std D | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 5000 to Initial | | | | | | | | | | |
| - | - | - | - | 2.205 | -250.0 | 95.5 | 650.0 | 154.76 | +26.71 | +8.73 | - | - | - | - | - | - |
| | | | | | | 6000 Hour Life | | | | | | | | | | |
| 200.0 | 427.2 | 1000. | 148.09 | 1.200 | -700.0 | -25.5 | 700.0 | 202.13 | -5.63 | -1.78 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 7000 Hour Life | | | | | | | | | | |
| 170.0 | 381.5 | 900. | 114.53 | .598 | -810.0 | -45.3 | 500.0 | 189.48 | -10.59 | -3.38 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 8000 Hour Life | | | | | | | | | | |
| 180.0 | 320.2 | 800. | 75.53 | .435 | -650.0 | -59.4 | 450.0 | 154.08 | -15.60 | -5.45 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 9000 Hour Life | | | | | | | | | | |
| 160.0 | 316.8 | 600. | 76.72 | 1.032 | -600.0 | -2.90 | 410.0 | 134.76 | -0.91 | -0.30 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 10,000 Hour Life | | | | | | | | | | |
| 150.0 | 285.9 | 500. | 77.00 | 1.01 | -400.0 | -32.4 | 250.0 | 107.40 | -10.23 | -4.27 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | Final Line - 10,000 to Initial | | | | | | | | | | |
| - | - | - | - | .715 | -350.0 | -71.65 | 200.0 | 113.9 | -20.04 | -8.90 | - | - | - | - | - | - |

LIFE TEST COMPUTED STATISTIC SHEETS

Page 7 of 12
JPL Test No. 019
Unit milli-microfarads

Test Code: 2
Vendor: Vitramon
Nominal Value 10

Component Code 001
Part No. CK06CW103K
Lower Limit 9

Parameter 1 Group C
Parameter CAP
Upper Limit 11

| Min | Mean | Max | Std | F | MinD | MeanD | MaxD | StdD | PC | t | No | Ny | Nu | Nl | Ne | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Measurement | | | | | | | | | | | | | | | | |
| 9.419 | 9.706 | 10.30 | .18641 | 00.00 | 00.00 | 00.00 | 00.00 | 00.000 | 000.00 | 00.00 | 200 | 0 | 0 | 0 | 0 | 0 |
| 50 Hour Life | | | | | | | | | | | | | | | | |
| 9.471 | 9.906 | 10.48 | .19578 | 1.103 | -.080 | .200 | .423 | .07820 | +2.06 | 36.17 | 200 | 200 | 0 | 0 | 0 | 0 |
| 168 Hour Life | | | | | | | | | | | | | | | | |
| 9.505 | 9.837 | 10.43 | .19138 | .955 | -.161 | -.069 | .268 | .06891 | +.70 | -14.16 | 200 | 200 | 0 | 0 | 0 | 0 |
| 336 Hour Life | | | | | | | | | | | | | | | | |
| 9.453 | 9.755 | 10.39 | .19073 | .991 | -.219 | -.082 | -.006 | .02962 | -.83 | -39.23 | 200 | 200 | 0 | 0 | 0 | 0 |
| 504 Hour Life | | | | | | | | | | | | | | | | |
| 9.241 | 9.568 | 10.12 | .18570 | .949 | -.322 | -.187 | -.083 | .04186 | -1.92 | -63.06 | 200 | 200 | 0 | 0 | 0 | 0 |
| 1008 Hour Life | | | | | | | | | | | | | | | | |
| 9.394 | 9.706 | 10.30 | .19178 | 1.067 | .043 | -.139 | .259 | .04132 | 1.45 | 47.45 | 200 | 200 | 0 | 0 | 0 | 0 |
| 2000 Hour Life | | | | | | | | | | | | | | | | |
| 9.291 | 9.642 | 10.23 | .20116 | 1.100 | -.163 | -.064 | .052 | .05255 | -.66 | -17.32 | 200 | 200 | 0 | 0 | 0 | 0 |
| 3000 Hour Life | | | | | | | | | | | | | | | | |
| 9.320 | 9.648 | 10.26 | .19127 | .904 | -.108 | .007 | .142 | .04944 | +.07 | 1.86 | 200 | 200 | 0 | 0 | 0 | 0 |
| 4000 Hour Life | | | | | | | | | | | | | | | | |
| 9.302 | 9.648 | 10.22 | .18594 | .945 | -.080 | .000 | .117 | .02966 | .00 | .00 | 200 | 200 | 0 | 0 | 0 | 0 |
| 5000 Hour Life | | | | | | | | | | | | | | | | |
| 9.346 | 9.653 | 10.24 | .1968 | 1.121 | -.066 | .005 | .155 | .03459 | +.05 | 2.01 | 200 | 200 | 0 | 0 | 0 | 0 |

