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EVALUATION OF WET TANTALUM CAPACITORS AFTER EXPOSURE TO EXTENDED PERIODS OF RIPPLE CURRENT

Volume I

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16. Abstract

The application of tantalum capacitors in the Viking Lander includes both dc voltage and ripple current electrical stress, high temperature during non-operating times (sterilization), and high vibration and shock loads. The capacitors must survive these severe environments without any degradation if reliable performance is to be achieved.

A test program was established to evaluate both wet-slug tantalum and wet-foil capacitors under conditions accurately duplicating actual Viking applications. Test results of the electrical performance characteristics during extended periods of ripple current, the characteristics of the internal silver migration as a function of extended periods of ripple current, and the existence of any memory characteristics are presented.

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1.0 INTRODUCTION

Wet slug tantalum capacitor failures were experienced in the Apollo Telescope Mount (ATM) during system tests. The NASA Marshall Space Flight Center (MSFC) organized a team in late 1972 to investigate[1] these failures and invited representatives of both the Viking Project Office (VPO) and the Martin Marietta Corporation (MMC) to participate. Both the VPO and MMC had expressed several concerns over these wet slug failures since the ATM application was similar to Viking applications. These concerns were:

A. What are the effects on the electrical performance characteristics of wet slug tantalum capacitors when they are subjected to ripple current over an extended period of time?

B. What are the characteristics of internal silver migration as a function of ripple current application for an extended period of time? and,

C. Does a "memory" effect exist in wet slug tantalum capacitors, i.e., will a wet slug fail in the "short" mode if it is subjected to a voltage stress (dc) far below its rated value for an extended period of time and then subjected to a voltage stress at or near its rated value?

Because very limited factual application data, considerable opinion and much speculation exists in the Aerospace Industry regarding proper application of wet slug tantalum capacitors and the fact that the Viking Lander employs wet slugs in 118 different applications, 77 of which involve

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1 This investigation is summarized in IBM Report No. 73W-00050, dated 3 Jan. 1973

some level of ripple current, the VPO and MMC decided to initiate a test program. The test program was designed to provide conclusive answers for the three concerns identified above and was performed jointly by the Flight Instrumentation Division (FID) of Langley Research Center (LRC) and MMC.

1.1 Purpose and Scope

The purpose of this report is to describe the approach taken and the resultant findings of the MMC portion of the Wet Slug Capacitor Test Program. The following objectives were established in order to adequately scope the effect of ripple current and low/high dc voltage stress in Viking applications:

A. Subject selected Viking wet slug tantalum capacitors (MIL-C-39006, CLR 65 style manufactured by General Electric) to dc voltage, ripple current and environmental stresses which closely duplicate actual Viking Lander applications and critically evaluate their electrical performance;

B. Perform an internal analysis of several test specimen capacitors selected at random from those used in (A) above to investigate the silver migration phenomena;

C. Determine if the so called "memory effect" exists in wet slug tantalum capacitors;

D. Expand the wet slug tantalum capacitor test program to include selected MIL-C-39006, CLR 25, wet foil capacitors since these were replacement candidates for the wet slug should the wet slug test program yield negative results. Also, wet foil capacitors are currently being used in a few ripple current applications in the Lander.

1.2 Summary

The application of tantalum capacitors in the Viking Lander includes both dc voltage and ripple current electrical stress, high temperature during non-operating times (sterilization), and high vibration and shock loads. The capacitors must survive these severe environments without any degradation if reliable performance is to be achieved.

A test program was established to evaluate both wet slug tantalum and wet foil capacitors under conditions accurately duplicating actual Viking applications. Included in the test program was a special test to determine if wet slug tantalum caps did exhibit a memory effect. The ripple test program was performed in two phases. The first phase, the results of which are reported herein, involved subjecting capacitors to electrical and environmental stresses of the same levels and durations as typical Viking applications.

The second phase of the test program (The results of which will be reported in Volume II) is the search for indications of silver migration in the wet slug caps. Included will be the effects of that migration on the electrical characteristics and performance of the capacitors.

No degradation of wet slug tantalum capacitors was detected due to ripple current. The electrical performance and silver migration data developed by MMC indicate that all current Viking applications are within the capability of this type of part. Supplemental test data developed by the LRC FID corroborates these findings.

The wet slug tantalum capacitors did exhibit excessive current leakage after exposure to vibration. The cause of this current leakage was traced to movement of the tantalum slug within the silver case. A modification

consisting of a second crimp near the bottom of the capacitor's case was developed by MMC and General Electric. This second crimp forces the spider to hold the slug much more tightly than in conventional capacitors and thereby prevents the slug from moving during vibration. This modification is not expected to alter a capacitor's ability to withstand ripple current; however, additional testing (requalification) is underway to ensure that there is no effect due to the double crimp.

No indication that a memory effect exists in wet slug tantalum capacitors was detected. Exposure of test specimens to a dc voltage stress equal to 13.4% of rated voltage for 1000 hours and then abruptly subjecting the test specimens to rated voltage stress did not induce any anomolous indications.

No degradation of wet foil capacitors was detected after exposure to voltage, ripple current and environmental stresses which were identical to the stresses to which the wet slug tantalum capacitors were subjected.

2.0 RIPPLE CURRENT TEST PROGRAM

Figure 2.1 presents an overview of the ripple current test program. Details of this plan are defined in MMC document CAP-73-1,[2] entitled "Evaluation Plan ....". The test program evolved after MMC and the VPO had reached agreement on the following factors:

A. Frequency and waveshapes of AC ripple current;

B. DC voltage stress levels;

C. Mission operating times;

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2 CAP-73-1, Revision D, "Evaluation Plan - Capacitor Evaluation of Wet Sintered Slug Capacitors," with Appendix A, dated 1/26/73, Martin Marietta Corporation

TEST ARTICLES

TEST SEQUENCE

60 HR HEAT SOAK @ 125°C - NO POWER

100 HR RIPPLE CURRENT ◆

60 HR HEAT SOAK @ 125°C - NO POWER

200 HR RIPPLE CURRENT ◆

60 HR HEAT SOAK @ 125°C - NO POWER

VIBRATION - 2 AXES 50G SINEWAVE (10-2000 Hz)

700 HR RIPPLE CURRENT (1) ◆

VIBRATION - 2 AXES 24 Grms RANDOM (3 MIN/AXIS)

MEASUREMENTS

ELECTRICAL PARAMETERS RECORDED FOR EACH CAPACITOR BETWEEN EACH STRESS @ AMBIENT CONDITIONS

- CAPACITANCE
- DC LEAKAGE CURRENT
- DISSIPATION FACTOR

TEST ARTICLE DETAILS

	WET SLUG							WET FOIL		
Reference Viking Lander Application	Output Filter (Bank of 40 Cap) — Lander Power Control And Distribution Assy (PCDA)		Input Filter (Bank of 15 Cap) — Lander PCDA		Output Filter — Data and Processing Unit (DAPU)	Input Filter (Bank of 20 Cap) — Bioshield Power Assy (BPA)		Filter/Coupling — Valve Drive Amplifier (VDA)	Output Filter — (3) PCDA	Input Filter — (3) DAPU
Configuration of CAPS in Test Circuit	40 CAPS Parallel	25 CAPS Parallel	15 CAPS Parallel	25 CAPS Parallel	25 CAPS Parallel	20 CAPS Parallel	25 CAPS Parallel	11 CAPS Parallel	22 CAPS Parallel	22 CAPS Parallel
Capacitor Part Number	CSV 90D39006 -10	CSV 90D39006 -10 (12) M3900609 -4350(13)	CSV 90D39006 -7	CSV 90D39006 -7	CSV 90D39006 -21	CSV 90D39006 -24	CSV 90D39006 -24	CSV 90D44-1	GE 16K212 AB21	GE 16K361 AB7
Case Size	GT3	GT3	GT3	GT3	GT2	GT3	GT3	G5	G3	G4
Capacitor Rating at 85°C	68µfd 60V	68µfd 60V	82µfd 50V	82µfd 50V	39µfd 60V	56µfd 75V	56µfd 75V	580µfd 15V	200µfd 15V	100µfd 50V
Test Fixture Designation	Sinks 1 & 2	Sink 3 Sink 11	Sink 4	Sink 5	Sink 7	Sink 9	Sink 8	Sink 6	Sink 14 & 15	Sink 12 & 13

RIPPLE CURRENT APPLICATION PARAMETERS

DC Bias Level	40V	40V	10V	10V	40V	40V	40V	10V	6V	35V
Ripple Waveshape	Square Wave	Square Wave			Square Wave	Square Wave	Square Wave	Square Wave	Square Wave	Square Wave
Ripple Current (RMS) per Cap	0.15A	0.3A	0.17A	0.27A	0.1A	0.25A	0.35A	1.5A	0.425A	0.425A
Ripple Frequency	10KHZ	10KHZ	10KHZ	10KHZ	72KHZ	20KHZ	20KHZ	5KHZ	50KHZ	72KHZ
Operating Temperature	+70°C	+70°C	+70°C	+70°C	+70°C	-37°C	-37°C	+80°C	+70°C	+70°C

NOTES

(1) Ripple current application #3 extended to 1200 HRs for caps on test sink 2,4,7,8

(2) Parts taken from test sample subjected to 2000 HR DC bias life test

(3) Potential applications of wet foil capacitors

Figure 2.1 - Ripple Current Test Program Overview

D. The types and levels of environmental stresses;

E. Test fixtures which duplicate as closely as possible the Viking electrical circuit, packaging and environmental characteristics;

F. The availability of adequate sample sizes of capacitors designated for flight usage;

G. The method of electrical parameter measurement and the number of times they would be measured;

H. The techniques to be used when dissecting test specimens and the quantity.

Figure 2.2 shows how the capacitors were mounted on aluminum plates (test sinks) to facilitate environmental and electrical testing. The capacitors were rigidly attached to the plates with epoxy and their axial leads were soldered to standoff terminals. The soldering and epoxy materials and processes were identical to those used in flight hardware. The plates with the capacitors attached, were designed to exhibit a transmissibility of one to ensure that vibration levels were not amplified.

Special waveform generators were designed and built to produce the ripple current waveforms and frequencies. A typical test setup which includes ripple current generators, DC power supplies, interface boxes and test sinks is shown in Figure 2.3

2.1 Test Anomalies and Changes

After the initial 50G sinewave vibration tests, a problem identified as out-of-spec forward DC leakage current was detected in 42 wet slug capacitors. Subsequent investigation isolated the cause to physical movement of the slug and verified that the problem was not ripple current related.

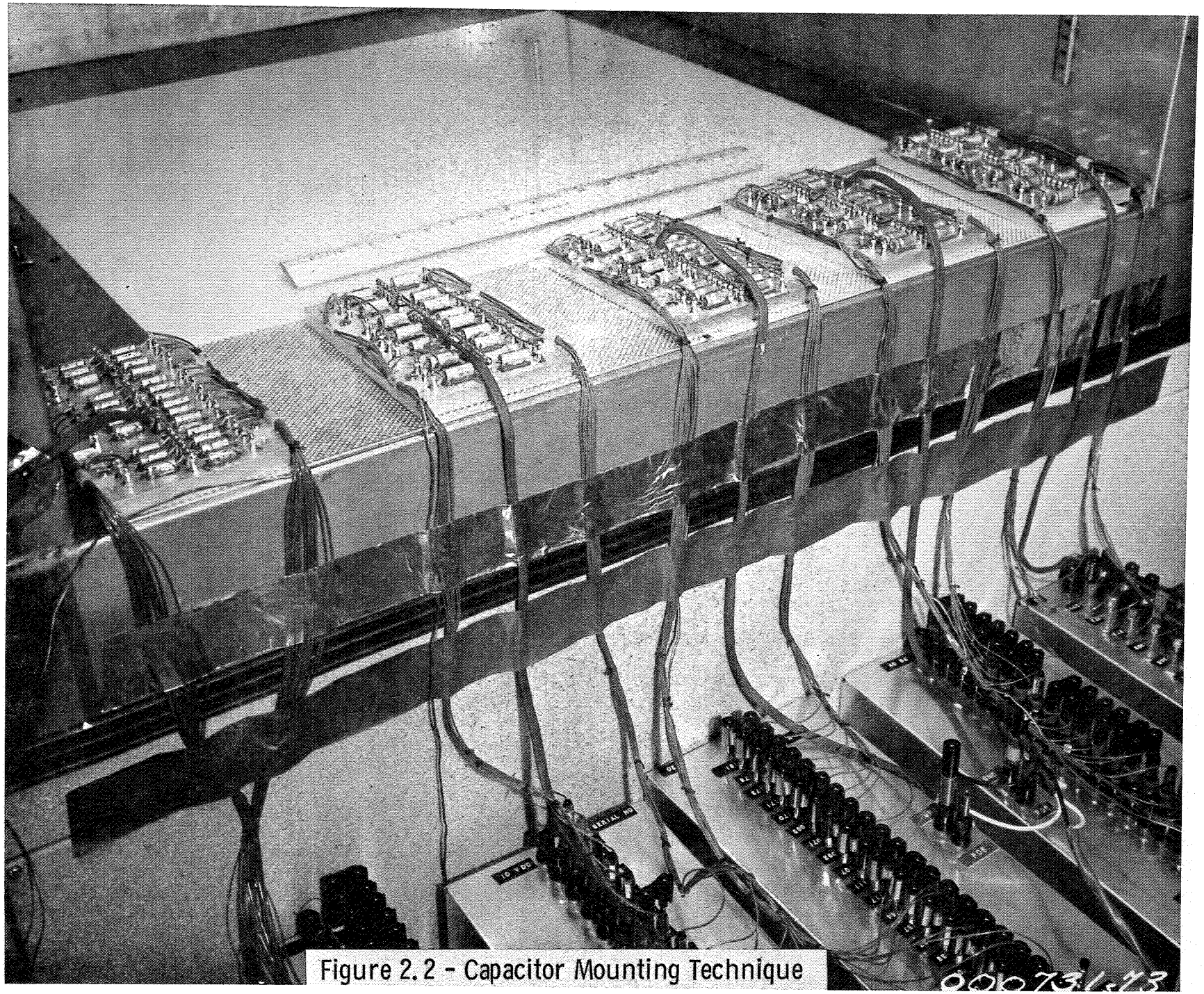

Figure 2.2 - Capacitor Mounting Technique

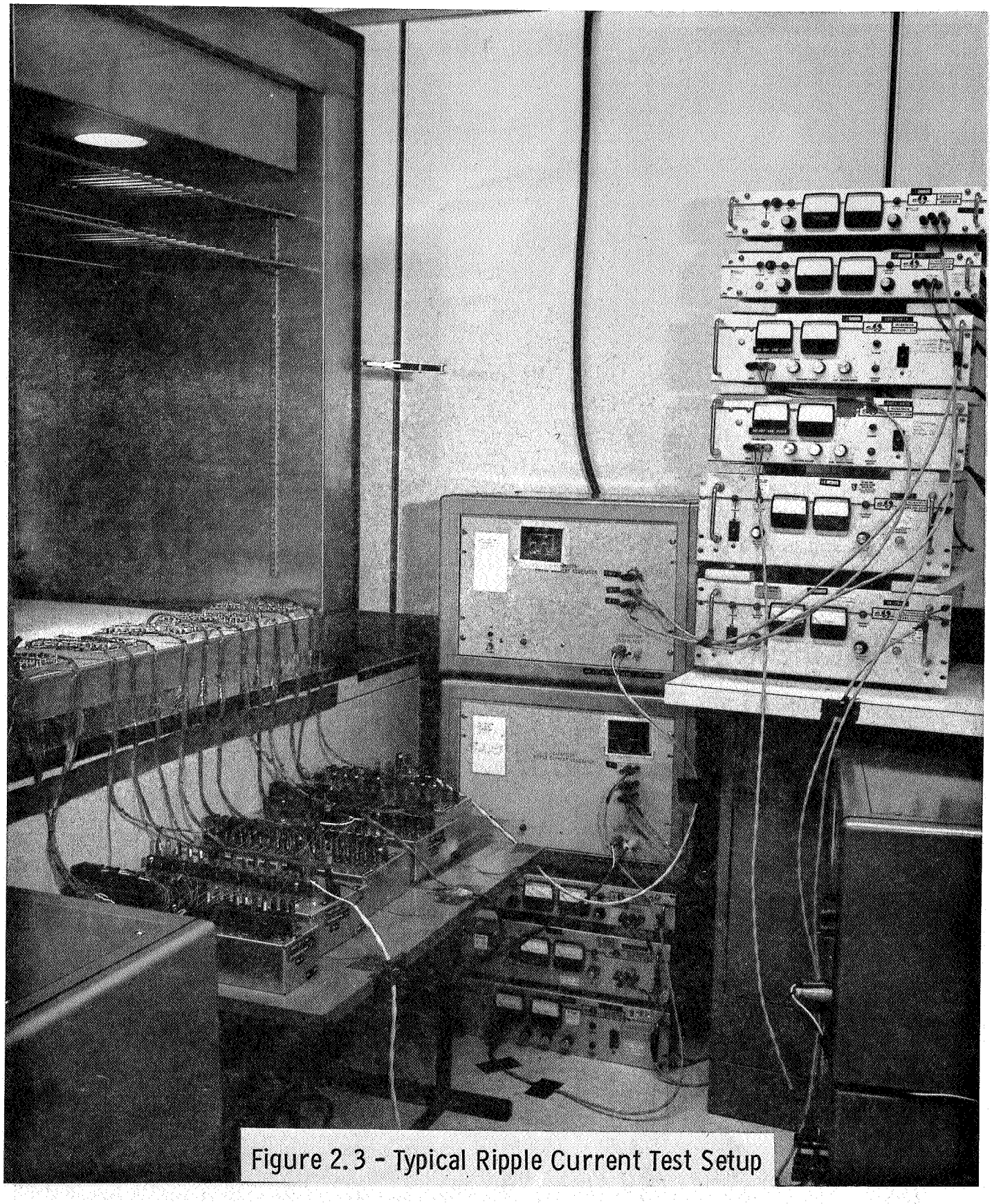

Figure 2.3 - Typical Ripple Current Test Setup

The test sequence was continued with a minor change in order to obtain additional information on the healing characteristics of the out-of-spec capacitors. This change included additional electrical measurements at the 20 and 150 hour points during the 700 hour portion of the ripple current test to identify capacitor recovery characteristics. Also, the original program was modified to accumulate up to 1500 hours of ripple current on selected capacitors.