## LIFE TEST COMPUTED STATISTIC SHEETS

| | | | |
|---|---|---|---|
| Page 8 of 12 | Test Code 2 | Component Code 001 | Parameter 1 Group C |
| JPL Test No. 019 | Vendor Vitramon | Part No. CK06CW103K | Parameter CAP |
| Unit milli-microfarads | Nominal Value 10 | Lower Limit 9 | Upper Limit 11 |

| Min | Mean | Max | Std | F | Min D | Mean D | Max D | Std D | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 5000 to Initial | | | | | | | | | | |
| - | - | - | - | 1.115 | -.220 | -.052 | .162 | .0532 | -.55 | -13.80 | - | - | - | - | - | - |
| | | | | | | 6000 Hour Life | | | | | | | | | | |
| 9.226 | 9.534 | 10.10 | .1836 | .870 | -.240 | -.118 | -.036 | .02786 | -1.22 | -60.16 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 7000 Hour Life | | | | | | | | | | |
| 9.322 | 9.635 | 10.20 | .1892 | 1.061 | -.414 | .104 | .252 | .04383 | 1.088 | 33.46 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 8000 Hour Life | | | | | | | | | | |
| 9.337 | 9.644 | 10.22 | .2011 | 1.130 | -.067 | .006 | .482 | .04090 | .063 | 2.11 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 9000 Hour Life | | | | | | | | | | |
| 9.263 | 9.581 | 10.14 | .1922 | .913 | -.119 | -.062 | .018 | .02169 | -.647 | -40.68 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 10,000 Hour Life | | | | | | | | | | |
| 9.030 | 9.343 | 9.89 | .1810 | .886 | -.891 | -.238 | -.106 | .07580 | -2.49 | -44.46 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | Final Line - 10,000 to Initial | | | | | | | | | | |
| - | - | - | - | .941 | -1.06 | -.362 | .001 | .09180 | -3.736 | -55.86 | - | - | - | - | - | - |