2.2 Test Data and Analysis

Capacitance, DC leakage current and Dissipation Factor (DF) were measured and recorded for each capacitor in the test program per Figure 2.1. The data for each capacitor, including a derived Equivalent Series Resistance (ESR), are tabulated in Tables 2.2 thru 2.13. The ESR was computed using the equation:

$$ESR = \frac{DF}{2\pi FC}$$

where, DF = Dissipation Factor

F = 120 cycles (measurement frequency)

C = capacitance, mfd.

Table 2.1 relates the data for each group of capacitor dash numbers and case sizes to a particular detail data Table (Tables 2.2 thru 2.13).

Before performing an analysis of the measurement data taken during this test program, it was determined that:

1. The product of ripple current amplitude and operating time is the measure of stress seen by a capacitor.
2. The worst case stress levels to be seen by capacitors in the Viking Lander by case size are:

Capacitor Type — Case Size	Cap Value (μfd)	DC Bias* (Volts)	Ripple Current* (RMS) (Amps)	Ripple Freq (KHZ)	Temp (°C)	Total Ripple Application (Hrs)	Detail Data Are Shown in Table:
Wet Slug (-010) GT-3	68	40/60	.150/.400	10	+70°C	1000	2.2
	68	40/60	.150/.400	10	+70°C	1500	2.3
	68	40/60	.300/.400	10	+70°C	1000	2.4
	68**	40/60	.300/.400	10	+70°C	1000	2.5
Wet Slug (-007) GT-3	82	10/50	.170/.400	10	+70°C	1500	2.6
	82	10/50	.270/.400	10	+70°C	1000	2.7
Wet Slug (-024) GT-3	56	40/75	.250/.400	20	-37°C	1000	2.8
	56	40/75	.350/.400	20	-37°C	1500	2.9
Wet Slug (-021) GT-2	39	40/60	.100/.250	72	+70°C	1500	2.10
Wet Foil G5	580	10/15	1.5/3.2	5	+80°C	1000	2.11
Wet Foil G3	200	6/15	0.425/3.5	50	+70°C	1000	2.12
Wet Foil G4	100	35/50	0.425/3.5	72	+70°C	1000	2.13

* Test/Mfgr Rated Value

** Capacitors Previously Subjected to 2000 Hrs DC Bias Life Test

TABLE 2.1 INDEX OF TABULATED ELECTRICAL PARAMETERS-
RIPPLE TEST PROGRAM

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 68µfd ± 5%)	184	68.1uf	67.1uf	68.3uf	68.0uf	68.0uf	68.0uf	68.0uf	68.2uf	NA	68.3uf	68.0uf
	188	67.3uf	68.0uf	66.6uf	66.8uf	66.9uf	66.7uf	66.7uf	66.8uf	NA	67.0uf	66.8uf
	189	67.3uf	67.1uf	66.9uf	67.2uf	67.3uf	67.2uf	67.1uf	67.3uf	NA	67.4uf	67.2uf
	203	67.3uf	67.1uf	66.9uf	67.2uf	67.0uf	67.1uf	67.1uf	67.3uf	NA	67.3uf	67.2uf
	207	67.4uf	67.1uf	67.2uf	67.4uf	67.4uf	67.4uf	67.2uf	67.3uf	NA	65.9uf	65.8uf
	236	67.7uf	67.1uf	67.7uf	67.7uf	67.8uf	67.7uf	67.6uf	67.8uf	NA	67.9uf	67.7uf
	237	67.3uf	67.1uf	67.0uf	67.0uf	66.9uf	67.8uf	66.7uf	66.8uf	NA	66.5uf	66.4uf
	257	67.5uf	67.1uf	67.2uf	67.4uf	67.3uf	67.2uf	67.1uf	67.3uf	NA	67.3uf	67.1uf
	244	68.5uf	68.0uf	68.5uf	68.4uf	68.3uf	68.4uf	68.3uf	68.5uf	NA	68.6uf	68.5uf
	117	67.9uf	67.0uf	67.8uf	67.9uf	67.9uf	67.8uf	67.8uf	68.0uf	NA	68.1uf	68.0uf
	111	66.8uf	67.0uf	66.6uf	66.6uf	66.8uf	66.5uf	66.4uf	66.5uf	NA	66.7uf	66.5uf
	107	67.4uf	67.0uf	66.6uf	66.2uf	65.0uf	64.7uf	64.6uf	64.8uf	NA	64.9uf	64.6uf
	092	67.4uf	68.0uf	67.0uf	67.1uf	66.8uf	66.8uf	66.8uf	66.8uf	NA	66.7uf	66.6uf
	071	68.0uf	67.0uf	67.7uf	67.8uf	67.9uf	67.6uf	67.5uf	67.8uf	NA	67.8uf	67.8uf
	069	68.1uf	67.0uf	67.9uf	68.0uf	68.2uf	68.0uf	67.9uf	68.2uf	NA	68.3uf	68.2uf
	170	67.3uf	67.0uf	67.0uf	67.1uf	67.0uf	66.9uf	66.9uf	67.1uf	NA	67.1uf	67.0uf
	171	68.1uf	68.0uf	67.9uf	68.0uf	68.0uf	67.9uf	67.8uf	68.0uf	NA	68.1uf	68.0uf
	173	66.9uf	67.0uf	66.8uf	66.8uf	66.8uf	66.7uf	66.6uf	66.9uf	NA	67.0uf	66.9uf
	178	67.6uf	67.0uf	65.5uf	65.5uf	65.7uf	65.5uf	65.4uf	65.7uf	NA	65.9uf	65.8uf
	181	68.3uf	68.0uf	67.9uf	68.1uf	68.2uf	68.0uf	67.9uf	68.2uf	NA	68.2uf	68.1uf
DC LEAKAGE CURRENT (SPEC: 2000 na) na = 10^{-9} amp ua = 10^{-6} amp	184	140 na	34 na	54 na	50 na	38 na	40 na	44 na	52 na	NA	54 na	60 na
	188	140 na	36 na	54 na	45 na	31 na	40 na	42 na	50 na	NA	50 na	52 na
	189	135 na	35 na	53 na	44 na	31 na	38 na	42 na	50 na	NA	48 na	50 na
	203	130 na	35 na	52 na	43 na	31 na	38 na	42 na	50 na	NA	48 na	50 na
	207	130 na	39 na	53 na	44 na	31 na	40 na	42 na	50 na	NA	52 na	54 na
	236	140 na	34 na	50 na	44 na	31 na	36 na	42 na	56 na	NA	46 na	48 na
	237	135 na	33 na	50 na	44 na	30 na	38 na	42 na	46 na	NA	44 na	50 na
	257	135 na	35 na	48 na	40 na	29 na	40 na	40 na	46 na	NA	44 na	48 na
	244	125 na	38 na	48 na	40 na	29 na	34 na	36 na	46 na	NA	42 na	46 na
	117	110 na	42 na	45 na	40 na	29 na	34 na	38 na	50 na	NA	42 na	46 na
	111	110 na	34 na	42 na	40 na	29 na	34 na	36 na	44 na	NA	42 na	42 na
	107	105 na	40 na	44 na	45 na	30 na	40 na	40 na	50 na	NA	44 na	46 na
	092	105 na	38 na	42 na	37 na	29 na	36 na	38 na	42 na	NA	42 na	46 na
	071	100 na	38 na	40 na	36 na	29 na	34 na	36 na	44 na	NA	42 na	40 na
	069	100 na	45 na	42 na	36 na	28 na	34 na	34 na	48 na	NA	40 na	42 na
	170	90 na	40 na	40 na	37 na	28 na	32 na	36 na	42 na	NA	40 na	42 na
	171	70 na	39 na	40 na	35 na	28 na	32 na	34 na	40 na	NA	38 na	40 na
	173	65 na	40 na	38 na	35 na	28 na	30 na	34 na	36 na	NA	36 na	40 na
	178	65 na	45 na	42 na	40 na	28 na	40 na	38 na	36 na	NA	36 na	40 na
	181	65 na	54 na	42 na	34 na	28 na	44 na	32 na	38 na	NA	36 na	40 na
ESR (SPEC: 1.5 Ohms)	184	.678	1.661	1.166	.703	.585	.663	.605	.603	NA	.602	.644
	188	.686	1.639	1.195	.715	.654	.676	.636	.615	NA	.614	.655
	189	.686	1.661	1.190	.711	.630	.612	.632	.630	NA	.590	.651
	203	.686	1.661	1.190	.711	.594	.613	.613	.611	NA	.611	.651
	207	.685	1.661	1.185	.709	.630	.630	.631	.670	NA	.756	.806
	236	.682	1.661	1.176	.706	.626	.607	.608	.606	NA	.586	.627
	237	.757	1.661	1.426	.852	.733	.724	.715	.695	NA	.718	.779
	257	.707	1.661	1.422	.847	.670	.691	.672	.690	NA	.650	.711
	244	.697	1.639	1.395	.834	.602	.620	.602	.619	NA	.599	.697
	117	.703	1.664	1.409	.840	.605	.606	.606	.624	NA	.565	.702
	111	.714	1.664	1.435	.857	.734	.718	.719	.718	NA	.696	.758
	107	.755	1.664	1.435	.962	1.02	1.086	1.088	1.105	NA	1.103	1.191
	092	.755	1.639	1.426	.712	.655	.695	.714	.715	NA	.775	.737
	071	.748	1.664	1.411	.842	.664	.667	.629	.665	NA	.626	.704
	069	.701	1.664	1.407	.703	.583	.585	.605	.525	NA	.582	.642
	170	.756	1.664	1.426	.712	.653	.694	.713	.712	NA	.692	.732
	171	.701	1.639	1.407	.703	.644	.625	.626	.624	NA	.604	.683
	173	.714	1.664	1.430	.715	.655	.636	.677	.674	NA	.633	.694
	178	.706	1.664	1.459	.973	.888	.931	.973	.787	NA	.905	.967
	181	.699	1.639	1.407	.701	.642	.624	.605	.583	NA	.583	.623

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
40/60	.15/.40	10	+70

Table 2.2 - Test Data, -010 Wet Slug Capacitors Operated at 37.5% of Rated Ripple Current for 1000 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (30G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 68µfd ± 5%)	050	64.0 µf	67.0 µf	65.5 µf	65.7 µf	65.8 µf	65.8 µf	65.5 µf	65.8 µf	N/A	66.0 µf	65.7 µf
	038	67.3 µf	68.0 µf	67.4 µf	67.3 µf	67.5 µf	67.1 µf	67.2 µf	67.4 µf	N/A	67.5 µf	67.3 µf
	056	67.2 µf	67.0 µf	67.4 µf	68.0 µf	67.9 µf	67.9 µf	67.8 µf	68.0 µf	N/A	68.0 µf	68.0 µf
	058	67.7 µf	68.0 µf	67.4 µf	67.6 µf	67.4 µf	67.4 µf	67.3 µf	67.3 µf	N/A	65.8 µf	65.7 µf
	064	67.1 µf	68.0 µf	67.4 µf	67.0 µf	67.0 µf	67.0 µf	66.9 µf	67.1 µf	N/A	67.2 µf	67.0 µf
	068	66.3 µf	67.0 µf	66.4 µf	66.0 µf	66.0 µf	65.9 µf	65.7 µf	65.9 µf	N/A	64.3 µf	64.2 µf
	139	67.7 µf	67.0 µf	68.0 µf	68.0 µf	68.0 µf	68.0 µf	67.8 µf	68.0 µf	N/A	68.0 µf	67.7 µf
	137	68.0 µf	68.0 µf	67.3 µf	67.4 µf	67.9 µf	67.9 µf	67.7 µf	68.0 µf	N/A	68.2 µf	68.0 µf
	118	67.8 µf	67.0 µf	67.3 µf	67.6 µf	67.6 µf	67.5 µf	67.5 µf	67.7 µf	N/A	67.8 µf	67.6 µf
	036	66.5 µf	67.0 µf	66.4 µf	66.5 µf	66.6 µf	66.5 µf	66.4 µf	66.6 µf	N/A	66.7 µf	66.6 µf
	028	67.7 µf	67.0 µf	67.5 µf	67.7 µf	67.6 µf	67.6 µf	67.5 µf	67.7 µf	N/A	67.5 µf	67.3 µf
	020	68.4 µf	67.0 µf	68.6 µf	68.2 µf	68.2 µf	68.1 µf	68.2 µf	68.4 µf	N/A	68.5 µf	68.3 µf
	018	67.5 µf	67.0 µf	67.9 µf	67.9 µf	68.0 µf	67.9 µf	67.8 µf	68.0 µf	N/A	68.2 µf	68.0 µf
	015	68.1 µf	67.0 µf	67.9 µf	68.0 µf	67.9 µf	67.9 µf	67.9 µf	68.1 µf	N/A	68.2 µf	68.0 µf
	010	66.7 µf	66.0 µf	66.2 µf	66.2 µf	66.2 µf	66.0 µf	65.8 µf	65.9 µf	N/A	64.7 µf	64.6 µf
	008	67.4 µf	67.0 µf	67.5 µf	67.5 µf	67.6 µf	67.6 µf	67.5 µf	67.7 µf	N/A	67.5 µf	67.6 µf
	007	66.0 µf	66.0 µf	67.5 µf	65.4 µf	65.2 µf	65.3 µf	65.2 µf	65.3 µf	N/A	65.2 µf	65.2 µf
	005	67.3 µf	68.0 µf	67.6 µf	67.5 µf	67.6 µf	67.7 µf	67.5 µf	67.6 µf	N/A	67.7 µf	67.5 µf
	259	67.9 µf	67.0 µf	67.6 µf	67.8 µf	67.9 µf	67.9 µf	67.7 µf	67.9 µf	N/A	67.7 µf	67.7 µf
	406	68.4 µf	67.0 µf	68.6 µf	68.4 µf	68.3 µf	68.2 µf	68.2 µf	68.4 µf	N/A	68.4 µf	68.2 µf
DC LEAKAGE CURRENT (SPEC: 2000 na) na = 10^{-9} amp ua = 10^{-6} amp	050	140 na	34 na	55 na	60 na	25 na	42 na	60 na	56 na	N/A	38 na	68 na
	038	125 na	29 na	50 na	50 na	21 na	30 na	50 na	54 na	N/A	34 na	54 na
	056	140 na	30 na	50 na	50 na	19 na	30 na	48 na	52 na	N/A	34 na	50 na
	058	120 na	32 na	50 na	50 na	18 na	30 na	50 na	52 na	N/A	32 na	56 na
	064	120 na	30 na	50 na	45 na	18 na	30 na	40 na	50 na	N/A	32 na	50 na
	068	130 na	38 na	55 na	55 na	25 na	38 na	50 na	66 na	N/A	40 na	64 na
	139	130 na	37 na	52 na	50 na	20 na	32 na	44 na	56 na	N/A	36 na	56 na
	137	110 na	28 na	45 na	45 na	20 na	30 na	38 na	46 na	N/A	30 na	48 na
	118	120 na	30 na	42 na	40 na	18 na	30 na	38 na	48 na	N/A	30 na	46 na
	036	130 na	38 na	52 na	48 na	20 na	35 na	44 na	56 na	N/A	36 na	54 na
	028	122 na	33 na	42 na	40 na	18 na	28 na	36 na	44 na	N/A	30 na	46 na
	020	110 na	40 na	42 na	40 na	18 na	28 na	36 na	46 na	N/A	28 na	44 na
	018	110 na	32 na	40 na	36 na	15 na	25 na	32 na	42 na	N/A	28 na	40 na
	015	110 na	44 na	42 na	38 na	15 na	28 na	34 na	46 na	N/A	28 na	50 na
	010	115 na	29 na	38 na	38 na	15 na	30 na	34 na	48 na	N/A	26 na	48 na
	008	110 na	30 na	38 na	40 na	18 na	28 na	34 na	40 na	N/A	26 na	40 na
	007	135 na	43 na	44 na	50 na	18 na	30 na	44 na	52 na	N/A	34 na	50 na
	005	115 na	36 na	42 na	40 na	15 na	28 na	36 na	44 na	N/A	30 na	42 na
	259	125 na	29 na	36 na	38 na	15 na	25 na	32 na	40 na	N/A	26 na	40 na
	406	105 na	35 na	36 na	36 na	15 na	25 na	32 na	40 na	N/A	26 na	38 na
ESR (SPEC: 1.5 Ohms)	050	.746	1.664	1.580	1.090	.967	.867	.931	.927	N/A	.924	.908
	038	.710	1.639	1.418	.710	.708	.553	.612	.630	N/A	.609	.611
	056	.711	1.664	1.418	.703	.704	.605	.626	.624	N/A	.624	.624
	058	.706	1.639	1.418	.707	.709	.709	.690	.630	N/A	.867	.868
	064	.712	1.639	1.418	.772	.713	.713	.714	.692	N/A	.710	.712
	068	.721	1.664	1.439	.724	.683	.684	.706	.704	N/A	.866	.867
	139	.706	1.664	1.405	.703	.624	.605	.606	.605	N/A	.624	.646
	137	.703	1.639	1.420	.709	.644	.605	.607	.605	N/A	.583	.585
	118	.705	1.664	1.420	.707	.646	.609	.609	.607	N/A	.606	.588
	036	.718	1.664	1.439	.718	.657	.618	.659	.637	N/A	.636	.637
	028	.706	1.664	1.415	.706	.647	.667	.648	.627	N/A	.668	.650
	020	.698	1.664	1.393	.700	.622	.604	.642	.620	N/A	.600	.602
	018	.708	1.664	1.407	.704	.585	.605	.606	.605	N/A	.603	.644
	015	.701	1.664	1.407	.703	.664	.605	.644	.662	N/A	.603	.644
	010	.716	1.689	1.443	.722	.722	.623	.665	.684	N/A	.758	.759
	008	.709	1.664	1.415	.708	.707	.608	.609	.627	N/A	.589	.608
	007	.724	1.689	1.415	.730	.631	.690	.671	.690	N/A	.651	.671
	005	.710	1.639	1.413	.708	.707	.666	.648	.667	N/A	.666	.629
	259	.704	1.664	1.413	.705	.644	.664	.646	.703	N/A	.666	.666
	406	.698	1.664	1.393	.698	.602	.661	.642	.620	N/A	.659	.700