# LIFE TEST COMPUTED STATISTIC SHEETS

Page 9 of 12
JPL Test No. 019
Unit Percent

Test Code: 2
Vendor: Vitramon
Nominal Value N/A

Component Code 001
Part No. CK06CW103K
Lower Limit N/A

Parameter 2 Group C
Parameter DF
Upper Limit 2.5

| Min | Mean | Max | Std | F | MinD | MeanD | MaxD | StdD | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Measurement (x.1) | | | | | | | | | | | | | | | | |
| 14.90 | 16.05 | 18.40 | .64520 | 00.00 | 00.00 | 00.00 | 00.00 | 00.000 | 000.00 | 00.00 | 200 | 0 | 0 | 0 | 0 | 0 |
| 50 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.40 | 17.21 | 19.50 | .72587 | 1.266 | -.40 | 1.16 | 2.80 | .59315 | +7.23 | 27.66 | 200 | 200 | 0 | 0 | 0 | 0 |
| 168 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.00 | 17.13 | 18.70 | .65819 | .822 | -2.00 | -.08 | 1.60 | .64221 | -.46 | -1.76 | 200 | 200 | 0 | 0 | 0 | 0 |
| 336 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.10 | 16.77 | 18.60 | .66606 | 1.024 | -1.80 | -.36 | 1.90 | .54630 | -2.10 | -9.37 | 200 | 200 | 0 | 0 | 0 | 0 |
| 504 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.50 | 16.56 | 18.50 | .58536 | .772 | -1.50 | -.21 | 1.40 | .54893 | -1.25 | -5.38 | 200 | 200 | 0 | 0 | 0 | 0 |
| 1008 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.50 | 16.56 | 18.00 | .55842 | .910 | -1.40 | -.00 | 1.50 | .47791 | -.05 | -.24 | 200 | 200 | 0 | 0 | 0 | 0 |
| 2000 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 14.90 | 16.30 | 18.00 | .62026 | 1.234 | -1.20 | -.25 | 1.60 | .51666 | -1.51 | -6.84 | 200 | 200 | 0 | 0 | 0 | 0 |
| 3000 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.50 | 16.60 | 18.50 | .52714 | .722 | -.80 | .31 | 1.50 | .45433 | +1.91 | 9.68 | 200 | 200 | 0 | 0 | 0 | 0 |
| 4000 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.40 | 16.80 | 18.40 | .53604 | 1.034 | -1.10 | .20 | 1.10 | .37388 | +1.19 | 7.45 | 200 | 200 | 0 | 0 | 0 | 0 |
| 5000 Hour Life (x.1) | | | | | | | | | | | | | | | | |
| 15.10 | 16.52 | 18.10 | .56272 | 1.102 | -1.60 | -.28 | .70 | .43523 | -1.64 | -8.94 | 200 | 200 | 0 | 0 | 0 | 0 |

LIFE TEST COMPUTED STATISTIC SHEETS

Page 10 of 12 — Test Code 2 — Component Code 001 — Parameter 2 Group C

JPL Test No. 019 — Vendor Vitramon — Part No. CK06CW103K — Parameter DF

Unit Percent — Nominal Value N/A — Lower Limit N/A — Upper Limit 2.5

| Min | Mean | Max | Std | F | Min D | Mean D | Max D | Std D | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 5000 to Initial | | | | | | | | | | |
| - | - | - | - | .761 | -1.10 | .49 | 1.90 | .47324 | +3.06 | 14.72 | - | - | - | - | - | - |
| | | | | | | 6000 Hour Life (x.1) | | | | | | | | | | |
| 15.00 | 16.39 | 17.90 | .52088 | .857 | -1.10 | -.14 | .90 | .38960 | -.86 | -5.15 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 7000 Hour Life (x.1) | | | | | | | | | | |
| 15.30 | 16.62 | 18.40 | .50822 | .952 | -.90 | .23 | 1.30 | .38067 | 1.43 | 8.75 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 8000 Hour Life (x.1) | | | | | | | | | | |
| 15.20 | 16.55 | 18.50 | .56710 | 1.245 | -1.60 | -.07 | .90 | .37876 | -.43 | -2.69 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 9000 Hour Life (x.1) | | | | | | | | | | |
| 14.70 | 15.86 | 17.50 | .54610 | .927 | -1.80 | -.07 | .20 | .37890 | -.42 | -2.61 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 10,000 Hour Life (x.1) | | | | | | | | | | |
| 14.30 | 15.47 | 16.70 | .54800 | 1.010 | -1.30 | -.39 | 1.10 | .45400 | -2.46 | -12.15 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | Final Line - 10,000 to Initial | | | | | | | | | | |
| - | - | - | - | .721 | -2.30 | -.58 | .90 | .57400 | -3.63 | -14.34 | - | - | - | - | - | - |

LIFE TEST COMPUTED STATISTIC SHEETS

Page 11 of 12
JPL Test No. 019
Unit K Megohms

Test Code: 2
Vendor: Vitramon
Nominal Value N/A

Component Code 001
Part No. CK06CW103K
Lower Limit 100

Parameter 3 Group C
Parameter IR
Upper Limit N/A

| Min | Mean | Max | Std | F | MinD | MeanD | MaxD | StdD | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Initial Measurement | | | | | | | | | | |
| 200.0 | 393.3 | 900.0 | 97.026 | 00.00 | 00.00 | 00.00 | 00.00 | 00.000 | 000.00 | 00.00 | 200 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | 50 Hour Life | | | | | | | | | | |
| 250.0 | 608.0 | 1000. | 215.51 | 4.933 | -400. | 214.7 | 700. | 241.43 | +54.59 | 12.58 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 168 Hour Life | | | | | | | | | | |
| 250.0 | 490.8 | 900.0 | 135.90 | .398 | -700. | -117.2 | 650.0 | 245.13 | -19.28 | -6.76 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 336 Hour Life | | | | | | | | | | |
| 200.0 | 452.5 | 900.0 | 127.67 | .883 | -550. | -38.3 | 450.0 | 183.35 | -7.80 | -2.95 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 504 Hour Life | | | | | | | | | | |
| 250.0 | 638.8 | 1000. | 247.83 | 3.768 | -550. | 186.3 | 800.0 | 284.04 | 41.17 | 9.27 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 1008 Hour Life | | | | | | | | | | |
| 200.0 | 438.3 | 1000. | 129.55 | .273 | -750. | -200.5 | 500.0 | 344.04 | -31.39 | -8.24 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 2000 Hour Life | | | | | | | | | | |
| 200.0 | 388.5 | 700. | 100.47 | .601 | -750. | -49.5 | 350.0 | 159.54 | -11.30 | -4.39 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 3000 Hour Life | | | | | | | | | | |
| 180.0 | 416.7 | 800. | 116.38 | 1.342 | -450. | 26.7 | 450.0 | 145.41 | +6.86 | 2.59 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 4000 Hour Life | | | | | | | | | | |
| 200.0 | 506.3 | 1000. | 152.69 | 1.721 | -400. | 89.6 | 650.0 | 182.00 | 21.50 | 6.98 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 5000 Hour Life | | | | | | | | | | |
| 250.0 | 547.5 | 1000. | 159.44 | 1.090 | -700. | 41.2 | 700.0 | 216.38 | 8.15 | 2.69 | 200 | 200 | 0 | 0 | 0 | 0 |

## LIFE TEST COMPUTED STATISTIC SHEETS

Page 12 of 12 | Test Code 2 | Component Code 001 | Parameter 3 Group C

JPL Test No. 019 | Vendor Vitramon | Part No. CK06CW103K | Parameter IR

Unit K Megohms | Nominal Value N/A | Lower Limit 100 | Upper Limit N/A

| Min | Mean | Max | Std | F | Min D | Mean D | Max D | Std D | PC | t | No | Ny | Nu | Nl | Nc | Nt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 5000 to Initial | | | | | | | | | | |
| - | - | - | - | 2.700 | -400. | 154.2 | 700.0 | 174.13 | 39.2 | 12.53 | - | - | - | - | - | - |
| | | | | | | 6000 Hour Life | | | | | | | | | | |
| 200.0 | 448.0 | 1000. | 130.70 | .672 | -700. | -99.5 | 600.0 | 207.30 | -18.17 | -6.79 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 7000 Hour Life | | | | | | | | | | |
| 200.0 | 477.5 | 1000. | 178.33 | 1.862 | -750. | 30.75 | 800.0 | 206.41 | 6.86 | 2.11 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 8000 Hour Life | | | | | | | | | | |
| 180.0 | 405.7 | 900. | 108.52 | .370 | -800. | -72.35 | 650.0 | 214.87 | -15.15 | -4.76 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 9000 Hour Life | | | | | | | | | | |
| 160.0 | 343.3 | 600. | 89.76 | .684 | -450. | -59.85 | 250.0 | 148.62 | -14.75 | -5.70 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | 10,000 Hour Life | | | | | | | | | | |
| 160.0 | 313.4 | 500. | 78.30 | .760 | -350. | -30.45 | 300.0 | 120.60 | -8.87 | -3.57 | 200 | 200 | 0 | 0 | 0 | 0 |
| | | | | | | Final Line - 10,000 to Initial | | | | | | | | | | |
| - | - | - | - | .649 | -520. | -79.90 | 250.0 | 121.0 | -20.32 | -9.34 | - | - | - | - | - | - |