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
40/60	.15/.40	10	+70

Table 2.3 - Test Data, -010 Wet Slug Capacitors Operated at 37.5% of Rated Ripple Current for 1500 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 68µfd ± 5%)	385	67.0 uf	67.0 uf	67.9 uf	68.0 uf	68.0 uf	67.9 uf	67.9 uf	68.1 uf	68.1 uf	68.1 uf	68.1 uf
	358	66.0 uf	67.0 uf	66.9 uf	67.0 uf	67.0 uf	66.9 uf	66.9 uf	67.2 uf	67.1 uf	67.1 uf	67.1 uf
	356	67.5 uf	68.0 uf	66.9 uf	67.2 uf	67.0 uf	66.8 uf	66.7 uf	66.9 uf	66.6 uf	65.2 uf	65.0 uf
	355	67.0 uf	67.0 uf	66.9 uf	66.7 uf	66.7 uf	66.5 uf	66.5 uf	F/A	F/A	F/A	F/A
	354	68.1 uf	67.0 uf	67.9 uf	68.0 uf	67.9 uf	68.0 uf	67.9 uf	68.2 uf	68.2 uf	68.2 uf	68.2 uf
	338	66.0 uf	66.0 uf	65.9 uf	66.1 uf	66.0 uf	66.0 uf	66.0 uf	66.2 uf	66.2 uf	66.2 uf	66.2 uf.
	309	68.4 uf	68.0 uf	68.2 uf	68.3 uf	68.2 uf	68.1 uf	68.1 uf	67.9 uf	67.5 uf	67.5 uf	68.2 uf
	308	67.6 uf	68.0 uf	67.6 uf	67.6 uf	67.5 uf	67.4 uf	67.4 uf	67.6 uf	68.3 uf	68.2 uf	67.4 uf
	302	65.0 uf	67.0 uf	66.2 uf	66.3 uf	66.2 uf	66.2 uf	66.2 uf	68.3 uf	66.4 uf	66.5 uf	66.5 uf
	278	67.8 uf	68.0 uf	67.8 uf	67.8 uf	68.0 uf	67.7 uf	67.6 uf	66.5 uf	67.8 uf	67.8 uf	67.8 uf
	273	67.6 uf	68.0 uf	67.5 uf	67.6 uf	67.4 uf	67.4 uf	67.4 uf	F/A	F/A	F/A	F/A
	271	68.0 uf	67.0 uf	68.4 uf	68.4 uf	68.5 uf	68.5 uf	68.4 uf	68.7 uf	68.7 uf	68.7 uf	68.7 uf
DC LEAKAGE CURRENT (SPEC: 2000 na) na = 10^{-9} amp ua = 10^{-6} amp	385	90 na	34 na	40 na	45 na	40 na	20 na	50 na	50 na	46 na	56 na	46 na
	358	90 na	35 na	39 na	45 na	40 na	20 na	48 na	48 na	40 na	54 na	44 na
	356	80 na	34 na	40 na	46 na	38 na	20 na	48 na	48 na	50 na	52 na	50 na
	355	90 na	45 na	44 na	56 na	42 na	22 na	58 na	F/A	F/A	F/A	F/A
	354	75 na	33 na	35 na	44 na	38 na	20 na	48 na	48 na	40 na	50 na	48 na
	338	70 na	32 na	35 na	43 na	38 na	19 na	50 na	42 na	42 na	52 na	46 na
	309	70 na	38 na	40 na	120 na	42 na	19 na	50 na	42 na	40 na	48 na	50 na
	308	70 na	41 na	33 na	40 na	37 na	18 na	42 na	44 na	38 na	50 na	50 na
	302	65 na	37 na	33 na	40 na	38 na	18 na	40 na	40 na	40 na	46 na	50 na
	278	65 na	40 na	40 na	38 na	35 na	19 na	44 na	46 na	38 na	48 na	50 na
	273	70 na	42 na	40 na	42 na	38 na	21 na	50 na	F/A	F/A	F/A	F/A
	271	70 na	39 na	35 na	35 na	35 na	19 na	40 na	40 na	38 na	44 na	56 na
ESR (SPEC: 1.5 Ohms	385	.713	1.664	1.407	.703	.703	.684	.684	.935	.701	.681	.613
	358	.724	1.664	1.190	.642	.594	.595	.614	.809	.711	.593	.877
	356	.708	1.639	1.190	.711	.713	.695	.716	.912	.717	.875	.642
	355	.713	1.664	1.190	.716	.676	.678	.698	F/A	F/A	F/A	F/A
	354	.701	1.664	1.173	.632	.586	.605	.625	.836	.700	.603	.642
	338	.724	1.689	1.208	.650	.623	.623	.643	.861	.701	.601	.621
	309	.698	1.639	1.167	.630	.661	.662	.623	.840	.688	.629	.622
	308	.707	1.639	1.178	.636	.609	.630	.669	.863	.680	.622	.649
	302	.735	1.664	1.203	.648	.621	.641	.641	.835	.699	.618	.638
	278	.705	1.639	1.174	.634	.585	.588	.608	.857	.665	.587	.587
	273	.707	1.639	1.180	.636	.630	.630	.630	F/A	F/A	F/A	F/A
	271	.703	1.664	1.164	.629	.600	.600	.620	.830	.656	.519	.579

NOTE

F/A INDICATES CAPACITOR REMOVED FROM TEST SINK AND FORWARDED TO FAILURE ANALYSIS LAB FOR INTERNAL SILVER ANALYSIS AND/OR FAILURE CAUSE ANALYSIS

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
40/60	.30/.40	10	+70

Table 2.4 - Test Data, -010 Wet Slug Capacitors Operated at 75% of Rated Ripple Current for 1000 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)		POST 60 HR HEAT SOAK #1		POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2		POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST SINEWAVE VIBRATION (50G)	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE	213	66.4 uf		66.4 uf			66.5 uf			66.4 uf	66.7 uf	66.5 uf	66.7 uf	66.6 uf	
	194	67.6 uf		67.7 uf			67.8 uf			67.6 uf	F/A	F/A	F/A	F/A	
	218	68.5 uf		68.6 uf			68.5 uf			68.5 uf	68.8 uf	68.7 uf	68.6 uf	68.5 uf	
	203	69.3 uf		69.0 uf			69.4 uf			69.4 uf	69.7 uf	69.4 uf	69.5 uf	69.4 uf	
	195	65.3 uf		65.4 uf			65.4 uf			65.3 uf	65.5 uf	65.4 uf	65.4 uf	65.3 uf	
	220	65.4 uf		65.5 uf			65.7 uf			65.5 uf	65.8 uf	65.8 uf	65.8 uf	65.7 uf	
	205	68.4 uf		68.5 uf			68.4 uf			68.5 uf	68.6 uf	68.5 uf	68.6 uf	68.5 uf	
	215	69.2 uf		68.8 uf			69.2 uf			69.2 uf	F/A	F/A	F/A	F/A	
	210	67.0 uf		67.0 uf			67.0 uf			67.2 uf	67.2 uf	67.1 uf	67.1 uf	67.0 uf	
	207	66.0 uf		66.4 uf			66.5 uf			66.1 uf	66.4 uf	66.2 uf	66.3 uf	66.1 uf	
(SPEC: 68µfd ± 5%)	211	69.1 uf		69.1 uf			69.2 uf			69.1 uf	69.4 uf	69.3 uf	69.3 uf	69.2 uf	
	222	65.0 uf		65.1 uf			65.0 uf			65.0 uf	65.3 uf	65.2 uf	65.3 uf	65.1 uf	
	199	65.9 uf		66.0 uf			66.2 uf			66.3 uf	F/A	F/A	F/A	F/A	
DC LEAKAGE CURRENT	213	90 na		32 na			30 na			52 na	40 na	40 na	52 na	56 na	
	194	80 na		32 na			28 na			70 ua	F/A	F/A	F/A	F/A	
	218	90 na		34 na			28 na			38 na	40 na	40 na	50 na	54 na	
	203	160 na		36 na			28 na			30 ua	500na	42 na	64 na	2.5ua	
	195	170 na		35 na			28 na			18 ua	46 na	40 na	46 na	90 ua	
	220	100 na		34 na			28 na			36 na	42 na	40 na	46 na	42 na	
	205	260 na		35 na			28 na			20 ua	42 na	46 na	46 na	5 ua	
	215	160 na		38 na			28 na			38 na	F/A	F/A	F/A	F/A	
	210	150 na		40 na			28 na			80 ua	46 na	46 na	44 na	9 ua	
	207	90 na		40 na			25 na			30 na	44 na	48 na	44 na	40 na	
(SPEC: 2000 na)	211	120 na		40 na			25 na			34 na	46 na	52 na	44 na	38 na	
	222	90 na		41 na			25 na			2 ua	50 na	50 na	42 na	36 na	
	199	100 na		40 na			25 na			30 ua	F/A	F/A	F/A	F/A	
ESR	213	1.207		1.799			1.196			1.198	1.372	1.196	1.113	1.155	
	194	1.335		1.646			1.056			1.177	F/A	F/A	F/A	F/A	
	218	1.162		1.741			1.045			1.045	1.233	1.042	1.005	1.007	
	203	1.241		1.731			1.146			1.185	1.370	1.146	1.145	1.185	
	195	1.219		1.704			1.095			1.117	1.316	1.135	1.095	1.117	
	220	1.339		1.823			1.210			1.255	1.431	1.290	1.209	1.231	
	205	1.280		1.860			1.163			1.239	1.430	1.239	1.179	1.220	
	215	1.243		1.620			1.150			1.150	F/A	F/A	F/A	F/A	
	210	1.188		1.664			1.187			1.107	1.302	1.146	1.087	1.108	
	207	1.367		1.799			1.196			1.304	1.478	1.302	1.240	1.324	
(SPEC: 1.5 Ohms)	211	1.152		1.613			1.150			1.113	1.299	1.148	1.052	1.073	
	222	1.323		1.712			1.224			1.224	1.442	1.220	1.198	1.222	
	199	1.208		1.689			1.082			1.120	F/A	F/A	F/A	F/A	

na = 10^{-9} amp
ua = 10^{-6} amp

NOTE

F/A INDICATES CAPACITOR REMOVED FROM TEST SINK AND FORWARDED TO FAILURE ANALYSIS LAB FOR INTERNAL SILVER ANALYSIS AND/OR FAILURE CAUSE ANALYSIS

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
40/60	.30/.40	10	+70

Table 2.5 - Test Data, -010 Wet Slug Capacitors with 2000 Hours of DC Life Test Time Operated at 75% of Rated Ripple Current for 1000 Hours

CAPACITANCE

(SPEC: 82μfd ± 5%)

CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
117	81.9 uf	80.0 uf	81.4 uf	82.0 uf	81.8 uf	82.0 uf	81.9 uf	82.1 uf	82.1 uf	82.1 uf	81.9 uf
113	82.6 uf	81.0 uf	82.5 uf	82.9 uf	82.7 uf	82.7 uf	82.7 uf	82.9 uf	82.9 uf	82.8 uf	82.6 uf
108	80.9 uf	83.0 uf	81.5 uf	81.6 uf	81.3 uf	81.6 uf	81.4 uf	81.7 uf	81.7 uf	81.5 uf	81.5 uf
104	82.6 uf	81.0 uf	82.4 uf	82.7 uf	82.7 uf	82.7 uf	82.6 uf	82.8 uf	82.8 uf	82.8 uf	82.8 uf
101	82.8 uf	82.0 uf	82.7 uf	82.7 uf	82.7 uf	82.9 uf	82.8 uf	83.0 uf	82.9 uf	83.0 uf	83.0 uf
086	81.0 uf	82.0 uf	81.4 uf	81.3 uf	81.3 uf	81.0 uf	80.8 uf	80.7 uf	80.7 uf	80.1 uf	80.0 uf
085	80.8 uf	82.0 uf	81.2 uf	80.9 uf	80.9 uf	80.8 uf	80.6 uf	80.9 uf	80.8 uf	80.7 uf	80.7 uf
082	81.0 uf	81.0 uf	81.2 uf	81.0 uf	81.0 uf	80.8 uf	80.7 uf	81.0 uf	80.9 uf	80.9 uf	80.9 uf
079	80.4 uf	79.0 uf	81.2 uf	80.4 uf	80.4 uf	80.5 uf	80.4 uf	80.7 uf	80.6 uf	80.5 uf	80.4 uf
075	81.8 uf	82.0 uf	81.9 uf	82.0 uf	81.9 uf	82.0 uf	82.0 uf	82.2 uf	82.1 uf	82.1 uf	82.1 uf
072	81.0 uf	81.0 uf	80.9 uf	81.3 uf	81.0 uf	81.4 uf	81.2 uf	81.4 uf	81.4 uf	81.4 uf	81.4 uf
070	81.4 uf	81.0 uf	81.4 uf	81.7 uf	81.3 uf	81.4 uf	81.5 uf	81.7 uf	81.6 uf	81.6 uf	81.5 uf
064	82.0 uf	82.0 uf	81.6 uf	82.0 uf	82.0 uf	81.9 uf	81.9 uf	82.1 uf	82.1 uf	82.1 uf	82.0 uf
044	80.8 uf	80.0 uf	80.3 uf	80.6 uf	80.6 uf	80.6 uf	80.6 uf	80.8 uf	80.8 uf	80.6 uf	F/A
039	82.5 uf	82.0 uf	82.3 uf	82.7 uf	82.8 uf	82.8 uf	82.6 uf	82.8 uf	82.8 uf	82.7 uf	82.7 uf

DC LEAKAGE CURRENT

(SPEC: 2000 na)

$na = 10^{-9}$ amp

$ua = 10^{-6}$ amp

CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
117	85 na	5 na	5 na	6 na	1.8 na	15 na	15 na	13 na	5 na	9 na	17 na
113	80 na	7 na	4 na	5.8na	1.4 na	12 na	14 na	12 na	5.4na	8 na	17 na
108	100 na	6 na	4 na	6 na	1.6 na	11 na	15 na	11 na	5 na	8 na	50 na
104	80 na	5 na	2 na	6 na	1.7 na	11 na	13 na	11 na	4.2na	8 na	14 na
101	480 na	160 na	4 na	250 na	1.0 na	150 na	8.4ua	600 na	220 na	8 na	2 ua
086	80 na	5 na	3 na	7.5na	1.0 na	10 na	3 ua	40 na	5 na	7 na	1 ua
085	90 na	5 na	2 na	7.5na	1.0 na	9 na	200 ua	12 na	6.2na	6 na	200na
082	75 na	8 na	2 na	9 na	1.0 na	9 na	1.3ua	9 na	5 na	6 na	600na
079	60 na	7 na	1 na	7.5na	1.2 na	9 na	9 na	8 na	5 na	5 na	12 na
075	70 na	6 na	2 na	6.5na	1.0 na	9 na	8 na	7 na	4 na	5 na	11 na
072	60 na	6 na	1 na	8 na	1.2 na	8 na	8 na	7 na	4 na	5 na	10 na
070	70 na	7 na	1 na	9 na	1.2 na	8 na	1.4ua	.6ua	50 na	200na	1 ua
064	75 na	6 na	2 na	10 na	1.0 na	8 na	4 ua	7 na	3.4na	6 na	12 na
044	70 na	6 na	2 na	10 na	1.1 na	8 na	14 ua	.7ua	100 na	1.3ua	F/A
039	65 na	9 na	2 na	12 na	1.0 na	8 na	7 na	6 na	3.4na	5 na	10 na