# APPENDIX II

## EQUIPMENT LIST AND TEST CIRCUITS

## EQUIPMENT LIST

| MEASUREMENT | EQUIPMENT | MANUFACTURER | MODEL NO. | SERIAL NO. | ACCURACY | FREQUENCY OF CALIBRATION* |
|---|---|---|---|---|---|---|
| Visual Examination | Magnifying Glass | Lufkin | 530X | none | N/A | N/A |
| Insulation Resistance | Megohmeter | Industrial Instruments | L-7 | 57327 | ±4% | 3 months |
| | Megohmeter | Industrial Instruments | L-7 | 72145 | ±4% | 3 months |
| Capacitance and Dissipation Factor | Capacitance Bridge | General Radio | 716-C | 1469 | ±0.2%F.S. | 3 months |
| | Capacitance Bridge | General Radio | 716-C | 4337 | ±0.2%F.S. | 3 months |
| | Null Detector | Hewlett-Packard | 400 D | 001-33709 | ±2% | 6 months |
| | Null Detector | Hewlett-Packard | 400 D | 001-33227 | ±2% | 6 months |
| | Signal Generator | Hewlett-Packard | 650 A | 3879 | ±1% | 3 months |
| | Signal Generator | Hewlett-Packard | 650 A | 007-0752 | ±1% | 3 months |
| Temperature | Chart Recorder | Bristol | E-27-T62-T7 | 662866 | ±2°C | 6 months |
| | Controller | Partlow | AAH-16 | 337095 | ±2°C | 12 months |
| | Chamber | Pacific Combustion | HA-100 | 563-2 | ±2°C | 12 months |
| Life Test | Power Supply | Storage Batteries | 12V | -- | N/A | N/A |
| Continuity | VOM | Simpson | 26 | none | ±3% | 6 months |
| Electrification | Stop Watch | Bidham | 60X | none | 0.1 sec | 12 months |
| Voltage | DC Voltmeter | Weston | 901 | 8413 | ±0.5% | 3 months |

* Calibration was conducted at these points to insure accuracy. Instruments used in test program were checked, but not adjusted.