ESR

(SPEC: 1.5 Ohms)

CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
117	.778	1.592	1.369	.777	.681	.582	.664	.808	.662	.646	.648
113	.771	1.573	1.351	.704	.625	.593	.593	.672	.576	.576	.562
108	.787	1.535	1.370	.716	.603	.601	.668	.844	.682	.650	.618
104	.771	1.573	1.353	.706	.577	.577	.578	.769	.577	.576	.609
101	.962	1.554	1.540	1.021	.962	.960	.737	.879	.704	.686	.687
086	.786	1.554	1.565	.832	.783	.786	.821	1.019	.854	.927	.912
085	.788	1.554	1.373	.787	.705	.607	.675	.820	.689	.673	.657
082	.786	1.573	1.373	.704	.655	.607	.657	.819	.672	.554	.656
079	.792	1.613	1.373	.710	.660	.609	.660	.822	.675	.625	.660
075	.779	1.554	1.361	.696	.599	.598	.598	.790	.614	.597	.581
072	.786	1.573	1.378	.783	.688	.652	.670	.847	.652	.667	.652
070	.783	1.573	1.369	.698	.652	.603	.602	.779	.618	.601	.602
064	.777	1.554	1.366	.696	.679	.599	.648	.775	.614	.613	.647
044	.788	1.592	1.388	.790	.691	.707	.707	.886	.722	.690	F/A
039	.772	1.554	1.354	.690	.593	.593	.594	.769	.609	.593	.577

NOTE

F/A INDICATES CAPACITOR REMOVED FROM TEST SINK AND FORWARDED TO FAILURE ANALYSIS LAB FOR INTERNAL SILVER ANALYSIS AND/OR FAILURE CAUSE ANALYSIS

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
10/50	.17/.40	10	+70

Table 2.6 - Test Data, -007 Wet Slug Capacitors Operated at 42.5% of Rated Ripple Current for 1500 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 82µfd ± 5%)	018	82.2 uf	81.0 uf	82.3 uf	82.5 uf	82.5 uf	82.3 uf	82.3 uf	F/A	F/A	F/A	F/A
	320	81.7 uf	81.0 uf	81.1 uf	81.7 uf	81.2 uf	81.7 uf	81.7 uf	81.8 uf	81.7 uf	81.7 uf	81.7 uf
	314	81.8 uf	81.0 uf	82.0 uf	81.8 uf	81.4 uf	82.0 uf	81.7 uf	81.9 uf	81.7 uf	81.8 uf	81.9 uf
	306	80.7 uf	81.0 uf	81.0 uf	80.9 uf	80.8 uf	81.1 uf	80.9 uf	81.1 uf	80.8 uf	81.0 uf	81.0 uf
	303	82.5 uf	81.0 uf	82.4 uf	82.6 uf	82.2 uf	82.5 uf	82.5 uf	82.8 uf	82.6 uf	82.7 uf	82.6 uf
	286	82.3 uf	81.0 uf	82.4 uf	82.4 uf	82.3 uf	82.5 uf	82.3 uf	82.5 uf	82.4 uf	82.2 uf	82.5 uf
	265	83.7 uf	81.0 uf	83.9 uf	84.0 uf	83.9 uf	83.9 uf	84.0 uf	84.3 uf	84.1 uf	84.1 uf	84.0 uf
	264	82.9 uf	81.0 uf	82.9 uf	82.9 uf	82.6 uf	82.9 uf	82.9 uf	83.0 uf	82.8 uf	82.8 uf	82.8 uf
	252	82.0 uf	81.0 uf	82.0 uf	82.5 uf	82.2 uf	82.4 uf	82.3 uf	F/A	F/A	F/A	F/A
	471	82.0 uf	81.0 uf	82.0 uf	82.4 uf	82.0 uf	82.4 uf	82.3 uf	82.4 uf	82.1 uf	82.1 uf	82.3 uf
	445	81.3 uf	81.0 uf	81.6 uf	81.5 uf	81.5 uf	81.5 uf	81.3 uf	81.5 uf	81.3 uf	81.4 uf	81.4 uf
	421	83.0 uf	82.0 uf	83.0 uf	82.0 uf	83.1 uf	83.1 uf	82.9 uf	83.1 uf	82.8 uf	83.0 uf	83.0 uf
	418	82.0 uf	81.0 uf	82.0 uf	83.0 uf	82.3 uf	82.3 uf	82.1 uf	82.4 uf	82.0 uf	82.3 uf	82.3 uf
	404	80.9 uf	81.0 uf	81.0 uf	81.0 uf	81.1 uf	81.0 uf	80.9 uf	81.1 uf	80.9 uf	80.9 uf	80.9 uf
	390C	82.5 uf	81.0 uf	82.7 uf	82.7 uf	82.5 uf	82.6 uf	82.6 uf	82.8 uf	81.9 uf	80.4 uf	79.7 uf
	377	81.1 uf	81.0 uf	80.9 uf	81.3 uf	81.3 uf	81.3 uf	81.2 uf	81.4 uf	81.0 uf	81.2 uf	81.2 uf
	374	81.0 uf	81.0 uf	81.0 uf	81.0 uf	81.2 uf	81.2 uf	81.0 uf	F/A	F/A	F/A	F/A
	367	83.9 uf	82.0 uf	84.0 uf	83.9 uf	84.0 uf	83.9 uf	83.9 uf	84.0 uf	83.9 uf	83.9 uf	83.9 uf
	363	81.1 uf	81.0 uf	81.3 uf	81.4 uf	81.2 uf	81.3 uf	81.1 uf	81.4 uf	81.1 uf	81.3 uf	81.3 uf
	357	82.5 uf	81.0 uf	82.4 uf	82.7 uf	82.3 uf	82.6 uf	82.7 uf	82.9 uf	82.6 uf	82.8 uf	82.8 uf
	337	82.7 uf	81.0 uf	82.4 uf	82.7 uf	82.4 uf	82.6 uf	82.6 uf	82.9 uf	82.6 uf	82.7 uf	82.7 uf
	336	81.0 uf	82.0 uf	81.1 uf	81.0 uf	81.2 uf	81.1 uf	81.0 uf	81.1 uf	80.9 uf	81.1 uf	81.0 uf
	331C	81.7 uf	81.0 uf	81.5 uf	81.6 uf	81.4 uf	81.3 uf	81.0 uf	81.4 uf	81.0 uf	80.9 uf	80.9 uf
	331A	83.2 uf	82.0 uf	82.9 uf	82.7 uf	82.1 uf	82.4 uf	82.2 uf	82.3 uf	82.0 uf	79.9 uf	79.7 uf
	390A	82.0 uf	82.0 uf	82.0 uf	82.0 uf	81.9 uf	82.0 uf	82.0 uf	82.2 uf	81.9 uf	81.9 uf	82.0 uf
DC LEAKAGE CURRENT (SPEC: 2000 na) na = 10^{-9} amp ua = 10^{-6} amp	018	115 na	9 na	9 na	12 na	4 na	7 na	100 ua	F/A	F/A	F/A	F/A
	320	105 na	9 na	9 na	11 na	6 na	7 na	5 ua	860 na	6.8na	12 na	800 na
	314	90 na	11 na	8 na	13 na	2 na	8 na	14 na	14 na	6 na	10 na	13 na
	306	90 na	9 na	8 na	11 na	2 na	8 na	12 na	12 na	5.4na	9 na	13 na
	303	95 na	9 na	8 na	11 na	2 na	8 na	400 na	11 na	4.8na	10 na	380 na
	286	115 na	9 na	7 na	11 na	2 na	8 na	11 na	11 na	4.2na	9 na	12 na
	265	210 na	12 na	7 na	11 na	2 na	8 na	6 ua	11 na	5 na	9 na	11 na
	264	100 na	9 na	7 na	12 na	2 na	7 na	18 ua	11 na	4.4na	9 na	3.4ua
	252	90 na	9 na	6 na	10 na	2 na	7 na	10 na	F/A	F/A	F/A	F/A
	471	110 na	9 na	6 na	9 na	2 na	7 na	500 na	10 na	5 na	8 na	3.4ua
	445	115 na	9 na	6 na	9 na	2 na	7 na	3 ua	13 na	3.6na	9 na	130 na
	421	70 na	9 na	6 na	8 na	2 na	7 na	9 na	9 na	3 na	9 na	8 na
	418	80 na	9 na	5 na	8 na	2 na	6 na	9 na	10 na	4.6na	8 na	8 na
	404	90 na	9 na	5 na	9 na	2 na	6 na	9 ua	200 na	5.2na	10 na	2.8ua
	390C	100 na	9 na	5 na	8 na	2 na	6 na	20 ua	20 na	6.8na	10 na	3.2ua
	377	85 na	10 na	5 na	8 na	2 na	6 na	7 na	8 na	4.6na	8 na	9 ua
	374	95 na	9 na	5 na	8 na	2 na	5 na	40 ua				
	367	90 na	9 na	5 na	8 na	2 na	5 na	6 na	7 na	2 na	10 na	1.4ua
	363	80 na	8 na	5 na	8 na	2 na	5 na	300 na	8 na	2.2na	7 na	19 ua
	357	100 na	9 na	5 na	8 na	2 na	5 na	15 ua	1.5ua	12 na	8 na	1.4ua
	337	85 na	9 na	5 na	7 na	2 na	5 na	9 ua	8 na	2 na	7 na	.5ua
	336	90 na	9 na	5 na	7 na	2 na	5 na	12 ua	46 na	60 na	8 na	3.2ua
	331C	90 na	9 na	5 na	7 na	2 na	5 na	3 ua	9 na	2 na	7 na	3 ua
	331A	90 na	9 na	6 na	8 na	2 na	5 na	6 na	7 na	2 na	7 na	10 na
	390A	90 na	9 na	5 na	8 na	2 na	6 na	40 ua	60 na	54 na	26 na	11 ua
ESR (SPEC: 1.5 Ohms)	018	.678	1.573	1.354	.708	.611	.612	.661	F/A	F/A	F/A	F/A
	320	.682	1.573	1.374	.715	.637	.617	.665	.811	.665	.601	.601
	314	.681	1.573	1.359	.714	.586	.598	.584	.810	.665	.584	.599
	306	.691	1.573	1.376	.722	.591	.621	.606	.850	.673	.606	.606
	303	.676	1.573	1.256	.707	.581	.611	.579	1.585	.658	.561	.578
	286	.677	1.573	1.256	.709	.580	.611	.580	.852	.660	.597	.595
	265	.666	1.573	1.330	.695	.601	.632	.568	.786	.646	.583	.584
	264	.600	1.573	1.345	.768	.642	.608	.656	.927	.705	.641	.641
	252	.680	1.573	1.359	.708	.581	.612	.612	F/A	F/A	F/A	F/A
	471	.680	1.573	1.359	.709	.582	.612	.612	1.593	.614	.565	.580
	445	.686	1.573	1.366	.716	.618	.651	.620	.813	.620	.603	.619
	421	.671	1.554	1.343	.712	.590	.606	.608	.798	.673	.575	.575
	418	.777	1.573	1.359	.703	.580	.580	.581	1.593	.614	.564	.580
	404	.689	1.573	1.376	.721	.621	.622	.672	.867	.688	.623	.639
	390C	.772	1.573	1.348	.706	.643	.610	.642	.849	.680	.599	.614
	377	.785	1.573	1.378	.718	.620	.620	.653	.863	.688	.653	.621
	374	.885	1.573	1.573	.983	.980	.865	.655	F/A	F/A	F/A	F/A
	367	.664	1.554	1.327	.633	.600	.601	.569	.789	.632	.569	.569
	353	.785	1.573	1.371	.717	.686	.652	.670	.880	.703	.652	.897
	357	.772	1.573	1.353	.706	.612	.594	.609	.832	.658	.577	.593
	337	.674	1.573	1.353	.706	.595	.594	.578	1.584	.610	.577	.577
	336	.786	1.554	1.374	.721	.637	.621	.622	.867	.688	.621	.638
	331C	.780	1.573	1.368	.781	.652	.685	.693	.863	.720	.672	.787
	331A	.766	1.554	1.345	.770	.711	.708	.742	.967	.809	.979	.998
	390A	.777	1.554	1.359	.712	.615	.614	.684	.855	.680	.709	.799

NOTE

F/A INDICATES CAPACITOR REMOVED FROM TEST SINK AND FORWARDED TO FAILURE ANALYSIS LAB FOR INTERNAL SILVER ANALYSIS AND/OR FAILURE CAUSE ANALYSIS

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
10/50	.27/.40	10	+70

Table 2.7 - Test Data, -007 Wet Slug Capacitors Operated at 67.5% of Rated Ripple Current for 1000 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINE WAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 56μfd ± 5%)	064	54.0uf	53.6uf	54.0uf	53.9uf	53.9uf	53.8uf	53.9uf	53.9uf	NA	54.0uf	53.9uf
	058	56.3uf	55.6uf	56.2uf	56.2uf	56.2uf	56.2uf	56.3uf	56.3uf	NA	56.4uf	56.2uf
	056	55.5uf	55.6uf	55.3uf	55.5uf	55.5uf	55.4uf	55.5uf	55.5uf	NA	55.6uf	55.5uf
	054	55.0uf	54.6uf	54.6uf	54.9uf	54.9uf	54.8uf	54.9uf	54.7uf	NA	55.0uf	54.9uf
	053	55.5uf	55.6uf	55.2uf	55.4uf	55.4uf	55.4uf	55.4uf	55.5uf	NA	55.5uf	55.3uf
	059	56.1uf	55.6uf	56.0uf	56.2uf	56.1uf	56.1uf	56.2uf	56.2uf	NA	56.3uf	56.2uf
	060	56.2uf	55.6uf	56.0uf	56.2uf	56.1uf	56.1uf	56.2uf	56.2uf	NA	56.2uf	56.2uf
	035	56.2uf	54.6uf	56.0uf	56.2uf	56.1uf	56.1uf	56.1uf	56.1uf	NA	56.2uf	56.1uf
	061	55.2uf	55.0uf	55.0uf	55.2uf	55.3uf	55.2uf	55.3uf	55.3uf	NA	55.4uf	55.3uf
	065	55.5uf	54.6uf	55.2uf	55.2uf	55.4uf	55.4uf	55.5uf	55.5uf	NA	55.6uf	55.5uf
	028	55.0uf	54.6uf	55.0uf	55.0uf	54.9uf	54.9uf	55.0uf	55.0uf	NA	55.0uf	54.9uf
	031	56.2uf	55.6uf	56.1uf	56.0uf	56.1uf	56.1uf	56.1uf	56.1uf	NA	56.2uf	56.1uf
	034	55.3uf	55.6uf	55.0uf	55.3uf	55.2uf	55.1uf	55.2uf	55.3uf	NA	55.3uf	55.2uf
	030	55.5uf	55.6uf	55.0uf	55.3uf	55.5uf	55.5uf	55.6uf	55.6uf	NA	55.7uf	55.6uf
	029	55.6uf	55.6uf	55.4uf	55.3uf	55.5uf	55.5uf	55.6uf	55.6uf	NA	55.6uf	55.6uf
	032	56.0uf	55.6uf	55.6uf	56.0uf	55.9uf	55.9uf	56.0uf	56.0uf	NA	56.0uf	56.0uf
	033	55.4uf	54.7uf	55.2uf	55.3uf	55.3uf	55.3uf	55.4uf	55.4uf	NA	55.5uf	55.4uf
	062	56.2uf	54.7uf	56.0uf	56.0uf	56.0uf	56.0uf	56.1uf	56.1uf	NA	56.2uf	56.1uf
	066	56.1uf	55.6uf	56.0uf	56.0uf	56.1uf	56.1uf	56.2uf	56.2uf	NA	56.3uf	56.1uf
	027	55.5uf	55.6uf	55.0uf	55.3uf	55.4uf	55.4uf	55.5uf	55.5uf	NA	55.6uf	55.4uf
DC LEAKAGE CURRENT (SPEC: 2000 na) na = 10^{-9} amp ua = 10^{-6} amp	064	70 na	28 na	27.5na	32 na	10 na	34 na	36 na	24 na	NA	30 na	36 na
	058	80 na	34 na	27.5na	36 na	9 na	36 na	38 na	26 na	NA	32 na	40 na
	056	80 na	32 na	25 na	32 na	9 na	32 na	36 na	24 na	NA	30 na	36 na
	054	80 na	30 na	27 na	32 na	9 na	32 na	36 na	24 na	NA	30 na	36 na
	053	80 na	31 na	27 na	32 na	10 na	30 na	36 na	24 na	NA	30 na	34 na
	059	80 na	36 na	27 na	32 na	9 na	36 na	36 na	24 na	NA	28 na	36 na
	060	75 na	35 na	26 na	34 na	9 na	36 na	36 na	26 na	NA	30 na	36 na
	035	90 na	42 na	26 na	32 na	9 na	32 na	34 na	26 na	NA	28 na	34 na
	061	80 na	38 na	25 na	30 na	8 na	30 na	34 na	24 na	NA	28 na	34 na
	065	110 na	29 na	23 na	28 na	7 na	28 na	32 na	22 na	NA	26 na	32 na
	028	80 na	30 na	23 na	26 na	7 na	28 na	32 na	26 na	NA	26 na	32 na
	031	90 na	40 na	25 na	28 na	7 na	28 na	30 na	22 na	NA	26 na	32 na
	034	90 na	35 na	22 na	29 na	7 na	28 na	32 na	22 na	NA	26 na	30 na
	030	100 na	40 na	25 na	25 na	8 na	28 na	28 na	24 na	NA	28 na	34 na
	029	80 na	36 na	20 na	25 na	7 na	28 na	28 na	22 na	NA	24 na	28 na
	032	90 na	40 na	22 na	22 na	7 na	27 na	28 na	22 na	NA	22 na	30 na
	033	80 na	38 na	20 na	24 na	7 na	26 na	28 na	22 na	NA	24 na	30 na
	062	90 na	40 na	20 na	24 na	6 na	26 na	26 na	22 na	NA	24 na	26 na
	066	95 na	44 na	18 na	23 na	7 na	28 na	28 na	22 na	NA	22 na	28 na
	027	100 na	43 na	18 na	24 na	6 na	26 na	28 na	22 na	NA	26 na	28 na
ESR (SPEC: 1.5 Ohms)	064	.737	1.218	1.548	1.177	.615	.641	.640	.640	NA	.614	.640
	058	.707	1.174	1.488	1.129	.590	.614	.612	.612	NA	.588	.613
	056	.717	1.174	1.512	1.143	.597	.622	.621	.618	NA	.596	.621
	054	.724	1.196	1.531	1.155	.604	.629	.628	.630	NA	.603	.628
	053	.717	1.174	1.515	1.145	.598	.622	.622	.621	NA	.597	.623
	059	.710	1.174	1.493	1.129	.591	.615	.590	.614	NA	.589	.613
	060	.850	1.174	1.493	1.129	.591	.615	.590	.614	NA	.590	.613
	035	.708	1.196	1.493	1.129	.615	.615	.591	.615	NA	.590	.615
	061	.865	1.187	1.520	1.149	.719	.721	.743	.743	NA	.718	.743
	065	.717	1.196	1.515	1.149	.622	.622	.597	.621	NA	.596	.645
	028	.724	1.196	1.520	1.153	.628	.700	.603	.627	NA	.603	.652
	031	.708	1.174	1.490	1.133	.591	.615	.615	.615	NA	.590	.638
	034	.720	1.174	1.520	1.147	.601	.626	.625	.624	NA	.599	.649
	030	.717	1.174	1.520	1.147	.597	.621	.620	.620	NA	.595	.620
	029	.716	1.174	1.509	1.147	.621	.621	.668	.620	NA	.620	.620
	032	.711	1.174	1.504	1.133	.641	.664	.663	.663	NA	.616	.616
	033	.719	1.194	1.515	1.147	.623	.671	.670	.670	NA	.645	.622
	062	.708	1.194	1.493	1.133	.616	.616	.615	.615	NA	.590	.615
	066	.710	1.174	1.493	1.133	.591	.615	.614	.614	NA	.612	.615
	027	.717	1.174	1.520	1.147	.622	.670	.621	.621	NA	.620	.622