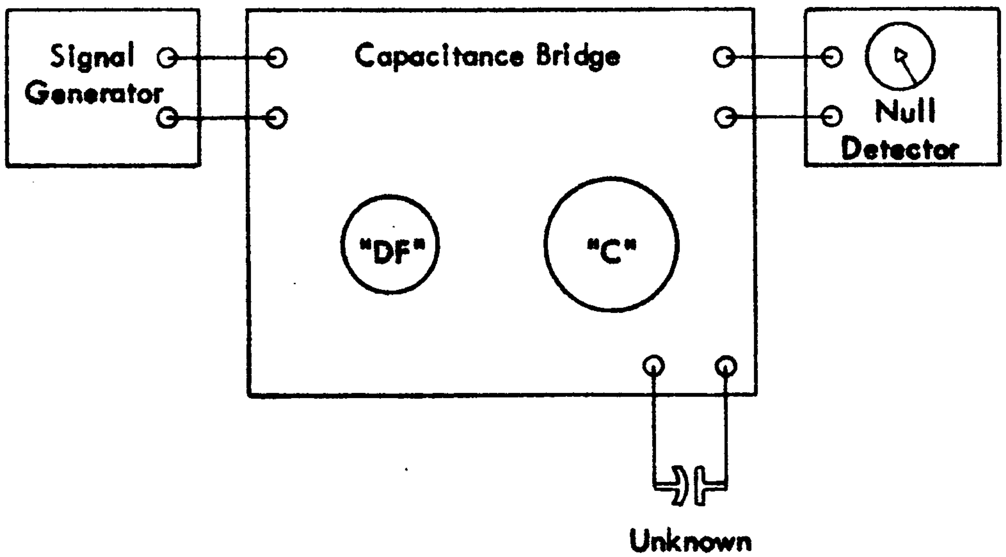



FIGURE NO. I

CAPACITANCE/DISSIPATION FACTOR TEST SET-UP

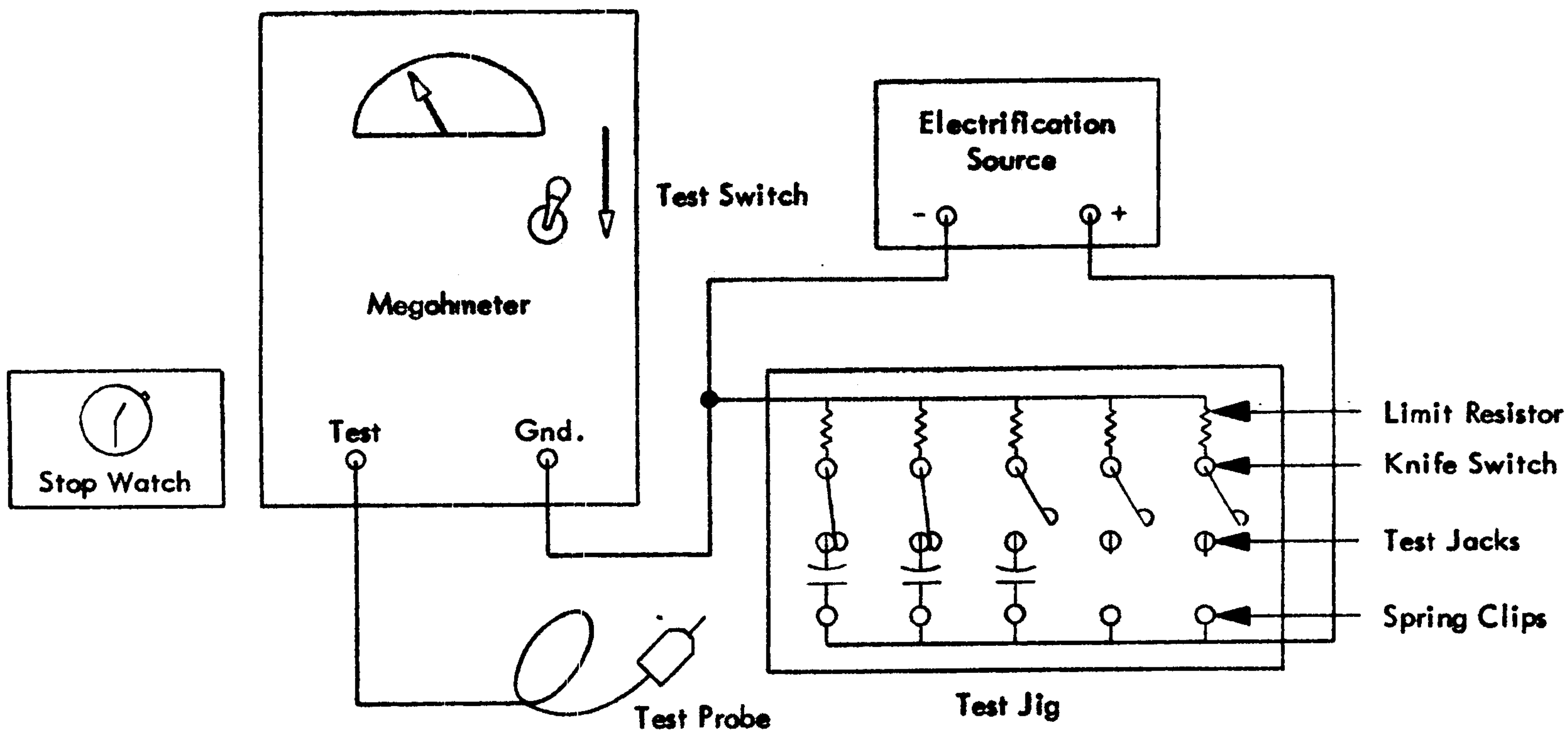



FIGURE NO. II

INSULATION RESISTANCE TEST SET-UP

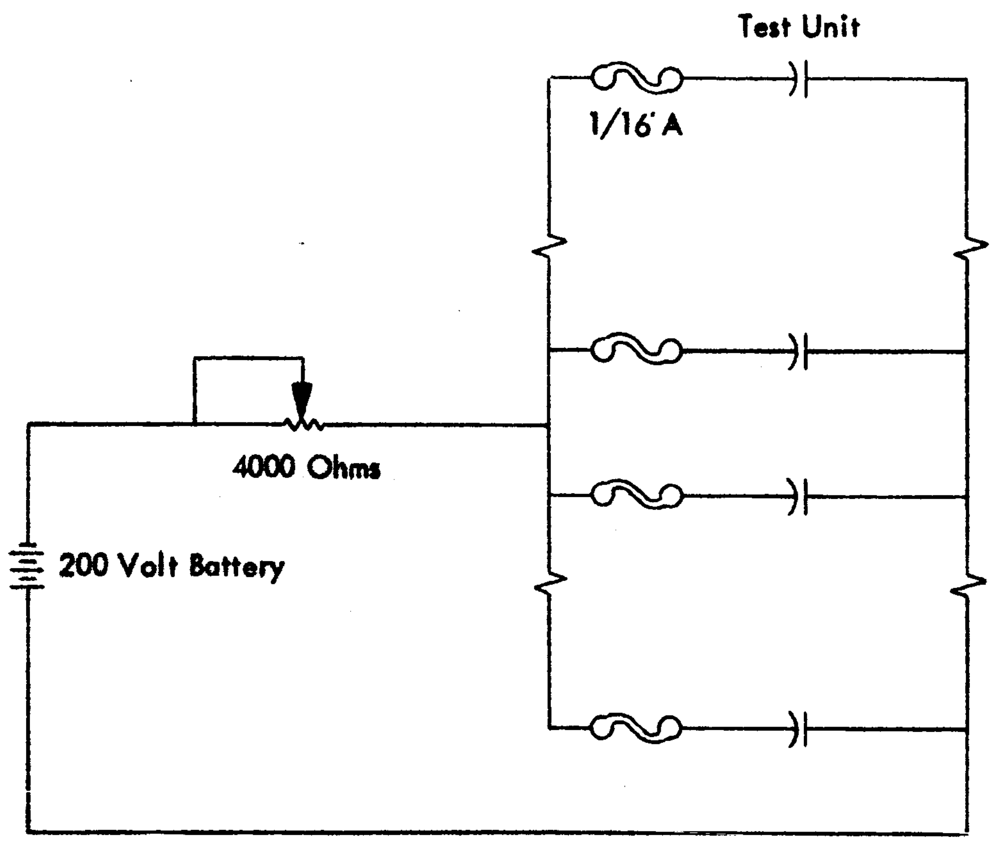



FIGURE NO. III

LIFE TEST SET-UP -- TYPICAL FOR EACH GROUP

# APPENDIX III

## t-COMPARISON TABLE BETWEEN GROUP P AND C

# APPENDIX III

## t-COMPARISON TABLE
## BETWEEN GROUP P AND C

| Step | Capacitance | | Dissipation Factor | | Insulation Resistance | |
|---|---|---|---|---|---|---|
| | t | Δ | t | Δ | t | Δ |
| Initial | - | - | - | - | - | - |
| 50 | 24.32*** | .184 | -2.12* | -.012 | -1.44 | -32.8 |
| 168 | 10.77*** | .077 | 5.26*** | .032 | 3.08*** | 73.1 |
| 336 | 1.01 | .003 | .94 | .005 | -1.96* | -34.7 |
| 504 | 8.12*** | .034 | 6.69*** | .035 | -5.41*** | -46.25 |