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
40/75	.25/.40	20	-37

Table 2.8 - Test Data, -024 Wet Slug Capacitors Operated at 62.5% of Rated Ripple Current for 1000 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 56µfd ± 5%)	017	56.1 uf	55.6 uf	55.1 uf	55.2 uf	55.2 uf	55.2 uf	55.3 uf	55.3 uf	N/A	55.3 uf	55.4 uf
	021	56.0 uf	55.6 uf	55.1 uf	55.2 uf	55.1 uf	55.1 uf	55.2 uf	55.0 uf		55.1 uf	55.2 uf
	001	56.3 uf	55.6 uf	55.4 uf	55.4 uf	55.4 uf	55.3 uf	54.9 uf	55.4 uf		55.4 uf	55.4 uf
	005	56.1 uf	55.6 uf	55.0 uf	55.4 uf	55.3 uf	55.3 uf	55.3 uf	55.2 uf		55.3 uf	55.4 uf
	003	55.6 uf	55.6 uf	56.1 uf	56.4 uf	56.2 uf	56.2 uf	56.3 uf	56.2 uf		56.3 uf	56.3 uf
	010	56.3 uf	55.6 uf	56.8 uf	56.8 uf	56.2 uf	56.8 uf	57.0 uf	56.2 uf		57.0 uf	57.0 uf
	008	56.4 uf	55.6 uf	55.4 uf	55.7 uf	55.6 uf	55.7 uf	55.7 uf	55.7 uf		55.7 uf	55.8 uf
	025	55.2 uf	55.6 uf	55.2 uf	55.7 uf	55.8 uf	56.0 uf	55.9 uf	55.8 uf		55.9 uf	55.9 uf
	009	56.1 uf	55.6 uf	55.2 uf	55.4 uf	55.3 uf	55.4 uf	55.5 uf	55.4 uf		55.5 uf	55.5 uf
	012	56.0 uf	55.6 uf	55.2 uf	55.2 uf	55.2 uf	55.1 uf	55.2 uf	55.1 uf		55.2 uf	55.3 uf
	024	56.2 uf	55.6 uf	55.4 uf	55.2 uf	55.3 uf	55.4 uf	55.4 uf	55.3 uf		55.3 uf	55.4 uf
	039	55.5 uf	54.6 uf	55.4 uf	55.2 uf	55.4 uf	55.4 uf	55.5 uf	55.4 uf		55.5 uf	55.5 uf
	040	53.5 uf	54.6 uf	53.2 uf	53.3 uf	53.4 uf	53.5 uf	53.4 uf	53.4 uf		53.5 uf	53.5 uf
	045	56.0 uf	54.6 uf	55.2 uf	56.0 uf	55.8 uf	55.8 uf	56.0 uf	55.8 uf		55.9 uf	55.9 uf
	042	55.7 uf	55.6 uf	55.2 uf	56.0 uf	55.4 uf	55.4 uf	55.4 uf	55.3 uf		55.4 uf	55.4 uf
	043	55.2 uf	54.6 uf	55.1 uf	55.4 uf	55.1 uf	55.1 uf	55.2 uf	55.1 uf		55.2 uf	55.2 uf
	041	56.4 uf	55.6 uf	56.1 uf	56.2 uf	56.2 uf	56.2 uf	56.3 uf	56.3 uf		56.3 uf	56.4 uf
	036	54.5 uf	54.6 uf	54.0 uf	54.4 uf	54.3 uf	54.4 uf	54.5 uf	54.4 uf		54.5 uf	54.5 uf
	038	56.3 uf	54.6 uf	55.9 uf	56.1 uf	56.1 uf	56.2 uf	56.3 uf	56.2 uf		56.2 uf	56.3 uf
	019	56.0 uf	54.6 uf	55.7 uf	56.0 uf	55.8 uf	55.8 uf	56.0 uf	55.8 uf		56.0 uf	56. 0 uf
	018	55.3 uf	55.6 uf	54.9 uf	55.3 uf	55.3 uf	55.3 uf	55.4 uf	55.3 uf		55.3 uf	55.4 uf
	022	55.2 uf	54.6 uf	54.6 uf	55.3 uf	55.0 uf	55.0 uf	55.1 uf	55.0 uf		55.2 uf	55.2 uf
	021	55.9 uf	55.6 uf	55.6 uf	55.7 uf	55.8 uf	55.8 uf	55.8 uf	55.7 uf		55.9 uf	55.7 uf
	026	56.3 uf	54.8 uf	55.6 uf	55.9 uf	56.2 uf	56.2 uf	56.3 uf	56.2 uf		56.3 uf	56.3 uf
	013	56.2 uf	54.6 uf	55.6 uf	55.9 uf	55.9 uf	56.0 uf	56.2 uf	56.1 uf	N/A	56.1 uf	56.2 uf
DC LEAKAGE CURRENT (SPEC: 2000 na) na = 10^{-9} amp ua = 10^{-6} amp	017	120 na	25 na	16 na	33 na	27 na	80 na	32 na	30 na	N/A	36 na	42 na
	021	100 na	24 na	16 na	31 na	27 na	68 na	34 na	30 na		30 na	42 na
	001	100 na	24 na	15 na	31 na	27 na	62 na	30 na	32 na		28 na	40 na
	005	100 na	23 na	16 na	30 na	26 na	68 na	30 na	28 na		28 na	38 na
	003	100 na	30 na	15 na	32 na	25 na	72 na	30 na	28 na		28 na	40 na
	010	85 na	27 na	15 na	32 na	28 na	60 na	30 na	30 na		27 na	38 na
	008	90 na	26 na	16 na	28 na	25 na	55 na	30 na	26 na		26 na	36 na
	025	85 na	28 na	13 na	28 na	24 na	55 na	28 na	26 na		26 na	36 na
	009	90 na	28 na	13 na	28 na	24 na	55 na	30 na	30 na		26 na	38 na
	012	85 na	26 na	10 na	26 na	21 na	55 na	28 na	26 na		24 na	34 na
	024	85 na	28 na	13 na	25 na	26 na	52 na	28 na	26 na		25 na	34 na
	039	100 na	26 na	12 na	25 na	22 na	40 na	26 na	24 na		24 na	32 na
	040	90 na	26 na	11 na	24 na	20 na	50 na	26 na	30 na		22 na	32 na
	045	100 na	30 na	12 na	26 na	20 na	52 na	26 na	24 na		24 na	30 na
	042	110 na	30 na	12 na	26 na	19 na	50 na	26 na	24 na		24 na	30 na
	043	100 na	28 na	12 na	26 na	19 na	50 na	24 na	22 na		22 na	28 na
	041	125 na	32 na	10 na	26 na	19 na	50 na	26 na	22 na		24 na	30 na
	036	90 na	28 na	12 na	23 na	19 na	50 na	24 na	22 na		20 na	30 na
	038	115 na	32 na	10 na	22 na	19 na	50 na	24 na	24 na		20 na	30 na
	019	100 na	36 na	11 na	22 na	19 na	48 na	24 na	24 na		22 na	28 na
	018	90 na	34 na	10 na	24 na	18 na	50 na	24 na	24 na		20 na	26 na
	022	90 na	30 na	10 na	22 na	17 na	50 na	22 na	20 na		18 na	26 na
	021	110 na	40 na	10 na	22 na	17 na	50 na	24 na	24 na		20 na	26 na
	026	110 na	40 na	10 na	22 na	17 na	50 na	24 na	20 na		18 na	26 na
	013	110 na	40 na	10 na	22 na	18 na	50 na	24 na	20 na	N/A	20 na	28 na
ESR (SPEC: 1.5 Ohms)	017	.852	1.174	1.590	1.149	.625	.601	.695	.671	N/A	.623	.670
	021	.853	1.174	1.590	1.149	.602	.602	.697	.627		.625	.601
	001	.849	1.174	1.581	1.145	.622	.599	.700	.622		.622	.598
	005	.852	1.174	1.592	1.145	.575	.599	.695	.625		.623	.598
	003	.859	1.174	1.561	1.125	.613	.590	.683	.613		.612	.589
	010	.849	1.174	1.542	1.167	.583	.700	.675	.661		.651	.651
	008	.847	1.174	1.581	1.139	.572	.595	.619	.595		.618	.594
	025	.865	1.174	1.587	1.139	.642	.592	.688	.689		.616	.664
	009	.852	1.174	1.587	1.145	.599	.622	.621	.598		.621	.597
	012	.853	1.174	1.587	1.149	.601	.626	.625	.602		.624	.575
	024	.850	1.174	1.581	1.149	.623	.622	.622	.671		.623	.622
	039	.717	1.196	1.581	1.149	.622	.622	.621	.670		.621	.621
	040	.744	1.196	1.646	1.190	.621	.644	.646	.621		.644	.595
	045	.711	1.196	1.587	1.133	.642	.618	.639	.665		.616	.617
	042	.715	1.174	1.587	1.133	.646	.622	.670	.671		.622	.670
	043	.721	1.196	1.590	1.145	.626	.626	.673	.626		.624	.601
	041	.706	1.174	1.561	1.129	.613	.613	.659	.612		.612	.588
	036	.730	1.196	1.622	1.164	.611	.634	.681	.634		.632	.608
	038	.707	1.196	1.567	1.131	.638	.613	.659	.613		.613	.589
	019	.711	1.196	1.572	1.133	.594	.618	.663	.594		.615	.592
	018	.720	1.174	1.595	1.147	.599	.623	.646	.671		.623	.598
	022	.721	1.196	1.604	1.147	.627	.627	.650	.675		.624	.625
	021	.712	1.174	1.575	1.139	.618	.618	.642	.667		.664	.667
	026	.707	1.191	1.575	1.135	.613	.613	.636	.661		.612	.612
	013	.708	1.196	1.575	1.135	.593	.616	.637	.662	N/A	.614	.613

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
40/75	.35/.40	20	-37

Table 2.9 - Test Data, -024 Wet Slug Capacitors Operated at 87.5% of Rated Ripple Current for 1500 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 39 µfd ± 5%)	026	38.0 uf	38.4 uf	38.0 uf	38.0 uf	38.0 uf	38.0 uf	37.5 uf	37.6 uf	37.2 uf	37.2 uf	37.1 uf
	021	38.4 uf	38.4 uf	39.0 uf	38.6 uf	38.6 uf	38.5 uf	38.6 uf	38.7 uf	38.7 uf	38.7 uf	38.7 uf
	097	38.0 uf	38.4 uf	38.2 uf	38.3 uf	38.3 uf	38.3 uf	38.3 uf	38.4 uf	38.4 uf	38.4 uf	38.4 uf
	014	38.0 uf	38.4 uf	38.2 uf	38.0 uf	38.0 uf	38.0 uf	37.9 uf	38.1 uf	38.1 uf	38.1 uf	38.1 uf
	101	37.9 uf	38.4 uf	38.2 uf	38.0 uf	38.0 uf	38.0 uf	37.9 uf	38.0 uf	38.0 uf	37.7 uf	37.3 uf
	093	37.6 uf	38.4 uf	38.1 uf	37.7 uf	37.7 uf	37.7 uf	37.6 uf	37.7 uf	37.7 uf	37.7 uf	37.7 uf
	081	38.0 uf	38.4 uf	37.7 uf	37.8 uf	37.8 uf	37.7 uf	37.7 uf	F/A	F/A	F/A	F/A
	067	38.6 uf	38.4 uf	38.6 uf	38.6 uf	38.6 uf	38.5 uf	37.8 uf	38.2 uf	38.2 uf	38.1 uf	38.2 uf
	060	38.2 uf	38.4 uf	38.3 uf	38.3 uf	38.2 uf	38.2 uf	39.1 uf	38.4 uf	38.3 uf	38.4 uf	F/A
	031	37.6 uf	38.4 uf	37.7 uf	37.7 uf	37.6 uf	37.6 uf	37.6 uf	37.8 uf	37.8 uf	37.8 uf	37.8 uf
	011	38.0 uf	38.4 uf	37.7 uf	37.8 uf	37.7 uf	37.7 uf	37.6 uf	37.8 uf	37.8 uf	37.8 uf	37.8 uf
	036	38.0 uf	38.4 uf	38.0 uf	38.0 uf	38.0 uf	38.0 uf	37.9 uf	38.1 uf	38.1 uf	38.1 uf	38.0 uf
	037	37.9 uf	38.4 uf	38.0 uf	37.9 uf	37.9 uf	37.9 uf	37.4 uf	38.1 uf	38.0 uf	38.0 uf	37.7 uf
	023	38.9 uf	38.4 uf	39.1 uf	39.0 uf	38.9 uf	38.9 uf	38.7 uf	38.2 uf	38.2 uf	38.2 uf	38.2 uf
	035	37.7 uf	38.4 uf	38.0 uf	37.8 uf	37.7 uf	37.7 uf	37.8 uf	F/A	F/A	F/A	F/A
	034	38.2 uf	38.4 uf	38.0 uf	38.3 uf	38.2 uf	38.2 uf	37.7 uf	38.2 uf	37.8 uf	37.7 uf	37.9 uf
	033	38.1 uf	38.4 uf	38.0 uf	38.1 uf	38.0 uf	38.0 uf	38.0 uf	38.2 uf	38.1 uf	38.1 uf	38.1 uf
	039	38.8 uf	38.4 uf	38.9 uf	38.8 uf	38.8 uf	38.8 uf	38.5 uf	38.9 uf	38.9 uf	38.7 uf	F/A
	041	37.4 uf	38.4 uf	37.3 uf	37.4 uf	37.3 uf	37.3 uf	37.3 uf	37.5 uf	37.4 uf	37.5 uf	37.4 uf
	042	38.4 uf	38.4 uf	38.4 uf	38.5 uf	38.4 uf	38.4 uf	38.4 uf	38.5 uf	38.6 uf	38.6 uf	38.6 uf
	040	37.2 uf	38.4 uf	37.3 uf	37.3 uf	37.2 uf	37.2 uf	37.1 uf	37.2 uf	37.3 uf	37.3 uf	37.3 uf
	047	38.0 uf	38.4 uf	38.0 uf	38.0 uf	38.0 uf	38.0 uf	37.9 uf	38.1 uf	38.1 uf	38.1 uf	38.1 uf
	027	38.4 uf	38.4 uf	38.5 uf	38.4 uf	38.4 uf	38.4 uf	38.0 uf	38.6 uf	38.5 uf	37.9 uf	37.9 uf
	050	38.7 uf	38.4 uf	38.8 uf	38.7 uf	38.8 uf	38.7 uf	38.6 uf	38.9 uf	38.8 uf	38.9 uf	38.8 uf
	051	38.8 uf	38.4 uf	38.7 uf	38.9 uf	38.9 uf	38.8 uf	38.9 uf	F/A	F/A	F/A	F/A
DC LEAKAGE CURRENT (SPEC: 1000 na) na = 10^{-9} amp ua = 10^{-6} amp	026	50 na	32 na	18 na	28 na	20 na	23 na	3 ma	800 ua	20 na	27 na	400 ua
	021	50 na	32 na	18 na	24 na	17 na	23 na	6 ua	70 na	24 na	26 na	3 ua
	097	50 na	35 na	16 na	23 na	17 na	20 na	4 ua	15 na	24 na	25 na	3 ua
	014	55 na	25 na	16 na	25 na	17 na	20 na	100 ua	180 na	64 na	200na	44 ua
	101	50 na	30 na	15 na	23 na	15 na	19 na	40 ua	50 na	22 na	26 na	100 ua
	093	50 na	26 na	15 na	21 na	15 na	19 na	16 ua	1 ua	20 na	23 na	24 ua
	081	55 na	34 na	14 na	21 na	15 na	19 na	2 ua	F/A	F/A	F/A	F/A
	067	50 na	28 na	14 na	22 na	17 na	19 na	200 ua	8.4ua	20 na	24 na	70 ua
	060	55 na	26 na	14 na	29 na	15 na	19 na	1 ma	180 ua	700 na	1.4ua	F/A
	031	55 na	28 na	14 na	19 na	15 na	20 na	50 na	14 na	20 na	18 na	20 na
	011	50 na	28 na	15 na	20 na	15 na	17 na	2.5ua	18 na	22 na	18 na	1 ua
	036	60 na	20 na	14 na	21 na	15 na	18 na	80 ua	180 na	200 na	110na	100 ua
	037	50 na	20 na	14 na	19 na	14 na	16 na	150 ua	110 na	36 na	20 na	160 ua
	023	60 na	24 na	12 na	18 na	15 na	16 na	80 ua	2.6 ua	22 na	20 na	5.4ua
	035	50 na	20 na	13 na	16 na	14 na	16 na	15 ma	F/A	F/A	F/A	F/A
	034	55 na	20 na	12 na	17 na	14 na	15 na	150 ua	1.5 ua	24 na	18 na	180 ua
	033	55 na	20 na	11 na	17 na	14 na	15 na	80 ua	200 na	26 na	28 na	28 ua
	039	55 na	20 na	12 na	18 na	14 na	15 na	500 ua	24 ua	26 na	150ua	F/A
	041	50 na	20 na	12 na	18 na	14 na	15 na	2 ua	18 na	24 na	16 na	200 na
	042	50 na	20 na	12 na	16 na	14 na	15 na	15 ua	2 ua	100 na	200na	20 ua
	040	60 na	22 na	13 na	16 na	17 na	15 na	15 ua	2 ua	24 na	15 na	10 ua
	047	50 na	23 na	12 na	17 na	17 na	15 na	3 na	22na	24 na	15 na	14 na
	027	50 na	22 na	13 na	16 na	14 na	14 na	.5 ma	2 ua	50 na	20 na	140 ua
	050	50 na	20 na	12 na	15 na	15 na	14 na	1.5 ma	25ua	220 na	100na	300 ua
	051	60 na	20 na	13 na	16 na	14 na	15 na	23 ma	F/A	F/A	F/A	F/A
ESR (SPEC: 2.9 Ohms)	026	.838	1.244	1.676	.838	.733	.698	1.096	1.340	.998	.998	1.072
	021	1.244	1.244	1.633	1.066	.928	.999	.996	1.268	.959	.993	.994
	097	1.257	1.244	1.668	1.247	1.073	1.073	1.177	1.278	1.070	1.277	1.070
	014	.838	1.244	1.668	.838	.977	.837	.840	1.114	.835	.835	.870
	101	.840	1.244	1.668	.838	.733	.837	.840	1.082	.837	.879	1.138
	093	1.080	1.244	1.672	1.056	.879	.914	.917	1.090	.914	.914	.914
	081	.838	1.244	1.690	.843	.772	.844	.703	F/A	F/A	F/A	F/A
	067	.825	1.244	1.650	.825	.824	.827	1.333	1.319	1.180	1.113	1.076
	060	.834	1.244	1.663	.832	.764	.903	6.104	1.036	.796	.759	F/A
	031	1.271	1.244	1.690	1.267	1.093	1.199	1.199	1.333	1.263	1.227	1.193
	011	.838	1.244	1.690	.843	.844	.844	.846	1.087	.877	.877	.877
	036	.838	1.244	1.676	.838	.837	.803	.840	1.044	.835	.800	.837
	037	.840	1.244	1.676	.840	.840	.805	.993	1.044	.803	.837	.985
	023	.819	1.244	1.629	.817	.682	.750	.822	1.423	1.250	1.214	1.284
	035	.845	1.244	1.676	.843	.774	.809	2.526	F/A	F/A	F/A	F/A
	034	.834	1.244	1.676	.832	.764	.833	1.020	1.041	1.052	1.055	1.015
	033	.836	1.244	1.676	.836	.872	.907	.837	1.041	.835	.800	.835
	039	.821	1.244	1.228	.821	.684	.684	1.102	.989	.750	.788	F/A
	041	.852	1.244	1.708	.852	.782	.824	.853	1.025	.851	.848	.851
	042	.829	1.244	1.659	.827	.760	.760	.829	.999	.790	.755	.756
	040	1.092	1.244	1.708	1.067	.891	.927	1.001	1.212	.889	.924	.995
	047	.838	1.244	1.676	.838	.872	.872	.840	1.044	.870	.835	.835
	027	.829	1.244	1.655	.829	.760	.760	1.012	.893	.758	1.014	1.050
	050	.823	1.244	1.642	.823	.752	.822	1.649	.989	.752	.749	.684
	051	.821	1.244	1.646	.819	.750	.684	2.454	F/A	F/A	F/A	F/A

NOTE

F/A INDICATES CAPACITOR REMOVED FROM TEST SINK AND FORWARDED TO FAILURE ANALYSIS LAB FOR INTERNAL SILVER ANALYSIS AND/OR FAILURE CAUSE ANALYSIS

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
40/60	.10/.25	72	70

Table 2.10 - Test Data, -021 Wet Slug Capacitors Operated at 40% of Rated Ripple Current for 1500 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 580 µfd +75%, -15%)	216	718 uf	545 uf	640 uf	640 uf	690 uf	711 uf	709 uf	716 uf	NA	716 uf	716 uf
	225	647 uf	546 uf	640 uf	640 uf	650 uf	662 uf	663 uf	658 uf	NA	655 uf	655 uf
	218	748 uf	545 uf	640 uf	730 uf	700 uf	735 uf	733 uf	734 uf	NA	736 uf	735 uf
	226	658 uf	545 uf	640 uf	660 uf	670 uf	658 uf	653 uf	654 uf	NA	655 uf	654 uf
	227	662 uf	565 uf	640 uf	650 uf	650 uf	648 uf	651 uf	650 uf	NA	652 uf	646 uf
	223	601 uf	546 uf	640 uf	620 uf	620 uf	601 uf	602 uf	600 uf	NA	601 uf	603 uf
	213	673 uf	545 uf	640 uf	660 uf	670 uf	673 uf	674 uf	671 uf	NA	674 uf	673 uf
	211	598 uf	545 uf	640 uf	620 uf	620 uf	600 uf	602 uf	600 uf	NA	600 uf	600 uf
	217	678 uf	545 uf	640 uf	660 uf	660 uf	665 uf	665 uf	664 uf	NA	664 uf	664 uf
	204	673 uf	545 uf	640 uf	660 uf	680 uf	672 uf	670 uf	670 uf	NA	670 uf	670 uf
	205	700 uf	545 uf	640 uf	680 uf	690 uf	693 uf	691 uf	690 uf	NA	690 uf	692 uf
DC LEAKAGE CURRENT (SPEC: 9,000 na) na = 10^{-9} amp ua = 10^{-6} amp	216	1.9 ua	2.1 ua	920 na	2.5 ua	.72 ua	2.5 ua	1.5 ua	1.0 ua	NA	1.0 ua	.8 ua
	225	1.9 ua	2.3 ua	860 na	2.4 ua	.7 ua	2.5 ua	1.8 ua	1.0 ua	NA	1.0 ua	.72 ua
	218	1.9 ua	2.2 ua	870 na	2.4 ua	.75 ua	2.0 ua	1.7 ua	1.0 ua	NA	1.0 ua	.8 ua
	226	1.9 ua	2.1 ua	780 na	2.0 ua	.6 ua	2.0 ua	1.6 ua	1.0 ua	NA	1.0 ua	.7 ua
	227	1.9 ua	2.3 ua	790 na	2.4 ua	.78 ua	2.0 ua	1.6 ua	1.0 ua	NA	1.0 ua	.75 ua
	223	1.8 ua	2.0 ua	570 na	2.0 ua	.62 ua	1.75 ua	1.5 ua	.9 ua	NA	1.0 ua	.7 ua
	213	1.9 ua	2.4 ua	640 na	2.4 ua	.6 ua	1.8 ua	1.5 ua	.9 ua	NA	.8 ua	.7 ua
	211	1.5 ua	2.0 ua	580 na	2.4 ua	.52 ua	1.8 ua	1.0 ua	.8 ua	NA	.8 ua	.6 ua
	217	1.5 ua	2.4 ua	600 na	2.2 ua	.58 ua	1.8 ua	1.4 ua	.8 ua	NA	.8 ua	.6 ua
	204	1.85 ua	3.0 ua	790 na	2.4 ua	.8 ua	2.0 ua	1.5 ua	1.0 ua	NA	.9 ua	.7 ua
	205	1.75 ua	3.4 ua	660 na	1.8 ua	.65 ua	2.0 ua	1.6 ua	1.0 ua	NA	.8 ua	.6 ua
ESR (SPEC: 0.46 Ohms)	216	.443	1.460	2.238	.849	3.459	.403	.404	.400	NA	.333	.556
	225	.492	1.457	1.989	.849	4.896	.433	.432	.435	NA	.437	.437
	218	.425	1.460	2.238	.654	3.410	.390	.391	.390	NA	.389	.368
	226	.484	1.460	1.989	.824	3.562	.435	.439	.438	NA	.437	.414
	227	.481	1.408	1.989	.836	4.080	.442	.440	.441	NA	.439	.419
	223	.530	1.457	1.989	.770	3.850	.450	.449	.398	NA	.424	.422
	213	.473	1.460	1.989	.723	3.958	.402	.425	.356	NA	.401	.378
	211	.532	1.460	1.989	.770	3.850	.451	.449	.398	NA	.398	.398
	217	.469	1.460	1.989	.723	4.018	.407	.407	.359	NA	.383	.383
	204	.473	1.460	1.989	.824	3.900	.426	.427	.427	NA	.404	.404
	205	.455	1.460	1.989	.702	3.843	.413	.415	.369	NA	.392	.391

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
10/15	1.5/3.2	5	80

Table 2.11 - Test Data, Case Size G-5 Wet Foil Capacitors
Operated at 47% of Rated Ripple Current for 1000 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 200µfd +75%, -15%)	014	230 µf	230 µf	228 µf	228 µf	229 µf	229 µf	229 µf	N/A	N/A	229 µf	229 µf
	018	224 µf	226 µf	224 µf	224 µf	225 µf	225 µf	225 µf	N/A	N/A	225 µf	225 µf
	021	217 µf	217 µf	214 µf	214 µf	215 µf	215 µf	215 µf	N/A	N/A	215 µf	215 µf
	022	222 µf	222 µf	221 µf	221 µf	222 µf	221 µf	223 µf	N/A	N/A	223 µf	223 µf
	024	229 µf	229 µf	226 µf	226 µf	227 µf	225 µf	227 µf	N/A	N/A	227 µf	227 µf
	031	225 µf	224 µf	222 µf	222 µf	223 µf	225 µf	224 µf	N/A	N/A	224 µf	224 µf
	032	218 µf	219 µf	217 µf	217 µf	218 µf	216 µf	217 µf	N/A	N/A	217 µf	217 µf
	038	223 µf	222 µf	220 µf	220 µf	221 µf	219 µf	221 µf	N/A	N/A	221 µf	221 µf
	043	215 µf	212 µf	211 µf	211 µf	212 µf	211 µf	212 µf	N/A	N/A	212 µf	212 µf
	049	212 µf	212 µf	210 µf	210 µf	212 µf	211 µf	212 µf	N/A	N/A	212 µf	212 µf
	052	220 µf	222 µf	221 µf	222 µf	222 µf	221 µf	222 µf	N/A	N/A	222 µf	222 µf
	062	214 µf	214 µf	211 µf	212 µf	213 µf	213 µf	213 µf	N/A	N/A	213 µf	213 µf
	059	219 µf	218 µf	217 µf	217 µf	217 µf	217 µf	217 µf	N/A	N/A	217 µf	217 µf
	058	220 µf	222 µf	221 µf	221 µf	222 µf	222 µf	222 µf	N/A	N/A	222 µf	222 µf
	055	220 µf	222 µf	221 µf	221 µf	222 µf	222 µf	222 µf	N/A	N/A	222 µf	222 µf
	002	214 µf	216 µf	215 µf	218 µf	215 µf	215 µf	215 µf	N/A	N/A	215 µf	215 µf
	005	220 µf	220 µf	218 µf	218 µf	219 µf	219 µf	219 µf	N/A	N/A	219 µf	219 µf
	009	229 µf	228 µf	226 µf	225 µf	227 µf	227 µf	227 µf	N/A	N/A	227 µf	227 µf
	010	218 µf	216 µf	214 µf	216 µf	215 µf	215 µf	215 µf	N/A	N/A	215 µf	215 µf
	011	223 µf	226 µf	224 µf	224 µf	225 µf	225 µf	225 µf	N/A	N/A	225 µf	225 µf
	013	234 µf	238 µf	237 µf	235 µf	238 µf	238 µf	238 µf	N/A	N/A	238 µf	238 µf
	054	220 µf	218 µf	217 µf	217 µf	217 µf	213 µf	217 µf	N/A	N/A	217 µf	217 µf
DC LEAKAGE CURRENT (SPEC: 3000 na) na = 10^{-9} amp ua = 10^{-6} amp	014	.72 ua	800 na	200 na	540 na	210 na	.44 ua	360 na	N/A	N/A	180 na	170 na
	018	.58 ua	750 na	200 na	520 na	200 na	.44 ua	340 na	N/A	N/A	170 na	160 na
	021	.66 ua	700 na	200 na	480 na	180 na	. 4 ua	320 na	N/A	N/A	160 na	150 na
	022	.53 ua	800 na	190 na	540 na	170 na	.44 ua	380 na	N/A	N/A	160 na	150 na
	024	.57 ua	800 na	190 na	520 na	170 na	.42 ua	360 na	N/A	N/A	160 na	150 na
	031	.61 ua	700 na	180 na	440 na	160 na	. 4 ua	320 na	N/A	N/A	150 na	140 na
	032	.55 ua	720 na	180 na	500 na	160 na	. 4 ua	340 na	N/A	N/A	150 na	140 na
	038	.53 ua	720 na	180 na	500 na	160 na	. 4 ua	340 na	N/A	N/A	150 na	130 na
	043	.48 ua	700 na	170 na	440 na	150 na	.38 us	320 na	N/A	N/A	140 na	130 na
	049	.52 ua	640 na	160 na	460 na	150 na	.41 ua	340 na	N/A	N/A	140 na	120 na
	052	.53 ua	650 na	160 na	440 na	150 na	.54 ua	500 na	N/A	N/A	140 na	120 na
	062	.67 ua	630 na	150 na	420 na	140 na	. 4 ua	420 na	N/A	N/A	150 na	160 na
	059	.67 ua	630 na	150 na	400 na	130 na	. 4 ua	400 na	N/A	N/A	140 na	160 na
	058	.65 ua	680 na	160 na	420 na	140 na	. 4 ua	420 na	N/A	N/A	150 na	160 na
	055	.73 ua	750 na	170 na	440 na	140 na	.52 ua	500 na	N/A	N/A	150 na	160 na
	002	.68 ua	750 na	160 na	460 na	140 na	.44 ua	440 na	N/A	N/A	150 na	160 na
	005	.71 ua	600 na	150 na	400 na	130 na	. 4 ua	400 na	N/A	N/A	140 na	150 na
	009	.71 ua	680 na	170 na	440 na	140 na	.45 ua	460 na	N/A	N/A	150 na	160 na
	010	. 6 ua	600 na	140 na	380 na	120 na	.38 ua	400 na	N/A	N/A	130 na	140 na
	011	.57 ua	620 na	150 na	380 na	120 na	.38 ua	400 na	N/A	N/A	130 na	140 na
	013	.63 ua	650 na	150 na	420 na	130 na	.43 ua	420 na	N/A	N/A	140 na	150 na
	054	.61 ua	600 na	150 na	400 na	130 na	. 4 ua	420 na	N/A	N/A	135 na	130 na
ESR (SPEC: 1.33 Ohms)	014	6.918	.761	.837	.837	.764	.764	.764	N/A	N/A	.764	.764
	018	7.104	.774	.781	.781	.849	1.414	2.534	N/A	N/A	.849	.919
	021	7.333	.733	.818	.818	.777	.814	.814	N/A	N/A	.814	.740
	022	7.168	.788	.792	.792	.747	.780	.785	N/A	N/A	.785	.785
	024	6.948	.764	.774	.774	.759	.796	.771	N/A	N/A	.771	.771
	031	7.072	.781	.788	.788	.773	.796	.781	N/A	N/A	.781	.781
	032	7.299	.799	.807	.807	.772	.810	.807	N/A	N/A	.807	.807
	038	7.135	.788	.796	.796	.756	.799	.792	N/A	N/A	.792	.792
	043	7.401	.751	.830	.830	.794	.767	.826	N/A	N/A	.826	.826
	049	7.506	.826	.833	.833	.794	.786	.826	N/A	N/A	.826	.826
	052	7.233	.717	.792	.788	.735	.750	.717	N/A	N/A	.788	.788
	062	7.436	.818	.830	.826	.766	.822	.822	N/A	N/A	.882	.747
	059	7.266	.730		.880	.752	.807	.807	N/A	N/A	.807	.807
	058	7.233	.788	.792	.794	.765	.788	.788	N/A	N/A	.788	.788
	055	7.233	.788	.864	.794	.806	.788	.860	N/A	N/A	.788	.788
	002	7.436	.810	.814	.803	.777	.814	.814	N/A	N/A	.814	.740
	005	7.233	.796	.803	.803	.763	.799	.799	N/A	N/A	.799	.799
	009	6.948	.768	.845	.849	.771	.771	.841	N/A	N/A	.841	.771
	010	7.299	.810	.818	.884	.789	.814	.814	N/A	N/A	.814	.814
	011	7.135	.774	.781	.781	.754	.778	.778	N/A	N/A	.778	.778
	013	6.80	.735	.806	.745	.769	.802	.802	N/A	N/A	.802	.735
	054	7.233	.803	.807	.807	.800	.822	.807	N/A	N#A	.807	.807