| 1008 | -4.82*** | -.020 | -4.85*** | -.331 | 1.06 | 34.5 |
| 2000 | 11.36*** | .049 | -5.77*** | -.028 | 1.36 | 20.2 |
| 3000 | -31.58*** | -.013 | 1.95 | .009 | -4.56*** | -64.8 |
| 4000 | .318 | .001 | -3.522*** | -.014 | 0.078 | -1.35 |
| 5000 | -8.299*** | -.0234 | +4.068** | +.0166 | -0.225 | -4.50 |
| 6000 | 3.91*** | .0113 | 0.08 | -.0003 | 3.61*** | 74.00 |
| 7000 | -18.24*** | -.0213 | -5.78*** | -.0235 | -3.836*** | -76.00 |
| 8000 | 4.126*** | .0138 | 5.270*** | .0196 | 0.693 | 12.95 |
| 9000 | -4.660*** | -.0102 | -27.782*** | -.1004 | 4.0145*** | 56.95 |
| 10000 | 9.385*** | .0585 | 11.423*** | .0496 | -.1706 | -1.950 |
| Final | 43.60*** | .3518 | 5.627*** | .0300 | .8316 | 8.250 |

*** Indicates significance at .005 level

** Indicates significance at .01 level

* Indicates significance at .05 level