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
6/15	0.425/	50	70

Table 2.12 - Test Data, Case Size G-3 Wet Foil Capacitors
Operated at 12.1% of Rated Ripple Current for 1000 Hours

	CAPACITOR S/N	INITIAL READINGS (RATED VOLTAGE)	POST 60 HR HEAT SOAK #1	POST 100 HR RIPPLE APPLICATION #1	POST 60 HR HEAT SOAK #2	POST 200 HR RIPPLE APPLICATION #2	POST 60 HR HEAT SOAK #3	POST SINEWAVE VIBRATION (50G)	POST 20 HR RIPPLE APPLICATION #3	POST 150 HR RIPPLE APPLICATION #3	POST 700/1200 HR RIPPLE APPLICATION #3	POST RANDOM VIBRATION
CAPACITANCE (SPEC: 100µfd +50%, -15%)	017	106 µf	105.1µf	105.0µf	105.0µf	105.0µf	105.0µf	105.0µf	N/A	N/A	105 µf	105 µf
	019	95 µf	94.8µf	94.9µf	95.0µf	95.0µf	95.0µf	94.8µf	N/A	N/A	94.8µf	94.8µf
	030	95 µf	94.5µf	94.5µf	94.5µf	94.0µf	94.4µf	94.4µf	N/A	N/A	94.4µf	94.4µf
	023	94 µf	94.0µf	94.1µf	94.1µf	94.0µf	94.0µf	94.0µf	N/A	N/A	94.0µf	94.2µf
	100	100 µf	99.6µf	99.7µf	99.7µf	100.0µf	100.0µf	99.6µf	N/A	N/A	99.6µf	99.7µf
	062	100 µf	100.0µf	99.9µf	99.9µf	100.0µf	100.0µf	100.0µf	N/A	N/A	100 µf	100 µf
	090	89 µf	89.0µf	89.2µf	89.2µf	89.0µf	89.0µf	89.0µf	N/A	N/A	89 µf	89.3µf
	047	89 µf	89.2µf	89.3µf	89.3µf	89.0µf	89.0µf	89.3µf	N/A	N/A	89.3µf	89.5µf
	045	98 µf	97.4µf	97.5µf	97.5µf	98.0µf	97.0µf	97.4µf	N/A	N/A	97.4µf	97.6µf
	044	89 µf	88.5µf	88.6µf	88.7µf	90.9µf	88.0µf	88.5µf	N/A	N/A	88.5µf	88.6µf
	043	104 µf	103.5µf	103.6µf	103.5µf	105.0µf	105.0µf	103.0µf	N/A	N/A	103 µf	103 µf
	040	99 µf	98.2µf	98.2µf	98.2µf	98 µf	98 µf	98 µf	N/A	N/A	98.0µf	98.3µf
	039	95 µf	94.8µf	94.8µf	94.7µf	95 µf	94 µf	95 µf	N/A	N/A	95.0µf	94.9µf
	036	88 µf	88.0µf	88.0µf	97.9µf	88 µf	87 µf	88 µf	N/A	N/A	88.0µf	88.0µf
	038	95 µf	94.3µf	94.2µf	94.2µf	94 µf	93 µf	94 µf	N/A	N/A	94.0µf	94.3µf
	035	91 µf	90.0µf	90.2µf	90.2µf	90 µf	90 µf	90 µf	N/A	N/A	90.0µf	90.2µf
	034	93 µf	93.1µf	93.0µf	92.9µf	93 µf	92 µf	93 µf	N/A	N/A	93.0µf	93.1µf
	032	89 µf	89.9µf	88.9µf	89.0µf	89 µf	89 µf	89 µf	N/A	N/A	89.0µf	88.9µf
	027	111 µf	115.0µf	111.6µf	111.6µf	112 µf	111 µf	111 µf	N/A	N/A	111.0µf	111.0µf
	026	97 µf	96.3µf	96.4µf	96.5µf	96 µf	96 µf	96 µf	N/A	N/A	96.0µf	96.4µf
	025	103 µf	102.9µf	103.0µf	103.0µf	103 µf	102 µf	103 µf	N/A	N/A	103.0µf	103.0µf
	024	90 µf	89.5µf	89.5µf	89.7µf	90 µf	90 µf	90 µf	N/A	N/A	90.0µf	89.7µf
DC LEAKAGE CURRENT (SPEC: 4000 na) na = 10^{-9} amp ua = 10^{-6} amp	017	.57 ua	450 na	110 na	140 na	110 na	.24 ua	100 na	N/A	N/A	110 na	120 na
	019	.40 ua	430 na	100 na	120 na	100 na	.24 ua	20 na	N/A	N/A	100 na	100 na
	030	.55 ua	400 na	100 na	110 na	90 na	.20 ua	160 na	N/A	N/A	100 na	100 na
	023	.36 ua	400 na	100 na	110 na	90 na	.20 ua	160 na	N/A	N/A	90 na	100 na
	100	.57 ua	450 na	100 na	120 na	100 na	.20 ua	180 na	N/A	N/A	100 na	100 na
	062	.46 ua	300 na	100 na	120 na	100 na	.20 ua	180 na	N/A	N/A	100 na	100 na
	090	.40 ua	300 na	80 na	90 na	80 na	.16 ua	180 na	N/A	N/A	80 na	100 na
	047	1.20 ua	700 na	100 na	130 na	100 na	.20 ua	180 na	N/A	N/A	90 na	100 na
	045	.30 ua	350 na	90 na	120 na	100 na	.20 ua	160 na	N/A	N/A	100 na	100 na
	044	.40 ua	400 na	80 na	110 na	80 na	.18 ua	160 na	N/A	N/A	80 na	80 na
	043	.30 ua	350 na	100 na	120 na	90 na	.20 ua	180 na	N/A	N/A	90 na	100 na
	040	.25 ua	400 na	80 na	110 na	90 na	.16 ua	160 na	N/A	N/A	100 na	130 na
	039	.30 ua	420 na	80 na	100 na	80 na	.16 ua	150 na	N/A	N/A	100 na	120 na
	036	.18 ua	350 na	80 na	100 na	80 na	.16 ua	140 na	N/A	N/A	90 na	110 na
	038	.18 ua	350 na	80 na	110 na	80 na	.16 ua	150 na	N/A	N/A	90 na	110 na
	035	.18 ua	300 na	70 na	90 na	80 na	.15 ua	140 na	N/A	N/A	90 na	110 na
	034	.18 ua	300 na	70 na	100 na	80 na	.14 ua	150 na	N/A	N/A	90 na	100 na
	032	.18 ua	250 na	80 na	80 na	80 na	.13 ua	130 na	N/A	N/A	80 na	100 na
	027	.28 ua	300 na	90 na	100 na	90 na	.16 ua	160 na	N/A	N/A	100 na	130 na
	026	.11 ua	250 na	80 na	90 na	78 na	.14 ua	150 na	N/A	N/A	90 na	100 na
	025	.20 ua	300 na	90 na	100 na	80 na	.15 ua	160 na	N/A	N/A	100 na	111 na
	024	.72 ua	600 na	80 na	110 na	80 na	.14 ua	140 na	N/A	N/A	85 na	100 na
ESR (SPEC: 1.99 Ohms)	017	.525	.555	.581	.606	.606	.758	.580	N/A	N/A	.581	.581
	019	.502	.532	.503	.516	.530	.670	.545	N/A	N/A	.546	.559
	030	.502	.533	.533	.533	.592	.677	.547	N/A	N/A	.548	.562
	023	.508	.536	.564	.592	.592	.677	.564	N/A	N/A	.550	.521
	100	.557	.586	.612	.638	.636	.636	.639	N/A	N/A	.639	.585
	062	.557	.530	.571	.584	.557	.636	.570	N/A	N/A	.570	.583
	090	.536	.551	.550	.565	.536	.536	.566	N/A	N/A	.566	.535
	047	.536	.550	.564	.594	.536	.536	.579	N/A	N/A	.579	.548
	045	.649	.599	.598	.626	.649	.656	.612	N/A	N/A	.613	.625
	044	.536	.599	.614	.643	.568	.723	.629	N/A	N/A	.629	.599
	043	.536	.525	.538	.589	.606	.568	.553	N/A	N/A	.554	.515
	040	.563	.567	.567	.581	.609	.609	.649	N/A	N/A	.555	.553
	039	.586	.573	.587	.602	.586	.635	.670	N/A	N/A	.586	.573
	036	.633	.618	.633	.582	.678	.686	.723	N/A	N/A	.633	.618
	038	.586	.619		.648	.677	.642	.677	N/A	N/A	.592	.647
	035	.525	.588	.617	.632	.619	.648	.707	N/A	N/A	.619	.603
	034	.513	.584	.599	.599	.642	.649	.684	N/A	N/A	.599	.584
	032	.536	.649	.686	.685	.685	.670	.715	N/A	N/A	.626	.686
	027	.573	.530	.558	.618	.568	.538	.573	N/A	N/A	.502	.561
	026	.656	.620	.743	.742	.663	.622	.663	N/A	N/A	.663	.729
	025	.618	.631	.644	.669	.618	.585	.618	N/A	N/A	.618	.682
	024	.530	.533	.548	.562	.575	.575	.530	N/A	N/A	.619	.547

RIPPLE CURRENT APPLICATION			
DC BIAS TEST/RATED (VOLTS)	RIPPLE CURRENT TEST/RATED (AMPS-RMS)	RIPPLE FREQ (KHZ)	OPER TEMP (°C)
35/50	0.425/	72	70

Table 2.13 - Test Data, Case Size G-4 Wet Foil Capacitors
Operated at 12.1% of Rated Ripple Current for 1000 Hours

Case Size	Amp-Hours
GT-1	60
GT-2	705
GT-3	1215

3. Those wet slug tantalum capacitors whose DC leakage current went out-of-spec after vibration would not be included in the population used to assess performance in ripple current applications.

2.2.1 Wet Slug Tantalum Capacitors

Three groups of case size GT-3 wet slug tantalum capacitors (Dash Nos.: -007, -010 and -024) were subjected to the ripple current test. Figure 2.4 is a family of curves which illustrate electrical performance trends versus part and design requirements for the GT-3 case size wet slug capacitors. Shown are ratios of measured parameter values to parameter spec values for ESR, Capacitance and DC leakage current plotted as a function of stress (i.e., ripple current amp-hours). Important milestones in the test program such as the end of each 60 hour sterilization heat soak cycle and the end of 50 G sinewave vibration testing are identified. All MMC measured data are presented as solid lines. Corroborating data from LRC FID are shown as dashed lines.

The LRC FID data is based upon -007 MIL-SPEC equivalent wet slug tantalum capacitors that were subjected to ripple currents of twice their rated value. The LRC FID tests, which were at ripple current frequencies of 120 Hz, 1.2 KHz, 12 KHz and 120 KHz, were basically a life test since no other stresses were induced. Measurements were made at the 100, 300, 500, 1000, 1500, 2000, 2500, and 3000 hour points during the tests. The

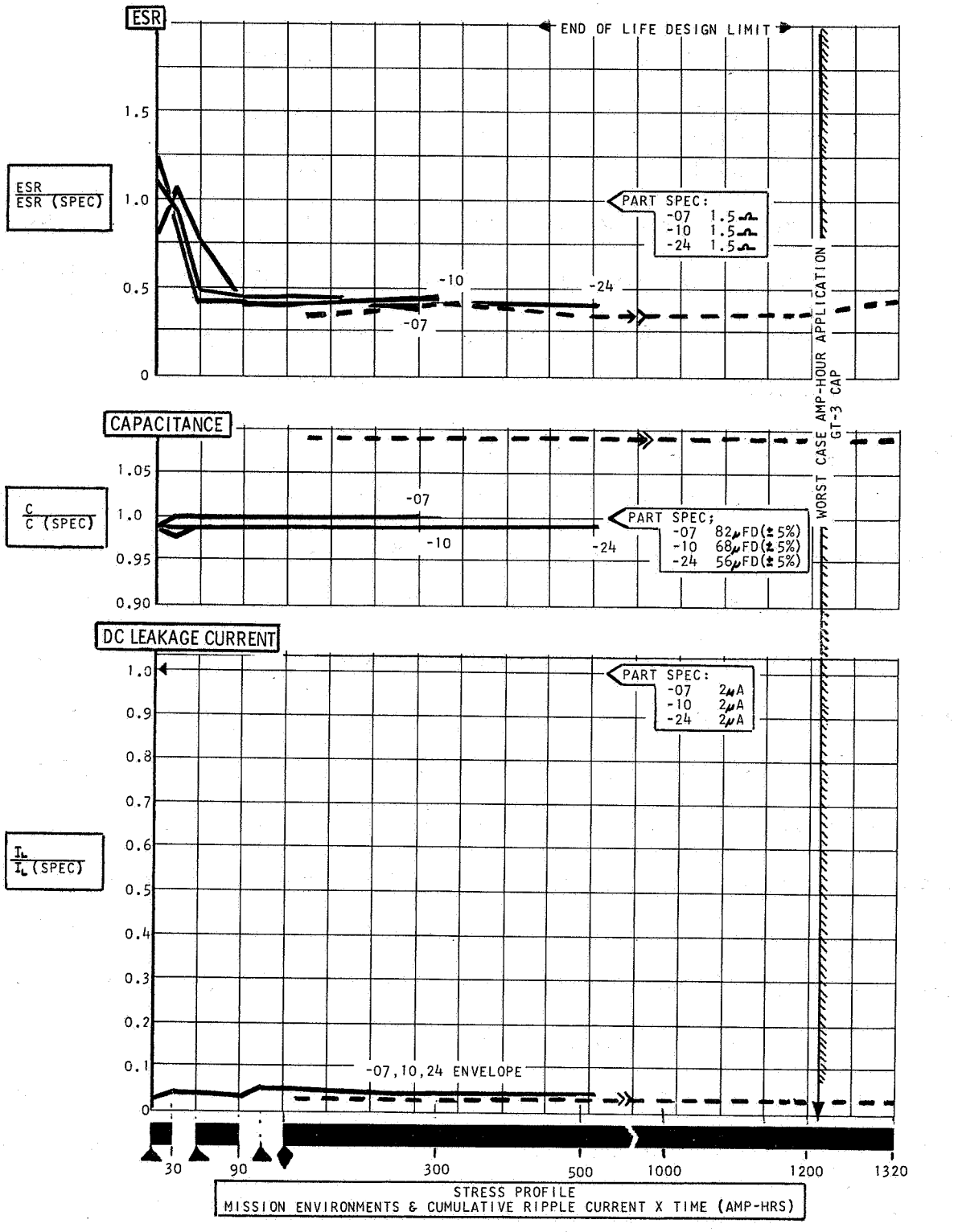

Figure 2.4 - Case Size GT-3 Wet Slug Tantalum Capacitor Performance Trends

high capacitance value ratio for the -007 MIL-SPEC equivalent wet slug tantalum capacitors tested by LRC FID is attributable to the fact that the MIL-SPEC equivalent parts are purchased to a ± 10% capacitance spec limit while Viking parts are purchased to a ± 5% capacitance spec.

The data thru the 150 amp-hour accumulated ripple current stress point for the 25 case size GT-2, Dash No. 021, wet slug tantalum capacitors tested (see Table 2.10) show trends similar to the GT-3 case size capacitors. No case size GT-1 wet slug tantalum capacitors were included in the ripple current test program.

Based upon the observed data trends and the similarity of construction of all Viking wet slug tantalum capacitors, it is concluded that Viking ripple current applications do not degrade the electrical performance characteristics of wet slug tantalum capacitors. Further, no significant difference in the capacitors measured electrical values were noted as a function of test variables (i.e., operating temperature, ripple frequency, ripple current magnitude and DC bias).

2.2.2 Wet Foil Capacitors

One group of each case size, G-3, G-4, and G-5, wet foil capacitors was subjected to the ripple current test.

Figure 2.5 is a family of curves which illustrate electrical performance trends versus part and design requirements for the case size G-3 and G-4 wet foil capacitors tested. Shown are ratios of measured parameter values to parameter spec values for ESR, Capacitance and DC leakage current plotted as a function of stress (i.e., ripple current amp-hour). The end of each 60 hour sterilization heat soak cycle and the end of 50 G vibration are identified. The trends shown in Figure 2.5 indicate that

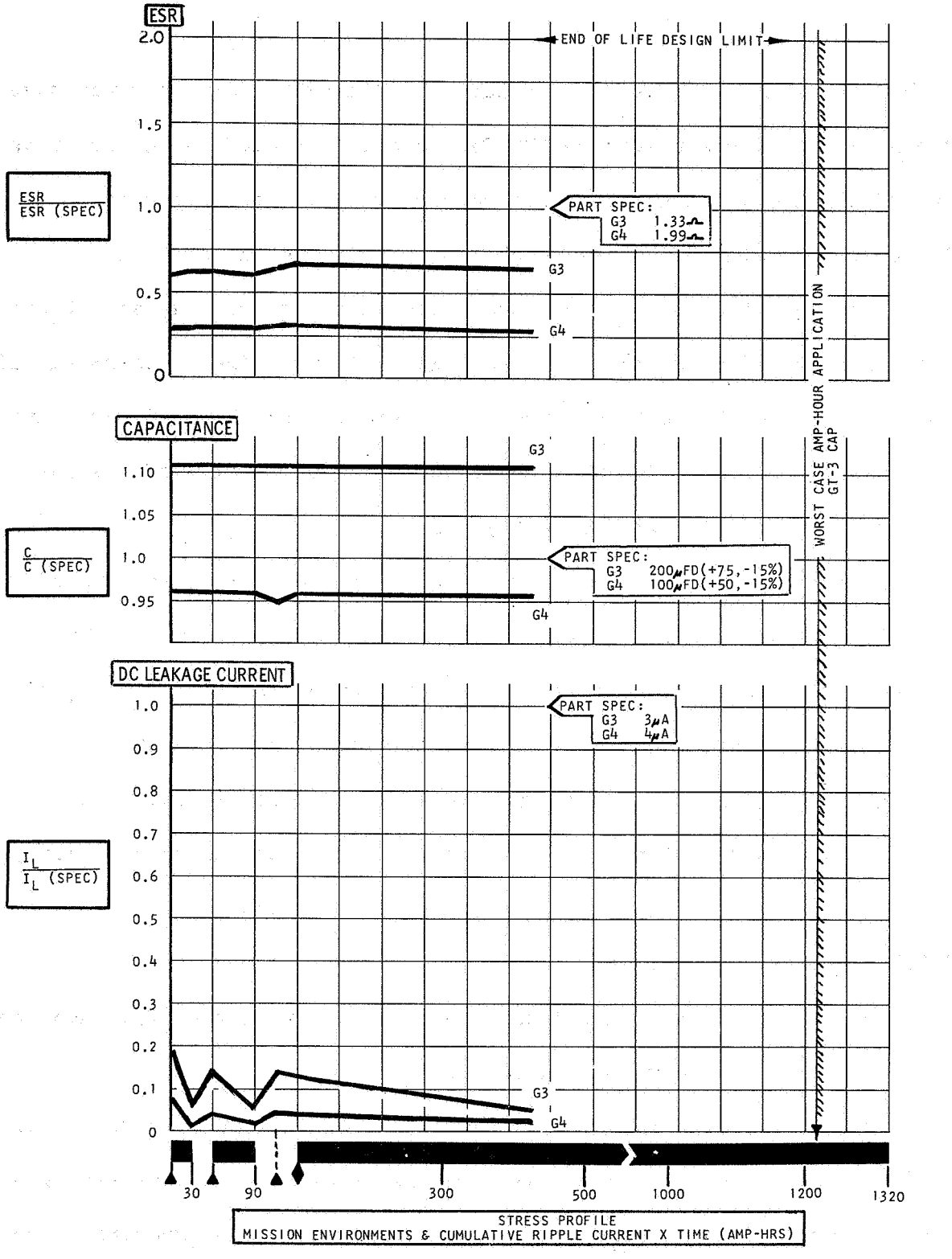

Figure 2.5 - Case Size G-3 and G-4 Wet Foil Capacitor Performance Trends

wet foil capacitor electrical parameters are not degraded in ripple current applications.

Detail data on the case size G-5 wet foil capacitors tested are presented in Table 2.11. The data for these capacitors is not as consistent as for the other capacitors tested. It has been concluded that:

1. Erratic ESRs up to the 200 hour point of ripple current application were most likely caused by measurement or recording errors; and,
2. The overall characteristics of the case size G-5 wet foil capacitors are in general accord with the case size G-3 and G-4 wet foil capacitors tested.

3.0 SILVER MIGRATION EVALUATION

Before the wet slug tantalum capacitor ripple current testing started, 21 wet slug capacitors were sent to the MMC Failure Analysis (FA) Laboratory for evaluation. These capacitors, selected at random from the same date codes as those capacitors mounted on the ripple current test sinks, formed the control sample against which ripple current test specimens would later be compared to determine if ripple current does induce silver migration.

The FA Lab dissected the 21 capacitors and performed a visual examination of the anode and case to detect the presence of free silver (caused by silver migration). The visual examination was followed by a quantitative chemical analysis of the anode and electrolyte to determine silver concentration levels.

Following the completion of wet slug tantalum capacitor ripple current testing, forty-six (46) additional parts were selected from the ripple current test specimens. These 46 capacitors were also sent to the FA Lab for dissection, visual examination and chemical analysis.

Detailed silver migration evaluation data is presented in Volume II of this report.

4.0 MEMORY TEST PROGRAM

The test program to determine if a memory phenomena does exist in wet slug tantalum capacitors consisted of:

1. Subjecting 25 wet slug capacitors to a constant DC bias level of 8 VDC for 1000 hours at a temperature of +70°C; followed by,
2. The application of the capacitors' rated voltage and measurement of charge current.

The test specimens were case size GT-1, 8.2 microfarad, 60 volt wet slug tantalum capacitors. Ten of the twenty-five were selected from a group of capacitors which had been previously subjected to a 2000 hour Life Test at a DC bias of 60 volts. The remaining fifteen were obtained from Viking flight inventory.

In electrolytic capacitors, a memory condition is denoted by excessive charge and/or leakage current when a significantly higher than normal operating voltage is applied. For example, if an electrolytic capacitor (typically an aluminum foil) is stressed by a voltage of only 10% or so of its rated value for an extended period of time and then rated voltage is applied, the capacitor will exhibit abnormally high charge and leakage currents until either the capacitor has reformed to the higher voltage or it catastrophically destroys itself. Becuase of this high charge and/or leakage current characteristic, capacitor charge current versus time was selected as the best evaluation parameter.

Figure 4.1 illustrates the setup used in making the memory test measurements. The power supply output voltage was set at 60 VDC with the aid of the digital voltmeter. Switch S-1 was kept open while the capacitor-under-test (CUT) was connected to the terminals of the test fixture. A stripchart recorder was connected across the 1000 ohm shunt resistor. Switch S-1 was then closed and the CUT charge current was recorded on the stripchart recorder.

Figure 4.2 shows the minimum and maximum charge currents of all the 25 capacitors tested. All test specimens yielded the standard RC charge curve. No excessive charge or leakage currents or other anomalies were observed.

It is concluded that once a wet slug tantalum capacitor is "formed" (at a given voltage during the manufacturing process), the subsequent application of voltage well below its rated value for an extended period of time has no effect on its operational characteristics.

5.0 CONCLUSION AND RECOMMENDATIONS

The test program was invaluable in establishing a better understanding of wet slug tantalum and wet foil capacitors. Because the ripple test accurately duplicated real life conditions, Viking Project Management has a greater confidence that wet slug tantalum capacitors are being properly applied in the Viking Program and that their reliability is acceptable.

As a result of this test program, it is concluded that:

1. Wet slug tantalum capacitors are being properly applied in the Viking Lander;

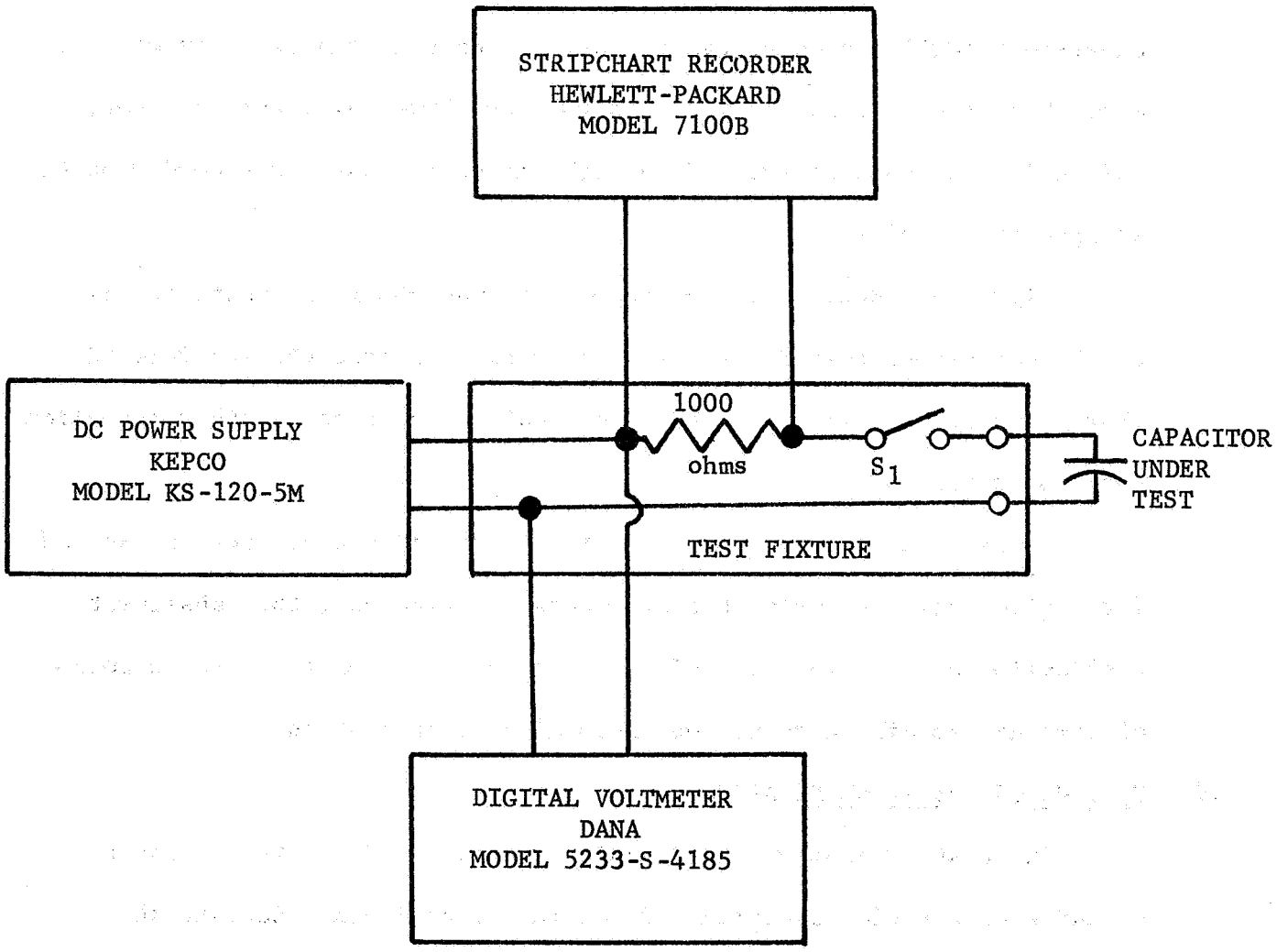

FIG 4.1 WET SLUG CAPACITOR TEST
MEASUREMENT SETUP

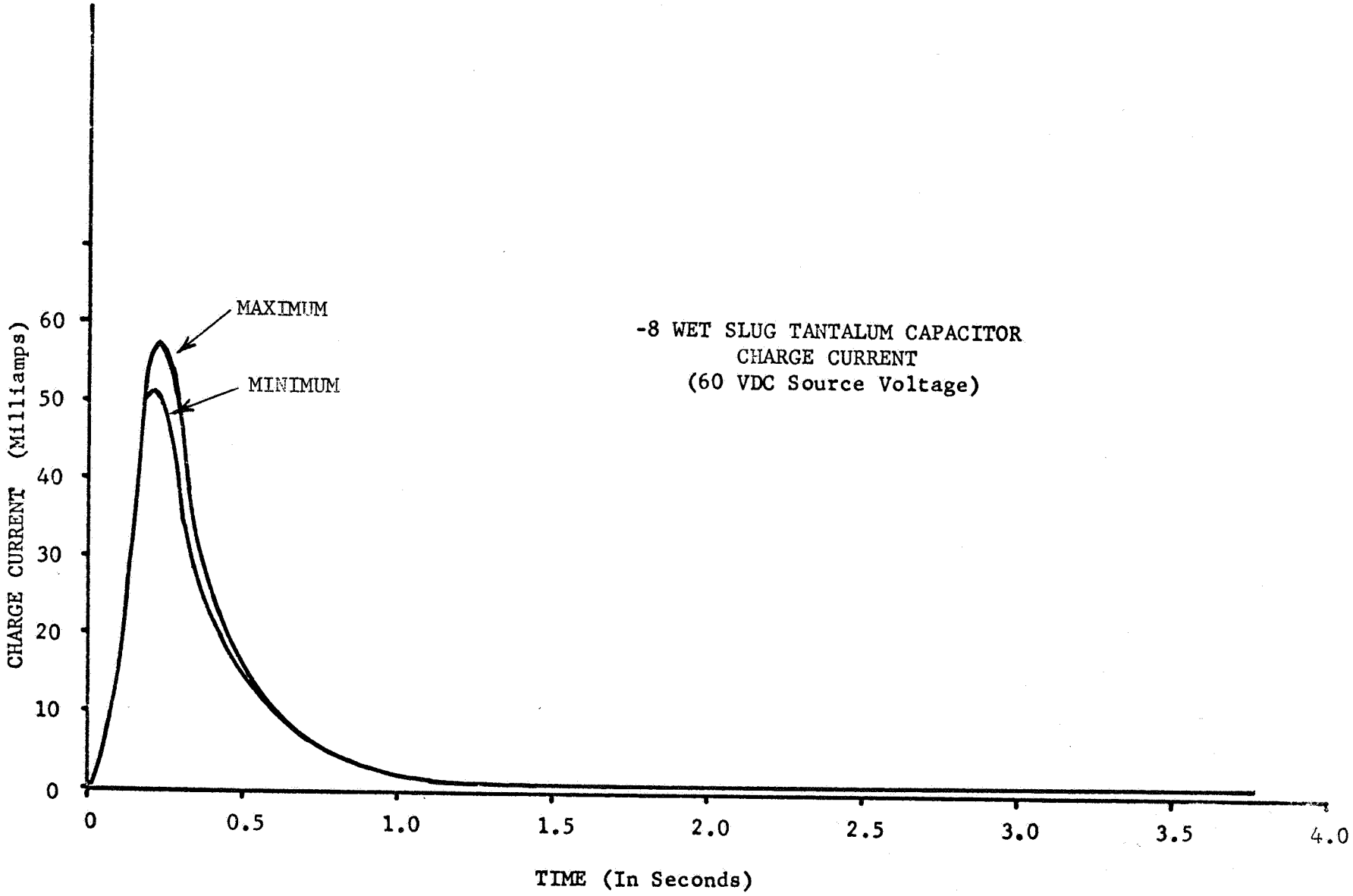

FIG 4.2 MEMORY TEST RESULTS

2. Viking ripple current levels, frequencies, and waveforms, have no significant effect on either wet slug tantalum or wet foil capacitors.
3. Wet foil capacitors are being properly applied in the Viking Lander and are acceptable alternates to wet slug tantalum capacitors in terms of electrical performance.
4. Wet slug tantalum capacitors do not exhibit a memory effect and can therefore be used in much lower than rated voltage applications without degradation.

It is recommended that the re-qualification of the double-crimp wet slug tantalum capacitor be pursued through its completion.

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